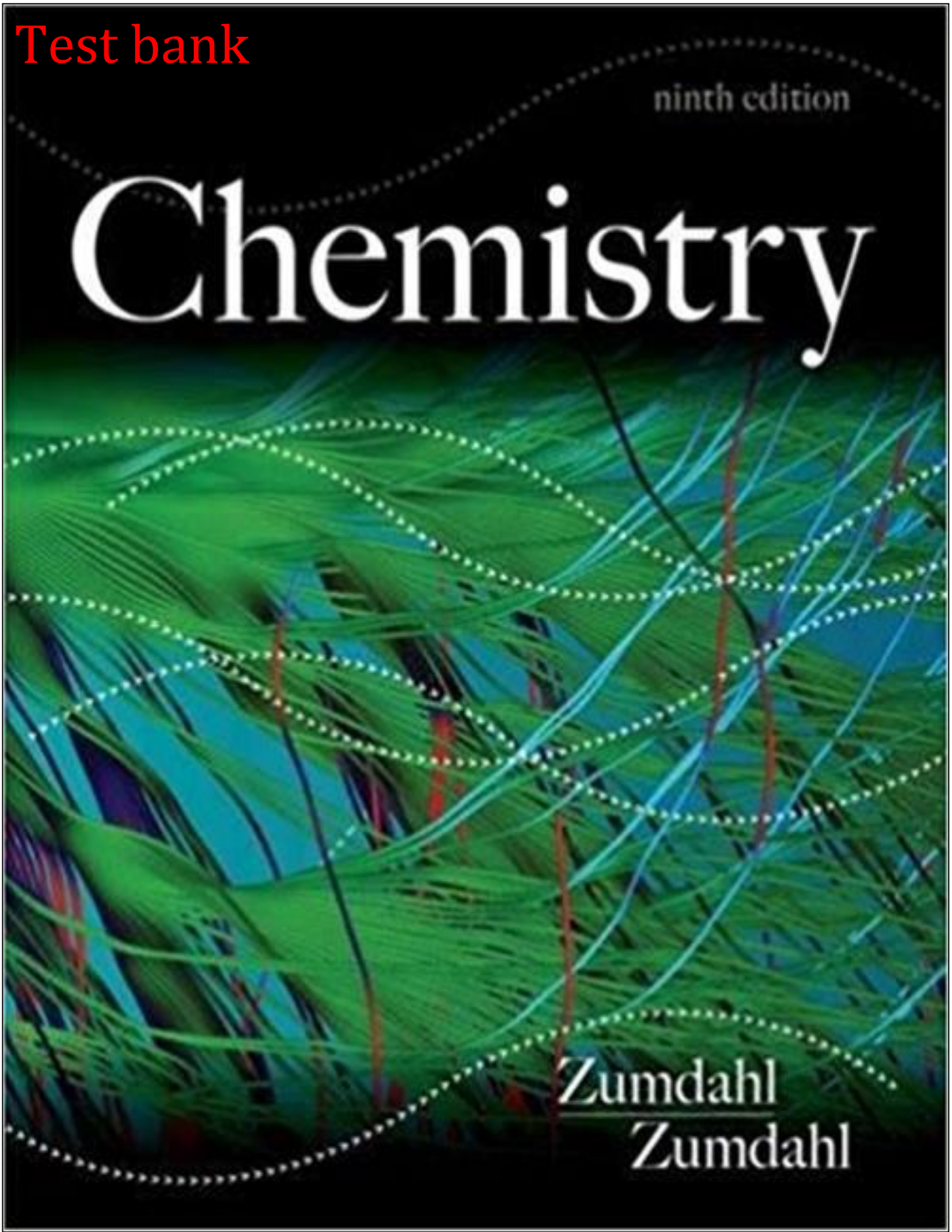
Test bank

ninth edition

Chemistry



Zumdahl

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This book is a gift that we hope would be of help to our family at STEM.

Sincerely,
STEM Freelancer's association

Chapter 1: Chemical Foundations

1. Which of the following is an example of a quantitative observation?
   A) The piece of metal is longer than the piece of wood.
   B) Solution 1 is much darker than solution 2.
   C) The liquid in beaker A is blue.
   D) The temperature of the liquid is 60°C.
   E) At least two of the above (A-D) are quantitative observations.

   ANS: D DIF: Easy REF: 1.2
   KEY: Chemistry | general chemistry | general concepts | scientific method
   MSC: Conceptual

2. A quantitative observation
   A) contains a number and a unit
   B) does not contain a number
   C) always makes a comparison
   D) must be obtained through experimentation
   E) is none of these

   ANS: A DIF: Easy REF: 1.2
   KEY: Chemistry | general chemistry | general concepts | scientific method
   MSC: Conceptual

3. Generally, observed behavior that can be formulated into a statement, sometimes mathematical in nature, is called a(n)
   A) observation
   B) measurement
   C) theory
   D) natural law
   E) experiment

   ANS: D DIF: Easy REF: 1.2
   KEY: Chemistry | general chemistry | general concepts | scientific method
   MSC: Conceptual

4. The statement "The total mass of materials is not affected by a chemical change in those materials" is called a(n)
   A) observation
   B) measurement
   C) theory
   D) natural law
   E) experiment

   ANS: D DIF: Easy REF: 1.2
   KEY: Chemistry | general chemistry | general concepts | scientific method
   MSC: Conceptual

5. A chemical theory that has been known for a long time becomes a law.

ANS: F DIF: Easy REF: 1.2
KEY: Chemistry | general chemistry | general concepts | scientific method
MSC: Conceptual

6. Which of the following metric relationships is incorrect?
   A) 1 microliter = 10^{-6} liters
   B) 1 gram = 10^{3} kilograms
   C) 10^{3} milliliters = 1 liter
   D) 1 gram = 10^{2} centigrams
   E) 10 decimeters = 1 meter

   ANS: B DIF: Easy REF: 1.3
   KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | prefixes
   MSC: Quantitative

7. For which pair is the SI prefix not matched correctly with its meaning?
   A) $\text{mega} = 10^{6}$
   B) $\text{kilo} = 1000$
   C) $\text{deci} = 10$
   D) $\text{nano} = 10^{-9}$
   E) $\text{centi} = 0.01$

   ANS: C DIF: Easy REF: 1.3
   KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | prefixes
   MSC: Conceptual

8. A metric unit for length is
   A) gram
   B) milliliter
   C) yard
   D) kilometer
   E) pound

   ANS: D DIF: Easy REF: 1.3
   KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | base unit
   MSC: Conceptual

9. Which of the following is *not* a unit in the SI system?
   A) ampere
   B) candela
   C) Kelvin
   D) meter
   E) calorie

   ANS: E DIF: Easy REF: 1.3
   KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | base unit
   MSC: Conceptual

10. Order the four metric prefixes from smallest to largest.

A) nano- < milli- < centi- < kilo-
B) milli- < nano- < centi- < kilo-
C) kilo- < centi- < nano- < milli-
D) kilo- < centi- < milli- < nano-
E) centi- < nano- < kilo- < milli-

ANS: A DIF: Easy REF: 1.3
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | prefixes
MSC: Conceptual

11. 8.1 kilogram(s) contains this many grams.
A) 8.1×10^{2}
B) 8.1×10^{3}
C) 81
D) 0.81
E) 8.1×10^{-3}

ANS: B DIF: Easy REF: 1.3
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | mass
MSC: Conceptual

12. Convert 0.3980 m to mm.
A) 398.0 mm
B) 3.980×10^{-3} mm
C) 3.980×10^{-4} mm
D) 0.03980 mm
E) none of these

ANS: A DIF: Easy REF: 1.3
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | prefixes
MSC: Conceptual

13. 6.1 seconds contain this many picoseconds.
A) 6.1×10^{12}
B) 6.1×10^{-12}
C) 6.1×10^{-9}
D) 6.1×10^{9}
E) 6.1×10^{15}

ANS: A DIF: Easy REF: 1.3
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | prefixes
MSC: Conceptual

14. 9.49 seconds contain this many nanoseconds.
A) 9.49×10^{7}
B) 9.49×10^{9}
C) 9.49×10^{12}
D) 9.49×10^{10}
E) 9.49×10^{8}

ANS: B DIF: Easy REF: 1.3
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | prefixes
MSC: Conceptual

15. The distance of 21 km equals
A) 0.021 m
B) 0.21 m
C) 210 m
D) 2100 m
E) 2.1×10^4 m

ANS: E DIF: Easy REF: 1.3
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | prefixes
MSC: Conceptual

16. What is the measure of resistance an object has to a change in its state of motion?
A) mass
B) weight
C) volume
D) length
E) none of these

ANS: A DIF: Easy REF: 1.3
KEY: Chemistry | general chemistry | general concepts | measurement
MSC: Conceptual

17. The degree of agreement among several measurements of the same quantity is called _____. It reflects the reproducibility of a given type of measurement.
A) accuracy
B) error
C) precision
D) significance
E) certainty

ANS: C DIF: Easy REF: 1.4
KEY: Chemistry | general chemistry | general concepts | measurement
MSC: Conceptual

18. As part of the calibration of a new laboratory balance, a 1.000-g mass is weighed with the following results:

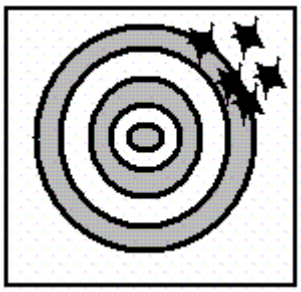
Trial	**Mass**
1	1.201 ± 0.001
2	1.202 ± 0.001
3	1.200 ± 0.001

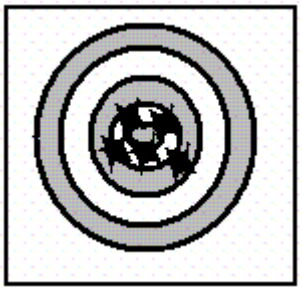
The balance is:
A) Both accurate and precise.
B) Accurate but imprecise.
C) Precise but inaccurate.
D) Both inaccurate and imprecise.
E) Accuracy and precision are impossible to determine with the available information.

ANS: C DIF: Easy REF: 1.4
KEY: Chemistry | general chemistry | general concepts | measurement
MSC: Conceptual

Consider the following three archery targets:

I.

II. 

III. 

19. Which of the following figure(s) represent a result having high precision?
A) Figure I only
B) Figure II only
C) Figure III only
D) Figure I and Figure II
E) Figure II and Figure III

ANS: E DIF: Easy REF: 1.4
KEY: Chemistry | general chemistry | general concepts | measurement
MSC: Conceptual

20. Which of the following statements concerning these figures is correct?
A) Figure I represents systematic error and Figure II represents random error.
B) Figure I represents random error and Figure II represents systematic error.
C) Figure I and Figure II represent random error.
D) Figure I and Figure II represent systematic error.
E) Figure III represents no errors.

ANS: B DIF: Easy REF: 1.4
KEY: Chemistry | general chemistry | general concepts | measurement
MSC: Conceptual

21. Which of the following is the least probable concerning five measurements taken in the lab?
A) The measurements are accurate and precise.
B) The measurements are accurate but not precise.
C) The measurements are precise but not accurate.
D) The measurements are neither accurate nor precise.
E) All of these are equally probable.

ANS: B DIF: Easy REF: 1.4
KEY: Chemistry | general chemistry | general concepts | measurement
MSC: Conceptual

22. You measure water in two containers: a 10-mL graduated cylinder with marks at every mL, and a 1-mL pipet marked at every 0.1 mL. If you have some water in each of the containers and add them together, to what decimal place could you report the total volume of water?
A) 0.01 mL
B) 0.1 mL
C) 1 mL
D) 10 mL
E) none of these

ANS: B DIF: Moderate REF: 1.4
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures
MSC: Conceptual

23. The agreement of a particular value with the true value is called
A) accuracy
B) error
C) precision
D) significance
E) certainty

ANS: A DIF: Easy REF: 1.4
KEY: Chemistry | general chemistry | general concepts | measurement
MSC: Conceptual

24. The amount of uncertainty in a measured quantity is determined by:
A) both the skill of the observer and the limitations of the measuring instrument
B) neither the skill of the observer nor the limitations of the measuring instrument
C) the limitations of the measuring instrument only
D) the skill of the observer only
E) none of these

ANS: A DIF: Easy REF: 1.4
KEY: Chemistry | general chemistry | general concepts | measurement
MSC: Conceptual

25. A scientist obtains the number 0.045006700 on a calculator. If this number actually has four (4) significant figures, how should it be written?
A) 0.4567
B) 0.4501
C) 0.0450
D) 0.04500
E) 0.04501

ANS: E DIF: Easy REF: 1.5
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures | rounding MSC: Conceptual

26. Express the number 0.000333 in scientific notation.
A) 333×10^{-6}
B) 3.33×10^{2}

C) 3.33×10^{4}
D) 3.33×10^{-4}
E) 0.333×10^{-3}

ANS: D DIF: Easy REF: 1.5
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures | scientific notation MSC: Conceptual

27. Express 165,000 in exponential notation.
A) 1.65000×10^{5}
B) 1.65×10^{5}
C) 1.65000×10^{-5}
D) 1.65×10^{-5}
E) 165×10^{3}

ANS: B DIF: Easy REF: 1.5
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures | scientific notation MSC: Conceptual

28. Express the number 0.0810 in scientific notation.
A) 810×10^{-4}
B) 8.10×10^{2}
C) 8.1×10^{-2}
D) 8.10×10^{-2}
E) 0.810×10^{-1}

ANS: D DIF: Easy REF: 1.5
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures | scientific notation MSC: Conceptual

29. Express the number 6.49×10^{-3} in common decimal form.
A) 0.00649
B) 6.49
C) 6490
D) 0.0649
E) 0.000649

ANS: A DIF: Easy REF: 1.5
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures | scientific notation MSC: Conceptual

30. Express the number 2.37×10^{4} in common decimal form.
A) 237000
B) 0.0000237
C) 0.000237
D) 23700
E) 2370

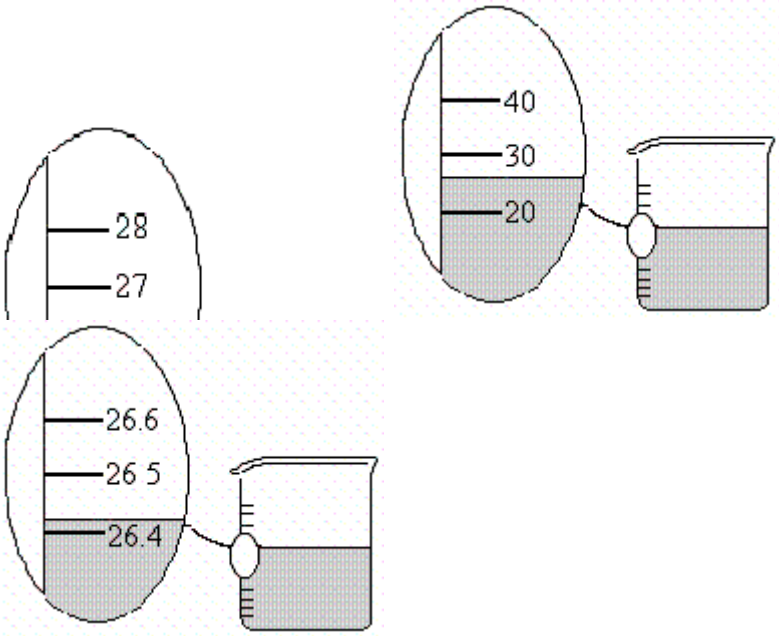
ANS: D DIF: Easy REF: 1.5

KEY: Chemistry | general chemistry | general concepts | measurement | significant figures | scientific notation MSC: Conceptual

31. We generally report a measurement by recording all of the certain digits plus ____ uncertain digit(s).
A) no
B) one
C) two
D) three
E) four

ANS: B DIF: Easy REF: 1.5
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures
MSC: Conceptual

32. The beakers shown below have different precisions as shown.



Suppose you pour the water from these three beakers into one container. What would be the volume in the container reported to the correct number of significant figures?
A) 78.817 mL
B) 78.82 mL
C) 78.8 mL
D) 80 mL
E) 79 mL

ANS: E DIF: Moderate REF: 1.5
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures
MSC: Conceptual

33. You are asked to determine the perimeter of the cover of your textbook. You measure the length as 39.36 cm and the width as 24.83 cm. How many significant figures should you report for the perimeter?
A) 1
B) 2

C) 3
D) 4
E) 5

ANS: E DIF: Moderate REF: 1.5
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures
MSC: Quantitative

34. Consider the numbers 23.68 and 4.12. The sum of these numbers has ____ significant figures, and the product of these numbers has ____ significant figures.
A) 3, 3
B) 4, 4
C) 3, 4
D) 4, 3
E) none of these

ANS: D DIF: Easy REF: 1.5
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures
MSC: Conceptual

35. Using the rules of significant figures, calculate the following:

$$\frac{6.167 + 68}{5.10}$$

A) 14.5
B) 16
C) 15
D) 82
E) 14.54

ANS: C DIF: Easy REF: 1.5
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures
MSC: Quantitative

36. Using the rules of significant figures, calculate the following: $4.0021 - 0.179$
A) 3.823
B) 4
C) 3.8231
D) 3.82
E) 3.8

ANS: A DIF: Easy REF: 1.5
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures
MSC: Quantitative

37. How many significant figures are there in the number 0.04560700?
A) 4
B) 5
C) 7
D) 8
E) 9

ANS: C DIF: Easy REF: 1.5
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures
MSC: Conceptual

38. How many significant figures are there in the number 0.0006428?
A) 7
B) 3
C) 8
D) 4
E) 0

ANS: D DIF: Easy REF: 1.5
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures
MSC: Conceptual

39. How many significant figures are there in the number 3.1400?
A) 1
B) 2
C) 3
D) 4
E) 5

ANS: E DIF: Easy REF: 1.5
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures
MSC: Conceptual

40. How many significant figures should be reported for the difference between 18.6172 mL and 18.57 mL?
A) 1
B) 2
C) 3
D) 4
E) 6

ANS: B DIF: Easy REF: 1.5
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures
MSC: Conceptual

41. What is the best answer to report for $\frac{3.478\ \text{g} \times 1.164\ \text{g}}{2.00\ \text{mL}} - 0.169\ \text{g/mL}$ g/mL?
A) 1.8510 g/mL
B) 1.851 g/mL
C) 1.85 g/mL
D) 1.9 g/mL
E) 2 g/mL

ANS: C DIF: Easy REF: 1.5
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures
MSC: Quantitative

42. What is the best answer to report for $(513 \times 0.0039) + 25.35$?

A) 27.351
B) 27.35
C) 27.3507
D) 27
E) 27.4

ANS: E DIF: Easy REF: 1.5
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures
MSC: Quantitative

43. Convert 2751.4 g to mg.
A) 2.7514 mg
B) 27.514 mg
C) 275.14 mg
D) 2.7514×10^3 mg
E) 2.7514×10^6 mg

ANS: E DIF: Easy REF: 1.7
KEY: Chemistry | general chemistry | general concepts | measurement | dimensional analysis MSC: Quantitative

44. Express the volume $781.2\ \text{cm}^3$ in liters.
A) 781.2 L
B) 78.12 L
C) 7.812 L
D) 0.7812 L
E) 0.07812 L

ANS: D DIF: Easy REF: 1.7
KEY: Chemistry | general chemistry | general concepts | measurement | dimensional analysis MSC: Quantitative

45. Convert 44.7 m^3 to mm^3.
A) $4.47 \times 10^7\ \text{mm}^3$
B) $4.47 \times 10^{10}\ \text{mm}^3$
C) $4.47 \times 10^4\ \text{mm}^3$
D) $4.47 \times 10^{-5}\ \text{mm}^3$
E) $4.47 \times 10^{-8}\ \text{mm}^3$

ANS: B DIF: Moderate REF: 1.7
KEY: Chemistry | general chemistry | general concepts | measurement | dimensional analysis MSC: Quantitative

46. The pressure of the earth's atmosphere at sea level is $14.7\ \text{lb/in}^2$. What is the pressure when expressed in g/m^2? (2.54 cm = 1 in., 2.205 lb = 1 kg)
A) $2.62 \times 10^5\ \text{g/m}^2$
B) $1.03 \times 10^7\ \text{g/m}^2$
C) $5.02 \times 10^4\ \text{g/m}^2$

D) $4.30 \times 10^{0}\ \text{g/m}^2$
E) $2.09 \times 10^{-5}\ \text{g/m}^2$

ANS: B DIF: Difficult REF: 1.7
KEY: Chemistry | general chemistry | general concepts | measurement | dimensional analysis MSC: Quantitative

47. Convert 4338 mL to qt. (1 L = 1.06 qt)
A) 4598 qt
B) 4.092 qt
C) 4.092×10^{-3} qt
D) 4092 qt
E) 4.598 qt

ANS: E DIF: Easy REF: 1.7
KEY: Chemistry | general chemistry | general concepts | measurement | dimensional analysis MSC: Quantitative

48. Convert 34.4 lb to g. (1 lb = 453.6 g)
A) 7.58×10^{-2} g
B) 1.56×10^{3} g
C) 7.58×10^{4} g
D) 1.56×10^{2} g
E) 1.56×10^{4} g

ANS: E DIF: Easy REF: 1.7
KEY: Chemistry | general chemistry | general concepts | measurement | dimensional analysis MSC: Quantitative

49. Convert 59.4 mi to km. (1 m = 1.094 yd, 1 mi = 1760 yd)
A) 6.50×10^{1} km
B) 3.69×10^{1} km
C) 9.56×10^{7} km
D) 5.43×10^{1} km
E) 9.56×10^{1} km

ANS: E DIF: Easy REF: 1.7
KEY: Chemistry | general chemistry | general concepts | measurement | dimensional analysis MSC: Quantitative

50. The density of liquid mercury is 13.6 g/mL. What is its density in units of lb/in^3? (2.54 cm = 1 in., 2.205 lb = 1 kg)
A) $1.57 \times 10^{-2}\ \text{lb/in}^3$
B) $4.91 \times 10^{-1}\ \text{lb/in}^3$
C) $1.01 \times 10^{-1}\ \text{lb/in}^3$
D) $7.62 \times 10^{-2}\ \text{lb/in}^3$
E) $1.83\ \text{lb/in}^3$

ANS: B DIF: Easy REF: 1.7
KEY: Chemistry | general chemistry | general concepts | measurement | dimensional analysis MSC: Quantitative

51. Convert 0.0494 ft^3 to L. (2.54 cm = 1 in., 1 L = 1 dm^3)
A) 1.40×10^{1} L
B) 1.40 L
C) 1.51×10^{-3} L
D) 1.74×10^{-3} L
E) 1.62 L

ANS: B DIF: Moderate REF: 1.7
KEY: Chemistry | general chemistry | general concepts | measurement | dimensional analysis MSC: Quantitative

52. In March 2008, gold reached a milestone value of $1000 per troy ounce. At that price, what was the cost of a gram of gold? (1 troy ounce = 31.10 g)
A) less than $1
B) between $1 and $10
C) between $10 and $50
D) between $50 and $100
E) over $100

ANS: C DIF: Easy REF: 1.7
KEY: Chemistry | general chemistry | general concepts | measurement | dimensional analysis MSC: Quantitative

53. It is estimated that uranium is relatively common in the earth's crust, occurring in amounts of 4 g / metric ton. A metric ton is 1000 kg. At this concentration, what mass of uranium is present in 1.5 mg of the earth's crust?
A) 6 ng
B) 6 μg
C) 6 mg
D) 6×10^{-5} g
E) 6 cg

ANS: A DIF: Moderate REF: 1.7
KEY: Chemistry | general chemistry | general concepts | measurement | dimensional analysis MSC: Quantitative

54. A 20.0 mL sample of glycerol has a mass of 25.2 grams. What is the density of glycerol in ounces/quart? (1.00 ounce = 28.4 grams, and 1.00 liter = 1.06 quarts)
A) 41.9 oz/qt
B) 4.19×10^{-2} oz/qt
C) 837 oz/qt
D) 47.0 oz/qt
E) 26.4 oz/qt

ANS: A DIF: Difficult REF: 1.7

KEY: Chemistry | general chemistry | general concepts | measurement | dimensional analysis MSC: Quantitative

55. During a physics experiment, an electron is accelerated to 93 percent of the speed of light. What is the speed of the electron in miles per hour? (speed of light = 3.00×10^8 m/s, 1 km = 0.6214 mi)
A) 2.8×10^8 mi/h
B) 6.2×10^{11} mi/h
C) 6.7×10^8 mi/h
D) 1.0×10^7 mi/h
E) 6.2×10^8 mi/h

ANS: E DIF: Moderate REF: 1.7
KEY: Chemistry | general chemistry | general concepts | measurement | dimensional analysis MSC: Quantitative

56. In the spring of 2008, petrol cost £1.179 per litre in London. On the same day, the exchange rate was $1 = £0.493. What was the price of London petrol in dollars ($) per gallon? (1 gal = 3.7854 L)
A) $4.46 /gal
B) $2.20 /gal
C) $9.05 /gal
D) $1.58 /gal
E) $7.68 /gal

ANS: C DIF: Easy REF: 1.7
KEY: Chemistry | general chemistry | general concepts | measurement | dimensional analysis MSC: Quantitative

57. For spring break you and some friends plan a road trip to a sunny destination that is 2105 miles away. If you drive a car that gets 33 miles per gallon and gas costs $3.199/gal, about how much will it cost to get to your destination?
A) $410
B) $220
C) $200
D) $660
E) $6700

ANS: C DIF: Easy REF: 1.7
KEY: Chemistry | general chemistry | general concepts | measurement | dimensional analysis MSC: Quantitative

58. Convert 7.9 kg to lb. (1 kg = 2.205 lb)
A) 17 lbs
B) 1.7 lbs
C) 3.6 lbs
D) 0.017 lbs
E) 17.42 lbs

ANS: A DIF: Easy REF: 1.7

KEY: Chemistry | general chemistry | general concepts | measurement | dimensional analysis MSC: Quantitative

59. Manganese makes up 1.3×10^{-4} percent by mass of the elements found in a normal healthy body. How many grams of manganese would be found in the body of a person weighing 206 lb? (2.205 lb = 1 kg)
A) 0.59 g
B) 0.12 g
C) 12 g
D) 59 g
E) 1.2×10^{-4} g

ANS: B DIF: Moderate REF: 1.7
KEY: Chemistry | general chemistry | general concepts | measurement | dimensional analysis MSC: Quantitative

60. In 1928, 29.3 g of a new element was isolated from 660 kg of the ore molybdenite. The percent by mass of this element in the ore was:
A) 44 %
B) 6.6 %
C) 29.3 %
D) 0.0044 %
E) 19.3 %

ANS: D DIF: Moderate REF: 1.7
KEY: Chemistry | general chemistry | general concepts | measurement | dimensional analysis MSC: Quantitative

61. 409 Kelvin equals
A) 136°F
B) 273°F
C) 682°F
D) 136°C
E) 682°C

ANS: D DIF: Easy REF: 1.8
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | temperature
MSC: Quantitative

62. The melting point of a certain element is 391°C. What is this on the Fahrenheit scale?

$$\left(T_{°F} = T_{°C} \times \left(\frac{9°F}{5°C} \right) + 32°F \right)$$

A) 490°F
B) 249°F
C) 977°F
D) 736°F
E) 672°F

ANS: D DIF: Easy REF: 1.8
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | temperature
MSC: Quantitative

63. Convert: –48.2°C = _____ °F. $\left(T_{°F} = T_{°C} \times \left(\frac{9°F}{5°C}\right) + 32°F\right)$

A) –86.8°F
B) –119°F
C) –54.8°F
D) 119°F
E) 224.8°F

ANS: C DIF: Easy REF: 1.8
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | temperature
MSC: Quantitative

64. As warm water sits in a cool room, you measure the temperature change ($\Delta T = T_{final} - T_{initial}$). Which of the following is true?

A) The temperature change (ΔT) is bigger if you are measuring in °F.
B) The temperature change (ΔT) is bigger if you are measuring in °C.
C) The temperature change (ΔT) will be the same regardless of the scale you use.
D) Answer A or B is correct, depending on the difference in temperature between the water and the room.
E) None of the above.

ANS: A DIF: Easy REF: 1.8
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | temperature
MSC: Conceptual

65. The melting point of picolinic acid is 136.5°C. What is the melting point of picolinic acid on the Fahrenheit scale?

$\left(T_{°F} = T_{°C} \times \left(\frac{9°F}{5°C}\right) + 32°F\right)$

A) 107.8°F
B) 245.7°F
C) 168.5°F
D) 409.5°F
E) 277.7°F

ANS: E DIF: Easy REF: 1.8
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | temperature
MSC: Quantitative

66. In 1984, some drums of uranium hexafluoride were lost in the English Channel, which is known for its cold water (about 17°C). The melting point of uranium hexafluoride is 148°F. In what physical state is the uranium hexafluoride in these drums?

$$\left(T_{°F} = T_{°C} \times \left(\frac{9°F}{5°C}\right) + 32°F\right)$$

A) solid
B) liquid
C) gas
D) a mixture of solid and liquid
E) not enough information

ANS: A DIF: Moderate REF: 1.8
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | temperature
MSC: Conceptual

67. The melting point of indium is 156.2°C. At 323°F, what is the physical state of indium?

$$\left(T_{°F} = T_{°C} \times \left(\frac{9°F}{5°C}\right) + 32°F\right)$$

A) Solid.
B) Liquid.
C) Gas.
D) Not enough information.
E) At 323°F, the indium is partially solid and partially liquid; there is an equilibrium between the two states.

ANS: D DIF: Moderate REF: 1.8
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | temperature
MSC: Conceptual

68. On a new temperature scale (°Z), water boils at 120.0°Z and freezes at 40.0°Z. Calculate the normal human body temperature using this temperature scale. On the Celsius scale, normal human body temperature could typically be 37.1°C, and water boils at 100.0°C and freezes at 0.00°C.
A) 2968°Z
B) 12.4°Z
C) 69.7°F
D) 111°Z
E) 29.7°Z

ANS: C DIF: Difficult REF: 1.8
KEY: Chemistry | general chemistry | general concepts | measurement
MSC: Quantitative

69. The calibration points for the linear Reaumur scale are the usual melting point of ice and boiling point of water, which are assigned the values 0°R and 80°R, respectively. The boiling point of ethanol is 78.4°F. What is this temperature in °R?
A) 158.4°R

B) 49.1°R
C) 25.8°R
D) 208.4°R
E) 20.6°R

ANS: E DIF: Difficult REF: 1.8
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | temperature
MSC: Conceptual

70. A monolayer containing 3.23×10^{-6} g of oleic acid has an area of 20.0 cm^2. The density of oleic acid is 0.895 g / mL. What is the thickness of the monolayer (the length of an oleic acid molecule)?
A) 7.22×10^{-5} cm
B) 5.54×10^{-6} cm
C) 5.78×10^{-5} cm
D) 1.80×10^{-7} cm
E) 1.45×10^{-7} cm

ANS: D DIF: Moderate REF: 1.9
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | density
MSC: Quantitative

71. The density of gasoline is 0.7025 g/mL at 20°C. When gasoline is added to water:
A) It will float on top.
B) It will sink to the bottom.
C) It will mix so, you can't see it.
D) The mixture will improve the running of the motor.
E) None of these things will happen.

ANS: A DIF: Easy REF: 1.9
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | density
MSC: Conceptual

72. A piece of zinc with a mass of 12.14 g is submerged in 46.3 cm^3 of water in a graduated cylinder. The water level increases to 48.0 cm^3. The correct value for the density of zinc from these data is:
A) 7.141 g/cm^3
B) 7.1 g/cm^3
C) 0.14 g/cm^3
D) 0.253 g/cm^3
E) 3.95 g/cm^3

ANS: B DIF: Moderate REF: 1.9
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | density
MSC: Quantitative

The density of a liquid is determined by successively weighing 25, 50, 75, 100, and 125 mL of the liquid in a 250-mL beaker.

73. If volume of liquid is plotted along the horizontal axis, and total mass of beaker plus liquid is plotted on the vertical axis:
A) The *x*, or horizontal, intercept is the negative value of the weight of the beaker.
B) The *y*, or vertical, intercept is the weight of the empty beaker.
C) The slope of the line is 1.0.
D) The line will pass through the origin.
E) The slope of the line is independent of the identity of the liquid.

ANS: B DIF: Moderate REF: 1.9
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | density
MSC: Conceptual

74. Considering the plot of total mass (*y*-axis) versus volume (*x*-axis), which of the following is true?
A) The plot should be rather linear because the slope measures the density of a liquid.
B) The plot should be curved upward because the slope measures the density of a liquid.
C) The plot should be curved upward because the mass of the liquid is higher in successive trials.
D) The plot should be linear because the mass of the beaker stays constant.
E) None of the above.

ANS: A DIF: Difficult REF: 1.9
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | density
MSC: Conceptual

75. A 20.0 mL sample of glycerol has a mass of 25.2 grams. What is the mass of a 57-mL sample of glycerol?
A) 8.8 g
B) 45 g
C) 2.9×10^4 g
D) 72 g
E) 71.8 g

ANS: D DIF: Easy REF: 1.9
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | density
MSC: Quantitative

76. Suppose that you purchased a water bed with the dimensions 2.55 m × 2.53 dm × 235 cm. What mass of water does this bed contain?
A) 1.52×10^3 g
B) 1.52×10^4 g
C) 1.52×10^5 g
D) 1.52×10^8 g
E) 1.52×10^6 g

ANS: E DIF: Moderate REF: 1.9

KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | density
MSC: Quantitative

77. A freighter carrying a cargo of uranium hexafluoride sank in the English Channel in late August 1984. The cargo of uranium hexafluoride weighed 2.253×10^8 kg and was contained in 30 drums, each containing 1.47×10^6 L of UF_6. What is the density (g/mL) of uranium hexafluoride?
A) 1.53 g/mL
B) 5.11 g/mL
C) 2.25 g/mL
D) 0.196 g/mL
E) 51.1 g/mL

ANS: B DIF: Moderate REF: 1.9
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | density
MSC: Quantitative

78. The boiling of water is a
A) physical change because the water merely disappears
B) physical change because the gaseous water is chemically the same as the liquid
C) chemical change because heat is needed for the process to occur
D) chemical change because a gas (steam) is given off
E) chemical and physical damage

ANS: B DIF: Easy REF: 1.1
KEY: Chemistry | general chemistry | general concepts | matter MSC: Conceptual

79. The state of matter for an object that has a definite volume but not a definite shape is
A) solid state
B) liquid state
C) gaseous state
D) elemental state
E) mixed state

ANS: B DIF: Easy REF: 1.1
KEY: Chemistry | general chemistry | general concepts | matter | states of matter
MSC: Conceptual

80. The state of matter for an object that has both definite volume and definite shape is
A) solid state
B) liquid state
C) gaseous state
D) elemental state
E) mixed state

ANS: A DIF: Easy REF: 1.1
KEY: Chemistry | general chemistry | general concepts | matter | states of matter
MSC: Conceptual

81. _____ are substances with constant composition that can be broken down into elements by chemical processes.
A) Solutions
B) Mixtures
C) Compounds
D) Quarks
E) Heterogeneous mixtures

ANS: C DIF: Easy REF: 1.1
KEY: Chemistry | general chemistry | general concepts | matter MSC: Conceptual

82. A method of separation that employs a system with two phases of matter, a mobile phase and a stationary phase, is called
A) filtration
B) chromatography
C) distillation
D) vaporization
E) homogenization

ANS: B DIF: Easy REF: 1.1
KEY: Chemistry | general chemistry | general concepts | matter | separation
MSC: Conceptual

83. Which of the following statements is false?
A) Solutions are always homogeneous mixtures.
B) The terms “atom” and “element” can have different meanings.
C) Elements can exist as atoms or molecules.
D) Compounds can exist as atoms or molecules.
E) At least two of the above statements (A-D) are false.

ANS: D DIF: Easy REF: 1.1
KEY: Chemistry | general chemistry | general concepts | matter MSC: Conceptual

84. An example of a pure substance is
A) elements
B) compounds
C) pure water
D) carbon dioxide
E) all of these

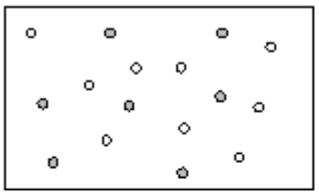
ANS: E DIF: Easy REF: 1.1
KEY: Chemistry | general chemistry | general concepts | matter MSC: Conceptual

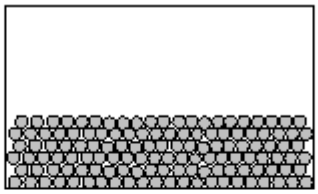
85. A solution is also called a
A) homogeneous mixture
B) heterogeneous mixture
C) pure mixture
D) compound
E) distilled mixture

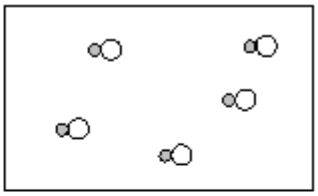
ANS: A DIF: Easy REF: 1.1

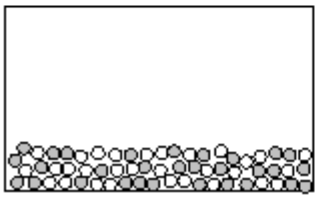
KEY: Chemistry | general chemistry | general concepts | matter | mixture
MSC: Conceptual

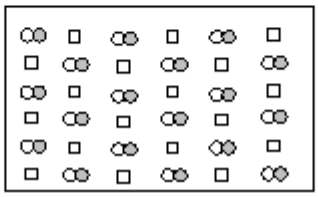
Consider the following choices when answering questions 86-89.

a) 

b) 

c) 

d) 

e) 

86. Which best represents a homogeneous mixture of an element and a compound?
A) option a
B) option b
C) option c
D) option d
E) option e

ANS: E DIF: Easy REF: 1.1
KEY: Chemistry | general chemistry | general concepts | matter | mixture
MSC: Conceptual

87. Which best represents a gaseous compound?
A) option a
B) option b
C) option c
D) option d
E) option e

ANS: C DIF: Easy REF: 1.1
KEY: Chemistry | general chemistry | general concepts | matter | states of matter
MSC: Conceptual

88. Which best represents a solid element?
A) option a
B) option b
C) option c
D) option d
E) option e

ANS: B DIF: Easy REF: 1.1
KEY: Chemistry | general chemistry | general concepts | matter | element
MSC: Conceptual

89. Which best represents a heterogeneous mixture of two elements?
A) option a
B) option b
C) option c
D) option d
E) option e

ANS: D DIF: Easy REF: 1.1
KEY: Chemistry | general chemistry | general concepts | matter | mixture
MSC: Conceptual

90. All physical changes are accompanied by chemical changes.

ANS: F DIF: Easy REF: 1.1
KEY: Chemistry | general chemistry | general concepts | matter MSC: Conceptual

91. Color changes always indicate a chemical change.

ANS: F DIF: Easy REF: 1.1
KEY: Chemistry | general chemistry | general concepts | matter MSC: Conceptual

92. What are the components of the scientific method?

ANS:
1) Making observations (collecting data)
2) Suggesting a possible explanation (formulating a hypothesis)
3) Doing experiments to test the possible explanation (testing the hypothesis)
Depending on the data from the experiments, the hypothesis may be modified and retested.
See Sec. 1.2 of Zumdahl, *Chemistry*.

DIF: Easy REF: 1.2
KEY: Chemistry | general chemistry | general concepts | scientific method
MSC: Conceptual

93. Garfield (weighing 24 lbs) took a flight to the moon on the space shuttle. As usual, he stuffed himself with lasagna during the entire flight and napped when he wasn't eating. Much to his delight when he got to the moon he found he weighed only 6 lbs. He immediately proclaimed a quick weight loss diet. Explain the fallacy in his reasoning. Assume gravity on the moon to be about one-sixth that of Earth.

ANS:
Garfield (the cartoon cat) may have a different weight on the moon, but he has the same mass. He has apparently forgotten that weight is the response of mass to gravity, and since the moon has a smaller gravitational field his weight there is less.
See Sec. 1.3 of Zumdahl, *Chemistry*.

DIF: Moderate REF: 1.3
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | mass
MSC: Conceptual

94. Contrast the terms precision and accuracy.

ANS:
Precision refers to the agreement among several measurements of the same quantity.
Accuracy refers to the agreement of a measurement with the true value.
Measurements may often be precise without being accurate.
See Sec. 1.4 of Zumdahl, *Chemistry*.

DIF: Easy REF: 1.4
KEY: Chemistry | general chemistry | general concepts | measurement
MSC: Conceptual

95. What data would you need to estimate the money you would spend on gas to drive your car from Los Angeles to Chicago? Provide a sample calculation.

ANS:

Data would include: average price per gallon of gasoline, average MPG of the car, mileage of trip.

$$\$ = \text{miles} \times \frac{\text{gal}}{\text{miles}} \times \frac{\$}{\text{gal}}$$

DIF: Easy REF: 1.7
KEY: Chemistry | general chemistry | general concepts | measurement | dimensional analysis MSC: Conceptual

96. On a new temperature scale (°Y), water boils at 155.0°Y and freezes at 0.00°Y. Calculate the normal human body temperature using this temperature scale. On the Fahrenheit scale, normal human body temperature is 98.6°F, and water boils at 212.0°F and freezes at 32.0°F.

ANS:
57.3°Y
The formula derived from the data is Y=(155/180)(F-32).

DIF: Difficult REF: 1.8
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | temperature
MSC: Quantitative

97. Explain how Archimedes might have used the concept of density to determine whether the king's crown was pure gold. (density of gold = 19.32 g/cm^3)

ANS:
If the density of gold was known to Archimedes, he could weigh the crown to determine its mass and then submerge the crown in water to measure the volume by displacement. By comparing the density of the crown calculated from this data to the known density of gold, he could find out if the crown was made of gold.
Archimedes' Principle is slightly different, and not specifically addressed in this text.

See Sec. 1.8 of Zumdahl, *Chemistry*.

DIF: Moderate REF: 1.9
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | density
MSC: Conceptual

98. Explain the main differences between a compound and a mixture.

ANS:
A mixture may be separated into pure substances by physical means, while a compound requires chemical means to separate it into elements.
A compound has constant composition (always the same ratio of elements), while a mixture may have varying composition.
See Sec. 1.10 of Zumdahl, *Chemistry*.

DIF: Easy REF: 1.1
KEY: Chemistry | general chemistry | general concepts | matter | compound; mixture
MSC: Conceptual

99. Give three physical methods used by chemists to separate mixtures and identify the type of mixture best suited for each process.

ANS:
Three common methods are distillation, filtration, and chromatography.
Distillation is useful for mixtures of volatile liquids (or mixtures of gases that can be condensed).
Filtration is useful to separate a mixture of a solid and a liquid.
Chromatography may be used for mixtures of volatile substances (gas chromatography) or soluble substances (paper chromatography).
See Sec. 1.10 of Zumdahl, *Chemistry*.

DIF: Moderate REF: 1.1
KEY: Chemistry | general chemistry | general concepts | matter | mixture
MSC: Conceptual

100. Name three methods for the separation of mixtures.

ANS:
Three common methods are distillation, filtration, and chromatography.
See Sec. 1.10 of Zumdahl, *Chemistry*.

DIF: Easy REF: 1.1
KEY: Chemistry | general chemistry | general concepts | matter | mixture
MSC: Conceptual

101. How many significant figures are in 0.00110

A) 2
B) 3
C) 4
D) 5

ANS: B DIF: Easy REF: 1.5
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures
MSC: Conceptual

102. Which of the following unit factors is incorrect?
A) 1 microliter/1000 nL
B) 1 cg/100 g
C) 1 L/1000 mL
D) 1000 m/1 km

ANS: B DIF: Easy REF: 1.7
KEY: Chemistry | general chemistry | general concepts | measurement | dimensional analysis MSC: Conceptual

103. Which of the following is not a fundamental metric unit?
A) meter
B) second
C) gram
D) mole

ANS: C DIF: Easy REF: 1.3
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | base unit
MSC: Conceptual

104. Which of the following is not a fundamental metric unit?
A) meter
B) second
C) kilogram
D) liter

ANS: D DIF: Easy REF: 1.3
KEY: Chemistry | general chemistry | general concepts | measurement | SI unit | base unit
MSC: Conceptual

105. Which of the following has a different value on the moon compared to earth?
A) mass
B) weight
C) time
D) moles

ANS: B DIF: Easy REF: 1.3
KEY: Chemistry | general chemistry | general concepts | measurement
MSC: Conceptual

106. How should the number 1.230×10^3 be properly expressed as a decimal?
A) 1230
B) 0.001230
C) 1230.0
D) 1230.

ANS: D DIF: Easy REF: 1.5
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures | scientific notation MSC: Conceptual

107. Calculate $5.1234 + 0.033 \div 1.650$ and report to the correct number of significant figures.
A) 3.1
B) 3.125
C) 5.143
D) 5.1

ANS: C DIF: Easy REF: 1.5
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures
MSC: Quantitative

108. When 87.7 is added to 73.841, the result should be reported with _____ significant figures. And when 87.7 is divided by 73.841 the result should be reported with _____ significant figures.

A) 3,3
B) 3,5
C) 4,3
D) 4,4

ANS: C DIF: Easy REF: 1.5
KEY: Chemistry | general chemistry | general concepts | measurement | significant figures
MSC: Conceptual

109. A wavelength of red light is measured at 655 nm. What is this measurement in cm?

A) 6.55 cm
B) 0.00655 cm
C) 6.55×10^{-5} cm
D) 6.55×10^{-7} cm

ANS: C DIF: Easy REF: 1.7
KEY: Chemistry | general chemistry | general concepts | measurement | dimensional analysis MSC: Quantitative

110. Which separation technique is based on differences in the volatility of the substances to be separated?

A) filtration
B) distillation
C) solvent extraction
D) paper chromatography

ANS: B DIF: Easy REF: 1.1
KEY: Chemistry | general chemistry | general concepts | matter | separation
MSC: Conceptual

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Chapter 2: Atoms, Molecules, and Ions

1. The first people to attempt to explain why chemical changes occur were
   A) alchemists
   B) metallurgists
   C) physicians
   D) physicists
   E) the Greeks

   ANS: E PTS: 1 DIF: Easy REF: 2.1
   KEY: Chemistry | general chemistry | early atomic theory MSC: Conceptual

2. The Greeks proposed that matter consisted of four fundamental substances:
   A) fire, earth, water, air
   B) fire, metal, water, air
   C) earth, metal, water, air
   D) atoms, fire, water, air
   E) atoms, metal, fire, air

   ANS: A PTS: 1 DIF: Easy REF: 2.1
   KEY: Chemistry | general chemistry | early atomic theory MSC: Conceptual

3. The first chemist to perform truly quantitative experiments was
   A) Paracelsus
   B) Boyle
   C) Priestly
   D) Bauer
   E) Lavoisier

   ANS: B PTS: 1 DIF: Easy REF: 2.1
   KEY: Chemistry | general chemistry | early atomic theory MSC: Conceptual

4. The scientist who discovered the law of conservation of mass and is also called the father of modern chemistry is
   A) Proust
   B) Boyle
   C) Priestly
   D) Bauer
   E) Lavoisier

   ANS: E PTS: 1 DIF: Easy REF: 2.2
   KEY: Chemistry | general chemistry | general concepts | matter | Law of Conservation of Mass MSC: Conceptual

5. Which of the following pairs of compounds can be used to illustrate the law of multiple proportions?
   A) NH_4 and NH_4Cl
   B) ZnO_2 and $ZnCl_2$
   C) H_2O and HCl
   D) NO and NO_2

E) CH_4 and CO_2

ANS: D PTS: 1 DIF: Easy REF: 2.2
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | Dalton's atomic theory MSC: Conceptual

6. Which of the following pairs can be used to illustrate the law of multiple proportions?
   A) SO and SO_2
   B) CO and $CaCO_3$
   C) H_2O and $C_{12}H_{22}O_{11}$
   D) H_2SO_4 and H_2S
   E) KCl and $KClO_2$

   ANS: A PTS: 1 DIF: Easy REF: 2.2
   KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter
   MSC: Conceptual

7. According to the law of multiple proportions:
   A) If the same two elements form two different compounds, they do so in the same ratio.
   B) It is not possible for the same two elements to form more than one compound.
   C) The ratio of the masses of the elements in a compound is always the same.
   D) The total mass after a chemical change is the same as before the change.
   E) None of these.

   ANS: E PTS: 1 DIF: Easy REF: 2.2
   KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | Dalton's atomic theory MSC: Conceptual

8. A sample of chemical X is found to contain 5.0 grams of oxygen, 10.0 grams of carbon, and 20.0 grams of nitrogen. The law of definite proportion would predict that a 70 gram sample of chemical X should contain how many grams of carbon?
   A) 5.0 grams
   B) 7.0 grams
   C) 10. grams
   D) 15 grams
   E) 20 grams

   ANS: E PTS: 1 DIF: Moderate REF: 2.2
   KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | Dalton's atomic theory MSC: Quantitative

9. Consider the following two compounds: H_2O and H_2O_2 . According to the law of multiple proportions, the ratio of hydrogen atoms per gram of oxygen in H_2O to hydrogen atoms per gram of oxygen in H_2O_2 is
   A) 1:1
   B) 2:1
   C) 1:2
   D) 2:2
   E) 4:1

ANS: B PTS: 1 DIF: Moderate REF: 2.2
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | Dalton's atomic theory MSC: Conceptual

10. Which of the following statements from Dalton's atomic theory is no longer true, according to modern atomic theory?
A) Elements are made up of tiny particles called atoms.
B) Atoms are not created or destroyed in chemical reactions.
C) All atoms of a given element are identical.
D) Atoms are indivisible in chemical reactions.
E) All of these statements are true according to modern atomic theory.

ANS: C PTS: 1 DIF: Easy REF: 2.3
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | Dalton's atomic theory MSC: Conceptual

11. How many of the following postulates of Dalton's atomic theory are still scientifically accepted?
I. All atoms of the same element are identical.
II. Compounds are combinations of different atoms.
III. A chemical reaction changes the way atoms are grouped together.
IV. Atoms are indestructible.

A) 0
B) 1
C) 2
D) 3
E) 4

ANS: C PTS: 1 DIF: Easy REF: 2.3
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | Dalton's atomic theory MSC: Conceptual

12. The chemist credited for inventing a set of symbols for writing elements and a system for writing the formulas of compounds (and for discovering selenium, silicon, and thorium) is
A) Boyle
B) Lavoisier
C) Priestly
D) Berzelius
E) Dalton

ANS: D PTS: 1 DIF: Easy REF: 2.3
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | chemical formula MSC: Conceptual

13. Avogadro's hypothesis states that:
A) Each atom of oxygen is 16 times more massive than an atom of hydrogen.
B) A given compound always contains exactly the same proportion of elements by mass.

C) When two elements form a series of compounds, the ratios of masses that combine with 1 gram of the first element can always be reduced to small whole numbers.
D) At the same temperature and pressure, equal volumes of different gases contain an equal number of particles.
E) Mass is neither created nor destroyed in a chemical reaction.

ANS: D PTS: 1 DIF: Easy REF: 2.3
KEY: Chemistry | general chemistry | early atomic theory MSC: Conceptual

14. The first scientist to show that atoms emit any negative particles was
A) J. J. Thomson
B) Lord Kelvin
C) Ernest Rutherford
D) William Thomson
E) John Dalton

ANS: A PTS: 1 DIF: Easy REF: 2.4
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | structure of the atom | discovery of electron MSC: Conceptual

15. Many classic experiments have given us indirect evidence of the nature of the atom. Which of the experiments listed below did not give the results described?
A) The Rutherford experiment proved the Thomson "plum-pudding" model of the atom to be essentially correct.
B) The Rutherford experiment was useful in determining the nuclear charge on the atom.
C) Millikan's oil-drop experiment showed that the charge on any particle was a simple multiple of the charge on the electron.
D) The electric discharge tube proved that electrons have a negative charge.
E) All of the above experiments gave the results described.

ANS: A PTS: 1 DIF: Easy REF: 2.4
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | structure of the atom MSC: Conceptual

16. The scientist whose alpha-particle scattering experiment led him to conclude that the nucleus of an atom contains a dense center of positive charge is
A) J. J. Thomson
B) Lord Kelvin
C) Ernest Rutherford
D) William Thomson
E) John Dalton

ANS: C PTS: 1 DIF: Easy REF: 2.4
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | structure of the atom | nuclear model of atom MSC: Conceptual

17. Alpha particles beamed at thin metal foil may
A) pass directly through without changing direction
B) be slightly diverted by attraction to electrons
C) be reflected by direct contact with nuclei

D) A and C
E) A, B, and C

ANS: E PTS: 1 DIF: Easy REF: 2.4
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | structure of the atom | nuclear model of atom MSC: Conceptual

18. Which one of the following statements about atomic structure is false?
A) An atom is mostly empty space.
B) Almost all of the mass of the atom is concentrated in the nucleus.
C) The protons and neutrons in the nucleus are very tightly packed.
D) The number of protons and neutrons is always the same in the neutral atom.
E) All of the above statements (A-D) are true.

ANS: D PTS: 1 DIF: Easy REF: 2.4
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | structure of the atom | nuclear model of atom MSC: Conceptual

19. If the Thomson model of the atom had been correct, Rutherford would have observed:
A) Alpha particles going through the foil with little or no deflection.
B) Alpha particles greatly deflected by the metal foil.
C) Alpha particles bouncing off the foil.
D) Positive particles formed in the foil.
E) None of the above observations is consistent with the Thomson model of the atom.

ANS: A PTS: 1 DIF: Easy REF: 2.4
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | structure of the atom | nuclear model of atom MSC: Conceptual

20. Which statement is *not* correct?
A) The mass of an alpha particle is 7300 times that of the electron.
B) An alpha particle has a 2+ charge.
C) Three types of radioactive emission are gamma rays, beta rays, and alpha particles.
D) A gamma ray is high-energy light.
E) There are only three types of radioactivity known to scientists today.

ANS: E PTS: 1 DIF: Easy REF: 2.4
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter
MSC: Conceptual

21. Rutherford's experiment was important because it showed that:
A) Radioactive elements give off alpha particles.
B) Gold foil can be made to be only a few atoms thick.
C) A zinc sulfide screen scintillates when struck by a charged particle.
D) The mass of the atom is uniformly distributed throughout the atom.
E) An atom is mostly empty space.

ANS: E PTS: 1 DIF: Easy REF: 2.4
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | structure of the atom | nuclear model of atom MSC: Conceptual

22. Bromine exists naturally as a mixture of bromine-79 and bromine-81 isotopes. An atom of bromine-79 contains
A) 35 protons, 44 neutrons, 35 electrons
B) 34 protons and 35 electrons, only
C) 44 protons, 44 electrons, and 35 neutrons
D) 35 protons, 79 neutrons, and 35 electrons
E) 79 protons, 79 electrons, and 35 neutrons

ANS: A PTS: 1 DIF: Easy REF: 2.5
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | nuclear structure MSC: Conceptual

23. Which of the following atomic symbols is incorrect?
A) $^{14}_{6}C$
B) $^{37}_{17}Cl$
C) $^{32}_{15}P$
D) $^{39}_{19}K$
E) $^{14}_{8}N$

ANS: E PTS: 1 DIF: Easy REF: 2.5
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | structure of the atom MSC: Conceptual

24. The element rhenium (Re) exists as two stable isotopes and 18 unstable isotopes. Rhenium-185 has in its nucleus
A) 75 protons, 75 neutrons
B) 75 protons, 130 neutrons
C) 130 protons, 75 neutrons
D) 75 protons, 110 neutrons
E) not enough information

ANS: D PTS: 1 DIF: Easy REF: 2.5
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | isotope
MSC: Conceptual

25. Which among the following represent a set of isotopes? Atomic nuclei containing:

I. 20 protons and 20 neutrons
II. 21 protons and 19 neutrons
III. 22 neutrons and 18 protons
IV. 20 protons and 22 neutrons
V. 21 protons and 20 neutrons

A) I, II, III
B) III, IV
C) I, V
D) I, IV and II, V

E) No isotopes are indicated.

ANS: D PTS: 1 DIF: Easy REF: 2.5
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | isotope
MSC: Conceptual

26. By knowing the number of protons a neutral atom has, you should be able to determine
A) the number of neutrons in the neutral atom
B) the number of electrons in the neutral atom
C) the name of the atom
D) two of the above
E) none of the above

ANS: D PTS: 1 DIF: Easy REF: 2.5
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | nuclear structure MSC: Conceptual

27. Which of the following statements are *true* of uranium-238?

I. Its chemical properties will be exactly like those of uranium-235.
II. Its mass will be slightly different from that of an atom of uranium-235.
III. It will contain a different number of protons than an atom of uranium-235.
IV. It is more plentiful in nature than uranium-235.

A) III, IV
B) I, II, III
C) I, II, IV
D) II, III, IV
E) all of these

ANS: C PTS: 1 DIF: Easy REF: 2.5
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | isotope
MSC: Conceptual

28. An isotope, *X*, of a particular element has an atomic number of 15 and a mass number of 31. Therefore:
A) *X* is an isotope of phosphorus.
B) *X* has 16 neutrons per atom.
C) *X* has an atomic mass of 30.973.
D) A and B.
E) A, B, and C.

ANS: D PTS: 1 DIF: Easy REF: 2.5
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | isotope
MSC: Conceptual

29. Which of the following statements is true?
    A) Ions are formed by adding or removing protons or electrons.
    B) Scientists believe that solids are mostly open space.
    C) Heating water with a Bunsen burner results in a 2:1 mixture of hydrogen and oxygen gases.
    D) At least two of the above statements (A-C) are true.
    E) All of the statements (A-C) are false.

    ANS: B PTS: 1 DIF: Moderate REF: 2.5
    KEY: Chemistry | general chemistry | early atomic theory MSC: Conceptual

30. The number of neutrons in an atom is the same for all neutral atoms of that element.

    ANS: F PTS: 1 DIF: Easy REF: 2.5
    KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | isotope
    MSC: Conceptual

31. The number of electrons in an atom is the same for all neutral atoms of that element.

    ANS: T PTS: 1 DIF: Easy REF: 2.5
    KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | nuclear structure MSC: Conceptual

32. $^{40}_{20}Ca^{2+}$ has
    A) 20 protons, 20 neutrons, and 18 electrons
    B) 22 protons, 20 neutrons, and 20 electrons
    C) 20 protons, 22 neutrons, and 18 electrons
    D) 22 protons, 18 neutrons, and 18 electrons
    E) 20 protons, 20 neutrons, and 22 electrons

    ANS: A PTS: 1 DIF: Easy REF: 2.6
    KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | isotope
    MSC: Conceptual

33. Which of the following statements is (are) true?
    A) $^{18}_{8}O$ and $^{19}_{9}F$ have the same number of neutrons.
    B) $^{14}_{6}C$ and $^{14}_{7}N$ are isotopes of each other because their mass numbers are the same.
    C) $^{18}_{8}O^{2-}$ has the same number of electrons as $^{20}_{10}Ne$.
    D) A and B
    E) A and C

    ANS: E PTS: 1 DIF: Easy REF: 2.6
    KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | isotope
    MSC: Conceptual

34. A species with 12 protons and 10 electrons is
A) Ne^{2+}
B) Ti^{2+}
C) Mg^{2+}
D) Mg
E) Ne^{2-}

ANS: C PTS: 1 DIF: Easy REF: 2.6
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | nuclear structure MSC: Conceptual

35. The numbers of protons, neutrons, and electrons in $^{39}_{19}K^{+}$ are:

A) 20 p, 19 n, 19 e
B) 20 p, 19 n, 20 e
C) 19 p, 20 n, 20 e
D) 19 p, 20 n, 19 e
E) 19 p, 20 n, 18 e

ANS: E PTS: 1 DIF: Easy REF: 2.6
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | nuclear structure MSC: Conceptual

36. An ion is formed
A) By either adding or subtracting protons from the atom.
B) By either adding or subtracting electrons from the atom
C) By either adding or subtracting neutrons from the atom.
D) All of the above are true.
E) Two of the above are true.

ANS: B PTS: 1 DIF: Easy REF: 2.6
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | chemical formula | ionic substance MSC: Conceptual

37. The formula of water, H_2O, suggests:
A) There is twice as much mass of hydrogen as oxygen in each molecule.
B) There are two hydrogen atoms and one oxygen atom per water molecule.
C) There is twice as much mass of oxygen as hydrogen in each molecule.
D) There are two oxygen atoms and one hydrogen atom per water molecule.
E) None of these.

ANS: B PTS: 1 DIF: Easy REF: 2.6
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | chemical formula | molecular substance MSC: Conceptual

38. All of the following are true *except*:
A) Ions are formed by adding electrons to a neutral atom.
B) Ions are formed by changing the number of protons in an atom's nucleus.
C) Ions are formed by removing electrons from a neutral atom.
D) An ion has a positive or negative charge.
E) Metals tend to form positive ions.

ANS: B PTS: 1 DIF: Easy REF: 2.6
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | chemical formula | ionic substance MSC: Conceptual

39. Which of the following are incorrectly paired?
A) K, alkali metal
B) Ba, alkaline earth metal
C) O, halogen
D) Ne, noble gas
E) Ni, transition metal

ANS: C PTS: 1 DIF: Easy REF: 2.7
KEY: Chemistry | general chemistry | early atomic theory | periodic table | group
MSC: Conceptual

40. Which of the following are *incorrectly* paired?
A) Sr, alkaline earth metal
B) Ta, transition metal
C) F, halogen
D) H, noble gas
E) Ru, transition metal

ANS: D PTS: 1 DIF: Easy REF: 2.7
KEY: Chemistry | general chemistry | early atomic theory | periodic table | group
MSC: Conceptual

41. Which of the following are *incorrectly* paired?
A) Phosphorus, Pr
B) Palladium, Pd
C) Platinum, Pt
D) Lead, Pb
E) Potassium, K

ANS: A PTS: 1 DIF: Easy REF: 2.7
KEY: Chemistry | general chemistry | early atomic theory | periodic table
MSC: Conceptual

42. Which of the following are *incorrectly* paired?
A) Copper, Cu
B) Carbon, C
C) Cobalt, Co
D) Calcium, Ca
E) Cesium, Ce

ANS: E PTS: 1 DIF: Easy REF: 2.7
KEY: Chemistry | general chemistry | early atomic theory | periodic table
MSC: Conceptual

43. Which of the following are *incorrectly* paired?
A) Antimony, Sb

B) Silicon, Si
C) Silver, Ag
D) Argon, Ar
E) Astatine, As

ANS: E PTS: 1 DIF: Easy REF: 2.7
KEY: Chemistry | general chemistry | early atomic theory | periodic table
MSC: Conceptual

44. All of the following are characteristics of metals *except*:
A) good conductors of heat
B) malleable
C) ductile
D) often lustrous
E) tend to gain electrons in chemical reactions

ANS: E PTS: 1 DIF: Easy REF: 2.7
KEY: Chemistry | general chemistry | early atomic theory | periodic table | metal
MSC: Conceptual

45. All of the following are characteristics of nonmetals *except*:
A) poor conductors of electricity
B) often bond to each other by forming covalent bonds
C) tend to form negative ions in chemical reactions with metals
D) appear in the upper left-hand corner of the periodic table
E) do not have a shiny (lustrous) appearance

ANS: D PTS: 1 DIF: Easy REF: 2.7
KEY: Chemistry | general chemistry | early atomic theory | periodic table | nonmetal
MSC: Conceptual

46. Which of the following has 61 neutrons, 47 protons, and 46 electrons?
A) $^{80}_{61}\text{Pm}$
B) $^{108}_{47}\text{Ag}^{+}$
C) $^{108}_{46}\text{Pd}^{-}$
D) $^{108}_{47}\text{Cd}^{+}$
E) $^{108}_{47}\text{Ag}$

ANS: B PTS: 1 DIF: Easy REF: 2.7
KEY: Chemistry | general chemistry | early atomic theory | periodic table
MSC: Conceptual

47. How many protons and electrons does the most stable ion for oxygen have?

protons # electrons

A) 10 p 8 e
B) 8 p 6 e
C) 6 p 8 e
D) 8 p 8 e
E) 8 p 10 e

ANS: E PTS: 1 DIF: Moderate REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | periodic table | group
MSC: Conceptual

48. You are given a compound with the formula MCl_2, in which M is a metal. You are told that the metal ion has 26 electrons. What is the identity of the metal?
A) Fe
B) Al
C) Zn
D) Co
E) Ni

ANS: E PTS: 1 DIF: Moderate REF: 2.7
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | chemical formula | ionic substance MSC: Conceptual

49. Which of the following names is incorrect?
A) cobalt(II) chloride
B) magnesium oxide
C) aluminum(III) oxide
D) diphosphorus pentoxide
E) All of the above names are correct.

ANS: C PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound MSC: Conceptual

50. Which of the following pairs is incorrect?
A) iodine trichloride, ICl_3
B) phosphorus pentoxide, P_2O_5
C) ammonia, NH_3
D) sulfur hexafluoride, SF_6
E) All of the above pairs are correct.

ANS: B PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | binary molecular compound MSC: Conceptual

51. The correct name for LiCl is
A) lithium monochloride
B) lithium(I) chloride
C) monolithium chloride
D) lithium chloride
E) monolithium monochloride

ANS: D PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | ionic compound MSC: Conceptual

52. How many oxygen atoms are there in one formula unit of $Ca_3(PO_4)_2$?
A) 2
B) 4
C) 6
D) 8
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | chemical formula | ionic substance MSC: Conceptual

53. How many oxygen atoms are there in 4 formula units of $Al_2(CO_3)_3$?
A) 9
B) 24
C) 36
D) 13
E) 39

ANS: C PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | chemical formula | ionic substance MSC: Conceptual

54. The correct name for FeO is
A) iron oxide
B) iron(II) oxide
C) iron(III) oxide
D) iron monoxide
E) iron(I) oxide

ANS: B PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | ionic compound MSC: Conceptual

55. The correct name for Ca^{2+} is
A) calcium
B) calcium(II) ion
C) calcium ion
D) calcium(I) ion
E) monocalcium ion

ANS: C PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | chemical formula | ionic substance MSC: Conceptual

56. The correct name for V^{3+} is
A) vanadide
B) vanadite ion

C) vanadium(III) ion
D) vanadium(V) ion
E) trivanadium ion

ANS: C PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | chemical formula | ionic substance MSC: Conceptual

57. The correct name for P^{3-} is
A) phosphide ion
B) phosphorus ion
C) phosphorus(III) ion
D) phospho(III) ion
E) phosphite

ANS: A PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | chemical formula | ionic substance MSC: Conceptual

58. What is the subscript of barium in the formula of barium sulfate?
A) 1
B) 2
C) 3
D) 4
E) 0

ANS: A PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | chemical formula | ionic substance MSC: Conceptual

59. The formula for calcium bisulfate is
A) $Ca(SO_4)_2$
B) CaS_2
C) $Ca(HSO_4)_2$
D) Ca_2HSO_4
E) Ca_2S

ANS: C PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | ionic compound MSC: Conceptual

60. The formula for sodium dihydrogen phosphate is
A) NaH_2PO_4
B) $Na(HPO_4)_2$
C) $NaHPO_4$
D) Na_2HPO_4
E) $Na_2H_2PO_4$

ANS: A PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | ionic compound MSC: Conceptual

61. Which of the following is *incorrectly* named?
    A) $Pb(NO_3)_2$, lead(II) nitrate
    B) NH_4ClO_4, ammonium perchlorate
    C) PO_4^{3-}, phosphate ion
    D) $Mg(OH)_2$, magnesium hydroxide
    E) NO^{3-}, nitrite ion

    ANS: E PTS: 1 DIF: Easy REF: 2.8
    KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | ionic compound MSC: Conceptual

62. Which of the following is *incorrectly* named?
    A) SO_3^{2-}, sulfite ion
    B) $S_2O_3^{2-}$, thiosulfate ion
    C) PO_4^{3-}, phosphate ion
    D) ClO_3^-, chlorite ion
    E) CN^-, cyanide ion

    ANS: D PTS: 1 DIF: Easy REF: 2.8
    KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | ionic compound MSC: Conceptual

63. All of the following are in aqueous solution. Which is *incorrectly* named?
    A) H_2SO_4, sulfuric acid
    B) H_2CO_3, carbonic acid
    C) H_3PO_4, phosphoric acid
    D) HCN, cyanic acid
    E) HCl, hydrochloric acid

    ANS: D PTS: 1 DIF: Easy REF: 2.8
    KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | acid MSC: Conceptual

64. All of the following are in aqueous solution. Which is *incorrectly* named?
    A) $HC_2H_3O_2$, acetic acid
    B) HBr, bromic acid
    C) H_2SO_3, sulfurous acid
    D) HNO_2, nitrous acid
    E) $HClO_3$, chloric acid

    ANS: B PTS: 1 DIF: Easy REF: 2.8
    KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | acid MSC: Conceptual

65. Which of the following pairs is *incorrect?*
    A) NH_4Br, ammonium bromide
    B) K_2CO_3, potassium carbonate
    C) $BaPO_4$, barium phosphate
    D) CuCl, copper(I) chloride
    E) MnO_2, manganese(IV) oxide

ANS: C PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | ionic compound MSC: Conceptual

66. Which of the following name(s) is(are) correct?
    1. sulfide, S^{2-}
    2. ammonium chloride, NH_4Cl
    3. acetic acid, $HC_2H_3O_2$
    4. barium oxide, BaO

    A) all
    B) none
    C) 1, 2
    D) 3, 4
    E) 1, 3, 4

    ANS: A PTS: 1 DIF: Easy REF: 2.8
    KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound MSC: Conceptual

67. Which metals form cations with varying positive charges?
    A) transition metals
    B) Group 1 metals
    C) Group 2 metals
    D) Group 3 metals
    E) metalloids

    ANS: A PTS: 1 DIF: Easy REF: 2.8
    KEY: Chemistry | general chemistry | early atomic theory | chemical substance | chemical formula | ionic substance MSC: Conceptual

68. Three samples of a solid substance composed of elements A and Z were prepared. The first contained 4.31 g A and 7.70 g Z. The second sample was 35.9% A and 64.1% Z. It was observed that 0.718 g A reacted with Z to form 2.00 g of the third sample. Show that these data illustrate the law of definite composition.

    ANS:
    Sample (1): ratio of masses (Z/A) = 7.70/4.13 = 1.785
    Sample (2): ratio of masses (Z/A) = 64.1/35.9 = 1.785
    Sample (3): ratio of masses (Z/A) = (2.00-0.718)/0.718 = 1.785
    These three samples thus illustrate that a given compound always contains the same proportion of elements by mass.
    See Sec. 2.2 of Zumdahl, *Chemistry*.

    PTS: 1 DIF: Moderate REF: 2.2
    KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | Dalton's atomic theory MSC: Conceptual

69. Explain how Dalton’s atomic theory accounts for:

a) the law of conservation of mass
b) the law of definite composition
c) the law of multiple proportion

ANS:
(a) Chemical reactions involve only reorganization of the atoms.
(b) A given compound always has the same relative numbers and types of atoms.
(c) Since, according to Dalton, atoms of a given element are identical and a given compound always has the same relative numbers and types of atoms, the observation of different mass ratio combinations of the same elements to give different compounds supports the law of multiple proportion.
See Sec. 2.3 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Moderate REF: 2.3
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | Dalton's atomic theory MSC: Conceptual

70. Complete the following table.

Symbol	# Protons	# Neutrons	# Electrons	Net Charge
^{206}Pb				
	31	38		3_+
	52	75	54	
Mn^{2+}		30		2_+

ANS:

Symbol	# Protons	# Neutrons	# Electrons	Net Charge
^{206}Pb	82	124	82	0
Ga^{3+}	31	38	28	3+
Te^{2-}	52	75	54	2-
Mn^{2+}	25	29	23	2+

PTS: 1 DIF: Easy REF: 2.5
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | nuclear structure MSC: Conceptual

71. Complete the following table.

Symbol	**$^{69}Ga^{3+}$**	
Number of protons		34
Number of neutrons		46

Number of electrons		
Atomic number		
Mass number		
Net charge		2–

ANS:

Symbol	**$^{69}Ga^{3+}$**	$^{80}Se^{2-}$
Number of protons	31	34
Number of neutrons	38	46
Number of electrons	28	36
Atomic number	31	34
Mass number	69	80
Net charge	+3	2–

PTS: 1 DIF: Easy REF: 2.5
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | nuclear structure MSC: Conceptual

72. Arsenopyrite is a mineral containing As, Fe, and S. Classify each element as metal, nonmetal, or metalloid.

ANS:
As = metalloid, Fe = metal, S = nonmetal

PTS: 1 DIF: Easy REF: 2.7
KEY: Chemistry | general chemistry | early atomic theory | periodic table
MSC: Conceptual

73. Write the symbol for each of the following elements.
a) silver _____
b) calcium _____
c) iodine _____
d) copper _____
e) phosphorus _____

ANS:
a) Ag, b) Ca, c) I, d) Cu, e) P

PTS: 1 DIF: Easy REF: 2.7
KEY: Chemistry | general chemistry | early atomic theory | periodic table
MSC: Conceptual

74. Write the names of the following compounds:
a) $FeSO_4$ _____
b) $NaC_2H_3O_2$ _____

c) KNO_2 _____
d) $Ca(OH)_2$ _____
e) $NiCO_3$ _____

ANS:
a) iron(II) sulfate
b) sodium acetate
c) potassium nitrite
d) calcium hydroxide
e) nickel(II) carbonate

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | ionic compound MSC: Conceptual

75. Write the chemical formulas for the following compounds or ions.
a) nitrate ion _____
b) aluminum oxide _____
c) ammonium ion _____
d) perchloric acid _____
e) copper(II) bromide _____

ANS:
a) NO_3^- b) Al_2O_3 c) NH_4^+ d) $HClO_4$ e) $CuBr_2$

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | chemical formula | ionic substance MSC: Conceptual

76. How many atoms (total) are there in one formula unit of $Ca_3(PO_4)_2$?

ANS:
13

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | chemical formula | ionic substance MSC: Conceptual

Name the following compounds:

77. $Al_2(SO_4)_3$

ANS:
aluminum sulfate

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | ionic compound MSC: Conceptual

78. NH_4NO_3

ANS:
ammonium nitrate

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | ionic compound MSC: Conceptual

79. NaH

ANS:
sodium hydride

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | ionic compound MSC: Conceptual

80. $K_2Cr_2O_7$

ANS:
potassium dichromate

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | ionic compound MSC: Conceptual

81. CCl_4

ANS:
carbon tetrachloride

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | binary molecular compound MSC: Conceptual

82. AgCl

ANS:
silver chloride

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | ionic compound MSC: Conceptual

83. $CaSO_4$

ANS:
calcium sulfate

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | ionic compound MSC: Conceptual

84. HNO_2

ANS:
nitrous acid

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | acid MSC: Conceptual

85. N_2O_3

ANS:
dinitrogen trioxide

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | binary molecular compound MSC: Conceptual

86. SnI_2

ANS:
tin(II) iodide

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | ionic compound MSC: Conceptual

Write the formula for:

87. sodium thiosulfate

ANS:
$Na_2S_2O_3$

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | chemical formula | ionic substance MSC: Conceptual

88. iron(III) oxide

ANS:
Fe_2O_3

PTS: 1 DIF: Easy REF: 2.8

KEY: Chemistry | general chemistry | early atomic theory | chemical substance | chemical formula | ionic substance MSC: Conceptual

89. dichlorine heptoxide

ANS:
Cl_2O_7

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | chemical formula | molecular substance MSC: Conceptual

90. cobalt(II) chloride

ANS:
$CoCl_2$

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | chemical formula | ionic substance MSC: Conceptual

91. aluminum hydroxide

ANS:
$Al(OH)_3$

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | chemical formula | ionic substance MSC: Conceptual

92. sulfurous acid

ANS:
H_2SO_3

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | acid MSC: Conceptual

93. nitric acid

ANS:
HNO_3

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | acid MSC: Conceptual

94. phosphoric acid

ANS:
H_3PO_4

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | acid MSC: Conceptual

95. acetic acid

ANS:
CH_3COOH

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | acid MSC: Conceptual

96. phosphorus trichloride

ANS:
PCl_3

PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | binary molecular compound MSC: Conceptual

97. Which of these statements is a consequence (follows from) the Law of Definite Proportion?
A) All samples of chlorine contain ^{35}Cl and ^{37}Cl in the same (definite) ratio.
B) The mass of oxygen that is combined with a fixed mass of nitrogen in each of the binary nitrogen oxides can be expressed as a ratio of small whole numbers.
C) The atomic masses of all of the elements in the periodic table have fixed values.
D) The % lead by mass in the compound galena is the same for all pure samples obtained from any source.
E) None of these is correct

ANS: D PTS: 1 DIF: Easy REF: 2.2
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | Dalton's atomic theory MSC: Conceptual

98. Which of these statements is a consequence (follows from) the Law of Multiple Proportions?
A) All samples of chlorine contain ^{35}Cl and ^{37}Cl in the same (definite) ratio.
B) The mass of oxygen that is combined with a fixed mass of nitrogen in each of the binary nitrogen oxides can be expressed as a ratio of small whole numbers.
C) The atomic masses of all of the elements in the periodic table have fixed values.
D) The % lead by mass in the compound galena is the same for all pure samples obtained from any source.
E) None of these is correct

ANS: B PTS: 1 DIF: Easy REF: 2.2

KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | Dalton's atomic theory MSC: Conceptual

99. Which of the following elements does NOT have a symbol taken from a LATIN name for the element or one of its compounds?
A) iron
B) copper
C) sodium
D) potassium
E) titanium

ANS: E PTS: 1 DIF: Easy REF: 2.7
KEY: Chemistry | general chemistry | early atomic theory | periodic table
MSC: Conceptual

100. Which of the following statements is FALSE?
A) sulfur does not conduct electricity
B) gold is malleable
C) germanium is a metal
D) silicon is a metalloid
E) hydrogen is a non-metal

ANS: C PTS: 1 DIF: Easy REF: 2.7
KEY: Chemistry | general chemistry | early atomic theory | periodic table |
MSC: Conceptual

101. Which of the following ions is NOT likely to form from the appropriate atom?
A) C^{4+}
B) As^{3-}
C) Mg^{2+}
D) Ti^{4+}
E) Na^{+}

ANS: A PTS: 1 DIF: Moderate REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | periodic table | group
MSC: Conceptual

102. How many protons, neutrons and electrons, in that order are present in the anion formed by one atom of ^{125}I?
A) 53, 74, 54
B) 52, 72, 53
C) 54, 72, 53
D) 53, 72, 54
E) 54, 74, 54

ANS: D PTS: 1 DIF: Moderate REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | isotope | periodic table MSC: Conceptual

103. How many protons, neutrons and electrons, in that order are present in the anion formed by one atom of ^{79}Se?
A) 34, 34, 45
B) 34, 45, 34
C) 32, 45, 34
D) 34, 45, 36
E) 36, 45, 36

ANS: D PTS: 1 DIF: Moderate REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | isotope | periodic table MSC: Conceptual

104. Which statement is INCORRECT?
A) An atom of ^{60}Zn has an equal number of protons and neutrons
B) An atom of ^{50}Mn has an equal number of electrons and neutrons
C) An atom of ^{18}O has an equal number of protons and neutrons
D) An atom of ^{41}K has an equal number of protons and electrons
E) An atom of ^{238}U contains 146 neutrons.

ANS: C PTS: 1 DIF: Moderate REF: 2.5
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | isotope | MSC: Conceptual

105. Which of the following atoms, isotopes or ions contains 23 protons, 18 electrons and 27 neutrons?
A) $^{45}Co^{5+}$
B) ^{50}Kr
C) $^{50}V^{5+}$
D) $^{41}Kr^{5-}$
E) $^{50}V^{5-}$

ANS: C PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | isotope | periodic table MSC: Conceptual

106. Which of the following compounds is incorrectly named?
A) $Mg(OH)_2$ is magnesium dihydroxide
B) CaO is calcium oxide
C) NH_4NO_3 is ammonium nitrate
D) K_3PO_4 is potassium phosphate
E) $MgSO_3$ is magnesium sulfite

ANS: A PTS: 1 DIF: Easy REF: 2.8
KEY: Chemistry | general chemistry | early atomic theory | chemical substance | nomenclature of simple compound | ionic compound MSC: Conceptual

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Chapter 3: Stoichiometry

1. The atomic mass of rhenium is 186.2. Given that 37.1% of natural rhenium is rhenium-185, what is the other stable isotope?
   A) $^{183}_{75}\mathrm{Re}$
   B) $^{187}_{75}\mathrm{Re}$
   C) $^{189}_{75}\mathrm{Re}$
   D) $^{181}_{75}\mathrm{Re}$
   E) $^{190}_{75}\mathrm{Re}$

   ANS: B PTS: 1 DIF: Moderate REF: 3.2
   KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | atomic weight | mass spectroscopy MSC: Quantitative

2. Consider the element indium, atomic number 49, atomic mass 114.8 g. The nucleus of an atom of indium-112 contains
   A) 49 protons, 63 neutrons, 49 electrons
   B) 49 protons, 49 neutrons
   C) 49 protons, 49 alpha particles
   D) 49 protons, 63 neutrons
   E) 49 protons, 112 neutrons

   ANS: D PTS: 1 DIF: Easy REF: 3.2
   KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | structure of the atom MSC: Conceptual

3. A hypothetical element consists of two isotopes of masses 69.95 amu and 71.95 amu with abundances of 25.7% and 74.3%, respectively. What is the average atomic mass of this element?
   A) 70.95 amu
   B) 69.95 amu
   C) 70.5 amu
   D) 71.4 amu
   E) 71.95 amu

   ANS: D PTS: 1 DIF: Easy REF: 3.2
   KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | atomic weight | mass spectroscopy MSC: Quantitative

4. Naturally occurring copper exists in two isotopic forms: ^{63}Cu and ^{65}Cu. The atomic mass of copper is 63.55 amu. What is the approximate natural abundance of ^{63}Cu?
   A) 63%
   B) 90%
   C) 70%
   D) 50%
   E) 30%

   ANS: C PTS: 1 DIF: Moderate REF: 3.2

KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | atomic weight | mass spectroscopy MSC: Quantitative

5. Naturally occurring element X exists in three isotopic forms: X-28 (27.977 amu, 92.23% abundance), X-29 (28.976 amu, 4.67% abundance), and X-30 (29.974 amu, 3.10% abundance). Calculate the atomic weight of X.
   A) 28.09 amu
   B) 48.63 amu
   C) 27.16 amu
   D) 28.97 amu
   E) 86.93 amu

   ANS: A PTS: 1 DIF: Easy REF: 3.2
   KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | atomic weight | mass spectroscopy MSC: Quantitative

6. Naturally occurring element X exists in three isotopic forms: X-28 (27.977 amu, 92.23% abundance), X-29 (28.976 amu, 4.67% abundance), and X-30 (29.974 amu, 3.10% abundance). What is the identity of element X?
   A) Cu
   B) Al
   C) Ni
   D) Si
   E) Sr

   ANS: D PTS: 1 DIF: Moderate REF: 3.2
   KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | atomic weight | mass spectroscopy MSC: Quantitative

7. The average mass of a carbon atom is 12.011. Assuming you were able to pick up only one carbon unit, the chances that you would randomly get one with a mass of 12.011 is
   A) 0%
   B) 0.011%
   C) about 12%
   D) 12.011%
   E) greater than 50%

   ANS: A PTS: 1 DIF: Easy REF: 3.2
   KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | atomic weight MSC: Conceptual

8. What is the mass of 4 atom(s) of copper in grams?
   A) 254.2 g
   B) 2.37×10^{21} g
   C) 9.57×10^{-24} g
   D) 6.022×10^{23} g
   E) 4.22×10^{-22} g

   ANS: E PTS: 1 DIF: Easy REF: 3.3
   KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | mole

MSC: Quantitative

9. Iron is biologically important in the transport of oxygen by red blood cells from the lungs to the various organs of the body. In the blood of an adult human, there are approximately 2.64×10^{13} red blood cells with a total of 2.90 g of iron. On the average, how many iron atoms are present in each red blood cell? (molar mass Fe = 55.85 g/mol)
   A) 8.44×10^{-10}
   B) 1.18×10^{9}
   C) 3.13×10^{22}
   D) 2.64×10^{13}
   E) 6.14×10^{-2}

   ANS: B PTS: 1 DIF: Moderate REF: 3.3
   KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | mole
   MSC: Quantitative

10. You have a sample of zinc (Zn) and a sample of aluminum (Al). You have an equal number of atoms in each sample. Which of the following statements concerning the masses of the samples is true?
   A) The mass of the zinc sample is more than twice as great as the mass of the aluminum sample.
   B) The mass of the zinc sample is more than the mass of the aluminum sample, but it is not twice as great.
   C) The mass of the aluminum sample is more than twice as great as the mass of the zinc sample.
   D) The mass of the aluminum sample is more than the mass of the zinc sample, but it is not twice as great.
   E) The masses of each sample are equal.

   ANS: A PTS: 1 DIF: Easy REF: 3.3
   KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | mole
   MSC: Conceptual

11. A sample of ammonia has a mass of 43.5 g. How many molecules are in this sample?
   A) 2.55 molecules
   B) 2.62×10^{25} molecules
   C) 2.36×10^{23} molecules
   D) 1.54×10^{24} molecules
   E) 8.63×10^{-16} molecules

   ANS: D PTS: 1 DIF: Moderate REF: 3.4
   KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | mole
   MSC: Quantitative

12. How many moles of hydrogen sulfide are contained in a 49.7-g sample of this gas?
   A) 0.686 mol
   B) 1.46 mol
   C) 83.8 mol
   D) 24.7 mol
   E) 2.92 mol

ANS: B PTS: 1 DIF: Easy REF: 3.4
KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | mole
MSC: Quantitative

13. What is the molar mass of ethanol (C_2H_5OH)?
A) 45.06 g/mol
B) 34.06 g/mol
C) 46.07 g/mol
D) 30.03 g/mol
E) 105.03 g/mol

ANS: C PTS: 1 DIF: Easy REF: 3.4
KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | molecular weight MSC: Quantitative

14. For which compound does 0.256 mole weigh 12.8 g?
A) C_2H_4O
B) CO_2
C) CH_3Cl
D) C_2H_6
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 3.4
KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | mole
MSC: Quantitative

15. Roundup, an herbicide manufactured by Monsanto, has the formula $C_3H_8NO_5P$. How many moles of molecules are there in a 295.1-g sample of Roundup?
A) 0.5729
B) 2.137
C) 1.745
D) 16.39
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 3.4
KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | mole
MSC: Quantitative

16. Calculate the molar mass of barium sulfite.
A) 233.40 g/mol
B) 201.40 g/mol
C) 354.73 g/mol
D) 514.87 g/mol
E) 217.40 g/mol

ANS: E PTS: 1 DIF: Moderate REF: 3.4
KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | molecular weight MSC: Conceptual

17. Phosphorus has the molecular formula P_4, and sulfur has the molecular formula S_8. How many grams of phosphorus contain the same number of molecules as 4.23 g of sulfur?
A) 2.04 g
B) 0.490 g
C) 4.08 g
D) 4.23 g
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 3.4
KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | mole
MSC: Quantitative

18. A given sample of a xenon fluoride compound contains molecules of a single type XeF_n, where n is some whole number. Given that 8.06×10^{20} molecules of XeF_n weigh 0.227 g, calculate n.
A) 1
B) 6
C) 4
D) 3
E) 2

ANS: E PTS: 1 DIF: Moderate REF: 3.4
KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | mole
MSC: Quantitative

19. Phosphoric acid can be prepared by reaction of sulfuric acid with "phosphate rock" according to the equation:

$$Ca_3(PO_4)_2 + 3H_2SO_4 \rightarrow 3CaSO_4 + 2H_3PO_4$$

What is the molar mass of $Ca_3(PO_4)_2$?
A) 310.18 g/mol
B) 87.05 g/mol
C) 278.18 g/mol
D) 215.21 g/mol
E) 166.02 g/mol

ANS: A PTS: 1 DIF: Easy REF: 3.4
KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | molecular weight MSC: Quantitative

20. Phosphoric acid can be prepared by reaction of sulfuric acid with "phosphate rock" according to the equation:

$$Ca_3(PO_4)_2 + 3H_2SO_4 \rightarrow 3CaSO_4 + 2H_3PO_4$$

How many oxygen atoms are there in 1.75 ng of $Ca_3(PO_4)_2$?
A) 3.40×10^{12}
B) 1.36×10^{13}
C) 8.43×10^{15}
D) 2.72×10^{22}
E) 2.72×10^{13}

ANS: E PTS: 1 DIF: Moderate REF: 3.4
KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | mole
MSC: Quantitative

21. What is the mass of a 6.761-mol sample of sodium hydroxide?
A) 40.00 g
B) 270.4 g
C) 162.3 g
D) 5.916 g
E) 0.1690 g

ANS: B PTS: 1 DIF: Easy REF: 3.4
KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | mole
MSC: Quantitative

22. How many atoms of hydrogen are present in 7.63 g of ammonia?
A) 2.70×10^{23}
B) 1.52×10^{24}
C) 1.38×10^{25}
D) 8.09×10^{23}
E) 1.12×10^{20}

ANS: D PTS: 1 DIF: Moderate REF: 3.4
KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | mole
MSC: Quantitative

23. The molar mass of the compound formed by potassium and selenium is
A) 157.2 g/mol
B) 197.0 g/mol
C) 118.1 g/mol
D) 276.0 g/mol
E) 196.3 g/mol

ANS: A PTS: 1 DIF: Moderate REF: 3.4
KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | molecular weight MSC: Conceptual

24. What is the molar mass of cryolite (Na_3AlF_6)?
A) 209.9 g/mol
B) 185.3 g/mol
C) 210.0 g/mol
D) 104.2 g/mol
E) 68.97 g/mol

ANS: C PTS: 1 DIF: Easy REF: 3.4
KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | molecular weight MSC: Quantitative

25. One molecule of a compound weighs 2.93×10^{-22} g. The molar mass of this compound is:
A) 2.06 g/mol

B) 567 g/mol
C) 168 g/mol
D) 176 g/mol
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 3.4
KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | mole
MSC: Quantitative

26. $NaHCO_3$ is the active ingredient in baking soda. How many grams of oxygen are in 0.52 g of $NaHCO_3$?
A) 0.099 g
B) 0.019 g
C) 6.19×10^3 g
D) 0.033 g
E) 0.30 g

ANS: E PTS: 1 DIF: Easy REF: 3.4
KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | mole
MSC: Quantitative

27. A compound is composed of element X and hydrogen. Analysis shows the compound to be 80% X by mass, with three times as many hydrogen atoms as X atoms per molecule. Which element is element X?
A) He
B) C
C) F
D) S
E) none of these

ANS: B PTS: 1 DIF: Difficult REF: 3.6
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | mass percentage MSC: Conceptual

28. Which compound contains the highest percent by mass of hydrogen?
A) HCl
B) H_2O
C) H_2SO_4
D) H_2S
E) HF

ANS: B PTS: 1 DIF: Easy REF: 3.6
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | mass percentage MSC: Quantitative

29. A substance contains 35.0 g nitrogen, 5.05 g hydrogen, and 60.0 g of oxygen. How many grams of hydrogen are there in a 153-g sample of this substance?
A) 7.72 g
B) 767 g
C) 15.4 g
D) 5.05 g

E) 30.3 g

ANS: A PTS: 1 DIF: Moderate REF: 3.6
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas
MSC: Quantitative

30. How many grams of potassium are in 27.8 g of K_2CrO_7?
A) 4.49 g
B) 1.422 g
C) 8.98 g
D) 78.2 g
E) 55.6 g

ANS: C PTS: 1 DIF: Easy REF: 3.6
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas
MSC: Quantitative

31. Chlorous acid, $HClO_2$, contains what percent hydrogen by mass?
A) 1.92%
B) 25.0%
C) 23.4%
D) 1.47%
E) 5.18%

ANS: D PTS: 1 DIF: Easy REF: 3.6
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas
MSC: Quantitative

32. A mixture of KCl and KNO_3 is 44.20% potassium by mass. The percentage of KCl in the mixture is closest to
A) 40%
B) 50%
C) 60%
D) 70%
E) 80%

ANS: A PTS: 1 DIF: Difficult REF: 3.6
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | mass percentage MSC: Quantitative

33. A substance, A_2B, has the composition by mass of 60% A and 40% B. What is the composition of AB_2 by mass?
A) 40% A, 60% B
B) 50% A, 50% B
C) 27% A, 73% B
D) 33% A, 67% B
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 3.6
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | mass percentage MSC: Conceptual

34. Each molecule of testosterone contains 19 atoms of carbon (plus other atoms). The mass percent of carbon in testosterone is 79.12%. What is the molar mass of testosterone?
A) 576.8 g/mol
B) 180.5 g/mol
C) 228.2 g/mol
D) 240.1 g/mol
E) 288.4 g/mol

ANS: E PTS: 1 DIF: Moderate REF: 3.6
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | mass percentage MSC: Quantitative

35. A substance contains 23.0 g sodium, 27.0 g aluminum, and 114 g fluorine. How many grams of sodium are there in a 102-g sample of the substance?
A) 4.43 g
B) 23.0 g
C) 14.3 g
D) 102 g
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 3.6
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | mass percentage MSC: Quantitative

36. An oxide of iron has the formula Fe_3O_4. What mass percent of iron does it contain?
A) 0.72%
B) 28%
C) 30%
D) 70%
E) 72%

ANS: E PTS: 1 DIF: Easy REF: 3.6
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | mass percentage MSC: Quantitative

37. The mineral vanadinite has the formula $Pb_5(VO_4)_3Cl$. What mass percent of chlorine does it contain?
A) 7.51 %
B) 3.08 %
C) 9.91 %
D) 2.50 %
E) 1.13 %

ANS: D PTS: 1 DIF: Easy REF: 3.6
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | mass percentage MSC: Quantitative

38. Which of the following compounds has the same percent composition by mass as styrene, C_8H_8?
A) acetylene, C_2H_2

B) benzene, C_6H_6
C) cyclobutadiene, C_4H_4
D) α-ethyl naphthalene, $C_{12}H_{12}$
E) all of these

ANS: E PTS: 1 DIF: Easy REF: 3.6
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas
MSC: Conceptual

39. The molar mass of an insecticide, dibromoethane, is 187.9 g/mol. Its molecular formula is $C_2H_4Br_2$. What percent by mass of bromine does dibromoethane contain?
A) 42.52%
B) 2.14%
C) 85.05%
D) 12.78%
E) 6.39%

ANS: C PTS: 1 DIF: Easy REF: 3.6
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | mass percentage MSC: Quantitative

40. Hydrocortisone valerate is an ingredient in hydrocortisone cream, prescribed for skin problems. Its molecular formula is $C_{26}H_{38}O_6$. What is the percent by mass of carbon in hydrocortisone valerate?
A) 69.9%
B) 43.6%
C) 54.2%
D) 76.9%
E) 60.1%

ANS: A PTS: 1 DIF: Easy REF: 3.6
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | mass percentage MSC: Quantitative

41. Ammonium chromate, $(NH_4)_2CrO_4$, contains what percent nitrogen by mass?
A) 36.8%
B) 9.2%
C) 18.4%
D) 11.9%
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 3.6
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | mass percentage MSC: Quantitative

42. You heat 3.854 g of a mixture of Fe_3O_4 and FeO to form 4.148 g Fe_2O_3. The mass percent of FeO originally in the mixture was:
A) 92.9%
B) 55.8%
C) 44.2%
D) 38.5%

E) none of these

ANS: B PTS: 1 DIF: Difficult REF: 3.6
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | mass percentage MSC: Quantitative

43. You take an aspirin tablet (a compound consisting solely of carbon, hydrogen, and oxygen) with a mass of 1.00 g, burn it in air, and collect 2.20 g of carbon dioxide and 0.400 g water. The molar mass of aspirin is between 170 and 190 g/mol. The molecular formula of aspirin is
A) $C_6H_8O_5$
B) $C_9H_8O_4$
C) $C_8H_{10}O_5$
D) $C_{10}H_6O_4$
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 3.7
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | elemental analysis | molecular formula MSC: Quantitative

44. Suppose you are given the percent by mass of the elements in a compound and you wish to determine the empirical formula. Which of the following is true?
A) You must convert percent by mass to relative numbers of atoms.
B) You must assume exactly 100.0 g of the compound.
C) You must divide all of the percent by mass numbers by the smallest percent by mass.
D) You cannot solve for the empirical formula without the molar mass.
E) At least two of the above (A-D) are true.

ANS: A PTS: 1 DIF: Easy REF: 3.7
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | empirical formula MSC: Conceptual

45. A chloride of rhenium contains 63.6% rhenium. What is the formula of this compound?
A) ReCl
B) $ReCl_3$
C) $ReCl_5$
D) $ReCl_7$
E) Re_2Cl_3

ANS: B PTS: 1 DIF: Easy REF: 3.7
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | mass percentage MSC: Quantitative

46. A 2.80-g sample of an oxide of bromine is converted to 4.698 g of AgBr. Calculate the empirical formula of the oxide. (molar mass for AgBr = 187.78 g/mol)
A) BrO_3
B) BrO_2
C) BrO
D) Br_2O
E) none of these

ANS: B PTS: 1 DIF: Difficult REF: 3.7
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | empirical formula MSC: Quantitative

47. A hydrocarbon (a compound consisting solely of carbon and hydrogen) is found to be 85.6% carbon by mass. What is the empirical formula for this compound?
A) CH
B) CH_2
C) C_2H
D) C_3H
E) CH_4

ANS: B PTS: 1 DIF: Easy REF: 3.7
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | mass percentage MSC: Quantitative

48. The empirical formula of a group of compounds is CHCl. Lindane, a powerful insecticide, is a member of this group. The molar mass of lindane is 290.8 g/mol. How many atoms of carbon does a molecule of lindane contain?
A) 2
B) 3
C) 4
D) 6
E) 8

ANS: D PTS: 1 DIF: Moderate REF: 3.7
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | molecular formula MSC: Quantitative

49. The empirical formula of styrene is CH; its molar mass is 104.1 g/mol. What is the molecular formula of styrene?
A) C_2H_4
B) C_8H_8
C) $C_{10}H_{12}$
D) C_6H_6
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 3.7
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | molecular formula MSC: Quantitative

50. Adipic acid contains 49.32% C, 43.84% O, and 6.85% H by mass. What is the empirical formula?
A) $C_3H_5O_2$
B) $C_3H_3O_4$
C) C_2HO_3
D) $C_2H_5O_4$
E) C_3HO_3

ANS: A PTS: 1 DIF: Easy REF: 3.7

KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | empirical formula MSC: Quantitative

51. Vitamin C contains the elements C, H, and O. It is known to contain 40.9% C and 4.58% H by mass. The molar mass of vitamin C has been found to be about 180 g/mol. The molecular formula for vitamin C is:
A) $C_2H_3O_2$
B) $C_3H_4O_3$
C) $C_4H_6O_4$
D) $C_6H_8O_6$
E) $C_{14}H_{18}$

ANS: D PTS: 1 DIF: Moderate REF: 3.7
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | molecular formula MSC: Quantitative

52. A compound composed of sulfur and fluorine is found to contain 62.79% by mass of sulfur. If the molar mass of the compound is 102.13 g/mol, what is its molecular formula?
A) S_3F
B) S_2F_4
C) SF
D) S_2F
E) S_2F_2

ANS: E PTS: 1 DIF: Easy REF: 3.7
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | molecular formula MSC: Quantitative

53. A 0.4987-g sample of a compound known to contain only carbon, hydrogen, and oxygen was burned in oxygen to yield 0.9267 g of CO_2 and 0.1897 g of H_2O. What is the empirical formula of the compound?
A) CHO
B) C_2H_2O
C) $C_3H_3O_2$
D) $C_6H_3O_2$
E) $C_3H_6O_2$

ANS: C PTS: 1 DIF: Difficult REF: 3.7
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | molecular formula MSC: Quantitative

54. Oxides of copper include CuO and Cu_2O. You heat 1.51 g of one of these copper oxides in the absence of air and obtain 1.21 g of Cu.
True or false: You must have had CuO.

ANS: T PTS: 1 DIF: Moderate REF: 3.7
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | mass percentage MSC: Quantitative

55. The molecular formula always represents the total number of atoms of each element present in a compound.

ANS: T PTS: 1 DIF: Easy REF: 3.7
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | molecular formula MSC: Conceptual

56. How many of the following are true concerning balanced chemical equations?
I. The number of molecules is conserved.
II. The coefficients for the reactants tell you how much of each reactant you are given.
III. Atoms are neither created nor destroyed.
IV. The coefficients indicate the mass ratios of the substances used.
V. The sum of the coefficients on the reactant side equals the sum of the coefficients on the product side.

A) 1
B) 2
C) 3
D) 4
E) 5

ANS: A PTS: 1 DIF: Easy REF: 3.8
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

57. Balanced chemical equations imply which of the following?
A) Numbers of molecules are conserved in chemical change.
B) Numbers of atoms are conserved in chemical change.
C) Volume is conserved in chemical change.
D) A and B
E) B and C

ANS: B PTS: 1 DIF: Easy REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

58. In balancing an equation, we change the _____ to make the number of atoms on each side of the equation balance.
A) formulas of compounds in the reactants
B) coefficients of compounds
C) formulas of compounds in the products
D) subscripts of compounds
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

59. What is the coefficient for water when the following equation is balanced?

$$As(OH)_3(s) + H_2SO_4(aq) \rightarrow As_2(SO_4)_3(aq) + H_2O(l)$$

A) 1
B) 2
C) 4
D) 6
E) 12

ANS: D PTS: 1 DIF: Easy REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

60. Which of the following equations is not balanced?
A) $4Al + 3O_2 \rightarrow 2Al_2O_3$
B) $C_2H_6 + \frac{7}{2}O_2 \rightarrow 2CO_2 + 3H_2O$
C) $2KClO_3 \rightarrow 2KCl + \frac{3}{2}O_2$
D) $4P_4 + 5S_8 \rightarrow 4P_4S_{10}$
E) $P_4 + 5O_2 \rightarrow P_4O_{10}$

ANS: C PTS: 1 DIF: Easy REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

Consider a specific chemical reaction represented by the equation $aA + bB \rightarrow cC + dD$. In this equation the letters A, B, C, and D represent chemicals, and the letters a, b, c, and d represent coefficients in the balanced equation.

61. How many possible values are there for the quantity "c/d"?
A) 1
B) 2
C) 3
D) 4
E) infinite

ANS: A PTS: 1 DIF: Easy REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

62. How many possible values are there for the quantity "c"?
A) 1
B) 2
C) 3
D) 4
E) infinite

ANS: E PTS: 1 DIF: Easy REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

63. What is the coefficient for oxygen when the following equation is balanced?

$$NH_3(g) + O_2(g) \rightarrow NO_2(g) + H_2O(g)$$

A) 3

B) 6
C) 7
D) 12
E) 14

ANS: C PTS: 1 DIF: Easy REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

64. How many of the following statements are true concerning chemical equations?
I. Coefficients can be fractions.
II. Subscripts can be fractions.
III. Coefficients represent the relative masses of the reactants and/or products.
IV. Changing the subscripts to balance an equation can only be done once.
V. Atoms are conserved when balancing chemical equations.
A) 1
B) 2
C) 3
D) 4
E) 5

ANS: B PTS: 1 DIF: Easy REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

65. Determine the coefficient for O_2 when the following equation is balanced in standard form (smallest whole numbers).

$$C_8H_{18}(g) + O_2(g) \rightarrow CO_2(g) + H_2O(g)$$

A) 8
B) 17
C) 18
D) 25
E) 16

ANS: D PTS: 1 DIF: Easy REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

66. What is the sum of the coefficients of the following equation when it is balanced using smallest whole numbers?

$$NaNH_2 + NaNO_3 \rightarrow NaN_3 + NaOH + NH_3$$

A) 5
B) 6
C) 7
D) 8
E) 9

ANS: E PTS: 1 DIF: Easy REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

67. $w PCl_5 + x H_2O \rightarrow y POCl_3 + z HCl$
The above equation is properly balanced when:
A) $w = 1, x = 2, y = 2, z = 4$
B) $w = 2, x = 2, y = 2, z = 2$
C) $w = 2, x = 2, y = 2, z = 1$
D) $w = 1, x = 1, y = 1, z = 2$
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

68. Potassium forms an oxide containing 1 oxygen atom for every 2 atoms of potassium. What is the coefficient of oxygen in the balanced equation for the reaction of potassium with oxygen to form this oxide?
A) 0
B) 1
C) 2
D) 3
E) 4

ANS: B PTS: 1 DIF: Moderate REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

69. Indium reacts with chlorine to form $InCl_3$. In the balanced equation for this reaction, the coefficient of the indium trichloride is
A) 1
B) 2
C) 3
D) 4
E) 6

ANS: B PTS: 1 DIF: Moderate REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

70. Give (in order) the correct coefficients to balance the following reaction:
$H_2SnCl_6 + H_2S \rightarrow SnS_2 + HCl$
A) 1, 2, 1, 6
B) 1, 2, 2, 2
C) 1, 1, 1, 6
D) 6, 2, 1, 1
E) 2, 4, 2, 6

ANS: A PTS: 1 DIF: Easy REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

71. In the balanced equation for the reaction:
$x P_4O_6(s) + y H_2O(l) \rightarrow z H_3PO_3(aq)$

if *x* equals 2, the coefficient *z* equals:

A) 2
B) 4
C) 6
D) 10
E) none of these

ANS: E PTS: 1 DIF: Moderate REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

72. The correct coefficients to balance the following reaction are, in order:

$$I_2O_5 + H_2S \rightarrow I_2 + SO_2 + H_2O$$

A) 1, 1, 1, 1, 1
B) 1, 2, 1, 2, 1
C) 2, 4, 1, 4, 5
D) 2, 5, 2, 5, 5
E) 3, 5, 3, 5, 5

ANS: E PTS: 1 DIF: Moderate REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

73. When the equation $C_6H_{14} + O_2 \rightarrow CO_2 + H_2O$ is balanced with the smallest set of integers, the sum of the coefficients is

A) 4
B) 47
C) 15
D) 27
E) 34

ANS: B PTS: 1 DIF: Easy REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

74. Which of the following equations correctly describes the combustion of CH_4 and O_2 to produce water (H_2O) and carbon dioxide (CO_2)?

A) $CH_4 + \frac{1}{2}O_2 \rightarrow CO_2 + H_2O$
B) $CH_4 + O_2 \rightarrow CO_2 + 2H_2O$
C) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
D) $CH_4 + 3O_2 \rightarrow 2CO_2 + H_2O$
E) $2CH_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$

ANS: C PTS: 1 DIF: Easy REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

75. A reaction occurs between sodium carbonate and hydrochloric acid producing sodium chloride, carbon dioxide, and water. The correct set of coefficients, respectively, for the balanced reaction is:

A) 3 6 6 3 4
B) 8 6 5 10 5
C) 5 10 10 5 5
D) 1 2 2 1 1
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

76. When the following equation is balanced, what is the sum of the coefficients?

$$Al_2(SO_4)_3 + Ca(OH)_2 \rightarrow Al(OH)_3 + CaSO_4$$

A) 4
B) 9
C) 8
D) 7
E) 10

ANS: B PTS: 1 DIF: Easy REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

77. When balancing a chemical equation, it is generally best to start with the least complicated molecules.

ANS: F PTS: 1 DIF: Easy REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

78. To balance a chemical equation, the coefficients must not be changed.

ANS: F PTS: 1 DIF: Easy REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

79. You heat 3.869 g of a mixture of Fe_3O_4 and FeO to form 4.141 g Fe_2O_3. The mass of oxygen reacted is
A) 0.272 g
B) 0.476 g
C) 1.242 g
D) 1.000 g
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 3.1
KEY: Chemistry | general chemistry | general concepts | matter | Law of Conservation of Mass MSC: Quantitative

80. The Claus reactions, shown below, are used to generate elemental sulfur from hydrogen sulfide.

$$2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$$

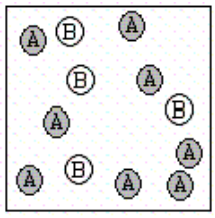
$SO_2 + 2H_2S \rightarrow 3S + 2H_2O$

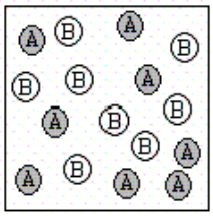
How much sulfur (in grams) is produced from 21.5 grams of O_2?

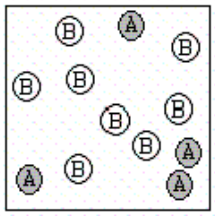
A) 97.0 g
B) 14.4 g
C) 21.5 g
D) 43.1 g
E) none of these

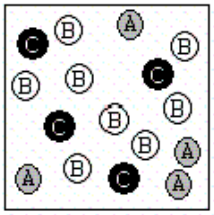
ANS: D PTS: 1 DIF: Moderate REF: 3.1
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | amounts of substances MSC: Quantitative

81. A chemical reaction has the equation: $2A + B \rightarrow C$. Which of the following figures best illustrates a stoichiometric ratio of A and B?

I. 

II. 

III. 

IV. 

A) I only
B) II only
C) III only
D) IV only
E) both I and IV

ANS: E PTS: 1 DIF: Easy REF: 3.1
KEY: Chemistry | general chemistry | stoichiometry MSC: Conceptual

82. When 233.1 g of ethylene (C_2H_4) burns in oxygen to give carbon dioxide and water, how many grams of CO_2 are formed?

A) 731.4 g
B) 365.7 g
C) 182.9 g
D) 8.31 g
E) 299.4 g

ANS: A PTS: 1 DIF: Moderate REF: 3.1
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | amounts of substances MSC: Quantitative

83. What would be the g Al / mole S ratio for the product of a reaction between aluminum and sulfur?

A) 26.98 g Al / mol S

B) 80.94 g Al / mol S
C) 40.47 g Al / mol S
D) 53.96 g Al / mol S
E) 17.99 g Al / mol S

ANS: E PTS: 1 DIF: Moderate REF: 3.1
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | molar interpretation MSC: Quantitative

84. A 7.11-g sample of potassium chlorate was decomposed according to the following equation:

$2KClO_3 \rightarrow 2KCl + 3O_2$

How many moles of oxygen are formed?
A) 2.78 g
B) 0.0580 mol
C) 0.0387 mol
D) 0.0870 mol
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 3.1
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | amounts of substances MSC: Quantitative

85. How many grams of $Ca(NO_3)_2$ can be produced by reacting excess HNO_3 with 6.33 g of $Ca(OH)_2$?
A) 7.01 g
B) 14.0 g
C) 28.0 g
D) 12.7 g
E) 6.33 g

ANS: B PTS: 1 DIF: Moderate REF: 3.1
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | amounts of substances MSC: Conceptual

86. Sulfuric acid may be produced by the following process:

$4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2$
$2SO_2 + O_2 \rightarrow 2SO_3$
$SO_3 + H_2O \rightarrow H_2SO_4$

How many moles of H_2SO_4 will be produced from 8.41 moles of FeS_2?
A) 46.3
B) 8.41
C) 16.8
D) 4.21
E) 2.10

ANS: C PTS: 1 DIF: Moderate REF: 3.1
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | molar interpretation MSC: Quantitative

87. Reaction of methane with oxygen really proceeds in two steps:

$$CH_4 + \tfrac{3}{2} O_2 \rightarrow CO + 2H_2O$$

$$CO + \tfrac{1}{2} O_2 \rightarrow CO_2$$

A sample of CH_4 is burned in an excess of O_2 to give 3.0 moles of H_2O. How many moles of CH_4 were in the original sample?

A) 1.5
B) 2.0
C) 6.0
D) 0.8
E) 3.0

ANS: A PTS: 1 DIF: Easy REF: 3.1
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | molar interpretation MSC: Quantitative

88. Iron is produced from its ore by the reactions:

$$2C(s) + O_2(g) \rightarrow 2CO(g)$$

$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$$

How many moles of $O_2(g)$ are needed to produce 4.6 moles of Fe(s)?

A) 2.3 mole O_2
B) 3.5 mole O_2
C) 4.6 mole O_2
D) 6.9 mole O_2
E) 13.8 mole O_2

ANS: B PTS: 1 DIF: Easy REF: 3.1
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | molar interpretation MSC: Quantitative

89. The refining of aluminum from bauxite ore (which contains 50.% Al_2O_3 by mass) proceeds by the overall reaction $2Al_2O_3 + 3C \rightarrow 4Al + 3CO_2$. How much bauxite ore is required to give the 5.0×10^{13} g of aluminum produced each year in the United States? (Assume 100% conversion.)

A) 1.3×10^{13} g
B) 5.3×10^{13} g
C) 1.9×10^{14} g
D) 7.6×10^{14} g
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 3.1
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | amounts of substances MSC: Quantitative

90. Consider the following reaction:

$$CH_4(g) + 4Cl_2(g) \rightarrow CCl_4(g) + 4HCl(g)$$

What mass of CCl_4 is formed by the reaction of 5.14 g of methane with an excess of chlorine?

A) 12.3 g

B) 0.54 g
C) 791 g
D) 49.3 g
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 3.1
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | amounts of substances MSC: Quantitative

91. One commercial system removes SO_2 emissions from smoke at 95.0°C by the following set of balanced reactions:

$$SO_2 + Cl_2 \rightarrow SO_2Cl_2$$
$$SO_2Cl_2 + 2H_2O \rightarrow H_2SO_4 + 2HCl$$
$$H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$$

Assuming the process is 95.0% efficient, how many grams of $CaSO_4$ may be produced from 100. grams of SO_2?
(molar masses: SO_2, 64.1 g/mol; $CaSO_4$, 136 g/mol)
A) 44.8 g
B) 47.1 g
C) 87.2 g
D) 202 g
E) 212 g

ANS: D PTS: 1 DIF: Difficult REF: 3.1
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | amounts of substances MSC: Quantitative

92. When rubidium metal is exposed to air, two atoms of rubidium, Rb, combine with one atom of oxygen. If 1.98 grams of rubidium is exposed to air, what will be the mass of the product in grams?
A) 17.98 g
B) 2.17 g
C) 9.98 g
D) 8.66 g
E) 4.33 g

ANS: B PTS: 1 DIF: Moderate REF: 3.1
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | amounts of substances MSC: Quantitative

93. The following two reactions are important in the blast furnace production of iron metal from iron ore (Fe_2O_3):

$$2C(s) + O_2(g) \rightarrow 2CO(g)$$
$$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$$

Using these balanced reactions, how many moles of O_2 are required for the production of 3.19 kg of Fe?
A) 42.8 moles
B) 19.0 moles
C) 171 moles
D) 57.1 moles

E) 2.39 moles

ANS: A PTS: 1 DIF: Difficult REF: 3.1
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | amounts of substances MSC: Quantitative

94. Nitric oxide, NO, is made from the oxidation of NH_3, and the reaction is represented by the equation:
$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$
What mass of NO can be produced from 7.55 g of NH_3?
A) 4.28 g NO
B) 13.3 g NO
C) 7.55 g NO
D) 20.0 g NO
E) 16.6 g NO

ANS: B PTS: 1 DIF: Easy REF: 3.1
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | amounts of substances MSC: Quantitative

95. Nitric oxide, NO, is made from the oxidation of NH_3, and the reaction is represented by the equation:
$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$
What mass of O_2 would be required to react completely with 6.85 g of NH_3?
A) 4.56 g O_2
B) 10.3 g O_2
C) 8.04 g O_2
D) 16.1 g O_2
E) 12.9 g O_2

ANS: D PTS: 1 DIF: Easy REF: 3.1
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | amounts of substances MSC: Quantitative

96. For the reaction $P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(aq)$, what mass of P_4O_{10} must be consumed if 3.71×10^{23} molecules of H_2O are also consumed?
A) 1.05×10^3 g P_4O_{10}
B) 29.1 g P_4O_{10}
C) 175 g P_4O_{10}
D) 1.85 g P_4O_{10}
E) 66.6 g P_4O_{10}

ANS: B PTS: 1 DIF: Moderate REF: 3.1
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | amounts of substances MSC: Quantitative

97. The limiting reactant in a reaction
A) has the lowest coefficient in a balanced equation
B) is the reactant for which you have the fewest number of moles
C) has the lowest ratio of moles available/coefficient in the balanced equation

D) has the lowest ratio of coefficient in the balanced equation/moles available
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Conceptual

98. Phosphoric acid can be prepared by reaction of sulfuric acid with "phosphate rock" according to the equation:

$$Ca_3(PO_4)_2 + 3H_2SO_4 \rightarrow 3CaSO_4 + 2H_3PO_4$$

Suppose the reaction is carried out starting with 129 g of $Ca_3(PO_4)_2$ and 97.4 g of H_2SO_4. Which substance is the limiting reactant?
A) $Ca_3(PO_4)_2$
B) H_2SO_4
C) $CaSO_4$
D) H_3PO_4
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Quantitative

99. Suppose the reaction $Ca_3(PO_4)_2 + 3H_2SO_4 \rightarrow 3CaSO_4 + 2H_3PO_4$ is carried out starting with 153 g of $Ca_3(PO_4)_2$
and 76.8 g of H_2SO_4. How much phosphoric acid will be produced?
A) 76.7 g
B) 51.1 g
C) 229.8 g
D) 115.1 g
E) 96.7 g

ANS: B PTS: 1 DIF: Moderate REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Quantitative

100. Phosphorus, P_4, can be prepared from calcium phosphate by the reaction

3370 g	1795 g	650 g				
$2Ca_3(PO_4)_2$	+ $6SiO_2$	+ $10C$	$\rightarrow 6CaSiO_3$	+ P_4	+ $10CO$	
310 g/mol	60.1 g/mol	12.0 g/mol				

The *molar mass* for each reactant is shown *below* the reactant, and the *mass* of each reactant for this problem is given *above*. Which reactant is the limiting reagent?
A) C
B) SiO_2
C) $Ca_3(PO_4)_2$
D) P_4
E) More information is needed.

ANS: B PTS: 1 DIF: Moderate REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Conceptual

101. SO_2 reacts with H_2S as follows:

$$2H_2S + SO_2 \rightarrow 3S + 2H_2O$$

When 7.50 g of H_2S reacts with 12.75 g of SO_2, which statement applies?
A) 6.38 g of sulfur are formed.
B) 10.6 g of sulfur are formed.
C) 0.0216 moles of H_2S remain.
D) 1.13 g of H_2S remain.
E) SO_2 is the limiting reagent.

ANS: B PTS: 1 DIF: Moderate REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Quantitative

102. How many grams of H_2O will be formed when 32.0 g H_2 is mixed with 12.0 g of O_2 and allowed to react to form water?
A) 13.5 g
B) 286 g
C) 6.8 g
D) 3.4 g
E) 144 g

ANS: A PTS: 1 DIF: Moderate REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Quantitative

103. A 15-g sample of lithium is reacted with 15 g of fluorine to form lithium fluoride: $2Li + F_2 \rightarrow 2LiF$. After the reaction is complete, what will be present?
A) 2.16 moles lithium fluoride only
B) 0.789 moles lithium fluoride only
C) 2.16 moles lithium fluoride and 0.395 moles fluorine
D) 0.789 moles lithium fluoride and 1.37 moles lithium
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Quantitative

104. Consider the fermentation reaction of glucose:

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

A 1.00-mole sample of $C_6H_{12}O_6$ was placed in a vat with 100 g of yeast. If 32.3 grams of C_2H_5OH was obtained, what was the percent yield of C_2H_5OH?
A) 35.1%
B) 17.5%
C) 100%
D) 32.3%
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Quantitative

105. A 5.95-g sample of $AgNO_3$ is reacted with $BaCl_2$ according to the equation

$$2AgNO_3(aq) + BaCl_2(aq) \rightarrow 2AgCl(s) + Ba(NO_3)_2(aq)$$

to give 3.17 g of AgCl. What is the percent yield of AgCl?
A) 45.0%
B) 53.3%
C) 31.6%
D) 63.1%
E) 100%

ANS: D PTS: 1 DIF: Moderate REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Quantitative

106. The reaction of 11.9 g of $CHCl_3$ with excess chlorine produced 10.2 g of CCl_4, carbon tetrachloride:

$$2CHCl_3 + 2Cl_2 \rightarrow 2CCl_4 + 2HCl$$

What is the percent yield?
A) 100%
B) 33.2%
C) 66.3%
D) 86%
E) 44.2%

ANS: C PTS: 1 DIF: Moderate REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Quantitative

107. When 20.0 g C_2H_6 and 60.0 g O_2 react to form CO_2 and H_2O, how many grams of water are formed?
A) 14.5 g
B) 18.0 g
C) 58.0 g
D) 20.0 g
E) none of these

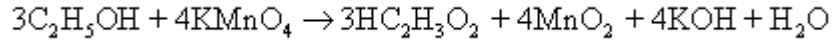
ANS: E PTS: 1 DIF: Moderate REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Quantitative

108. Given the equation $3A + B \rightarrow C + D$, you react 2 moles of *A* with 1 mole of *B*. Which of the following is true?
A) *A* is the limiting reactant because of its higher molar mass.
B) *A* is the limiting reactant because you need 3 moles of *A* and have 2.
C) *B* is the limiting reactant because you have fewer moles of *B* than *A*.
D) *B* is the limiting reactant because 3 *A* molecules react with 1 *B* molecule.

E) Neither reactant is limiting.

ANS: B PTS: 1 DIF: Easy REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Conceptual

109. The following equation describes the oxidation of ethanol to acetic acid by potassium permanganate:

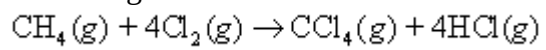


$$3C_2H_5OH + 4KMnO_4 \rightarrow 3HC_2H_3O_2 + 4MnO_2 + 4KOH + H_2O$$

5.00 g of ethanol and an excess of aqueous $KMnO_4$ are reacted, and 4.24 g of $HC_2H_3O_2$ result. What is the percent yield?
A) 100%
B) 65.1%
C) 21.7%
D) 34.9%
E) 4.24 g $HC_2H_3O_2$ is impossible since it represents more than 100% yield.

ANS: B PTS: 1 DIF: Moderate REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Quantitative

110. Consider the following reaction:



$$CH_4(g) + 4Cl_2(g) \rightarrow CCl_4(g) + 4HCl(g)$$

What mass of CCl_4 will be formed if 1.20 moles of methane react with 1.11 moles of chlorine?
A) 185 g
B) 171 g
C) 683 g
D) 42.7 g
E) 19.7 g

ANS: D PTS: 1 DIF: Easy REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Quantitative

111. The limiting reactant in a reaction
A) is the reactant for which there is the least amount in grams
B) is the reactant which has the lowest coefficient in a balanced equation
C) is the reactant for which there is the most amount in grams
D) is the reactant for which there is the fewest number of moles
E) none of the above

ANS: E PTS: 1 DIF: Easy REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Conceptual

112. The limiting reactant is the reactant
A) for which you have the lowest mass in grams
B) which has the lowest coefficient in the balanced equation
C) which has the lowest molar mass

D) which is left over after the reaction has gone to completion
E) none of the above

ANS: E PTS: 1 DIF: Easy REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Conceptual

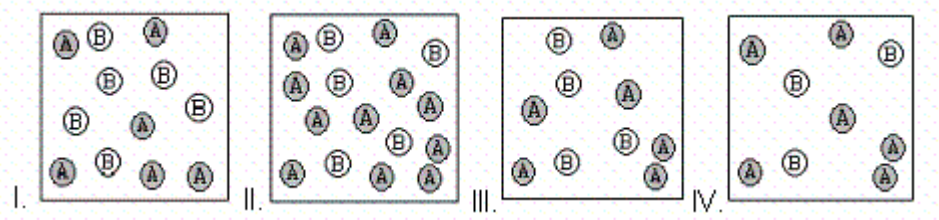
113. Consider the following reaction:

$$2A + B \rightarrow 3C + D$$

3.0 mol *A* and 2.0 mol *B* react to form 4.0 mol *C*. What is the percent yield of this reaction?
A) 50%
B) 67%
C) 75%
D) 89%
E) 100%

ANS: D PTS: 1 DIF: Moderate REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Conceptual

114. A chemical reaction has the equation: $2A + B \rightarrow C$. In which case is B the limiting reactant?



A) I
B) II
C) III
D) IV
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Conceptual

115. Which of the following statements is always true concerning a reaction represented by the following balanced chemical equation?

$2C_2H_6(g) + 7O_2(g) \rightarrow 6H_2O(l) + 4CO_2(g)$

A) If we have equal masses of C_2H_6 and O_2, there is no limiting reactant.
B) If we have an equal number of moles of C_2H_6 and O_2, there is no limiting reactant.
C) If we have more mass of C_2H_6, then O_2 must be limiting.
D) If we have more mass of O_2, then C_2H_6 must be limiting.
E) None of these statements are true.

ANS: C PTS: 1 DIF: Easy REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Conceptual

116. Equal masses (in grams) of hydrogen gas and oxygen gas are reacted to form water. Which substance is limiting?
A) Oxygen gas is limiting.
B) Hydrogen gas is limiting.
C) Water is limiting.
D) Nothing is limiting.
E) More information is needed to answer this question.

ANS: A PTS: 1 DIF: Easy REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Conceptual

117. If 45.0 g of O_2 are mixed with 45.0 g of H_2 and the mixture is ignited, what mass of water is produced?
A) 45.0 g
B) 50.7 g
C) 79.9 g
D) 25.3 g
E) 90.0 g

ANS: B PTS: 1 DIF: Moderate REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Quantitative

118. For the reaction $N_2(g) + 2H_2(g) \rightarrow N_2H_4(l)$, if the percent yield for this reaction is 82.0%, what is the actual mass of hydrazine (N_2H_4) produced when 25.57 g of nitrogen reacts with 4.45 g of hydrogen?
A) 35.7 g N_2H_4
B) 24.0 g N_2H_4
C) 30.0 g N_2H_4
D) 29.2 g N_2H_4
E) 28.9 g N_2H_4

ANS: B PTS: 1 DIF: Difficult REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Quantitative

119. Nitric oxide, NO, is made from the oxidation of NH_3, and the reaction is represented by the equation:
$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$
An 8.7-g sample of NH_3 gives 12.0 g of NO. The *percent yield* of NO is
A) 73%
B) 63%
C) 41%
D) 78%
E) 20%

ANS: D PTS: 1 DIF: Moderate REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Quantitative

120. Ammonia can be made by reaction of water with magnesium nitride as shown by the following *unbalanced* equation:

$$Mg_3N_2(s) + H_2O(l) \rightarrow Mg(OH)_2(s) + NH_3(g)$$

If this process is 80% efficient, what mass of ammonia can be prepared from 19.0 kg magnesium nitride?

A) 2.6 kg NH_3
B) 6.4 kg NH_3
C) 5.1 kg NH_3
D) 3.2 kg NH_3
E) 15 kg NH_3

ANS: C PTS: 1 DIF: Difficult REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Quantitative

121. Given the equation $3A + B \rightarrow C + D$, you react 1 mole of *A* with 3 moles of *B*.
True or false: *A* is the limiting reactant because you have fewer moles of *A* than *B*.

ANS: F PTS: 1 DIF: Easy REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Conceptual

122. The reactant with the highest molar mass is always the limiting reactant.

ANS: F PTS: 1 DIF: Easy REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Conceptual

123. The reactant which, when used up completely, can produce the least amount of product, is the limiting reactant.

ANS: T PTS: 1 DIF: Easy REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Conceptual

124. Naturally occurring iron contains 5.82% $^{54}_{26}Fe$, 91.66% $^{56}_{26}Fe$, 2.19% $^{57}_{26}Fe$, and 0.33% $^{58}_{26}Fe$. The respective atomic masses are 53.940 amu, 55.935 amu, 56.935 amu, and 57.933 amu. Calculate the average atomic mass of iron.

ANS:
55.85 amu

See Sec. 3.2 of Zumdahl, *Chemistry*.
0.0582(53.940 amu) + 0.9166(55.935 amu) + 0.0219(56.935 amu) + 0.0033(57.933 amu) = 55.85 amu

PTS: 1 DIF: Easy REF: 3.2
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | atomic weight | mass spectroscopy MSC: Quantitative

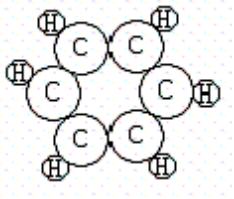
125. Vitamin B_{12}, cyanocobalamin, is essential for human nutrition. It's concentrated in animal tissue but not in higher plants. People who abstain completely from animal products may develop anemia, so cyanocobalamin is used in vitamin supplements. It contains 4.35% cobalt by mass. Calculate the molar mass of cyanocobalamin assuming there is one cobalt per molecule.

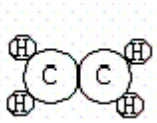
ANS:
1355 g/mol

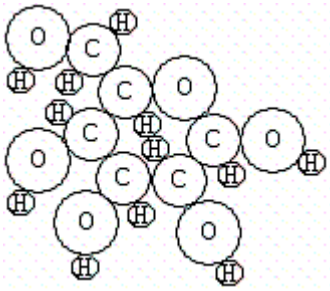
See Sec. 3.6 of Zumdahl, *Chemistry*.
(1 mol Co/1 mol $VitB_{12}$)*(58.93 g Co/mol Co)*(100 g $VitB_{12}$/4.35 g Co) = 1355 g $VitB_{12}$/mol $VitB_{12}$

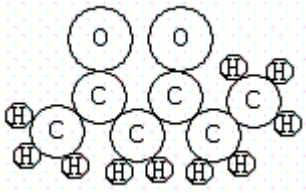
PTS: 1 DIF: Moderate REF: 3.6
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas
MSC: Quantitative

126. Give the empirical formula for the following compounds:

a) 

b) 

c) 

d) 

ANS:
a) CH b) CH_2 c) CH_2O d) C_3H_5O

See Sec. 3.7 of Zumdahl, *Chemistry*.

observed molecular formulas: a) C_6H_6 b) C_2H_4 c) $C_6H_{12}O_6$ d) $C_6H_{10}O_2$

PTS: 1 DIF: Easy REF: 3.7
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | empirical formula MSC: Conceptual

127. The hormone epinephrine is released in the human body during stress and increases the body's metabolic rate. Epinephrine, like many biochemical compounds, is composed of carbon, hydrogen, oxygen, and nitrogen. The percentage composition of the hormone is 59.0% C, 7.15% H, 26.2% O, and 7.65% N. Determine the empirical formula.

ANS:
$C_9H_{13}NO_3$

See Sec. 3.7 of Zumdahl, *Chemistry*.
59.0 g C * (1 mol C/12.01 g) = 4.91 mol C (÷ 0.546) = 9 mol C
7.15 g H * (1 mol H/1.008 g) = 7.09 mol H (÷ 0.546) = 13 mol H
26.2 g O * (1 mol O/16.00 g) = 1.64 mol O (÷ 0.546) = 3 mol O
7.65 g N * (1 mol N/14.01 g) = 0.546 mol N (÷ 0.546) = 1 mol N

PTS: 1 DIF: Easy REF: 3.7
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | empirical formula MSC: Quantitative

128. The characteristic odor of pineapple is due to ethyl butanoate, a compound containing carbon, hydrogen, and oxygen. Combustion of 2.78 g of ethyl butanoate leads to formation of 6.32 g of CO_2 and 2.58 g of H_2O. The properties of the compound suggest that the molar mass should be between 100 and 150 g/mol. What is the molecular formula?

ANS:
$C_6H_{12}O_2$

See Sec. 3.7 of Zumdahl, *Chemistry*.
6.32 g CO_2 * (12.01 g C/44.01 g CO_2) = 1.72 g C
2.58 g H_2O * (2.016 g H/18.02 g H_2O) = 0.289 g H
2.78 g ethyl butanoate - 1.72 g C - 0.289 g H = 0.77 g O
1.72 g C * (1 mol C/12.01 g) = 0.143 mol C (÷ 0.048) = 3 mol C
0.289 g H * (1 mol H/1.008 g H) = 0.287 mol H (÷ 0.048) = 6 mol H
0.77 g O * (1 mol O/16.00 g) = 0.048 mol O (÷ 0.048) = 1 mol O
empirical formula = C_3H_6O
empirical formula mass = 58.08 g/mol
58.08 * 2 = 116 g/mol which is between 100 and 150 (58.08 * 3 = 174.2, too much)
therefore, molecular formula = 2(C_3H_6O) = $C_6H_{12}O_2$

PTS: 1 DIF: Difficult REF: 3.7
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | molecular formula MSC: Quantitative

129. In order to determine the molecular formula from the empirical formula, we must know the _____.

ANS:
molar mass

PTS: 1 DIF: Easy REF: 3.7
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | molecular formula MSC: Conceptual

130. In a chemical equation, the _____ are written on the left side of the arrow, and the _____ are written on the right side of the arrow.

ANS:
reactants, products

PTS: 1 DIF: Easy REF: 3.8
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | writing equation MSC: Conceptual

131. The _____ in a chemical equation represent the number of atoms in a particular molecule or formula unit.

ANS:
subscripts

PTS: 1 DIF: Easy REF: 3.8
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | writing equation MSC: Conceptual

132. The _____ in a balanced equation represent numbers of molecules.

ANS:
coefficients

PTS: 1 DIF: Easy REF: 3.8
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | writing equation MSC: Conceptual

133. One of the major commercial uses of sulfuric acid is in the production of phosphoric acid and calcium sulfate. The phosphoric acid is used for fertilizer. The reaction is $Ca_3(PO_4)_2 + 3H_2SO_4 \rightarrow 3CaSO_4 + 2H_3PO_4$. What mass of concentrated H_2SO_4 (98% by mass) must be used to react completely with 100.00 g of calcium phosphate?

ANS:
97 g H_2SO_4

See Sec. 3.10 of Zumdahl, *Chemistry*.

(100.00g) * (1 mol $Ca_3(PO_4)_2$/310.18 g)*(3 mol H_2SO_4/1 mol $Ca_3(PO_4)_2$)*(98.09 g/1 mol H_2SO_4) *(100 g solution/98 g H_2SO_4) = 96.81 = 97 g H_2SO_4

PTS: 1 DIF: Moderate REF: 3.1
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | amounts of substances MSC: Quantitative

134. In a metallurgical process the mineral pyrite, FeS_2, is roasted in air:

$$FeS_2 + O_2 \rightarrow Fe_2O_3 + SO_2$$

The SO_2 is then converted into H_2SO_4 in the following reactions:

$$2SO_2 + O_2 \rightarrow 2SO_3$$
$$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$$
$$H_2S_2O_7 + H_2O \rightarrow 2H_2SO_4$$

Assuming the mineral is 24.0% FeS_2 and the remainder is inert, what mass of H_2SO_4 is produced if 155 g of the mineral is used?

ANS:
60.8 g H_2SO_4

See Sec. 3.10 of Zumdahl, *Chemistry*.
Calculate moles SO_2 from FeS_2: 155 g mineral * (24 g FeS_2/100 g mineral) *(1 mol FeS_2/119.99g)*(2 mol SO_2/1 mol FeS_2) = 0.620 mol SO_2
Overall rxn SO_2 to H_2SO_4: $SO_2 + 1/2O_2 + H_2O$ --> H_2SO_4
0.620 mol SO_2 * (1 mol H_2SO_4/1 mol SO_2) * (98.09 g H_2SO_4/mol) = 60.8 g H_2SO_4

PTS: 1 DIF: Difficult REF: 3.1
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | amounts of substances MSC: Quantitative

135. The percent yield is a ratio of the _____ yield to the _____ yield, multiplied by 100%.

ANS:
actual, theoretical

PTS: 1 DIF: Easy REF: 3.11
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Conceptual

136. Tellurium consists of 3 common isotopes. Half of tellurium atoms have a mass of 127, and another 0.45 of tellurium atoms weigh 128. What is the mass of the remaining isotope? The atomic mass of tellurium is 127.6.
A) 126
B) 127
C) 129
D) 130
E) 131

ANS: D PTS: 1 DIF: Moderate REF: 3.2

KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | atomic weight MSC: Quantitative

137. Magnesium has an atomic mass of 24.3. There are two isotopes of magnesium – one contains 12 neutrons and the other contains 13 neutrons in the nucleus. What is the fractional abundance of the one that contains 12 neutrons?
A) 0.3
B) 0.5
C) 0.67
D) 0.7
E) 0.75

ANS: D PTS: 1 DIF: Easy REF: 3.2
KEY: Chemistry | general chemistry | early atomic theory | atomic theory of matter | atomic weight MSC: Quantitative

138. What is the mass of 9.00×10^{22} atoms of magnesium, Mg?
A) 0.150 g
B) 0.363 g
C) 1.80 g
D) 3.63 g
E) 36.3 g

ANS: D PTS: 1 DIF: Easy REF: 3.3
KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | mole
MSC: Quantitative

139. What is the molar mass of tetraphosphorus decaoxide?
A) 140 g/mol
B) 410 g/mol
C) 253 g/mol
D) 204 g/mol
E) 284 g/mol

ANS: E PTS: 1 DIF: Easy REF: 3.4
KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | mole
MSC: Quantitative

140. Calculate the number of nitrogen atoms in 240. g of ammonium nitrate.
A) 2.01×10^{23} nitrogen atoms
B) 6.02×10^{23} nitrogen atoms
C) 1.20×10^{24} nitrogen atoms
D) 1.81×10^{24} nitrogen atoms
E) 3.61×10^{24} nitrogen atoms

ANS: E PTS: 1 DIF: Moderate REF: 3.4
KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | mole
MSC: Quantitative

141. 32.0 grams of the element oxygen:
A) contain 6.02×10^{23} atoms of oxygen

B) contain 1.204 x 10^{24} molecules of oxygen
C) contain the same number of oxygen atoms as 18.0 g of water
D) contain the same number of oxygen atoms as 36.0 g of water
E) contain the same number of oxygen atoms as 72.0 g of water

ANS: D PTS: 1 DIF: Easy REF: 3.4
KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | mole
MSC: Quantitative

142. Which of the following samples contains the greatest number of moles of carbon atoms?
A) 58 g of C_4H_{10}
B) 46 g of C_2H_5OH
C) 44 g of CO_2
D) 180 g of $C_6H_{12}O_6$
E) all contain the same number of moles of carbon atoms

ANS: D PTS: 1 DIF: Easy REF: 3.4
KEY: Chemistry | general chemistry | stoichiometry | mass and moles of substance | mole
MSC: Quantitative

143. An unknown molecule is found to consist of 24.2% carbon by mass, 4.0% hydrogen by mass and the remaining mass is due to chlorine. What is the molecular formula of the molecule given that the molar mass is found to be approximately 150?
A) CH_2Cl
B) $C_2H_4Cl_2$
C) CH_2Cl_4
D) $C_3H_6Cl_3$
E) $C_6H_{10}Cl_2$

ANS: D PTS: 1 DIF: Moderate REF: 3.7
KEY: Chemistry | general chemistry | stoichiometry | determining chemical formulas | molecular formula MSC: Quantitative

144. Balance this equation using the smallest possible integers, $S + HNO_3 \rightarrow H_2SO_4 + NO_2 + H_2O$. What is the coefficient of water.
A) 1
B) 2
C) 4
D) 6
E) 10

ANS: B PTS: 1 DIF: Moderate REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

145. Balance this equation using the smallest possible integers, $NO + NH_3 \rightarrow N_2 + H_2O$. What is the coefficient of the water?
A) 1
B) 2
C) 3
D) 6

E) 12

ANS: D PTS: 1 DIF: Moderate REF: 3.9
KEY: Chemistry | general chemistry | early atomic theory | chemical equation | balancing chemical equation MSC: Conceptual

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Chapter 4: Chemical Reactions and Solutions Stoichiometry

1. An unknown substance dissolves readily in water but not in benzene (a nonpolar solvent). Molecules of what type are present in the substance?
   A) neither polar nor nonpolar
   B) polar
   C) either polar or nonpolar
   D) nonpolar
   E) none of these

   ANS: B PTS: 1 DIF: Easy REF: 4.1
   KEY: Chemistry | general chemistry | solutions | solution formation
   MSC: Conceptual

2. The interaction between solute particles and water molecules, which tends to cause a salt to fall apart in water, is called
   A) hydration
   B) polarization
   C) dispersion
   D) coagulation
   E) conductivity

   ANS: A PTS: 1 DIF: Easy REF: 4.1
   KEY: Chemistry | general chemistry | solutions | solution formation
   MSC: Conceptual

3. Consider two organic molecules, ethanol and benzene. One dissolves in water and the other does not. Why?
   A) They have different molar masses.
   B) One is ionic, the other is not.
   C) One is an electrolyte, the other is not.
   D) Ethanol contains a polar O–H bond, and benzene does not.
   E) Two of these are correct.

   ANS: D PTS: 1 DIF: Moderate REF: 4.1
   KEY: Chemistry | general chemistry | solutions | solution formation
   MSC: Conceptual

4. Polar molecules have an unequal distribution of charge within the molecule.

   ANS: T PTS: 1 DIF: Easy REF: 4.1
   KEY: Chemistry | general chemistry | solutions | solution formation
   MSC: Conceptual

5. Which of the following is a strong acid?
   A) HF
   B) KOH
   C) $HClO_4$
   D) HClO
   E) HBrO

ANS: C PTS: 1 DIF: Easy REF: 4.2
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | electrolyte | strong electrolyte MSC: Conceptual

6. All of the following are weak acids *except*
   A) HCNO
   B) HBr
   C) HF
   D) HNO_2
   E) HCN

   ANS: B PTS: 1 DIF: Easy REF: 4.2
   KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | electrolyte | strong electrolyte MSC: Conceptual

7. Which of the following is *not* a strong base?
   A) $Ca(OH)_2$
   B) KOH
   C) NH_3
   D) LiOH
   E) $Sr(OH)_2$

   ANS: C PTS: 1 DIF: Easy REF: 4.2
   KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | electrolyte MSC: Conceptual

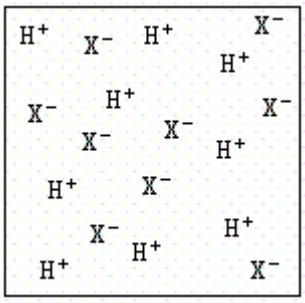
8. Which of the following is paired incorrectly?
   A) H_2SO_4 – strong acid
   B) HNO_3 – weak acid
   C) $Ba(OH)_2$ – strong base
   D) HCl – strong acid
   E) NH_3 – weak base

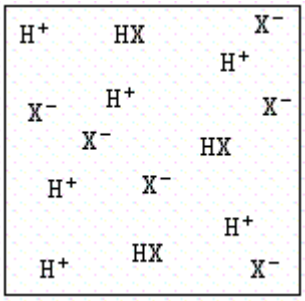
   ANS: B PTS: 1 DIF: Easy REF: 4.2
   KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | electrolyte MSC: Conceptual

9. The man who discovered the essential nature of acids through solution conductivity studies is
   A) Priestly
   B) Boyle
   C) Einstein
   D) Mendeleev
   E) Arrhenius

   ANS: E PTS: 1 DIF: Easy REF: 4.2
   KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | electrolyte MSC: Conceptual

10. A solid acid HX is mixed with water. Two possible solutions can be obtained. Which of the following is true?

I. 

II. 

A) In case I, HX is acting like a weak acid, and in case II, HX is acting like a strong acid.
B) In case I, HX is acting like a strong acid, and in case II, HX is acting like a weak acid.
C) In both cases, HX is acting like a strong acid.
D) In both cases, HX is acting like a weak acid.
E) HX is not soluble in water.

ANS: B PTS: 1 DIF: Moderate REF: 4.2
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | electrolyte MSC: Conceptual

11. An acid is a substance that produces OH^- ions in water.

ANS: F PTS: 1 DIF: Easy REF: 4.2
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | acid-base reaction | acid definition MSC: Conceptual

12. A 16.4-g sample of HF is dissolved in water to give 2.0×10^2 mL of solution. The concentration of the solution is:
A) 0.82 *M*
B) 0.16 *M*
C) 0.08 *M*
D) 4.1 *M*
E) 8.2 *M*

ANS: D PTS: 1 DIF: Easy REF: 4.3
KEY: Chemistry | general chemistry | chemical reactions | working with solutions | concentration MSC: Quantitative

13. 1.00 mL of a 3.50×10^{-4} *M* solution of oleic acid is diluted with 9.00 mL of petroleum ether, forming solution A. Then 2.00 mL of solution A is diluted with 8.00 mL of petroleum ether, forming solution B. What is the concentration of solution B?
    A) 3.50×10^{-6} *M*
    B) 9.72×10^{-6} *M*
    C) 7.00×10^{-5} *M*
    D) 7.78×10^{-5} *M*
    E) 7.00×10^{-6} *M*

    ANS: E PTS: 1 DIF: Moderate REF: 4.3
    KEY: Chemistry | general chemistry | chemical reactions | working with solutions | diluting solutions MSC: Quantitative

14. 1.00 mL of a 4.05×10^{-4} *M* solution of oleic acid is diluted with 9.00 mL of petroleum ether, forming solution A. Then 2.00 mL of solution A is diluted with 8.00 mL of petroleum ether, forming solution B. How many grams of oleic acid are 5.00 mL of solution B? (Molar mass for oleic acid = 282 g/mol)
    A) 5.71×10^{-6} g
    B) 1.59×10^{-5} g
    C) 2.28×10^{-2} g
    D) 1.14×10^{-5} g
    E) 5.71×10^{-4} g

    ANS: D PTS: 1 DIF: Difficult REF: 4.3
    KEY: Chemistry | general chemistry | chemical reactions | working with solutions | diluting solutions MSC: Quantitative

15. How many grams of NaCl are contained in 350. mL of a 0.287 *M* solution of sodium chloride?
    A) 16.8 g
    B) 5.87 g
    C) 11.74 g
    D) 100.5 g
    E) none of these

    ANS: B PTS: 1 DIF: Moderate REF: 4.3
    KEY: Chemistry | general chemistry | chemical reactions | working with solutions | concentration MSC: Quantitative

16. Which of the following aqueous solutions contains the greatest number of ions?
    A) 400.0 mL of 0.10 *M* NaCl
    B) 300.0 mL of 0.10 *M* $CaCl_2$
    C) 200.0 mL of 0.10 *M* $FeCl_3$
    D) 200.0 mL of 0.10 *M* KBr
    E) 800.0 mL of 0.10 *M* sucrose

    ANS: B PTS: 1 DIF: Easy REF: 4.3
    KEY: Chemistry | general chemistry | chemical reactions | working with solutions | concentration MSC: Conceptual

17. What mass of calcium chloride, $CaCl_2$, is needed to prepare 3.950 L of a 1.49 *M* solution?
A) 294 g
B) 5.89 g
C) 41.9 g
D) 111 g
E) 653 g

ANS: E PTS: 1 DIF: Easy REF: 4.3
KEY: Chemistry | general chemistry | chemical reactions | working with solutions | concentration MSC: Quantitative

18. A 38.1-g sample of $SrCl_2$ is dissolved in 112.5 mL of solution. Calculate the molarity of this solution.
A) 27.0 *M*
B) 2.14 *M*
C) 53.7 *M*
D) 0.339 *M*
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 4.3
KEY: Chemistry | general chemistry | chemical reactions | working with solutions | concentration MSC: Quantitative

19. What mass of solute is contained in 256 mL of a 0.838 *M* ammonium chloride solution?
A) 11.5 g
B) 175 g
C) 16.3 g
D) 215 g
E) 3.27 g

ANS: A PTS: 1 DIF: Easy REF: 4.3
KEY: Chemistry | general chemistry | chemical reactions | working with solutions | concentration MSC: Quantitative

20. A 74.28-g sample of $Ba(OH)_2$ is dissolved in enough water to make 2.450 liters of solution. How many mL of this solution must be diluted with water in order to make 1.000 L of 0.100 *M* $Ba(OH)_2$?
A) 565 mL
B) 177 mL
C) 17.7 mL
D) 4.34 mL
E) 231 mL

ANS: A PTS: 1 DIF: Moderate REF: 4.3
KEY: Chemistry | general chemistry | chemical reactions | working with solutions | diluting solutions MSC: Quantitative

21. What volume of 18 *M* sulfuric acid must be used to prepare 2.30 L of 0.145 *M* H_2SO_4?
A) 19 mL
B) 0.33 mL
C) 1.1×10^3 mL

D) 2.9 mL
E) 6.0 mL

ANS: A PTS: 1 DIF: Easy REF: 4.3
KEY: Chemistry | general chemistry | chemical reactions | working with solutions | diluting solutions MSC: Quantitative

22. How many grams of NaOH are contained in 5.0×10^2 mL of a 0.74 *M* sodium hydroxide solution?
A) 15 g
B) 74 g
C) 0.37 g
D) 30 g
E) 370 g

ANS: A PTS: 1 DIF: Easy REF: 4.3
KEY: Chemistry | general chemistry | chemical reactions | working with solutions | concentration MSC: Quantitative

23. An analytical procedure requires a solution of chloride ions. How many grams of NaCl must be dissolved to make 1.95 L of 0.0561 *M* Cl^-?
A) 3.28 g
B) 0.595 g
C) 6.39 g
D) 1.64 g
E) 12.8 g

ANS: C PTS: 1 DIF: Moderate REF: 4.3
KEY: Chemistry | general chemistry | chemical reactions | working with solutions | concentration MSC: Quantitative

24. The concentration of a salt water solution that sits in an open beaker decreases over time.

ANS: F PTS: 1 DIF: Easy REF: 4.3
KEY: Chemistry | general chemistry | chemical reactions | working with solutions | concentration MSC: Conceptual

25. You have two solutions of chemical *A*. To determine which has the highest concentration of *A* in molarity, what is the minimum number of the following you must know?
I. the mass in grams of *A* in each solution
II. the molar mass of *A*
III. the volume of water added to each solution
IV. the total volume of the solution

A) 0
B) 1
C) 2
D) 3
E) You must know all of them.

ANS: C PTS: 1 DIF: Easy REF: 4.3
KEY: Chemistry | general chemistry | chemical reactions | working with solutions | concentration MSC: Conceptual

26. Diabetics often need injections of insulin to help maintain the proper blood glucose levels in their bodies. How many moles of insulin are needed to make up 45 mL of 0.0062 *M* insulin solution?
A) 0.00056 mol
B) 0.14 mol
C) 7.3 mol
D) 0.28 mol
E) 0.00028 mol

ANS: E PTS: 1 DIF: Easy REF: 4.3
KEY: Chemistry | general chemistry | chemical reactions | working with solutions | concentration MSC: Quantitative

27. You have two solutions of sodium chloride. One is a 2.00 *M* solution, the other is a 4.00 *M* solution. You have much more of the 4.00 *M* solution and you add the solutions together. Which of the following could be the concentration of the final solution?
A) 2.70 *M*
B) 3.00 *M*
C) 3.50 *M*
D) 6.00 *M*
E) 8.10 *M*

ANS: C PTS: 1 DIF: Easy REF: 4.3
KEY: Chemistry | general chemistry | chemical reactions | working with solutions | concentration MSC: Conceptual

28. You have equal masses of different solutes dissolved in equal volumes of solution. Which of the solutes would make the solution having the highest molar concentration?
A) NaOH
B) KCl
C) KOH
D) LiOH
E) all the same

ANS: D PTS: 1 DIF: Moderate REF: 4.3
KEY: Chemistry | general chemistry | chemical reactions | working with solutions | concentration MSC: Conceptual

29. Which of the following do you need to know to be able to calculate the molarity of a salt solution?
I. the mass of salt added
II. the molar mass of the salt
III. the volume of water added
IV. the total volume of the solution
A) I, III
B) I, II, III

C) II, III
D) I, II, IV
E) You need all of the information.

ANS: D PTS: 1 DIF: Easy REF: 4.3
KEY: Chemistry | general chemistry | chemical reactions | working with solutions | concentration MSC: Conceptual

30. A 230.0-mL sample of a 0.275 *M* solution is left on a hot plate overnight; the following morning the solution is 1.29 *M*. What volume of solvent has evaporated from the 0.275 *M* solution?
A) 49.0 mL
B) 63.3 mL
C) 181.0 mL
D) 230. mL
E) 279.0 mL

ANS: C PTS: 1 DIF: Moderate REF: 4.3
KEY: Chemistry | general chemistry | chemical reactions | working with solutions | diluting solutions MSC: Quantitative

31. For the reaction $4FeCl_2(aq) + 3O_2(g) \rightarrow 2Fe_2O_3(s) + 4Cl_2(g)$, what volume of a 0.760 *M* solution of $FeCl_2$ is required to react completely with 6.36×10^{21} molecules of O_2?
A) 5.26×10^3 mL
B) 10.7 mL
C) 10.4 mL
D) 18.5 mL
E) 6.02 mL

ANS: D PTS: 1 DIF: Difficult REF: 4.3
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | amounts of substances MSC: Quantitative

32. Phosphoric acid, H_3PO_4, is a triprotic acid. What is the total number of moles of H^+ available for reaction in 2.50 L of 0.700 *M* H_3PO_4?
A) 0.233 mole
B) 2.10 mole
C) 0.583 mole
D) 3.00 moles
E) 5.25 moles

ANS: E PTS: 1 DIF: Easy REF: 4.3
KEY: Chemistry | general chemistry | chemical reactions | working with solutions | concentration MSC: Quantitative

33. The following reactions:

$$Pb^{2+} + 2I^- \rightarrow PbI_2$$
$$2Ce^{4+} + 2I^- \rightarrow I_2 + 2Ce^{3+}$$
$$HOAc + NH_3 \rightarrow NH_4^+ + OAc^-$$

are examples of

A) acid-base reactions
B) unbalanced reactions
C) precipitation, acid-base, and redox reactions, respectively
D) redox, acid-base, and precipitation reactions, respectively
E) precipitation, redox, and acid-base reactions, respectively

ANS: E PTS: 1 DIF: Easy REF: 4.4
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions
MSC: Conceptual

34. The following reactions

$$2K(s) + Br_2(l) \rightarrow 2KBr(s)$$
$$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$
$$HCl(aq) + KOH(aq) \rightarrow H_2O(l) + KCl(aq)$$

are examples of
A) precipitation reactions
B) redox, precipitation, and acid-base, respectively
C) precipitation (two) and acid-base reactions, respectively
D) redox reactions
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 4.4
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions
MSC: Conceptual

35. The following reactions

$$ZnBr_2(aq) + 2AgNO_3(aq) \rightarrow Zn(NO_3)_2(aq) + 2AgBr(s)$$
$$KBr(aq) + AgNO_3(aq) \rightarrow AgBr(s) + KNO_3(aq)$$

are examples of
A) oxidation-reduction reactions
B) acid-base reactions
C) precipitation reactions
D) A and C
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 4.4
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions
MSC: Conceptual

36. All of the following reactions

$$2Al(s) + 3Br_2(l) \rightarrow 2AlBr_3(s)$$
$$2Ag_2O(s) \rightarrow 4Ag(s) + O_2(g)$$
$$CH_4(l) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

can be classified as
A) oxidation-reduction reactions
B) combustion reactions
C) precipitation reactions
D) A and B
E) A and C

ANS: A PTS: 1 DIF: Easy REF: 4.4
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction MSC: Conceptual

37. You have exposed electrodes of a light bulb in a solution of H_2SO_4 such that the light bulb is on. You add a dilute solution and the bulb grows dim. Which of the following could be in the solution?
A) $Ba(OH)_2$
B) $NaNO_3$
C) K_2SO_4
D) $Cu(NO_3)_2$
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 4.5
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | solubility rules MSC: Conceptual

38. Aqueous solutions of sodium sulfide and copper(II) chloride are mixed together. Which statement is correct?
A) Both NaCl and CuS precipitate from solution.
B) No reaction will occur.
C) CuS will precipitate from solution.
D) NaCl will precipitate from solution.
E) A gas is released.

ANS: C PTS: 1 DIF: Easy REF: 4.5
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | solubility rules MSC: Conceptual

39. Aqueous solutions of potassium sulfate and ammonium nitrate are mixed together. Which statement is correct?
A) Both KNO_3 and NH_4SO_4 precipitate from solution.
B) A gas is released.
C) NH_4SO_4 will precipitate from solution.
D) KNO_3 will precipitate from solution.
E) No reaction will occur.

ANS: E PTS: 1 DIF: Easy REF: 4.5
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | solubility rules MSC: Conceptual

40. Which of the following salts is insoluble in water?
A) Na_2S
B) K_2CO_3
C) $Pb(NO_3)_2$
D) $CaCl_2$
E) All of these are soluble in water.

ANS: E PTS: 1 DIF: Easy REF: 4.5
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | solubility rules MSC: Conceptual

41. How many of the following salts are expected to be insoluble in water?
sodium sulfide barium nitrate
ammonium sulfate potassium phosphate

A) none
B) 1
C) 2
D) 3
E) 4

ANS: A PTS: 1 DIF: Easy REF: 4.5
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | solubility rules MSC: Conceptual

42. When $NH_3(aq)$ is added to $Cu^{2+}(aq)$, a precipitate initially forms. Its formula is:
A) $Cu(NH)_3$
B) $Cu(NO_3)_2$
C) $Cu(OH)_2$
D) $Cu(NH_3)_2{}^{2+}$
E) CuO

ANS: C PTS: 1 DIF: Moderate REF: 4.5
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | solubility rules MSC: Conceptual

43. Which of the following ions is most likely to form an insoluble sulfate?
A) K^+
B) Li^+
C) Ca^{2+}
D) S^{2-}
E) Cl^-

ANS: C PTS: 1 DIF: Easy REF: 4.5
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | solubility rules MSC: Conceptual

44. Which of the following compounds is soluble in water?
A) $Ni(OH)_2$
B) K_3PO_4
C) $BaSO_4$
D) $CoCO_3$
E) $PbCl_2$

ANS: B PTS: 1 DIF: Easy REF: 4.5
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | solubility rules MSC: Conceptual

45. Which pair of ions would *not* be expected to form a precipitate when dilute solutions of each are mixed?
A) Al^{3+}, S^{2-}

B) Pb^{2+}, Cl^{-}
C) Ba^{2+}, PO_4^{3-}
D) Pb^{2+}, OH^{-}
E) Mg^{2+}, SO_4^{2-}

ANS: E PTS: 1 DIF: Easy REF: 4.5
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | solubility rules MSC: Conceptual

46. A solution contains the ions Ag^{+}, Pb^{2+}, and Ni^{2+}. Dilute solutions of NaCl, Na_2SO_4, and Na_2S are available to separate the positive ions from each other. In order to effect separation, the solutions should be added in which order?
A) Na_2SO_4, NaCl, Na_2S
B) Na_2SO_4, Na_2S, NaCl
C) Na_2S, NaCl, Na_2SO_4
D) NaCl, Na_2S, Na_2SO_4
E) NaCl, Na_2SO_4, Na_2S

ANS: A PTS: 1 DIF: Difficult REF: 4.5
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | precipitation reaction | selective precipitation MSC: Conceptual

47. Consider an aqueous solution of calcium nitrate added to an aqueous solution of sodium phosphate. What is the formula of the solid formed in the reaction?
A) $Ca(PO_4)_2$
B) $CaPO_4$
C) $Ca_3(PO_4)_2$
D) $Ca_3(PO_3)_2$
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 4.5
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | precipitation reaction MSC: Conceptual

48. The filtrate is the solid formed when two solutions are mixed.

ANS: F PTS: 1 DIF: Easy REF: 4.5
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | precipitation reaction MSC: Conceptual

Aqueous solutions of barium chloride and silver nitrate are mixed to form solid silver chloride and aqueous barium nitrate.

49. The balanced molecular equation contains which one of the following terms?
A) AgCl (*s*)
B) 2AgCl (*s*)
C) $2Ba(NO_3)_2$ (*aq*)
D) $BaNO_3$ (*aq*)
E) 3AgCl (*aq*)

ANS: B PTS: 1 DIF: Easy REF: 4.6

KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | molecular equation MSC: Conceptual

50. The balanced complete ionic equation contains which of the following terms?
A) $2Ba^{2+}(aq)$
B) $Cl^{-}(aq)$
C) $2Ag^{+}(aq)$
D) $NO_3^{-}(aq)$
E) $AgCl(aq)$

ANS: C PTS: 1 DIF: Easy REF: 4.6
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | ionic equation MSC: Conceptual

51. The net ionic equation contains which of the following terms?
A) $Ag^{+}(aq)$
B) $Ba^{2+}(aq)$
C) $NO_3^{-}(aq)$
D) $H^{+}(aq)$
E) $AgCl(aq)$

ANS: A PTS: 1 DIF: Easy REF: 4.6
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | ionic equation MSC: Conceptual

52. In writing the complete ionic equation for the reaction (if any) that occurs when aqueous solutions of KOH and $Mg(NO_3)_2$ are mixed, which of the following would *not* be written as ionic species?
A) KOH
B) $Mg(NO_3)_2$
C) $Mg(OH)_2$
D) KNO_3
E) All of the above would be written as ionic species.

ANS: C PTS: 1 DIF: Easy REF: 4.6
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | precipitation reaction MSC: Conceptual

53. The net ionic equation for the reaction of calcium bromide and sodium phosphate contains which of the following species?
A) $2Br^{-}(aq)$
B) $PO_4^{3-}(aq)$
C) $2Ca_3(PO_4)_2(s)$
D) $6NaBr(aq)$
E) $3Ca^{2+}(aq)$

ANS: E PTS: 1 DIF: Moderate REF: 4.6
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | ionic equation | net ionic equation MSC: Conceptual

54. When sodium chloride and lead(II) nitrate react in an aqueous solution, which of the following terms will be present in the balanced molecular equation?
A) $PbCl(s)$
B) $Pb_2Cl(s)$
C) $NaNO_3(aq)$
D) $2NaNO_3(aq)$
E) $2PbCl_2(s)$

ANS: D PTS: 1 DIF: Easy REF: 4.6
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | molecular equation MSC: Conceptual

55. Consider an aqueous solution of calcium nitrate added to an aqueous solution of sodium phosphate. Write and balance the equation for this reaction to answer the following question.What is the sum of the coefficients when the molecular equation is balanced in standard form?
A) 4
B) 5
C) 7
D) 11
E) 12

ANS: E PTS: 1 DIF: Moderate REF: 4.6
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | molecular equation MSC: Conceptual

56. When solutions of phosphoric acid and iron(III) nitrate react, which of the following terms will be present in the balanced molecular equation?
A) $HNO_3(aq)$
B) $3HNO_3(aq)$
C) $2FePO_4(s)$
D) $3FePO_4(s)$
E) $2HNO_3(aq)$

ANS: B PTS: 1 DIF: Easy REF: 4.6
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | solubility rules MSC: Conceptual

57. When solutions of cobalt(II) chloride and carbonic acid react, which of the following terms will be present in the net ionic equation?
A) $CoCO_3(s)$
B) $H^+(aq)$
C) $2CoCO_3(s)$
D) $2Cl^-(aq)$
E) two of these

ANS: A PTS: 1 DIF: Moderate REF: 4.6
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | ionic equation | net ionic equation MSC: Conceptual

58. When solutions of strontium chloride and sodium sulfate react, which of the following is a spectator ion?
A) strontium ion
B) chloride ion
C) sodium ion
D) sulfate ion
E) two of these

ANS: E PTS: 1 DIF: Moderate REF: 4.6
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | ionic equation | net ionic equation MSC: Conceptual

59. The net ionic equation for the reaction of aluminum sulfate and sodium hydroxide contains which of the following species?
A) $3Al^{3+}(aq)$
B) $OH^{-}(aq)$
C) $3OH^{-}(aq)$
D) $2Al^{3+}(aq)$
E) $2Al(OH)_3(s)$

ANS: C PTS: 1 DIF: Moderate REF: 4.6
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | ionic equation | net ionic equation MSC: Conceptual

60. Consider the reaction between 15.0 mL of a 1.00 *M* aqueous solution of $AgNO_3$ and 10.0 mL of a 1.00 *M* aqueous solution of K_2CrO_4. When these react, a precipitate is observed. What is present in solution **after** the reaction is complete? Note: the solid is not considered to be in solution.
A) Ag^+, NO_3^-, K^+, CrO_4^{2-}, water
B) Ag^+, NO_3^-, K^+, water
C) K^+, CrO_4^{2-}, water
D) NO_3^-, K^+, CrO_4^{2-}, water
E) water

ANS: D PTS: 1 DIF: Moderate REF: 4.7
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | precipitation reaction MSC: Quantitative

61. You mix 275.0 mL of 1.20 *M* lead(II) nitrate with 300.0 mL of 1.85 *M* potassium iodide. The lead(II) iodide is insoluble. Which of the following is false?
A) The final concentration of Pb^{2+} ions is 0.0913 *M*.
B) You form 128 g of lead(II) iodide.
C) The final concentration of K^+ is 0.965 *M*.
D) The final concentration of NO_3^- is 0.965 *M*.
E) All are true.

ANS: D PTS: 1 DIF: Moderate REF: 4.7
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Quantitative

62. If all of the chloride in a 3.734-g sample of an unknown metal chloride is precipitated as AgCl with 70.90 mL of 0.2010 *M* $AgNO_3$, what is the percentage of chloride in the sample?
A) 50.52%
B) 13.53%
C) 1.425%
D) 7.391%
E) none of the above

ANS: B PTS: 1 DIF: Moderate REF: 4.7
KEY: Chemistry | general chemistry | chemical reactions | quantitative analysis | gravimetric analysis MSC: Quantitative

63. A mixture of $BaCl_2$ and NaCl is analyzed by precipitating all the barium as $BaSO_4$. After addition of an excess of Na_2SO_4 to a 3.725-g sample of the mixture, the mass of precipitate collected is 2.734 g. What is the mass percentage of barium chloride in the mixture?
A) 82.28%
B) 73.40%
C) 43.18%
D) 65.47%
E) 19.60%

ANS: D PTS: 1 DIF: Moderate REF: 4.7
KEY: Chemistry | general chemistry | chemical reactions | quantitative analysis | gravimetric analysis MSC: Quantitative

64. A 3.00-g sample of an alloy (containing only Pb and Sn) was dissolved in nitric acid (HNO_3). Sulfuric acid was added to this solution, which precipitated 2.37 g of $PbSO_4$. Assuming that all of the lead was precipitated, what is the percentage of Sn in the sample? (molar mass of $PbSO_4$ = 303.3 g/mol)
A) 46.0% Sn
B) 0.781% Sn
C) 79.0% Sn
D) 54.0% Sn
E) 1.62% Sn

ANS: A PTS: 1 DIF: Moderate REF: 4.7
KEY: Chemistry | general chemistry | chemical reactions | quantitative analysis | gravimetric analysis MSC: Quantitative

65. A mixture contained no fluorine compound except methyl fluoroacetate, FCH_2COOCH_3 (molar mass = 92.07 g/mol). When chemically treated, all the fluorine was converted to CaF_2 (molar mass = 78.08 g/mol). The mass of CaF_2 obtained was 35.8 g. Find the mass of methyl fluoroacetate in the original mixture.
A) 60.7 g
B) 84.4 g
C) 30.4 g
D) 42.2 g
E) 21.1 g

ANS: B PTS: 1 DIF: Moderate REF: 4.7
KEY: Chemistry | general chemistry | chemical reactions | quantitative analysis |

gravimetric analysis MSC: Quantitative

66. A 1.59-g sample of a metal chloride, MCl_2, is dissolved in water and treated with excess aqueous silver nitrate. The silver chloride that formed weighed 3.60 g. Calculate the molar mass of M.
A) 70.9 g/mol
B) 28 g/mol
C) 55.9 g/mol
D) 63 g/mol
E) 72.4 g/mol

ANS: C PTS: 1 DIF: Difficult REF: 4.7
KEY: Chemistry | general chemistry | chemical reactions | quantitative analysis | gravimetric analysis MSC: Quantitative

67. You have 88.6 mL of a 2.50 *M* solution of $Na_2CrO_4(aq)$. You also have 125 mL of a 2.50 *M* solution of $AgNO_3(aq)$. Calculate the concentration of Na^+ after the two solutions are mixed together.
A) 0.00 *M*
B) 1.04 *M*
C) 2.07 *M*
D) 5.00 *M*
E) 0.443 *M*

ANS: C PTS: 1 DIF: Easy REF: 4.7
KEY: Chemistry | general chemistry | chemical reactions | working with solutions | diluting solutions MSC: Quantitative

68. You have 75.0 mL of a 2.50 *M* solution of $Na_2CrO_4(aq)$. You also have 125 mL of a 2.01 *M* solution of $AgNO_3(aq)$. Calculate the concentration of CrO_4^{2-} after the two solutions are mixed together.
A) 0.00 *M*
B) 0.309 *M*
C) 0.938 *M*
D) 0.251 *M*
E) 2.50 *M*

ANS: B PTS: 1 DIF: Moderate REF: 4.7
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Quantitative

69. You have 75.0 mL of a 2.50 *M* solution of $Na_2CrO_4(aq)$. You also have 125 mL of a 1.72 *M* solution of $AgNO_3(aq)$. Calculate the concentration of Ag^+ after the two solutions are mixed together.
A) 0.00 *M*
B) 0.538 *M*
C) 1.08 *M*
D) 0.088 *M*
E) 0.215 *M*

ANS: A PTS: 1 DIF: Moderate REF: 4.7

KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Quantitative

70. You have 75.0 mL of a 2.50 *M* solution of $Na_2CrO_4(aq)$. You also have 125 mL of a 1.88 *M* solution of $AgNO_3(aq)$. Calculate the concentration of NO_3^- after the two solutions are mixed together.
A) 0.00 *M*
B) 0.588 *M*
C) 1.18 *M*
D) 2.35 *M*
E) 4.50 *M*

ANS: C PTS: 1 DIF: Easy REF: 4.7
KEY: Chemistry | general chemistry | chemical reactions | working with solutions | diluting solutions MSC: Quantitative

71. You mix 55 mL of 1.00 *M* silver nitrate with 25 mL of 0.84 *M* sodium chloride. What mass of silver chloride should you form?
A) 3.0 g
B) 6.0 g
C) 3.3 g
D) 6.6
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 4.7
KEY: Chemistry | general chemistry | stoichiometry | stoichiometry calculation | limiting reactant MSC: Quantitative

72. When solutions of carbonic acid and potassium hydroxide react, which of the following are NOT present in the *complete ionic equation*?
A) hydrogen ion
B) carbonate ion
C) potassium ion
D) hydroxide ion
E) water

ANS: A PTS: 1 DIF: Moderate REF: 4.8
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | ionic equation | complete ionic equation MSC: Conceptual

73. When solutions of acetic acid and sodium hydroxide react, which of the following are NOT present in the *net ionic equation*?
I. hydrogen ion
II. acetate ion
III. sodium ion
IV. hydroxide ion

A) I and II
B) I, II, and III
C) I and IV

D) I and III
E) II and III

ANS: D PTS: 1 DIF: Moderate REF: 4.8
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | ionic equation | net ionic equation MSC: Conceptual

74. When solutions of carbonic acid and aluminum hydroxide react, which of the following are NOT present in the *net ionic equation*?
I. hydrogen ion
II. carbonate ion
III. aluminum ion
IV. hydroxide ion

A) I and II
B) I, II, and III
C) I and IV
D) I and III
E) II and III

ANS: C PTS: 1 DIF: Moderate REF: 4.8
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | ionic equation | net ionic equation MSC: Conceptual

75. When solutions of carbonic acid and copper(II) hydroxide react, which of the following are spectator ions?
A) hydrogen ion
B) carbonate ion
C) copper(II) ion
D) hydroxide ion
E) none of these

ANS: E PTS: 1 DIF: Moderate REF: 4.8
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | ionic equation | net ionic equation MSC: Conceptual

76. In the balanced molecular equation for the neutralization of sodium hydroxide with sulfuric acid, the products are:
A) $NaSO_4 + H_2O$
B) $NaSO_3 + 2H_2O$
C) $2NaSO_4 + H_2O$
D) $Na_2S + 2H_2O$
E) $Na_2SO_4 + 2H_2O$

ANS: E PTS: 1 DIF: Easy REF: 4.8
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | acid-base reaction | neutralization reaction MSC: Conceptual

77. A 0.307-g sample of an unknown triprotic acid is titrated to the third equivalence point using 35.2 mL of 0.106 *M* NaOH. Calculate the molar mass of the acid.
A) 247 g/mol

B) 171 g/mol
C) 165 g/mol
D) 151 g/mol
E) 82.7 g/mol

ANS: A PTS: 1 DIF: Difficult REF: 4.8
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | acid-base reaction | neutralization reaction MSC: Quantitative

78. An unknown diprotic acid requires 44.39 mL of 0.111 *M* NaOH to completely neutralize a 0.580-g sample. Calculate the approximate molar mass of the acid.
A) 406 g/mol
B) 235 g/mol
C) 118 g/mol
D) 59 g/mol
E) 203 g/mol

ANS: B PTS: 1 DIF: Difficult REF: 4.8
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | acid-base reaction | neutralization reaction MSC: Quantitative

79. You have separate solutions of HCl and H_2SO_4 with the same concentrations in terms of molarity. You wish to neutralize a solution of NaOH. Which acid solution would require more volume (in mL) to neutralize the base?
A) The HCl solution.
B) The H_2SO_4 solution.
C) You need to know the acid concentrations to answer this question.
D) You need to know the volume and concentration of the NaOH solution to answer this question.
E) C and D

ANS: A PTS: 1 DIF: Easy REF: 4.8
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | acid-base reaction | neutralization reaction MSC: Conceptual

80. What mass of NaOH is required to react exactly with 25.0 mL of 2.7 *M* H_2SO_4?
A) 2.7 g
B) 0.7 g
C) 5.4 g
D) 135 g
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 4.8
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | acid-base reaction | neutralization reaction MSC: Quantitative

81. With what volume of 5.00 *M* HF will 4.72 g of calcium hydroxide react completely, according to the following reaction?

$$2HF + Ca(OH)_2 \rightarrow CaF_2 + 2H_2O$$

A) 12.7 mL

B) 127 mL
C) 637 mL
D) 25.5 mL
E) 39.2 mL

ANS: D PTS: 1 DIF: Easy REF: 4.8
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | acid-base reaction | neutralization reaction MSC: Quantitative

82. Sulfamic acid, HSO_3NH_2 (molar mass = 97.1 g/mol), is a strong monoprotic acid that can be used to standardize a strong base:

$$HSO_3NH_2(aq) + KOH(aq) \rightarrow KSO_2NH_2(aq) + H_2O(l)$$

A 0.165-g sample of HSO_3NH_2 required 19.4 mL of an aqueous solution of KOH for a complete reaction. What is the molarity of the KOH solution?
A) 0.00170 *M*
B) 8.76 *M*
C) 0.0876 *M*
D) 0.0330 *M*
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 4.8
KEY: Chemistry | general chemistry | chemical reactions | quantitative analysis | volumetric analysis MSC: Quantitative

83. A student weighs out 0.512 g of KHP (molar mass = 204.22 g/mol) and titrates to the equivalence point with 36.78 mL of a stock NaOH solution. What is the concentration of the stock NaOH solution? KHP is an acid with one acidic proton.
A) 0.00251 *M*
B) 0.092 *M*
C) 0.0139 *M*
D) 0.0682 *M*
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 4.8
KEY: Chemistry | general chemistry | chemical reactions | quantitative analysis | volumetric analysis MSC: Quantitative

84. A chemical that changes color at the endpoint of a reaction is called a colorimeter.

ANS: F PTS: 1 DIF: Easy REF: 4.8
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | acid-base reaction | neutralization reaction MSC: Conceptual

85. In which of the following does nitrogen have an oxidation state of +4?
A) HNO_3
B) NO_2
C) N_2O
D) NH_4Cl
E) $NaNO_2$

ANS: B PTS: 1 DIF: Easy REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction | assigning oxidation number MSC: Conceptual

86. The oxidation state of iodine in IO_3^- is:
A) 0
B) +3
C) –3
D) +5
E) –5

ANS: D PTS: 1 DIF: Easy REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction | assigning oxidation number MSC: Conceptual

87. The oxidation state of chlorine in ClO^- is:
A) 0
B) +1
C) -1
D) +3
E) -3

ANS: B PTS: 1 DIF: Easy REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction | assigning oxidation number MSC: Conceptual

88. Which of the following statements is *not* true?
A) When a metal reacts with a nonmetal, an ionic compound is formed.
B) A metal-nonmetal reaction can always be assumed to be an oxidation-reduction reaction.
C) Two nonmetals can undergo an oxidation-reduction reaction.
D) When two nonmetals react, the compound formed is ionic.
E) A metal-nonmetal reaction involves electron transfer.

ANS: D PTS: 1 DIF: Easy REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction MSC: Conceptual

89. In the reaction $2Ca(s) + O_2(g) \rightarrow 2CaO(s)$, which species is oxidized?
A) O_2
B) O^{2-}
C) Ca
D) Ca^{2+}
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction MSC: Conceptual

90. In the reaction $2Cs(s) + Cl_2(g) \rightarrow 2CsCl(s)$, Cl_2 is
A) the reducing agent

B) the oxidizing agent
C) oxidized
D) the electron donor
E) two of these

ANS: B PTS: 1 DIF: Easy REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction MSC: Conceptual

91. In the reaction $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$, N_2 is
A) oxidized
B) reduced
C) the electron donor
D) the reducing agent
E) two of these

ANS: B PTS: 1 DIF: Easy REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction MSC: Conceptual

92. In the reaction $P_4(s) + 10Cl_2(g) \rightarrow 4PCl_5(s)$, the reducing agent is
A) chlorine
B) PCl_5
C) phosphorus
D) Cl^-
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction MSC: Conceptual

93. In the reaction $C(s) + O_2(g) \rightarrow CO_2(g)$ carbon is _____.
A) the reducing agent
B) the electron acceptor
C) reduced
D) the oxidizing agent
E) more than one of these

ANS: A PTS: 1 DIF: Easy REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction MSC: Conceptual

94. Which of the following reactions does *not* involve oxidation-reduction?
A) $CH_4 + 3O_2 \rightarrow 2H_2O + CO_2$
B) $Zn + 2HCl \rightarrow ZnCl_2 + H_2$
C) $2Na + 2H_2O \rightarrow 2NaOH + H_2$
D) $MnO_2 + 4HCl \rightarrow Cl_2 + 2H_2O + MnCl_2$
E) All are oxidation-reduction reactions.

ANS: E PTS: 1 DIF: Easy REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions |

oxidation-reduction reaction MSC: Conceptual

95. Which of the following are oxidation-reduction reactions?
I. $PCl_3 + Cl_2 \rightarrow PCl_5$
II. $Cu + 2AgNO_3 \rightarrow Cu(NO_3)_2 + 2Ag$
III. $CO_2 + 2LiOH \rightarrow Li_2CO_3 + H_2O$
IV. $FeCl_2 + 2NaOH \rightarrow Fe(OH)_2 + 2NaCl$

A) III
B) IV
C) I and II
D) I, II, and III
E) I, II, III, and IV

ANS: C PTS: 1 DIF: Easy REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction MSC: Conceptual

96. Which of the following statements is(are) *true*? Oxidation and reduction
A) cannot occur independently of each other
B) accompany all chemical changes
C) describe the loss and gain of electron(s), respectively
D) result in a change in the oxidation states of the species involved
E) A, C, and D

ANS: E PTS: 1 DIF: Easy REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction MSC: Conceptual

97. In the reaction $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$, which, if any, element is oxidized?
A) zinc
B) hydrogen
C) sulfur
D) oxygen
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction MSC: Conceptual

98. In the following reaction, which species is oxidized?
$$8NaI + 5H_2SO_4 \rightarrow 4I_2 + H_2S + 4Na_2SO_4 + 4H_2O$$
A) sodium
B) iodine
C) sulfur
D) hydrogen
E) oxygen

ANS: B PTS: 1 DIF: Easy REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions |

oxidation-reduction reaction MSC: Conceptual

99. How many of the following are oxidation-reduction reactions?

$NaOH + HCl \rightarrow NaCl + H_2O$
$Cu + 2AgNO_3 \rightarrow 2Ag + Cu(NO_3)_2$
$Mg(OH)_2 \rightarrow MgO + H_2O$
$N_2 + 3H_2 \rightarrow 2NH_3$

A) 0
B) 1
C) 2
D) 3
E) 4

ANS: C PTS: 1 DIF: Easy REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction MSC: Conceptual

100. In the reaction shown below, what species is oxidized?

$2NaI + Br_2 \rightarrow 2NaBr + I_2$

A) Na^+
B) I^-
C) Br_2
D) Br^-
E) I_2

ANS: B PTS: 1 DIF: Easy REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction MSC: Conceptual

101. Oxidation is the gain of electrons.

ANS: F PTS: 1 DIF: Easy REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction MSC: Conceptual

102. A reducing agent is an electron donor.

ANS: T PTS: 1 DIF: Easy REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction MSC: Conceptual

103. Balance the following oxidation-reduction reaction using the oxidation number method:

$Fe^{3+} + I^- \rightarrow Fe^{2+} + I_2$

In the balanced equation, the coefficient of Fe^{2+} is

A) 1
B) 2
C) 3
D) 4
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 4.1
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | balancing oxidation-reduction equations | oxidation number method
MSC: Conceptual

104. Balance the following oxidation-reduction reaction using the oxidation number method:

$$Fe + Br_2 \rightarrow Fe^{3+} + Br^-$$

In the balanced equation, the coefficient of Br^- is
A) 2
B) 3
C) 4
D) 6
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 4.1
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | balancing oxidation-reduction equations | oxidation number method
MSC: Conceptual

105. Consider the following unbalanced oxidation-reduction reaction:

$$Fe^{2+} + Br_2 \rightarrow Fe^{3+} + Br^-$$

In the balanced equation, the number of electrons transferred is
A) 1
B) 3
C) 2
D) 4
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 4.1
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | balancing oxidation-reduction equations | oxidation number method
MSC: Conceptual

106. The MnO_4^- is often used to analyze for the Fe^{2+} content of an aqueous solution via the reaction
$MnO_4^-(aq) + Fe^{2+}(aq) + H^+(aq) \rightarrow Fe^{3+}(aq) + Mn^{2+}(aq) + H_2O(l)$
What is the ratio of Fe^{2+} : MnO_4^- in the balanced equation?
A) 1 : 1
B) 2 : 1
C) 3 : 1
D) 4 : 1
E) 5 : 1

ANS: E PTS: 1 DIF: Moderate REF: 4.1
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | balancing oxidation-reduction equations | oxidation number method
MSC: Conceptual

107. Given the reaction:

$$2MnO_4^- + 5H_2O_2 + 6H^+ \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$$

determine the number of electrons involved in this reaction.

A) 10
B) 8
C) 6
D) 4
E) 2

ANS: A PTS: 1 DIF: Easy REF: 4.1
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction MSC: Quantitative

108. A molecule with an unequal charge distribution is said to be a _____ molecule.

ANS:
polar

PTS: 1 DIF: Easy REF: 4.1
KEY: Chemistry | general chemistry | solutions | solution formation
MSC: Conceptual

109. Soluble ionic compounds containing the hydroxide ion are called strong _____.

ANS:
bases

PTS: 1 DIF: Easy REF: 4.2
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | acid-base reaction | base definition MSC: Conceptual

110. A _____ is a substance dissolved in a liquid to make a solution.

ANS:
solute

PTS: 1 DIF: Easy REF: 4.2
KEY: Chemistry | general chemistry | solutions | solution formation | types of solutions
MSC: Conceptual

111. A _____ electrolyte dissociates to a great extent in an aqueous solution.

ANS:
strong

PTS: 1 DIF: Easy REF: 4.2
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | electrolyte | strong electrolyte MSC: Conceptual

112. Molarity is defined as _____ of solute per volume of solution in _____.

ANS:
moles, liters

PTS: 1 DIF: Easy REF: 4.3
KEY: Chemistry | general chemistry | chemical reactions | working with solutions | concentration MSC: Conceptual

Selecting from the following reagents, indicate which reagents would be mixed to give the compounds described.

$CuSO_4(aq)$	$Fe_2(CO_3)_3(s)$	$NH_3(aq)$
$CuCO_3(s)$	$FeCl_3(aq)$	$Na_2SO_4(aq)$
$Cr(OH)_3(s)$	$H_2SO_4(aq)$	

113. $Cu(OH)_2(s)$

ANS:
$CuSO_4(aq)$ and $NH_3(aq)$

PTS: 1 DIF: Moderate REF: 4.6
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | precipitation reaction MSC: Conceptual

114. $FeCl_3(aq) + Na_2SO_4(aq)$

ANS:
$FeCl_3(aq) + Na_2SO_4(aq)$

PTS: 1 DIF: Easy REF: 4.6
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | precipitation reaction MSC: Conceptual

Write balanced equations for each of the processes, choosing from the following substances as reactants:

$BaCl_2$	O_2	H_2SO_4	HNO_3
C_2H_5OH	H_2O	$Ca(OH)_2$	K
Na_2CrO_4	KOH	$Pb(NO_3)_2$	

115. Precipitation of $BaSO_4$ from solution

ANS:
$H_2SO_4 + BaCl_2 \rightarrow BaSO_4 + 2HCl$

PTS: 1 DIF: Moderate REF: 4.6
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | precipitation reaction MSC: Conceptual

116. Neutralization of sulfuric acid

ANS:
$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$ or
$H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 + 2H_2O$

PTS: 1 DIF: Moderate REF: 4.8
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | acid-base reaction MSC: Conceptual

117. Combustion reaction

ANS:
$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

PTS: 1 DIF: Moderate REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction MSC: Conceptual

118. Dissolution of calcium hydroxide with another reagent

ANS:
$Ca(OH)_2 + 2HNO_3 \rightarrow Ca(NO_3)_2 + 2H_2O$

PTS: 1 DIF: Difficult REF: 4.8
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | acid-base reaction MSC: Conceptual

119. Formation of hydrogen gas

ANS:
$2K + H_2O \rightarrow 2KOH + H_2$

PTS: 1 DIF: Moderate REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction MSC: Conceptual

120. Balance the following equation: $C_3H_5(NO_3)_3 \rightarrow N_2 + CO_2 + H_2O + O_2$

ANS:
$4C_3H_5(NO_3)_3 \rightarrow 6N_2 + 12CO_2 + 10H_2O + O_2$

PTS: 1 DIF: Difficult REF: 4.1
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | balancing oxidation-reduction equations | oxidation number method
MSC: Conceptual

121. Balance the following equation: $KI + HNO_3 \rightarrow KNO_3 + NO + I_2 + H_2O$

ANS:

$6KI + 8HNO_3 \rightarrow 6KNO_3 + 2NO + 3I_2 + 4H_2O$

PTS: 1 DIF: Moderate REF: 4.1
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | balancing oxidation-reduction equations | oxidation number method
MSC: Conceptual

122. Select the spectator ions for the following reaction, $Pb(NO_3)_2 + 2\ KCl \rightarrow PbCl_2 + 2\ NaNO_3$
A) $K^+(aq)$, $NO_3^-(aq)$
B) $Pb^{2+}(aq)$, $NO_3^-(aq)$
C) $K^+(aq)$, $Cl^-(aq)$
D) $Pb^{2+}(aq)$, $Cl^-(aq)$, $K^+(aq)$, $NO_3^-(aq)$
E) $Pb^{2+}(aq)$, $Cl^-(aq)$

ANS: A PTS: 1 DIF: Easy REF: 4.6
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | ionic equation | net ionic equation MSC: Conceptual

123. Select the spectator ions for the following reaction in aqueous solution, $AgNO_3 + LiI \rightarrow AgI + LiNO_3$
A) $Li^+(aq)$, $NO_3^-(aq)$
B) $Ag^+(aq)$, $NO_3^-(aq)$
C) $Li^+(aq)$, $I^-(aq)$
D) $Ag^+(aq)$, $I^-(aq)$, $Li^+(aq)$, $NO_3^-(aq)$
E) $Ag^+(aq)$, $I^-(aq)$

ANS: A PTS: 1 DIF: Easy REF: 4.6
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | ionic equation | net ionic equation MSC: Conceptual

124. Complete the following reaction in aqueous solution and select the spectator ions, $Fe(NO_3)_2 + (NH_4)_2CO_3 \rightarrow$
A) $Fe^{2+}(aq)$, $NO_3^-(aq)$
B) $NH_4^+(aq)$, $NO_3^-(aq)$
C) $NH_4^+(aq)$, $CO_3^{2-}(aq)$
D) $Fe^{2+}(aq)$, $NH_4^+(aq)$, $NO_3^-(aq)$, $CO_3^{2-}(aq)$
E) $Fe^{2+}(aq)$, $CO_3^{2-}(aq)$

ANS: B PTS: 1 DIF: Easy REF: 4.6
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | ionic equation | net ionic equation MSC: Conceptual

125. Identify the precipitate(s) formed (if any) in the following reaction in aqueous solution, $Fe(NO_3)_2 + (NH_4)_2CO_3 \rightarrow$
A) $Fe_2(CO_3)_3$
B) $FeCO_3(s)$
C) $(NH_4)_2CO_3(s)$
D) $NH_4NO_3(s)$
E) No precipitate will be observed

ANS: B PTS: 1 DIF: Easy REF: 4.6
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | ionic equation | net ionic equation MSC: Conceptual

126. Which of the following ions forms the fewest insoluble salts?
A) Al^{3+}
B) Cl^{-}
C) NO_3^{-}
D) OH^{-}
E) Mg^{2+}

ANS: C PTS: 1 DIF: Easy REF: 4.5
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | solubility rules MSC: Conceptual

127. Which of the following ions forms the fewest insoluble salts?
A) Al^{3+}
B) Cl^{-}
C) NH_4^{+}
D) OH^{-}
E) Mg^{2+}

ANS: C PTS: 1 DIF: Easy REF: 4.5
KEY: Chemistry | general chemistry | chemical reactions | ions in aqueous solution | solubility rules MSC: Conceptual

128. In which of the following does nitrogen have the highest oxidation state?
A) HNO_3
B) NO_2
C) N_2O
D) NH_4Cl
E) $NaNO_2$

ANS: A PTS: 1 DIF: Easy REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction | assigning oxidation number MSC: Conceptual

129. In which of the following does nitrogen have the lowest oxidation state?
A) HNO_3
B) NO_2
C) N_2O
D) NH_4Cl
E) $NaNO_2$

ANS: D PTS: 1 DIF: Easy REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction | assigning oxidation number MSC: Conceptual

130. In which of the following does iodine have the lowest oxidation state?
A) $LiIO_3$
B) IO_2

C) I_2O
D) NH_4I
E) I_2

ANS: D PTS: 1 DIF: Easy REF: 4.9
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction | assigning oxidation number MSC: Conceptual

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Chapter 5: Gases

1. Gases generally have
   A) low density
   B) high density
   C) closely packed particles
   D) no increase in volume when temperature is increased
   E) no decrease in volume when pressure is increased

   ANS: A PTS: 1 DIF: Easy REF: 5.1
   KEY: Chemistry | general chemistry | phases | gas MSC: Conceptual

2. Pressure is
   A) defined as the mass that an object exerts when at rest
   B) measured in Newtons
   C) defined as the number of moles of substance divided by the mass of the substance
   D) defined as the force per unit area
   E) measured in grams

   ANS: D PTS: 1 DIF: Easy REF: 5.1
   KEY: Chemistry | general chemistry | phases | gas | gas pressure MSC: Conceptual

3. The SI unit of pressure is the
   A) ampere
   B) kilojoule
   C) newton
   D) gram
   E) pascal

   ANS: E PTS: 1 DIF: Easy REF: 5.1
   KEY: Chemistry | general chemistry | phases | gas | gas pressure MSC: Conceptual

4. Which of the following would represent the *greatest* pressure?
   A) 0.680 atm
   B) 517 mmHg
   C) 11.4 psi
   D) 62106 Pa
   E) 14.1 in Hg

   ANS: C PTS: 1 DIF: Moderate REF: 5.1
   KEY: Chemistry | general chemistry | phases | gas | gas pressure MSC: Quantitative

5. A glass column is filled with mercury and inverted in a pool of mercury. The mercury column stabilizes at a height of 729 mm above the pool of mercury. What is the pressure of the atmosphere?
   A) 1.04 atm
   B) 0.729 atm
   C) 0.959 atm
   D) 456 atm
   E) 0.639 atm

ANS: C PTS: 1 DIF: Easy REF: 5.1
KEY: Chemistry | general chemistry | phases | gas | gas pressure MSC: Quantitative

6. The local weather forecaster reports that the current barometric pressure is 30.4 inches of mercury. What is the current pressure in atmospheres?
   A) 1.02 atm
   B) 10.29 atm
   C) 1.00 atm
   D) 4.05 atm
   E) 910 atm

   ANS: A PTS: 1 DIF: Easy REF: 5.1
   KEY: Chemistry | general chemistry | phases | gas | gas pressure MSC: Quantitative

7. A physics experiment is conducted at a pressure of 14.4 kPa. What is this pressure in mmHg?
   A) 18.9 mmHg
   B) 1.92 mmHg
   C) 1.44×10^{4} mmHg
   D) 108 mmHg
   E) 1.89×10^{-2} mmHg

   ANS: D PTS: 1 DIF: Easy REF: 5.1
   KEY: Chemistry | general chemistry | phases | gas | gas pressure MSC: Quantitative

8. The air pressure in the inner tube of a tire on a typical racing bike is held at a pressure of about 112 psi. Convert this pressure to atm.
   A) 0.147 atm
   B) 7.62 atm
   C) 0.112 atm
   D) 0.131 atm
   E) 112 atm

   ANS: B PTS: 1 DIF: Easy REF: 5.1
   KEY: Chemistry | general chemistry | phases | gas | gas pressure MSC: Quantitative

9. Boyle's law states that:
   A) Equal amounts of gases occupy the same volume at constant temperature and pressure.
   B) The volume of a fixed amount of gas is inversely proportional to its pressure at constant temperature.
   C) The volume of a fixed amount of gas is directly proportional to its temperature in Kelvin at constant pressure.
   D) The total pressure of a mixture of gases is the simple sum of the partial pressure of all of the gaseous compounds.
   E) The rates of effusion of gases are inversely proportional to the square roots of their molar masses.

   ANS: B PTS: 1 DIF: Easy REF: 5.2
   KEY: Chemistry | general chemistry | phases | gas | empirical gas laws | Boyle's law

MSC: Conceptual

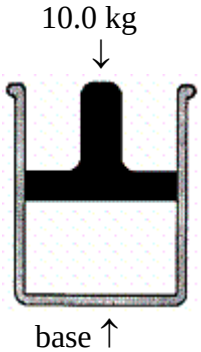
10. Avogadro's law states that:
    A) Equal amounts of gases occupy the same volume at constant temperature and pressure.
    B) The volume of a fixed amount of gas is inversely proportional to its pressure at constant temperature.
    C) The volume of a fixed amount of gas is directly proportional to its temperature in Kelvin at constant pressure.
    D) The total pressure of a mixture of gases is the simple sum of the partial pressure of all of the gaseous compounds.
    E) The rates of effusion of gases are inversely proportional to the square roots of their molar masses.

    ANS: A PTS: 1 DIF: Easy REF: 5.2
    KEY: Chemistry | general chemistry | phases | gas | empirical gas laws | Avogadro's law
    MSC: Conceptual

11. Charles's law states that:
    A) Equal amounts of gases occupy the same volume at constant temperature and pressure.
    B) The volume of a fixed amount of gas is inversely proportional to its pressure at constant temperature.
    C) The volume of a fixed amount of gas is directly proportional to its temperature in Kelvin at constant pressure.
    D) The total pressure of a mixture of gases is the simple sum of the partial pressure of all of the gaseous compounds.
    E) The rates of effusion of gases are inversely proportional to the square roots of their molar masses.

    ANS: C PTS: 1 DIF: Easy REF: 5.2
    KEY: Chemistry | general chemistry | phases | gas | empirical gas laws | Charles's law
    MSC: Conceptual

12. Consider a sample of helium gas in a container fitted with a piston, as pictured below. The piston is frictionless, but has a mass of 10.0 kg. How many of the following processes will cause the piston to move away from the base **and** decrease the pressure of the gas? Assume ideal behavior.



    I. heating the helium

II. removing some of the helium from the container
III. turning the container on its side
IV. decreasing the pressure outside the container

A) 0
B) 1
C) 2
D) 3
E) 4

ANS: B PTS: 1 DIF: Easy REF: 5.2
KEY: Chemistry | general chemistry | phases | gas | empirical gas laws
MSC: Conceptual

13. A gas sample is held at constant pressure. The gas occupies 3.62 L of volume when the temperature is 21.6°C. Determine the temperature at which the volume of the gas is 3.42 L.
A) 312 K
B) 278 K
C) 20.4 K
D) 295 K
E) 552 K

ANS: B PTS: 1 DIF: Easy REF: 5.2
KEY: Chemistry | general chemistry | phases | gas | empirical gas laws | Charles's law
MSC: Quantitative

14. You have 41.6 g of O_2 gas in a container with twice the volume as one with CO_2 gas. The pressure and temperature of both containers are the same. Calculate the mass of carbon dioxide gas you have in the container.
A) 57.2 g
B) 0.650 g
C) 28.6 g
D) 2.60 g
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 5.2
KEY: Chemistry | general chemistry | phases | gas | empirical gas laws | Avogadro's law
MSC: Quantitative

15. Gaseous chlorine is held in two separate containers at identical temperature and pressure. The volume of container 1 is 1.30 L, and it contains 6.70 mol of the gas. The volume of container 2 is 2.33 L. How many moles of the gas are in container 2?
A) 12.0 mol
B) 20.3 mol
C) 0.452 mol
D) 3.74 mol
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 5.2
KEY: Chemistry | general chemistry | phases | gas | empirical gas laws | Avogadro's law
MSC: Quantitative

16. A balloon has a volume of 2.32 liters at 24.0°C. The balloon is heated to 48.0°C. Calculate the new volume of the balloon.
    A) 2.32 L
    B) 2.51 L
    C) 2.15 L
    D) 4.64 L
    E) 1.16 L

    ANS: B PTS: 1 DIF: Easy REF: 5.2
    KEY: Chemistry | general chemistry | phases | gas | empirical gas laws | Charles's law
    MSC: Quantitative

17. Consider a sample of gas in a container on a comfortable spring day. The Celsius temperature suddenly doubles, and you transfer the gas to a container with twice the volume of the first container. If the original pressure was 12 atm, what is a good estimate for the new pressure?
    A) 3 atm
    B) 5.5 atm
    C) 6.4 atm
    D) 12 atm
    E) 15 atm

    ANS: C PTS: 1 DIF: Moderate REF: 5.3
    KEY: Chemistry | general chemistry | phases | gas | empirical gas laws | combined gas law
    MSC: Conceptual

18. Body temperature is about 309 K. On a cold day, what volume of air at 276 K must a person with a lung capacity of 2.2 L breathe in to fill the lungs?
    A) 2.46 L
    B) 1.97 L
    C) 2.08 L
    D) 3.93 L
    E) none of these

    ANS: B PTS: 1 DIF: Easy REF: 5.2
    KEY: Chemistry | general chemistry | phases | gas | empirical gas laws | Charles's law
    MSC: Quantitative

19. You have a certain mass of helium gas (He) in a rigid steel container. You add the same mass of neon gas (Ne) to this container. Which of the following best describes what happens? Assume the temperature is constant.
    A) The pressure in the container doubles.
    B) The pressure in the container increases but does not double.
    C) The pressure in the container more than doubles.
    D) The volume of the container doubles.
    E) The volume of the container more than doubles.

    ANS: B PTS: 1 DIF: Easy REF: 5.2
    KEY: Chemistry | general chemistry | phases | gas | empirical gas laws | Avogadro's law
    MSC: Conceptual

20. You are holding two balloons, an orange balloon and a blue balloon. The orange balloon is filled with neon (Ne) gas and the blue balloon is filled with argon (Ar) gas. The orange balloon has twice the volume of the blue balloon. Which of the following best represents the mass ratio of Ne:Ar in the balloons?
    A) 1:1
    B) 1:2
    C) 2:1
    D) 1:3
    E) 3:1

    ANS: A PTS: 1 DIF: Moderate REF: 5.2
    KEY: Chemistry | general chemistry | phases | gas | empirical gas laws | Avogadro's law
    MSC: Conceptual

21. You are holding four identical balloons each containing 10.0 g of a different gas. The balloon containing which gas is the largest balloon?
    A) H_2
    B) He
    C) Ne
    D) O_2
    E) All have the same volume.

    ANS: A PTS: 1 DIF: Easy REF: 5.2
    KEY: Chemistry | general chemistry | phases | gas | empirical gas laws | Avogadro's law
    MSC: Conceptual

    Consider three 1-L flasks at STP. Flask A contains NH_3 gas, flask B contains NO_2 gas, and flask C contains N_2 gas.

22. Which contains the largest number of molecules?
    A) Flask A
    B) Flask B
    C) Flask C
    D) All are the same.
    E) More information is need to answer this.

    ANS: D PTS: 1 DIF: Easy REF: 5.3
    KEY: Chemistry | general chemistry | phases | gas | ideal gas law
    MSC: Conceptual

23. In which flask are the molecules least polar and therefore most ideal in behavior?
    A) Flask A
    B) Flask B
    C) Flask C
    D) All are the same.
    E) More information is needed to answer this.

    ANS: C PTS: 1 DIF: Easy REF: 5.8
    KEY: Chemistry | general chemistry | phases | gas | ideal gas law
    MSC: Conceptual

24. In which flask do the molecules have the highest average velocity?
    A) Flask A
    B) Flask B
    C) Flask C
    D) All are the same.
    E) More information is needed to answer this.

    ANS: A PTS: 1 DIF: Easy REF: 5.6
    KEY: Chemistry | general chemistry | phases | gas | molecular speed
    MSC: Conceptual

    You have two samples of the same gas in the same size container, with the same pressure. The gas in the first container has a Kelvin temperature four times that of the gas in the other container.

25. The ratio of the number of moles of gas in the first container compared to that in the second is
    A) 1:1
    B) 4:1
    C) 1:4
    D) 2:1
    E) 1:2

    ANS: C PTS: 1 DIF: Easy REF: 5.3
    KEY: Chemistry | general chemistry | phases | gas | ideal gas law
    MSC: Conceptual

26. The ratio of the average velocity of particles in the first container compared to that in the second is
    A) 1:1
    B) 4:1
    C) 1:4
    D) 2:1
    E) 1:2

    ANS: D PTS: 1 DIF: Moderate REF: 5.6
    KEY: Chemistry | general chemistry | phases | gas | kinetic-molecular theory
    MSC: Conceptual

    Three 1.00-L flasks at 25°C and 725 torr contain the gases CH_4 (flask A), CO_2 (flask B), and C_2H_6 (flask C).

27. In which flask is there 0.039 mol of gas?
    A) Flask A
    B) Flask B
    C) Flask C
    D) all
    E) none

    ANS: D PTS: 1 DIF: Easy REF: 5.3

KEY: Chemistry | general chemistry | phases | gas | ideal gas law
MSC: Quantitative

28. In which single flask do the molecules have the greatest mass, the greatest average velocity, *and* the highest kinetic energy?
A) Flask A
B) Flask B
C) Flask C
D) All are the same.
E) No one flask has all these.

ANS: E PTS: 1 DIF: Moderate REF: 5.6
KEY: Chemistry | general chemistry | phases | gas | kinetic-molecular theory
MSC: Conceptual

29. A gas sample is heated from -20.0°C to 57.0°C and the volume is increased from 2.00 L to 4.50 L. If the initial pressure is 0.140 atm, what is the final pressure?
A) 0.0477 atm
B) –0.177 atm
C) 0.411 atm
D) 0.242 atm
E) 0.0811 atm

ANS: E PTS: 1 DIF: Easy REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | empirical gas laws | combined gas law
MSC: Quantitative

30. A sample of oxygen gas has a volume of 1.72 L at 27°C and 800.0 torr. How many oxygen molecules does it contain?
A) 4.43×10^{22}
B) 3.36×10^{25}
C) 4.92×10^{23}
D) 8.19×10^{24}
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | ideal gas law
MSC: Quantitative

31. You fill a balloon with 2.50 moles of gas at 22°C at a pressure of 1.62 atm. What is the volume of the balloon?
A) 15.7 L
B) 98.0 L
C) 37.4 L
D) 2.79 L
E) 22.4 L

ANS: C PTS: 1 DIF: Easy REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | ideal gas law
MSC: Quantitative

32. A sample of helium gas occupies 14.7 L at 23°C and 0.956 atm. What volume will it occupy at 40°C and 1.20 atm?
A) 19.5 L
B) 20.4 L
C) 11.1 L
D) 12.4 L
E) 14.9 L

ANS: D PTS: 1 DIF: Easy REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | empirical gas laws | combined gas law
MSC: Quantitative

33. A 3.60-L sample of carbon monoxide is collected at 55°C and 0.869 atm. What volume will the gas occupy at 1.05 atm and 25°C?
A) 1.35 L
B) 3.95 L
C) 2.71 L
D) 3.28 L
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | empirical gas laws | combined gas law
MSC: Quantitative

34. Mercury vapor contains Hg atoms. What is the volume of 201 g of mercury vapor at 822 K and 0.512 atm?
A) 132 L
B) 2.65×10^4 L
C) 175 L
D) 34.5 L
E) 17.3 L

ANS: A PTS: 1 DIF: Easy REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | ideal gas law
MSC: Quantitative

35. What volume is occupied by 21.0 g of methane (CH_4) at 27°C and 1.25 atm?
A) 37.2 L
B) 25.8 L
C) 2.32 L
D) 4.14×10^2 L
E) not enough data to calculate

ANS: B PTS: 1 DIF: Easy REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | ideal gas law
MSC: Quantitative

36. An automobile tire is filled with air at a pressure of 27.0 lb/in^2 at 25°C. A cold front moves through and the temperature drops to 5°C. Assuming no change in volume, what is the new tire pressure?
A) 5.40 lb/in^2
B) 25.2 lb/in^2
C) 28.9 lb/in^2
D) 135 lb/in^2
E) 4.63 lb/in^2

ANS: B PTS: 1 DIF: Easy REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | empirical gas laws | Charles's law
MSC: Quantitative

37. Which conditions of *P*, *T*, and *n*, respectively, are most ideal?
A) high *P*, high *T*, high *n*
B) low *P*, low *T*, low *n*
C) high *P*, low *T*, high *n*
D) low *P*, high *T*, high *n*
E) low *P*, high *T*, low *n*

ANS: E PTS: 1 DIF: Easy REF: 5.8
KEY: Chemistry | general chemistry | phases | gas | ideal gas law
MSC: Conceptual

38. A 7.94-g piece of solid CO_2 (dry ice) is allowed to sublime in a balloon. The final volume of the balloon is 1.00 L at 301 K. What is the pressure of the gas?
A) 4.46 atm
B) 1.96×10^2 atm
C) 3.11 atm
D) 0.224 atm
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | ideal gas law
MSC: Quantitative

39. A sample of 35.1 g of methane gas has a volume of 3.11 L at a pressure of 2.70 atm. Calculate the temperature.
A) 2.92 K
B) 46.8 K
C) 320 K
D) 32.4 K
E) 35.0 K

ANS: B PTS: 1 DIF: Easy REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | ideal gas law
MSC: Quantitative

40. A 41.1-g sample of Ne gas exerts a certain pressure in a container of fixed volume. What mass of Ar is required to exert half the pressure at the same conditions of volume and temperature?

A) 81.4 g Ar
B) 1.02 g Ar
C) 163 g Ar
D) 821 g Ar
E) 40.7 g Ar

ANS: E PTS: 1 DIF: Moderate REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | ideal gas law
MSC: Quantitative

41. A sample of gas is in a 50.0-mL container at a pressure of 645 torr and a temperature of 25°C. The entire sample is heated to a temperature of 35°C and transferred to a new container whose volume is 98.7 mL. The pressure of the gas in the second container is about:
A) 457 torr
B) 316 torr
C) 1.32×10^3 torr
D) 65 torr
E) 338 torr

ANS: E PTS: 1 DIF: Easy REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | empirical gas laws | combined gas law
MSC: Quantitative

42. Given a cylinder of fixed volume filled with 1 mol of argon gas, which of the following is correct? (Assume all gases obey the ideal gas law.)
A) If the temperature of the cylinder is changed from 25°C to 50°C, the pressure inside the cylinder will double.
B) If a second mole of argon is added to the cylinder, the ratio *T*/*P* would remain constant.
C) A cylinder of identical volume filled with the same *pressure* of helium must contain more atoms of gas because He has a smaller atomic radius than argon.
D) Two of the above.
E) None of the above.

ANS: E PTS: 1 DIF: Moderate REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | ideal gas law
MSC: Conceptual

43. For an ideal gas, which pairs of variables are inversely proportional to each other (if all other factors remain constant)?

1. *V* and *T*
2. *T* and *n*
3. *n* and *V*
4. *P* and *T*

A) 1 and 2 only
B) 3 and 4 only
C) 2 only
D) 1 and 3 only

E) 1, 3, and 4 only

ANS: C PTS: 1 DIF: Easy REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | ideal gas law
MSC: Conceptual

44. For a gas, which two variables are *directly* proportional to each other (if all other conditions remain constant)?

1. *T* and *n*
2. *V* and *n*
3. *V* and *T*

A) 1 only
B) 2 only
C) 3 only
D) 1 and 2 only
E) 2 and 3 only

ANS: E PTS: 1 DIF: Easy REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | ideal gas law
MSC: Conceptual

45. The temperature of a specific amount of gas in a sealed container changes from 20.0°C to 40.0°C. If the volume remains constant, the pressure will change from 755 mmHg to
A) 1510 mmHg
B) 707 mmHg
C) 378 mmHg
D) 807 mmHg
E) 755 mmHg

ANS: D PTS: 1 DIF: Easy REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | empirical gas laws | combined gas law
MSC: Quantitative

Four identical 1.0-L flasks contain the gases He, Cl_2, CH_4, and NH_3, each at 0°C and 1 atm pressure.

46. Which gas has the highest density?
A) He
B) Cl_2
C) CH_4
D) NH_3
E) all gases the same

ANS: B PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | gas density
MSC: Conceptual

47. For which gas do the molecules have the highest average velocity?
A) He
B) Cl_2

C) CH_4
D) NH_3
E) all gases the same

ANS: A PTS: 1 DIF: Easy REF: 5.6
KEY: Chemistry | general chemistry | phases | gas | molecular speed
MSC: Conceptual

48. Which gas sample has the greatest number of molecules?
A) He
B) Cl_2
C) CH_4
D) NH_3
E) all gases the same

ANS: E PTS: 1 DIF: Easy REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | ideal gas law
MSC: Conceptual

49. For which gas are the molecules diatomic?
A) He
B) Cl_2
C) CH_4
D) NH_3
E) all gases the same

ANS: B PTS: 1 DIF: Easy REF: 5.3
KEY: Chemistry | general chemistry | phases MSC: Conceptual

50. For which gas are the collisions elastic?
A) He
B) Cl_2
C) CH_4
D) NH_3
E) all gases the same

ANS: E PTS: 1 DIF: Easy REF: 5.6
KEY: Chemistry | general chemistry | phases | gas | kinetic-molecular theory
MSC: Conceptual

51. For which gas do the molecules have the smallest average kinetic energy?
A) He
B) Cl_2
C) CH_4
D) NH_3
E) all gases the same

ANS: E PTS: 1 DIF: Easy REF: 5.6
KEY: Chemistry | general chemistry | phases | gas | kinetic-molecular theory
MSC: Conceptual

52. The mass of 1.12 liters of gas *Y* at STP is found to be 6.23 g. The density of gas *Y* is
A) 10.6 g/L
B) 5.56 g/L
C) 15.6 g/L
D) 0.200 g/L
E) 0.180 g/L

ANS: B PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | gas density
MSC: Quantitative

53. The mass of 1.12 liters of gas *Y* at STP is found to be 6.23 g. The molar mass of gas *Y* is
A) 56.0 g/mol
B) 89.0 g/mol
C) 125 g/mol
D) 140. g/mol
E) 157 g/mol

ANS: C PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | molar mass
MSC: Quantitative

54. A plastic bag is weighed and then filled successively with two gases, *X* and *Y*. The following data are gathered:

Temperature: 0.0°C (273 K)
Pressure: 1.00 atmosphere
Mass of empty bag: 20.77 g
Mass of bag filled with gas *X*: 24.97 g
Mass of 1.12 liters of air at conditions given: 1.30 g
Volume of bag: 1.12 liter
Molar volume at STP: 22.4 liters

The bag is emptied and refilled, successively, with gases *X* and *Y*, this time at 1 atm pressure and a temperature 30°C *higher*. Assume that the volume of the bag is the same as before. Which one of the following statements is *wrong*?
A) The full bag contains fewer molecules of each gas than it did at 0.0°C.
B) The *ratio* of the density of gas Y to the density of gas X is the same as at 0.0°C.
C) The molar masses of the two gases are the same as they were at 0.0°C.
D) The mass of each gas filling the bag is now 303/273 times the mass held at 0.0°C.
E) The average velocity of the molecules of gas X at 30°C is higher than it was at 0.0°C.

ANS: D PTS: 1 DIF: Moderate REF: 5.6
KEY: Chemistry | general chemistry | phases | gas | ideal gas law
MSC: Conceptual

55. Argon has a density of 1.78 g/L at STP. How many of the following gases have a density at STP *greater* than that of argon?

Cl_2 He NH_3 NO_2

A) 0

B) 1
C) 2
D) 3
E) 4

ANS: C PTS: 1 DIF: Easy REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | gas density
MSC: Conceptual

56. Which of the following is the best qualitative graph of *P* versus molar mass of a 1-g sample of different gases at constant volume and temperature?

A)

B)

C)

D)

E) none of these

ANS: E PTS: 1 DIF: Difficult REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | gas density
MSC: Conceptual

57. It is found that 250. mL of a gas at STP has a mass of 0.700 g. What is the molar mass?
A) 62.7 g/mol
B) 2.80 g/mol
C) 15.9 g/mol
D) 11.2 g/mol
E) 128 g/mol

ANS: A PTS: 1 DIF: Easy REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | molar mass
MSC: Quantitative

58. Given reaction $2NH_3(g) + 3Cl_2(g) \rightarrow N_2(g) + 6HCl(g)$, you react 5.0 L of NH_3 with 5.0 L of Cl_2 measured at the same conditions in a closed container. Calculate the ratio of pressures in the container ($P_{final}/P_{initial}$).
A) 0.75
B) 1.00
C) 1.33
D) 1.50
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | stoichiometry and gas

volumes MSC: Conceptual

59. Given reaction $N_2 + 3H_2 \rightarrow 2NH_3$, you mix 1 mol each of nitrogen and hydrogen gases under the same conditions in a container fitted with a piston. Calculate the ratio of volumes of the container ($V_{final}/V_{initial}$).
A) 0.67
B) 1.00
C) 1.33
D) 1.50
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | stoichiometry and gas volumes MSC: Conceptual

60. You carry out the reaction represented by the following balanced equation:
$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$
You add an equal number of moles of nitrogen and hydrogen gases in a balloon. The volume of the balloon is 1.00 L before any reaction occurs. Determine the volume of the balloon after the reaction is complete. Assume constant temperature.
A) 0.330 L
B) 0.670 L
C) 1.00 L
D) 1.50 L
E) 3.00 L

ANS: B PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | stoichiometry and gas volumes MSC: Conceptual

61. When 0.72 g of a liquid is vaporized at 110°C and 0.967 atm, the gas occupies a volume of 0.559 L. The empirical formula of the gas is CH_2. What is the molecular formula of the gas?
A) CH_2
B) C_2H_4
C) C_3H_6
D) C_4H_8
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | molar mass
MSC: Quantitative

62. Gaseous C_2H_4 reacts with O_2 according to the following equation:

$$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2 + H_2O(g)$$

What volume of oxygen gas at STP is needed to react with 5.75 mol of C_2H_4?
A) 17.3 L
B) 42.9 L
C) 3.86×10^2 L

D) 1.29×10^2 L
E) Not enough information is given to solve the problem.

ANS: C PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | stoichiometry and gas volumes MSC: Quantitative

63. A 3.54 gram sample of a certain diatomic gas occupies a volume of 3.30-L at 1.00 atm and a temperature of 45°C. Identify this gas.
A) N_2
B) O_2
C) F_2
D) H_2
E) Cl_2

ANS: A PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | molar mass
MSC: Quantitative

64. Air has an average molar mass of 29.0 g/mol. The density of air at 0.97 atm and 30.0°C is:
A) 29.0 g/L
B) 39.0 g/mL
C) 1.13 g/L
D) 1.35 g/mL
E) 11.4 g/L

ANS: C PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | gas density
MSC: Quantitative

65. Calculate the density of nitrogen at STP.
A) 0.312 g/L
B) 0.625 g/L
C) 0.800 g/L
D) 1.25 g/L
E) 1.60 g/L

ANS: D PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | gas density
MSC: Quantitative

66. If a 17.90-g sample of a gas occupies 10.0 L at STP, what is the molar mass of the gas at 125°C?
A) 5.48 g/mol
B) 40.1 g/mol
C) 18.4 g/mol
D) 58.5 g/mol
E) Not enough information is given.

ANS: B PTS: 1 DIF: Easy REF: 5.4

KEY: Chemistry | general chemistry | phases | gas | ideal gas law | molar mass
MSC: Quantitative

67. A 3.31-g sample of lead nitrate, $Pb(NO_3)_2$, molar mass = 331 g/mol, is heated in an evacuated cylinder with a volume of 2.37 L. The salt decomposes when heated, according to the equation:

$$2Pb(NO_3)_2(s) \rightarrow 2PbO(s) + 4NO_2(g) + O_2(g)$$

Assuming complete decomposition, what is the pressure in the cylinder after decomposition and cooling to a temperature of 300. K? Assume the $PbO(s)$ takes up negligible volume.

A) 0.260 atm
B) 0.208 atm
C) 0.0519 atm
D) 0.364 atm
E) 34.4 atm

ANS: A PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | stoichiometry and gas volumes MSC: Quantitative

68. The purity of a sample containing zinc and weighing 0.312 g is determined by measuring the amount of hydrogen formed when the sample reacts with an excess of hydrochloric acid. The determination shows the sample to be 84.0% zinc. What amount of hydrogen (measured at STP) was obtained?

A) 2.62×10^{-1} L
B) 1.30×10^{-1} g
C) 4.77×10^{-3} mole
D) 2.41×10^{21} molecules
E) 2.41×10^{21} atoms

ANS: D PTS: 1 DIF: Difficult REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | stoichiometry and gas volumes MSC: Quantitative

69. What volume of carbon dioxide measured at STP will be formed by the reaction of 1.47 mol of oxygen with 0.900 mol of ethyl alcohol, CH_3CH_2OH?

A) 40.3 mL
B) 22.0 L
C) 32.9 L
D) 49.4 L
E) 0.980 L

ANS: B PTS: 1 DIF: Difficult REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | stoichiometry and gas volumes MSC: Quantitative

70. What volume of $H_2O(g)$ measured at STP is produced by the combustion of 6.27 g of natural gas (CH_4) according to the following equation?

$CH_4(g) + 2O_2(g) \rightarrow CO_2 + 2H_2O(g)$

A) 8.76 L
B) 17.5 L
C) 4.38 L
D) 19.1 L
E) 3.14 L

ANS: B PTS: 1 DIF: Easy REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | stoichiometry and gas volumes MSC: Quantitative

71. At 1000°C and 10. torr, the density of a certain element in the gaseous state is 2.9×10^{-3} g/L. The element is:

A) F
B) He
C) Na
D) Zn
E) Hg

ANS: C PTS: 1 DIF: Easy REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | gas density
MSC: Quantitative

72. Into a 2.22-liter container at 25°C are placed 1.23 moles of O_2 gas and 3.20 moles of solid C (graphite). If the carbon and oxygen react completely to form CO(*g*), what will be the final pressure in the container at 25°C?

A) 27.1 atm
B) 13.5 atm
C) 2.27 atm
D) 35.2 atm
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | stoichiometry and gas volumes MSC: Quantitative

73. Calcium hydride combines with water according to the equation:

$CaH_2(s) + 2H_2O(l) \rightarrow 2H_2(g) + Ca(OH)_2(s)$

Beginning with 84.0 g of CaH_2 and 42.0 g of H_2O, what volume of H_2 will be produced at 273 K and a pressure of 1327 torr?

A) 29.9 L
B) 15.0 L
C) 5.39×10^2 L
D) 25.7 L
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | stoichiometry and gas volumes MSC: Quantitative

74. What volume does 40.5 g of N_2 occupy at STP?
A) 64.8 L
B) 1.81 L
C) 32.4 L
D) 50.7 L
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law
MSC: Quantitative

75. A mixture is prepared from 15.0 L of ammonia and 15.0 L chlorine measured at the same conditions; these compounds react according to the following equation:

$$2NH_3(g) + 3Cl_2(g) \rightarrow N_2(g) + 6HCl(g)$$

When the reaction is completed, what is the volume of each gas (NH_3, Cl_2, N_2, and HCl, respectively)? Assume the final volumes are measured under identical conditions.
A) 0.00 L, 5.00 L, 7.50 L, 45.0 L
B) 5.00 L, 0.00 L, 5.00 L, 30.0 L
C) 0.00 L, 0.00 L, 7.50 L, 45.0 L
D) 0.00 L, 0.00 L, 5.00 L, 30.0 L
E) 0.00 L, 10.0 L, 15.0 L, 90.0 L

ANS: B PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | stoichiometry and gas volumes MSC: Quantitative

76. An excess of sodium hydroxide is treated with 26.5 L of dry hydrogen chloride gas measured at STP. What is the mass of sodium chloride formed?
A) 1.55 kg
B) 1.69 g
C) 0.138 kg
D) 69.1 g
E) 13.3 g

ANS: D PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | stoichiometry and gas volumes MSC: Quantitative

77. A 1.00-g sample of a gaseous compound of boron and hydrogen occupies 0.820 L at 1.00 atm and 3°C. What could be the molecular formula for the compound?
A) BH_3
B) B_2H_6
C) B_4H_{10}
D) B_3H_{12}
E) B_5H_{14}

ANS: B PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | molar mass
MSC: Quantitative

78. A mixture of KCl and $KClO_3$ weighing 1.34 grams was heated; the dry O_2 generated occupied 143 mL at STP. What percent of the original mixture was $KClO_3$, which decomposes as follows:

$$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$

A) 38.9%
B) 58.4%
C) 87.6%
D) 10.7%
E) 23.7%

ANS: A PTS: 1 DIF: Difficult REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | stoichiometry and gas volumes MSC: Quantitative

79. Given the equation:

$$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$

A 3.00-g sample of $KClO_3$ is decomposed and the oxygen at 24.0°C and 0.717 atm is collected. What volume of oxygen gas will be collected assuming 100% yield?

A) 8.32×10^2 mL
B) 1.01×10^2 mL
C) 1.25×10^3 mL
D) 5.55×10^2 mL
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | stoichiometry and gas volumes MSC: Quantitative

80. If M is the molar mass, *R* the gas constant, *T* the temperature, and *P* its pressure, which of the following expressions represents the density of a gas?

A) $\frac{PM}{RT}$
B) $\frac{RM}{PT}$
C) $\frac{RMP}{T}$
D) $\frac{RTM}{P}$
E) $\frac{RT}{PM}$

ANS: A PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | gas density
MSC: Conceptual

81. One way to isolate metals from their ores is to react the metal oxide with carbon as shown in the following reaction:

$$2MO(s) + C(s) \rightarrow 2M(s) + CO_2(g)$$

If 34.08 g of a metal oxide reacted with excess carbon and 4.37 L of CO_2 formed at 100°C and 1.50 atm, what is the identity of the metal?

A) Hg
B) Mg
C) Cu
D) Cd
E) Zn

ANS: C PTS: 1 DIF: Difficult REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | stoichiometry and gas volumes MSC: Quantitative

82. The standard temperature for gases is

A) 100°C
B) 0°C
C) 32°C
D) 212°F
E) 0°F

ANS: B PTS: 1 DIF: Easy REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | STP MSC: Conceptual

83. Standard pressure for gases is

A) 0 atm
B) 1 atm
C) 100 atm
D) dependent upon temperature
E) none of the above

ANS: B PTS: 1 DIF: Easy REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | STP MSC: Conceptual

Zinc metal is added to hydrochloric acid to generate hydrogen gas, which is collected over a liquid whose vapor pressure is the same as pure water at 20.0°C (18 torr). The volume of the gas mixture is 1.7 L and its total pressure is 0.810 atm.

84. Determine the partial pressure of the hydrogen gas in this mixture.

A) 562 torr
B) 580 torr
C) 598 torr
D) 616 torr
E) 634 torr

ANS: C PTS: 1 DIF: Easy REF: 5.5
KEY: Chemistry | general chemistry | phases | gas | gas mixtures | collecting gases over water MSC: Quantitative

85. Determine the number of moles of hydrogen gas present in the sample.

A) 42 mol

B) 0.82 mol
C) 1.3 mol
D) 0.056 mol
E) 22 mol

ANS: D PTS: 1 DIF: Easy REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | calculations with the ideal gas law MSC: Quantitative

86. A 142-mL sample of gas is collected over water at 22°C and 753 torr. What is the volume of the dry gas at STP? (The vapor pressure of water at 22°C = 20. torr)
A) 122 mL
B) 162 mL
C) 136 mL
D) 111 mL
E) none of these

ANS: E PTS: 1 DIF: Easy REF: 5.5
KEY: Chemistry | general chemistry | phases | gas | gas mixtures | collecting gases over water MSC: Quantitative

87. A vessel with a volume of 26.9 L contains 2.80 g of nitrogen gas, 0.605 g of hydrogen gas, and 79.9 g of argon gas. At 25°C, what is the pressure in the vessel?
A) 75.5 atm
B) 0.183 atm
C) 2.55 atm
D) 2.18 atm
E) 58.7 atm

ANS: D PTS: 1 DIF: Moderate REF: 5.5
KEY: Chemistry | general chemistry | phases | gas | gas mixtures | Dalton's law of partial pressures MSC: Quantitative

88. Oxygen gas, generated by the reaction $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$ is collected over water at 27°C in a 1.55-L vessel at a total pressure of 1.00 atm. (The vapor pressure of H_2O at 27°C is 26.0 torr.) How many moles of $KClO_3$ were consumed in the reaction?
A) 0.0608 moles
B) 0.0912 moles
C) 0.0405 moles
D) 0.0434 moles
E) 1.50 moles

ANS: C PTS: 1 DIF: Moderate REF: 5.5
KEY: Chemistry | general chemistry | phases | gas | gas mixtures | collecting gases over water MSC: Quantitative

You have a 400-mL container containing 55.0% He and 45.0% Ar by mass at 25°C and 1.5 atm total pressure. You heat the container to 100°C.

89. Calculate the total pressure.
A) 1.20 atm

B) 1.50 atm
C) 1.88 atm
D) 2.01 atm
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 5.5
KEY: Chemistry | general chemistry | phases | gas | gas mixtures | Dalton's law of partial pressures MSC: Conceptual

90. Calculate the ratio of $P_{He} : P_{Ar}$.
A) 1/1.22
B) 1.22/1
C) 1/12.2
D) 12.2/1
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 5.5
KEY: Chemistry | general chemistry | phases | gas | gas mixtures | Dalton's law of partial pressures MSC: Conceptual

91. The valve between a 5-L tank containing a gas at 9 atm and a 10-L tank containing a gas at 6 atm is opened. Calculate the final pressure in the tanks.
A) 3 atm
B) 4 atm
C) 7 atm
D) 15 atm
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 5.5
KEY: Chemistry | general chemistry | phases | gas | gas mixtures | Dalton's law of partial pressures MSC: Quantitative

92. A balloon contains an anesthetic mixture of cyclopropane (cp) and oxygen (O_2) at 171 torr and 570. torr, respectively. What is the ratio of the number of moles of cyclopropane to moles of oxygen?

$$\frac{n_{cp}}{n_{O_2}} = ?$$

A) 3.33
B) 0.230
C) 0.300
D) 0.390
E) 0.460

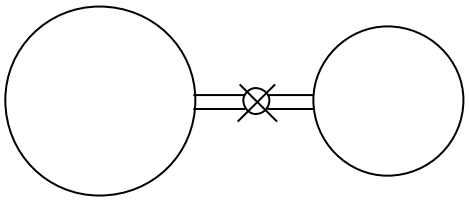
ANS: C PTS: 1 DIF: Moderate REF: 5.2
KEY: Chemistry | general chemistry | phases | gas | gas mixtures | Dalton's law of partial pressures MSC: Quantitative

93. A gaseous mixture containing 1.5 mol Ar and 3.5 mol CO_2 has a total pressure of 7.3 atm. What is the partial pressure of CO_2?

A) 2.2 atm
B) 1.4 atm
C) 17 atm
D) 5.1 atm
E) 7.3 atm

ANS: D PTS: 1 DIF: Easy REF: 5.5
KEY: Chemistry | general chemistry | phases | gas | gas mixtures | Dalton's law of partial pressures MSC: Quantitative

94. The valve between the 2.00-L bulb, in which the gas pressure is 1.80 atm, and the 3.00-L bulb, in which the gas pressure is 3.00 atm, is opened. What is the final pressure in the two bulbs, the temperature remaining constant?



A) 0.720 atm
B) 2.28 atm
C) 2.52 atm
D) 1.80 atm
E) 2.40 atm

ANS: C PTS: 1 DIF: Moderate REF: 5.5
KEY: Chemistry | general chemistry | phases | gas | gas mixtures | Dalton's law of partial pressures MSC: Quantitative

95. The partial pressures of CH_4, N_2, and O_2 in a sample of gas were found to be 135 mmHg, 508 mmHg, and 571 mmHg, respectively. Calculate the mole fraction of nitrogen.
A) 20.4
B) 0.470
C) 0.418
D) 0.751
E) 0.359

ANS: C PTS: 1 DIF: Moderate REF: 5.5
KEY: Chemistry | general chemistry | phases | gas | gas mixtures | Dalton's law of partial pressures MSC: Quantitative

96. Dalton's law of partial pressures states that:
A) Equal amounts of gases occupy the same volume at constant temperature and pressure.
B) The volume of a fixed amount of gas is inversely proportional to its pressure at constant temperature.
C) The volume of a fixed amount of gas is directly proportional to its temperature in Kelvin at constant pressure.
D) The total pressure of a mixture of gases is the sum of the partial pressure of all of

the gaseous compounds.

E) The rates of effusion of gases are inversely proportional to the square roots of their molar masses.

ANS: D PTS: 1 DIF: Easy REF: 5.5
KEY: Chemistry | general chemistry | phases | gas | gas mixtures | Dalton's law of partial pressures MSC: Conceptual

97. Which of the following is *not* a postulate of the kinetic molecular theory?

A) Gas particles have most of their mass concentrated in the nucleus of the atom.
B) The moving particles undergo perfectly elastic collisions with the walls of the container.
C) The forces of attraction and repulsion between the particles are insignificant.
D) The average kinetic energy of the particles is directly proportional to the absolute temperature.
E) All of the above are postulates of the kinetic molecular theory.

ANS: A PTS: 1 DIF: Easy REF: 5.6
KEY: Chemistry | general chemistry | phases | gas | kinetic theory of an ideal gas | postulates of kinetic theory MSC: Conceptual

98. Consider the following gas samples:

Sample A	**Sample B**
$S_2(g)$	$O_2(g)$
n = 1 mol	n = 2 mol
T = 800 K	T = 400 K
P = 0.20 atm	P = 0.40 atm

Which of the following statements is *false*?

A) The volume of sample A is twice the volume of sample B.
B) The average kinetic energy of the molecules in sample A is twice the average kinetic energy of the molecules in sample B.
C) The fraction of molecules in sample A, having a kinetic energy greater than some high fixed value, is larger than the fraction of molecules in sample B, having kinetic energies greater than that same high fixed value.
D) The mean square velocity of molecules in sample A is twice as large as the mean square velocity of molecules in sample B.
E) Assuming identical intermolecular forces in the two samples, sample A should be more nearly ideal than sample B.

ANS: D PTS: 1 DIF: Moderate REF: 5.6
KEY: Chemistry | general chemistry | phases | gas | kinetic-molecular theory
MSC: Conceptual

99. What would happen to the average kinetic energy of the molecules of a gas sample if the temperature of the sample increased from 20°C to 40°C?

A) It would double.
B) It would increase.
C) It would decrease.
D) It would become half its value.

E) Two of these.

ANS: B PTS: 1 DIF: Easy REF: 5.6
KEY: Chemistry | general chemistry | phases | gas | kinetic-molecular theory
MSC: Conceptual

100. In the kinetic molecular theory we assume an ideal gas has no mass.

ANS: F PTS: 1 DIF: Easy REF: 5.6
KEY: Chemistry | general chemistry | phases | gas | kinetic-molecular theory
MSC: Conceptual

101. At 200 K, the molecules or atoms of an unknown gas, X, have an average velocity equal to that of Ar atoms at 400 K. What is X? (Assume ideal behavior.)
A) He
B) CO
C) HF
D) HBr
E) F_2

ANS: C PTS: 1 DIF: Moderate REF: 5.6
KEY: Chemistry | general chemistry | phases | gas | molecular speed
MSC: Conceptual

102. Which of the following is *not* an assumption of the kinetic molecular theory for a gas?
A) Gases are made up of tiny particles in constant chaotic motion.
B) Gas particles are very small compared to the average distance between the particles.
C) Gas particles collide with the walls of their container in elastic collisions.
D) The average velocity of the gas particles is directly proportional to the absolute temperature.
E) All of the above are assumptions of the kinetic molecular theory.

ANS: D PTS: 1 DIF: Easy REF: 5.6
KEY: Chemistry | general chemistry | phases | gas | kinetic-molecular theory
MSC: Conceptual

103. Use the kinetic molecular theory of gases to predict what would happen to a closed sample of a gas whose temperature increased while its volume decreased.
A) Its pressure would decrease.
B) Its pressure would increase.
C) Its pressure would hold constant.
D) The number of moles of the gas would decrease.
E) The average kinetic energy of the molecules of the gas would decrease.

ANS: B PTS: 1 DIF: Moderate REF: 5.6
KEY: Chemistry | general chemistry | phases | gas | kinetic-molecular theory
MSC: Conceptual

104. Calculate the root mean square velocity for the O_2 molecules in a sample of O_2 gas at 11.8°C. (R = 8.3145 J/K mol)

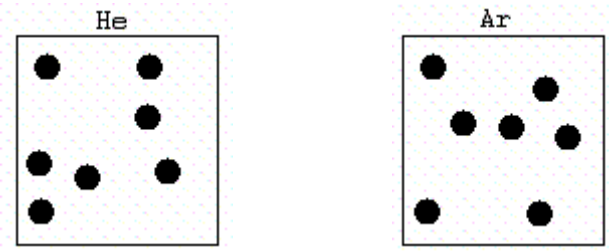
A) 95.91 m/s
B) 14.90 m/s
C) 471.2 m/s
D) 272.0 m/s
E) 8.973×10^{26} m/s

ANS: C PTS: 1 DIF: Easy REF: 5.6
KEY: Chemistry | general chemistry | phases | gas | molecular speed
MSC: Quantitative

105. Which of the following is true about the kinetic molecular theory?
A) The volume of a gas particle is considered to be small – about 0.10 mL.
B) Pressure is due to the collisions of the gas particles with the walls of the container.
C) Gas particles repel each other, but do not attract one another.
D) Adding an ideal gas to a closed container will cause an increase in temperature.
E) At least two of the above statements are correct.

ANS: B PTS: 1 DIF: Easy REF: 5.6
KEY: Chemistry | general chemistry | phases | gas | kinetic-molecular theory
MSC: Conceptual

106. Consider the following containers, one with helium at 27°C and the other with argon at 27°C.



Which of the following statements are true?

A) The speed of each atom of helium is 926 m/s.
B) The rms speed of the He and the Ar atoms are the same.
C) The average kinetic energy of the two samples are equal.
D) All of the above are true.
E) None of the above are true.

ANS: C PTS: 1 DIF: Moderate REF: 5.6
KEY: Chemistry | general chemistry | phases | gas | molecular speed
MSC: Conceptual

107. Which of the following statements is true concerning ideal gases?
A) The temperature of the gas sample is directly related to the average velocity of the gas particles.
B) At STP, 1.0 L of Ar(*g*) contains about twice the number of atoms as 1.0 L of Ne(*g*) since the molar mass of Ar is about twice that of Ne.
C) A gas exerts pressure as a result of the collisions of the gas molecules with the walls of the container.
D) The gas particles in a sample exert attraction for one another.

E) All of the above are false.

ANS: C PTS: 1 DIF: Easy REF: 5.6
KEY: Chemistry | general chemistry | phases | gas | kinetic-molecular theory
MSC: Conceptual

108. At the same temperature, lighter molecules have a higher average kinetic energy than heavier molecules.

ANS: F PTS: 1 DIF: Easy REF: 5.6
KEY: Chemistry | general chemistry | phases | gas | kinetic-molecular theory
MSC: Conceptual

109. According to the postulates of the kinetic theory of gases, the average speed of the molecules of a given gas is proportional to the
A) absolute temperature squared
B) square root of the absolute temperature
C) absolute temperature
D) Celsius temperature squared
E) reciprocal of the absolute temperature

ANS: B PTS: 1 DIF: Easy REF: 5.6
KEY: Chemistry | general chemistry | phases | gas | kinetic-molecular theory
MSC: Conceptual

110. Which statement is *inconsistent* with the kinetic theory of an ideal gas?
A) The forces of repulsion between gas molecules are very weak or negligible.
B) Most of the volume occupied by a gas is empty space.
C) When two gas molecules collide, they both gain kinetic energy.
D) The average kinetic energy of a gas is proportional to the absolute temperature.
E) Gas molecules move in a straight line between collisions.

ANS: C PTS: 1 DIF: Easy REF: 5.6
KEY: Chemistry | general chemistry | phases | gas | kinetic-molecular theory
MSC: Conceptual

111. Which of the following is included as a postulate in the kinetic molecular theory of an ideal gas?
A) The distance between gas molecules is small compared with the size of the molecule.
B) All collisions between molecules are elastic.
C) In an average collision between molecules, both molecules have the same kinetic energy.
D) All molecules move randomly in zigzag directions.
E) All the molecules have the same velocity.

ANS: B PTS: 1 DIF: Easy REF: 5.6
KEY: Chemistry | general chemistry | phases | gas | kinetic-molecular theory
MSC: Conceptual

112. All the following are postulates of the kinetic-molecular theory of gases *except:*

A) The collisions between molecules are elastic.
B) The gas molecules are in constant motion.
C) At a constant temperature, each molecule has the same kinetic energy.
D) The volumes of the molecules are negligible compared with the volume of the container.
E) The gas molecules are in rapid motion.

ANS: C PTS: 1 DIF: Easy REF: 5.6
KEY: Chemistry | general chemistry | phases | gas | kinetic-molecular theory
MSC: Conceptual

113. Graham's law states that:
A) Equal amounts of gases occupy the same volume at constant temperature and pressure.
B) The volume of a fixed amount of gas is inversely proportional to its pressure at constant temperature.
C) The volume of a fixed amount of gas is directly proportional to its temperature in Kelvin at constant pressure.
D) The total pressure of a mixture of gases is the simple sum of the partial pressure of all of the gaseous compounds.
E) The rates of effusion of gases are inversely proportional to the square roots of their molar masses.

ANS: E PTS: 1 DIF: Easy REF: 5.7
KEY: Chemistry | general chemistry | phases | gas | molecular speed | effusion
MSC: Conceptual

114. Which of the following would have a higher rate of effusion than C_2H_2?
A) N_2
B) O_2
C) Cl_2
D) CH_4
E) CO_2

ANS: D PTS: 1 DIF: Easy REF: 5.7
KEY: Chemistry | general chemistry | phases | gas | molecular speed | effusion
MSC: Conceptual

115. A sample of N_2 gas is contaminated with a gas (A) of unknown molar mass. The partial pressure of each gas is known to be 200. torr at 25°C. The gases are allowed to effuse through a pinhole, and it is found that gas A escapes at 4 times the rate of N_2. The molar mass of gas A is:
A) 1.75 g/mol
B) 112 g/mol
C) 7.01 g/mol
D) 448 g/mol
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 5.7
KEY: Chemistry | general chemistry | phases | gas | molecular speed | effusion
MSC: Quantitative

116. The rate of effusion of an unknown gas was measured and found to be 11.9 mL/min. Under identical conditions, the rate of effusion of pure oxygen (O_2) gas is 14.0 mL/min. Based on this information, the identity of the unknown gas could be:
A) F_2
B) NO
C) CO_2
D) C_2H_2
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 5.7
KEY: Chemistry | general chemistry | phases | gas | molecular speed | effusion
MSC: Quantitative

117. Calculate the ratio of the effusion rates of N_2 and N_2O.
A) 0.637
B) 1.57
C) 1.25
D) 0.798
E) 1.61

ANS: C PTS: 1 DIF: Moderate REF: 5.7
KEY: Chemistry | general chemistry | phases | gas | molecular speed | effusion
MSC: Conceptual

118. Hydrogen and chlorine gases react to form HCl. You and a friend are on opposite sides of a long hallway, you with H_2 and your friend with Cl_2. You both want to form HCl in the middle of the room. Which of the following is true?
A) You should release the H_2 first.
B) Your friend should release the Cl_2 first.
C) You both should release the gases at the same time.
D) You need to know the length of the room to answer this question.
E) You need to know the temperature to answer this question.

ANS: B PTS: 1 DIF: Easy REF: 5.7
KEY: Chemistry | general chemistry | phases | gas | molecular speed | diffusion
MSC: Conceptual

119. Order the following in increasing rate of effusion:
F_2, Cl_2, NO, NO_2, CH_4
A) $Cl_2 < NO_2 < F_2 < NO < CH_4$
B) $Cl_2 < F_2 < NO_2 < CH_4 < NO$
C) $CH_4 < NO_2 < NO < F_2 < Cl_2$
D) $CH_4 < NO < F_2 < NO_2 < Cl_2$
E) $F_2 < NO < Cl_2 < NO_2 < CH_4$

ANS: A PTS: 1 DIF: Easy REF: 5.7
KEY: Chemistry | general chemistry | phases | gas | molecular speed | effusion
MSC: Conceptual

120. The diffusion of a gas is faster than the effusion of a gas.

ANS: F PTS: 1 DIF: Easy REF: 5.7
KEY: Chemistry | general chemistry | phases | gas | molecular speed | diffusion | effusion
MSC: Conceptual

121. Complete the following: Because real gas particles have attraction for one another:
A) Real gases act most ideally at STP.
B) We assume gas particles have negligible (zero) volume.
C) One mole of an ideal gas at STP has a volume of 22.4 L.
D) Real gases act more ideally at higher temperatures and lower pressures.
E) At least two of the above statements (A-D) correctly complete the statement.

ANS: D PTS: 1 DIF: Easy REF: 5.8
KEY: Chemistry | general chemistry | phases | gas | real gases MSC: Conceptual

122. The van der Waals equation, $nRT = [P + a(n/V)^2] (V - nb)$, incorporates corrections to the ideal gas law in order to account for the properties of real gases. One of the corrections accounts for
A) the possibility of chemical reaction between molecules
B) the finite volume of molecules
C) the quantum behavior of molecules
D) the fact that average kinetic energy is inversely proportional to temperature
E) the possibility of phase changes when the temperature is decreased or the pressure is increased

ANS: B PTS: 1 DIF: Easy REF: 5.8
KEY: Chemistry | general chemistry | phases | gas | real gases MSC: Conceptual

123. Which of the following properties of a real gas is related to the *b* coefficient in the van der Waals equation?
A) Real gases consist of molecules or atoms that have volume.
B) The average speed of the molecules of a real gas increases with temperature.
C) There are attractive forces between atoms or molecules of a real gas.
D) The rate of effusion of a gas is inversely proportional to the square root of the molecular weight of the gas.
E) None of these.

ANS: A PTS: 1 DIF: Moderate REF: 5.8
KEY: Chemistry | general chemistry | phases | gas | real gases MSC: Conceptual

124. Which of the following effects will make PV/nRT less than one for a real gas?
A) The gas molecules are large enough to occupy a substantial amount of space.
B) A large number of molecules have speeds greater than the average speed.
C) The gas molecules have a very low molar mass.
D) The gas molecules attract one another.
E) None of these.

ANS: D PTS: 1 DIF: Moderate REF: 5.8
KEY: Chemistry | general chemistry | phases | gas | real gases MSC: Conceptual

125. Which of the following statements is *least* likely to be true of a sample of nitrogen gas?
A) Molecules of gaseous nitrogen are in constant random motion.
B) The pressure exerted by gaseous nitrogen is due to collisions of the molecules with the walls of the container.
C) The average kinetic energy of the gaseous nitrogen is proportional to the absolute temperature of the gas.
D) Collisions between the gaseous molecules are elastic.
E) The volume of the sample would be zero at –273°C.

ANS: E PTS: 1 DIF: Easy REF: 5.8
KEY: Chemistry | general chemistry | phases | gas | real gases MSC: Conceptual

126. Real gases are those that
A) only behave ideally at high pressures or low temperatures
B) deviate from ideal behavior
C) are only available naturally in the earth's atmosphere
D) are called real gases because their behavior can easily be modeled
E) have an even number of protons

ANS: B PTS: 1 DIF: Easy REF: 5.8
KEY: Chemistry | general chemistry | phases | gas | real gases MSC: Conceptual

127. Gases behave most ideally at STP.

ANS: F PTS: 1 DIF: Easy REF: 5.8
KEY: Chemistry | general chemistry | phases | gas | real gases MSC: Conceptual

128. The pressure a gas would exert under ideal conditions is always greater than the observed pressure of a real gas.

ANS: F PTS: 1 DIF: Easy REF: 5.8
KEY: Chemistry | general chemistry | phases | gas | real gases MSC: Conceptual

129. Of the following real gases, which would be expected to have the lowest van der Waals correction for intermolecular attractions?
A) H_2
B) Cl_2
C) NH_3
D) O_2
E) not enough information to determine

ANS: A PTS: 1 DIF: Easy REF: 5.9
KEY: Chemistry | general chemistry | phases | gas | real gases MSC: Conceptual

130. What is the name for the lowest layer of the atmosphere, which is most influenced by human activities?
A) stratosphere
B) mesosphere
C) terrasphere
D) troposphere

E) ionosphere

ANS: D PTS: 1 DIF: Easy REF: 5.1
KEY: Chemistry | general chemistry | phases | gas MSC: Conceptual

131. Which of the following pollutant gases is not produced directly in a combustion engine?
A) CO
B) CO_2
C) O_3
D) NO
E) NO_2

ANS: C PTS: 1 DIF: Easy REF: 5.1
KEY: Chemistry | general chemistry | phases | gas MSC: Conceptual

132. Combustion of coal releases sulfur dioxide into the atmosphere. The following process converts this gas into sulfuric acid, a component of acid rain.

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

$$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$$

If each tonne of coal produces 1.30×10^4 L of sulfur dioxide (measured at STP), what mass of sulfuric acid can result from combustion of each tonne of coal? (1 tonne = 1000 kg)
A) 2.85×10^1 kg H_2SO_4
B) 2.86×10^4 kg H_2SO_4
C) 5.69×10^7 kg H_2SO_4
D) 5.69×10^1 kg H_2SO_4
E) 1.14×10^2 kg H_2SO_4

ANS: D PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | stoichiometry and gas volumes MSC: Quantitative

133. A room is 16 ft × 12 ft × 12 ft. Would air enter or leave the room if the temperature changed from 27°C to –3°C while the pressure remained constant? Determine the volume of the air that moved in or out of the room.

ANS:
Air enters the room. 210 ft^3 of air moves.

See Sec. 5.2 of Zumdahl, *Chemistry*.
Volume of room = 16ft*12ft*12ft = 2304 ft^3
Room gas volume at lower temp (V_2) = $V_1(T_2/T_1)$ = 2304(270/300) = 2097 ft^3
2304-2097 = 210 ft must enter room to compensate.

PTS: 1 DIF: Moderate REF: 5.2
KEY: Chemistry | general chemistry | phases | gas | empirical gas laws | Charles's law
MSC: Conceptual

134. Toy balloons are filled with hydrogen gas, at standard temperature, from a 10.0-liter cylinder. The initial pressure of the gas in the cylinder is exactly 100 atm. Assuming each balloon is filled to a volume of 1.0 liter at standard pressure, how many balloons could be filled?

ANS:
9990 balloons

See Sec. 5.4 of Zumdahl, *Chemistry*.
The cylinder volume at standard pressure (V_2) = V_1*(P_1/P_2) = 10.0L*(100 atm/1 atm) = 10000L gas at standard pressure.
10.0L must remain in cylinder at 1 atm.
10000 – 10.0 = 9990 L = 9990 1-L balloons

PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law
MSC: Conceptual

135. Calculate the density of F_2 gas at 26°C and 755 torr.

ANS:
1.54 g/L

See Sec. 5.4 of Zumdahl, *Chemistry*.
MM = *dRT/P*
38.0 = *d**(0.08206)*(273+26)/(755/760)

PTS: 1 DIF: Easy REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | gas density
MSC: Quantitative

136. If equal masses of hydrogen gas and helium gas are placed in the same container, determine the ratio of partial pressure of hydrogen : partial pressure of helium.

ANS:
2

See Sec. 5.5 of Zumdahl, *Chemistry*.
Ratio of partial pressures will be same as ratio of mole fractions.
mole fraction H_2 : mole fraction He = $X_{H2}/2.016$: $X_{He}/4.003$, which reduces to 2:1

PTS: 1 DIF: Moderate REF: 5.5
KEY: Chemistry | general chemistry | phases | gas | gas mixtures | Dalton's law of partial pressures MSC: Quantitative

137. A manometer is attached to a sample of gas that occupies a volume of 2.34 liters. The mercury level in arm of the manometer attached to the gas sample is 24.3 torr lower than that of the arm open to the atmosphere. Atmospheric pressure is measured to be 1.23 atm. What is the pressure of the sample of gas?

A) 23.1 torr
B) 25.5 torr
C) 911 torr
D) 935 torr
E) 959 torr

ANS: E PTS: 1 DIF: Moderate REF: 5.1
KEY: Chemistry | general chemistry | phases | gas | gas pressure MSC: Quantitative

138. A sample of a gas occupies a volume of 2.62 liters at 25 °C and 1.00 atm. What will be the volume at 50.0 °C and 2.00 atm?
A) 1.42 liters
B) 2.62 liters
C) 4.83 liters
D) 5.68 liters
E) 10.5 liters

ANS: A PTS: 1 DIF: Easy REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | combined gas law
MSC: Quantitative

139. A chemical reaction produced 10.1 cm^3 of nitrogen gas at 23 °C and 746 mmHg. What is the volume of this gas if the temperature and pressure are changed to 0 °C and 760 mmHg?
A) 9.14 cm^3
B) 9.49 cm^3
C) 10.8 cm^3
D) 11.2 cm^3
E) 10.1 cm^3

ANS: A PTS: 1 DIF: Easy REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | combined gas law
MSC: Quantitative

140. A sample of gas occupies 20.0 liters at 32 °C when the pressure is 0.750 atm. What temperature in °C is required to increase the volume to 25.0 liters at a pressure of 0.680 atm?
A) -3.90 °C
B) 309 °C
C) 72.7 °C
D) 346 °C
E) 36.1 °C

ANS: C PTS: 1 DIF: Easy REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | combined gas law
MSC: Quantitative

141. What will be the pressure of a sample of 48.0 grams of oxygen gas in a glass container of volume 5.2 L at 25 °C?
A) 0.591 atm
B) 1.18 atm

C) 7.05 atm
D) 14.1 atm
E) 226 atm

ANS: C PTS: 1 DIF: Easy REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | empirical gas laws | ideal gas law
MSC: Quantitative

142. A sample of nitrous oxide, N_2O, occupies 16,500 mL at STP. What is the mass of the sample?
A) 18.9
B) 22.1
C) 22.8
D) 32.4
E) 46.0

ANS: D PTS: 1 DIF: Easy REF: 5.3
KEY: Chemistry | general chemistry | phases | gas | empirical gas laws | ideal gas law
MSC: Quantitative

143. A sample of an unknown gas takes 434 s to diffuse through a porous plug at a given temperature. At the same temperature, $N_2(g)$ takes 175 s to diffuse through the same plug. What is the molar mass of the unknown gas?
A) 172 g/mol
B) 69.1 g/mol
C) 44.0 g/mol
D) 11.3 g/mol
E) 21.1 g/mol

ANS: A PTS: 1 DIF: Moderate REF: 5.7
KEY: Chemistry | general chemistry | phases | gas | molecular speed | diffusion
MSC: Quantitative

144. What is the density of oxygen gas, in g per liter, at 25 °C and 0.850 atm?
A) 1.11
B) 0.901
C) 0.556
D) 1.33
E) 0.750

ANS: A PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | gas density
MSC: Quantitative

145. Which of the following statements is false?
A) The density of a gas is directly proportional to the external pressure.
B) The density of helium gas is double that of hydrogen gas.
C) The density of a gas is indirectly proportional to the temperature in Kelvin.
D) All gases have the same density at STP.
E) The density of a gas is independent of the volume.

ANS: D PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | gas density
MSC: Conceptual

146. Consider the reaction between Mg(s) and HCl(aq) to produce aqueous magnesium chloride and hydrogen gas. How many liters of hydrogen gas at STP will be produced when 12.15 g of magnesium reacts with an excess of hydrochloric acid?
A) 1.00 L
B) 2.00 L
C) 5.60 L
D) 11.2 L
E) 22.4 L

ANS: D PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | stoichiometry and gas volumes MSC: Quantitative

147. Consider the reaction between ethane (C_2H_6) and oxygen gas (O_2) to produce carbon dioxide and water, as shown. What volume of carbon dioxide will be produced at STP from the reaction of 4.00 L of ethane with 7.00 L of oxygen?
A) 2.00 L CO_2
B) 3.00 L CO_2
C) 4.00 L CO_2
D) 6.00 L CO_2
E) 8.00 L CO_2

ANS: C PTS: 1 DIF: Moderate REF: 5.4
KEY: Chemistry | general chemistry | phases | gas | ideal gas law | stoichiometry and gas volumes MSC: Quantitative

148. At a given temperature and pressure, a sample of Gas A is observed to diffuse twice as fast as a sample of a different gas, B. Based on this:
A) The molar mass of A is one fourth that of B
B) The molar mass of A is one half that of B
C) The molar mass of A is 0.707 times that of B
D) The molar mass of A is 1.414 times that of B
E) The molar mass of A is four times that of B

ANS: A PTS: 1 DIF: Moderate REF: 5.7
KEY: Chemistry | general chemistry | phases | gas | molecular speed | diffusion
MSC: Conceptual

149. A gas is found to diffuse at half the rate of methane (CH_4). Which of the following could be this gas?

A) O_2
B) N_2
C) CO_2
D) SO_2
E) C_2H_6

ANS: D PTS: 1 DIF: Moderate REF: 5.7
KEY: Chemistry | general chemistry | phases | gas | molecular speed | diffusion
MSC: Conceptual

150. Calculate the ratio of the rate of effusion of CO_2 to He.
A) 0.090/1
B) 0.30/1
C) 3.3/1
D) 11/1
E) 12/1

ANS: B PTS: 1 DIF: Moderate REF: 5.7
KEY: Chemistry | general chemistry | phases | gas | molecular speed | effusion
MSC: Quantitative

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Chapter 6: Thermochemistry

1. A gas absorbs 0.0 J of heat and then performs 30.7 J of work. The change in internal energy of the gas is
   A) 61.4 J
   B) 30.7 J
   C) –61.4 J
   D) –30.7 J
   E) none of these

   ANS: D PTS: 1 DIF: Easy REF: 6.1
   KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | energy | internal energy MSC: Quantitative

2. What is the kinetic energy of a 1.56-kg object moving at 94.0 km/hr?
   A) 5.32×10^2 kJ
   B) 6.89×10^3 kJ
   C) 5.32×10^{-4} kJ
   D) 1.06×10^3 kJ
   E) 2.04×10^1 kJ

   ANS: A PTS: 1 DIF: Moderate REF: 6.1
   KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | energy | kinetic energy MSC: Quantitative

3. Which of the following statements correctly describes the signs of q and w for the following exothermic process at P = 1 atm and T = 370 K?

   $$H_2O(g) \rightarrow H_2O(l)$$

   A) q and w are negative.
   B) q is positive, w is negative.
   C) q is negative, w is positive.
   D) q and w are both positive.
   E) q and w are both zero.

   ANS: C PTS: 1 DIF: Easy REF: 6.1
   KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | energy | internal energy MSC: Conceptual

4. For a particular process q = 20 kJ and w = 15 kJ. Which of the following statements is true?
   A) Heat flows from the system to the surroundings.
   B) The system does work on the surroundings.
   C) ΔE = 35 kJ
   D) All of the above are true.
   E) None of the above are true.

   ANS: C PTS: 1 DIF: Easy REF: 6.1
   KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | energy | internal energy MSC: Conceptual

5. Which of the following statements is correct?

A) The internal energy of a system increases when more work is done by the system than heat was flowing into the system.
B) The internal energy of a system decreases when work is done on the system and heat is flowing into the system.
C) The system does work on the surroundings when an ideal gas expands against a constant external pressure.
D) All statements are true.
E) All statements are false.

ANS: C PTS: 1 DIF: Easy REF: 6.1
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | energy | internal energy MSC: Conceptual

6. For a particular process $q = -17$ kJ and $w = 21$ kJ. Which of the following statements is *false*?
A) Heat flows from the system to the surroundings.
B) The system does work on the surroundings.
C) $\Delta E = +4$ kJ
D) The process is exothermic.
E) None of the above is false.

ANS: B PTS: 1 DIF: Easy REF: 6.1
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | energy | internal energy MSC: Conceptual

7. One mole of an ideal gas is expanded from a volume of 1.00 liter to a volume of 8.93 liters against a constant external pressure of 1.00 atm. How much work (in joules) is performed on the surroundings? Ignore significant figures for this problem. (T = 300 K; 1 L·atm = 101.3 J)
A) 402 J
B) 803 J
C) 2.41×10^3 J
D) 905 J
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 6.1
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | first law of thermodynamics MSC: Quantitative

8. Calculate the work for the expansion of CO_2 from 1.0 to 4.7 liters against a pressure of 1.0 atm at constant temperature.
A) 3.7 L·atm
B) 4.7 L·atm
C) 0 L·atm
D) –3.7 L·atm
E) –4.7 L·atm

ANS: D PTS: 1 DIF: Easy REF: 6.1
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | first law of thermodynamics MSC: Quantitative

9. A fuel-air mixture is placed in a cylinder fitted with a piston. The original volume is 0.310-L. When the mixture is ignited, gases are produced and 935 J of energy is released. To what volume will the gases expand against a constant pressure of 635 mmHg, if all the energy released is converted to work to push the piston?
   A) 10.7 L
   B) 8.02 L
   C) 11.4 L
   D) 11.0 L
   E) 1.78 L

   ANS: C PTS: 1 DIF: Moderate REF: 6.1
   KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | first law of thermodynamics MSC: Quantitative

10. Which statement is *true* of a process in which one mole of a gas is expanded from state A to state B?
   A) When the gas expands from state A to state B, the surroundings are doing work on the system.
   B) The amount of work done in the process must be the same, regardless of the path.
   C) It is not possible to have more than one path for a change of state.
   D) The final volume of the gas will depend on the path taken.
   E) The amount of heat released in the process will depend on the path taken.

   ANS: E PTS: 1 DIF: Moderate REF: 6.1
   KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | first law of thermodynamics MSC: Conceptual

11. Calculate the work associated with the expansion of a gas from 42.0 L to 79.0 L at a constant pressure of 14.0 atm.
   A) 518 L·atm
   B) –518 L·atm
   C) -1.11×10^3 L·atm
   D) 588 L·atm
   E) 1.11×10^3 L·atm

   ANS: B PTS: 1 DIF: Easy REF: 6.1
   KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | first law of thermodynamics MSC: Quantitative

12. Calculate the work associated with the compression of a gas from 121.0 L to 80.0 L at a constant pressure of 13.1 atm.
   A) –537 L atm
   B) 537 L atm
   C) 3.13 L atm
   D) –3.13 L atm
   E) 101 L atm

   ANS: B PTS: 1 DIF: Easy REF: 6.1
   KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | first law of thermodynamics MSC: Quantitative

13. According to the first law of thermodynamics, the energy of the universe is constant. Does this mean that ΔE is always equal to zero?
    A) Yes, $\Delta E = 0$ at all times, which is why $q = -w$.
    B) No, ΔE does not always equal zero, but this is only due to factors like friction and heat.
    C) No, ΔE does not always equal zero because it refers to the system's internal energy, which is affected by heat and work.
    D) No, ΔE never equals zero because work is always being done on the system or by the system.
    E) No, ΔE never equals zero because energy is always flowing between the system and surroundings.

    ANS: C PTS: 1 DIF: Easy REF: 6.1
    KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | first law of thermodynamics MSC: Conceptual

Consider a gas in a 1.0 L bulb at STP that is connected via a valve to another bulb that is initially evacuated. Answer the following concerning what occurs when the valve between the two bulbs is opened.

14. What is true about the value of q?
    A) It is greater than zero.
    B) It is equal to zero.
    C) It is less than zero.
    D) More information is needed.
    E) None of these.

    ANS: B PTS: 1 DIF: Easy REF: 6.1
    KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | enthalpy
    MSC: Conceptual

15. What is true about the value of w?
    A) It is greater than zero.
    B) It is equal to zero.
    C) It is less than zero.
    D) More information is needed.
    E) None of these.

    ANS: B PTS: 1 DIF: Easy REF: 6.1
    KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | first law of thermodynamics MSC: Conceptual

16. What is true about the value of ΔE?
    A) It is greater than zero.
    B) It is equal to zero.
    C) It is less than zero.
    D) More information is needed.
    E) None of these.

    ANS: B PTS: 1 DIF: Easy REF: 6.1

KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | energy | internal energy MSC: Conceptual

17. What is true about the value of ΔH?
    A) It is greater than zero.
    B) It is equal to zero.
    C) It is less than zero.
    D) More information is needed.
    E) None of these.

    ANS: B PTS: 1 DIF: Easy REF: 6.2
    KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | enthalpy | enthalpy and internal energy MSC: Conceptual

18. A property that is independent of the pathway is called an intensive property.

    ANS: F PTS: 1 DIF: Easy REF: 6.1
    KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | first law of thermodynamics MSC: Conceptual

19. A state function does not depend on the system's past or future.

    ANS: T PTS: 1 DIF: Easy REF: 6.1
    KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | first law of thermodynamics MSC: Conceptual

20. When a system performs work on the surroundings, the work is reported with a negative sign.

    ANS: T PTS: 1 DIF: Easy REF: 6.1
    KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | first law of thermodynamics MSC: Conceptual

21. In exothermic reaction, potential energy stored in chemical bonds is being converted to thermal energy via heat.

    ANS: T PTS: 1 DIF: Easy REF: 6.1
    KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | energy | potential energy MSC: Conceptual

22. Of energy, work, enthalpy, and heat, how many are state functions?
    A) 0
    B) 1
    C) 2
    D) 3
    E) 4

    ANS: C PTS: 1 DIF: Easy REF: 6.2
    KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | first law of thermodynamics MSC: Conceptual

23. Which of the following properties is (are) intensive properties?
I. mass
II. temperature
III. volume
IV. concentration
V. energy
A) I, III, and V
B) II only
C) II and IV
D) III and IV
E) I and V

ANS: C PTS: 1 DIF: Easy REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | enthalpy | enthalpy change MSC: Conceptual

24. For the reaction $H_2O(l) \rightarrow H_2O(g)$ at 298 K and 1.0 atm, ΔH is more positive than ΔE by 2.5 kJ/mol. This quantity of energy can be considered to be
A) the heat flow required to maintain a constant temperature
B) the work done in pushing back the atmosphere
C) the difference in the H–O bond energy in $H_2O(l)$ compared to $H_2O(g)$
D) the value of ΔH itself
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | enthalpy | enthalpy and internal energy MSC: Conceptual

25. Which one of the following statements is *false*?
A) The change in internal energy, ΔE, for a process is equal to the amount of heat absorbed at constant volume, q_v.
B) The change in enthalpy, ΔH, for a process is equal to the amount of heat absorbed at constant pressure, q_p.
C) A bomb calorimeter measures ΔH directly.
D) If q_p for a process is negative, the process is exothermic.
E) The freezing of water is an example of an exothermic reaction.

ANS: C PTS: 1 DIF: Moderate REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction
MSC: Conceptual

26. $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$, $\Delta H = -1.37 \times 10^3$ kJ
For the combustion of ethyl alcohol as described in the above equation, which of the following is true?
I. The reaction is exothermic.
II. The enthalpy change would be different if gaseous water was produced.
III. The reaction is not an oxidation–reduction one.
IV. The products of the reaction occupy a larger volume than the reactants.

A) I, II
B) I, II, III
C) I, III, IV
D) III, IV
E) only I

ANS: A PTS: 1 DIF: Easy REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction
MSC: Conceptual

27. Consider the reaction:

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l);\ \Delta H = -1.37 \times 10^3\ \text{kJ}$$

Consider the following propositions:

I. The reaction is endothermic

II. The reaction is exothermic.

III. The enthalpy term would be different if the water formed was gaseous.

Which of these propositions is (are) true?

A) I
B) II
C) III
D) I, II
E) II, III

ANS: E PTS: 1 DIF: Moderate REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction
MSC: Conceptual

28. How much heat is required to raise the temperature of a 5.75-g sample of iron (specific heat = 0.450 J/g°C) from 25.0°C to 79.8°C?

A) 2.54 J
B) 315 J
C) 700 J
D) 848 J
E) 142 J

ANS: E PTS: 1 DIF: Easy REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry
MSC: Quantitative

29. Two metals of equal mass with different heat capacities are subjected to the same amount of heat. Which undergoes the smallest change in temperature?

A) The metal with the higher heat capacity.
B) The metal with the lower heat capacity.
C) Both undergo the same change in temperature.
D) You need to know the initial temperatures of the metals.
E) You need to know which metals you have.

ANS: A PTS: 1 DIF: Easy REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry | heat capacity MSC: Conceptual

30. A 32.5 g piece of aluminum (which has a molar heat capacity of 24.03 J/°C·mol) is heated to 82.4°C and dropped into a calorimeter containing water (specific heat capacity of water is 4.18 J/g°C) initially at 22.3°C. The final temperature of the water is 24.2°C. Ignoring significant figures, calculate the mass of water in the calorimeter.
A) 212 g
B) 5.72 kg
C) 6.42 g
D) 1.68 kg
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry
MSC: Quantitative

31. A 45.9 g sample of a metal is heated to 95.2°C and then placed in a calorimeter containing 120.0 g of water (c = 4.18 J/g°C) at 21.6°C. The final temperature of the water is 24.5°C. Which metal was used?
A) Aluminum (c = 0.89 J/g°C)
B) Iron (c = 0.45 J/g°C)
C) Copper (c = 0.20 J/g°C)
D) Lead (c = 0.14 J/g°C)
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry | specific heat MSC: Quantitative

32. You take 295.5 g of a solid at 30.0°C and let it melt in 425 g of water. The water temperature decreases from 85.1°C to 30.0°C. Calculate the heat of fusion of this solid.
A) 160 J/g
B) 166 J/g
C) 331 J/g
D) 721 J/g
E) cannot solve without the heat capacity of the solid

ANS: C PTS: 1 DIF: Moderate REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry
MSC: Quantitative

33. The enthalpy of fusion of ice is 6.020 kJ/mol. The heat capacity of liquid water is 75.4 J/mol·°C. What is the smallest number of ice cubes at 0°C, each containing one mole of water, necessary to cool 500 g of liquid water initially at 20°C to 0°C?
A) 1
B) 7
C) 14
D) 15
E) 126

ANS: B PTS: 1 DIF: Moderate REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry

MSC: Conceptual

34. 30.0 mL of pure water at 282 K is mixed with 50.0 mL of pure water at 306 K. What is the final temperature of the mixture?
A) 294 K
B) 297 K
C) 342 K
D) 588 K
E) 24 K

ANS: B PTS: 1 DIF: Moderate REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry
MSC: Quantitative

35. Consider the reaction

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(l) \qquad \Delta H° = -286 \text{ kJ}$$

Which of the following is true?
A) The reaction is exothermic.
B) The reaction is endothermic.
C) The enthalpy of the products is less than that of the reactants.
D) Heat is absorbed by the system.
E) Both A and C are true.

ANS: E PTS: 1 DIF: Easy REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | heat | heats of reaction MSC: Conceptual

36. In the lab, you mix two solutions (each originally at the same temperature) and the temperature of the resulting solution decreases. Which of the following is true?
A) The chemical reaction is releasing energy.
B) The energy released is equal to $s \times m \times \Delta T$.
C) The chemical reaction is absorbing energy.
D) The chemical reaction is exothermic.
E) More than one of these.

ANS: C PTS: 1 DIF: Easy REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry
MSC: Conceptual

37. What is the specific heat capacity of a metal if it requires 178.1 J to change the temperature of 15.0 g of the metal from 25.00°C to 32.00°C?
A) 0.590 J/g°C
B) 11.9 J/g°C
C) 25.4 J/g°C
D) 1.70 J/g°C
E) 283 J/g°C

ANS: D PTS: 1 DIF: Easy REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry | specific heat MSC: Quantitative

38. A 140.0-g sample of water at 25.0°C is mixed with 111.7 g of a certain metal at 100.0°C. After thermal equilibrium is established, the (final) temperature of the mixture is 29.6°C. What is the specific heat capacity of the metal, assuming it is constant over the temperature range concerned?
A) 0.34 J/g°C
B) 0.68 J/g°C
C) 0.22 J/g°C
D) 2.9 J/g°C
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry | specific heat MSC: Quantitative

39. If 5.0 kJ of energy is added to a 15.5-g sample of water at 10.°C, the water is
A) boiling
B) completely vaporized
C) frozen solid
D) decomposed
E) still a liquid

ANS: E PTS: 1 DIF: Moderate REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry | heat capacity MSC: Conceptual

40. Exactly 123.7 J will raise the temperature of 10.0 g of a metal from 25.0°C to 60.0°C. What is the specific heat capacity of the metal?
A) 2.83 J/g°C
B) 0.353 J/g°C
C) 24.9 J/g°C
D) 29.6 J/g°C
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry | specific heat MSC: Quantitative

41. A chunk of lead at 91.6°C was added to 200.0 g of water at 15.5°C. The specific heat of lead is 0.129 J/g°C, and the specific heat of water is 4.18 J/g°C. When the temperature stabilized, the temperature of the mixture was 17.9°C. Assuming no heat was lost to the surroundings, what was the mass of lead added?
A) 1.57 kg
B) 170 g
C) 204 g
D) 211 g
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry | specific heat MSC: Quantitative

42. On a cold winter day, a steel metal fence post feels colder than a wooden fence post of identical size because:
    A) The specific heat capacity of steel is higher than the specific heat capacity of wood.
    B) The specific heat capacity of steel is lower than the specific heat capacity of wood.
    C) Steel has the ability to resist a temperature change better than wood.
    D) The mass of steel is less than wood so it loses heat faster.
    E) Two of the above statements are true.

    ANS: B PTS: 1 DIF: Easy REF: 6.2
    KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry | specific heat MSC: Conceptual

43. What is the specific heat capacity of silver if it requires 86.3 J to raise the temperature of 15 grams of silver by 25°C?
    A) 4.3 J/g°C
    B) 0.23 J/g°C
    C) 0.14 J/g°C
    D) 0.60 J/g°C
    E) none of these

    ANS: B PTS: 1 DIF: Easy REF: 6.2
    KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry | specific heat MSC: Quantitative

44. A 4.4-g sample of Colorado oil shale is burned in a bomb calorimeter, which causes the temperature of the calorimeter to increase by 5.0°C. The calorimeter contains 1.00 kg of water (heat capacity of H_2O = 4.184 J/g°C) and the heat capacity of the empty calorimeter is 0.10 kJ/°C. How much heat is released per gram of oil shale when it is burned?
    A) 21 kJ/g
    B) 42 kJ/g
    C) 0 kJ/g
    D) 4.9 kJ/g
    E) 0.21 kJ/g

    ANS: D PTS: 1 DIF: Moderate REF: 6.2
    KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry | measuring heats of reaction MSC: Quantitative

45. If a student performs an endothermic reaction in a calorimeter, how does the calculated value of ΔH differ from the actual value if the heat exchanged with the calorimeter is not taken into account?
    A) ΔH_{calc} would be more negative because the calorimeter always absorbs heat from the reaction.
    B) ΔH_{calc} would be less negative because the calorimeter would absorb heat from the reaction.
    C) ΔH_{calc} would be more positive because the reaction absorbs heat from the calorimeter.
    D) ΔH_{calc} would be less positive because the reaction absorbs heat from the

calorimeter.

E) ΔH_{calc} would equal the actual value because the calorimeter does not absorb heat.

ANS: D PTS: 1 DIF: Moderate REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry | measuring heats of reaction MSC: Conceptual

46. A bomb calorimeter has a heat capacity of 2.47 kJ/K. When a 0.109-g sample of ethylene (C_2H_4) was burned in this calorimeter, the temperature increased by 2.22 K. Calculate the energy of combustion for one mole of ethylene.

A) –5.29 kJ/mol
B) –50.3 kJ/mol
C) –636 kJ/mol
D) –0.269 kJ/mol
E) -1.41×10^3 kJ/mol

ANS: E PTS: 1 DIF: Moderate REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry | measuring heats of reaction MSC: Quantitative

47. Consider the reaction:

$$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l), \Delta H = -1.37 \times 10^3 \text{ kJ}$$

When a 21.1-g sample of ethyl alcohol (molar mass = 46.07 g/mol) is burned, how much energy is released as heat?

A) 0.458 kJ
B) 0.627 kJ
C) 6.27×10^2 kJ
D) 2.89×10^4 kJ
E) 2.18 kJ

ANS: C PTS: 1 DIF: Easy REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | thermochemical equation | stoichiometry and heats of reaction MSC: Quantitative

48. The ΔH value for the reaction $\frac{1}{2}O_2(g) + Hg(l) \rightarrow HgO(s)$ is -90.8 kJ. How much heat is released when 66.9 g Hg is reacted with oxygen?

A) 0.333 kJ
B) 6.07×10^3 kJ
C) 30.3 kJ
D) 90.8 kJ
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | thermochemical equation | stoichiometry and heats of reaction MSC: Quantitative

49. The total volume of hydrogen gas needed to fill the Hindenburg was 2.11×10^8 L at 1.00 atm and 24.7°C. How much energy was evolved when it burned?

$$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l), \Delta H = -286 \text{ kJ}$$

A) 8.64×10^6 kJ
B) 2.98×10^{10} kJ
C) 3.02×10^4 kJ
D) 2.47×10^9 kJ
E) 4.94×10^9 kJ

ANS: D PTS: 1 DIF: Moderate REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | thermochemical equation | stoichiometry and heats of reaction MSC: Quantitative

50. $CH_4(g) + 4Cl_2(g) \rightarrow CCl_4(g) + 4HCl(g)$, $\Delta H = -434$ kJ
Based on the above reaction, what energy change occurs when 1.2 moles of methane (CH_4) reacts?
A) 5.2×10^5 J are released.
B) 5.2×10^5 J are absorbed.
C) 3.6×10^5 J are released.
D) 3.6×10^5 J are absorbed.
E) 4.4×10^5 J are released.

ANS: A PTS: 1 DIF: Easy REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | thermochemical equation | stoichiometry and heats of reaction MSC: Quantitative

51. Given the equation $S(s) + O_2(g) \rightarrow SO_2(g)$, $\Delta H = -296$ kJ, which of the following statement(s) is (are) true?
I. The reaction is exothermic.
II. When 0.500 mole sulfur is reacted, 148 kJ of energy is released.
III. When 32.0 g of sulfur are burned, 2.96×10^5 J of energy is released.
A) All are true.
B) None is true.
C) I and II are true.
D) I and III are true.
E) Only II is true.

ANS: A PTS: 1 DIF: Moderate REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | thermochemical equation | stoichiometry and heats of reaction MSC: Conceptual

52. When 0.236 mol of a weak base (A^-) is reacted with excess HCl, 6.91 kJ of energy is released as heat. What is ΔH for this reaction per mole of A^- consumed?
A) –34.2 kJ
B) –59.4 kJ
C) –29.3 kJ
D) 34.2 kJ
E) 29.3 kJ

ANS: C PTS: 1 DIF: Easy REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | thermochemical equation | stoichiometry and heats of reaction MSC: Quantitative

53. What is the enthalpy change when 49.4 mL of 0.430 *M* sulfuric acid reacts with 23.3 mL of 0.309 *M* potassium hydroxide?
$H_2SO_4(aq) + 2KOH(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$ $\Delta H° = -111.6$ kJ/mol

A) –0.402 kJ
B) –3.17 kJ
C) –2.37 kJ
D) –0.803 kJ
E) –112 kJ

ANS: A PTS: 1 DIF: Moderate REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | enthalpy | enthalpy change MSC: Quantitative

54. How much heat is liberated at constant pressure when 2.35 g of potassium metal reacts with 5.68 mL of liquid iodine monochloride (d = 3.24 g/mL)?
$2K(s) + ICl(l) \rightarrow KCl(s) + KI(s)$ $\Delta H° = -740.71$ kJ/mol

A) 2.22×10^3 kJ
B) 8.40×10^1 kJ
C) 1.28×10^2 kJ
D) 2.23×10^1 kJ
E) 7.41×10^2 kJ

ANS: D PTS: 1 DIF: Moderate REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | enthalpy | enthalpy change MSC: Quantitative

55. Consider the following specific heats of metals.

Metal	Specific Heat
Zinc	0.387 J/(g°C)
Magnesium	1.02 J/(g°C)
Iron	0.450 J/(g°C)
Silver	0.237 J/(g°C)
Lead	0.127 J/(g°C)

If the same amount of heat is added to 25.0 g of each of the metals, which are all at the same initial temperature, which metal will have the highest temperature?
A) Zinc
B) Magnesium
C) Iron
D) Silver
E) Lead

ANS: E PTS: 1 DIF: Easy REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry | specific heat MSC: Conceptual

56. The heat of combustion of benzene, C_6H_6, is –41.74 kJ/g. Combustion of 2.82 g of benzene causes a temperature rise of 3.29°C in a certain bomb calorimeter. What is the heat capacity of this bomb calorimeter?

A) 387 kJ/°C
B) 35.8 kJ/°C
C) 0.222 kJ/°C
D) 5.96 kJ/°C
E) 118 kJ/°C

ANS: B PTS: 1 DIF: Moderate REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry | heat capacity MSC: Quantitative

57. The specific heat capacities of metals are relatively low.

ANS: T PTS: 1 DIF: Easy REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry | specific heat MSC: Conceptual

58. The change in enthalpy can always be thought of as equal to energy flow as heat.

ANS: F PTS: 1 DIF: Easy REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | enthalpy
MSC: Conceptual

59. Which of the following statements is/are true?
I. q (heat) is a state function because ΔH is a state function and $q = \Delta H$.
II. When 50.0 g of aluminum at 20.0°C is placed in 50.0 mL of water at 30.0°C, the H_2O will undergo a smaller temperature change than the aluminum. (The density of H_2O = 1.0 g/mL, specific heat capacity of H_2O = 4.18 J/g°C, specific heat capacity of aluminum = 0.89 J/g°C)
III. When a gas is compressed, the work is negative since the surroundings are doing work on the system and energy flows out of the system.
IV. For the reaction (at constant pressure) $2N_2(g) + 5O_2(g) \rightarrow 2N_2O_5(g)$, the change in enthalpy is the same whether the reaction takes place in one step or in a series of steps.

A) I, II, IV
B) II, III
C) II, III, IV
D) II, IV
E) All of the above statements are true.

ANS: D PTS: 1 DIF: Moderate REF: 6.3
KEY: Chemistry | general chemistry | thermochemistry MSC: Conceptual

60. Consider the following processes:

$2A \rightarrow (1/2)B + C$ $\Delta H_1 = 5$ kJ/mol

$(3/2)B + 4C \rightarrow 2A + C + 3D$ $\Delta H_2 = -15$ kJ/mol

$E + 4A \rightarrow C$ $\Delta H_3 = 10$ kJ/mol

Calculate ΔH for: $C \rightarrow E + 3D$

A) 0 kJ/mol
B) 10 kJ/mol
C) –10 kJ/mol
D) –20 kJ/mol
E) 20 kJ/mol

ANS: C PTS: 1 DIF: Moderate REF: 6.3
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | Hess's law
MSC: Quantitative

61. Consider the following processes:

	ΔH (kJ/mol)
$3B \rightarrow 2C + D$	–125
$(1/2)A \rightarrow B$	150
$E + A \rightarrow D$	350

Calculate ΔH for: $B \rightarrow E + 2C$
A) 325 kJ/mol
B) 525 kJ/mol
C) –175 kJ/mol
D) –325 kJ/mol
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 6.3
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | Hess's law
MSC: Quantitative

62. Consider the following numbered processes:
1. $A \rightarrow 2B$
2. $B \rightarrow C + D$
3. $E \rightarrow 2D$

ΔH for the process $A \rightarrow 2C + E$ is
A) $\Delta H_1 + \Delta H_2 + \Delta H_3$
B) $\Delta H_1 + \Delta H_2$
C) $\Delta H_1 + \Delta H_2 - \Delta H_3$
D) $\Delta H_1 + 2\Delta H_2 - \Delta H_3$
E) $\Delta H_1 + 2\Delta H_2 + \Delta H_3$

ANS: D PTS: 1 DIF: Easy REF: 6.3
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | Hess's law
MSC: Conceptual

63. At 25°C, the following heats of reaction are known:

	ΔH (kJ/mol)
$2ClF + O_2 \rightarrow Cl_2O + F_2O$	167.4
$2ClF_3 + 2O_2 \rightarrow Cl_2O + 3F_2O$	341.4

$2F_2 + O_2 \rightarrow 2F_2O$ –43.4

At the same temperature, calculate ΔH for the reaction: $ClF + F_2 \rightarrow ClF_3$

A) –217.5 kJ/mol
B) –130.2 kJ/mol
C) +217.5 kJ/mol
D) –108.7 kJ/mol
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 6.3
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | Hess's law
MSC: Quantitative

64. Calculate $\Delta H°$ for the reaction $C_4H_4(g) + 2H_2(g) \rightarrow C_4H_8(g)$, using the following data:

$\Delta H°_{combustion}$ for $C_4H_4(g)$ = –2341 kJ/mol
$\Delta H°_{combustion}$ for $H_2(g)$ = –286 kJ/mol
$\Delta H°_{combustion}$ for $C_4H_8(g)$ = –2755 kJ/mol

A) –128 kJ
B) –158 kJ
C) 128 kJ
D) 158 kJ
E) none of these

ANS: B PTS: 1 DIF: Difficult REF: 6.3
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | Hess's law
MSC: Quantitative

65. Given the heats of the following reactions:

		$\Delta H°$(kJ)
I.	$P_4(s) + 6Cl_2(g) \rightarrow 4PCl_3(g)$	–1225.6
II.	$P_4(s) + 5O_2(g) \rightarrow P_4O_{10}(s)$	–2967.3
III.	$PCl_3(g) + Cl_2(g) \rightarrow PCl_5(g)$	–84.2
IV.	$PCl_3(g) + \frac{1}{2}O_2(g) \rightarrow Cl_3PO(g)$	–285.7

Calculate the value of $\Delta H°$ for the reaction below:

$$P_4O_{10}(s) + 6PCl_5(g) \rightarrow 10Cl_3PO(g)$$

A) –110.5 kJ
B) –610.1 kJ
C) –2682.2 kJ
D) –7555.0 kJ
E) None of these is within 5% of the correct answer.

ANS: B PTS: 1 DIF: Moderate REF: 6.3
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | Hess's law
MSC: Quantitative

66. Using the following thermochemical data:

$2Cr(s) + 6HF(g) \rightarrow 2CrF_3(s) + 3H_2(g)$ $\Delta H° = –691.4$ kJ/mol
$2Cr(s) + 6HCl(g) \rightarrow 2CrCl_3(s) + 3H_2(g)$ $\Delta H° = –559.2$ kJ/mol

calculate $\Delta H°$ for the following reaction:
$CrF_3(s) + 3HCl(g) \rightarrow CrCl_3(s) + 3HF(g)$
A) –1250.6 kJ/mol
B) 132.2 kJ/mol
C) 66.1 kJ/mol
D) 264.4 kJ/mol
E) –625.3 kJ/mol

ANS: C PTS: 1 DIF: Easy REF: 6.3
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | Hess's law
MSC: Quantitative

67. Using the following thermochemical data, calculate $\Delta H_f°$ of $Tm_2O_3(s)$.
$2TmCl_3(s) + 3H_2O(l) \rightarrow Tm_2O_3(s) + 6HCl(g)$ $\Delta H° = 388.1$ kJ/mol
$2Tm(s) + 3Cl_2(g) \rightarrow 2TmCl_3(s)$ $\Delta H° = –1973.2$ kJ/mol
$4HCl(g) + O_2(g) \rightarrow 2Cl_2(g) + 2H_2O(l)$ $\Delta H° = –202.4$ kJ/mol

A) –1888.7 kJ/mol
B) –1787.5 kJ/mol
C) 2563.7 kJ/mol
D) –2158.9 kJ/mol
E) 1382.7 kJ/mol

ANS: A PTS: 1 DIF: Moderate REF: 6.3
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | Hess's law
MSC: Quantitative

68. The heat of formation of $Fe_2O_3(s)$ is –826.0 kJ/mol. Calculate the heat of the reaction $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$ when a 53.99-g sample of iron is reacted.
A) –199.6 kJ
B) –399.2 kJ
C) –798.5 kJ
D) –1597 kJ
E) $–2.230 \times 10^4$ kJ

ANS: B PTS: 1 DIF: Easy REF: 6.4
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | standard enthalpies of formation MSC: Quantitative

69. Which of the following does *not* have a standard enthalpy of formation equal to zero at 25°C and 1.0 atm?
A) $F_2(g)$
B) $Al(s)$
C) $H_2O(l)$
D) $H_2(g)$
E) They all have a standard enthalpy equal to zero.

ANS: C PTS: 1 DIF: Easy REF: 6.4
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | standard enthalpies of formation MSC: Conceptual

70. Given the following two reactions at 298 K and 1 atm, which of the statements is true?
1. $N_2(g) + O_2(g) \rightarrow 2NO(g)$ ΔH_1
2. $NO(g) + \frac{1}{2}O_2(g) \rightarrow NO_2(g)$ ΔH_2

A) $\Delta H_f°$ for $NO_2(g) = \Delta H_2$
B) $\Delta H_f°$ for $NO(g) = \Delta H_1$
C) $\Delta H_f° = \Delta H_2$
D) $\Delta H_f°$ for $NO_2(g) = \Delta H_2 + \frac{1}{2}\Delta H_1$
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 6.4
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | standard enthalpies of formation MSC: Conceptual

71. Given:
$Cu_2O(s) + \frac{1}{2}O_2(g) \rightarrow 2CuO(s)$ $\Delta H° = -144$ kJ
$Cu_2O(s) \rightarrow Cu(s) + CuO(s)$ $\Delta H° = +11$ kJ
Calculate the standard enthalpy of formation of $CuO(s)$.
A) –166 kJ
B) –299 kJ
C) +299 kJ
D) +155 kJ
E) –155 kJ

ANS: E PTS: 1 DIF: Moderate REF: 6.4
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | standard enthalpies of formation MSC: Quantitative

72. Using the following data, calculate the standard heat of formation of the compound ICl in kJ/mol:

	$\Delta H°$ (kJ/mol)
$Cl_2(g) \rightarrow 2Cl(g)$	242.3
$I_2(g) \rightarrow 2I(g)$	151.0
$ICl(g) \rightarrow I(g) + Cl(g)$	211.3
$I_2(s) \rightarrow I_2(g)$	62.8

A) –211 kJ/mol
B) –14.6 kJ/mol
C) 16.8 kJ/mol
D) 245 kJ/mol
E) 439 kJ/mol

ANS: C PTS: 1 DIF: Moderate REF: 6.4
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | standard enthalpies of formation MSC: Quantitative

73. The heat combustion of acetylene, $C_2H_2(g)$, at 25°C is –1299 kJ/mol. At this temperature, $\Delta H_f°$ values for $CO_2(g)$ and $H_2O(l)$ are –393 and –286 kJ/mol, respectively. Calculate $\Delta H_f°$ for acetylene.
A) 2376 kJ/mol
B) 625 kJ/mol
C) 227 kJ/mol
D) –625 kJ/mol
E) –227 kJ/mol

ANS: C PTS: 1 DIF: Moderate REF: 6.4
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | standard enthalpies of formation MSC: Quantitative

74. Choose the correct equation for the standard enthalpy of formation of $CO(g)$, where $\Delta H_f°$ for CO = –110.5 kJ/mol (gr indicates graphite).
A) $2C(gr) + O_2(g) \rightarrow 2CO(g)$, $\Delta H° = –110.5$ kJ
B) $C(gr) + O(g) \rightarrow CO(g)$, $\Delta H° = –110.5$ kJ
C) $C(gr) + \frac{1}{2}O_2(g) \rightarrow CO(g)$, $\Delta H° = –110.5$ kJ
D) $C(gr) + CO_2(g) \rightarrow 2CO(g)$, $\Delta H° = –110.5$ kJ
E) $CO(g) \rightarrow C(gr) + O(g)$, $\Delta H° = –110.5$ kJ

ANS: C PTS: 1 DIF: Easy REF: 6.4
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | standard enthalpies of formation MSC: Conceptual

75. For the reaction:
$AgI(s) + \frac{1}{2}Br_2(g) \rightarrow AgBr(s) + \frac{1}{2}I_2(s)$, $\Delta H° = –54.0$ kJ
$\Delta H_f°$ for $AgBr(s) = –100.4$ kJ/mol
$\Delta H_f°$ for $Br_2(g) = +30.9$ kJ/mol
The value of $\Delta H_f°$ for $AgI(s)$ is:
A) –123.5 kJ/mol
B) +77.3 kJ/mol
C) +61.8 kJ/mol
D) –77.3 kJ/mol
E) –61.8 kJ/mol

ANS: E PTS: 1 DIF: Easy REF: 6.4
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | standard enthalpies of formation MSC: Quantitative

76. Using the information below, calculate $\Delta H_f°$ for $PbO(s)$
$PbO(s) + CO(g) \rightarrow Pb(s) + CO_2(g)$ $\Delta H° = –131.4$ kJ
$\Delta H_f°$ for $CO_2(g) = –393.5$ kJ/mol
$\Delta H_f°$ for $CO(g) = –110.5$ kJ/mol
A) –151.6 kJ/mol
B) –283.0 kJ/mol
C) +283.0 kJ/mol
D) –372.6 kJ/mol
E) +252.1 kJ/mol

ANS: A PTS: 1 DIF: Moderate REF: 6.4
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | standard enthalpies of formation MSC: Quantitative

77. For which of the following reaction(s) is the enthalpy change for the reaction *not* equal to $\Delta H_f°$ of the product?

I. $2H(g) \rightarrow H_2(g)$
II. $H_2(g) + O_2(g) \rightarrow H_2O_2(l)$
III. $H_2O(l) + O(g) \rightarrow H_2O_2(l)$

A) I
B) II
C) III
D) I and III
E) II and III

ANS: D PTS: 1 DIF: Moderate REF: 6.4
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | standard enthalpies of formation MSC: Conceptual

78. Consider the reaction:
$2ClF_3(g) + 2NH_3(g) \rightarrow N_2(g) + 6HF(g) + Cl_2(g)$
When calculating the $\Delta H°_{rxn}$, why is the $\Delta H_f°$ for N_2 not important?
A) Because nitrogen is in its standard elemental state and no energy is needed for this product to exist.
B) Because any element or compound in the gaseous state requires a negligible amount of energy to exist.
C) Because the products are not included when calculating $\Delta H°_{rxn}$.
D) Because nitrogen is in its elemental state and does not contribute to the reaction itself.
E) Two of the above statements explain why N_2 is not important when calculating $\Delta H°_{rxn}$.

ANS: A PTS: 1 DIF: Easy REF: 6.4
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | standard enthalpies of formation MSC: Conceptual

79. The following statements concerning petroleum are all true *except*:
A) It is a thick, dark liquid composed mostly of hydrocarbons.
B) It must be separated into fractions (by boiling) in order to be used efficiently.
C) Some of the commercial uses of petroleum fractions include gasoline and kerosene.
D) It was probably formed from the remains of ancient marine organisms.
E) All of its hydrocarbon chains contain the same number of carbon atoms.

ANS: E PTS: 1 DIF: Easy REF: 6.5
KEY: Chemistry | general chemistry | thermochemistry MSC: Conceptual

80. This fossil fuel was formed from the remains of plants that were buried and exposed to high pressure and heat over time.
    A) coal
    B) natural gas
    C) diesel fuel
    D) propane
    E) gasoline

    ANS: A PTS: 1 DIF: Easy REF: 6.5
    KEY: Chemistry | general chemistry | thermochemistry MSC: Conceptual

81. The coal with the highest energy available per unit burned is
    A) Lignite.
    B) Subbituminous.
    C) Bituminous.
    D) Anthracite.
    E) They are equal in energy value.

    ANS: D PTS: 1 DIF: Easy REF: 6.5
    KEY: Chemistry | general chemistry | thermochemistry MSC: Conceptual

82. All of the following statements about the greenhouse effect are true *except*:
    A) It occurs only on earth.
    B) The molecules H_2O and CO_2 play an important role in retaining the atmosphere's heat.
    C) Low humidity allows efficient radiation of heat back into space.
    D) The carbon dioxide content of the atmosphere is quite stable.
    E) A and D

    ANS: E PTS: 1 DIF: Moderate REF: 6.5
    KEY: Chemistry | general chemistry | thermochemistry MSC: Conceptual

83. Which of the following is both a greenhouse gas and a fuel?
    A) carbon dioxide
    B) coal
    C) freon
    D) methane
    E) nitrogen

    ANS: D PTS: 1 DIF: Easy REF: 6.5
    KEY: Chemistry | general chemistry | thermochemistry MSC: Conceptual

84. One of the main advantages of hydrogen as a fuel is that:
    A) The only product of hydrogen combustion is water.
    B) It exists as a free gas.
    C) It can be economically supplied by the world's oceans.
    D) Plants can economically produce the hydrogen needed.
    E) It contains a large amount of energy per unit volume of hydrogen gas.

    ANS: A PTS: 1 DIF: Easy REF: 6.6
    KEY: Chemistry | general chemistry | thermochemistry MSC: Conceptual

85. Which of the following is *not* being considered as an energy source for the future?
A) ethanol
B) methanol
C) seed oil
D) shale oil
E) carbon dioxide

ANS: E PTS: 1 DIF: Easy REF: 6.6
KEY: Chemistry | general chemistry | thermochemistry MSC: Conceptual

86. The combustion of hydrogen gas releases 286 kJ per mol of hydrogen. If 13.0 L of hydrogen at STP was burned to produce electricity, how long would it power a 100-watt (W) light bulb? Assume no energy is lost to the surroundings. (1 W = 1 J/s)
A) 27.7 min
B) 1.92 days
C) 1.66 hr
D) 10.3 hr
E) 4.61 hr

ANS: A PTS: 1 DIF: Moderate REF: 6.6
KEY: Chemistry | general chemistry | thermochemistry MSC: Quantitative

87. The _____ of a system is the sum of the kinetic and potential energies of all the particles in the system.

ANS:
internal energy

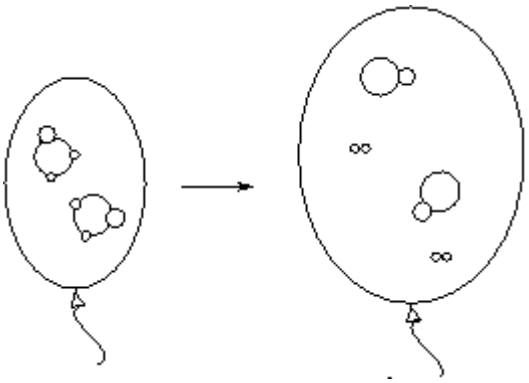
PTS: 1 DIF: Easy REF: 6.1
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | energy | internal energy MSC: Conceptual

88. _____ involves the transfer of energy between two objects due to a temperature difference.

ANS:
Heat

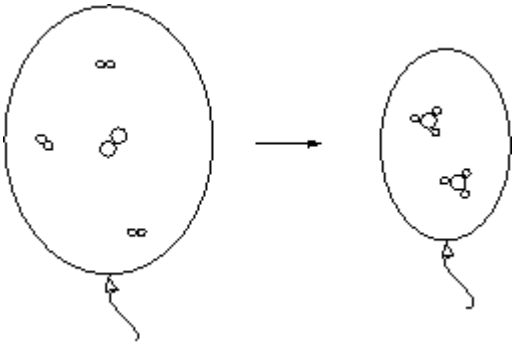
PTS: 1 DIF: Easy REF: 6.1
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | heat
MSC: Conceptual

89. Consider the reaction:
$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$
Assuming this reaction takes place in an elastic balloon with an atmospheric pressure of 1.0 atm, and that you have a stoichiometric mixture of nitrogen and hydrogen, draw a microscopic diagram before and after the reaction occurs. See the example below to assist you.
$ABC_2(g) \rightarrow AB(g) + C_2(g)$ (could be drawn as)



In addition, explain whether *w* (the work done) is positive, negative, or zero.

ANS:



Work (*w*) will be positive since the surroundings are doing work on the system. The balanced reaction has fewer moles of product gases than moles of reactant gases, so the volume will get smaller (ΔV is negative) and the surroundings do compression work on the system.
See Sec. 6.1 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Moderate REF: 6.1
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | first law of thermodynamics MSC: Conceptual

90. Consider the following reaction:

$$2Al(s) + 3Cl_2(g) \rightarrow 2AlCl_3(s); \qquad \Delta H = -1390.81 \text{ kJ}$$

a) Is the reaction exothermic or endothermic?
b) How much heat is produced/required when 10.0 g $AlCl_3$ forms.
c) How many grams of Al are required to absorb/evolve 1.00 kJ of energy?

ANS:
a) Exothermic; b) 52.2 kJ; c) 0.0388 g Al

See Sec. 6.2 of Zumdahl, *Chemistry*.
a) Exothermicity is apparent from the negative ΔH.
b) 10.0 g * (1 mol $AlCl_3$/133.33 g) * (-1390.81 kJ/2 mol $AlCl_3$) = -52.2 kJ = 52.2 kJ produced
c) 1.00 kJ * (2 mol Al/1390.81 kJ) * (26.98 g /mol Al) = 0.0388 g Al

PTS: 1 DIF: Moderate REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction

MSC: Quantitative

To carry out the reaction $N_2 + 2O_2 \rightarrow 2NO_2$ requires 67.7 kJ.
To carry out the reaction $N_2 + 2O_2 \rightarrow N_2O_4$ requires 9.7 kJ.
Consider the reaction $2NO_2 \rightarrow N_2O_4$.

91. How much energy (absolute value) is involved in the reaction $2NO_2 \rightarrow N_2O_4$?

ANS:
58.0 kJ

Apply Hess's law, see Sec. 6.3 of Zumdahl *Chemistry*.
$2NO_2 \rightarrow N_2 + 2O_2$ $\Delta H = -67.7$ kJ
$N_2 + 2O_2 \rightarrow N_2O_4$ $\Delta H = 9.7$ kJ
-67.7 kJ + 9.7 kJ = -58.0 kJ

PTS: 1 DIF: Easy REF: 6.3
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | Hess's law
MSC: Quantitative

92. Is the reaction endothermic or exothermic?

ANS:
exothermic

PTS: 1 DIF: Easy REF: 6.3
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | heat | heats of reaction MSC: Conceptual

93. Consider the following data:

	$\Delta H°$ (kJ)
$Ca(s) + 2C(\text{graphite}) \rightarrow CaC_2(s)$	–62.8
$Ca(s) + \frac{1}{2}O_2(g) \rightarrow CaO(s)$	–635.5
$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$	–653.1
$C_2H_2(g) + \frac{1}{2}O_2(g) \rightarrow 2CO_2(g) + H_2O(l)$	–1300
$C(\text{graphite}) + O_2(g) \rightarrow CO_2(g)$	–393.51

Use Hess' law to find the change in enthalpy at 25°C for the following equation:

$$CaC_2(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + C_2H_2(g)$$

ANS:
–713 kJ

See Sec. 6.3 of Zumdahl *Chemistry*.

$\Delta H°$ (kJ)

$CaC_2(s) \rightarrow 2C(\text{graphite}) + Ca(s)$	+62.8
$Ca(s) + \frac{1}{2}O_2(g) \rightarrow CaO(s)$	–635.5
$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$	–653.1
$2CO_2(g) + H_2O(l) \rightarrow C_2H_2(g) + \frac{5}{2}O_2(g)$	+1300
$2C(\text{graphite}) + 2O_2(g) \rightarrow 2CO_2(g)$	–787.02
total	–713 kJ

PTS: 1 DIF: Moderate REF: 6.3
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | Hess's law
MSC: Quantitative

94. Consider the following standard heats of formation:
$P_4O_{10}(s) = –3110$ kJ/mol
$H_2O(l) = –286$ kJ/mol
$H_3PO_4(s) = –1279$ kJ/mol
Calculate the change in enthalpy for the following process:
$P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(s)$

ANS:
–290 kJ

See Sec. 6.4 of Zumdahl *Chemistry*.
$4(–1279) - [–3110 + 6(–286)] = –5116 + 3110 + 1716 = –290$

PTS: 1 DIF: Moderate REF: 6.4
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | standard enthalpies of formation MSC: Quantitative

95. Acetylene (C_2H_2) and butane (C_4H_{10}) are gaseous fuels. Determine the ratio of energy available from the combustion of a given volume of acetylene to butane at the same temperature and pressure using the following data:
The change in enthalpy of combustion for $C_2H_2(g) = –49.9$ kJ/g.
The change in enthalpy of combustion for $C_4H_{10}(g) = –49.5$ kJ/g.

ANS:
About 2.21 times the volume of acetylene is needed to furnish the same energy as a given volume of butane.

For stoichiometry of thermochemical processes, see Sec. 6.2 of Zumdahl *Chemistry*.
At the same temperature and pressure, equal volumes will contain equal number of moles of gas.
1 mol C_2H_2 * 26.03 g/mol * –49.9 kJ/g = –1299 kJ
1 mol C_4H_{10} * 58.12 g/mol * –49.5 kJ/g = –2877 kJ
–2877 kJ/-1299 kJ = 2.21

PTS: 1 DIF: Difficult REF: 6.6
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | thermochemical equation | stoichiometry and heats of reaction MSC: Quantitative

96. A gas absorbs 188 J of heat and then performs 310 J of work. The change in internal energy of the gas is
A) 498 J
B) 122 J
C) –122 J
D) –498 J
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 6.1
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | energy | internal energy MSC: Quantitative

97. A gas absorbs 825 J of heat and then has 841 J of work done upon it. The change in internal energy of the gas is
A) 1666 J
B) 16 J
C) –16 J
D) –1666 J
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 6.1
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | energy | internal energy MSC: Quantitative

98. A gas delivers 659 J of heat and then has 636 J of work done upon it. The change in internal energy of the gas is
A) 1295 J
B) –23 J
C) 23 J
D) –1295 J
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 6.1
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | energy | internal energy MSC: Quantitative

99. A gas delivers 816 J of heat and then performs 495 J of work. The change in internal energy of the gas is
A) 1311 J
B) –321 J
C) 321 J
D) –1311 J
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 6.1
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | energy | internal energy MSC: Quantitative

100. For the complete combustion of 1.000 mole of methane gas at 298 K and 1 atm pressure, $\Delta H°$ = -890.4 kJ/mol. What will be the heat released when 1.85 g of methane is combusted under these conditions?
A) –103 kJ
B) 103 kJ
C) –7701 kJ
D) 7701 kJ
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | thermochemical equation | stoichiometry and heats of reaction MSC: Quantitative

101. For the complete combustion of 1.000 mole of ethane gas at 298 K and 1 atm pressure, $\Delta H°$ = -1560 kJ/mol. What will be the heat released when 4.42 g of ethane is combusted under these conditions?
A) –230 kJ
B) 230 kJ
C) 10588 kJ
D) –10588 kJ
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | thermochemical equation | stoichiometry and heats of reaction MSC: Quantitative

102. For the complete combustion of 1.000 mole of propane gas at 298 K and 1 atm pressure, $\Delta H°$ = -2220 kJ/mol. What will be the heat released when 4.13 g of propane is combusted under these conditions?
A) –208 kJ
B) 208 kJ
C) 23651 kJ
D) –23651 kJ
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | thermochemical equation | stoichiometry and heats of reaction MSC: Quantitative

103. For the complete combustion of 1.000 mole of butane gas at 298 K and 1 atm pressure, $\Delta H°$ = -2877 kJ/mol. What will be the heat released when 2.43 g of butane is combusted under these conditions?
A) –121 kJ
B) 121 kJ
C) 68669 kJ
D) –68669 kJ
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 6.2

KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | thermochemical equation | stoichiometry and heats of reaction MSC: Quantitative

104. A 36.2 g piece of metal is heated to 81°C and dropped into a calorimeter containing 50.0 g of water (specific heat capacity of water is 4.18 J/g°C) initially at 21.7°C. The empty calorimeter has a heat capacity of 125 J/K. The final temperature of the water is 29.7°C. Ignoring significant figures, calculate the specific heat of the metal..
A) 1.439 J/gK
B) 0.900 J/gK
C) 0.360 J/gK
D) 0.968 J/gK
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 6.2
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | calorimetry
MSC: Quantitative

105. Nitric acid, HNO_3, was first prepared 1200 years ago by heating naturally occurring sodium nitrate (called saltpeter) with sulfuric acid to produce sodium bisulfate and collecting the vapors of HNO_3 produced. Calculate $\Delta H°_{rxn}$ for this reaction. $\Delta H°_f[NaNO_3(s)] = -467.8$ kJ/mol; $\Delta H°_f[NaHSO_4(s)] = -1125.5$ kJ/mol; $\Delta H°_f[H_2SO_4(l)] = -814.0$ kJ/mol; $\Delta H°_f[HNO_3(g)] = -135.1$ kJ/mol.

$NaNO_3(s) + H_2SO_4(l) \Rightarrow NaHSO_4(s) + HNO_3(g)$
A) -644.2 kJ
B) -21.2 kJ
C) 21.2 kJ
D) 644.2 kJ
E) -1606.8 kJ

ANS: C PTS: 1 DIF: Easy REF: 6.4
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | standard enthalpies of formation MSC: Quantitative

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1. When ignited, a uranium compound burns with a green flame. The wavelength of the light given off by this flame is greater than that of
   A) red light
   B) infrared light
   C) radio waves
   D) ultraviolet light
   E) gamma rays

   ANS: D PTS: 1 DIF: Easy REF: 7.1
   KEY: Chemistry | general chemistry | atomic theory | light | electromagnetic radiation
   MSC: Conceptual

2. Which form of electromagnetic radiation has the longest wavelengths?
   A) gamma rays
   B) microwaves
   C) radio waves
   D) infrared radiation
   E) x-rays

   ANS: C PTS: 1 DIF: Easy REF: 7.1
   KEY: Chemistry | general chemistry | atomic theory | light | electromagnetic radiation
   MSC: Conceptual

3. Which of the following frequencies corresponds to light with the longest wavelength?
   A) $3.00 \times 10^{13}\ s^{-1}$
   B) $4.12 \times 10^{5}\ s^{-1}$
   C) $8.50 \times 10^{20}\ s^{-1}$
   D) $9.12 \times 10^{12}\ s^{-1}$
   E) $3.20 \times 10^{9}\ s^{-1}$

   ANS: B PTS: 1 DIF: Easy REF: 7.1
   KEY: Chemistry | general chemistry | atomic theory | light | electromagnetic radiation
   MSC: Conceptual

4. Which of the following are incorrectly paired?
   A) wavelength – λ
   B) frequency – ν
   C) speed of light – c
   D) hertz – s^{-1}
   E) x-rays – shortest wavelength

   ANS: E PTS: 1 DIF: Easy REF: 7.1
   KEY: Chemistry | general chemistry | atomic theory | light | electromagnetic radiation
   MSC: Conceptual

5. When a strontium salt is ignited, it burns with a red flame. The frequency of the light given off by this flame is greater than
   A) yellow light

B) infrared light
C) ultraviolet light
D) radio waves
E) x-rays

ANS: B PTS: 1 DIF: Easy REF: 7.1
KEY: Chemistry | general chemistry | atomic theory | light | electromagnetic radiation
MSC: Conceptual

6. A line in the spectrum of atomic mercury has a wavelength of 254 nm. When mercury emits a photon of light at this wavelength, the frequency of this light is
A) $8.47 \times 10^{-16}\ s^{-1}$
B) $7.82 \times 10^{-19}\ s^{-1}$
C) $1.18 \times 10^{15}\ s^{-1}$
D) $76.1\ s^{-1}$
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 7.1
KEY: Chemistry | general chemistry | atomic theory | light | electromagnetic radiation
MSC: Quantitative

7. What is the wavelength of a photon of red light (in nm) whose frequency is 4.55×10^{14} Hz?
A) 659 nm
B) 1.52×10^{6} nm
C) 152 nm
D) 455 nm
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 7.1
KEY: Chemistry | general chemistry | atomic theory | light | electromagnetic radiation
MSC: Quantitative

8. The SI unit for frequency is cycles per second.

ANS: F PTS: 1 DIF: Easy REF: 7.1
KEY: Chemistry | general chemistry | atomic theory | light | electromagnetic radiation
MSC: Conceptual

9. Green light can have a wavelength of 543 nm. The energy of a photon of this light is
A) 1.08×10^{-31} J
B) 5.43×10^{-7} J
C) 3.66×10^{-19} J
D) 5.52×10^{14} J
E) 2.73×10^{18} J

ANS: C PTS: 1 DIF: Easy REF: 7.2
KEY: Chemistry | general chemistry | atomic theory | light | electromagnetic radiation
MSC: Quantitative

10. Consider an atom traveling at 1% of the speed of light. The de Broglie wavelength is found to be 1.46×10^{-3} pm. Which element is this?
    A) Be
    B) Zr
    C) Kr
    D) Fe
    E) P

    ANS: B PTS: 1 DIF: Moderate REF: 7.2
    KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | de Broglie relation MSC: Quantitative

11. Which one of the following types of radiation has the shortest wavelength, the greatest energy, and the highest frequency?
    A) Ultraviolet radiation.
    B) Infrared radiation.
    C) Visible red light.
    D) Visible blue light.
    E) None, because short wavelength is associated with low energy and low frequency, not high energy and high frequency.

    ANS: A PTS: 1 DIF: Easy REF: 7.2
    KEY: Chemistry | general chemistry | atomic theory | light | electromagnetic radiation
    MSC: Conceptual

12. What is the energy of a photon of blue light that has a wavelength of 453 nm?
    A) 4.53×10^{-7} J
    B) 4.39×10^{-19} J
    C) 6.62×10^{14} J
    D) 9.00×10^{-32} J
    E) 2.28×10^{18} J

    ANS: B PTS: 1 DIF: Easy REF: 7.2
    KEY: Chemistry | general chemistry | atomic theory | light | electromagnetic radiation
    MSC: Quantitative

13. How many of the following is/are *incorrect*?
    i. The importance of the equation $E = mc^2$ is that energy has mass.
    ii. Electromagnetic radiation can be thought of as a stream of particles called photons.
    iii. Electromagnetic radiation exhibits wave properties.
    iv. Energy can only occur in discrete units called quanta.
    A) 0
    B) 1
    C) 2
    D) 3
    E) 4

    ANS: A PTS: 1 DIF: Easy REF: 7.2
    KEY: Chemistry | general chemistry | atomic theory | light | electromagnetic radiation
    MSC: Conceptual

From the following list of observations, choose the one that most clearly supports the following conclusion:

a) emission spectrum of hydrogen
b) the photoelectric effect
c) scattering of alpha particles by metal foil
d) diffraction
cathode "rays"
e)

14. Electrons have wave properties.
A) observation a
B) observation b
C) observation c
D) observation d
E) observation e

ANS: D PTS: 1 DIF: Easy REF: 7.2
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics
MSC: Conceptual

15. Electromagnetic radiation has wave characteristics.
A) observation a
B) observation b
C) observation c
D) observation d
E) observation e

ANS: D PTS: 1 DIF: Easy REF: 7.2
KEY: Chemistry | general chemistry | atomic theory | light | electromagnetic radiation
MSC: Conceptual

16. Electrons in atoms have quantized energies.
A) observation a
B) observation b
C) observation c
D) observation d
E) observation e

ANS: A PTS: 1 DIF: Easy REF: 7.3
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum effects and photons MSC: Conceptual

17. Spacing between atoms in a crystal is on the same order as the de Broglie wavelength of accelerated electrons.
A) observation a
B) observation b
C) observation c
D) observation d
E) observation e

ANS: D PTS: 1 DIF: Easy REF: 7.2
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | de Broglie relation MSC: Conceptual

18. Diffraction results when light is scattered from a regular array of points or lines.

ANS: T PTS: 1 DIF: Easy REF: 7.2
KEY: Chemistry | general chemistry | atomic theory | light MSC: Conceptual

19. All matter exhibits either particulate or wave properties exclusively.

ANS: F PTS: 1 DIF: Easy REF: 7.2
KEY: Chemistry | general chemistry | atomic theory | light MSC: Conceptual

20. The four lines observed in the visible emission spectrum of hydrogen tell us that:
A) The hydrogen molecules they came from have the formula H_4.
B) We could observe more lines if we had a stronger prism.
C) There are four electrons in an excited hydrogen atom.
D) Only certain energies are allowed for the electron in a hydrogen atom.
E) The spectrum is continuous.

ANS: D PTS: 1 DIF: Easy REF: 7.3
KEY: Chemistry | general chemistry | atomic theory | light | Bohr theory | atomic line spectra MSC: Conceptual

21. In an investigation of the electronic absorption spectrum of a particular element, it is found that a photon having $\lambda = 500$ nm provides just enough energy to promote an electron from the second quantum level to the third. From this information, we can deduce
A) the energy of the $n = 2$ level
B) the energy of the $n = 3$ level
C) the sum of the energies of $n = 2$ and $n = 3$
D) the difference in energies between $n = 2$ and $n = 3$
E) all of these

ANS: D PTS: 1 DIF: Moderate REF: 7.4
KEY: Chemistry | general chemistry | atomic theory | light | Bohr theory
MSC: Conceptual

Consider the following portion of the energy-level diagram for hydrogen:

$n = 4$ -0.1361×10^{-18} J
$n = 3$ -0.2420×10^{-18} J
$n = 2$ -0.5445×10^{-18} J
$n = 1$ -2.178×10^{-18} J

22. For which of the following transitions does the light emitted have the longest wavelength?
A) $n = 4$ to $n = 3$
B) $n = 4$ to $n = 2$
C) $n = 4$ to $n = 1$
D) $n = 3$ to $n = 2$
E) $n = 2$ to $n = 1$

ANS: A PTS: 1 DIF: Easy REF: 7.4
KEY: Chemistry | general chemistry | atomic theory | light | Bohr theory | atomic line spectra MSC: Conceptual

23. In the hydrogen spectrum, what is the wavelength of light associated with the $n = 3$ to $n = 1$ electron transition?
A) 3.97×10^{-25} nm
B) 8.21×10^{2} nm
C) 9.75×10^{6} cm
D) 1.94×10^{-18} m
E) 1.03×10^{-7} m

ANS: E PTS: 1 DIF: Moderate REF: 7.4
KEY: Chemistry | general chemistry | atomic theory | light | Bohr theory | atomic line spectra MSC: Quantitative

24. The wavelength of light associated with the $n = 2$ to $n = 1$ electron transition in the hydrogen spectrum is 1.216×10^{-7} m. By what coefficient should this wavelength be multiplied to obtain the wavelength associated with the same electron transition in the Li^{2+} ion?
A) 1/9
B) 1/7
C) 1/4
D) 1/3
E) 1

ANS: A PTS: 1 DIF: Difficult REF: 7.4
KEY: Chemistry | general chemistry | atomic theory | light | Bohr theory | atomic line spectra MSC: Conceptual

25. When a hydrogen electron makes a transition from $n = 3$ to $n = 1$, which of the following statements is *true*?
I. Energy is emitted.
II. Energy is absorbed.
III. The electron loses energy.
IV. The electron gains energy.
V. The electron cannot make this transition.

A) I, IV
B) I, III
C) II, III
D) II, IV
E) V

ANS: B PTS: 1 DIF: Easy REF: 7.4
KEY: Chemistry | general chemistry | atomic theory | light | Bohr theory | atomic line spectra MSC: Conceptual

26. What is the wavelength of light that is emitted when an excited electron in the hydrogen atom falls from $n = 5$ to $n = 1$?
A) 1.05×10^{7} m
B) 9.50×10^{-8} m
C) 2.09×10^{-18} m
D) 9.12×10^{-8} m
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 7.4
KEY: Chemistry | general chemistry | atomic theory | light | Bohr theory | atomic line spectra MSC: Quantitative

27. Which of the following is a reasonable criticism of the Bohr model of the atom?
A) It makes no attempt to explain why the negative electron does not eventually fall into the positive nucleus.
B) It does not adequately predict the line spectrum of hydrogen.
C) It does not adequately predict the ionization energy of the valence electron(s) for elements other than hydrogen.
D) It does not adequately predict the ionization energy of the first energy level electrons for one-electron species for elements other than hydrogen.
E) It shows the electrons to exist outside of the nucleus.

ANS: C PTS: 1 DIF: Moderate REF: 7.4
KEY: Chemistry | general chemistry | atomic theory | light | Bohr theory
MSC: Conceptual

28. When an electron in a 2*p* orbital of a particular atom makes a transition to the 2*s* orbital, a photon of approximate wavelength 629.1 nm is emitted. The energy difference between these 2*p* and 2*s* orbitals is
A) 3.16×10^{-28} J
B) 3.16×10^{-19} J
C) 3.16×10^{-17} J
D) 1.25×10^{-31} J
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 7.4
KEY: Chemistry | general chemistry | atomic theory | light | electromagnetic radiation
MSC: Quantitative

29. The energy of the light emitted when a hydrogen electron goes from $n = 2$ to $n = 1$ is what fraction of its ground-state ionization energy?
A) 3/4
B) 1/2
C) 1/4
D) 1/8
E) 1/9

ANS: A PTS: 1 DIF: Moderate REF: 7.4
KEY: Chemistry | general chemistry | atomic theory | light | Bohr theory | atomic line spectra MSC: Conceptual

30. In Bohr's atomic theory, when an electron moves from one energy level to another energy level more distant from the nucleus:
    A) Energy is emitted.
    B) Energy is absorbed.
    C) No change in energy occurs.
    D) Light is emitted.
    E) None of these.

    ANS: B PTS: 1 DIF: Easy REF: 7.4
    KEY: Chemistry | general chemistry | atomic theory | light | Bohr theory
    MSC: Conceptual

31. Which of the following is *incorrect*?
    A) The emission spectrum of hydrogen contains a continuum of colors.
    B) Diffraction produces both constructive and destructive interference.
    C) All matter displays both particle and wavelike characteristics.
    D) Niels Bohr developed a quantum model for the hydrogen atom.
    E) The lowest possible energy state of a molecule or atom is called its ground state.

    ANS: A PTS: 1 DIF: Easy REF: 7.4
    KEY: Chemistry | general chemistry | atomic theory MSC: Conceptual

32. Which of the following statements is (are) true?
    I. An excited atom can return to its ground state by absorbing electromagnetic radiation.
    II. The energy of an atom is increased when electromagnetic radiation is emitted from it.
    III. The energy of electromagnetic radiation increases as its frequency increases.
    IV. An electron in the n = 4 state in the hydrogen atom can go to the n = 2 state by emitting electromagnetic radiation at the appropriate frequency.
    V. The frequency and wavelength of electromagnetic radiation are inversely proportional to each other.

    A) II, III, IV
    B) III, V
    C) I, II, III
    D) III, IV, V
    E) I, II, IV

    ANS: D PTS: 1 DIF: Moderate REF: 7.4
    KEY: Chemistry | general chemistry | atomic theory | light MSC: Conceptual

33. Bohr's model correctly describes the hydrogen atom and other small atoms.

    ANS: F PTS: 1 DIF: Easy REF: 7.4
    KEY: Chemistry | general chemistry | atomic theory | light | Bohr theory
    MSC: Conceptual

34. A gamma ray of wavelength 1.00×10^{-8} cm has enough energy to remove an electron from a hydrogen atom.

ANS: T PTS: 1 DIF: Moderate REF: 7.4
KEY: Chemistry | general chemistry | atomic theory | light | Bohr theory
MSC: Quantitative

35. Which of the following statements best describes the Heisenberg uncertainty principle?
A) The exact position of an electron is always uncertain.
B) The velocity of a particle can only be estimated.
C) It is impossible to accurately know both the exact location and momentum of a particle.
D) The location and momentum of a macroscopic object are not known with certainty.
E) The location and momentum of a particle can be determined accurately, but not the identity of the particle.

ANS: C PTS: 1 DIF: Easy REF: 7.5
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | wave functions | Heisenberg's uncertainty principle MSC: Conceptual

36. Which of the following best describes an orbital?
A) space where electrons are unlikely to be found in an atom
B) space which may contain electrons, protons, and/or neutrons
C) the space in an atom where an electron is most likely to be found
D) small, walled spheres that contain electrons
E) a single space within an atom that contains all electrons of that atom

ANS: C PTS: 1 DIF: Easy REF: 7.5
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics
MSC: Conceptual

37. Which of the following is *not* determined by the principal quantum number, *n*, of the electron in a hydrogen atom?
A) The energy of the electron.
B) the minimum wavelength of the light needed to remove the electron from the atom.
C) The size of the corresponding atomic orbital(s).
D) The shape of the corresponding atomic orbital(s).
E) All of the above are determined by *n*.

ANS: C PTS: 1 DIF: Easy REF: 7.6
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers | principal quantum number MSC: Conceptual

38. How many *f* orbitals have the value $n = 3$?
A) 0
B) 3
C) 5
D) 7
E) 1

ANS: A PTS: 1 DIF: Easy REF: 7.6

KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers MSC: Conceptual

39. How many *f* orbitals have $n = 6$?
A) 2
B) 7
C) 10
D) 5
E) 18

ANS: B PTS: 1 DIF: Easy REF: 7.6
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers MSC: Conceptual

40. If $n = 2$, how many orbitals are possible?
A) 3
B) 4
C) 2
D) 8
E) 6

ANS: B PTS: 1 DIF: Easy REF: 7.6
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers MSC: Conceptual

41. A given set of *p* orbitals consists of _____ orbitals.
A) 1
B) 2
C) 3
D) 4
E) 5

ANS: C PTS: 1 DIF: Easy REF: 7.6
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers MSC: Conceptual

42. Which of the following is an incorrect designation for an atomic orbital?
A) 1*s*
B) 3*d*
C) 1*p*
D) 4*f*
E) 6*s*

ANS: C PTS: 1 DIF: Easy REF: 7.6
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers MSC: Conceptual

43. The number of orbitals having a given value of l is equal to
A) $2l + 1$
B) $2n + 2$
C) $3l$

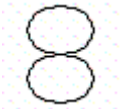
D) $l + m_l$
E) the number of lobes in each orbital

ANS: A PTS: 1 DIF: Easy REF: 7.6
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers | angular momentum quantum number MSC: Conceptual

44. The magnetic quantum number is related to the orientation of the orbital in space relative to the other orbitals in the atom.

ANS: T PTS: 1 DIF: Easy REF: 7.6
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers | magnetic quantum number MSC: Conceptual

45. Consider the following representation of a 2*p*-orbital:



Which of the following statements best describes the movement of electrons in a *p*-orbital?
A) The electrons move along the outer surface of the *p*-orbital, similar to a "figure 8" type of movement.
B) The electrons move within the two lobes of the *p*-orbital, but never beyond the outside surface of the orbital.
C) The electrons are concentrated at the center (node) of the two lobes.
D) The electrons are only moving in one lobe at any given time.
E) The electron movement cannot be exactly determined.

ANS: E PTS: 1 DIF: Moderate REF: 7.7
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | wave functions | Heisenberg's uncertainty principle MSC: Conceptual

46. A point in the wave function where the amplitude is zero defines
A) the node
B) the excited state
C) the amplitude of the wave function
D) the frequency of radiation
E) none of the above

ANS: A PTS: 1 DIF: Easy REF: 7.7
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | wave functions
MSC: Conceptual

47. The size of an orbital is arbitrarily defined.

ANS: T PTS: 1 DIF: Easy REF: 7.7
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | atomic orbital shapes MSC: Conceptual

48. How many electrons in an atom can have the quantum numbers $n = 3$, $l = 2$?
A) 2

B) 5
C) 10
D) 18
E) 6

ANS: C PTS: 1 DIF: Easy REF: 7.8
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers MSC: Conceptual

49. How many electrons can be described by the quantum numbers $n = 3$, $l = 3$, $m_l = 1$?
A) 0
B) 2
C) 6
D) 10
E) 14

ANS: A PTS: 1 DIF: Easy REF: 7.8
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers MSC: Conceptual

50. How many electrons can be contained in all of the orbitals with $n = 4$?
A) 2
B) 8
C) 10
D) 18
E) 32

ANS: E PTS: 1 DIF: Moderate REF: 7.8
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers MSC: Conceptual

51. What is the l quantum number for a 4*s* orbital?
A) 1
B) 0
C) 3
D) 2
E) more than one of the above

ANS: B PTS: 1 DIF: Easy REF: 7.8
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers MSC: Conceptual

52. Which of the following could not be a valid m_l quantum number for a 4*d* orbital?
A) 2
B) 0
C) –2
D) 1
E) 4

ANS: E PTS: 1 DIF: Easy REF: 7.8
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum

numbers MSC: Conceptual

53. How many electrons in an atom can have the quantum numbers $n = 4$, $l = 2$?
A) 14
B) 12
C) 5
D) 10
E) 6

ANS: D PTS: 1 DIF: Easy REF: 7.8
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers MSC: Conceptual

54. Which of the following combinations of quantum numbers (n, l, m_l, m_s) do *not* represent permissible solutions of the Schrödinger equation for the electron in the hydrogen atom (i.e., which combination of quantum numbers is *not* allowed)?
A) 9, 8, -4, 1/2
B) 8, 2, 2, 1/2
C) 6, -5, -1, 1/2
D) 6, 5, -5, 1/2
E) All are allowed.

ANS: C PTS: 1 DIF: Easy REF: 7.8
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers MSC: Conceptual

55. If $l = 3$, how many electrons can be contained in all the possible orbitals?
A) 7
B) 6
C) 14
D) 10
E) 5

ANS: C PTS: 1 DIF: Easy REF: 7.8
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers MSC: Conceptual

56. Which of the following combinations of quantum numbers is not allowed?
A) $n = 1$, $l = 1$, $m_l = 0$, $m_s = \frac{1}{2}$
B) $n = 3$, $l = 0$, $m_l = 0$, $m_s = -\frac{1}{2}$
C) $n = 2$, $l = 1$, $m_l = -1$, $m_s = \frac{1}{2}$
D) $n = 4$, $l = 3$, $m_l = -2$, $m_s = -\frac{1}{2}$
E) $n = 4$, $l = 2$, $m_l = 0$, $m_s = \frac{1}{2}$

ANS: A PTS: 1 DIF: Easy REF: 7.8
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers MSC: Conceptual

57. The small, but important, energy differences between 3*s*, 3*p*, and 3*d* orbitals are due mainly to

A) the number of electrons they can hold
B) their principal quantum number
C) the Heisenberg uncertainty principle
D) the penetration effect
E) Hund's rule

ANS: D PTS: 1 DIF: Moderate REF: 7.9
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics
MSC: Conceptual

58. Who was the first chemist to recognize patterns in chemical properties of the elements?
A) Mendeleev
B) Newlands
C) Meyer
D) Dobereiner
E) Bohr

ANS: D PTS: 1 DIF: Easy REF: 7.1
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements
MSC: Conceptual

59. Mendeleev is given the most credit for the concept of a periodic table of the elements because:
A) He had the longest history of research in elemental properties.
B) He emphasized its usefulness in predicting the existence and properties of unknown elements.
C) His representation of the table was the most understandable.
D) His periodic table was arranged in octaves.
E) He grouped elements into triads of similar properties.

ANS: B PTS: 1 DIF: Easy REF: 7.1
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | Mendeleev's predictions MSC: Conceptual

60. Which of the following was not an elemental property usually predicted by Mendeleev for as-yet-unknown elements?
A) electron configuration
B) atomic mass
C) density
D) boiling point
E) oxide formula

ANS: A PTS: 1 DIF: Moderate REF: 7.1
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | Mendeleev's predictions MSC: Conceptual

61. Which of the following atoms or ions has three unpaired electrons?
A) N
B) O
C) Al
D) S^{2-}

E) Ti^{2+}

ANS: A PTS: 1 DIF: Moderate REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration | aufbau principle MSC: Conceptual

62. The electron configuration for the barium atom is:
A) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10}$
B) $[Xe]6s^2$
C) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
D) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration | aufbau principle MSC: Conceptual

63. The electron configuration for the carbon atom is:
A) $1s^2 2s^2 2p^2$
B) $[He]2s^4$
C) $[Ne]2s^2 2p^2$
D) $1s^2 2p^4$
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration | aufbau principle MSC: Conceptual

64. The complete electron configuration of tin is
A) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5d^{10} 5p^2$
B) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4d^{10} 4p^2$
C) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4p^6 5s^2 4d^{10} 5d^{10} 5p^2$
D) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^2$
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration | aufbau principle MSC: Conceptual

65. Which of the following statements about quantum theory is *incorrect*?
A) The energy and position of an electron cannot be determined simultaneously.
B) Lower energy orbitals are filled with electrons before higher energy orbitals.
C) When filling orbitals of equal energy, two electrons will occupy the same orbital before filling a new orbital.
D) No two electrons can have the same four quantum numbers.
E) All of these are correct.

ANS: C PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory MSC: Conceptual

66. Which of the following statements is *true*?

A) The exact location of an electron can be determined if we know its energy.
B) An electron in a 2*s* orbital can have the same *n*, *l*, and m_l quantum numbers as an electron in a 3*s* orbital.
C) Ni has two unpaired electrons in its 3*d* orbitals.
D) In the buildup of atoms, electrons occupy the 4*f* orbitals before the 6*s* orbitals.
E) Only three quantum numbers are needed to uniquely describe an electron.

ANS: C PTS: 1 DIF: Moderate REF: 7.11
KEY: Chemistry | general chemistry | atomic theory MSC: Conceptual

67. Which of the following statements is *false*?
A) An orbital can accommodate at most two electrons.
B) The electron density at a point is proportional to ψ^2 at that point.
C) The spin quantum number of an electron must be either $+\frac{1}{2}$ or $-\frac{1}{2}$.
D) A 2*p* orbital is more penetrating than a 2*s*; i.e., it has a higher electron density near the nucleus and inside the charge cloud of a 1*s* orbital.
E) In the usual order of filling, the 6*s* orbital is filled before the 4*f* orbital.

ANS: D PTS: 1 DIF: Moderate REF: 7.11
KEY: Chemistry | general chemistry | atomic theory MSC: Conceptual

68. The statement that "the lowest energy configuration for an atom is the one having the maximum number of unpaired electrons allowed by the Pauli principle in a particular set of degenerate orbitals" is known as
A) the aufbau principle
B) Hund's rule
C) Heisenberg uncertainty principle
D) the Pauli exclusion principle
E) the quantum model

ANS: B PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration | Hund's rule MSC: Conceptual

69. An element has the electron configuration [Kr] $5s^2 4d^{10} 5p^2$. The element is a(n)
A) nonmetal
B) transition element
C) metal
D) lanthanide
E) actinide

ANS: C PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration and the periodic table MSC: Conceptual

70. An element *E* has the electron configuration [Kr] $5s^2 4d^{10} 5p^2$. The formula for the fluoride of *E* is most likely
A) EF_{14}
B) EF_4
C) EF

D) EF_6
E) EF_8

ANS: B PTS: 1 DIF: Moderate REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration and the periodic table MSC: Conceptual

71. An element with the electron configuration [Xe] $6s^2 4f^{14} 5d^7$ would belong to which class on the periodic table?
A) transition elements
B) alkaline earth elements
C) halogens
D) rare earth elements
E) none of the above

ANS: A PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration and the periodic table MSC: Conceptual

72. All alkaline earths have the following number of valence electrons:
A) 1
B) 3
C) 6
D) 2
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration and the periodic table MSC: Conceptual

73. Ti has _____ in its d orbitals.
A) one electron
B) two electrons
C) three electrons
D) four electrons
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration MSC: Conceptual

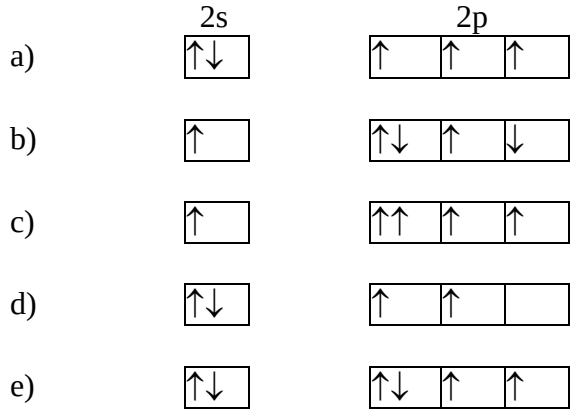
74. Germanium has _____ in its 4p orbitals.
A) one electron
B) two electrons
C) three electrons
D) four electrons
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration MSC: Conceptual

75. Fe has _____ that is (are) unpaired in its d orbitals.
A) one electron
B) two electrons
C) three electrons
D) four electrons
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration | magnetic properties of atoms MSC: Conceptual

Nitrogen has five valence electrons. Consider the following electron arrangements.



76. Which represents the ground state for N?
A) option a
B) option b
C) option c
D) option d
E) option e

ANS: A PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration | orbital diagram MSC: Conceptual

77. Which represents the ground state for the N^- ion?
A) option a
B) option b
C) option c
D) option d
E) option e

ANS: E PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration | orbital diagram MSC: Conceptual

78. In which group do all the elements have the same number of valence electrons?
A) P, S, Cl

B) Ag, Cd, Ar
C) Na, Ca, Ba
D) P, As, Se
E) none of these

ANS: E PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration MSC: Conceptual

79. An atom of fluorine contains nine electrons. How many of these electrons are in *s* orbitals?
A) 2
B) 4
C) 6
D) 8
E) none

ANS: B PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration | aufbau principle MSC: Conceptual

80. How many unpaired electrons are there in an atom of sulfur in its ground state?
A) 0
B) 1
C) 2
D) 3
E) 4

ANS: C PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration | magnetic properties of atoms MSC: Conceptual

81. Of the following elements, which has occupied *d* orbitals in its ground-state neutral atoms?
A) Ba
B) Ca
C) Si
D) P
E) Cl

ANS: A PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration and the periodic table MSC: Conceptual

82. Of the following elements, which needs three electrons to complete its valence shell?
A) Ba
B) Ca
C) Si
D) P
E) Cl

ANS: D PTS: 1 DIF: Easy REF: 7.11

KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration and the periodic table MSC: Conceptual

83. Which of the following electron configurations is correct?
A) Ga: $[Kr]4s^2 3d^{10} 4p^1$
B) Mo: $[Kr]5s^2 4d^5$
C) Ca: $[Ar]4s^1 3d^{10}$
D) Br: $[Kr]4s^2 3d^{10} 4p^7$
E) Bi: $[Xe]6s^2 4f^{14} 5d^{10} 6p^3$

ANS: E PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration MSC: Conceptual

84. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$ is the correct electron configuration for which of the following atoms?
A) Ca
B) Ti
C) Ge
D) Zr
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration MSC: Conceptual

85. Which of the following atoms has three electrons in *p* orbitals in its valence shell?
A) Ba
B) Ga
C) V
D) Bi
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration and the periodic table MSC: Conceptual

86. How many of the following electron configurations for the species in their ground state are correct?

I.	Ca:	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
II.	Mg:	$1s^2 2s^2 2p^6 3s^1$
III.	V:	$[Ar]3s^2 3d^3$
IV.	As:	$[Ar]4s^2 3d^{10} 4p^3$
V.	P:	$1s^2 2s^2 2p^6 3p^5$

A) 1
B) 2
C) 3
D) 4
E) 5

ANS: B PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration and the periodic table MSC: Conceptual

87. The number of unpaired electrons in the outer subshell of a Cl atom is
A) 0
B) 1
C) 2
D) 3
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration MSC: Conceptual

88. For which of the following elements does the electron configuration for the lowest energy state show a partially filled *d* orbital?
A) Ti
B) Rb
C) Cu
D) Ga
E) Kr

ANS: A PTS: 1 DIF: Moderate REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration MSC: Conceptual

89. Which of the following electron configurations is different from that expected?
A) Ca
B) Sc
C) Ti
D) V
E) Cr

ANS: E PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration and the periodic table | exceptions to the aufbau principle
MSC: Conceptual

90. Which of the following have 10 electrons in the *d* orbitals?
A) Mn
B) Fe
C) Cu
D) Zn
E) two of the above

ANS: E PTS: 1 DIF: Moderate REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration and the periodic table MSC: Conceptual

91. Which of the following is the highest energy orbital for a silicon atom?

A) 1*s*
B) 2*s*
C) 3*s*
D) 3*p*
E) 3*d*

ANS: D PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration and the periodic table MSC: Conceptual

92. When electron configurations differ from expected, it is because orbitals want to be half-filled.

ANS: T PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration and the periodic table | exceptions to the aufbau principle
MSC: Conceptual

93. Copper exhibits the expected electron configuration.

ANS: F PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration and the periodic table | exceptions to the aufbau principle
MSC: Conceptual

94. Which of the following processes represents the ionization energy of bromine?
A) $Br(s) \longrightarrow Br^+(g) + e^-$
B) $Br(l) \longrightarrow Br^+(g) + e^-$
C) $Br(g) \longrightarrow Br^+(g) + e^-$
D) $Br(s) \longrightarrow Br^+(s) + e^-$
E) $Br_2(g) \longrightarrow Br_2^+(g) + e^-$

ANS: C PTS: 1 DIF: Easy REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

95. Order the elements S, Cl, and F in terms of increasing ionization energy.
A) S, Cl, F
B) Cl, F, S
C) F, S, Cl
D) F, Cl, S
E) S, F, Cl

ANS: A PTS: 1 DIF: Easy REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

96. Order the elements S, Cl, and F in terms of increasing atomic radii.
A) S, Cl, F

B) Cl, F, S
C) F, S, Cl
D) F, Cl, S
E) S, F, Cl

ANS: D PTS: 1 DIF: Easy REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | atomic radius MSC: Conceptual

97. Which of the following atoms would have the largest second ionization energy?
A) Mg
B) Cl
C) S
D) Ca
E) Na

ANS: E PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

98. The first ionization energy of Mg is 735 kJ/mol. The second ionization energy is
A) 735 kJ/mol
B) less than 735 kJ/mol
C) greater than 735 kJ/mol
D) More information is needed to answer this question.
E) None of these.

ANS: C PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

99. Which of the following exhibits the correct orders for both atomic radius and ionization energy, respectively? (smallest to largest)
A) S, O, F, and F, O, S
B) F, S, O, and O, S, F
C) S, F, O, and S, F, O
D) F, O, S, and S, O, F
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties MSC: Conceptual

100. Choose the element with the highest ionization energy.
A) Na
B) Mg
C) Al
D) P
E) S

ANS: D PTS: 1 DIF: Easy REF: 7.12

KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

101. Which of the following concerning second ionization energies is true?
A) That of Al is higher than that of Mg because Mg wants to lose the second electron, so it is easier to take the second electron away.
B) That of Al is higher than that of Mg because the electrons are taken from the same energy level, but the Al atom has one more proton.
C) That of Al is lower than that of Mg because Mg wants to lose the second electron, thus the energy change is greater.
D) That of Al is lower than that of Mg because the second electron taken from Al is in a p orbital, thus it is easier to take.
E) The second ionization energies are equal for Al and Mg.

ANS: B PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

102. Consider a planet where the temperature is so high that the ground state of an electron in the hydrogen atom is $n = 4$. What is the ratio of ionization energy for hydrogen on this planet compared to that on Earth?
A) 1 : 4
B) 4 : 1
C) 1 : 16
D) 16 : 1
E) 1 : 1

ANS: C PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

103. Consider the following orderings.

I. $Na^+ < Mg^{2+} < Al^{3+} < Si^{4+}$
II. Be < Mg < Ca < Sr
III. I < Br < Cl < F
IV. Al < Si < P < Cl

Which of these give(s) a correct trend in ionization energy?
A) III
B) II, IV
C) I, IV
D) I, III, IV
E) none of them

ANS: D PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodic table | periodic properties | ionization energy MSC: Conceptual

104. List the following atoms in order of increasing ionization energy: Li, Na, C, O, F.
A) Li < Na < C < O < F

B) Na < Li < C < O < F
C) F < O < C < Li < Na
D) Na < Li < F < O < C
E) Na < Li < C < F < O

ANS: B PTS: 1 DIF: Easy REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

105. Consider the ionization energy (IE) of the magnesium atom. Which of the following is *not* true?
A) The IE of Mg is lower than that of sodium.
B) The IE of Mg is lower than that of neon.
C) The IE of Mg is lower than that of beryllium.
D) The IE of Mg is higher than that of calcium.
E) The IE of Mg is lower than that of Mg^+.

ANS: A PTS: 1 DIF: Easy REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

106. Of the following elements, which has the lowest first ionization energy?
A) Ba
B) Ca
C) Si
D) P
E) Cl

ANS: A PTS: 1 DIF: Easy REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

107. Of the following elements, which is most likely to form a negative ion with charge 1–?
A) Ba
B) Ca
C) Si
D) P
E) Cl

ANS: E PTS: 1 DIF: Easy REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | electron affinity MSC: Conceptual

108. Which of the following atoms has the largest ionization energy?
A) O
B) Li
C) Ne
D) Be
E) K

ANS: C PTS: 1 DIF: Easy REF: 7.12

KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

109. Which of the following statements is true?
A) The first ionization potential of H is greater than that of He.
B) The ionic radius of Fe^{+} is larger than that of Fe^{3+}.
C) The ionization energy of S^{2-} is greater than that of Cl^{-}.
D) The atomic radius of Li is larger than that of Cs.
E) All are false.

ANS: B PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties MSC: Conceptual

110. Which of the following statements is *false*?
A) A sodium atom has a smaller radius than a potassium atom.
B) A neon atom has a smaller radius than an oxygen atom.
C) A fluorine atom has a smaller first ionization energy than an oxygen atom.
D) A cesium atom has a smaller first ionization energy than a lithium atom.
E) All are true.

ANS: C PTS: 1 DIF: Easy REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | atomic radius MSC: Conceptual

111. The statement that the first ionization energy for an oxygen atom is lower than the first ionization energy for a nitrogen atom is
A) consistent with the general trend relating changes in ionization energy across a period from left to right, because it is easier to take an electron from an oxygen atom than from a nitrogen atom
B) consistent with the general trend relating changes in ionization energy across a period from left to right, because it is harder to take an electron from an oxygen atom than from a nitrogen atom
C) inconsistent with the general trend relating changes in ionization energy across a period from left to right, due to the fact that the oxygen atom has two doubly-occupied 2*p* orbitals and nitrogen has only one
D) inconsistent with the general trend relating changes in ionization energy across a period from left to right, due to the fact that oxygen has one doubly-occupied 2*p* orbital and nitrogen does not
E) incorrect

ANS: D PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

112. Sodium losing an electron is an _____ process and fluorine losing an electron is an _____ process.
A) endothermic, exothermic
B) exothermic, endothermic
C) endothermic, endothermic

D) exothermic, exothermic
E) more information needed

ANS: C PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties MSC: Conceptual

113. Which of the following statements is true about the ionization energy of Mg^+?
A) It will be equal to the ionization energy of Li.
B) It will be equal to and opposite in sign to the electron affinity of Mg.
C) It will be equal to and opposite in sign to the electron affinity of Mg^+.
D) It will be equal to and opposite in sign to the electron affinity of Mg^{2+}.
E) None of the above.

ANS: D PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties MSC: Conceptual

114. Which of the following statements is true?
A) The krypton 1*s* orbital is smaller than the helium 1*s* orbital because krypton's nuclear charge draws the electrons closer.
B) The krypton 1*s* orbital is larger than the helium 1*s* orbital because krypton contains more electrons.
C) The krypton 1*s* orbital is smaller than the helium 1*s* orbital because krypton's *p* and *d* orbitals crowd the *s* orbitals.
D) The krypton 1*s* orbital and helium 1*s* orbital are the same size because both *s* orbitals can only have two electrons.
E) The krypton 1*s* orbital is larger than the helium 1*s* orbital because krypton's ionization energy is lower, so it's easier to remove electrons.

ANS: A PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | atomic radius MSC: Conceptual

115. Which of the following statements are *false*?
I. It takes less energy to add an electron to nitrogen than to carbon because nitrogen will be closer to achieving a noble gas configuration.
II. It takes more energy to add an electron to fluorine than to oxygen because the radius of fluorine is smaller and more repulsion would occur in the *p*-orbitals.
III. It takes more energy to add an electron to nitrogen than to carbon because of the extra repulsions that would occur in the 2*p* orbitals.
IV. Less energy is released in adding an electron to iodine than to chlorine because the radius of iodine is larger and the electron is added at a distance further from the nucleus.

A) II, III
B) I, II, IV
C) III only
D) I, II
E) All of the above are false statements.

ANS: D PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | electron affinity MSC: Conceptual

116. The second ionization energy for calcium is smaller than the first ionization energy.

ANS: F PTS: 1 DIF: Easy REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

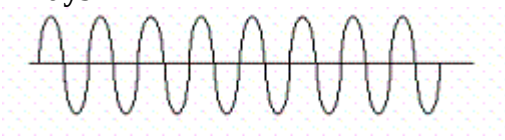
117. Ionization energy increases with an increasing number of electrons.

ANS: F PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

118. When examining the electromagnetic spectrum, why is it more harmful to be exposed to x-rays than radio waves over a period of time? In your explanation, include the concepts of frequency, waves, and energy. Also, draw transverse waves to assist in your explanation.

ANS:
X-rays have a shorter wavelength (in the 10^{-10} m range) and therefore a higher frequency (since $c = \lambda\nu$). This means that the number of waves that penetrate your body over a period of time will be greater than the number of radio waves that hit your body in that same period of time (since radio waves have a longer wavelength and lower frequency). Refer to the picture below:

X rays



shorter λ, higher ν

Radio Waves

longer λ, lower ν

Since more x-ray waves penetrate your body, you are being exposed to more energy in the form of radiation, which can be harmful.
See Sec 7.1 and 7.2 of Zumdahl *Chemistry*.

PTS: 1 DIF: Moderate REF: 7.2
KEY: Chemistry | general chemistry | atomic theory | light | electromagnetic radiation
MSC: Conceptual

119. Photogray lenses incorporate small amounts of silver chloride in the glass of the lens. The following reaction occurs in the light, causing the lenses to darken:

$$AgCl \rightarrow Ag + Cl$$

The enthalpy change for this reaction is 3.10×10^2 kJ/mol. Assuming all this energy is supplied by light, what is the maximum wavelength of light that can cause this reaction?

ANS:
3.86×10^{-7} m

Enthalpy change per AgCl = $(3.10 \times 10^2$ kJ/mol)(1 mol/6.022×10^{23} molecules)(1000 J/1kJ) = 5.15×10^{-19} J/molecule
$E = hc/\lambda$, therefore $\lambda = hc/E$
l = $(6.626 \times 10^{-34}$ J s)$(2.998 \times 10^8$ m/s) / $(5.15 \times 10^{-19}$ J) = 3.86×10^{-7} m (or 386 nm)

PTS: 1 DIF: Easy REF: 7.2
KEY: Chemistry | general chemistry | atomic theory | light | electromagnetic radiation
MSC: Quantitative

120. Electromagnetic radiation can be viewed as a stream of "particles" called _____.

ANS:
photons

PTS: 1 DIF: Easy REF: 7.2
KEY: Chemistry | general chemistry | atomic theory | light | electromagnetic radiation
MSC: Conceptual

121. _____ results when light is scattered from a regular array of points or lines.

ANS:
Diffraction

PTS: 1 DIF: Easy REF: 7.2
KEY: Chemistry | general chemistry | atomic theory | light MSC: Conceptual

122. How does the Bohr theory explain the emission and absorption spectra of hydrogen?

ANS:
The Bohr model assumes the electron can occupy circular orbits with specific energies at corresponding specific distances from the nucleus. The electron can move from one orbital (energy level) to another by releasing or absorbing the amount of energy corresponding to the difference in energy between the two orbitals. The observed emission and absorption spectra show only the discrete emissions or absorptions for these energy differences.

See Sec. 7.4 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Moderate REF: 7.4
KEY: Chemistry | general chemistry | atomic theory | light | Bohr theory | atomic line spectra MSC: Conceptual

123. A specific wave function is called a(n) _____.

ANS:
orbital

PTS: 1 DIF: Easy REF: 7.5
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | wave functions
MSC: Conceptual

124. The _____ quantum number is related to the size and energy of the orbital.

ANS:
principal (or *n*)

PTS: 1 DIF: Easy REF: 7.6
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers | principal quantum number MSC: Conceptual

125. Consider the following sets of quantum numbers. Which set(s) represent(s) impossible combinations?

	n	l	m_l
Set a	1	0	1
Set b	3	3	0
Set c	2	1	1
Set d	3	2	–2
Set e	3	1	–2
Set f	2	0	0

ANS:
Sets a, b, and e represent impossible combinations.

Set a is impossible because m_l can only have values from $-l$ to $+l$. If l is 0, m_l can only be 0.
Set b is impossible because l can only have values from 0 to n-1. When n = 3, l may be only 0, 1, or 2.
Set e is impossible because m_l can only have values from $-l$ to $+l$. If l is 1, m_l can only be -1, 0, or +1.
See Sec. 7.6 in Zumdahl *Chemistry*.

PTS: 1 DIF: Easy REF: 7.6
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers MSC: Conceptual

126. A hydrogen 3*s* wave function has _____ (how many?) nodal planes and _____ (how many?) radial nodes (not counting $r = 0$).

ANS:
0 nodal planes and 2 radial nodes

Since *s* orbitals are spherical, so the nodes are also spherical surfaces. For *s* orbitals, the number of nodes is given by n-1.

See Sec. 7.7 in Zumdahl *Chemistry*.

PTS: 1 DIF: Difficult REF: 7.7
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | atomic orbital shapes MSC: Conceptual

127. Areas of zero probability of finding an electron are called _____.

ANS:
nodes (or nodal surfaces)

PTS: 1 DIF: Easy REF: 7.7
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | atomic orbital shapes MSC: Conceptual

128. The _____ states that in a given atom no two electrons can have the same set of four quantum numbers.

ANS:
Pauli exclusion principle

PTS: 1 DIF: Easy REF: 7.8
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration | Pauli exclusion principle MSC: Conceptual

129. How many electrons in an atom can have the following quantum numbers?
a) $n = 3$
b) $n = 2$, $l = 0$
c) $n = 2$, $l = 2$, $m_l = 0$
d) $n = 2$, $l = 0$, $m_l = 0$, $m_s = 1/2$

ANS:
a) 18; b) 2; c) 0; d) 1

a) The $n = 3$ level consists of an *s*, three *p*, and five *d* orbitals, each of which may contain 2 electrons, for a total of 18 electrons.
b) $n = 2$, $l = 0$ describes the 2*s* orbital, which may contain 2 electrons.
c) This set of quantum numbers is impossible, since when $n = 2$, l can only be 0 or 1.
d) This set of four quantum numbers describes one specific electron in the 2*s* orbital.
See Sec. 7.6 and 7.8 in Zumdahl *Chemistry*.

PTS: 1 DIF: Moderate REF: 7.8
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers MSC: Conceptual

130. Give the quantum numbers for the last electron in:
a) gold
b) magnesium

c) iodine
d) cadmium

ANS:
a) gold: 5, 2, 2, ½ (into a 5*d*-orbital)
b) magnesium: 3, 0, 0, ½ (into a 3*s*-orbital)
c) iodine: 5, 1, 1, ½ (into a 5*p*-orbital)
d) cadmium: 4, 2, 2, ½ (into a 4*d*-orbital)

PTS: 1 DIF: Moderate REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers MSC: Conceptual

Given the following electronic configuration of neutral atoms, identify the element and state the number of unpaired electrons in its ground state:

131. $[Ar]4s^1 3d^5$

ANS:
The element is Cr with six unpaired electrons in its ground state.

PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration and the periodic table | exceptions to the aufbau principle
MSC: Conceptual

132. $[Ne]3s^2 3p^5$

ANS:
The element is Cl with one unpaired electron in its ground state.

PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration and the periodic table MSC: Conceptual

133. $[Kr]5s^2 4d^{10} 5p^4$

ANS:
The element is Te with two unpaired electrons in its ground state.

PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration and the periodic table MSC: Conceptual

134. $[Ar]4s^1 3d^{10}$

ANS:
The element is Cu with one unpaired electron in its ground state.

PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration and the periodic table | exceptions to the aufbau principle
MSC: Conceptual

135. [He]$2s^2 2p^3$

ANS:
The element is N with three unpaired electrons in its ground state.

PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration and the periodic table MSC: Conceptual

Write the electron configuration for the following:

136. P

ANS:
$1s^2 2s^2 2p^6 3s^2 3p^3$ or [Ne]$3s^2 3p^3$

PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration MSC: Conceptual

137. Ag

ANS:
$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^1 4d^{10}$ or [Kr]$5s^1 4d^{10}$

PTS: 1 DIF: Moderate REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration MSC: Conceptual

138. S^{2-}

ANS:
$1s^2 2s^2 2p^6 3s^2 3p^6$ or [Ne]$3s^2 3p^6$

PTS: 1 DIF: Moderate REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration MSC: Conceptual

139. I

ANS:
$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^5$ or [Kr]$5s^2 4d^{10} 5p^5$

PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration MSC: Conceptual

140. K^+

ANS:
$1s^2 2s^2 2p^6 3s^2 3p^6$ or [Ar]

PTS: 1 DIF: Moderate REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration MSC: Conceptual

141. The _____ electrons are in the outermost principal quantum level of an atom.

ANS:
valence

PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration MSC: Conceptual

142. In general, the ionization energy and electron affinity involve more energy from _____ (left to right or right to left) in a period of the periodic table. Why?

ANS:
The increase is from left to right because of the increase in nuclear charge.

PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties MSC: Conceptual

143. In general, the ionization energy and electron affinity involve more energy from _____ (top to bottom or bottom to top) in a family of the periodic table. Why?

ANS:
The increase is from bottom to top because the electrons being removed or added are closer to the nucleus.

PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties MSC: Conceptual

144. For the set of elements Be, B, C, and N, which element has the smallest ionization energy? Explain any deviation from the expected pattern.

ANS:

B has the smallest ionization energy. This is a deviation from the expectation that ionization energy increases from left to right across a row on the periodic table. In boron, the outermost electron is in a higher *p* sublevel, and the filled 2*s* orbital just below it provides some shielding from the nuclear charge.
See Sec. 7.12 in Zumdahl *Chemistry*.

PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

145. For the set of elements Li, O, Ne, and Na, which element has the largest atomic radius? Explain any deviation from the expected pattern.

ANS:
Na has the largest atomic radius. There is no deviation from the expected pattern.

Atomic radius is larger toward the left-hand end of a row, and increases as you go down a column.
See Sec. 7.12, especially Fig. 7.35, in Zumdahl *Chemistry*.

PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | atomic radius MSC: Conceptual

Choose the atom or ion using a periodic table.

146. Larger first ionization energy, Li or Be

ANS:
Be

PTS: 1 DIF: Easy REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

147. Larger first ionization energy, Na or Rb

ANS:
Na

PTS: 1 DIF: Easy REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

148. Larger first ionization energy, Be or B

ANS:
Be

PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

149. Larger first ionization energy, C or N

ANS:
N

PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

150. Larger second ionization energy, Na or Mg

ANS:
Na

PTS: 1 DIF: Easy REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

151. Larger atomic radius, P or Sb

ANS:
Sb

PTS: 1 DIF: Easy REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | atomic radius MSC: Conceptual

152. Larger atomic radius, N or O

ANS:
N

PTS: 1 DIF: Easy REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | atomic radius MSC: Conceptual

153. Larger atomic or ionic radius, F or F^-

ANS:
F^-

PTS: 1 DIF: Easy REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | atomic radius MSC: Conceptual

154. Larger atomic or ionic radius, Mg or Mg^{2+}

ANS:
Mg

PTS: 1 DIF: Easy REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | atomic radius MSC: Conceptual

155. Larger atomic radius, Fe^{2+} or Fe^{3+}

ANS:
Fe^{2+}

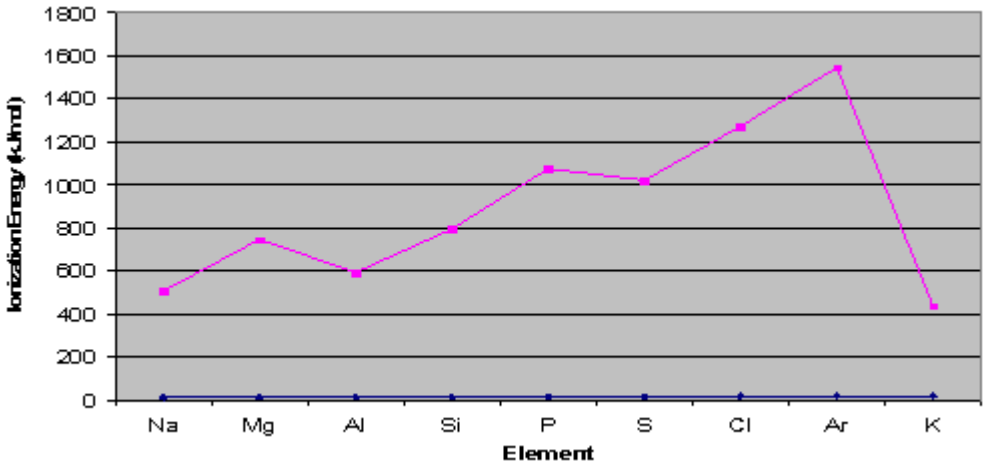
PTS: 1 DIF: Easy REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | atomic radius MSC: Conceptual

156. The calcium atom is much larger than the calcium ion, while the fluorine atom is much smaller than the fluorine ion. Explain this natural occurrence.

ANS:
A cation has a larger proton to electron ratio than the corresponding neutral atom, so the remaining electrons are more closely held. An anion has a smaller proton to electron ratio than its corresponding neutral atom, so the electrons can not be held as closely.
See Sec. 7.12 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | atomic radius MSC: Conceptual

Consider the graph below to answer the next two questions:



157. Explain why argon has the highest ionization energy.

ANS:

Argon has the highest ionization energy because the electrons in the valence shell are more tightly bound due to the higher nuclear charge. (NOTE: A common misconception among students is to say that argon has the highest ionization energy because it has a "filled outer valence shell.")
See Sec. 7.12 in Zumdahl *Chemistry*.

PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

158. Explain the ionization energy difference between sodium and potassium.

ANS:
Potassium has a slightly lower ionization energy than sodium because the electron being removed from potassium is farther from the nucleus (the electron is in a higher energy level) so it is not as tightly bound.
See Sec. 7.12 in Zumdahl *Chemistry*.

PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

159. Which has these types of electromagnetic radiation arranged in order of decreasing frequency?
A) visible, ultraviolet, x-ray
B) radiowaves, visible, ultraviolet
C) ultraviolet, visible, infrared
D) x-ray, visible, ultraviolet
E) gamma, microwave, visible

ANS: C PTS: 1 DIF: Easy REF: 7.1
KEY: Chemistry | general chemistry | atomic theory | light | electromagnetic radiation
MSC: Conceptual

160. Which has these types of electromagnetic radiation arranged in order of increasing wavelength?
A) visible, ultraviolet, x-ray
B) radiowaves, visible, ultraviolet
C) ultraviolet, visible, infrared
D) x-ray, visible, ultraviolet
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 7.1
KEY: Chemistry | general chemistry | atomic theory | light | electromagnetic radiation
MSC: Conceptual

161. Which has these types of electromagnetic radiation arranged in order of decreasing energy?
A) visible, ultraviolet, x-ray
B) radiowaves, visible, ultraviolet
C) ultraviolet, visible, infrared

D) x-ray, visible, ultraviolet
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 7.1
KEY: Chemistry | general chemistry | atomic theory | light | electromagnetic radiation
MSC: Conceptual

162. The first three levels of the hydrogen atom are shown below with their energies in J. Which answer contains all the possible photons that could be generated by transitions among the three levels and no others?

n	E (J)
3 _____	-2.42×10^{-19}
2 _____	-5.45×10^{-19}
1 _____	-2.18×10^{-18}

A) one photon, $E = 1.94 \times 10^{-18}$ J
B) two photons, $E = 1.94 \times 10^{-18}$ J and 1.64×10^{-18} J
C) two photons, $E = 3.03 \times 10^{-19}$ J and 1.64×10^{-18} J
D) photons, $E = 3.03 \times 10^{-19}$ J, 1.94×10^{-18} J and 1.64×10^{-18} J

ANS: D PTS: 1 DIF: Moderate REF: 7.4
KEY: Chemistry | general chemistry | atomic theory | light | Bohr theory | atomic line spectra MSC: Quantitative

163. The energy of the light emitted when a hydrogen electron goes from $n = 3$ to $n = 1$ is what fraction of its ground-state ionization energy?
A) 2/3
B) 1/3
C) 10/9
D) 8/9
E) 1/9

ANS: D PTS: 1 DIF: Moderate REF: 7.4
KEY: Chemistry | general chemistry | atomic theory | light | Bohr theory | atomic line spectra MSC: Conceptual

164. In the quantum theory, the magnetic orbital momentum quantum number is most directly associated with which property of orbitals?
A) energy
B) size
C) orientation
D) shape

ANS: C PTS: 1 DIF: Easy REF: 7.6
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers | magnteic quantum number MSC: Conceptual

165. In the quantum theory, the angular orbital momentum quantum number is most directly associated with which property of orbitals?
A) energy
B) size
C) orientation
D) shape

ANS: D PTS: 1 DIF: Easy REF: 7.6
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers | angular quantum number MSC: Conceptual

166. Select a correct set of quantum numbers (n, l, m_l, m_s) for the highest energy electron in the ground state of tin, Sn
A) 5, 1, 2, +1/2
B) 5, 2, -1, 1/2
C) 5, 1, 1, 1
D) 5, 1, 0, +1/2
E) 5, 2, 0, -1/2

ANS: D PTS: 1 DIF: Easy REF: 7.8
KEY: Chemistry | general chemistry | atomic theory | quantum mechanics | quantum numbers MSC: Conceptual

167. The ground state electron configuration for Te is:
A) $[Kr]5s^2 4d^{10} 5p^4$
B) $[Kr]5s^2 5p^6 4d^8$
C) $[Kr]5s^2 5d^{10} 5p^4$
D) $[Kr]5s^2 4f^{14}$
E) $Kr]5s^2 5d^{10} 5p^6$

ANS: A PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration | aufbau principle MSC: Conceptual

168. Select the correct electron configuration for Cu.
A) $[Ar]4s^2 3d^9$
B) $[Ar]4s^1 3d^{10}$
C) $[Ar]4s^2 4p^6 3d^3$
D) $[Ar]4s^2 4d^9$
E) $[Ar]3d^{10}$

ANS: B PTS: 1 DIF: Easy REF: 7.11
KEY: Chemistry | general chemistry | atomic theory | electronic structure of atoms | electron configuration and the periodic table | exceptions to the aufbau principle
MSC: Conceptual

169. Which of the following equations correctly represents the process involved in the electron affinity of X?
A) $X^+(g) + e^- \Rightarrow X(g)$
B) $X^+(g) + Y^-(g) \Rightarrow XY(g)$
C) $X(g) + e^- \Rightarrow X^-(g)$
D) $X(g) \Rightarrow X^+(g) + e^-$
E) $X^+(g) \Rightarrow X^+(aq)$

ANS: C PTS: 1 DIF: Easy REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | electron affinity MSC: Conceptual

170. Which of the following lists of atoms are arranged in order of INCREASING first ionization energy?

A) Li < O < N < F
B) Li < N < O < F
C) F < O < N < Li
D) Na < Sr < O < F
E) Ca > Cs > S > Se

ANS: A PTS: 1 DIF: Moderate REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

171. Which of the following lists of atoms are arranged in order of DECREASING atomic radius?

A) Li > O > N > F
B) Li > N > O > F
C) F > O > N > Li
D) Na > Sr > O > F
E) Ca < Cs < S < Se

ANS: B PTS: 1 DIF: Easy REF: 7.12
KEY: Chemistry | general chemistry | atomic theory | periodicity of the elements | periodic properties | ionization energy MSC: Conceptual

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Chapter 8: Bonding: General Concepts

1. The force between two bodies having identical electric charges
   A) is a force of repulsion
   B) is a force of repulsion if the charges are negative, and one of attraction if they are positive
   C) increases as the bodies are moved further apart
   D) is independent of the distance between them
   E) is directly proportional to the distance between them

   ANS: A PTS: 1 DIF: Easy REF: 8.1
   KEY: Chemistry | general chemistry | bonding MSC: Conceptual

2. Which of the following groups contains no ionic compounds?
   A) HCN, NO_2, $Ca(NO_3)_2$
   B) PCl_5, LiBr, $Zn(OH)_2$
   C) KOH, CCl_4, SF_4
   D) NaH, CaF_2, $NaNH_2$
   E) CH_2O, H_2S, NH_3

   ANS: E PTS: 1 DIF: Easy REF: 8.1
   KEY: Chemistry | general chemistry | bonding | ionic bonding MSC: Conceptual

3. In which pair do both compounds exhibit predominantly ionic bonding?
   A) SCl_6 and HF
   B) Na_2SO_3 and NH_3
   C) KI and O_3
   D) LiF and H_2O
   E) LiBr and MgO

   ANS: E PTS: 1 DIF: Easy REF: 8.1
   KEY: Chemistry | general chemistry | bonding | ionic bonding MSC: Conceptual

4. When a metal reacts with a nonmetal a covalent bond is formed.

   ANS: F PTS: 1 DIF: Easy REF: 8.1
   KEY: Chemistry | general chemistry | bonding | ionic bonding MSC: Conceptual

5. A nonpolar covalent bond results from the unequal sharing of a pair of electrons between atoms in a molecule.

   ANS: F PTS: 1 DIF: Easy REF: 8.1
   KEY: Chemistry | general chemistry | bonding | covalent bonding
   MSC: Conceptual

6. Atoms having equal or nearly equal electronegativities are expected to form
   A) no bonds
   B) polar covalent bonds
   C) nonpolar covalent bonds
   D) ionic bonds

E) covalent bonds

ANS: C PTS: 1 DIF: Easy REF: 8.2
KEY: Chemistry | general chemistry | bonding | covalent bonding | electronegativity
MSC: Conceptual

7. Choose the compound with the most ionic bond.
A) LiCl
B) KF
C) NaCl
D) LiF
E) KCl

ANS: B PTS: 1 DIF: Moderate REF: 8.2
KEY: Chemistry | general chemistry | bonding | covalent bonding | electronegativity
MSC: Conceptual

8. Atoms with greatly different electronegativity values are expected to form
A) no bonds
B) covalent bonds
C) triple bonds
D) ionic bonds
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 8.2
KEY: Chemistry | general chemistry | bonding | covalent bonding | electronegativity
MSC: Conceptual

9. Which of the following bonds is least polar?
A) C—O
B) H—C
C) S—Cl
D) Br—Br
E) They are all nonpolar.

ANS: D PTS: 1 DIF: Moderate REF: 8.2
KEY: Chemistry | general chemistry | bonding | covalent bonding | electronegativity
MSC: Conceptual

10. For the elements Cs, F, and P, the order of increasing electronegativity is:
A) Cs < F < P
B) Cs < P < F
C) P < F < Cs
D) F < Cs < P
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 8.2
KEY: Chemistry | general chemistry | bonding | covalent bonding | electronegativity
MSC: Conceptual

11. For the elements Cs, F, and Cl, the order of increasing electronegativity is:

A) F < Cl < Cs
B) Cs < Cl < F
C) Cl < Cs < F
D) F < Cs < Cl
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 8.2
KEY: Chemistry | general chemistry | bonding | covalent bonding | electronegativity
MSC: Conceptual

12. In the gaseous phase, which of the following diatomic molecules would be the most polar?
A) CsF
B) CsCl
C) NaCl
D) NaF
E) LiF

ANS: A PTS: 1 DIF: Moderate REF: 8.2
KEY: Chemistry | general chemistry | bonding | covalent bonding | electronegativity
MSC: Conceptual

13. Based on electronegativities, which of the following would you expect to be most ionic?
A) N_2
B) CaF_2
C) CO_2
D) CH_4
E) CF_4

ANS: B PTS: 1 DIF: Moderate REF: 8.2
KEY: Chemistry | general chemistry | bonding | covalent bonding | electronegativity
MSC: Conceptual

14. In which case is the bond polarity *incorrect?*
A) $^{\delta+}H–F^{\delta-}$
B) $^{\delta+}K–O^{\delta-}$
C) $^{\delta+}Mg–H^{\delta-}$
D) $^{\delta+}Cl–I^{\delta-}$
E) $^{\delta+}Si–S^{\delta-}$

ANS: D PTS: 1 DIF: Easy REF: 8.2
KEY: Chemistry | general chemistry | bonding | covalent bonding | electronegativity
MSC: Conceptual

15. Metals typically have _____ electronegativity values.
A) high
B) low
C) negative
D) no
E) two of these

ANS: B PTS: 1 DIF: Easy REF: 8.2

KEY: Chemistry | general chemistry | bonding | covalent bonding | electronegativity
MSC: Conceptual

16. The electron pair in a C-F bond could be considered
    A) closer to C because carbon has a larger radius and thus exerts greater control over the shared electron pair
    B) closer to F because fluorine has a higher electronegativity than carbon
    C) closer to C because carbon has a lower electronegativity than fluorine
    D) an inadequate model since the bond is ionic
    E) centrally located directly between the C and F

    ANS: B PTS: 1 DIF: Easy REF: 8.2
    KEY: Chemistry | general chemistry | bonding | covalent bonding | electronegativity
    MSC: Conceptual

17. Based on electronegativity differences, which of the following is most likely to be ionic?
    A) CaF_2
    B) Br_2
    C) BH_3
    D) NO
    E) CF_4

    ANS: A PTS: 1 DIF: Easy REF: 8.2
    KEY: Chemistry | general chemistry | bonding | covalent bonding | electronegativity
    MSC: Conceptual

18. What is the correct order of the following bonds in terms of decreasing polarity?
    A) N-Cl, P-Cl, As-Cl
    B) P-Cl, N-Cl, As-Cl
    C) As-Cl, N-Cl, P-Cl
    D) P-Cl, As-Cl, N-Cl
    E) As-Cl, P-Cl, N-Cl

    ANS: E PTS: 1 DIF: Moderate REF: 8.2
    KEY: Chemistry | general chemistry | bonding | covalent bonding | electronegativity | polar covalent bond MSC: Conceptual

19. Which of the following bonds would be the most polar without being considered ionic?
    A) Mg-O
    B) C-O
    C) O-O
    D) Si-O
    E) N-O

    ANS: D PTS: 1 DIF: Moderate REF: 8.2
    KEY: Chemistry | general chemistry | bonding | covalent bonding | electronegativity | polar covalent bond MSC: Conceptual

20. Which of the following bonds would be the least polar, yet still be considered polar covalent?
    A) Mg-O

B) C-O
C) O-O
D) Si-O
E) N-O

ANS: E PTS: 1 DIF: Moderate REF: 8.2
KEY: Chemistry | general chemistry | bonding | covalent bonding | electronegativity | polar covalent bond MSC: Conceptual

21. In which of the following compounds does the bond between the central atom and bromine have the greatest ionic character?
A) LiBr
B) KBr
C) $SeBr_2$
D) $AsBr_3$
E) $CaBr_2$

ANS: B PTS: 1 DIF: Moderate REF: 8.2
KEY: Chemistry | general chemistry | bonding | covalent bonding | electronegativity
MSC: Conceptual

22. Which of the following statements is *incorrect*?
A) Ionic bonding results from the transfer of electrons from one atom to another.
B) Dipole moments result from the unequal distribution of electrons in a molecule.
C) The electrons in a polar bond are found nearer to the more electronegative element.
D) A molecule with very polar bonds can be nonpolar.
E) Linear molecules cannot have a net dipole moment.

ANS: E PTS: 1 DIF: Easy REF: 8.3
KEY: Chemistry | general chemistry | bonding | molecular geometry | dipole moment
MSC: Conceptual

23. Which of the following molecules has no dipole moment?
A) CO_2
B) NH_3
C) H_2O
D) all
E) none

ANS: A PTS: 1 DIF: Easy REF: 8.3
KEY: Chemistry | general chemistry | bonding | molecular geometry | dipole moment
MSC: Conceptual

24. Which of the following has the smallest radius?
A) Br^-
B) S^{2-}
C) Xe
D) Ca^{2+}
E) Kr

ANS: D PTS: 1 DIF: Easy REF: 8.4

KEY: Chemistry | general chemistry | bonding | ionic bonding | ionic radii
MSC: Conceptual

25. Which of these is an isoelectronic series?
A) Na^+, K^+, Rb^+, Cs^+
B) K^+, Ca^{2+}, Ar, S^{2-}
C) Na^+, Mg^{2+}, S^{2-}, Cl^-
D) Li, Be, B, C
E) none of these (A-D)

ANS: B PTS: 1 DIF: Easy REF: 8.4
KEY: Chemistry | general chemistry | bonding | ionic bonding MSC: Conceptual

26. Which of the following has the smallest radius?
A) K^+
B) Cl^-
C) Rb^+
D) S^{2-}
E) Ar

ANS: A PTS: 1 DIF: Easy REF: 8.4
KEY: Chemistry | general chemistry | bonding | ionic bonding | ionic radii
MSC: Conceptual

27. Which of the following has the smallest radius?
A) F^-
B) Ne
C) O^{2-}
D) Mg^{2+}
E) Na^+

ANS: D PTS: 1 DIF: Easy REF: 8.4
KEY: Chemistry | general chemistry | bonding | ionic bonding | ionic radii
MSC: Conceptual

28. Which of the following pairs is isoelectronic?
A) Li^+ and K^+
B) Na^+ and Ne
C) I^- and Cl^-
D) S^{2-} and Ne
E) Al^{3+} and B^{3+}

ANS: B PTS: 1 DIF: Easy REF: 8.4
KEY: Chemistry | general chemistry | bonding | ionic bonding MSC: Conceptual

29. Which of the following arrangements is in order of increasing size?
A) $Ga^{3+} > Ca^{2+} > K^+ > Cl^- > S^{2-}$
B) $S^{2-} > Cl^- > K^+ > Ca^{2+} > Ga^{3+}$
C) $Ga^{3+} > S^{2-} > Ca^{2+} > Cl^- > K^+$
D) $Ga^{3+} > Ca^{2+} > S^{2-} > Cl^- > K^+$
E) $Ga^{3+} > Ca^{2+} > S^{2-} > K^+ > Cl^-$

ANS: A PTS: 1 DIF: Moderate REF: 8.4
KEY: Chemistry | general chemistry | bonding | ionic bonding | ionic radii
MSC: Conceptual

30. The size in a series of isoelectronic ions increases as the nuclear charge increases.

ANS: F PTS: 1 DIF: Easy REF: 8.4
KEY: Chemistry | general chemistry | bonding | ionic bonding | ionic radii
MSC: Conceptual

31. Which of the following species would be expected to have the lowest ionization energy?
A) F^-
B) Ne
C) O^{2-}
D) Mg^{2+}
E) Na^+

ANS: C PTS: 1 DIF: Easy REF: 8.5
KEY: Chemistry | general chemistry | bonding | ionic bonding | Born-Haber cycle
MSC: Conceptual

32. Which of the following ionic compounds has the largest lattice energy (i.e., the lattice energy most favorable to a stable lattice)?
A) BaO
B) BeO
C) CsI
D) NaBr
E) BaS

ANS: B PTS: 1 DIF: Moderate REF: 8.5
KEY: Chemistry | general chemistry | bonding | ionic bonding | Born-Haber cycle
MSC: Conceptual

33. Which of the following ionic compounds has the smallest lattice energy (i.e., the lattice energy least favorable to a stable lattice)?
A) LiF
B) CsI
C) NaCl
D) BaO
E) MgO

ANS: B PTS: 1 DIF: Moderate REF: 8.5
KEY: Chemistry | general chemistry | bonding | ionic bonding | Born-Haber cycle
MSC: Conceptual

34. Calculate the lattice energy for LiCl(*s*) given the following:

sublimation energy for Li(*s*)	+166 kJ/mol
ΔH_f for Cl(*g*)	+119 kJ/mol
first ionization energy of Li(*g*)	+520. kJ/mol
electron affinity of Cl(*g*)	–349 kJ/mol

enthalpy of formation of LiCl(*s*) –409 kJ/mol

A) 47 kJ/mol
B) 171 kJ/mol
C) –580 kJ/mol
D) –865 kJ/mol
E) none of these

ANS: D PTS: 1 DIF: Difficult REF: 8.5
KEY: Chemistry | general chemistry | bonding | ionic bonding | Born-Haber cycle
MSC: Quantitative

35. Which of the following statements are *true* concerning ionic bonding?
A) Ionic bonding occurs between a metal, which has a high affinity for electrons, and a nonmetal, which loses electrons relatively easy.
B) $CaCl_2$ forms because Ca^{2+} is always a more stable species than the calcium atom alone.
C) Compounds with ionic bonds tend to have low melting points.
D) The electronegativity difference between the bonding atoms of ionic compounds is small since the electrons are not shared but rather held together by electrostatic forces.
E) All of the above statements are false.

ANS: E PTS: 1 DIF: Moderate REF: 8.5
KEY: Chemistry | general chemistry | bonding | ionic bonding MSC: Conceptual

36. Which of the following statements concerning lattice energy is *false*?
A) It is often defined as the energy released when an ionic solid forms from its ions.
B) MgO has a larger lattice energy than NaF.
C) The lattice energy for a solid with 2+ and 2– ions should be two times that for a solid with 1+ and 1– ions.
D) MgO has a larger lattice energy than LiF.
E) All of these are true.

ANS: C PTS: 1 DIF: Easy REF: 8.5
KEY: Chemistry | general chemistry | bonding | ionic bonding | Born-Haber cycle
MSC: Conceptual

37. Given the following information:

$Li(s) \rightarrow Li(g)$	enthalpy of sublimation of Li(*s*) = 166 kJ/mol
$HBr(g) \rightarrow H(g) + Br(g)$	bond energy of HBr = 363 kJ/mol
$Li(g) \rightarrow Li^+(g) + e^-$	ionization energy of Li(*g*) = 520. kJ/mol
$Br(g) + e^- \rightarrow Br^-(g)$	electron affinity of Br(*g*) = –325 kJ/mol
$Li^+(g) + Br^-(g) \rightarrow LiBr(s)$	lattice energy of LiBr(*s*) = –809 kJ/mol
$H_2(g) \rightarrow 2H(g)$	bond energy of H_2 = 432 kJ/mol

Calculate the change in enthalpy for:
$2Li(s) + 2HBr(g) \rightarrow H_2(g) + 2LiBr(s)$
A) 262 kJ
B) –602 kJ
C) –517 kJ

D) –992 kJ
E) none of these

ANS: B PTS: 1 DIF: Difficult REF: 8.5
KEY: Chemistry | general chemistry | bonding | ionic bonding | Born-Haber cycle
MSC: Quantitative

38. The first electron affinity value for oxygen is _____ and the second electron affinity value is _____.
A) unfavorable (endothermic), favorable (exothermic)
B) unfavorable (endothermic), unfavorable (endothermic)
C) favorable (exothermic), favorable (exothermic)
D) favorable (exothermic), unfavorable (endothermic)
E) More information is needed.

ANS: D PTS: 1 DIF: Moderate REF: 8.5
KEY: Chemistry | general chemistry | bonding | ionic bonding | Born-Haber cycle
MSC: Conceptual

39. In the reaction between magnesium and sulfur, the magnesium atoms
A) become anions
B) become cations
C) become part of polyatomic ions
D) share electrons with sulfur
E) crystallize

ANS: B PTS: 1 DIF: Easy REF: 8.5
KEY: Chemistry | general chemistry | bonding | ionic bonding | Born-Haber cycle
MSC: Conceptual

40. When electrons in a molecule are not found between a pair of atoms but move throughout the molecule, this is called
A) ionic bonding
B) covalent bonding
C) polar covalent bonding
D) delocalization of the electrons
E) a dipole moment

ANS: D PTS: 1 DIF: Easy REF: 8.7
KEY: Chemistry | general chemistry | bonding | covalent bonding | delocalization
MSC: Conceptual

41. Which of the following statements is *false*?
A) Models are human interpretations, not the same as reality.
B) Models are often wrong.
C) Models usually start out simple and become more complex over time.
D) We often learn more when a model is wrong than when it is right.
E) A model should be discarded when any exception to it is found.

ANS: E PTS: 1 DIF: Easy REF: 8.7
KEY: Chemistry | general chemistry | bonding MSC: Conceptual

42. Choose the molecule with the strongest bond.
    A) F_2
    B) Cl_2
    C) Br_2
    D) I_2
    E) All are equal.

    ANS: B PTS: 1 DIF: Easy REF: 8.8
    KEY: Chemistry | general chemistry | bonding | covalent bonding | bond energy
    MSC: Conceptual

43. Choose the molecule with the strongest bond.
    A) HF
    B) HCl
    C) HBr
    D) HI
    E) All are equal.

    ANS: A PTS: 1 DIF: Easy REF: 8.8
    KEY: Chemistry | general chemist | bonding | covalent bonding | bond energy
    MSC: Conceptual

44. Choose the molecule with the strongest bond.
    A) CH_4
    B) H_2O
    C) NH_3
    D) HF
    E) All are equal

    ANS: D PTS: 1 DIF: Easy REF: 8.8
    KEY: Chemistry | general chemistry | bonding | covalent bonding | bond energy
    MSC: Conceptual

45. Which of the following molecules exhibits the greatest bond energy?
    A) F_2
    B) Cl_2
    C) Br_2
    D) I_2
    E) all the same

    ANS: B PTS: 1 DIF: Easy REF: 8.8
    KEY: Chemistry | general chemistry | bonding | covalent bonding | bond energy
    MSC: Conceptual

46. As the number of bonds between two carbon atoms increases, which one of the following decreases?
    A) number of electrons between the carbon atoms
    B) bond energy
    C) bond length
    D) all of these

E) none of these

ANS: C PTS: 1 DIF: Easy REF: 8.8
KEY: Chemistry | general chemistry | bonding | covalent bonding
MSC: Conceptual

47. Using the following bond energies:

Bond	Bond Energy (kJ/mol)
C≡C	839
C–H	413
O=O	495
C=O	799
O–H	467

estimate the heat of combustion for one mole of acetylene:

$C_2H_2(g) + \frac{5}{2}O_2(g) \rightarrow 2CO_2(g) + H_2O(g)$

A) 1228 kJ
B) –1228 kJ
C) –447 kJ
D) +447 kJ
E) +365 kJ

ANS: B PTS: 1 DIF: Moderate REF: 8.8
KEY: Chemistry | general chemistry | bonding | covalent bonding | bond energy
MSC: Quantitative

48. Using the following data reactions:

	$\Delta H°$ (kJ)
$H_2(g) + F_2(g) \rightarrow 2HF(g)$	–542
$H_2(g) \rightarrow 2H(g)$	432
$F_2(g) \rightarrow 2F(g)$	154

calculate the energy of an H-F bond.

A) 1128 kJ
B) 22 kJ
C) 44 kJ
D) 271 kJ
E) 564 kJ

ANS: E PTS: 1 DIF: Moderate REF: 8.8
KEY: Chemistry | general chemistry | bonding | covalent bonding | bond energy
MSC: Quantitative

49. Given the following bond energies:

C–C	347 kJ/mol
C=C	614 kJ/mol
C–O	358 kJ/mol
C=O	799 kJ/mol
C–H	413 kJ/mol
O–H	463 kJ/mol
O–O	146 kJ/mol

estimate ΔH for the reaction $H_2O_2 + CH_3OH \rightarrow H_2CO + 2H_2O$.

A) –345 kJ
B) –199 kJ
C) –105 kJ
D) +199 kJ
E) +345 kJ

ANS: A PTS: 1 DIF: Moderate REF: 8.8
KEY: Chemistry | general chemistry | bonding | covalent bonding | bond energy
MSC: Quantitative

50. Given the following information:
Br_2 bond energy = 193 kJ/mol
F_2 bond energy = 154 kJ/mol
$\frac{1}{2}Br_2(g) + \frac{3}{2}F_2(g) \rightarrow BrF_3(g)$ $\Delta H° = -384$ kJ/mol
calculate the Br-F bond energy.

A) 244 kJ/mol
B) 237 kJ/mol
C) 712 kJ/mol
D) 128 kJ/mol
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 8.8
KEY: Chemistry | general chemistry | bonding | covalent bonding | bond energy
MSC: Quantitative

51. Consider the following reaction:
$A_2 + B_2 \rightarrow 2AB$ $\Delta H = -365$ kJ
The bond energy for A_2 is half the amount of AB. The bond energy of B_2 = 447 kJ/mol. What is the bond energy of A_2?

A) 812 kJ/mol
B) 630 kJ/mol
C) 271 kJ/mol
D) –183 kJ/mol
E) none of these

ANS: C PTS: 1 DIF: Difficult REF: 8.8
KEY: Chemistry | general chemistry | bonding | covalent bonding | bond energy
MSC: Conceptual

52. A double bond occurs when two atoms share two pairs of electrons.

ANS: T PTS: 1 DIF: Easy REF: 8.8
KEY: Chemistry | general chemistry | bonding | covalent bonding | multiple bonds
MSC: Conceptual

53. As indicated by Lewis structures, which of the following would probably not exist as a stable molecule?

A) CH_3OH
B) CH_2O

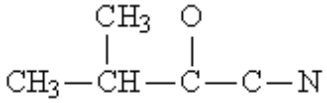
C) CH_3O
D) C_2H_2
E) C_3H_4

ANS: C PTS: 1 DIF: Moderate REF: 8.1
KEY: Chemistry | general chemistry | bonding | covalent bonding | Lewis dot formula
MSC: Conceptual

54. In the Lewis structure for elemental nitrogen there is (are)
A) a single bond between the nitrogens
B) a double bond between the nitrogens
C) a triple bond between the nitrogens
D) three unpaired electrons
E) none of the above

ANS: C PTS: 1 DIF: Easy REF: 8.1
KEY: Chemistry | general chemistry | bonding | covalent bonding | Lewis dot formula
MSC: Conceptual

55. Complete the Lewis structure for the molecule:



This molecule has _____ single bonds and _____ multiple bonds.
A) 4, 2
B) 6, 3
C) 11, 5
D) 11, 2
E) 13, 0

ANS: D PTS: 1 DIF: Moderate REF: 8.1
KEY: Chemistry | general chemistry | bonding | covalent bonding | multiple bonds
MSC: Conceptual

Draw the Lewis structures of the molecules below and use them to answer the following questions:
I. BH_3
II. NO_2
III. SF_6
IV. O_3
V. PCl_5

56. Which of the molecules obeys the octet rule?
A) I
B) II
C) III
D) IV
E) V

ANS: D PTS: 1 DIF: Easy REF: 8.1
KEY: Chemistry | general chemistry | bonding | covalent bonding | octet rule

MSC: Conceptual

57. How many of the molecules have no dipole moment?
A) 1
B) 2
C) 3
D) 4
E) They are all polar.

ANS: C PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | dipole moment
MSC: Conceptual

58. Which of these molecules show resonance?
A) I, II
B) II, IV
C) II, V
D) III, IV
E) III, V

ANS: B PTS: 1 DIF: Moderate REF: 8.12
KEY: Chemistry | general chemistry | bonding | covalent bonding | resonance
MSC: Conceptual

Using the following electronegativity values:

C	2.5	Cl	3.0
H	2.1	O	3.5

select from the following group the molecule that fits the given statement:
a) CH_3CHO
b) CO_2
c) CH_3Cl
d) C_2H_6
e) none

59. This molecule contains a carbon atom with trigonal planar geometry.
A) CH_3CHO
B) CO_2
C) CH_3Cl
D) C_2H_6
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry
MSC: Conceptual

60. This molecule is the most polar.
A) CH_3CHO
B) CO_2
C) CH_3Cl
D) C_2H_6

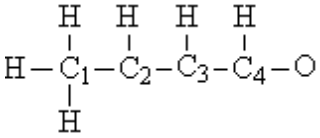
E) All are nonpolar.

ANS: A PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | dipole moment
MSC: Conceptual

61. This molecule shows the smallest number of lone pairs in its Lewis structure.
A) CH_3CHO
B) CO_2
C) CH_3Cl
D) C_2H_6
E) All have zero lone pairs.

ANS: D PTS: 1 DIF: Easy REF: 8.1
KEY: Chemistry | general chemistry | bonding | covalent bonding | Lewis dot formula
MSC: Conceptual

Consider the compound crotonaldehyde, whose skeleton is:



62. How many electrons must be shown (as bonding or nonbonding electrons) in the Lewis structure of this molecule?
A) 12
B) 18
C) 24
D) 28
E) 32

ANS: D PTS: 1 DIF: Easy REF: 8.1
KEY: Chemistry | general chemistry | bonding | covalent bonding | Lewis dot formula
MSC: Conceptual

63. How many nonbonding electrons appear in the Lewis structure of this molecule?
A) 2
B) 4
C) 6
D) 8
E) 10

ANS: B PTS: 1 DIF: Easy REF: 8.1
KEY: Chemistry | general chemistry | bonding | covalent bonding | Lewis dot formula
MSC: Conceptual

64. Which carbon in this molecule has tetrahedral bonding?
A) 1
B) 2
C) 3
D) 4

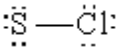
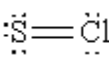
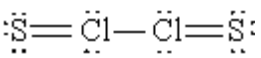
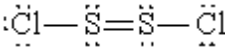
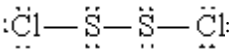
E) all

ANS: A PTS: 1 DIF: Easy REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

65. Which of the following molecules contains a double bond?
A) CO_2
B) NH_3
C) H_2O
D) all
E) none

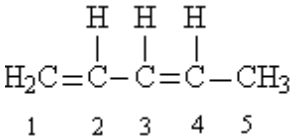
ANS: A PTS: 1 DIF: Easy REF: 8.1
KEY: Chemistry | general chemistry | bonding | covalent bonding | multiple bonds
MSC: Conceptual

66. When molten sulfur reacts with chlorine gas, a vile-smelling orange liquid forms that is found to have the empirical formula SCl. Which of the following could be the correct Lewis structure for this compound?

A) 
B) 
C) 
D) 
E) 

ANS: E PTS: 1 DIF: Easy REF: 8.1
KEY: Chemistry | general chemistry | bonding | covalent bonding | Lewis dot formula
MSC: Conceptual

Given the following Lewis structure:



67. How many unshared pairs of electrons are present in this molecule?
A) 0
B) 1
C) 2
D) 3
E) 4

ANS: A PTS: 1 DIF: Easy REF: 8.1
KEY: Chemistry | general chemistry | bonding | covalent bonding | Lewis dot formula
MSC: Conceptual

68. How many electrons are shared between carbons 1 and 2?
A) 0
B) 2
C) 4
D) 6
E) 8

ANS: C PTS: 1 DIF: Easy REF: 8.1
KEY: Chemistry | general chemistry | bonding | covalent bonding | Lewis dot formula
MSC: Conceptual

69. Which of the following compounds contains only one unshared pair of valence electrons?
A) NH_3
B) H_2O
C) CH_4
D) NaCl
E) BF_3

ANS: A PTS: 1 DIF: Easy REF: 8.1
KEY: Chemistry | general chemistry | bonding | covalent bonding | Lewis dot formula
MSC: Conceptual

70. The Lewis structure for $CHCl_3$ has nine lone electron pairs.

ANS: T PTS: 1 DIF: Easy REF: 8.1
KEY: Chemistry | general chemistry | bonding | covalent bonding | Lewis dot formula
MSC: Conceptual

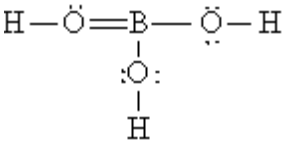
71. Which of the following atoms cannot exceed the octet rule in a molecule?
A) N
B) S
C) P
D) I
E) All of the atoms (A-D) can exceed the octet rule.

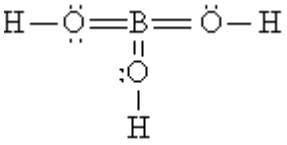
ANS: A PTS: 1 DIF: Easy REF: 8.11
KEY: Chemistry | general chemistry | bonding | covalent bonding | exceptions to the octet rule MSC: Conceptual

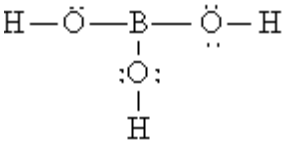
72. As indicated by Lewis structures, which of the following species could probably not exist as a stable molecule?
A) NH_3
B) N_2H_2
C) N_2H_4
D) N_2H_6
E) N_2O_4

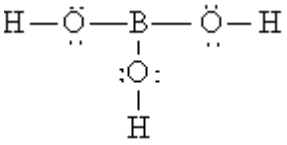
ANS: D PTS: 1 DIF: Moderate REF: 8.11
KEY: Chemistry | general chemistry | bonding | covalent bonding | exceptions to the octet rule MSC: Conceptual

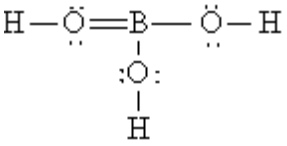
73. The Lewis structure for H_3BO_3 is

A) 

B) 

C) 

D) 

E) 

ANS: D PTS: 1 DIF: Moderate REF: 8.11
KEY: Chemistry | general chemistry | bonding | covalent bonding | exceptions to the octet rule MSC: Conceptual

74. In the Lewis structure for ICl_2^-, how many lone pairs of electrons are around the central iodine atom?

A) 0
B) 1
C) 2
D) 3
E) 4

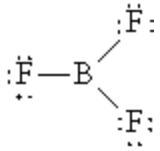
ANS: D PTS: 1 DIF: Easy REF: 8.11
KEY: Chemistry | general chemistry | bonding | covalent bonding | exceptions to the octet rule MSC: Conceptual

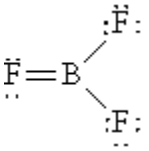
75. In the Lewis structure for SF_6, the central sulfur atom shares _____ electrons.

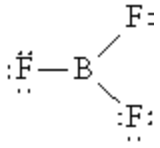
A) 4
B) 8
C) 10
D) 12
E) None of the above, because SF_6 is an ionic compound.

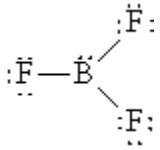
ANS: D PTS: 1 DIF: Easy REF: 8.11
KEY: Chemistry | general chemistry | bonding | covalent bonding | exceptions to the octet rule MSC: Conceptual

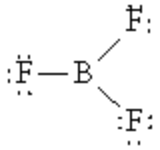
76. Which of the following Lewis structures best describes BF_3?

A) 

B) 

C) 

D) 

E) 

ANS: A PTS: 1 DIF: Easy REF: 8.11
KEY: Chemistry | general chemistry | bonding | covalent bonding | exceptions to the octet rule MSC: Conceptual

77. Which of the following has an incomplete octet in its Lewis structure?
A) SO_2
B) ICl
C) CO_2
D) F_2
E) NO

ANS: E PTS: 1 DIF: Easy REF: 8.11
KEY: Chemistry | general chemistry | bonding | covalent bonding | exceptions to the octet rule MSC: Conceptual

Consider the following molecules.
I. BF_3
II. $CHBr_3$ (C is the central atom)
III. Br_2
IV. $XeCl_2$
V. CO
VI. SF_4
Select the molecule(s) that fit the given statement.

78. These molecules violate the octet rule.
A) I, II, IV

B) I, III, IV, VI
C) III, V, VI
D) I, IV, VI
E) I, II, IV, VI

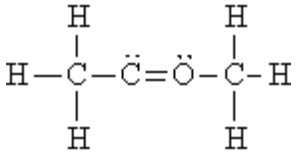
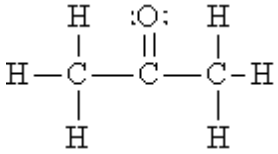
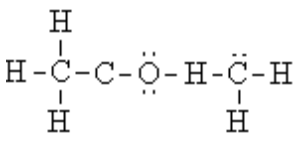
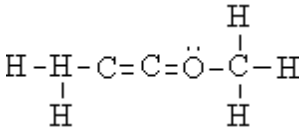
ANS: D PTS: 1 DIF: Easy REF: 8.11
KEY: Chemistry | general chemistry | bonding | covalent bonding | exceptions to the octet rule MSC: Conceptual

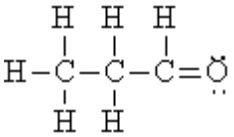
79. These molecules have a zero net dipole moment.
A) III, V
B) I, III, IV
C) III, IV, V
D) I, III, IV, VI
E) none of them

ANS: B PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | dipole moment
MSC: Conceptual

80. These molecules have a trigonal bipyramidal electron pair arrangement.
A) II, IV, VI
B) I, IV
C) IV, VI
D) VI only
E) none of them

ANS: C PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model | trigonal bipyramidal arrangement MSC: Conceptual

81. Select the best Lewis structure for acetone, CH_3COCH_3.
A)

B)

C)

D)


E) 

ANS: B PTS: 1 DIF: Easy REF: 8.12
KEY: Chemistry | general chemistry | bonding | covalent bonding | Lewis dot formula
MSC: Conceptual

82. Which of the following exhibits resonance?
A) NH_3
B) PCl_5
C) H_2O
D) O_3
E) At least two of the molecules (A-D) exhibit resonance.

ANS: D PTS: 1 DIF: Easy REF: 8.12
KEY: Chemistry | general chemistry | bonding | covalent bonding | resonance
MSC: Conceptual

83. Which of the following species is best described by drawing resonance structures?
A) PH_3
B) NH_4^+
C) O_3
D) SO_3
E) HCN

ANS: C PTS: 1 DIF: Easy REF: 8.12
KEY: Chemistry | general chemistry | bonding | covalent bonding | resonance
MSC: Conceptual

84. In the cyanide ion (CN^-), the nitrogen has a formal charge of
A) -2
B) -1
C) 0
D) 2
E) More information is needed.

ANS: C PTS: 1 DIF: Easy REF: 8.12
KEY: Chemistry | general chemistry | bonding | covalent bonding | formal charge
MSC: Conceptual

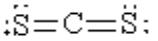
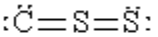
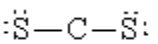
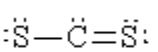
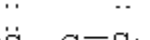
85. Which has the greater N–O bond length, NO_2^- or NO_3^-?
A) NO_2^-
B) NO_3^-
C) The bond lengths are the same.
D) More information is needed.
E) None of these (A-D).

ANS: B PTS: 1 DIF: Moderate REF: 8.12
KEY: Chemistry | general chemistry | bonding | covalent bonding | resonance

MSC: Conceptual

86. How many resonance structures can be drawn for the molecule O_3?
A) 1
B) 2
C) 3
D) 4
E) 5

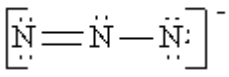
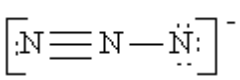
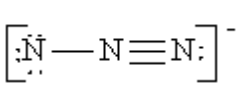
ANS: B PTS: 1 DIF: Easy REF: 8.12
KEY: Chemistry | general chemistry | bonding | covalent bonding | resonance
MSC: Conceptual

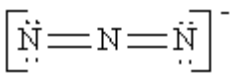
87. Choose the electron dot formula that most accurately describes the bonding in CS_2. (Hint: Consider formal charges.)
A) 
B) 
C) 
D) 
E) 

ANS: A PTS: 1 DIF: Easy REF: 8.12
KEY: Chemistry | general chemistry | bonding | covalent bonding | formal charge
MSC: Conceptual

88. Which of the following has a Lewis structure most like that of CO_3^{2-}?
A) CO_2
B) SO_3^{2-}
C) NO_3^-
D) O_3
E) NO_2

ANS: C PTS: 1 DIF: Moderate REF: 8.12
KEY: Chemistry | general chemistry | bonding | covalent bonding | resonance
MSC: Conceptual

89. Which of the following is not a valid resonance structure for N_3^-?
A) 
B) 
C) 

D) 

E) all are correct

ANS: A PTS: 1 DIF: Easy REF: 8.12
KEY: Chemistry | general chemistry | bonding | covalent bonding | resonance
MSC: Conceptual

90. How many of the following molecules possess dipole moments?
BH_3, CH_4, PCl_5, H_2O, HF, H_2
A) 1
B) 2
C) 3
D) 4
E) 5

ANS: B PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | dipole moment
MSC: Conceptual

91. Which of the following molecules has a dipole moment?
A) CH_4
B) CCl_4
C) CO_2
D) SO_2
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | dipole moment
MSC: Conceptual

92. Select the molecule from the following that has a dipole moment.
A) CO_2
B) SeO_3
C) XeF_4
D) SF_4
E) $BeCl_2$

ANS: D PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | dipole moment
MSC: Conceptual

93. Which of the following molecules (or ions) has a dipole moment?
A) CO_2
B) CO_3^{2-}
C) NH_4^+
D) PF_3
E) two of them

ANS: D PTS: 1 DIF: Moderate REF: 8.13

KEY: Chemistry | general chemistry | bonding | molecular geometry | dipole moment
MSC: Conceptual

94. Which of the following molecules has a dipole moment?
A) BH_3
B) SiF_4
C) PF_3
D) O_2
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | dipole moment
MSC: Conceptual

95. Choose the statement that best describes the $PbCl_4$ molecule in the gas phase.
A) The bond angles are all about 109°.
B) The molecule is polar.
C) The molecule has a dipole moment.
D) The bonds are nonpolar.
E) More than one of the above.

ANS: A PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry
MSC: Conceptual

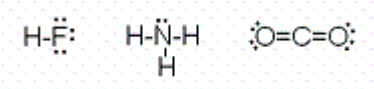
96. Which of the following has a zero dipole moment?
A) NH_3
B) NO_2
C) PF_5
D) SO_2
E) HCN

ANS: C PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | dipole moment
MSC: Conceptual

97. Which of the following types of molecules always has a dipole moment?
A) Linear molecules with two identical bonds.
B) Tetrahedral molecules (four identical bonds equally spaced).
C) Trigonal pyramid molecules (three identical bonds).
D) Trigonal planar molecules (three identical bonds equally spaced).
E) None has a dipole moment.

ANS: C PTS: 1 DIF: Easy REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | dipole moment
MSC: Conceptual

98. Consider the following drawings:



Which of the following statements are true?

I. The electrons in each molecule tend to orient themselves around the most electronegative element.
II. Each molecular drawing follows the localized electron model.
III. Both HF and CO_2 are linear molecules and therefore polar.
IV. The bond angles of NH_3 are slightly less than 109.5° because the lone pair compresses the angles between the bonding pairs.

A) I, III, IV
B) I, II, IV
C) I, II, III
D) II, IV
E) All of the above statements are correct.

ANS: B PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding MSC: Conceptual

99. If a compound has a number of individual dipoles, then:

I. It is polar overall.
II. There is an electronegativity difference between the bonded atoms.
III. it is ionic.
IV. It doesn't have resonance.

A) II only
B) II, IV
C) I, II, IV
D) I, III
E) All of the above statements are correct.

ANS: A PTS: 1 DIF: Easy REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | dipole moment
MSC: Conceptual

100. Of the following, which molecule has the largest bond angle?

A) O_3
B) OF_2
C) HCN
D) H_2O
E) More than one of the above have equally large bond angles.

ANS: C PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | bond angle
MSC: Conceptual

101. According to the VSEPR model, the arrangement of electron pairs around NH_3 and CH_4 is

A) different, because in each case there are a different number of atoms around the central atom
B) different, because in each case there are a different number of electron pairs around the central atom
C) the same, because both nitrogen and carbon are both in the second period

D) the same, because in each case there are the same number of electron pairs around the central atom
E) different or the same, depending on the conditions leading to maximum repulsion

ANS: D PTS: 1 DIF: Easy REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

102. The Cl–Kr–Cl bond angle in $KrCl_4$ is closest to
A) 90°
B) 109°
C) 120°
D) 150°
E) 360°

ANS: A PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | bond angle
MSC: Conceptual

103. How many of the following molecules—SF_2, SF_4, SF_6, SiO_2—are polar?
A) 0
B) 1
C) 2
D) 3
E) 4

ANS: C PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | dipole moment
MSC: Conceptual

104. Which of the following molecules is non-polar overall?
A) SF_4
B) SF_2
C) CCl_4
D) H_2S
E) OCl_2

ANS: C PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | dipole moment
MSC: Conceptual

105. Which of the following is the correct order for molecules from most to least polar?
A) $CH_4 > CF_2Cl_2 > CF_2H_2 > CCl_4 > CCl_2H_2$
B) $CH_4 > CF_2H_2 > CF_2Cl_2 > CCl_4 > CCl_2H_2$
C) $CF_2Cl_2 > CF_2H_2 > CCl_2H_2 > CH_4 = CCl_4$
D) $CF_2H_2 > CCl_2H_2 > CF_2Cl_2 > CH_4 = CCl_4$
E) $CF_2Cl_2 > CF_2H_2 > CCl_4 > CCl_2H_2 > CH_4$

ANS: D PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | dipole moment
MSC: Conceptual

106. Which of the following molecules has a nonlinear structure?
A) XeF_2
B) $BeCl_2$
C) O_3
D) CO_2
E) N_2O (central atom is N)

ANS: C PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

107. Which of the following molecules are nonlinear?
NO_2^-, C_2H_2, N_3^-, HCN, CO_2, H_2O_2
A) C_2H_2, HCN
B) CO_2, N_3^-
C) NO_2^-, H_2O_2
D) N_3^-, NO_2^-
E) all are linear

ANS: C PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

108. How many of the following molecules or ions are linear?
NH_3 OF_2 HCN CO_2 NO_2

A) 0
B) 1
C) 2
D) 3
E) 4

ANS: C PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model | linear arrangement MSC: Conceptual

109. The molecular structure of $SOCl_2$ is
A) pyramidal
B) none of these
C) octahedral
D) trigonal planar
E) bent

ANS: A PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

110. The molecular structure of OF_2 is
A) pyramidal
B) none of these

C) octahedral
D) trigonal planar
E) bent

ANS: E PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

111. The molecular structure of NCl_3 is
A) pyramidal
B) none of these
C) octahedral
D) trigonal planar
E) bent

ANS: A PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

112. The molecular structure of BeF_3^- is
A) pyramidal
B) none of these
C) octahedral
D) trigonal planar
E) bent

ANS: D PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

113. The molecular structure of BrF_6^+ is
A) pyramidal
B) none of these
C) octahedral
D) trigonal planar
E) bent

ANS: C PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

114. The molecular structure of $AsCl_5$ is
A) trigonal bipyramidal
B) square pyramidal
C) distorted tetrahedral
D) octahedral
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

115. The molecular structure of XeF_5^+ is
A) trigonal bipyramidal
B) square pyramidal
C) distorted tetrahedral
D) octahedral
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

116. What type of structure does the $XeOF_2$ molecule have?
A) pyramidal
B) tetrahedral
C) T-shaped
D) trigonal planar
E) octahedral

ANS: C PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

117. The bond angles about the carbon atom in the formaldehyde molecule, $H_2C{=}O$, are about:
A) 120°
B) 60°
C) 109°
D) 180°
E) 90°

ANS: A PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | bond angle
MSC: Conceptual

118. Which of the following species has a trigonal bipyramid structure?
A) NH_3
B) IF_5
C) I_3^-
D) PCl_5
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model | trigonal bipyramidal arrangement MSC: Conceptual

119. The bond angle in H_2Se is about:
A) 120°
B) 60°
C) 180°
D) 109°
E) 90°

ANS: D PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | bond angle
MSC: Conceptual

120. Which ion is planar?
A) NH_4^+
B) CO_3^{2-}
C) SO_3^{2-}
D) ClO_3^-
E) all are planar

ANS: B PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

Select the correct molecular structure for the given species from the choices below:

121. PF_6^-
A) pyramidal
B) tetrahedral
C) square planar
D) octahedral
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

122. PCl_4^+
A) pyramidal
B) tetrahedral
C) square planar
D) octahedral
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

123. XeF_6
A) pyramidal
B) tetrahedral
C) square planar
D) octahedral
E) none of these

ANS: E PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

124. NI_3
A) pyramidal
B) tetrahedral
C) square planar
D) octahedral
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

125. SiH_4
A) pyramidal
B) tetrahedral
C) square planar
D) octahedral
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

126. ClO_2
A) pyramidal
B) tetrahedral
C) square planar
D) octahedral
E) none of these

ANS: E PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

127. IF_4^-
A) pyramidal
B) tetrahedral
C) square planar
D) octahedral
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

128. SO_3^{2-}
A) pyramidal
B) tetrahedral
C) square planar
D) octahedral
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

Select the correct molecular structure for the given species from the choices below:

129. H_2O
A) linear
B) trigonal planar
C) tetrahedral
D) bent
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

130. CO_2
A) linear
B) trigonal planar
C) tetrahedral
D) bent
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

131. $BeCl_2$
A) linear
B) trigonal planar
C) tetrahedral
D) bent
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

132. SF_4
A) linear
B) trigonal planar
C) tetrahedral
D) bent
E) none of these

ANS: E PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

133. NO_3^-

A) linear
B) trigonal planar
C) tetrahedral
D) bent
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

134. I_3^-
A) linear
B) trigonal planar
C) tetrahedral
D) bent
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

135. PF_5
A) linear
B) trigonal planar
C) tetrahedral
D) bent
E) none of these

ANS: E PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

136. ClF_2^+
A) linear
B) trigonal planar
C) tetrahedral
D) bent
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

137. In the molecule XeF_2, how many pairs of electrons surround Xe and what is the molecular geometry?
A) 4, bent
B) 4, pyramidal
C) 5, linear
D) 5, bent
E) 6, linear

ANS: C PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

138. According to VSEPR theory, which of the following species has a square planar molecular structure?
A) $TeBr_4$
B) BrF_3
C) IF_5
D) XeF_4
E) SCl_2

ANS: D PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

139. How many of the following molecules have all of their atoms in the same plane?
$H_2C{=}CH_2$ OF_2 H_2CO NH_3 CO_2 $BeCl_2$

A) 3
B) 4
C) 5
D) 6
E) 7

ANS: C PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

140. The shape of an ammonia molecule is tetrahedral.

ANS: F PTS: 1 DIF: Easy REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

141. The shape of a carbon dioxide molecule is linear.

ANS: T PTS: 1 DIF: Easy REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | the valence-shell electron-pair repulsion model MSC: Conceptual

142. When nonmetals chemically combine, they tend to form what type of bond?

ANS:
covalent

PTS: 1 DIF: Easy REF: 8.1
KEY: Chemistry | general chemistry | bonding | covalent bonding
MSC: Conceptual

143. The ability of an atom in a molecule to attract shared electrons to itself is called _____.

ANS:
electronegativity

PTS: 1 DIF: Easy REF: 8.2
KEY: Chemistry | general chemistry | bonding | covalent bonding | electronegativity
MSC: Conceptual

144. A molecule that has a center of positive charge and a center of negative charge is said to be _____.

ANS:
polar

PTS: 1 DIF: Easy REF: 8.3
KEY: Chemistry | general chemistry | bonding | covalent bonding
MSC: Conceptual

145. Match the ions below with the pictures that represent their relative sizes. Justify your answers.
Ions:
Se^{2-} K^{+} Ga^{3+} Br^{-} Ca^{2+}

ANS:

K^{+} Ca^{2+} Ga^{3+} Se^{2-} Br^{-}

Se^{2-} and Br^{-} each have the electron configuration of Kr. K^{+}, Ca^{2+}, and Ga^{3+} each have the electron configuration of Ar. The Se^{2-} and Br^{-} contain electrons in a higher energy level, therefore making their radii larger than the other three ions. Since Br^{-} has more protons, this will draw the electrons in slightly more than Se^{2-} (due to a slightly higher effective nuclear charge). For the other three ions, Ga^{3+} will be the smallest because it has the highest number of protons. K^{+} has the least number of protons and is thus the biggest ion of the three.
See Sec. 8.4 in Zumdahl, *Chemistry*.

PTS: 1 DIF: Moderate REF: 8.4
KEY: Chemistry | general chemistry | bonding | ionic bonding | ionic radii
MSC: Conceptual

146. The _____ is the change in energy that takes place when separated gaseous ions are packed together to form an ionic solid.

ANS:
lattice energy

PTS: 1 DIF: Easy REF: 8.5
KEY: Chemistry | general chemistry | bonding | ionic bonding | Born-Haber cycle
MSC: Conceptual

147. Stable molecules usually contain atoms that have filled _____ orbitals.

ANS:
valence

PTS: 1 DIF: Easy REF: 8.7
KEY: Chemistry | general chemistry | bonding MSC: Conceptual

148. The _____ of a molecule shows how the valence electrons are arranged among the atoms in the molecule.

ANS:
Lewis structure

PTS: 1 DIF: Easy REF: 8.1
KEY: Chemistry | general chemistry | bonding | covalent bonding | Lewis dot formula
MSC: Conceptual

149. When several nonequivalent Lewis structures can be drawn for a molecule, _____ is used to determine the most appropriate structure(s).

ANS:
formal charge

PTS: 1 DIF: Easy REF: 8.12
KEY: Chemistry | general chemistry | bonding | covalent bonding | formal charge
MSC: Conceptual

150. In spite of larger electronegativity differences between bonded atoms, $BeCl_2$ has no dipole while SCl_2 does. Explain fully.

ANS:
$BeCl_2$ has a linear electron pair geometry and a linear molecular geometry, so the bond dipoles cancel. SCl_2 has a tetrahedral electron pair geometry but a bent molecular geometry, giving it an overall dipole.
See Sec. 8.13 of Zumdahl, *Chemistry*.

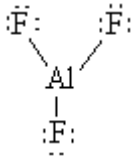
PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry | dipole moment
MSC: Conceptual

For each of the following compounds:

a) Draw the Lewis structure.
b) Give the shape of the molecule.
c) Indicate the polarity of the molecule.

151. AlF_3

ANS:
Part A:

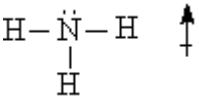


Part B: trigonal planar
Part C: nonpolar

PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry
MSC: Conceptual

152. NH_3

ANS:
Part A:

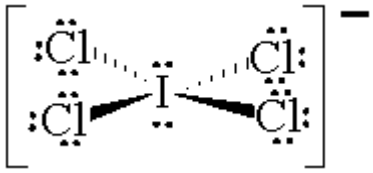


Part B: pyramidal
Part C: polar

PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry
MSC: Conceptual

153. ICl_4^-

ANS:
Part A:

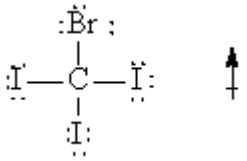


Part B: square planar
Part C: nonpolar

PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry
MSC: Conceptual

154. $CBrI_3$

ANS:
Part A:



Part B: tetrahedral
Part C: polar

PTS: 1 DIF: Moderate REF: 8.13
KEY: Chemistry | general chemistry | bonding | molecular geometry
MSC: Conceptual

155. Choose the member of each set that best matches the label.

More metallic	Be or Ba
More covalent	N_2O(g), MgO(s)
Highest electronegativity	O, S, Br

A) Be, N_2O, O
B) Ba, MgO, Br
C) Ba, N_2O, S
D) Be, MgO, O
E) Ba, N_2O, O

ANS: E PTS: 1 DIF: Moderate REF: 8.2
KEY: Chemistry | general chemistry | bonding | covalent bonding | electronegativity
MSC: Conceptual

156. Which set contains the atoms listed in order of INCREASING electronegativity?
A) F < N < C < Si
B) P < N < O < F
C) N < O < Cl < F
D) F > O > S > Si
E) S > O > Cl > F

ANS: B PTS: 1 DIF: Easy REF: 8.2
KEY: Chemistry | general chemistry | bonding | covalent bonding | electronegativity
MSC: Conceptual

157. Which bond is most polar?
A) C-F
B) S-F
C) O-F
D) Si-F
E) C-O

ANS: D PTS: 1 DIF: Easy REF: 8.2

KEY: Chemistry | general chemistry | bonding | covalent bonding | electronegativity
MSC: Conceptual

158. In a phosphorous-chlorine bond, the bond is _____ and the _____ atoms bears _____ charge
A) polar, P, a partial negative
B) nonpolar, Cl, no partial
C) polar, P, a partial positive
D) nonpolar, P, no partial
E) polar, Cl, a partial positive

ANS: C PTS: 1 DIF: Easy REF: 8.2
KEY: Chemistry | general chemistry | bonding | covalent bonding | electronegativity
MSC: Conceptual

159. Which ion is larger in each pair? i) O^{2-} or S^{2-} ii) Fe^{2+} or Fe^{3+} iii) S^{2-} or K^{+}
A) S^{2-}, Fe^{2+}, S^{2-}
B) S^{2-}, Fe^{3+}, S^{2-}
C) O^{2-}, Fe^{3+}, K^{+}
D) S^{2-}, Fe^{2+}, K^{+}
E) O^{2-}, Fe^{2+}, S^{2-}

ANS: A PTS: 1 DIF: Moderate REF: 8.4
KEY: Chemistry | general chemistry | bonding | ionic bonding | ionic radii
MSC: Conceptual

160. Consider the set of isoelectronic atoms and ions A^{2-}, B^{-}, C, D^{+} and E^{2+}. Which arrangement of relative radii is correct?
A) $A^{2-} > B^{-} > C < D^{+} > E^{2+}$
B) $A^{2-} < B^{-} < C > D^{+} < E^{2+}$
C) $A^{2-} > B^{-} > C > D^{+} > E^{2+}$
D) $E^{2+} > D^{+} > C > B^{-} > A^{2-}$
E) $E^{2+} < D^{+} < C < B^{-} < A^{2-}$

ANS: C PTS: 1 DIF: Moderate REF: 8.4
KEY: Chemistry | general chemistry | bonding | ionic bonding | ionic radii
MSC: Conceptual

161. Calculate the lattice energy of the ionic compound MCl_2 given the information below:

$\Delta H°_f$ $MCl_2(s)$ = -342 kJ/mol
IE_1 of M = +600 kJ/mol
IE_2 of M = +1150 kJ/mol
$Cl_2(g) \Rightarrow 2\ Cl(g)$ ΔH = +244 kJ
$Cl(g) + 1\ e^{-} \Rightarrow Cl^{-}(g)$ ΔH = -349 kJ
$M(s) \Rightarrow M(g)$ ΔH = +150 kJ
A) -2136 kJ
B) -2015 kJ
C) -1446 kJ
D) -1788 kJ

E) -1666 kJ

ANS: D PTS: 1 DIF: Difficult REF: 8.5
KEY: Chemistry | general chemistry | bonding | ionic bonding | Born-Haber cycle
MSC: Quantitative

162. Select the lattice energy for rubidium chloride from the following data [in kJ/mol]

Rb(s) => Rb(g)	ΔH = 85.8
IE1(Rb)	ΔH = 397.5
BE(Cl_2)	ΔH = 226
ΔHf(RbCl)	= -431
EA Cl	= -332

A) -53.7
B) +53.7
C) -695
D) -808
E) +808

ANS: C PTS: 1 DIF: Difficult REF: 8.5
KEY: Chemistry | general chemistry | bonding | ionic bonding | Born-Haber cycle
MSC: Quantitative

163. Which choice has the bonds listed in the order of INCREASING bond energy?
A) HF < HCl < HBr
B) C-O < C=O < C≡O
C) F_2 < Cl_2 < Br_2
D) N_2 < CC bond in C_2H_4 < CC Bond in C_2H_6
E) all the same

ANS: B PTS: 1 DIF: Easy REF: 8.8
KEY: Chemistry | general chemistry | bonding | covalent bonding | bond energy
MSC: Conceptual

164. Use the bond energies given below to calculate the enthalpy change for the reaction, $HCN(g) + 2\ H_2(g) \rightarrow CH_3NH_2(g)$

Bond	Bond Energy (kJ/mol)	Bond	Bond Energy (kJ/mol)
H-H	432	C-H	413
C-N	305	C=N	615
C≡N	891	N-H	391

A) -590 kJ
B) -158 kJ
C) +18 kJ
D) +133 kJ
E) +158 kJ

ANS: B PTS: 1 DIF: Moderate REF: 8.8
KEY: Chemistry | general chemistry | bonding | covalent bonding | bond energy
MSC: Quantitative

165. Calculate the value of $\Delta H°$ for the reaction $C_2H_6 + 2\ Cl_2 \rightarrow C_2H_4Cl_2 + 2\ HCl$ given the bond energies (kJ/mol):

H-H 432 kJ/mol
C-H 314 kJ/mol
H-Cl 427 kJ/mol
C-C 347 kJ/mol
Cl-Cl 243 kJ/mol
C-Cl 339 kJ/mol

A) -209 kJ
B) -418 kJ
C) +318kJ
D) -318 kJ
E) -518 kJ

ANS: B PTS: 1 DIF: Moderate REF: 8.8
KEY: Chemistry | general chemistry | bonding | covalent bonding | bond energy
MSC: Quantitative

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1. The hybridization of the carbon atom in the cation CH_3^+ is:
   A) sp^2
   B) sp^3
   C) *dsp*
   D) *sp*
   E) none of these

   ANS: A PTS: 1 DIF: Moderate REF: 9.1
   KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
   MSC: Conceptual

2. In the molecule C_2H_4 the valence orbitals of the carbon atoms are assumed to be
   A) not hybridized
   B) *sp* hybridized
   C) sp^2 hybridized
   D) sp^3 hybridized
   E) *dsp* hybridized

   ANS: C PTS: 1 DIF: Moderate REF: 9.1
   KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
   MSC: Conceptual

3. Atoms that are sp^2 hybridized form ____ pi bond(s).
   A) 0
   B) 1
   C) 2
   D) 3
   E) 4

   ANS: B PTS: 1 DIF: Easy REF: 9.1
   KEY: Chemistry | general chemistry | bonding | bonding theories | multiple bonding
   MSC: Conceptual

4. The hybridization of the central atom in XeF_5^+ is:
   A) *sp*
   B) sp^2
   C) sp^3
   D) dsp^3
   E) d^2sp^3

   ANS: E PTS: 1 DIF: Moderate REF: 9.1
   KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
   MSC: Conceptual

5. The hybridization of the central atom in ClF_2^+ is:
   A) *sp*
   B) sp^2
   C) sp^3

D) dsp^3
E) d^2sp^3

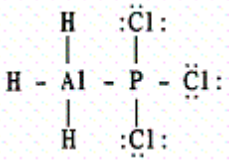
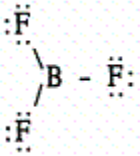
ANS: C PTS: 1 DIF: Moderate REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

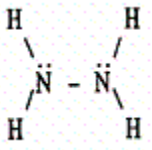
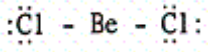
6. The hybridization of the central atom in I_3^- is:
A) sp
B) sp^2
C) sp^3
D) dsp^3
E) d^2sp^3

ANS: D PTS: 1 DIF: Moderate REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

7. The hybridization of the central atom in O_3 is:
A) sp
B) sp^2
C) sp^3
D) dsp^3
E) d^2sp^3

ANS: B PTS: 1 DIF: Moderate REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

8. Which of the following molecules contains a central atom with sp^2 hybridization?
A)

B)

C)

D)

E)


ANS: B PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization

MSC: Conceptual

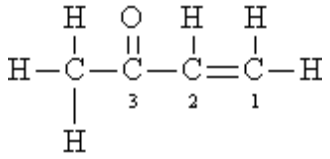
9. What hybridization is predicted for the nitrogen atom in the NO_3^- ion?
   A) sp^2
   B) sp^3
   C) dsp^3
   D) d^2sp^3
   E) none of these

   ANS: A PTS: 1 DIF: Moderate REF: 9.1
   KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
   MSC: Conceptual

10. Which of the following does not contain at least one pi bond?
    A) H_2CO
    B) CO_2
    C) C_2H_4
    D) C_2H_6
    E) All of the above (A-D) contain at least one pi bond.

    ANS: D PTS: 1 DIF: Moderate REF: 9.1
    KEY: Chemistry | general chemistry | bonding | bonding theories | multiple bonding
    MSC: Conceptual

11. Consider the following Lewis structure:



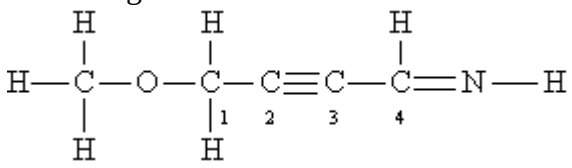
    Which statement about the molecule is false?
    A) There are 10 sigma and 2 pi bonds.
    B) C-2 is sp^2 hybridized with bond angles of 120°.
    C) Oxygen is sp^3 hybridized.
    D) This molecule contains 28 valence electrons.
    E) There are some H–C–H bond angles of about 109° in the molecule.

    ANS: C PTS: 1 DIF: Easy REF: 9.1
    KEY: Chemistry | general chemistry | bonding | bonding theories
    MSC: Conceptual

12. Which statement about N_2 is false?
    A) It is a gas at room temperature.
    B) The oxidation state is +3 on one N and –3 on the other.
    C) It has one sigma and two pi bonds between the two atoms.
    D) It can combine with H_2 to form NH_3.
    E) It has two pairs of nonbonding electrons.

    ANS: B PTS: 1 DIF: Easy REF: 9.1
    KEY: Chemistry | general chemistry | bonding | bonding theories
    MSC: Conceptual

13. Consider the following Lewis structure:



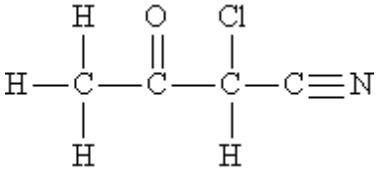
What is the hybridization of the atoms O, C-1, C-2, and C-4?

A) sp^3 sp^3 sp sp^2
B) sp sp^3 sp sp
C) sp sp^2 sp sp^2
D) sp^2 sp^3 sp^2 sp^3
E) sp^3 sp sp sp^2

O C-1 C-2 C-4

ANS: A PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

Consider the molecule and the following hybridization choices:



14. What is the hybridization of the carbon atom that is double-bonded to oxygen?

A) sp
B) sp^2
C) sp^3
D) dsp^3
E) d^2sp^3

ANS: B PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

15. What is the hybridization of the carbon atom that is bonded to chlorine?

A) sp
B) sp^2
C) sp^3
D) dsp^3
E) d^2sp^3

ANS: C PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

16. What is the hybridization of the nitrogen atom?

A) sp

B) sp^2
C) sp^3
D) dsp^3
E) d^2sp^3

ANS: A PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

17. What is the hybridization of the oxygen atom?
A) sp
B) sp^2
C) sp^3
D) dsp^3
E) d^2sp^3

ANS: B PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

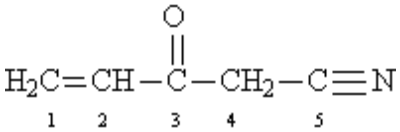
18. The hybridization of I in IF_4^- is
A) sp
B) sp^2
C) sp^3
D) dsp^3
E) d^2sp^3

ANS: E PTS: 1 DIF: Moderate REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

19. The hybridization of Cl in ClF_2^+ is
A) sp
B) sp^2
C) sp^3
D) dsp^3
E) d^2sp^3

ANS: C PTS: 1 DIF: Moderate REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

20. Consider the molecule:



Specify the hybridization of each carbon atom.

C-1 C-2 C-3 C-4 C-5

A) sp^2 sp^2 sp^2 sp^3 sp
B) sp^2 sp^2 sp^2 sp^3 sp^3
C) sp^2 sp^2 sp^3 sp^3 sp^2
D) sp^2 sp^2 sp^3 sp^3 sp^3
E) sp^2 sp sp sp^2 sp

ANS: A PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

21. The hybridization of the central atom, Al, in $AlBr_3$ is
A) sp
B) sp^2
C) sp^3
D) dsp^3
E) d^2sp^3

ANS: B PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

22. The hybridization of Se in SeF_6 is
A) sp
B) sp^2
C) sp^3
D) dsp^3
E) d^2sp^3

ANS: E PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

23. The hybridization of Br in BrF_3 is
A) sp
B) sp^2
C) sp^3
D) dsp^3
E) d^2sp^3

ANS: D PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

24. The hybridization of the lead atom in $PbCl_4$ is
A) dsp^2
B) sp^2
C) d^2sp^3
D) dsp^3
E) none of these

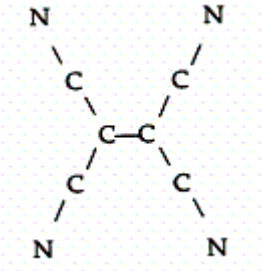
ANS: E PTS: 1 DIF: Easy REF: 9.1

KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

25. The hybridization of the central atom in NO_3^- is
A) p^3
B) sp^2
C) sp^3
D) sp
E) dsp^2

ANS: B PTS: 1 DIF: Moderate REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

Tetracyanoethylene has the skeleton shown below:



From its Lewis structure determine the following:

26. How many sigma and pi bonds are in the molecule?
A) 4 sigma and 5 pi
B) 6 sigma and 8 pi
C) 9 sigma and 8 pi
D) 9 sigma and 9 pi
E) 5 sigma and 8 pi

ANS: D PTS: 1 DIF: Moderate REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | multiple bonding
MSC: Conceptual

27. How many nonbonded electron pairs are in the molecule?
A) 0
B) 2
C) 4
D) 5
E) 8

ANS: C PTS: 1 DIF: Moderate REF: 9.1
KEY: Chemistry | general chemistry | bonding | covalent bonding | Lewis dot formula
MSC: Conceptual

28. How many of the atoms are sp^2 hybridized?
A) 2
B) 4
C) 6

D) 8
E) 10

ANS: A PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

29. How many of the atoms are *sp* hybridized?
A) 2
B) 4
C) 6
D) 8
E) 10

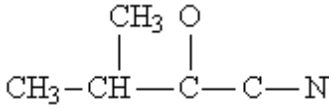
ANS: D PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

30. In which of the compounds below is there more than one kind of hybridization (*sp*, sp^2, sp^3) for carbon?
I. $CH_3CH_2CH_2CH_3$
II. $CH_3CH = CHCH_3$
III. $CH_2 = CH - CH = CH_2$
IV. $H - C \equiv C - H$

A) II and III
B) II only
C) III and IV
D) I, II, and III
E) III only

ANS: B PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

31. Complete the Lewis structure for the following molecule:



This molecule has _____ sigma and _____ pi bonds.
A) 4, 5
B) 6, 3
C) 11, 5
D) 13, 2
E) 13, 3

ANS: E PTS: 1 DIF: Moderate REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | multiple bonding
MSC: Conceptual

32. Which of the following substances contains two pi bonds?

A) C_2H_4
B) C_3H_8
C) C_2H_2
D) C_2H_6
E) CH_4

ANS: C PTS: 1 DIF: Moderate REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | multiple bonding
MSC: Conceptual

33. Consider the molecule C_2H_4. The hybridization of each C atom is
A) *sp*
B) sp^2
C) sp^3
D) dsp^3
E) d^2sp^3

ANS: B PTS: 1 DIF: Moderate REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

34. A π (pi) bond is the result of the
A) overlap of two *s* orbitals
B) overlap of an *s* orbital and a *p* orbital
C) overlap of two *p* orbitals along their axes
D) sidewise overlap of two parallel *p* orbitals
E) sidewise overlap of two *s* orbitals

ANS: D PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | multiple bonding
MSC: Conceptual

35. When a carbon atom has sp^3 hybridization, it has
A) four π bonds
B) three π bonds and one σ bond
C) two π bonds and two σ bonds
D) one π bond and three σ bonds
E) four σ bonds

ANS: E PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

Consider the skeletal structure shown below:

N—C—C—N

Draw the Lewis structure and answer the following:

36. How many of the atoms are *sp* hybridized?
A) 0
B) 1

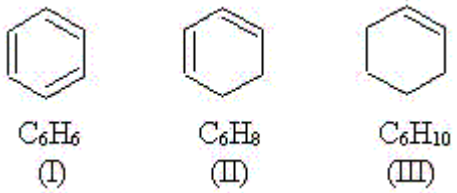
C) 2
D) 3
E) 4

ANS: E PTS: 1 DIF: Moderate REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

37. How many pi bonds does the molecule contain?
A) 0
B) 2
C) 4
D) 6
E) 7

ANS: C PTS: 1 DIF: Moderate REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | multiple bonding
MSC: Conceptual

Use the molecules below to answer the next three questions.



38. Which molecule(s) have *p* orbitals that share an electron pair to create π bonding?
A) I
B) II
C) III
D) all of the above
E) none of the above

ANS: D PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | multiple bonding
MSC: Conceptual

39. Which molecule(s) have at least one carbon atom that is *sp* hybridized?
A) I
B) II
C) III
D) all of the above
E) none of the above

ANS: E PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

40. Which molecule(s) have equivalent C–C bonds throughout the molecule?

A) I
B) II
C) III
D) all of the above
E) none of the above

ANS: A PTS: 1 DIF: Easy REF: 9.5
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital and delocalized bonding MSC: Conceptual

41. Whenever a set of equivalent tetrahedral atomic orbitals is required, an atom will adopt a set of sp^3 orbitals.

ANS: T PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

42. The hybridization of the B in BH_3 is sp^3.

ANS: F PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

43. The hybridization of a molecule is measured to determine the shape of the molecule.

ANS: F PTS: 1 DIF: Moderate REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

44. Which of the following statements is true?
A) Electrons are never found in an antibonding MO.
B) All antibonding MOs are higher in energy than the atomic orbitals of which they are composed.
C) Antibonding MOs have electron density mainly outside the space between the two nuclei.
D) None of the above is true.
E) Two of the above statements are true.

ANS: E PTS: 1 DIF: Easy REF: 9.2
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory
MSC: Conceptual

45. Which of the following statements is (are) incorrect?
I. The hybridization of boron in BF_3 is sp^2.
II. The molecule XeF_4 is nonpolar.
III. The bond order of N_2 is three.
IV. The molecule HCN has two pi bonds and two sigma bonds.

A) All four statements are correct.

B) II is incorrect.
C) I and IV are incorrect.
D) II and III are incorrect.
E) II, III, and IV are incorrect.

ANS: A PTS: 1 DIF: Moderate REF: 9.2
KEY: Chemistry | general chemistry | bonding | bonding theories
MSC: Conceptual

46. Which of the following molecules contains the shortest C–C bond?
A) C_2H_2
B) C_2H_4
C) C_2H_6
D) C_2Cl_4
E) b and d

ANS: A PTS: 1 DIF: Moderate REF: 9.2
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory | bond order MSC: Conceptual

47. The electron configuration of a particular diatomic species is $(\sigma_{2s})^2(\sigma^*_{2s})^2(\sigma_{2p})^2(\pi_{2p})^4(\pi^*_{2p})^2$. What is the bond order for this species?
A) 3.5
B) 3
C) 2.5
D) 2
E) 1.5

ANS: D PTS: 1 DIF: Easy REF: 9.2
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory | bond order MSC: Conceptual

48. What is the bond order of He_2^+?
A) 0
B) $\frac{1}{2}$
C) 1
D) $1\frac{1}{2}$
E) 2

ANS: B PTS: 1 DIF: Moderate REF: 9.2
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory | bond order MSC: Conceptual

49. If four orbitals on one atom overlap four orbitals on a second atom, how many molecular orbitals will form?
A) 1
B) 4
C) 8
D) 16

E) none of these

ANS: C PTS: 1 DIF: Easy REF: 9.2
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory
MSC: Conceptual

50. Larger bond order means greater bond strength.

ANS: T PTS: 1 DIF: Easy REF: 9.2
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory | bond order MSC: Conceptual

51. When an electron pair is shared in the area centered on a line joining the atoms, a σ (sigma) bond is formed.

ANS: T PTS: 1 DIF: Easy REF: 9.2
KEY: Chemistry | general chemistry | bonding | bonding theories | multiple bonding
MSC: Conceptual

52. As the bond order of a bond increases, the bond energy _____ and the bond length _____.
A) increases, increases
B) decreases, decreases
C) increases, decreases
D) decreases, increases
E) More information is needed to answer this question.

ANS: C PTS: 1 DIF: Easy REF: 9.2
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory | bond order MSC: Conceptual

53. When comparing Be_2 and H_2:
I. Be_2 is more stable because it contains both bonding and antibonding valence electrons.
II. H_2 has a higher bond order than Be_2.
III. H_2 is more stable because it only contains σ_{1s} electrons.
IV. H_2 is more stable because it is diamagnetic, whereas Be_2 is paramagnetic.

A) I, II
B) III only
C) II, III
D) II, III, IV
E) III, IV

ANS: C PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

54. If a molecule demonstrates paramagnetism, then :
I. The substance can have both paired and unpaired electrons.
II. The bond order is not a whole number.

III. It can be determined by drawing a Lewis structure.
IV. It must be an ion.

A) I, II
B) I, II, IV
C) II, III
D) I only
E) All of the above are correct.

ANS: D PTS: 1 DIF: Easy REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

55. For which of the following diatomic molecules would the bond order become greater if an electron is removed (i.e., if the molecule is converted to the positive ion in its ground state)?
A) B_2
B) C_2
C) P_2
D) F_2
E) Na_2

ANS: D PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

56. The configuration $(\sigma_{2s})^2(\sigma_{2s}^*)^2(\pi_{2py})^1(\pi_{2px})^1$ is the molecular orbital description for the ground state of
A) Li_2^+
B) Be_2
C) B_2
D) B_2^{2-}
E) C_2

ANS: C PTS: 1 DIF: Easy REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

57. Which of the following species is paramagnetic?
A) C_2
B) O_2
C) F_2
D) Li_2
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

58. Which of the following species has the largest dissociation energy?
A) O_2
B) O_2^-

C) O_2^{2-}
D) O_2^{+}
E) O_2^{2+}

ANS: E PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory | bond order MSC: Conceptual

59. The fact that O_2 is paramagnetic can be explained by
A) the Lewis structure of O_2
B) resonance
C) a violation of the octet rule
D) the molecular orbital diagram for O_2
E) hybridization of atomic orbitals in O_2

ANS: D PTS: 1 DIF: Easy REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

60. For how many of the following does the bond order decrease if you add one electron to the neutral molecule?

B_2, C_2, P_2, F_2

A) 0
B) 1
C) 2
D) 3
E) 4

ANS: C PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

61. Which of the following diatomic molecules has a bond order of 2?
A) B_2
B) C_2
C) P_2
D) F_2
E) Li_2

ANS: B PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

62. Which of the following has the largest bond order?
A) N_2
B) N_2^{-}
C) N_2^{2-}
D) N_2^{+}
E) N_2^{2+}

ANS: A PTS: 1 DIF: Moderate REF: 9.3

KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory | bond order MSC: Conceptual

63. How many of the following: F_2, B_2, O_2, N_2 , are paramagnetic?
A) 0
B) 1
C) 2
D) 3
E) 4

ANS: C PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

64. Order the following from shortest to longest bond:
C_2, B_2, H_2, N_2
A) H_2, N_2, C_2, B_2
B) N_2, C_2, B_2, H_2
C) C_2, N_2, H_2, B_2
D) C_2, B_2, H_2, N_2
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

65. Which charge(s) on an O_2 ion would give a bond order of 2.5?
A) –2
B) –1
C) +1
D) two of these
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory | bond order MSC: Conceptual

66. For how many of the following does bond order decrease if you take away one electron from the neutral molecule?
B_2, C_2, P_2, F_2
A) 0
B) 1
C) 2
D) 3
E) 4

ANS: D PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

67. Which of the following has the shortest bond length?

A) O_2^{2-}
B) O_2
C) O_2^-
D) O_2^+
E) Two of these have the shortest bond length.

ANS: D PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

68. Which of the following has a bond order of 1.5?
A) O_2^+
B) N_2
C) O_2^-
D) C_2
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory | bond order MSC: Conceptual

69. How many unpaired electrons in the F_2^{2+} ion are based on molecular orbital theory? The order of the molecular orbitals are $(\sigma_{2s})(\sigma^*_{2s})(\sigma_{2p})(\pi_{2p})(\pi^*_{2p})(\sigma^*_{2p})$.
A) 0
B) 1
C) 2
D) 3
E) 4

ANS: C PTS: 1 DIF: Easy REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

70. A species has the following MO configuration:
$$(\sigma_{1s})^2(\sigma_{1s}^*)^2(\sigma_{2s})^2(\sigma_{2s}^*)^2(\sigma_{2p})^2(\pi_{2p})^2$$
This substance is
A) paramagnetic with one unpaired electron
B) paramagnetic with two unpaired electrons
C) paramagnetic with three unpaired electrons
D) paramagnetic with four unpaired electrons
E) diamagnetic

ANS: B PTS: 1 DIF: Easy REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

71. What is the bond order of Ne_2?
A) 0
B) $\frac{1}{2}$
C) 1

D) $1\frac{1}{2}$

E) 2

ANS: A PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory | bond order MSC: Conceptual

72. What is the bond order of C_2^+?

A) 0

B) $\frac{1}{2}$

C) 1

D) $1\frac{1}{2}$

E) 2

ANS: D PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory | bond order MSC: Conceptual

73. Which of the following statements is false?

A) C_2 is paramagnetic.

B) C_2 is diamagnetic.

C) The carbon-carbon bond in C_2^{2-} is stronger than the one in CH_3CH_3.

D) The carbon-carbon bond in C_2^{2-} is shorter than the one in CH_3CH_3.

E) Two of the above.

ANS: A PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

74. According to MO theory, F_2 should be diamagnetic.

ANS: T PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

75. The H_2^- ion is more stable than H_2 since it has an additional electron to produce a net lowering of energy.

ANS: F PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

76. Paramagnetism is associated with paired electrons.

ANS: F PTS: 1 DIF: Easy REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

77. Which of the following statements about the molecule BN is false?
A) It is paramagnetic.
B) Its bond order is 2.
C) The total number of electrons is 12.
D) It has two pi bonds.
E) All of these are true.

ANS: A PTS: 1 DIF: Moderate REF: 9.4
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

78. Which of the following statements about the species CN^- is false?
A) It is paramagnetic.
B) The total number of electrons is 14.
C) Its bond order is 3.
D) It has two pi bonds.
E) All of these are true.

ANS: A PTS: 1 DIF: Moderate REF: 9.4
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

79. Which of the nitrogen-containing molecules below is paramagnetic in its lowest energy state?
A) N_2
B) NO
C) NH_3
D) N_2H_4
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 9.4
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

80. Which of the following statements is incorrect?
A) For the molecule NO, the molecular orbital model is preferred over the localized electron model because NO contains an unpaired electron.
B) Electrons in antibonding orbitals will cause a molecule to be paramagnetic.
C) According to the molecular orbital model, when bonding occurs between hydrogen and bromine to make HBr, the 1*s* orbital of the hydrogen atom no longer exists.
D) Antibonding electrons are higher in energy than the atomic orbitals from which they came.
E) At least two of the above are incorrect.

ANS: B PTS: 1 DIF: Moderate REF: 9.4
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

81. Which of the following molecules or ions is not paramagnetic in its ground state?
A) O_2

B) O_2^+
C) B_2
D) NO
E) F_2

ANS: E PTS: 1 DIF: Moderate REF: 9.4
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

82. Which of the following electron distributions among the molecular orbitals best describes the NO molecule?

	σ_{2s}	σ_{2s}^*	$\pi_{2py}=\pi_{2px}$	σ_{2pz}	$\pi_{2py}^*=\pi_{2px}^*$	σ_{2pz}^*
A)	2	2	4	2	4	2
B)	2	2	4	2	4	1
C)	2	2	4	1	3	0
D)	2	2	4	2	2	0
E)	2	2	4	2	1	0

ANS: E PTS: 1 DIF: Moderate REF: 9.4
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory
MSC: Conceptual

83. Consider the molecular orbital energy level diagrams for O_2 and NO. Which of the following is true?
I. Both molecules are paramagnetic.
II. The bond strength of O_2 is greater than the bond strength of NO.
III. NO is an example of a homonuclear diatomic molecule.
IV. The ionization energy of NO is smaller than the ionization energy of NO^+.

A) I only
B) I and II
C) I and IV
D) II and III
E) I, II, and IV

ANS: C PTS: 1 DIF: Difficult REF: 9.4
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

84. In the molecular orbital description of CO:
A) The highest energy electrons occupy antibonding orbitals.
B) Six molecular orbitals contain electrons.
C) There are two unpaired electrons.
D) The bond order is 3.

E) All of the above are false.

ANS: D PTS: 1 DIF: Moderate REF: 9.4
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

85. Consider the molecular orbital description of the NO^- anion. Which of the following statements is false?
A) NO^- is paramagnetic.
B) NO^- is isoelectronic with CO.
C) The bond energy in NO^+ is greater than the bond energy in NO^-.
D) The bond order in NO^- is 2.
E) Statements A through D are false.

ANS: B PTS: 1 DIF: Moderate REF: 9.4
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

86. Which of the following has the greatest bond strength?
A) B_2
B) O_2^-
C) CN^-
D) O_2^+
E) NO^-

ANS: C PTS: 1 DIF: Difficult REF: 9.4
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

87. The bond order in the NO molecule is
A) 1
B) $1\frac{1}{2}$
C) 2
D) $2\frac{1}{2}$
E) 3

ANS: D PTS: 1 DIF: Moderate REF: 9.4
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory | bond order MSC: Conceptual

88. The CO molecule has the bond order:
A) 0
B) 1
C) 2
D) 3
E) 4

ANS: D PTS: 1 DIF: Moderate REF: 9.4
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory

| bond order MSC: Conceptual

89. The bond order for CN^- is 2.

ANS: F PTS: 1 DIF: Moderate REF: 9.4
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory | bond order MSC: Conceptual

90. Which of the following statements about the CO_3^{2-} ion is false?
A) The orbitals on the carbon atom are sp^2 hybridized.
B) The ion is expected to be diamagnetic.
C) The C–O bonds are different lengths.
D) The ion has a total of 24 electrons.
E) All the above statements are true.

ANS: C PTS: 1 DIF: Moderate REF: 9.5
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital and delocalized bonding MSC: Conceptual

91. The following statements concern molecules that require resonance. Which is true?
A) The pi bonding is most clearly delocalized.
B) The sigma bonding is most clearly delocalized.
C) Both the sigma and pi bonding are delocalized.
D) The benzene molecule is best described by the MO theory.
E) The benzene molecule is best described by the localized electron model.

ANS: A PTS: 1 DIF: Easy REF: 9.5
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital and delocalized bonding MSC: Conceptual

92. Sulfur trioxide is known to be planar with all the oxygen atoms equidistant from the central sulfur atom. On the basis of these facts, which of the following conclusions may be drawn concerning this molecule?
I. It can be represented by three equivalent resonance structures.
II. The dipoles associated with each S–O bond are equal in magnitude.
III. The sulfur atom is sp^2 hybridized.
A) I only
B) II only
C) III only
D) I and II only
E) I, II, and III

ANS: E PTS: 1 DIF: Moderate REF: 9.5
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital and delocalized bonding MSC: Conceptual

93. How many electrons are involved in pi bonding in benzene, C_6H_6?
A) 12
B) 30
C) 3

D) 6
E) 18

ANS: D PTS: 1 DIF: Moderate REF: 9.5
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital and delocalized bonding MSC: Conceptual

94. Which of these statements about benzene is true?
A) All carbon atoms in benzene are sp^3 hybridized.
B) Benzene contains only π bonds between C atoms.
C) The bond order of each C–C bond in benzene is 1.5.
D) Benzene is an example of a molecule that displays ionic bonding.
E) All of these statements are false.

ANS: C PTS: 1 DIF: Moderate REF: 9.5
KEY: Chemistry | general chemistry | bonding | bonding theories
MSC: Conceptual

95. Consider the benzene molecule. Which of the following statements about the molecule is false?
A) All six C–C bonds are known to be equivalent.
B) Each carbon atom is sp^2 hybridized.
C) The localized electron model must invoke resonance to account for the six equal C–C bonds.
D) It has delocalized pi bonding in the molecule.
E) The pi bonds of carbon involve sp^2 orbitals.

ANS: E PTS: 1 DIF: Moderate REF: 9.5
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital and delocalized bonding MSC: Conceptual

96. The C–C–H bond angles in ethylene, C_2H_4, are 120°. What is the hybridization of the carbon orbitals?

ANS:
sp^2

PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

97. The mixing of native atomic orbitals to form special orbitals for bonding is called _____.

ANS:
hybridization

PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

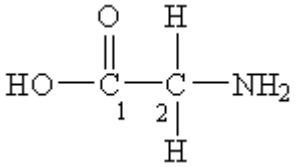
98. Consider three molecules – A, B, C. Molecule A has a hybridization of sp^3. Molecule B has two more effective pairs (electron pairs around the central atom) than molecule A. Molecule C consists of one σ bond and two π bonds. Give the molecular structure, hybridization, bond angles, and an example for each molecule.

ANS:

	Molecule A	**Molecule B**	**Molecule C**
Molecular Structure	tetrahedral	octahedral	linear
Hybridization	sp^3	d^2sp^3	sp
Bond Angles	109.5°	90°, 180°	180°
Example	CH_4	SF_6	CO

PTS: 1 DIF: Moderate REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

99. Consider the structure of glycine, the simplest amino acid:



a) Indicate the hybridizations at each N and C atom in the molecule.
b) What is the total number of bonds in the molecule?
c) What is the total number of π bonds in the molecule?

ANS:

a) C_1 sp^2
C_2 sp^3
N sp^3
b) 10 bonds
c) 1 π bond

PTS: 1 DIF: Moderate REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories
MSC: Conceptual

100. A(n) _____ molecular orbital is lower in energy than the atomic orbital of which it is composed.

ANS:
bonding

PTS: 1 DIF: Easy REF: 9.2
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory | bonding orbital MSC: Conceptual

101. The number of molecular orbitals formed is always _____ the number of atomic orbitals combined.

ANS:
the same as

PTS: 1 DIF: Easy REF: 9.2
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory
MSC: Conceptual

102. _____ is the difference between the number of bonding electrons and the number of antibonding electrons divided by two.

ANS:
Bond order

PTS: 1 DIF: Easy REF: 9.2
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory | bond order MSC: Conceptual

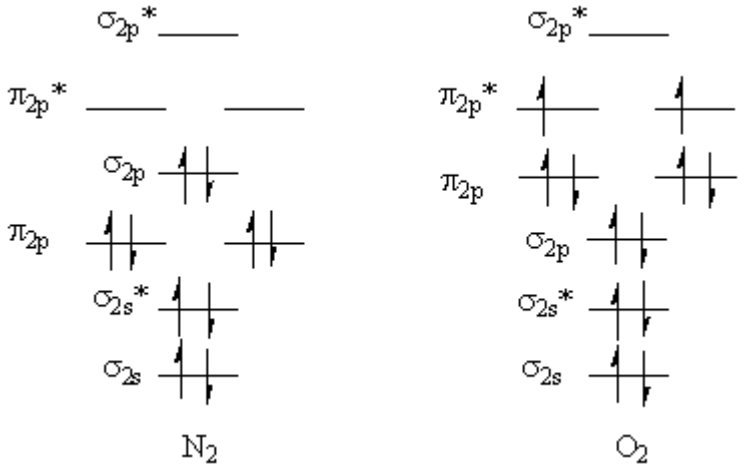
103. _____ causes a substance to be attracted into the inducing magnetic field.

ANS:
Paramagnetism

PTS: 1 DIF: Easy REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

104. Draw a molecular orbital diagram for O_2 and N_2. Using molecular orbital theory, explain why the removal of one electron in O_2 strengthens bonding, while the removal of one electron in N_2 weakens bonding.

ANS:



The bond order for N_2 is 3, but removing an electron will make the bond order 2.5.
The bond order for O_2 is 2, but removing an electron will make the bond order 2.5.
In N_2 the electron is removed from a bonding orbital (σ_{2p}), whereas in O_2 the electron is removed from an antibonding orbital (π_{2p}*).

See Sec. 9.3 of Zumdahl, Chemistry

PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

105. Give the bond order for each of the following:
a) H_2
b) H_2^+
c) H_2^-
d) CN^-
e) CN
f) CN^+

ANS:
a) 1
b) $\frac{1}{2}$
c) $\frac{1}{2}$
d) 3
e) $2\frac{1}{2}$
f) 2

PTS: 1 DIF: Moderate REF: 9.4
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

106. Which of the following are paramagnetic?
O_2 O_2^- O_2^{2-} B_2 C_2 N_2 F_2 CN^- P_2

ANS:
O_2, O_2^-, B_2

PTS: 1 DIF: Moderate REF: 9.4
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

107. The concept of _____ is required for certain molecules because the localized electron model assumes electrons are located between a given pair of atoms in a molecule.

ANS:
resonance

PTS: 1 DIF: Easy REF: 9.5

KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital and delocalized bonding MSC: Conceptual

108. Explain the concept of delocalization of electrons in SO_3. Indicate how this idea relates to resonance.

ANS:
When we draw the Lewis dot structure for SO_3, we must share a pair of electrons from one of the oxygens back to the sulfur to give the sulfur an octet. Since there are three equivalent oxygens in the Lewis structure, we can represent this equally well with three different Lewis structures. In each of these structures, there is a double bond to one of the oxygens. The double bond, therefore, is delocalized over the molecule, and these three Lewis structures are resonance structures that, as a set, represent that delocalization.
See Sec. 9.5 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Difficult REF: 9.5
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital and delocalized bonding MSC: Conceptual

109. The hybridization of the central atom in SF_4 is:
A) *sp*
B) sp^2
C) sp^3
D) dsp^3
E) d^2sp^3

ANS: D PTS: 1 DIF: Moderate REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

110. Which of the following contains the strongest bond?
A) N_2
B) N_2^-
C) N_2^{2-}
D) N_2^+
E) N_2^{2+}

ANS: A PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory | bond energy MSC: Conceptual

111. Which of the following contains the shortest bond?
A) N_2
B) N_2^-
C) N_2^{2-}
D) N_2^+
E) N_2^{2+}

ANS: A PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory

| bond order MSC: Conceptual

112. Which of the following has the highest bond dissociation energy?
A) N_2
B) N_2^-
C) N_2^{2-}
D) N_2^+
E) N_2^{2+}

ANS: A PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory | bond energy MSC: Conceptual

113. Which charge(s) on an N_2 ion would give a bond order of 2.5?
A) –2
B) –1
C) +1
D) +2
E) two of the choices

ANS: E PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | molecular orbital theory | bond order MSC: Conceptual

114. For how many of the following does the bond order increase if you add one electron to the neutral molecule?

B_2, C_2, P_2, F_2

A) 0
B) 1
C) 2
D) 3
E) 4

ANS: C PTS: 1 DIF: Moderate REF: 9.3
KEY: Chemistry | general chemistry | bonding | bonding theories | diatomic molecule
MSC: Conceptual

115. Which of the following molecules or ions does not contain a central atom with sp^2 hybridization?
A) nitrate
B) carbonate
C) sulfite
D) C_2H_4
E) BF_3

ANS: C PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

116. Which of the following molecules or ions contains a central atom with dsp^3 hybridization?
A) SO_4^{2-}

B) SF_4
C) SiF_4
D) ClO_4^{2-}
E) all of these contain a central atom with sp^3 hybridization

ANS: B PTS: 1 DIF: Moderate REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

117. Which of the following molecules or ions does not contain a central atom with sp^2 hybridization?
A) nitrate
B) ozone
C) H_3O^+
D) CH_3^+
E) SO_2

ANS: C PTS: 1 DIF: Easy REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

118. Which of the following molecules or ions does not contain a central atom with d^2sp^3 hybridization?
A) XeF_5^+
B) IF_4^-
C) SF_6
D) SeF_5^-
E) all of these contain a central atom with d^2sp^3 hybridization

ANS: E PTS: 1 DIF: Moderate REF: 9.1
KEY: Chemistry | general chemistry | bonding | bonding theories | hybridization
MSC: Conceptual

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Chapter 10: Liquids and Solids

1. Order the intermolecular forces (dipole-dipole, London dispersion, ionic, and hydrogen-bonding) from weakest to strongest .
   A) dipole-dipole, London dispersion, ionic, and hydrogen-bonding
   B) London dispersion, dipole-dipole, hydrogen-bonding, and ionic
   C) hydrogen-bonding, dipole-dipole, London dispersion, and ionic
   D) dipole-dipole, ionic, London dispersion, and hydrogen-bonding
   E) London dispersion, ionic, dipole-dipole, and hydrogen-bonding

   ANS: B PTS: 1 DIF: Easy REF: 10.1
   KEY: Chemistry | general chemistry | phases | intermolecular forces |
   MSC: Conceptual

2. Hydrogen bonds account for which of the following observation?
   A) Hydrogen naturally exists as a diatomic molecule.
   B) Hydrogen is easily combustible with oxygen.
   C) Water molecules are bent or "V-shaped."
   D) Air is more dense than hydrogen gas.
   E) For its molar mass, water has a high boiling point.

   ANS: E PTS: 1 DIF: Easy REF: 10.1
   KEY: Chemistry | general chemistry | phases | intermolecular forces | hydrogen bonds
   MSC: Conceptual

3. Which of the following would you expect to have the highest boiling point?
   A) F_2
   B) Cl_2
   C) Br_2
   D) I_2
   E) All of the above have the same boiling point.

   ANS: D PTS: 1 DIF: Easy REF: 10.1
   KEY: Chemistry | general chemistry | phases | liquid | intermolecular forces
   MSC: Conceptual

4. Which of the following should have the lowest boiling point?
   A) Na_2S
   B) HF
   C) NH_3
   D) N_2
   E) H_2O

   ANS: D PTS: 1 DIF: Easy REF: 10.1
   KEY: Chemistry | general chemistry | phases | liquid | intermolecular forces
   MSC: Conceptual

5. Which of the species below would you expect to show the least hydrogen bonding?
   A) NH_3
   B) H_2O

C) HF
D) CH_4
E) all the same

ANS: D PTS: 1 DIF: Moderate REF: 10.1
KEY: Chemistry | general chemistry | phases | intermolecular forces | hydrogen bonds
MSC: Conceptual

6. The molecules in a sample of solid SO_2 are attracted to each other by a combination of
A) London forces and H-bonding
B) H-bonding and ionic bonding
C) covalent bonding and dipole-dipole interactions
D) London forces and dipole-dipole interactions
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 10.1
KEY: Chemistry | general chemistry | phases | intermolecular forces
MSC: Conceptual

7. In which of the following groups of substances would dispersion forces be the only *significant* factors in determining boiling points?
I. Cl_2 II. HF III. Ne IV. KNO_2 V. CCl_4

A) I, III, V
B) I, II, III
C) II, IV
D) II, V
E) III, IV, V

ANS: A PTS: 1 DIF: Easy REF: 10.1
KEY: Chemistry | general chemistry | phases | liquid | intermolecular forces | London forces
MSC: Conceptual

8. The elements of group 5A, the nitrogen family, form compounds with hydrogen having the boiling points listed below:
SbH_3 –17°C, AsH_3 –55°C, PH_3 –87°C, NH_3 –33°C
The first three compounds illustrate a trend where the boiling point decreases as the mass decreases; however, ammonia (NH_3) does not follow the trend because of
A) dipole-dipole attraction
B) metallic bonding
C) hydrogen bonding
D) London dispersion forces
E) ionic bonding

ANS: C PTS: 1 DIF: Easy REF: 10.1
KEY: Chemistry | general chemistry | phases | liquid | intermolecular forces
MSC: Conceptual

9. Which substance involves no bonding forces except London dispersion forces?
A) NaCl(*l*)

B) HF(*l*)
C) N_2(*s*)
D) H_2O(*l*)
E) K(*s*)

ANS: C PTS: 1 DIF: Easy REF: 10.1
KEY: Chemistry | general chemistry | phases | intermolecular forces | London forces
MSC: Conceptual

10. In general, the density of a compound as a gas is closer in value to that of the compound as a liquid than the density of the compound as a liquid is in value to that of the compound as a solid.

ANS: F PTS: 1 DIF: Easy REF: 10.1
KEY: Chemistry | general chemistry | phases MSC: Conceptual

11. Second row hydrides generally have higher than expected boiling points for their position on the periodic table.

ANS: T PTS: 1 DIF: Easy REF: 10.1
KEY: Chemistry | general chemistry | phases | liquid | intermolecular forces
MSC: Conceptual

12. The bonds between hydrogen and oxygen within a water molecule can be characterized as _____.
A) hydrogen bonds
B) London dispersion forces
C) intermolecular forces
D) intramolecular forces
E) dispersion forces

ANS: D PTS: 1 DIF: Easy REF: 10.1
KEY: Chemistry | general chemistry | phases | intermolecular forces | hydrogen bonds
MSC: Conceptual

13. When a water molecule forms a hydrogen bond with another water molecule, which atoms are involved in the interaction?
A) a hydrogen from one molecule and a hydrogen from the other molecule
B) a hydrogen from one molecule and an oxygen from the other molecule
C) an oxygen from one molecule and an oxygen from the other molecule
D) an oxygen and a hydrogen from the same molecule
E) two hydrogens from one molecule and one hydrogen from the other molecule

ANS: B PTS: 1 DIF: Easy REF: 10.1
KEY: Chemistry | general chemistry | phases | intermolecular forces | hydrogen bonding
MSC: Conceptual

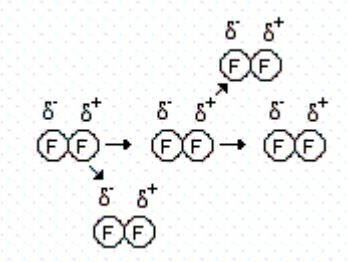
14. Which of the following is the correct order of boiling points for KNO_3, CH_3OH, C_2H_6, Ne?
A) Ne < CH_3OH < C_2H_6 < KNO_3
B) KNO_3 < CH_3OH < C_2H_6 < Ne

C) $Ne < C_2H_6 < KNO_3 < CH_3OH$
D) $Ne < C_2H_6 < CH_3OH < KNO_3$
E) $C_2H_6 < Ne < CH_3OH < KNO_3$

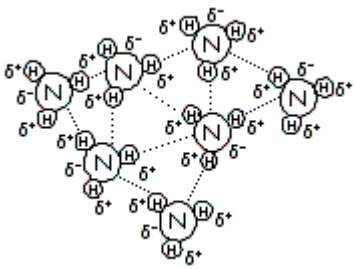
ANS: D PTS: 1 DIF: Moderate REF: 10.1
KEY: Chemistry | general chemistry | phases | liquid MSC: Conceptual

Consider the representations below to answer the next three questions.

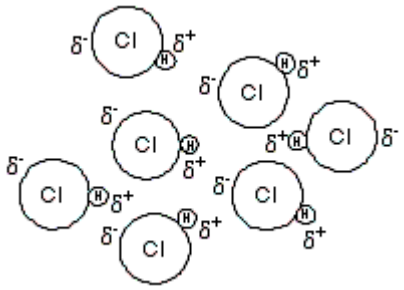
(I)



(II)



(III)



15. How many of the following statements are correct concerning drawing I?
I. Each molecule induces a dipole onto the next molecule in close proximity.
II. The phenomenon shown is relatively weak and short-lived.
III. C_8H_{18} contains this type of interaction.
IV. The forces that exist in this example are London dispersion forces.

A) 0
B) 1
C) 2
D) 3
E) 4

ANS: E PTS: 1 DIF: Moderate REF: 10.1
KEY: Chemistry | general chemistry | phases | intermolecular forces | London forces

MSC: Conceptual

16. Which drawing *best* represents the interactions in a sample of HF?
    A) I
    B) II
    C) III
    D) I, II
    E) all of the above

    ANS: B PTS: 1 DIF: Easy REF: 10.1
    KEY: Chemistry | general chemistry | phases | intermolecular forces | hydrogen bonding
    MSC: Conceptual

17. Which of the following statements are incorrect concerning drawing III?
    A) Electrostatic interactions exist between the molecules.
    B) The molecules find the best compromise between attraction and repulsion.
    C) These molecules exhibit ionic bonding.
    D) OCS exhibits this type of interaction.
    E) Two of the above statements are incorrect.

    ANS: C PTS: 1 DIF: Easy REF: 10.1
    KEY: Chemistry | general chemistry | phases | intermolecular forces
    MSC: Conceptual

18. The freezing point of helium is –270°C. The freezing point of xenon is –112°C. Both of these are in the noble gas family. Which of the following statements is supported by these data?
    A) Helium and xenon form highly polar molecules.
    B) As the molecular weight of the noble gas increases, the freezing point decreases.
    C) The London dispersion forces between the helium molecules are greater than the London dispersion between the xenon molecules.
    D) The London dispersion forces between the helium molecules are less than the London dispersion forces between the xenon molecules.
    E) None of these.

    ANS: D PTS: 1 DIF: Easy REF: 10.1
    KEY: Chemistry | general chemistry | phases | liquid | intermolecular forces
    MSC: Conceptual

19. Which best explains the following trend?

Element	b.p. (K)
He	4
Ne	25
Ar	95
Kr	125
Xe	170

    A) London dispersion forces
    B) dipole-dipole interaction
    C) hydrogen bonding

D) Le Chatelier's principle
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 10.1
KEY: Chemistry | general chemistry | phases | liquid | intermolecular forces | London forces
MSC: Conceptual

20. Intermolecular forces are weaker than intramolecular bonds.

ANS: T PTS: 1 DIF: Easy REF: 10.1
KEY: Chemistry | general chemistry | phases | intermolecular forces
MSC: Conceptual

21. Hydrogen bonding is a type of London dispersion force.

ANS: F PTS: 1 DIF: Easy REF: 10.1
KEY: Chemistry | general chemistry | phases | intermolecular forces | hydrogen bonding
MSC: Conceptual

22. Methane (CH_4) exhibits stronger hydrogen bond interactions than ammonia (NH_3).

ANS: F PTS: 1 DIF: Easy REF: 10.1
KEY: Chemistry | general chemistry | phases | intermolecular forces | hydrogen bonding
MSC: Conceptual

23. Which of the following compounds has the lowest viscosity?
A) $CCl_4(l)$
B) $N_2(g)$
C) $H_2O(l)$
D) $CH_3\text{-}(CH_2)_{25}\text{-}CH_3(l)$
E) $HCl(g)$

ANS: B PTS: 1 DIF: Easy REF: 10.2
KEY: Chemistry | general chemistry | phases | liquid | properties of liquids | viscosity
MSC: Conceptual

24. Which of the following statements about liquids is true?
A) Droplet formation occurs because of the higher stability associated with increased surface area.
B) Substances that can form hydrogen bonds will display lower melting points than predicted from periodic trends.
C) London dispersion forces arise from a distortion of the electron clouds within a molecule or atom.
D) Liquid rise within a capillary tube because of the small size lowers the effective atmospheric pressure over the surface of the liquid.
E) The boiling point of a solution is dependent solely on the atmospheric pressure over the solution.

ANS: C PTS: 1 DIF: Easy REF: 10.2

KEY: Chemistry | general chemistry | phases | liquid | properties of liquids
MSC: Conceptual

25. What is responsible for capillary action, a property of liquids?
A) surface tension
B) cohesive forces
C) adhesive forces
D) viscosity
E) two of these

ANS: E PTS: 1 DIF: Easy REF: 10.2
KEY: Chemistry | general chemistry | phases | liquid | properties of liquids
MSC: Conceptual

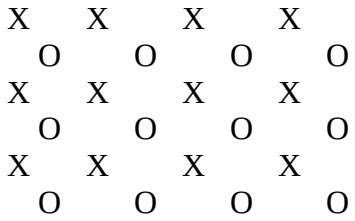
26. When a nonpolar liquid displays a convex meniscus, which of the following explains this behavior?
A) It has a low surface tension, and therefore clings to the glass.
B) The cohesive forces are stronger than the adhesive forces to the glass.
C) The adhesive forces to the glass are stronger than the cohesive forces.
D) The liquid's viscosity is low.
E) None of these.

ANS: B PTS: 1 DIF: Easy REF: 10.2
KEY: Chemistry | general chemistry | phases | liquid | properties of liquids
MSC: Conceptual

27. Liquids with large intermolecular forces tend to have high surface tension.

ANS: T PTS: 1 DIF: Easy REF: 10.2
KEY: Chemistry | general chemistry | phases | liquid | properties of liquids | surface tension
MSC: Conceptual

28. The unit cell in this two-dimensional crystal contains _____ Xs and _____ Os.



A) 1,1
B) 2,1
C) 1,2
D) 4,1
E) 1,4

ANS: A PTS: 1 DIF: Easy REF: 10.3
KEY: Chemistry | general chemistry | phases | solid | crystalline solids | crystal lattice
MSC: Conceptual

29. Which of the following is paired incorrectly?
    A) crystalline solids—highly regular arrangement of their components
    B) amorphous solids—considerable disorder in their structures
    C) unit cell—the smallest repeating unit of the lattice
    D) gold metal—simple cubic unit cell
    E) glass—amorphous solid

    ANS: D PTS: 1 DIF: Easy REF: 10.3
    KEY: Chemistry | general chemistry | phases | solid | classification of solids
    MSC: Conceptual

30. Table salt and table sugar are both crystalline solids.

    ANS: T PTS: 1 DIF: Easy REF: 10.3
    KEY: Chemistry | general chemistry | phases | solid | crystalline solids
    MSC: Conceptual

31. Atomic solids generally have low melting points.

    ANS: F PTS: 1 DIF: Moderate REF: 10.3
    KEY: Chemistry | general chemistry | phases | solid | classification of solids
    MSC: Conceptual

32. A crystal was analyzed with x-rays having 1.57 Å wavelength. A reflection was produced at $\theta = 21.9°$. Assuming $n = 1$, what is the distance between the layers of atoms in the crystal?
    A) 8.42 Å
    B) 4.21 Å
    C) 0.475 Å
    D) 0.846 Å
    E) 2.10 Å

    ANS: E PTS: 1 DIF: Moderate REF: 10.3
    KEY: Chemistry | general chemistry | phases | solid | x-ray diffraction
    MSC: Quantitative

33. A crystal was analyzed with x-rays having 2.33 Å wavelength. The angle of first-order diffraction ($n = 1$) was 19.2°. What would be the angle for second-order diffraction ($n = 2$)?
    A) 38.4 Å
    B) 41.1 Å
    C) 9.46 Å
    D) 14.2 Å
    E) 4.72 Å

    ANS: B PTS: 1 DIF: Difficult REF: 10.3
    KEY: Chemistry | general chemistry | phases | solid | x-ray diffraction
    MSC: Quantitative

    The molar volume of a certain form of solid lead is 18 cm^3/mol. Assuming cubic closest packed structure, determine the following:

34. The number of Pb atoms per unit cell.
    A) 1
    B) 2
    C) 4
    D) 6
    E) 10

    ANS: C PTS: 1 DIF: Moderate REF: 10.4
    KEY: Chemistry | general chemistry | phases | solid | calculations with unit cell dimensions
    MSC: Quantitative

35. The volume of a single cell.
    A) 1.20×10^2 pm^3
    B) 1.20×10^4 pm^3
    C) 1.20×10^6 pm^3
    D) 1.20×10^8 pm^3
    E) none of these

    ANS: D PTS: 1 DIF: Moderate REF: 10.4
    KEY: Chemistry | general chemistry | phases | solid | calculations with unit cell dimensions
    MSC: Quantitative

36. The radius of a Pb atom.
    A) 1.74 pm
    B) 17.4 pm
    C) 174 pm
    D) 1740 pm
    E) none of these

    ANS: C PTS: 1 DIF: Moderate REF: 10.4
    KEY: Chemistry | general chemistry | phases | solid | calculations with unit cell dimensions
    MSC: Quantitative

37. Cubic closest packing is another name for _____.
    A) simple cubic packing
    B) body-centered cubic packing
    C) face-centered cubic packing
    D) hexagonal closest packing
    E) more than one of these

    ANS: C PTS: 1 DIF: Moderate REF: 10.4
    KEY: Chemistry | general chemistry | phases | solid | crystalline solids | cubic unit cell
    MSC: Conceptual

38. Which one of the following statements about solid Cu (face-centered cubic unit cell) is incorrect?
    A) It will conduct electricity.
    B) There are two atoms per unit cell.
    C) The number of atoms surrounding each Cu atom is 12.
    D) The solid has a cubic closest-packed structure.

E) The length of a face diagonal is four times the Cu radius.

ANS: B PTS: 1 DIF: Moderate REF: 10.4
KEY: Chemistry | general chemistry | phases | solid | crystalline solids | cubic unit cell
MSC: Conceptual

39. In any cubic lattice an atom lying at the corner of a unit cell is shared equally by how many unit cells?
A) 1
B) 4
C) 8
D) 2
E) 6

ANS: C PTS: 1 DIF: Easy REF: 10.4
KEY: Chemistry | general chemistry | phases | solid | crystalline solids | cubic unit cell
MSC: Conceptual

40. Which of the following statements is (are) *false?*
I. The layering in a hexagonal closest-packed structure is *aba*.
II. A body-centered cubic unit cell has four atoms per unit cell.
III. For unit cells having the same edge length, a simple cubic structure would have a smaller density than a body-centered cube.
IV. Atoms in a solid consisting of only one element would have six nearest neighbors if the crystal structure were a simple cubic array.

A) I
B) II
C) II, III
D) I, IV
E) II, III, IV

ANS: B PTS: 1 DIF: Moderate REF: 10.4
KEY: Chemistry | general chemistry | phases | solid MSC: Conceptual

41. Aluminum metal crystallizes in a face-centered cubic structure. The relationship between the radius of an Al atom (r) and the length of an edge of the unit cell (E) is:
A) $r = E/2$
B) $r = \frac{E}{\sqrt{8}}$
C) $r = \frac{\sqrt{3}E}{4}$
D) $r = 2E$
E) $r = \sqrt{2}E$

ANS: B PTS: 1 DIF: Easy REF: 10.4
KEY: Chemistry | general chemistry | phases | solid | crystalline solids | cubic unit cell
MSC: Conceptual

42. Chromium metal crystallizes as a body-centered cubic lattice. If the atomic radius of Cr is 1.25 angstroms, what is the density of Cr metal in g/cm^3?
A) 5.52
B) 7.18
C) 14.4
D) 2.76
E) 3.59

ANS: B PTS: 1 DIF: Difficult REF: 10.4
KEY: Chemistry | general chemistry | phases | solid | calculations with unit cell dimensions
MSC: Quantitative

43. You are given a small bar of an unknown metal, M. You find the density of the metal to be 10.5 g/cm^3. An X-ray diffraction experiment measures the edge of the unit cell as 409 pm. Assuming that the metal crystallizes in a face-centered cubic lattice, what is M most likely to be?
A) Ag
B) Rh
C) Pt
D) Pb
E) none of these

ANS: A PTS: 1 DIF: Difficult REF: 10.4
KEY: Chemistry | general chemistry | phases | solid | calculations with unit cell dimensions
MSC: Quantitative

44. Silver chloride crystallizes with the sodium chloride (rock salt) structure. The length of a unit cell edge is 555 pm. What is the density of AgCl?
A) 5.57 g/cm^3
B) 4.19 g/cm^3
C) 2.79 g/cm^3
D) 2.10 g/cm^3
E) 1.39 g/cm^3

ANS: A PTS: 1 DIF: Moderate REF: 10.4
KEY: Chemistry | general chemistry | phases | solid | calculations with unit cell dimensions
MSC: Quantitative

45. A metal crystallizes in a body-centered unit cell with an edge length of 2.00×10^2 pm. Assume the atoms in the cell touch along the cube diagonal. The percentage of empty volume in the unit cell will be:
A) 0%
B) 26.0%
C) 32.0%
D) 68.0%
E) none of these

ANS: C PTS: 1 DIF: Difficult REF: 10.4
KEY: Chemistry | general chemistry | phases | solid | calculations with unit cell dimensions
MSC: Quantitative

46. A metal crystallizes with a face-centered cubic lattice. The edge of the unit cell is 395 pm. The diameter of the metal atom is:
A) 140 pm
B) 198 pm
C) 279 pm
D) 395 pm
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 10.4
KEY: Chemistry | general chemistry | phases | solid | calculations with unit cell dimensions
MSC: Quantitative

47. If equal, rigid spheres are arranged in a simple cubic lattice in the usual way (i.e., in such a way that they touch each other), what fraction of the corresponding solid will be empty space? [The volume of a sphere is $(4/3)\pi r^3$, with $\pi = 3.14$.]
A) 0.52
B) 0.32
C) 0.68
D) 0.48
E) none of these

ANS: D PTS: 1 DIF: Difficult REF: 10.4
KEY: Chemistry | general chemistry | phases | solid | calculations with unit cell dimensions
MSC: Quantitative

48. Which substance can be described as cations bonded together by mobile electrons?
A) Ag(*s*)
B) S_8(*s*)
C) Kr(*l*)
D) KCl(*s*)
E) HCl(*l*)

ANS: A PTS: 1 DIF: Easy REF: 10.4
KEY: Chemistry | general chemistry | phases | solid | classification of solids
MSC: Conceptual

49. Steel is considered to be a(n) _____.
A) interstitial alloy
B) ionic solid
C) molecular solid
D) substitutional alloy
E) two of these

ANS: A PTS: 1 DIF: Easy REF: 10.4
KEY: Chemistry | general chemistry | materials chemistry | metal
MSC: Conceptual

50. Which of the following statements about steel is *false?*
A) It contains carbon atoms in the holes of its iron crystals.
B) The presence of carbon-iron bonds in the alloy make steel harder and stronger than pure iron.

C) Pure iron is relatively soft and ductile because it lacks directional bonding.
D) The amount of carbon directly affects the properties of steel.
E) All of these are true.

ANS: E PTS: 1 DIF: Easy REF: 10.4
KEY: Chemistry | general chemistry | materials chemistry | metal
MSC: Conceptual

51. What is the *simplest* formula of a solid containing A, B, and C atoms in a cubic lattice in which the A atoms occupy the corners, the B atoms the body-center position, and the C atoms the faces of the unit cell?
A) ABC
B) ABC_3
C) ABC_6
D) A_8BC_6
E) A_4BC_3

ANS: B PTS: 1 DIF: Easy REF: 10.4
KEY: Chemistry | general chemistry | phases | solid | crystalline solids | cubic unit cell
MSC: Conceptual

52. A solid material consists of an array of A atoms with Z atoms located in the spaces in the lattice. This solid would be classified as
A) an amalgam
B) an interstitial alloy
C) a substitutional alloy
D) a semiconductor
E) ceramic

ANS: B PTS: 1 DIF: Easy REF: 10.4
KEY: Chemistry | general chemistry | materials chemistry | metal
MSC: Conceptual

53. The net number of spheres in the face-centered cubic unit cell is 4.

ANS: T PTS: 1 DIF: Easy REF: 10.4
KEY: Chemistry | general chemistry | phases | solid | crystalline solids | cubic unit cell
MSC: Conceptual

54. Steel is a substitutional alloy.

ANS: F PTS: 1 DIF: Easy REF: 10.4
KEY: Chemistry | general chemistry | materials chemistry | metal
MSC: Conceptual

55. Which of the following statements is true about *p*-type silicon?
A) It is produced by doping Si with P or As.
B) Protons are the mobile charge carriers.
C) It does not conduct electricity as well as pure Si.
D) All are true.

E) None is true.

ANS: E PTS: 1 DIF: Easy REF: 10.5
KEY: Chemistry | general chemistry | materials chemistry | metal | semiconductor
MSC: Conceptual

56. Doping Se with B would produce a(n) _____ semiconductor with _____ conductivity compared to pure Se.
A) *p*-type, increased
B) *n*-type, decreased
C) *n*-type, increased
D) *p*-type, decreased
E) intrinsic, identical

ANS: A PTS: 1 DIF: Easy REF: 10.5
KEY: Chemistry | general chemistry | materials chemistry | metal | semiconductor
MSC: Conceptual

57. A material is made from Al, Ga, and As. The mole fraction of each element is 0.25, 0.26, and 0.49, respectively. This material would be
A) a metallic conductor because Al is present
B) an insulator
C) a *p*-type semiconductor
D) an *n*-type semiconductor
E) none of the above

ANS: C PTS: 1 DIF: Moderate REF: 10.5
KEY: Chemistry | general chemistry | materials chemistry | metal | semiconductor
MSC: Conceptual

58. Which of the compounds below is an example of a network solid?
A) $S_8(s)$
B) $SiO_2(s)$
C) $MgO(s)$
D) $NaCl(s)$
E) $C_{25}H_{52}(s)$

ANS: B PTS: 1 DIF: Easy REF: 10.5
KEY: Chemistry | general chemistry | phases | solid | structures of crystalline solids | covalent network solid MSC: Conceptual

59. Which of the compounds below is *not* an example of a molecular solid?
A) $I_2(s)$
B) $SiO_2(s)$
C) $CO_2(s)$
D) $H_2O(s)$
E) $C_{25}H_{52}(s)$

ANS: B PTS: 1 DIF: Easy REF: 10.6
KEY: Chemistry | general chemistry | phases | solid | structures of crystalline solids | molecular solid MSC: Conceptual

60. Ice is a molecular solid.

ANS: T PTS: 1 DIF: Easy REF: 10.6
KEY: Chemistry | general chemistry | phases | solid | classification of solids | molecular solid MSC: Conceptual

61. Which of these statements is incorrect?
A) Molecular solids have high melting points.
B) The binding forces in a molecular solid include London dispersion forces.
C) Ionic solids have high melting points.
D) Ionic solids are insulators.
E) All of the statements (A-D) are correct.

ANS: A PTS: 1 DIF: Easy REF: 10.7
KEY: Chemistry | general chemistry | phases | solid | classification of solids
MSC: Conceptual

62. At room temperature, CsF is expected to be
A) a gas
B) a conducting solid
C) a liquid
D) a brittle solid
E) a soft solid

ANS: D PTS: 1 DIF: Easy REF: 10.7
KEY: Chemistry | general chemistry | phases | solid | properties of solids
MSC: Conceptual

63. A solid crystal of NaCl is
A) soft, low melting, a good electrical conductor
B) hard, high melting, a good electrical conductor
C) soft, low melting, a poor electrical conductor
D) hard, high melting, a poor electrical conductor
E) soft, high melting, a poor electrical conductor

ANS: D PTS: 1 DIF: Easy REF: 10.7
KEY: Chemistry | general chemistry | phases | solid | properties of solids
MSC: Conceptual

64. Solid MgO has the same crystal structure as NaCl. How many oxide ions surround each Mg^{2+} ion as nearest neighbors in MgO?
A) 4
B) 6
C) 8
D) 12
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 10.7
KEY: Chemistry | general chemistry | phases | solid | structures of crystalline solids | ionic solid MSC: Conceptual

65. Which of the following has the highest melting temperature?
A) H_2O
B) CO_2
C) S_8
D) MgF_2
E) P_4

ANS: D PTS: 1 DIF: Easy REF: 10.7
KEY: Chemistry | general chemistry | phases | solid | properties of solids | melting point
MSC: Conceptual

66. A certain solid substance that is very hard, has a high melting point, and is nonconducting unless melted is most likely to be:
A) I_2
B) NaCl
C) CO_2
D) H_2O
E) Cu

ANS: B PTS: 1 DIF: Easy REF: 10.7
KEY: Chemistry | general chemistry | phases | solid | classification of solids
MSC: Conceptual

67. Which of these statements is false?
A) Diamond is a covalent crystal.
B) The size of the unit cell of Li and Cs is the same.
C) Molecular crystals usually have low melting points.
D) Metallic crystals are usually good electrical conductors.
E) None of the statements is false.

ANS: B PTS: 1 DIF: Easy REF: 10.7
KEY: Chemistry | general chemistry | phases | solid MSC: Conceptual

68. An ionic crystalline solid, MX_2, has a cubic unit cell. Which of the following arrangements of the ions is consistent with the stoichiometry of the compound?
A) M^{2+} ions at the corners and at each face, 8 X^- ions at the tetrahedral centers
B) M^{2+} ions at each face, X^- ions at the corners
C) M^{2+} ions at the corners, X^- ions at the faces, and 2 X^- ions at the tetrahedralcenters
D) 4 M^{2+} ions at the body centers, X^- ions at the corners and at the faces
E) M^{2+} ions at the corners and at the faces, 4 X^- ions at the octahedral centers

ANS: A PTS: 1 DIF: Easy REF: 10.7
KEY: Chemistry | general chemistry | phases | solid | structures of crystalline solids | ionic solid MSC: Conceptual

69. Lithium chloride crystallizes in a face-centered cubic structure. The unit cell length is 5.14×10^{-8} cm. The chloride ions are touching each other along the face diagonal of the unit cell. The lithium ions fit into the holes between the chloride ions. What is the mass of LiCl in a unit cell?
A) 7.04×10^{-23} g

B) 1.41×10^{-22} g
C) 2.82×10^{-22} g
D) 4.22×10^{-22} g
E) 5.63×10^{-22} g

ANS: C PTS: 1 DIF: Difficult REF: 10.7
KEY: Chemistry | general chemistry | phases | solid | structures of crystalline solids | ionic solid MSC: Quantitative

70. How would you expect the melting point of CCl_4 to compare to that of NaCl?
A) It should be lower because NaCl forms an extended ionic crystal lattice, whereas CCl_4 is a covalently-bonded small molecule.
B) It should be similar since they are both ionic solids.
C) It should be higher because the bonds are stronger due to the higher charge on C (+4).
D) It should be higher because CCl_4 is larger than NaCl.
E) It is not possible to say anything about their melting points without more information.

ANS: A PTS: 1 DIF: Easy REF: 10.7
KEY: Chemistry | general chemistry | phases | solid | properties of solids | melting point
MSC: Conceptual

71. In the unit cell of sphalerite, Zn^{2+} ions occupy half the tetrahedral holes in a face-centered cubic lattice of S^{2-} ions. The number of formula units of ZnS in the unit cell is:
A) 6
B) 4
C) 3
D) 2
E) 1

ANS: B PTS: 1 DIF: Difficult REF: 10.7
KEY: Chemistry | general chemistry | phases | solid | structures of crystalline solids
MSC: Conceptual

72. The unit cell in a certain lattice consists of a cube formed by an anion at each corner, an anion in the center, and a cation at the center of each face. The unit cell contains a net:
A) 5 anions and 6 cations
B) 5 anions and 3 cations
C) 2 anions and 3 cations
D) 3 anions and 4 cations
E) 2 anions and 2 cations

ANS: C PTS: 1 DIF: Moderate REF: 10.7
KEY: Chemistry | general chemistry | phases | solid | crystalline solids | cubic unit cell
MSC: Conceptual

73. Which of the following statements about the closest packing of spheres in binary ionic solids is *false*?
A) The packing is done in a way that minimizes repulsions among ions with like

charges.
B) The packing arrangement maximizes electrostatic attractions among oppositely charged ions.
C) For spheres of a given diameter, tetrahedral holes are larger than octahedral holes.
D) Trigonal holes are so small that they are never occupied.
E) None of these.

ANS: C PTS: 1 DIF: Moderate REF: 10.7
KEY: Chemistry | general chemistry | phases | solid | structures of crystalline solids
MSC: Conceptual

74. An atom in an octahedral hole is surrounded by ____ atoms.
A) 2
B) 3
C) 4
D) 6
E) 8

ANS: D PTS: 1 DIF: Moderate REF: 10.7
KEY: Chemistry | general chemistry | phases | solid | structures of crystalline solids
MSC: Conceptual

75. A salt, MY, crystallizes in a body-centered cubic structure with a Y^- anion at each cube corner and an M^+ cation at the cube center. Assuming that the Y^- anions touch each other and the M^+ cation at the center, and the radius of Y^- is 1.50×10^2 pm, the radius of M^+ is:
A) 62.0 pm
B) 110. pm
C) 124 pm
D) 220. pm
E) none of these

ANS: B PTS: 1 DIF: Difficult REF: 10.7
KEY: Chemistry | general chemistry | phases | solid | calculations with unit cell dimensions
MSC: Quantitative

76. Sodium oxide (Na_2O) crystallizes in a structure in which the O^{2-} ions are in a face-centered cubic lattice and the Na^+ ions are in tetrahedral holes. The number of Na^+ ions in the unit cell is:
A) 2
B) 4
C) 6
D) 8
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 10.7
KEY: Chemistry | general chemistry | phases | solid | structures of crystalline solids | ionic solid MSC: Conceptual

77. A certain metal fluoride crystallizes in such a way that the fluoride ions occupy simple cubic lattice sites, while the metal atoms occupy the body centers of half the cubes. The formula for the metal fluoride is:

A) MF_2
B) M_2F
C) MF
D) MF_8
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 10.7
KEY: Chemistry | general chemistry | phases | solid | structures of crystalline solids | ionic solid MSC: Conceptual

78. Which of the following is most likely to be a solid at room temperature?
A) Na_2S
B) HF
C) NH_3
D) N_2
E) H_2O

ANS: A PTS: 1 DIF: Easy REF: 10.7
KEY: Chemistry | general chemistry | phases | solid | classification of solids
MSC: Conceptual

79. On the basis of your knowledge of bonding in liquids and solids, which of the following has the lowest melting temperature?
A) NaCl
B) Na
C) Cl_2
D) SiO_2
E) More information is needed.

ANS: C PTS: 1 DIF: Moderate REF: 10.7
KEY: Chemistry | general chemistry | phases | solid | classification of solids
MSC: Conceptual

80. Which of the following substances would you expect to have the lowest boiling point?
A) diamond
B) methane, CH_4
C) sodium nitrate, $NaNO_3$
D) glycerine, $C_3H_5(OH)_3$
E) copper

ANS: B PTS: 1 DIF: Moderate REF: 10.7
KEY: Chemistry | general chemistry | phases | solid | classification of solids
MSC: Conceptual

81. On a relative basis, the weaker the intermolecular forces in a substance,
A) the greater its heat of vaporization
B) the more it deviates from ideal gas behavior
C) the greater its vapor pressure at a particular temperature
D) the higher its melting point
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 10.8
KEY: Chemistry | general chemistry | phases | liquid | intermolecular forces
MSC: Conceptual

82. At normal atmospheric pressure and a temperature of 0°C, which phase(s) of H_2O can exist?
A) ice and water
B) ice and water vapor
C) water only
D) water vapor only
E) ice only

ANS: A PTS: 1 DIF: Easy REF: 10.8
KEY: Chemistry | general chemistry | phases | phase transitions | melting point
MSC: Conceptual

83. The process of condensation happens when which of the following occurs?
A) A solid becomes a liquid.
B) A liquid becomes a solid.
C) A gas becomes a liquid.
D) A liquid becomes a gas.
E) A gas becomes a solid.

ANS: C PTS: 1 DIF: Easy REF: 10.8
KEY: Chemistry | general chemistry | phases | phase transitions MSC: Conceptual

84. Which of the following processes must exist in equilibrium with the evaporation process when a measurement of vapor pressure is made?
A) fusion
B) vaporization
C) sublimation
D) boiling
E) condensation

ANS: E PTS: 1 DIF: Easy REF: 10.8
KEY: Chemistry | general chemistry | phases | phase transitions | vapor pressure
MSC: Conceptual

85. Assume 12,500 J of energy is added to 2.0 moles (36 grams) of H_2O as an ice sample at 0°C. The molar heat of fusion is 6.02 kJ/mol. The specific heat of liquid water is 4.18 J/g °C. The molar heat of vaporization is 40.6 kJ/mol. The resulting sample contains which of the following?
A) only ice
B) ice and water
C) only water
D) water and water vapor
E) only water vapor

ANS: C PTS: 1 DIF: Moderate REF: 10.8
KEY: Chemistry | general chemistry | phases | phase transitions | Clausius-Clapeyron equation MSC: Quantitative

86. You are given the following boiling point data. Which one of the liquids would you expect to have the highest vapor pressure at room temperature?

A) water, H_2O 100°C
B) methanol, CH_3OH 64.96°C
C) ethanol, CH_3CH_2OH 78.5°C
D) diethyl ether, $CH_3OH_2–O–CH_2CH_3$ 34.5°C
E) ethylene glycol, $HO–CH_2–CH_2–OH$ 198°C

ANS: D PTS: 1 DIF: Easy REF: 10.8
KEY: Chemistry | general chemistry | phases | phase transitions | vapor pressure
MSC: Conceptual

87. Given below are the temperatures at which two different liquid compounds with the same empirical formula have a vapor pressure of 400 torr.

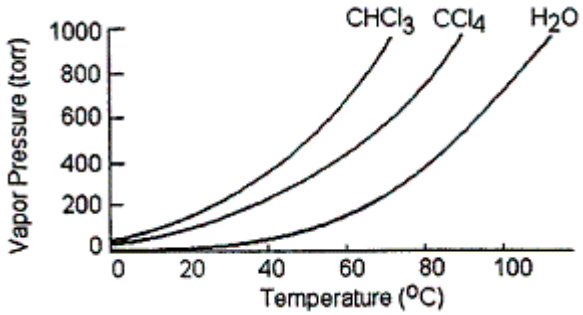
Compound	T (°C)
dimethyl ether, $CH_3–O–CH_3$	–37.8
ethanol, CH_3CH_2OH	63.5

Which of the following statements (a–d) is *false*?

A) Increasing the temperature will increase the vapor pressure of both liquids.
B) Intermolecular attractive forces are stronger in (liquid) ethanol than in (liquid) dimethyl ether.
C) The normal boiling point of dimethyl ether will be higher than the normal boiling point of ethanol.
D) The reason that the temperature at which the vapor pressure is 400 torr is higher for ethanol (than for dimethyl ether) is that there is strong hydrogen bonding in ethanol.
E) None of these is false.

ANS: C PTS: 1 DIF: Easy REF: 10.8
KEY: Chemistry | general chemistry | phases | phase transitions | vapor pressure
MSC: Conceptual

88. Given the graph below, what is the boiling point of chloroform at standard pressure?



A) 77°C
B) 34°C
C) 98°C
D) 60°C
E) The graph does not give that information.

ANS: D PTS: 1 DIF: Easy REF: 10.8

KEY: Chemistry | general chemistry | phases | phase transitions | vapor pressure
MSC: Conceptual

89. A liquid placed in a closed container will evaporate until equilibrium is reached. At equilibrium, which of the statements (A-D) is *false?*
A) The partial pressure exerted by the vapor molecules is called the vapor pressure of the liquid.
B) Liquid molecules are still evaporating.
C) The number of vapor molecules remains essentially constant.
D) The boundary (meniscus) between liquid and vapor disappears.
E) All of these are true.

ANS: D PTS: 1 DIF: Easy REF: 10.8
KEY: Chemistry | general chemistry | phases | phase transitions | vapor pressure
MSC: Conceptual

90. Which one of the following decreases as the strength of the attractive intermolecular forces increases?
A) the heat of vaporization
B) the normal boiling temperature
C) the extent of deviations from the ideal gas law
D) the sublimation temperature of a solid
E) the vapor pressure of a liquid

ANS: E PTS: 1 DIF: Easy REF: 10.8
KEY: Chemistry | general chemistry | phases | liquid | intermolecular forces
MSC: Conceptual

91. Knowing that ΔH_{vap} for water is 40.7 kJ/mol, calculate P_{vap} of water at 58°C.
A) 5.3 torr
B) 456 torr
C) 14.8 torr
D) 759 torr
E) 144 torr

ANS: E PTS: 1 DIF: Moderate REF: 10.8
KEY: Chemistry | general chemistry | phases | phase transitions | Clausius-Clapeyron equation MSC: Quantitative

92. Water sits in an open beaker. Assuming constant temperature and pressure, the rate of evaporation decreases as the water evaporates.

ANS: F PTS: 1 DIF: Easy REF: 10.8
KEY: Chemistry | general chemistry | phases | phase transitions MSC: Conceptual

93. Water sits in an open beaker. Assuming constant temperature and pressure, the vapor pressure of the water decreases as the water evaporates.

ANS: F PTS: 1 DIF: Easy REF: 10.8
KEY: Chemistry | general chemistry | phases | phase transitions | vapor pressure

MSC: Conceptual

94. Generally the vapor pressure of a liquid is related to:
    I. the amount of liquid
    II. atmospheric pressure
    III. temperature
    IV. intermolecular forces

    A) I, III
    B) II, III, IV
    C) I, III, IV
    D) III, IV
    E) I, II, III, IV

    ANS: D PTS: 1 DIF: Easy REF: 10.8
    KEY: Chemistry | general chemistry | phases | phase transitions | vapor pressure
    MSC: Conceptual

95. In which of the following processes will energy be evolved as heat?
    A) sublimation
    B) crystallization
    C) vaporization
    D) melting
    E) none of these

    ANS: B PTS: 1 DIF: Easy REF: 10.8
    KEY: Chemistry | general chemistry | phases | phase transitions MSC: Conceptual

96. When one mole of benzene is vaporized at a constant pressure of 1.00 atm and at its boiling point of 353.0 K, 30.56 kJ of energy (heat) is absorbed and the volume change is +28.90 L. What is ΔE for this process? (1 L·atm = 101.3 J)
    A) 30.56 kJ
    B) 59.46 kJ
    C) 33.49 kJ
    D) 1.66 kJ
    E) 27.63 kJ

    ANS: E PTS: 1 DIF: Moderate REF: 10.8
    KEY: Chemistry | general chemistry | phases | phase transitions | Clausius-Clapeyron equation MSC: Quantitative

97. When one mole of benzene is vaporized at a constant pressure of 1.00 atm and at its boiling point of 353.0 K, 30.53 kJ of energy (heat) is absorbed and the volume change is +28.90 L. What is ΔH for this process? (1 L·atm = 101.3 J)
    A) 27.60 kJ
    B) 33.46 kJ
    C) 1.63 kJ
    D) 30.53 kJ
    E) 59.43 kJ

    ANS: D PTS: 1 DIF: Moderate REF: 10.8

KEY: Chemistry | general chemistry | phases | phase transitions | Clausius-Clapeyron equation MSC: Quantitative

98. The normal boiling point of liquid X is less than that of Y, which is less than that of Z. Which of the following is the correct order of increasing vapor pressure of the three liquids at STP?
A) X, Y, Z
B) Z, Y, X
C) Y, X, Z
D) X, Z, Y
E) Y, Z, X

ANS: B PTS: 1 DIF: Easy REF: 10.8
KEY: Chemistry | general chemistry | phases | phase transitions | vapor pressure
MSC: Conceptual

99. The vapor pressure of water at 100.0°C is
A) 85 torr
B) 760 torr
C) 175 torr
D) 1 torr
E) More information is needed.

ANS: B PTS: 1 DIF: Easy REF: 10.8
KEY: Chemistry | general chemistry | phase | phase transitions | vapor pressure
MSC: Conceptual

100. How much energy is needed to convert 54.1 grams of ice at 0.00°C to water at 75.0°C?
specific heat (ice) = 2.10 J/g°C
specific heat (water) = 4.18 J/g°C
heat of fusion = 333 J/g
heat of vaporization = 2258 J/g
A) 17.0 kJ
B) 1.94 kJ
C) 26.5 kJ
D) 35.0 kJ
E) 139 kJ

ANS: D PTS: 1 DIF: Moderate REF: 10.8
KEY: Chemistry | general chemistry | phases | phase transitions | phase transition enthalpy change MSC: Quantitative

101. The vapor pressure of water at 80°C is
A) 0.48 atm
B) 1.00 atm
C) 1.20 atm
D) 2.00 atm
E) 5.00 atm

ANS: A PTS: 1 DIF: Easy REF: 10.8
KEY: Chemistry | general chemistry | phases | phase transitions | vapor pressure

MSC: Conceptual

102. Which of the following has the highest boiling point?
A) chalk (calcium carbonate)
B) ice (water)
C) window cleaner (ammonia)
D) motor oil (hydrocarbon chains)
E) helium gas inside a party balloon

ANS: A PTS: 1 DIF: Easy REF: 10.8
KEY: Chemistry | general chemistry | phases | phase transitions | vapor pressure
MSC: Conceptual

103. How many grams of ice would be melted by the energy obtained as 16.2 g of steam is condensed at 100°C and cooled to 0°C?
specific heat (ice) = 2.10 J/g°C
specific heat (water) = 4.18 J/g°C
heat of fusion = 333 J/g
heat of vaporization = 2258 J/g
A) 43.4 kg
B) 36.6 kg
C) 130 g
D) 6.77 kg
E) 20 g

ANS: C PTS: 1 DIF: Moderate REF: 10.8
KEY: Chemistry | general chemistry | phases | phase transitions | phase transition enthalpy change MSC: Quantitative

104. The heat of combustion of bituminous coal is 2.50×10^4 J/g. What quantity of the coal is required to produce the energy to convert 106.9 pounds of ice at 0.00°C to steam at 100.°C?
specific heat (ice) = 2.10 J/g°C
specific heat (water) = 4.18 J/g°C
heat of fusion = 333 J/g
heat of vaporization = 2258 J/g
A) 5.84 kg
B) 0.646 kg
C) 0.811 kg
D) 4.38 kg
E) 1.46 kg

ANS: A PTS: 1 DIF: Moderate REF: 10.8
KEY: Chemistry | general chemistry | phases | phase transitions | phase transition enthalpy change MSC: Quantitative

105. The process of changing from a vapor to a liquid is vaporization.

ANS: F PTS: 1 DIF: Easy REF: 10.8
KEY: Chemistry | general chemistry | phases | phase transitions MSC: Conceptual

106. A certain substance, *X*, has a triple-point temperature of 20°C at a pressure of 2.0 atm. Which one of the statements (A-D) cannot possibly be true?
A) *X* can exist as a liquid above 20°C.
B) *X* can exist as a solid above 20°C.
C) Liquid *X* can exist as a stable phase at 25°C, 1 atm.
D) Both liquid and solid *X* have the same vapor pressure at 20°C.
E) All of the statements (A-D) could be true.

ANS: C PTS: 1 DIF: Moderate REF: 10.9
KEY: Chemistry | general chemistry | phases | phase transitions | phase diagram | triple point MSC: Conceptual

107. Which statement regarding water is true?
A) Energy must be given off in order to break down the crystal lattice of ice to a liquid.
B) Hydrogen bonds are stronger than covalent bonds.
C) Liquid water is less dense than solid water.
D) Only covalent bonds are broken when ice melts.
E) All of the statements (A–D) are false.

ANS: E PTS: 1 DIF: Easy REF: 10.9
KEY: Chemistry | general chemistry | phases | phase transitions MSC: Conceptual

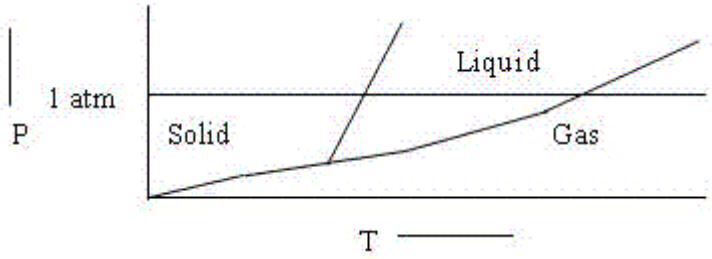
108. The triple point of iodine is at 90 torr and 115°C. This means that liquid I_2
A) is more dense than $I_2(s)$
B) cannot exist above 115°C
C) cannot exist at 1 atmosphere pressure
D) cannot have a vapor pressure less than 90 torr
E) can exist at pressure of 10 torr

ANS: D PTS: 1 DIF: Easy REF: 10.9
KEY: Chemistry | general chemistry | phases | phase transitions | phase diagram | triple point MSC: Conceptual

109. The triple point of CO_2 is at 5.2 atm and –57°C. Under atmospheric conditions present in a typical Boulder, Colorado, laboratory (P = 630 torr, T = 23°C), solid CO_2 will:
A) remain solid
B) boil
C) melt
D) sublime
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 10.9
KEY: Chemistry | general chemistry | phases | phase transitions | phase diagram | triple point MSC: Conceptual

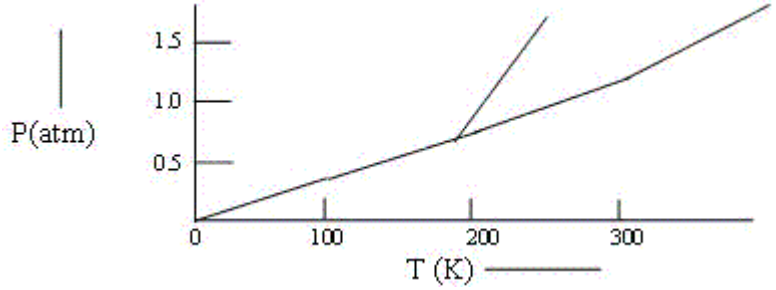
110. Choose the correct statement about the diagram below.



A) The diagram is qualitatively correct for water.
B) The diagram shows that the melting point of the solid increases with increasing pressure.
C) The diagram shows the triple point above 1 atm pressure.
D) The diagram could represent the phase diagram of CO_2.
E) None of the above statements is correct.

ANS: B PTS: 1 DIF: Easy REF: 10.9
KEY: Chemistry | general chemistry | phases | phase transitions | phase diagram
MSC: Conceptual

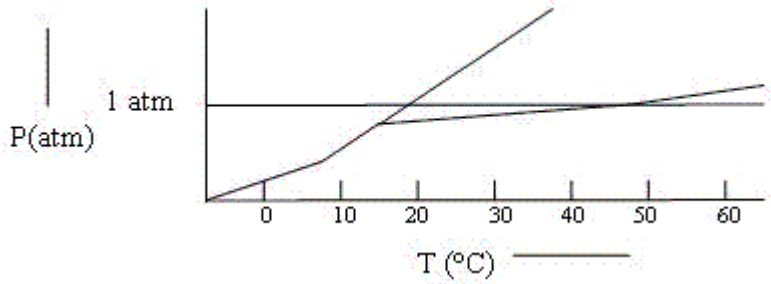
111. Below is a phase diagram for compound *Q*. You wish to purify a sample of *Q* that was collected at *P* = 1.0 atm and *T* = 100 K by subliming it. In order to sublime the sample, you should:



A) Increase *P* to 1.5 atm and then increase *T* to 300 K.
B) Increase *T* to 300 K, keeping *P* = 1.0 atm.
C) Lower *P* to 0.5 atm and then increase *T* to 200 K.
D) Increase *T* to 300 K and then lower *P* to 0.5 atm.
E) Abandon the attempt to sublime *Q*.

ANS: C PTS: 1 DIF: Easy REF: 10.9
KEY: Chemistry | general chemistry | phases | phase transitions | phase diagram
MSC: Conceptual

112. Shown below is a phase diagram for compound *Y*. At 25°C and 1 atm *Y* will exist as a:

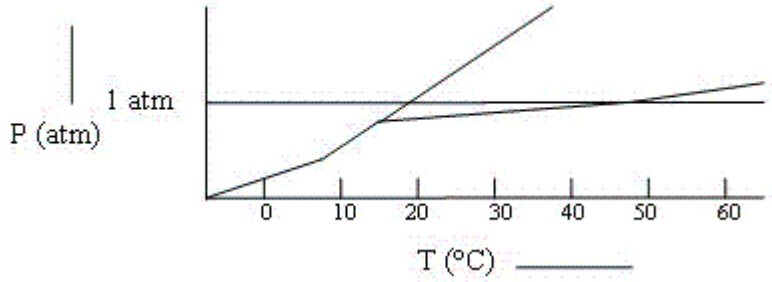


A) solid

B) liquid
C) gas
D) gas/liquid at equilibrium
E) gas/solid at equilibrium

ANS: B PTS: 1 DIF: Easy REF: 10.9
KEY: Chemistry | general chemistry | phases | phase transitions | phase diagram
MSC: Conceptual

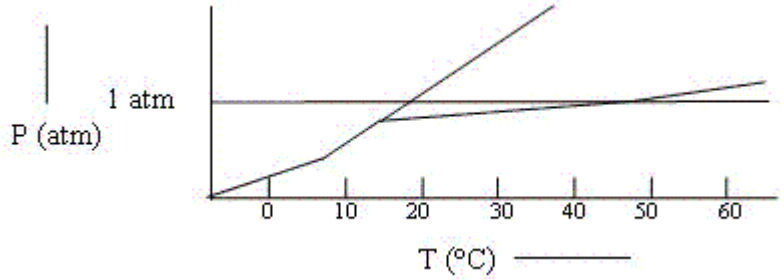
113. Below is a phase diagram for compound *Y*. The normal boiling point of *Y* is most likely:



A) 21°C
B) 47°C
C) 63°C
D) 18°C
E) 0°C

ANS: B PTS: 1 DIF: Easy REF: 10.9
KEY: Chemistry | general chemistry | phases | phase transitions | phase diagram
MSC: Conceptual

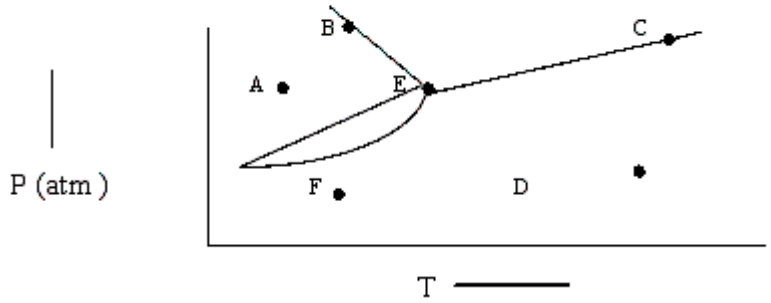
114. Shown below is a phase diagram for compound *Y*.



How will the melting point of *Y* change with increased pressure?
A) increase
B) decrease
C) remain the same
D) not enough information given
E) increase and then decrease

ANS: A PTS: 1 DIF: Easy REF: 10.9
KEY: Chemistry | general chemistry | phases | phase transitions | phase diagram
MSC: Conceptual

115. Based on the phase diagram shown below, which of the following statements are correct?

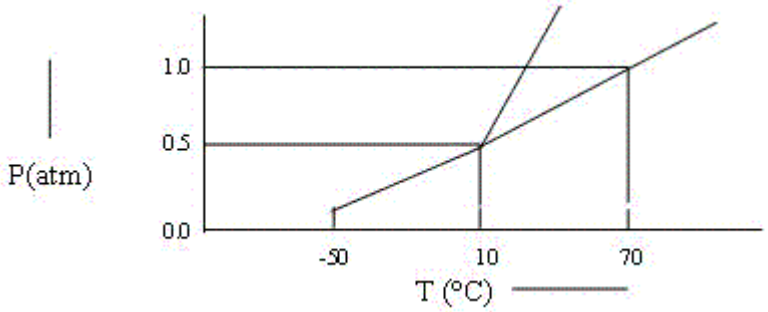


I. Sublimation occurs at a point in the transformation that occurs along a straight line from point A to point F.
II. C and E represent points where the gas and liquid phases are in equilibrium.
III. ΔH_{vap} can be measured at point B.
IV. Molecules at point D have a greater average kinetic energy than those at point F.
V. The temperature at point E is called the critical temperature of the compound.

A) II, V
B) I, III, IV
C) I, II, III
D) II, IV, V
E) I, II, IV

ANS: E PTS: 1 DIF: Moderate REF: 10.9
KEY: Chemistry | general chemistry | phases | phase transitions | phase diagram
MSC: Conceptual

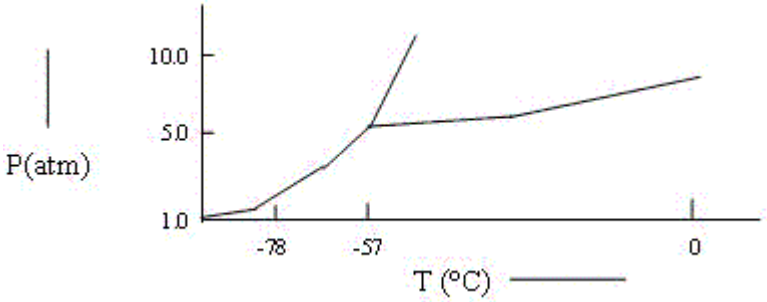
116. A certain substance has the phase diagram shown below. At which of the following values of *T* and *P* is the substance a pure liquid?



A) *T* = 8°C, *P* = 1 atm
B) *T* = 10°C, *P* = 0.5 atm
C) *T* = 70°C, *P* = 1.2 atm
D) *T* = 80°C, *P* = 1 atm
E) *T* = 10°C, *P* = 1 atm

ANS: C PTS: 1 DIF: Easy REF: 10.9
KEY: Chemistry | general chemistry | phases | phase transitions | phase diagram
MSC: Conceptual

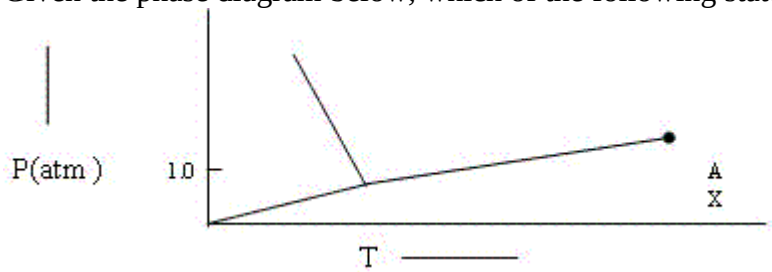
117. A sample consisting of $CO_2(g)$ and $CO_2(s)$ at equilibrium at –78°C and 1 atm pressure is heated to –30°C and the pressure is increased to 8 atm. Based on the phase diagram below, what will happen?



A) At equilibrium, only $CO_2(g)$ will be present.
B) All of the CO_2 will be converted to $CO_2(l)$.
C) At equilibrium, $CO_2(g)$ and $CO_2(l)$ will be present.
D) The melting point of the $CO_2(s)$ will decrease.
E) None of these.

ANS: B PTS: 1 DIF: Easy REF: 10.9
KEY: Chemistry | general chemistry | phases | phase transitions | phase diagram
MSC: Conceptual

118. Given the phase diagram below, which of the following statements (A–D) is *false*?



A) The solid has a higher density than the liquid.
B) At some (constant) temperature, the gaseous substance can be compressed into a solid and then into a liquid in this order.
C) When phase A is compressed at constant temperature at point X, no change is observed.
D) When heated at 1 atm, this substance will first melt, then boil.
E) None of the above statements is false.

ANS: A PTS: 1 DIF: Easy REF: 10.9
KEY: Chemistry | general chemistry | phases | phase transitions | phase diagram
MSC: Conceptual

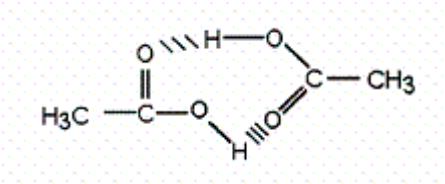
119. The density of the solid phase of a substance is 0.90 g/cm^3 and the density of the liquid phase is 1.0 g/cm^3. A large increase in pressure will
A) lower the freezing point
B) raise the freezing point
C) lower the boiling point
D) raise the triple point
E) lower the triple point

ANS: A PTS: 1 DIF: Moderate REF: 10.9

KEY: Chemistry | general chemistry | phases | phase transitions | phase diagram
MSC: Conceptual

120. Make a sketch to show the hydrogen bonding between two acetic acid molecules ($HC_2H_3O_2$).

ANS:



See Sec. 10.1 of Zumdahl, *Chemistry*

PTS: 1 DIF: Easy REF: 10.1
KEY: Chemistry | general chemistry | phases | liquid | intermolecular forces | hydrogen bonding MSC: Conceptual

121. If you have 10.0 moles of BH_3 and 5.0 moles of HF, which amount exhibits the most hydrogen bonding? Explain.
Check question

ANS:
HF; Hydrogen bonding only occurs between molecules where hydrogen is bonded to nitrogen, oxygen, or fluorine. Even though more BH_3 is present, it does not exhibit any hydrogen bonding at all.

See Sec. 10.1 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Easy REF: 10.1
KEY: Chemistry | general chemistry | phases | liquid | intermolecular forces
MSC: Conceptual

122. The particularly strong dipole-dipole interaction between hydrogen in one molecule and nitrogen in another molecule is known as a _____.

ANS:
hydrogen bond

PTS: 1 DIF: Easy REF: 10.1
KEY: Chemistry | general chemistry | phases | liquid | intermolecular forces | hydrogen bonding MSC: Conceptual

123. The relatively weak forces that exist among noble gas atoms are _____.

ANS:
London dispersion forces

PTS: 1 DIF: Easy REF: 10.1
KEY: Chemistry | general chemistry | phases | liquid | intermolecular forces | London forces
MSC: Conceptual

124. The meniscus of mercury curves downward at the edges. Explain using the concepts of cohesion and adhesion.

ANS:
In mercury the cohesive forces within the liquid are stronger than the adhesive forces toward glass.

See Sec. 10.2 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Moderate REF: 10.2
KEY: Chemistry | general chemistry | phases | liquid | properties of liquids
MSC: Conceptual

125. The resistance of a liquid to an increase in its surface area is the _____ of the liquid.

ANS:
surface tension

PTS: 1 DIF: Easy REF: 10.2
KEY: Chemistry | general chemistry | phases | liquid | properties of liquids | surface tension
MSC: Conceptual

126. The structures of crystalline solids are most commonly determined by _____.

ANS:
x-ray diffraction

PTS: 1 DIF: Easy REF: 10.3
KEY: Chemistry | general chemistry | phases | solid | x-ray diffraction
MSC: Conceptual

127. In a(n) _____ alloy some of the host metal atoms are replaced by other metal atoms of similar size.

ANS:
substitutional

PTS: 1 DIF: Easy REF: 10.4
KEY: Chemistry | general chemistry | materials chemistry | metal
MSC: Conceptual

128. Iodine moves directly from solid to gas in a process called _____.

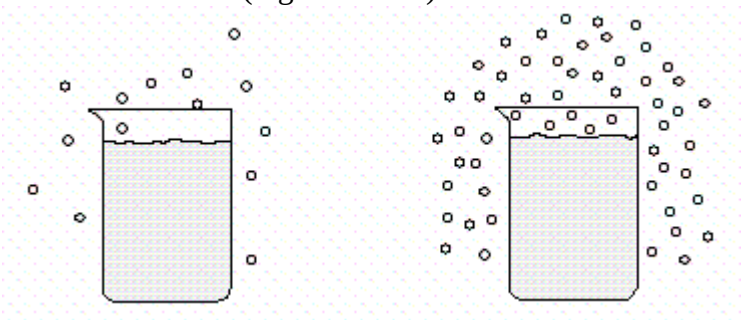
ANS:
sublimation

PTS: 1 DIF: Easy REF: 10.8
KEY: Chemistry | general chemistry | phases | phase transitions MSC: Conceptual

129. Explain why water boils at a lower temperature up in the mountains versus at sea level. Include at least one microscopic drawing in your explanation.

ANS:
The boiling point of a liquid is the temperature at which the vapor pressure of the liquid is exactly the same as the pressure of the atmosphere around it. Water boils at a lower temperature up in the mountains because at high altitudes the atmospheric pressure is lower (see pictures A and B). Boiling occurs when the water is hot enough to have the same vapor pressure as the surrounding air pressure, so that it can form bubbles. Since the air pressure is lower at high altitudes, the water does not have to get as hot for boiling to occur. It will take more heat for water at sea level to attain the same pressure as the surrounding air since the atmospheric pressure is higher (see picture B).

Picture A (high altitudes) Picture B (low altitudes)



See Sec. 10.8 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Moderate REF: 10.8
KEY: Chemistry | general chemistry | phases | phase transitions | vapor pressure
MSC: Conceptual

130. 100. g of ice at 0°C is added to 300.0 g of water at 60°C. Assuming no transfer of heat to the surroundings, what is the temperature of the liquid water after all the ice has melted and equilibrium is reached?
specific heat (ice) = 2.10 J/g°C
specific heat (water) = 4.18 J/g°C
heat of fusion = 333 J/g
heat of vaporization = 2258 J/g

ANS:
25.0°C

$100.\text{g}\ (333\ \text{J/g}) + 100.\text{g}(T_f - 0°\text{C})(4.18\ \text{J/g°C}) = -300.0\text{g}(T_f - 60°\text{C})(4.18\ \text{J/g°C})$

$33\underline{3}00 + 418T_f = -12\underline{5}4T_f + 7\underline{5}240$ (using underline to track sig figs)
$16\underline{7}2T_f = 4\underline{1}940$; $T_f = 25°C$

PTS: 1 DIF: Moderate REF: 10.8
KEY: Chemistry | general chemistry | phases | phase transitions | phase transition enthalpy change MSC: Quantitative

131. For each of the following pairs of substances, select the one expected to have the higher melting point:
I. H_2O, H_2S II. HCl, NaCl III. CH_4, C_3H_8
A) H_2O, HCl, C_3H_8
B) H_2O, NaCl, C_3H_8
C) H_2O, NaCl, CH_4
D) H_2S, HCl, CH_4
E) H_2S, NaCl, CH_4

ANS: B PTS: 1 DIF: Moderate REF: 10.1
KEY: Chemistry | general chemistry | phases | intermolecular forces
MSC: Conceptual

132. For each of the following pairs of substances, select the one expected to have the lower melting point:
I. H_2O, H_2S II. HCl, NaCl III. CH_4, C_3H_8
A) H_2O, HCl, C_3H_8
B) H_2O, NaCl, C_3H_8
C) H_2O, HCl, CH_4
D) H_2S, HCl, CH_4
E) H_2S, NaCl, CH_4

ANS: D PTS: 1 DIF: Moderate REF: 10.1
KEY: Chemistry | general chemistry | phases | intermolecular forces
MSC: Conceptual

133. Which of the following compounds is expected to have the HIGHEST boiling point?
A) CH_3OCH_3
B) CH_3CH_2OH
C) $CH_3CH_2CH_2CH_3$
D) $CH_3CH_2CH_3$
E) CH_3Cl

ANS: B PTS: 1 DIF: Moderate REF: 10.1
KEY: Chemistry | general chemistry | phases | intermolecular forces | hydrogen bonds
MSC: Conceptual

134. Which of the following compounds is expected to have the HIGHEST melting point?
A) CH_3OCH_3
B) CH_3CH_2OH
C) $CH_3CH_2CH_2CH_3$
D) $CH_3CH_2CH_3$
E) CH_3Cl

ANS: B PTS: 1 DIF: Moderate REF: 10.1
KEY: Chemistry | general chemistry | phases | intermolecular forces | hydrogen bonds
MSC: Conceptual

135. Which of the following compounds is expected to have the LOWEST melting point?
A) CH_3OCH_3
B) CH_3CH_2OH
C) $CH_3CH_2CH_2CH_3$
D) $CH_3CH_2CH_3$
E) CH_3Cl

ANS: D PTS: 1 DIF: Moderate REF: 10.1
KEY: Chemistry | general chemistry | phases | intermolecular forces
MSC: Conceptual

136. Which of the following compounds is expected to have the LOWEST boiling point?
A) CH_3OCH_3
B) CH_3CH_2OH
C) $CH_3CH_2CH_2CH_3$
D) $CH_3CH_2CH_3$
E) CH_3Cl

ANS: D PTS: 1 DIF: Moderate REF: 10.1
KEY: Chemistry | general chemistry | phases | intermolecular forces
MSC: Conceptual

137. The measure of resistance to flow of a liquid is
A) van der Waals forces
B) vapor pressure
C) London forces
D) surface tension
E) viscosity

ANS: E PTS: 1 DIF: Easy REF: 10.2
KEY: Chemistry | general chemistry | phases | liquid | properties of liquids
MSC: Conceptual

138. Which of the following would be expected to have the lowest heat of vaporization?
A) H_2O
B) NH_3
C) PH_3
D) AsH_3
E) CH_4

ANS: E PTS: 1 DIF: Easy REF: 10.8
KEY: Chemistry | general chemistry | phases | liquid | intermolecular forces
MSC: Conceptual

139. Which of the following is indicative of the existence of strong intermolecular forces of attraction in a liquid?
A) a very low boiling point

B) a very low viscosity
C) a very low vapor pressure
D) a very low heat of vaporization
E) a very low freezing point

ANS: C PTS: 1 DIF: Easy REF: 10.8
KEY: Chemistry | general chemistry | phases | liquid | intermolecular forces
MSC: Conceptual

140. Which of the following intermolecular forces exist in all solid substances?
A) Dispersion forces
B) Dipole-dipole forces
C) Covalent bonding
D) Hydrogen bonding
E) Ion-induced dipole forces

ANS: A PTS: 1 DIF: Easy REF: 10.1
KEY: Chemistry | general chemistry | phases | intermolecular forces
MSC: Conceptual

141. Consider the compounds CH_3OH, CCl_4, and CH_3Br. For each compound, list the strongest intermolecular force that operates within a sample of that compound.
A) H-bonding is the strongest intermolecular force in CH_3OH, dispersion is the strongest intermolecular force in CCl_4, and dipole-dipole is the strongest intermolecular force in CH_3Br
B) Dispersion is the strongest intermolecular force in CH_3OH, dispersion is the strongest intermolecular force in CCl_4, and dispersion is the strongest intermolecular force in CH_3Br.
C) Ion-dipole is the strongest intermolecular force in CH_3OH, Ion-dipole is the strongest intermolecular force in CCl_4, and dipole-dipole is the strongest intermolecular force in CH_3Br.
D) Dipole-induced dipole is the strongest intermolecular force in CH_3OH, dispersion is the strongest intermolecular force in CCl_4, and dipole-dipole is the strongest intermolecular force in CH_3Br.
E) Ion-induced dipole is the strongest intermolecular force in CH_3OH, dispersion is the strongest intermolecular force in CCl_4, and H-bonding is the strongest intermolecular force in CH_3Br.

ANS: A PTS: 1 DIF: Easy REF: 10.1
KEY: Chemistry | general chemistry | phases | intermolecular forces
MSC: Conceptual

142. In a standard phase diagram that plots temperature versus pressure, which one of the following statements is TRUE?
A) Three phases coexist at equilibrium at any point along one of the lines that separate regions (areas) on the phase diagram.
B) Two phases coexist at equilibrium at the triple point on the phase diagram.
C) The gas-solid line ends at a critical point on the phase diagram, beyond which evaporation cannot occur.
D) The gas-liquid line ends at the critical point on the phase diagram, beyond which a

gas cannot be compressed to form a liquid.

E) In fact, all the above statements are false

ANS: D PTS: 1 DIF: Easy REF: 10.9
KEY: Chemistry | general chemistry | phases | phase transitions | phase diagram
MSC: Conceptual

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Chapter 11: Properties of Solutions

1. In a 0.1 molar solution of NaCl in water, which one of the following will be closest to 0.1?
   A) The mole fraction of NaCl.
   B) The mass fraction of NaCl.
   C) The mass percent of NaCl.
   D) The molality of NaCl.
   E) All of these are about 0.1.

   ANS: D PTS: 1 DIF: Easy REF: 11.1
   KEY: Chemistry | general chemistry | solutions | expressing concentration
   MSC: Conceptual

2. Which of the following concentration measures will change in value as the temperature of a solution changes?
   A) mass percent
   B) mole fraction
   C) molality
   D) molarity
   E) all of these

   ANS: D PTS: 1 DIF: Easy REF: 11.1
   KEY: Chemistry | general chemistry | solutions | expressing concentration
   MSC: Conceptual

3. For an acid-base reaction, 1 *M* $Al(OH)_3$ has a normality of 3 *N*. This is <u>best</u> explained because:
   A) The equivalent mass is three times the molar mass.
   B) Each mole contains 3 moles of hydroxide ions that can react with 3 moles of hydrated protons.
   C) The mole fraction is equal to 3 when aluminum hydroxide is mixed with water.
   D) The normality is *always* three times stronger than the concentration of a solution.
   E) At least two of the above statements are correct.

   ANS: B PTS: 1 DIF: Easy REF: 11.1
   KEY: Chemistry | general chemistry | solutions | expressing concentration
   MSC: Conceptual

4. How many milliliters of 15.7 *M* H_2SO_4 are needed to prepare 600.0 mL of 0.10 *M* H_2SO_4?
   A) 0.26 mL
   B) 94 mL
   C) 3.8 mL
   D) 1.9 mL
   E) 4.8 mL

   ANS: C PTS: 1 DIF: Easy REF: 11.1
   KEY: Chemistry | general chemistry | solutions | expressing concentration | molarity
   MSC: Quantitative

5. 1.68 L of an aqueous solution containing 25.00 g of KCl dissolved in pure water is prepared. The molarity of the solution is:
   A) 0.200 *M*
   B) 14.9 *M*
   C) 5.01 *M*
   D) 0.399 *M*
   E) 0.0998 *M*

   ANS: A PTS: 1 DIF: Easy REF: 11.1
   KEY: Chemistry | general chemistry | solutions | expressing concentration | molarity
   MSC: Quantitative

6. What volume of a 0.771 *M* solution of $CaCl_2$ contains 1.28 g of solute?
   A) 66.8 mL
   B) 15.0 mL
   C) 1.66 mL
   D) 8.89 mL
   E) 85.0 mL

   ANS: B PTS: 1 DIF: Easy REF: 11.1
   KEY: Chemistry | general chemistry | solutions | expressing concentration | molarity
   MSC: Quantitative

7. Determine the molarity of a solution containing 6.76 g $BaCl_2$ in 750.0 mL of solution.
   A) $3.25 \times 10^{-2}\ M$
   B) $2.44 \times 10^{-2}\ M$
   C) $9.01 \times 10^{-3}\ M$
   D) $4.33 \times 10^{-2}\ M$
   E) 9.01 *M*

   ANS: D PTS: 1 DIF: Easy REF: 11.1
   KEY: Chemistry | general chemistry | solutions | expressing concentration | molarity
   MSC: Quantitative

8. A solution containing 306.5 g of $Mg(NO_3)_2$ per liter has a density of 1.114 g/mL. The molarity of the solution is:
   A) 2.066 *M*
   B) 1.855 *M*
   C) 6.199 *M*
   D) 2.302 *M*
   E) none of these

   ANS: A PTS: 1 DIF: Easy REF: 11.1
   KEY: Chemistry | general chemistry | solutions | expressing concentration | molarity
   MSC: Quantitative

9. Calculate the molality of C_2H_5OH in a water solution that is prepared by mixing 50.0 mL of C_2H_5OH with 112.7 mL of H_2O at 20°C. The density of the C_2H_5OH is 0.789 g/mL at 20°C. (Assume the density of water at this temperature is 1.00 g/mL.)
   A) 0.00963 *m*

B) 0.155 *m*
C) 0.132 *m*
D) 7.60 *m*
E) 9.63 *m*

ANS: D PTS: 1 DIF: Easy REF: 11.1
KEY: Chemistry | general chemistry | solutions | expressing concentration | molarity
MSC: Quantitative

10. What is the molality of a solution of 30.1 g of propanol ($CH_3CH_2CH_2OH$) in 152 mL water, if the density of water is 1.00 g/mL?
A) 3.29 *m*
B) 0.00330 *m*
C) 0.303 *m*
D) 0.501 *m*
E) 5.01 *m*

ANS: A PTS: 1 DIF: Easy REF: 11.1
KEY: Chemistry | general chemistry | solutions | expressing concentration | molarity
MSC: Quantitative

11. A solution containing 292 g of $Mg(NO_3)_2$ per liter has a density of 1.108 g/mL. The molality of the solution is:
A) 2.00 *m*
B) 2.41 *m*
C) 1.77 *m*
D) 6.39 *m*
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 11.1
KEY: Chemistry | general chemistry | solutions | expressing concentration | molarity
MSC: Quantitative

12. A 3.140 molal solution of NaCl is prepared. How many grams of NaCl are present in a sample containing 2.314 kg of water?
A) 726.6 g
B) 124.3 g
C) 257.6 g
D) 424.6 g
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 11.1
KEY: Chemistry | general chemistry | solutions | expressing concentration | molarity
MSC: Quantitative

13. How many molecules of sucrose (table sugar), $C_{12}H_{22}O_{11}$, dissolved in 450.0 g of water are needed to make a 1.81 *m* solution?
A) 4.90×10^{23} molecules
B) 8.15×10^{23} molecules
C) 2.42×10^{24} molecules

D) 2.72×10^{25} molecules
E) 1.50×10^{23} molecules

ANS: A PTS: 1 DIF: Easy REF: 11.1
KEY: Chemistry | general chemistry | solutions | expressing concentration | molarity
MSC: Quantitative

14. A 20.0-g sample of methyl alcohol (CH_3OH, molar mass = 32.04 g/mol) was dissolved in 43.3 g of water. The mole fraction of CH_3OH is:
A) 0.260
B) 0.624
C) 0.316
D) 4.85
E) 0.206

ANS: E PTS: 1 DIF: Easy REF: 11.1
KEY: Chemistry | general chemistry | solutions | expressing concentration | mole fraction
MSC: Quantitative

15. What is the mole percent of ethanol (C_2H_5OH), which consists of 71.0 g of ethanol for every 16.7 g of water present?
A) 62.4%
B) 1.66%
C) 9.23%
D) 81.0%
E) 37.6%

ANS: A PTS: 1 DIF: Moderate REF: 11.1
KEY: Chemistry | general chemistry | solutions | expressing concentration | mole fraction
MSC: Quantitative

16. If 2.00 g of helium gas and 3.82 g of oxygen gas are mixed together, what is the mole fraction of helium in the solution?
A) 0.344
B) 0.193
C) 0.807
D) 0.119
E) 1.24

ANS: C PTS: 1 DIF: Easy REF: 11.1
KEY: Chemistry | general chemistry | solutions | expressing concentration | mole fraction
MSC: Quantitative

17. Calculate the mole fraction of NaCl in a solution prepared by dissolving 117 g NaCl in 1.15 kg H_2O.
A) 9.90×10^{-1}
B) 1.11×10^{-2}
C) 6.08×10^{-2}
D) 1.52×10^{-2}
E) 3.04×10^{-2}

ANS: E PTS: 1 DIF: Easy REF: 11.1
KEY: Chemistry | general chemistry | solutions | expressing concentration | mole fraction
MSC: Quantitative

18. Find the mass percent of $CuSO_4$ in a solution whose density is 1.30 g/mL and whose molarity is 1.36 *M*.
A) 83.3%
B) 1.77%
C) 16.7%
D) 2.66%
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 11.1
KEY: Chemistry | general chemistry | solutions | expressing concentration | mass percentage of solute MSC: Quantitative

19. Find the mass percent of $CaCl_2$ in a solution whose molarity is 2.20 *M* and whose density is 1.18 g/mL.
A) 20.7%
B) 26.1%
C) 79.3%
D) 24.4%
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 11.1
KEY: Chemistry | general chemistry | solutions | expressing concentration | mass percentage of solute MSC: Quantitative

20. A solution of hydrogen peroxide is 23.6% H_2O_2 by mass and has a density of 1.11 g/cm^3. The molarity of the solution is:
A) 7.23 *M*
B) 0.262 *M*
C) 7.70 *M*
D) 8.03 *M*
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 11.1
KEY: Chemistry | general chemistry | solutions | expressing concentration | conversion of concentration units MSC: Quantitative

21. The term "proof" is defined as twice the percent by volume of pure ethanol in solution. Thus, a solution that is 95% (by volume) ethanol is 190 proof. What is the molarity of ethanol in a 92 proof ethanol/water solution?
density of ethanol = 0.80 g/cm^3
density of water = 1.0 g/cm^3
mol. wt. of ethanol = 46 g/mol

A) 0.46 *M*
B) 0.80 *M*
C) 0.92 *M*

D) 8.0 *M*
E) 17 *M*

ANS: D PTS: 1 DIF: Moderate REF: 11.1
KEY: Chemistry | general chemistry | solutions | expressing concentration | conversion of concentration units MSC: Quantitative

22. Calculate the molarity of a solution of magnesium chloride with a concentration of 26.8 mg/mL.
A) 0.563 *M*
B) 0.281 *M*
C) 0.141 *M*
D) 3.55 *M*
E) 0.448 *M*

ANS: B PTS: 1 DIF: Easy REF: 11.1
KEY: Chemistry | general chemistry | solutions | expressing concentration | conversion of concentration units MSC: Quantitative

23. What is the molarity of a HNO_3 solution prepared by adding 255.4 mL of water to 350.0 mL of 12.3 *M* HNO_3?
A) 16.9 *M*
B) 7.45 *M*
C) 7.11 *M*
D) 2.61 *M*
E) 3.14 *M*

ANS: C PTS: 1 DIF: Easy REF: 11.1
KEY: Chemistry | general chemistry | solutions | expressing concentration | dilution calculation MSC: Quantitative

24. When 0.811 g of NH_4NO_3 was added to 150.0 g of water in a Styrofoam cup, the temperature dropped by 0.413°C. The heat capacity of H_2O is 4.18 J/g°C. Assume the specific heat of the solution equals that of pure H_2O and that the calorimeter neither absorbs nor leaks heat. The molar heat of solution of solid NH_4NO_3 is:
A) +257 J/mol
B) +25.7 kJ/mol
C) +2.57 kJ/mol
D) –2.57 kJ/mol
E) –257 J/mol

ANS: B PTS: 1 DIF: Moderate REF: 11.2
KEY: Chemistry | general chemistry | solutions | solution formation
MSC: Quantitative

25. Which of the following chemical or physical changes is an endothermic process?
A) the evaporation of water
B) the combustion of gasoline
C) the mixing of sulfuric acid and water
D) the freezing of water
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 11.2
KEY: Chemistry | general chemistry | solutions | solution formation
MSC: Conceptual

26. How many of the following help determine whether or not a solution forms?
    I. the polarities of the solute and solvent
    II. the densities of the solute and solvent
    III. the probability of the mixed state (of the solution)
    IV. the energies needed for the solution formation to occur
    V. the state of matter of the solute (solid, liquid, gas)

    A) 1
    B) 2
    C) 3
    D) 4
    E) 5

    ANS: C PTS: 1 DIF: Easy REF: 11.2
    KEY: Chemistry | general chemistry | solutions | solution formation
    MSC: Conceptual

27. Rank the following compounds according to increasing solubility in water.
    I. $CH_3–CH_2–CH_2–CH_3$
    II. $CH_3–CH_2–O–CH_2–CH_3$
    III. $CH_3–CH_2–OH$
    IV. $CH_3–OH$

    A) I < III < IV < II
    B) I < II < IV < III
    C) III < IV < II < I
    D) I < II < III < IV
    E) None of these (A-D) is correct.

    ANS: D PTS: 1 DIF: Easy REF: 11.2
    KEY: Chemistry | general chemistry | solutions | solution formation | solubility
    MSC: Conceptual

28. Which statement about hydrogen bonding is true?
    A) Hydrogen bonding is the intermolecular attractive forces between two hydrogen atoms in solution.
    B) The hydrogen bonding capabilities of water molecules cause $CH_3CH_2CH_2CH_3$ to be more soluble in water than CH_3OH.
    C) Hydrogen bonding of solvent molecules with a solute will not affect the solubility of the solute.
    D) Hydrogen bonding interactions between molecules are stronger than the covalent bonds within the molecule.
    E) Hydrogen bonding arises from the dipole moment created by the unequal sharing of electrons within certain covalent bonds within a molecule.

    ANS: E PTS: 1 DIF: Easy REF: 11.3

KEY: Chemistry | general chemistry | solutions | solution formation | solubility
MSC: Conceptual

29. Which of the following favors the solubility of an ionic solid in a liquid solvent?
A) a large magnitude of the solvation energy of the ions
B) a small magnitude of the lattice energy of the solute
C) a large polarity of the solvent
D) all of the above
E) none of the above

ANS: D PTS: 1 DIF: Easy REF: 11.2
KEY: Chemistry | general chemistry | solutions | solution formation | solubility | ionic solution MSC: Conceptual

30. Solid KF has a lattice energy of 804 kJ/mol and a heat of solution (in water) of –15 kJ/mol. RbF has a lattice energy of 768 kJ/mol and a heat of solution (in water) of –24 kJ/mol. Which salt forms stronger attractions with water?
A) KF, since it has a larger lattice energy.
B) RbF, since it has a smaller lattice energy.
C) KF, since it has a more negative heat of hydration.
D) RbF, since it has a more negative heat of hydration
E) They form equally strong attractions with water, since they both have negative heats of mixing.

ANS: D PTS: 1 DIF: Easy REF: 11.2
KEY: Chemistry | general chemistry | solutions | solution formation | solubility | ionic solution MSC: Conceptual

31. The lattice energy of KF is 808 kJ/mol and its heat of solution is –17.7 kJ/mol. Calculate the hydration of energy of KF(*s*).
A) –35.4 kJ/mol
B) –790.3 kJ/mol
C) –825.7 kJ/mol
D) 790.3 kJ/mol
E) 825.7 kJ/mol

ANS: C PTS: 1 DIF: Easy REF: 11.2
KEY: Chemistry | general chemistry | solutions | solution formation | solubility | ionic solution MSC: Quantitative

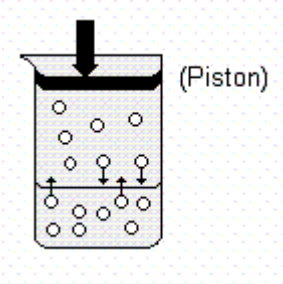
32. When a substance dissolves in water, heat energy is released if:
A) The lattice energy is positive.
B) The hydration energy is positive.
C) The hydration energy is more negative than the lattice energy is positive.
D) The hydration energy is negative.
E) None of these (A-D).

ANS: C PTS: 1 DIF: Easy REF: 11.2
KEY: Chemistry | general chemistry | solutions | solution formation | solubility | ionic solution MSC: Conceptual

33. We can predict the solubility of a compound by looking at the sign of the enthalpy of solution.

ANS: F PTS: 1 DIF: Easy REF: 11.2
KEY: Chemistry | general chemistry | solutions | solution formation
MSC: Conceptual

34. Use the following drawing of a gaseous solute in equilibrium with a solution to help answer the question below.



Which of the following statements are true when the piston is pushed in (downward)?
A) This will cause the pressure of the gas to increase and the concentration of the dissolved gas to go down.
B) This will cause the pressure of the gas to decrease and the concentration of the dissolved gas to go down.
C) This will cause the pressure of the gas to increase and the concentration of the dissolved gas to go up.
D) This will cause the volume of the gas to decrease and the concentration of the dissolved gas to go down.
E) This will cause the volume of the gas to increase and the concentration of the dissolved gas to go up.

ANS: C PTS: 1 DIF: Easy REF: 11.3
KEY: Chemistry | general chemistry | solutions | solution formation | effect of temperature and pressure on solubility MSC: Conceptual

35. Which of the following correctly states the relationship between temperature and the solubility of a substance in water?
A) The solubility of a substance in water increases as the temperature rises, especially for gases.
B) The solubility of a substance in water decreases as the temperature rises, especially for ionic solids.
C) The solubility of a substance in water with temperature cannot be accurately predicted, especially for ionic solids.
D) The solubility of a substance in water decreases as the temperature lowers, especially for gases.
E) Both A and D are correct.

ANS: C PTS: 1 DIF: Easy REF: 11.3
KEY: Chemistry | general chemistry | solutions | solution formation | effect of temperature and pressure on solubility MSC: Conceptual

36. When solid $Ca(CH_3COO)_2$ is dissolved in a nearly saturated solution of $Ca(CH_3COO)_2$, the solution becomes warmer. This information indicates that if the temperature of a solution is decreased:
A) ΔH will become negative.
B) ΔH will become zero.
C) The solubility of $Ca(CH_3COO)_2$ will decrease.
D) The solubility of $Ca(CH_3COO)_2$ will increase.
E) The solubility of $Ca(CH_3COO)_2$ will not change.

ANS: D PTS: 1 DIF: Easy REF: 11.3
KEY: Chemistry | general chemistry | solutions | solution formation | effect of temperature and pressure on solubility MSC: Conceptual

37. A correct statement of Henry's law is:
A) The concentration of a gas in solution is inversely proportional to temperature.
B) The concentration of a gas in solution is directly proportional to the mole fraction of solvent.
C) The concentration of a gas in solution is independent of pressure.
D) The concentration of a gas in a solution is inversely proportional to pressure.
E) None of these.

ANS: E PTS: 1 DIF: Easy REF: 11.3
KEY: Chemistry | general chemistry | solutions | solution formation | effect of temperature and pressure on solubility | Henry's law MSC: Conceptual

38. The solubility of O_2 in water is 0.590 g/L at an oxygen pressure of around 14.5 atm. What is the Henry's law constant for O_2 (in units of mol/L·atm)?
A) 4.07×10^{-2}
B) 1.27×10^{-3}
C) 7.86×10^{2}
D) 2.67×10^{-1}
E) None of the above are within 5% of the correct answer.

ANS: B PTS: 1 DIF: Easy REF: 11.3
KEY: Chemistry | general chemistry | solutions | solution formation | effect of temperature and pressure on solubility | Henry's law MSC: Quantitative

39. What partial pressure of nitrogen gas is required in order for 0.00134 g of the gas to dissolve in 13.1 mL of pure water? The Henry's law constant for nitrogen gas is 6.1×10^{-4} M atm^{-1}.
A) 6.2×10^{-8} atm
B) 1.7×10^{-1} atm
C) 6.0×10^{0} atm
D) 2.9×10^{-8} atm
E) 1.7×10^{-2} atm

ANS: C PTS: 1 DIF: Easy REF: 11.3
KEY: Chemistry | general chemistry | solutions | solution formation | effect of temperature and pressure on solubility | Henry's law MSC: Quantitative

40. The solubility of a gas usually increases with increasing temperature.

ANS: F PTS: 1 DIF: Easy REF: 11.3
KEY: Chemistry | general chemistry | solutions | solution formation | effect of temperature and pressure on solubility MSC: Conceptual

41. The vapor pressure of water at 25.0°C is 23.8 torr. Determine the mass of glucose (molar mass = 180 g/mol) needed to add to 500.0 g of water to change the vapor pressure to 22.8 torr.
A) 21.9 g
B) 219 g
C) 180 g
D) 6.21 kg
E) 188 g

ANS: B PTS: 1 DIF: Difficult REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | vapor pressure lowering MSC: Quantitative

42. A solution is prepared from 53.8 g of a nonvolatile, nondissociating solute and 85.0 g of water. The vapor pressure of the solution at 60°C is 132 torr. The vapor pressure of water at 60°C is 150. torr. What is the molar mass of the solute?
A) 61.1 g/mol
B) 11.4 g/mol
C) 34.6 g/mol
D) 186 g/mol
E) 83.6 g/mol

ANS: E PTS: 1 DIF: Difficult REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | vapor pressure lowering MSC: Quantitative

43. An ideal solution is formed from a mixture of the nonvolatile solute urea, $CO(NH_2)_2$, and methanol, CH_3OH. The vapor pressure of pure methanol at 20°C is 89 mmHg. If 4.4 g of urea is mixed with 39.9 g of methanol, calculate the vapor pressure of the methanol solution.
A) 4.9 mmHg
B) 80 mmHg
C) 74 mmHg
D) 15 mmHg
E) 84 mmHg

ANS: E PTS: 1 DIF: Easy REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | vapor pressure lowering MSC: Quantitative

44. A salt solution sits in an open beaker. Assuming constant temperature and pressure, the vapor pressure of the solution
A) increases over time
B) decreases over time
C) stays the same over time
D) need to know which salt is in the solution to answer this

E) need to know the temperature and pressure to answer this

ANS: B PTS: 1 DIF: Easy REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution MSC: Conceptual

For each of the following solutions, describe the deviation with respect to Raoult's Law.

45. hexane (C_6H_{14}) and chloroform ($CHCl_3$)
A) relatively ideal
B) positive deviation
C) negative deviation
D) more information needed
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | Raoult's law MSC: Conceptual

46. acetone (C_3H_6O) and water
A) relatively ideal
B) positive deviation
C) negative deviation
D) more information needed
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 11.4
KEY: Chemistry | general chemistry | solubility | colligative properties | vapor pressure of a solution | Raoult's law MSC: Conceptual

47. hexane (C_6H_{14}) and octane (C_8H_{18})
A) relatively ideal
B) positive deviation
C) negative deviation
D) more information needed
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | Raoult's law MSC: Conceptual

48. At a given temperature, you have a mixture of benzene (vapor pressure of pure benzene = 745 torr) and toluene (vapor pressure of pure toluene = 290. torr). The mole fraction of benzene in the solution is 0.590. Assuming ideal behavior, calculate the mole fraction of toluene in the vapor above the solution.
A) 0.213
B) 0.778
C) 0.641
D) 0.359
E) 0.590

ANS: A PTS: 1 DIF: Moderate REF: 11.4
KEY: Chemistry | general chemistry | solubility | colligative properties | vapor pressure of a solution | Raoult's law MSC: Quantitative

49. At a given temperature, you have a mixture of benzene (vapor pressure of pure benzene = 745 torr) and toluene (vapor pressure of pure toluene = 290 torr). The mole fraction of benzene *in the vapor* above the solution is 0.590. Assuming ideal behavior, calculate the mole fraction of toluene *in the solution*.
A) 0.213
B) 0.778
C) 0.641
D) 0.359
E) 0.590

ANS: C PTS: 1 DIF: Difficult REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | Raoult's law MSC: Quantitative

50. At 40°C, heptane has a vapor pressure of about 92.2 torr and octane has a vapor pressure of about 31.2 torr. Assuming ideal behavior, what is the vapor pressure of a solution that contains twice as many moles of heptane as octane?
A) 61.5 torr
B) 51.5 torr
C) 71.9 torr
D) 82.3 torr
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | Raoult's law MSC: Quantitative

51. A solution contains 1 mole of liquid A and 3 moles of liquid B. This solution has a vapor pressure of 314 torr at 25°C. At 25°C, liquid A has a vapor pressure of 265 torr and liquid B has a vapor pressure of 355 torr. Which of the following is true?
A) This solution exhibits a positive deviation from Raoult's Law.
B) This solution exhibits a negative deviation from Raoult's Law.
C) This solution is ideal.
D) More information is needed to answer this question.
E) None of these (A-D).

ANS: B PTS: 1 DIF: Easy REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | Raoult's law MSC: Conceptual

52.

	Vapor pressure at 25°C
benzene (C_6H_6)	94.4 torr
chloroform ($CHCl_3$)	172.0 torr

Using the above data, calculate the vapor pressure of chloroform over a chloroform-benzene solution at 25°C, which contains 43.3 g $CHCl_3$ and 43.3 g C_6H_6. Assume the solution behaves ideally.

A) 68.0 torr
B) 37.3 torr
C) 104 torr
D) 86.0 torr
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | Raoult's law MSC: Quantitative

Solutions of benzene and toluene obey Raoult's law. The vapor pressures at 20°C are: benzene, 76 torr; toluene, 21 torr.

53. What is the mole fraction of benzene in a benzene-toluene solution whose vapor pressure is 51 torr at 20°C?

A) 0.26
B) 0.45
C) 0.55
D) 0.67
E) 0.74

ANS: C PTS: 1 DIF: Easy REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | Raoult's law MSC: Quantitative

54. If the mole fraction of benzene in a particular benzene-toluene solution is 0.64, what is the mole fraction of benzene in the vapor phase in equilibrium with that solution?

A) 0.24
B) 0.50
C) 0.64
D) 0.78
E) 0.87

ANS: E PTS: 1 DIF: Moderate REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | Raoult's law MSC: Quantitative

55. A benzene-toluene solution is allowed to come to equilibrium with its vapor. The vapor is then condensed and found to contain 50.0 mole percent of each component. Calculate the composition (mole percent) of the original solution. The vapor pressures of pure benzene and toluene at this temperature are: 750. torr and 300. torr, respectively.

A) 50.2% benzene
B) 28.6% benzene
C) 71.0% benzene
D) 40.0% benzene
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 11.4

KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | Raoult's law MSC: Quantitative

56. A solution is made by adding 0.100 mole of ethyl ether to 0.491 mole of ethyl alcohol. If the vapor pressure of ethyl ether and ethyl alcohol at 20°C are 375 torr and 20.0 torr, respectively, the vapor pressure of the solution at 20°C (assuming ideal behavior) is:
A) 80.1 torr
B) 315 torr
C) 46.8 torr
D) 395 torr
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | Raoult's law MSC: Quantitative

57. A solution of two liquids, A and B, shows negative deviation from Raoult's law. This means that:
A) The molecules of A interact strongly with other A-type molecules.
B) The two liquids have a positive heat of solution.
C) Molecules of A interact weakly, if at all, with B molecules.
D) The molecules of A hinder the strong interaction between B molecules.
E) Molecules of A interact more strongly with B than A with A, or B with B.

ANS: E PTS: 1 DIF: Easy REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | Raoult's law MSC: Conceptual

58. Benzene and toluene form an ideal solution. At 298 K, what is the mole fraction of benzene in the liquid that is in equilibrium with a vapor that has equal partial pressures of benzene and toluene? At 298 K, the vapor pressures of pure benzene and pure toluene are 95 and 28 torr, respectively.
A) 0.50
B) 0.77
C) 0.23
D) 0.30
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | Raoult's law MSC: Quantitative

59. A solution of CH_3OH in H_2O would most likely
A) be ideal
B) show positive deviations from Raoult's law
C) show negative deviations from Raoult's law
D) not be ideal, but the deviations cannot be predicted
E) obey Raoult's law

ANS: C PTS: 1 DIF: Easy REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a

solution | Raoult's law MSC: Conceptual

60. A liquid-liquid solution is called an ideal solution if:
I. It obeys $PV = nRT$.
II. It obeys Raoult's law.
III. Solute-solute, solvent-solvent, and solute-solvent interactions are very similar.
IV. Solute-solute, solvent-solvent, and solute-solvent interactions are quite different.

A) I, II, III
B) I, II, IV
C) II, III
D) II, IV
E) I, III, IV

ANS: C PTS: 1 DIF: Easy REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | Raoult's law MSC: Conceptual

61. Liquid A and liquid B form a solution that behaves ideally according to Raoult's law. The vapor pressures of the pure substances A and B are 233 torr and 135 torr, respectively. Determine the vapor pressure over the solution if 1.21 moles of liquid A is added to 5.30 moles of liquid B.
A) 153 torr
B) 188 torr
C) 215 torr
D) 760 torr
E) 43.3 torr

ANS: A PTS: 1 DIF: Moderate REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | Raoult's law MSC: Quantitative

62. Two liquids form a solution and release a quantity of heat. How does the pressure above the solution compare to that predicted by Raoult's law?
A) It will be greater.
B) It will be less.
C) It will be the same.
D) It will show positive deviation.
E) None of these.

ANS: B PTS: 1 DIF: Moderate REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | Raoult's law MSC: Conceptual

63. Consider a solution containing liquids A and B where the mole fraction of B is 0.60. Assuming ideality, calculate the mole fraction of A in the vapor at equilibrium with this solution at 25°C. (The vapor pressures of pure liquid A and B at 25°C are 117.7 torr and 400.0 torr, respectively.)
A) 0.16

B) 196
C) 0.31
D) 3.40×10^{-3}
E) 4.90×10^{-3}

ANS: A PTS: 1 DIF: Moderate REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | Raoult's law MSC: Quantitative

64. Consider a solution containing liquids A and B where the mole fraction of B is 0.60. Assuming ideality, calculate the mole fraction of B in the vapor at equilibrium with this solution at 25°C. (The vapor pressures of pure liquid A and B at 25°C are 129.4 torr and 400.0 torr, respectively.)
A) 0.18
B) 0.22
C) 0.33
D) 0.78
E) 0.82

ANS: E PTS: 1 DIF: Moderate REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | Raoult's law MSC: Quantitative

65. A solution with a positive enthalpy of solution (ΔH_{soln}) is expected to show positive deviations from Raoult's law.

ANS: T PTS: 1 DIF: Easy REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | Raoult's law MSC: Conceptual

66. Determine the mass of a nonvolatile, nonionizing compound that must be added to 3.83 kg of water to lower the freezing point to 98.70°C. The molar mass of the compound is 50.0 g/mol and the K_f for water is 1.86°C kg/mol.
A) 203 g
B) 134 g
C) 463 g
D) 9.12 g
E) 18.7 g

ANS: B PTS: 1 DIF: Moderate REF: 11.5
KEY: Chemistry | general chemistry | solutions | colligative properties | freezing point depression MSC: Quantitative

67. The freezing point (T_f) for t-butanol is 25.50°C and K_f is 9.1°C/*m*. Usually t-butanol absorbs water on exposure to the air. If the freezing point of a 12.9-g sample of t-butanol is measured as 24.59°C, how many grams of water are present in the sample?
A) 0.10 g
B) 0.023 g
C) 10. g
D) 2.3 g

E) 23 g

ANS: B PTS: 1 DIF: Moderate REF: 11.5
KEY: Chemistry | general chemistry | solutions | colligative properties | freezing point depression MSC: Quantitative

68. The molar mass of a solid as determined by freezing point depression is 10% higher than the true molar mass. Which of the following experimental errors could not account for this discrepancy?
A) Not all the solid was dissolved.
B) More than the recorded amount of solvent was pipetted into the solution.
C) The solid dissociated slightly into two particles when it dissolved.
D) Some solid was left on the weighing paper.
E) Before the solution was prepared, the container was rinsed with solvent and not dried.

ANS: C PTS: 1 DIF: Moderate REF: 11.5
KEY: Chemistry | general chemistry | solutions | colligative properties | freezing point depression MSC: Conceptual

69. A solution consisting of 0.250 mol of methylbenzene, $C_6H_5CH_3$, in 244 g of nitrobenzene, $C_6H_5NO_2$, freezes at –1.2°C. Pure nitrobenzene freezes at 6.0°C. What is the freezing-point depression constant of nitrobenzene?
A) 4.8°C/*m*
B) 3.5°C/*m*
C) 29°C/*m*
D) 7.0°C/*m*
E) 14°C/*m*

ANS: D PTS: 1 DIF: Moderate REF: 11.5
KEY: Chemistry | general chemistry | solutions | colligative properties | freezing point depression MSC: Quantitative

70. A 6.06-gram sample of a compound is dissolved in 250. grams of benzene. The freezing point of this solution is 1.02°C below that of pure benzene. What is the molar mass of this compound? (Note: K_f for benzene = 5.12°C/m.) Ignore significant figures for this problem.
A) 30.4 g/mol
B) 122 g/mol
C) 243 g/mol
D) 4.83 g/mol
E) 60.8 g/mol

ANS: B PTS: 1 DIF: Moderate REF: 11.5
KEY: Chemistry | general chemistry | solutions | colligative properties | freezing point depression MSC: Quantitative

71. Thyroxine, an important hormone that controls the rate of metabolism in the body, can be isolated from the thyroid gland. If 0.455 g of thyroxine is dissolved in 10.0 g of benzene, the freezing point of the solution could be measured as 5.144°C. Pure benzene freezes at 5.444°C and has a value for the molal freezing point depression constant of K_f of 5.12°C/m. What is the approximate molar mass of thyroxine?

A) 7.77×10^5 g/mol
B) 777 g/mol
C) 7.77 g/mol
D) 11.3 g/mol
E) 42.8 g/mol

ANS: B PTS: 1 DIF: Moderate REF: 11.5
KEY: Chemistry | general chemistry | solutions | colligative properties | freezing point depression MSC: Quantitative

72. When a 49.1-g sample of an unknown compound is dissolved in 500.g of benzene, the freezing point of the resulting solution is 3.77°C. The freezing point of pure benzene is 5.48°C and K_f for benzene is 5.12°C/m. Calculate the molar mass of the unknown compound.
A) 147 g/mol
B) 28.7 g/mol
C) 251 g/mol
D) 588 g/mol
E) 294 g/mol

ANS: E PTS: 1 DIF: Moderate REF: 11.5
KEY: Chemistry | general chemistry | solutions | colligative properties | freezing point depression MSC: Quantitative

73. To calculate the freezing point of an ideal dilute solution of a single, nondissociating solute of a solvent, the minimum information one must know is:
A) the molality (of the solute)
B) the molality (of the solute) and the freezing point depression constant of the solvent
C) the same quantities as in B, plus the freezing point of the pure solvent
D) all of the quantities in C, plus the molecular weight of the solute
E) all of the quantities in C, plus the weight of the solvent

ANS: C PTS: 1 DIF: Easy REF: 11.5
KEY: Chemistry | general chemistry | solutions | colligative properties | freezing point depression MSC: Conceptual

74. Which of the following will cause the calculated molar mass of a compound determined by the freezing-point depression method to be greater than the true molar mass?
A) Water gets into the solvent after the freezing point of the pure solvent is determined.
B) Some of the solute molecules break apart.
C) The mass of solvent is smaller than determined from the weighing.
D) While adding the solute, some was spilled on the lab bench.
E) All of the above.

ANS: D PTS: 1 DIF: Moderate REF: 11.5
KEY: Chemistry | general chemistry | solutions | colligative properties | freezing point depression MSC: Conceptual

75. Determine the change in boiling point for 397.7 g of carbon disulfide (K_b = 2.34°C kg/mol) if 35.0 g of a nonvolatile, nonionizing compound is dissolved in it. The molar mass of the compound is 70.0 g/mol and the boiling point of the pure carbon disulfide is 46.2°C.
A) 0.206 °C
B) 1.86 °C
C) 5.88 °C
D) 24.8 °C
E) 2.94 °C

ANS: E PTS: 1 DIF: Easy REF: 11.5
KEY: Chemistry | general chemistry | solutions | colligative properties | boiling point elevation MSC: Quantitative

76. What is the boiling point change for a solution containing 0.736 moles of naphthalene (a nonvolatile, nonionizing compound) in 250. g of liquid benzene? (K_b = 2.53°C/m for benzene)
A) 7.45 °C
B) 0.859 °C
C) 3.44 °C
D) 1.86 °C
E) 0.466 °C

ANS: A PTS: 1 DIF: Easy REF: 11.5
KEY: Chemistry | general chemistry | solutions | colligative properties | boiling point elevation MSC: Quantitative

77. A solute added to a solvent raises the boiling point of the solution because:
A) The temperature to cause boiling must be great enough to boil not only the solvent but also the solute.
B) The solute particles lower the solvent's vapor pressure, thus requiring a higher temperature to cause boiling.
C) The solute particles raise the solvent's vapor pressure, thus requiring a higher temperature to cause boiling.
D) The solute increases the volume of the solution, and an increase in volume requires an increase in the temperature to reach the boiling point (derived from $PV = nRT$).
E) Two of the above are correct.

ANS: B PTS: 1 DIF: Easy REF: 11.5
KEY: Chemistry | general chemistry | solutions | colligative properties | boiling point elevation MSC: Conceptual

78. Adding salt to water decreases the freezing point of the water since it lowers the vapor pressure of the ice.

ANS: F PTS: 1 DIF: Easy REF: 11.5
KEY: Chemistry | general chemistry | solutions | colligative properties | freezing point depression MSC: Conceptual

79. When a nonvolatile solute is added to a volatile solvent, the solution vapor pressure _____, the boiling point _____, the freezing point _____, and the osmotic pressure across a semipermeable membrane _____.
A) decreases, increases, decreases, decreases
B) increases, increases, decreases, increases
C) increases, decreases, increases, decreases
D) decreases, decreases, increases, decreases
E) decreases, increases, decreases, increases

ANS: E PTS: 1 DIF: Easy REF: 11.6
KEY: Chemistry | general chemistry | solutions | colligative properties
MSC: Conceptual

80. All of the following are colligative properties except:
A) osmotic pressure
B) boiling point elevation
C) freezing point depression
D) density elevation
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 11.6
KEY: Chemistry | general chemistry | solutions | colligative properties
MSC: Conceptual

81. A cucumber is placed in a concentrated salt solution. What will most likely happen?
A) Water will flow from the cucumber to the solution.
B) Water will flow from the solution to the cucumber.
C) Salt will flow into the cucumber.
D) Salt will precipitate out.
E) No change will occur.

ANS: A PTS: 1 DIF: Easy REF: 11.6
KEY: Chemistry | general chemistry | solutions | colligative properties | osmotic pressure
MSC: Conceptual

82. Polyethylene is a synthetic polymer or plastic with many uses. 1.36 g of a polyethylene sample was dissolved in enough benzene to make 100. mL of solution, and the osmotic pressure was found to be 1.86 torr at 25°C. What is the approximate molar mass of the polyethylene?
A) 179 g/mol
B) 1.14×10^4 g/mol
C) 7.35×10^3 g/mol
D) 1.24×10^5 g/mol
E) 1.36×10^5 g/mol

ANS: E PTS: 1 DIF: Easy REF: 11.6
KEY: Chemistry | general chemistry | solutions | colligative properties | osmotic pressure
MSC: Quantitative

83. A 0.2 molar solution of a solute, X, in benzene, displays an osmotic pressure given by the formula $\pi = (0.1)RT$. Which of the following is most likely to be the case?
A) X exists in benzene as X.
B) X exists in benzene as X_2.
C) X exists in benzene dissociated into two particles.
D) This solution strongly deviates from ideal behavior.
E) None of these is plausible.

ANS: B PTS: 1 DIF: Moderate REF: 11.6
KEY: Chemistry | general chemistry | solutions | colligative properties | osmotic pressure
MSC: Conceptual

84. Osmotic pressure depends on all but which of the following?
A) atmospheric pressure
B) the molarity of the solution
C) temperature
D) the ratio of moles of solute to solution volume
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 11.6
KEY: Chemistry | general chemistry | solutions | colligative properties | osmotic pressure
MSC: Conceptual

85. A solution of water and a nonvolatile, nonionizing compound is placed in a tube with a semipermeable membrane on one side. The tube is placed in a beaker of pure water. What initial net effect will occur?
A) Water will flow from the beaker to the tube.
B) Water will flow from the tube to the beaker.
C) The compound will pass through the membrane into the solution.
D) Nothing will move through the membrane either way.
E) Equilibrium is immediately established.

ANS: A PTS: 1 DIF: Easy REF: 11.6
KEY: Chemistry | general chemistry | solutions | colligative properties | osmotic pressure
MSC: Conceptual

86. Determine the osmotic pressure of a solution that contains 0.048 g of a hydrocarbon solute (molar mass = 340 g/mol) dissolved in benzene to make a 350-mL solution. The temperature is 20.0°C.
A) 0.50 torr
B) 2.5 torr
C) 3.3 torr
D) 7.4 torr
E) 6.9 torr

ANS: D PTS: 1 DIF: Easy REF: 11.6
KEY: Chemistry | general chemistry | solutions | colligative properties | osmotic pressure
MSC: Quantitative

87. Consider pure water separated from an aqueous sugar solution by a semipermeable membrane, which allows water to pass freely but not sugar. After some time has passed, the concentration of sugar solution:
A) will have increased
B) will have decreased
C) will not have changed
D) might have increased or decreased depending on other factors
E) will be the same on both sides of the membrane

ANS: B PTS: 1 DIF: Easy REF: 11.6
KEY: Chemistry | general chemistry | solutions | colligative properties | osmotic pressure
MSC: Conceptual

88. In osmosis:
A) Knowing the osmotic pressure can help determine the molar mass of a solute dissolved in a solvent.
B) The semipermeable membrane is used to change the freezing and melting points of a solution.
C) Solutions cannot have identical osmotic pressures.
D) Temperature does not affect the osmotic pressure of a solution.
E) At least two of the above statements are correct.

ANS: A PTS: 1 DIF: Easy REF: 11.6
KEY: Chemistry | general chemistry | solutions | colligative properties | osmotic pressure
MSC: Conceptual

89. What is reverse osmosis?
A) the application, to a concentrated solution, of a pressure that is greater than the osmotic pressure, such that solvent flows from the concentrated solution to the dilute solution
B) the application, to a dilute solution, of a pressure that is greater than the osmotic pressure, such that solvent flows from the concentrated solution to the dilute solution
C) the application, to a concentrated solution, of a pressure that is greater than the osmotic pressure, such that solute flows from the concentrated solution to the dilute solution
D) the application, to a dilute solution, of a pressure that is greater than the osmotic pressure, such that solute flows from the concentrated solution to the dilute solution
E) the application, to a concentrated solution, of a pressure that is greater than the osmotic pressure, such that solvent flows from the dilute solution to the concentrated solution

ANS: A PTS: 1 DIF: Easy REF: 11.6
KEY: Chemistry | general chemistry | solutions | colligative properties | osmotic pressure
MSC: Conceptual

90. Solutions that have identical osmotic pressures are called _____ solutions.
A) hypertonic
B) isotonic

C) hypotonic
D) hemolytic
E) dyalitic

ANS: B PTS: 1 DIF: Easy REF: 11.6
KEY: Chemistry | general chemistry | solutions | colligative properties | osmotic pressure | isotonic solution MSC: Conceptual

91. Calculate the molarity of a solution containing KCl and water whose osmotic pressure at 21.6°C is 125 torr. Assume complete dissociation of the salt.
A) 0.00680 *M*
B) 5.17 *M*
C) 0.0464 *M*
D) 0.00340 *M*
E) 0.0928 *M*

ANS: D PTS: 1 DIF: Moderate REF: 11.7
KEY: Chemistry | general chemistry | solutions | colligative properties | osmotic pressure
MSC: Quantitative

92. The observed van't Hoff factor for an electrolyte is less than the expected factor because of _____.
A) electrolytic repulsion
B) complete dissociation
C) coagulation
D) ion pairing
E) gelation

ANS: D PTS: 1 DIF: Easy REF: 11.7
KEY: Chemistry | general chemistry | solutions | colligative properties
MSC: Conceptual

93. Which of the following solutions would have the highest osmotic pressure?
A) 0.2 *M* KBr, potassium bromide
B) 0.2 *M* $MgBr_2$, magnesium bromide
C) 0.3 *M* CH_3COOH, acetic acid
D) 0.3 *M* $C_6H_{12}O_6$, glucose
E) 0.3 *M* $C_{12}H_{22}O_{11}$, sucrose

ANS: B PTS: 1 DIF: Easy REF: 11.7
KEY: Chemistry | general chemistry | solutions | colligative properties | osmotic pressure
MSC: Conceptual

94. Which of the following solutions has the *lowest* boiling point?
A) 0.15 *M* NaCl
B) 0.10 *M* $MgBr_2$
C) 0.15 *M* $Ba(NO_3)_2$
D) 0.20 *M* $C_2H_6O_2$
E) 0.10 *M* $Fe(NO_3)_3$

ANS: D PTS: 1 DIF: Moderate REF: 11.7

KEY: Chemistry | general chemistry | solutions | colligative properties | boiling point elevation MSC: Conceptual

95. What is the freezing point of an aqueous 1.58 molal NaCl solution? (K_f = 1.86°C/*m*)
A) –2.94°C
B) 2.94°C
C) –5.88°C
D) 5.88°C
E) 0.00°C

ANS: C PTS: 1 DIF: Easy REF: 11.7
KEY: Chemistry | general chemistry | solutions | colligative properties | freezing point depression MSC: Quantitative

96. What is the expected boiling point of a solution prepared by dissolving 7.27 g of sodium iodide (NaI) in 68.6 g of water (H_2O)? For water, T_b = 100.00ºC and K_b = 0.512ºC m^{-1}.
A) 0.72ºC
B) 100.36ºC
C) 103.72ºC
D) 100.72ºC
E) 0.36ºC

ANS: D PTS: 1 DIF: Easy REF: 11.7
KEY: Chemistry | general chemistry | solutions | colligative properties | boiling point elevation MSC: Quantitative

97. 292.5 g of NaCl completely dissolves (producing Na^+ and Cl^- ions) in 1.00 kg of water at 25.0°C. The vapor pressure of pure water at this temperature is 23.8 torr. Determine the vapor pressure of the solution.
A) 20.2 torr
B) 21.8 torr
C) 18.7 torr
D) 18.0 torr
E) 23.8 torr

ANS: A PTS: 1 DIF: Moderate REF: 11.7
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | vapor pressure lowering MSC: Quantitative

98. The vapor pressure of water at 90°C is 0.692 atm. What is the vapor pressure (in atm) of a solution made by dissolving 4.13 mole(s) of CsF(s) in 1.00 kg of water? Assume that Raoult's law applies.
A) 0.644 atm
B) 0.795 atm
C) 0.602 atm
D) 0.692 atm
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 11.7
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution | vapor pressure lowering MSC: Quantitative

99. You have a 10.40-g mixture of table sugar ($C_{12}H_{22}O_{11}$) and table salt (NaCl). When this mixture is dissolved in 150. g of water, the freezing point is found to be –2.24°C. Calculate the percent by mass of sugar in the original mixture.
A) 39.0%
B) 43.8%
C) 53.9%
D) 61.0%
E) none of these

ANS: C PTS: 1 DIF: Difficult REF: 11.7
KEY: Chemistry | general chemistry | solutions | colligative properties | freezing point depression MSC: Quantitative

100. A 5.05-gram sample of a compound is dissolved in enough water to form 100.0 mL of solution. This solution has an osmotic pressure of 25.0 torr at 25°C. If it is assumed that each molecule of the solute dissociates into two particles (in this solvent), what is the molar mass of this solute?
A) 9.88×10^1 g/mol
B) 6.30×10^3 g/mol
C) 3.75×10^3 g/mol
D) 7.51×10^4 g/mol
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 11.7
KEY: Chemistry | general chemistry | solutions | colligative properties | osmotic pressure
MSC: Quantitative

101. Calculate the osmotic pressure (in torr) of 6.00 L of an aqueous 0.958 *M* solution at 30.°C, if the solute concerned is totally ionized into three ions (e.g., it could be Na_2SO_4 or $MgCl_2$).
A) 71.5 torr
B) 5.43×10^4 torr
C) 3.23×10^4 torr
D) 1.81×10^4 torr
E) 6.03×10^3 torr

ANS: B PTS: 1 DIF: Easy REF: 11.7
KEY: Chemistry | general chemistry | solutions | colligative properties | osmotic pressure
MSC: Quantitative

102. A 0.20 *M* solution of $MgSO_4$ has an observed osmotic pressure of 7.6 atm at 25°C. Determine the observed van't Hoff factor for this experiment.
A) 19
B) 0.31
C) 1.6
D) 1.8
E) 2.0

ANS: C PTS: 1 DIF: Easy REF: 11.7
KEY: Chemistry | general chemistry | solutions | colligative properties | osmotic pressure

MSC: Quantitative

103. The osmotic pressure of a 0.0100 *M* solution of NaCl in water at 25°C is found to be different from 372 torr because:
A) Osmotic pressures are hard to measure.
B) Na^+ and Cl^- ions are strongly hydrated.
C) Na^+ and Cl^- ions can form ion pairs.
D) NaCl does not dissociate in water.
E) None of these.

ANS: C PTS: 1 DIF: Easy REF: 11.7
KEY: Chemistry | general chemistry | solutions | colligative properties | osmotic pressure
MSC: Conceptual

104. The most likely reason for colloidal dispersion is _____.
A) the Tyndall effect
B) coagulation
C) precipitation
D) emulsion formation
E) electrostatic repulsion

ANS: E PTS: 1 DIF: Easy REF: 11.8
KEY: Chemistry | general chemistry | solutions | colloid formation | colloid
MSC: Conceptual

105. What type of colloid is formed when a liquid is dispersed in a gas?
A) foam
B) aerosol
C) emulsion
D) sol
E) gel

ANS: B PTS: 1 DIF: Easy REF: 11.8
KEY: Chemistry | general chemistry | solutions | colloid formation | colloid
MSC: Conceptual

106. What type of colloid is formed when a gas is dispersed in a liquid?
A) foam
B) gel
C) emulsion
D) sol
E) aerosol

ANS: A PTS: 1 DIF: Easy REF: 11.8
KEY: Chemistry | general chemistry | solutions | colloid formation | colloid
MSC: Conceptual

107. Shaving cream is an example of which colloid type?
A) aerosol
B) foam
C) emulsion

D) sol
E) coagulate

ANS: B PTS: 1 DIF: Easy REF: 11.8
KEY: Chemistry | general chemistry | solutions | colloid formation | colloid
MSC: Conceptual

108. Calculate the mole fraction of H_2SO_4 in 9.61 *M* H_2SO_4. The density of the solution is 1.520 g/mL.

ANS:
0.231

Assume 1 L (1000 mL) of solution.
moles H_2SO_4 in 1 L = 9.61 mol H_2SO_4
mass of H_2SO_4 in solution = 9.61 mol * (98.09g/mol) = 943 g H_2SO_4
mass of 1 L solution = 1000 mL * 1.520 g/mL = 1520. g solution
mass of H_2O in solution = 1520. g - 943 g = 577 g H_2O
moles H_2O in solution = 577 g * (1 mol/18.02 g) = 32.0 mol H_2O
mole fraction H_2SO_4 = 9.61/(9.61 + 32.0) = 0.231

PTS: 1 DIF: Easy REF: 11.1
KEY: Chemistry | general chemistry | solutions | colligative properties | expressing concentration | conversion of concentration units MSC: Quantitative

109. What is the percent by mass of ethanol (C_2H_5OH) in a 1.5-*m* aqueous solution?

ANS:
6.5%

1.5 *m* = 1.5 mol C_2H_5OH/1.0 kg water
1.5 mol * 46.07 g/mol = 69 g ethanol
69/(1000 + 69) = 6.5%

PTS: 1 DIF: Easy REF: 11.1
KEY: Chemistry | general chemistry | solutions | colligative properties | expressing concentration | conversion of concentration units MSC: Quantitative

110. Diagram and label a vapor pressure diagram for an ideal solution of two volatile liquids. Indicate the deviation predicted by an endothermic heat of solution.

ANS:
positive deviation;
see Figure 11.13b, Sec. 11.4 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Difficult REF: 11.4
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure of a solution MSC: Conceptual

111. A chemist is given a white solid that is suspected of being pure cocaine. When 1.22 g of the solid is dissolved in 15.60 g of benzene, the freezing point is lowered by 1.32°C. Calculate the molar mass of the solid. The molal freezing point constant (K_f) for benzene is 5.12°C/*m*.

ANS:
303 g/mol

1.32°C = 5.12°C/*m* * (*n* mol/0.01560 kg); *n* = 0.00402 mol
molar mass = 1.22 g/0.00402 mol = 303 g/mol

PTS: 1 DIF: Moderate REF: 11.5
KEY: Chemistry | general chemistry | solutions | colligative properties | freezing point depression MSC: Quantitative

112. A chemist is given a white solid that is suspected of being pure cocaine (molar mass = 303.35 g/mol). When 1.22 g of the solid is dissolved in 15.60 g of benzene, the freezing point is lowered by 1.32°C. The molar mass is calculated from these data to be 303 g. Assuming the following uncertainties, can the chemist be sure the substance is not codeine (molar mass 299.36)? K_f for benzene is 5.12°C/*m*.

Uncertainties
Mass of solid = ±0.01 g
Mass of benzene = ±0.01 g
ΔT (freezing point lowering) = ±0.04°C
K_f = ±0.01
Support your answer with calculations.

ANS:
We want to find the minimum molar mass given these errors. First we want the largest possible *m* value.

$$m = \frac{\Delta T}{K_f} = \frac{1.36}{5.11} = .2661$$

max mol present = $.2661 \times .01561 = 4.154 \times 10^{-3}$

$$\text{molar mass} = \frac{1.21\text{g (min value)}}{4.154 \times 10^{-3}} = 291 \text{ g}$$

Clearly, the solid could be codeine.

PTS: 1 DIF: Difficult REF: 11.5
KEY: Chemistry | general chemistry | solutions | colligative properties | freezing point depression MSC: Quantitative

113. What is the molar mass of glucose if 22.5 g gives a freezing point of –0.930°C when dissolved in 250.0 g of water? If the empirical formula is CH_2O, what is the molecular formula?

ANS:
180. g/mol, $C_6H_{12}O_6$

0.930°C = 1.86°C/*m* * (*n* mol/0.2500 kg); *n* = 0.125 mol

molar mass = 22.5 g/0.125 mol = 180. g/mol
empirical mass CH_2O = 30.0; n = 180/30.0 = 6
molecular formula = 6(CH_2O) = $C_6H_{12}O_6$

PTS: 1 DIF: Moderate REF: 11.5
KEY: Chemistry | general chemistry | solutions | colligative properties | freezing point depression MSC: Quantitative

114. When 92.0 g of a compound is dissolved in 1000. g of water, the freezing point of the solution is lowered to –3.72°C. Determine the molar mass of the compound.

ANS:
46.0 g/mol

3.72°C = 1.86°C/m * (n mol/1.000 kg); n = 2.00 mol
molar mass = 92.0 g/2.00 mol = 46.0 g/mol

PTS: 1 DIF: Moderate REF: 11.5
KEY: Chemistry | general chemistry | solutions | colligative properties | freezing point depression MSC: Quantitative

115. Calculate both the boiling point and the freezing point if 46.0 g of glycerol, $C_3H_5(OH)_3$, is dissolved in 500.0 g of H_2O.

ANS:
freezing point = –1.86°C boiling point = 100.51°C

46.0 g/92.09 g/mol = 0.500 mol glycerol
molality of solution = 0.500 mol/0.5000 kg = 1 m
boiling point = 100.00°C + (0.51°C/m * 1m) = 100.51°C
freezing point = 0.00°C – (1.86°C/m * 1m) = –1.86°C

PTS: 1 DIF: Easy REF: 11.5
KEY: Chemistry | general chemistry | solutions | colligative properties
MSC: Quantitative

116. Calculate the molarity of an aqueous solution that is 12.8% by mass NaCl, given that the density of the solution is 1.08 g/mL.
A) 2.03 M
B) 2.19 M
C) 2.36 M
D) 2.71 M
E) 13.8 M

ANS: C PTS: 1 DIF: Easy REF: 11.1
KEY: Chemistry | general chemistry | solutions | expressing concentration | conversion of concentration units MSC: Quantitative

117. Calculate the molality of an aqueous solution that is 12.8% by mass NaCl, given that the density of the solution is 1.08 g/mL.

A) 2.03 *M*
B) 2.19 *M*
C) 2.36 *M*
D) 2.51 *M*
E) 13.8 *M*

ANS: D PTS: 1 DIF: Easy REF: 11.1
KEY: Chemistry | general chemistry | solutions | expressing concentration | conversion of concentration units MSC: Quantitative

118. A solution is made by dissolving 27.8 g of nicotine (molar mass = 160 g/mol) in 145 g of cyclohexane (C_6H_{12}) to form 142 mL of solution. Calculate the mole fraction of the solute and the molarity, respectively, of this solution.
A) 0.174, 1.22 M
B) 0.101, 12.1 M
C) 0.101, 1.22 M
D) 0.091, 1.22 M
E) 0.174, 12.1 M

ANS: D PTS: 1 DIF: Easy REF: 11.1
KEY: Chemistry | general chemistry | solutions | expressing concentration |
MSC: Quantitative

119. A solution is made by dissolving 100. g of cobalt(III)chloride in 250. g of water. to make a solution that has a density of 1.25 g/mL. Calculate (I) the molality and (II) the molarity of the solution.
A) (I) 2.42 m (II) 2.16 M
B) (I) 2.16 m (II) 2.42 M
C) (I) 0.400 m (II) 0.500 M
D) (I) 0.0417 m (II) 0.0522 M
E) (I) 0.0522 m (II) 0.0417 M

ANS: A PTS: 1 DIF: Easy REF: 11.1
KEY: Chemistry | general chemistry | solutions | expressing concentration | conversion of concentration units MSC: Quantitative

120. Which of the following statements is true?
A) Ionic compounds with a high lattice energy will be very soluble.
B) The solubility of a gas in a liquid always increases as the temperature rises.
C) Some mixtures that have an ENDOTHERMIC heat of solution will happen due to a decrease in entropy.
D) NaCl(s) has a smaller (less exothermic) ΔH_{hyd} than MgS(s).
E) All of these are false.

ANS: D PTS: 1 DIF: Easy REF: 11.3
KEY: Chemistry | general chemistry | solutions | solution formation | solubility |
MSC: Conceptual

121. Which of the following substances should be the most soluble in ethanol (CH_3CH_2OH)?
A) CH_4
B) O_2

C) CH_2Cl_2
D) NaCl
E) $Mg_3(PO_4)_2$

ANS: D PTS: 1 DIF: Easy REF: 11.2
KEY: Chemistry | general chemistry | solutions | solution formation | solubility
MSC: Conceptual

122. Which one of each of the following pairs would be more soluble in water?
I. CH_3OH or CH_4
II. NaCl or AgCl;
III. CH_3CH_2OH or $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2OH$
A) CH_3OH, NaCl, $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2OH$
B) CH_3OH, NaCl, CH_3CH_2OH
C) CH_4, NaCl, CH_3CH_2OH
D) CH_4, AgCl, $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2OH$
E) CH_3OH, AgCl, CH_3CH_2OH

ANS: B PTS: 1 DIF: Moderate REF: 11.3
KEY: Chemistry | general chemistry | solutions | solution formation | solubility
MSC: Conceptual

123. Which of the following statements is/are true?
I. Because ionic forces are so much stronger than hydrogen bonds, no ionic compound will be soluble in ethanol (CH_3CH_2OH)
II. Making of any solution in which a solid is dissolved in a liquid will always have a positive entropy.
III. the heats of hydration of ions increase (become more exothermic) as ionic charge increases
A) I and II only
B) I and III only
C) II and III only
D) all three are true
E) none are true

ANS: C PTS: 1 DIF: Easy REF: 11.2
KEY: Chemistry | general chemistry | solutions | solution formation | solubility | ionic solution MSC: Qualitative

124. Which of the following statements is/are true?
I. Supersaturated solutions are very stable
II. The solubility of gases in liquids increases as the temperature is raised
III. The solubility of gases in liquids is independent of the external pressure

A) I and II only
B) I and III only
C) II and III only
D) II only
E) none are true

ANS: E PTS: 1 DIF: Easy REF: 11.3

KEY: Chemistry | general chemistry | solutions | solution formation | effect of temperature and pressure on solubility MSC: Conceptual

125. Which of the following aqueous solutions will have the LOWEST vapor pressure?
A) 0.20 m $C_6H_{12}O_6$
B) 0.20 m NaCl
C) 0.10 m $CaCl_2$
D) 0.40 m C_2H_5OH
E) 0.20 m Na_2SO_4

ANS: E PTS: 1 DIF: Moderate REF: 11.7
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure | van't Hoff effect MSC: Conceptual

126. Which of these solutions 0.1 m NaCl, 0.15 m glucose, 0.1 m $CaCl_2$ would have
I. the highest vapor pressure
II. the lowest boiling point

A) 0.1 m $CaCl_2$, 0.1 m $CaCl_2$
B) 0.15 m glucose, 0.1 m $CaCl_2$
C) 0.1 m $CaCl_2$, 0.15 m glucose
D) 0.15 m glucose, 0.15 m glucose
E) 0.1 m NaCl, 0.1 m $CaCl_2$

ANS: D PTS: 1 DIF: Moderate REF: 11.7
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure | van't Hoff effect MSC: Conceptual

127. Which of these solutions 0.1 m NaCl, 0.15 m glucose, 0.1 m $CaCl_2$ would have
I. the lowest vapor pressure
II. the lowest boiling point

A) 0.1 m $CaCl_2$, 0.1 m $CaCl_2$
B) 0.15 m glucose, 0.1 m $CaCl_2$
C) 0.1 m $CaCl_2$, 0.15 m glucose
D) 0.15 m glucose, 0.15 m glucose
E) 0.1 m NaCl, 0.1 m $CaCl_2$

ANS: C PTS: 1 DIF: Moderate REF: 11.7
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure | van't Hoff effect MSC: Conceptual

128. Which of these solutions 0.1 m NaCl, 0.15 m glucose, 0.1 m $CaCl_2$ would have
I. the highest vapor pressure
II. the highest boiling point

A) 0.1 m $CaCl_2$, 0.1 m $CaCl_2$
B) 0.15 m glucose, 0.1 m $CaCl_2$
C) 0.1 m $CaCl_2$, 0.15 m glucose
D) 0.15 m glucose, 0.15 m glucose

E) 0.1 m NaCl, 0.1 m $CaCl_2$

ANS: B PTS: 1 DIF: Moderate REF: 11.7
KEY: Chemistry | general chemistry | solutions | colligative properties | vapor pressure | van't Hoff effect MSC: Conceptual

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Chapter 12: Chemical Kinetics

1. The average rate of disappearance of ozone in the reaction $2O_3(g) \rightarrow 3O_2(g)$ is found to be 7.25×10^{-3} atm over a certain interval of time. What is the rate of appearance of O_2 during this interval?
   A) 10.9×10^{-3} atm/s
   B) 7.25×10^{-3} atm/s
   C) 4.83×10^{-3} atm/s
   D) 191×10^{-3} atm/s
   E) 17.5×10^{-3} atm/s

   ANS: A PTS: 1 DIF: Easy REF: 12.1
   KEY: Chemistry | general chemistry | rates of reaction | reaction rate
   MSC: Quantitative

2. The balanced equation for the reaction of bromate ion with bromide ion in acidic solution is given by:

   $BrO_3^- + 5Br^- + 6H^+ \rightarrow 3Br_2 + 3H_2O$

   At a particular instant in time, the value of $\frac{-\Delta[Br^-]}{\Delta t}$ is 2.2×10^{-3} mol/L s. What is the value of $\frac{\Delta[Br_2]}{\Delta t}$ in the same units?
   A) 1.3×10^{-3}
   B) 2.2×10^{-3}
   C) 3.7×10^{-3}
   D) 1.1×10^{-3}
   E) 1.8×10^{-3}

   ANS: A PTS: 1 DIF: Easy REF: 12.1
   KEY: Chemistry | general chemistry | rates of reaction | reaction rate
   MSC: Quantitative

3. Consider the reaction $2H_2 + O_2 \rightarrow 2H_2O$
   What is the ratio of the initial rate of the appearance of water to the initial rate of disappearance of oxygen?
   A) 1 : 1
   B) 2 : 1
   C) 1 : 2
   D) 2 : 2
   E) 3 : 2

   ANS: B PTS: 1 DIF: Easy REF: 12.1
   KEY: Chemistry | general chemistry | rates of reaction | reaction rate
   MSC: Conceptual

4. Consider the reaction: $4NH_3 + 7O_2 \rightarrow 4NO_2 + 6H_2O$
   At a certain instant the initial rate of disappearance of the oxygen gas is X. What is the value of the appearance of water at the same instant?
   A) 1.2 X
   B) 1.1 X
   C) 0.86 X
   D) 0.58 X
   E) cannot be determined from the data

   ANS: C PTS: 1 DIF: Easy REF: 12.1
   KEY: Chemistry | general chemistry | rates of reaction | reaction rate
   MSC: Conceptual

5. For the reaction $5A + 5B \rightarrow 2C + 2D$, at a particular instant in time, the rate of the reaction is 0.0223 *M*/s. What is the rate of change of A?
   A) –0.0223 *M*/s
   B) 0.112 M/s
   C) –0.112 *M*/s
   D) –0.00446 *M*/s
   E) 0.00446 *M*/s

   ANS: C PTS: 1 DIF: Easy REF: 12.1
   KEY: Chemistry | general chemistry | rates of reaction | reaction rate
   MSC: Conceptual

6. Consider the reaction X → Y + Z
   Which of the following is a possible rate law?
   A) Rate = *k*[X]
   B) Rate = *k*[Y]
   C) Rate = *k*[Y][Z]
   D) Rate = *k*[X][Y]
   E) Rate = *k*[Z]

   ANS: A PTS: 1 DIF: Easy REF: 12.2
   KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration MSC: Conceptual

7. Consider the following rate law: $\text{Rate} = k[A]^n[B]^m$
   How are the exponents *n* and *m* determined?
   A) by using the balanced chemical equation
   B) by using the subscripts for the chemical formulas
   C) by using the coefficients of the chemical formulas
   D) by educated guess
   E) by experiment

   ANS: E PTS: 1 DIF: Easy REF: 12.3
   KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | determining the rate law MSC: Conceptual

8. The following data were obtained for the reaction of NO with O_2. Concentrations are in molecules/cm^3 and rates are in molecules/cm^3·s.

$[NO]_0$	$[O_2]_0$	Initial Rate
1×10^{18}	1×10^{18}	2.0×10^{16}
2×10^{18}	1×10^{18}	8.0×10^{16}
3×10^{18}	1×10^{18}	18.0×10^{16}
1×10^{18}	2×10^{18}	4.0×10^{16}
1×10^{18}	3×10^{18}	6.0×10^{16}

What is the rate law?
A) Rate = $k[NO][O_2]$
B) Rate = $k[NO][O_2]^2$
C) Rate = $k[NO]^2[O_2]$
D) Rate = $k[NO]^2$
E) Rate = $k[NO]^2[O_2]^2$

ANS: C PTS: 1 DIF: Easy REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | determining the rate law MSC: Quantitative

9. The reaction of $(CH_3)_3CBr$ with hydroxide ion proceeds with the formation of $(CH_3)_3COH$.

$$(CH_3)_3CBr(aq) + OH^-(aq) \rightarrow (CH_3)_3COH(aq) + Br^-(aq)$$

The following data were obtained at 55°C.

Exp.	$[(CH_3)_3CBr]_0$ (mol/L)	$[OH^-]_0$ (mol/L)	Initial Rate (mol/L)
1	0.10	0.10	1.0×10^{-3}
2	0.20	0.10	2.0×10^{-3}
3	0.10	0.20	1.0×10^{-3}
4	0.30	0.20	?

What will the initial rate (in mol/L·s) be in Experiment 4?
A) 3.0×10^{-3}
B) 6.0×10^{-3}
C) 9.0×10^{-3}
D) 18×10^{-3}
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | experimental determination of rate MSC: Conceptual

10. For a reaction in which A and B react to form C, the following initial rate data were obtained:

[A] (mol/L)	[B] (mol/L)	Initial Rate of Formation of C (mol/L·s)
0.10	0.10	1.00
0.10	0.20	4.00
0.20	0.20	8.00

What is the rate law?

A) Rate = k[A][B]
B) Rate = k[A]^2[B]
C) Rate = k[A][B]^2
D) Rate = k[A]^2[B]^2
E) Rate = k[A]^3

ANS: C PTS: 1 DIF: Easy REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | determining the rate law MSC: Quantitative

11. Tabulated below are initial rate data for the reaction

$$2Fe(CN)_6^{3-} + 2I^- \rightarrow Fe(CN)_6^{4-} + I_2$$

Run	$\left[Fe(CN)_6^{3-}\right]_0$	$\left[I^-\right]_0$	$\left[Fe(CN)_6^{4-}\right]_0$	$\left[I_2\right]_0$	Initial Rate (M/s)
1	0.01	0.01	0.01	0.01	1×10^{-5}
2	0.01	0.02	0.01	0.01	2×10^{-5}
3	0.02	0.02	0.01	0.01	8×10^{-5}
4	0.02	0.02	0.02	0.01	8×10^{-5}
5	0.02	0.02	0.02	0.02	8×10^{-5}

The experimental rate law is:

A) $\frac{\Delta[I_2]}{\Delta t} = k[Fe(CN)_6^{3-}]^2[I^-]^2[Fe(CN)_6^{4-}]^2[I_2]$
B) $\frac{\Delta[I_2]}{\Delta t} = k[Fe(CN)_6^{3-}]^2[I^-][Fe(CN)_6^{4-}]^2[I_2]$
C) $\frac{\Delta[I_2]}{\Delta t} = k[Fe(CN)_6^{3-}]^2[I^-]$
D) $\frac{\Delta[I_2]}{\Delta t} = k[Fe(CN)_6^{3-}][I^-]^2$
E) $\frac{\Delta[I_2]}{\Delta t} = k[Fe(CN)_6^{3-}][I^-][Fe(CN)_6^{4-}]$

ANS: C PTS: 1 DIF: Moderate REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | determining the rate law MSC: Quantitative

12. Tabulated below are initial rate data for the reaction:

$$2Fe(CN)_6^{3-} + 2I^- \rightarrow 2Fe(CN)_6^{4-} + I_2$$

Run	$[Fe(CN)_6^{3-}]_0$	$[I^-]_0$	$[Fe(CN)_6^{4-}]_0$	$[I_2]_0$	Rate (M/s)
1	0.01	0.01	0.01	0.01	1×10^{-5}
2	0.01	0.02	0.01	0.01	2×10^{-5}
3	0.02	0.02	0.01	0.01	8×10^{-5}
4	0.02	0.02	0.02	0.01	8×10^{-5}
5	0.02	0.02	0.02	0.02	8×10^{-5}

What is the value of k?
A) $10^7\ M^{-5}\ s^{-1}$
B) $10^3\ M^{-3}\ s^{-1}$
C) $10\ M^{-2}\ s^{-1}$
D) $50\ M^{-2}\ s^{-1}$
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | determining the rate law MSC: Quantitative

A general reaction written as $A + 2B \rightarrow C + 2D$ is studied and yields the following data:

$[A]_0$	$[B]_0$	Initial $\Delta[C]/\Delta t$
0.150 M	0.150 M	8.00×10^{-3} mol/L·s
0.150 M	0.300 M	1.60×10^{-2} mol/L·s
0.300 M	0.150 M	3.20×10^{-2} mol/L·s

13. What is the order of the reaction with respect to B?
A) 0
B) 1
C) 2
D) 3
E) 4

ANS: B PTS: 1 DIF: Easy REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | reaction order MSC: Conceptual

14. What is the order of the reaction with respect to A?
A) 0
B) 1
C) 2
D) 3
E) 4

ANS: C PTS: 1 DIF: Easy REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | reaction order MSC: Conceptual

15. What is the overall order of the reaction?
A) 0
B) 1
C) 2
D) 3
E) 4

ANS: D PTS: 1 DIF: Easy REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | reaction order MSC: Conceptual

16. What is the numerical value of the rate constant?
    A) 0.053
    B) 1.19
    C) 2.37
    D) 5.63
    E) none of these (A-D)

    ANS: C PTS: 1 DIF: Moderate REF: 12.3
    KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration MSC: Quantitative

17. Determine the initial rate of B consumption ($\Delta[B]/\Delta t$) for the first trial?
    A) 8.00×10^{-3} mol/L·s
    B) 1.60×10^{-2} mol/L·s
    C) 3.20×10^{-2} mol/L·s
    D) 4.00×10^{-3} mol/L·s
    E) none of these (A-D)

    ANS: B PTS: 1 DIF: Moderate REF: 12.3
    KEY: Chemistry | general chemistry | rates of reaction | reaction rate | change of concentration with time MSC: Conceptual

18. Determine the initial rate of C production ($\Delta[C]/\Delta t$) if [A] = 0.200 *M* and [B] = 0.500 *M*.
    A) 4.74×10^{-2} mol/L·s
    B) 2.37×10^{-1} mol/L·s
    C) 1.19×10^{-1} mol/L·s
    D) 8.23×10^{-2} mol/L·s
    E) none of these (A-D)

    ANS: A PTS: 1 DIF: Moderate REF: 12.3
    KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration MSC: Quantitative

Consider the following data concerning the equation:

$$H_2O_2 + 3I^- + 2H^+ \rightarrow I_3^- + 2H_2O$$

	$[H_2O_2]$	$[I^-]$	$[H^+]$	rate
I	0.100 *M*	5.00×10^{-4} *M*	1.00×10^{-2} *M*	0.137 *M*/sec
II.	0.100 *M*	1.00×10^{-3} *M*	1.00×10^{-2} *M*	0.268 *M*/sec
III.	0.200 *M*	1.00×10^{-3} *M*	1.00×10^{-2} *M*	0.542 *M*/sec
IV.	0.400 *M*	1.00×10^{-3} *M*	2.00×10^{-2} *M*	1.084 *M*/sec

19. The rate law for this reaction is
    A) rate = $k[H_2O_2][I^-][H^+]$
    B) rate = $k[H_2O_2]^2[I^-]^2[H^+]^2$
    C) rate = $k[I^-][H^+]$
    D) rate = $k[H_2O_2][H^+]$
    E) rate = $k[H_2O_2][I^-]$

    ANS: E PTS: 1 DIF: Easy REF: 12.3

KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | determining the rate law MSC: Conceptual

20. The average value for the rate constant *k* (without units) is
A) 2710
B) 2.74×10^4
C) 137
D) 108
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration MSC: Quantitative

21. Two mechanisms are proposed:

I. $H_2O_2 + I^- \rightarrow H_2O + OI^-$

$OI^- + H^+ \rightarrow HOI$

$HOI + I^- + H^+ \rightarrow I_2 + H_2O$

$I_2 + I^- \rightarrow I_3^-$

II. $H_2O_2 + I^- + H^+ \rightarrow H_2O + HOI$

$HOI + I^- + H^+ \rightarrow I_2 + H_2O$

$I_2 + I^- \rightarrow I_3^-$

Which mechanism and which step as the rate determining step would best fit the data?

A) Mechanism I, with the first step the rate determining step.
B) Mechanism I, with the second step the rate determining step.
C) Mechanism II, with the first step rate determining.
D) Mechanism II, with the second step rate determining.
E) None of the above could be correct.

ANS: A PTS: 1 DIF: Easy REF: 12.5
KEY: Chemistry | general chemistry | rates of reaction | reaction mechanism | the rate law and the mechanism | rate determining step MSC: Conceptual

The following initial rate data were found for the reaction

$$2MnO_4^- + 5H_2C_2O_4 + 6H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

$[MnO_4^-]_0$	$[H_2C_2O_4]_0$	$[H^+]_0$	Initial Rate (*M*/s)
1×10^{-3}	1×10^{-3}	1.0	2×10^{-4}
2×10^{-3}	1×10^{-3}	1.0	8×10^{-4}
2×10^{-3}	2×10^{-3}	1.0	1.6×10^{-3}
2×10^{-3}	2×10^{-3}	2.0	1.6×10^{-3}

22. Which of the following is the correct rate law?
A) Rate = $k[MnO_4^-]^2[H_2C_2O_4]^5[H^+]^6$
B) Rate = $k[MnO_4^-]^2[H_2C_2O_4][H^+]$
C) Rate = $k[MnO_4^-][H_2C_2O_4][H^+]$
D) Rate = $k[MnO_4^-]^2[H_2C_2O_4]$
E) Rate = $k[MnO_4^-]^2[H_2C_2O_4]^2$

ANS: D PTS: 1 DIF: Easy REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | determining the rate law MSC: Conceptual

23. What is the value of the rate constant?
A) $2 \times 10^5\ M \cdot s^{-1}$
B) $2 \times 10^5\ M^{-2} \cdot s^{-1}$
C) $200\ M^{-1} \cdot s^{-1}$
D) $200\ M^{-2} \cdot s^{-1}$
E) $2 \times 10^{-4}\ M \cdot s^{-1}$

ANS: B PTS: 1 DIF: Moderate REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration MSC: Quantitative

The following questions refer to the reaction between nitric oxide and hydrogen

$$2NO + H_2 \rightarrow N_2O + H_2O$$

Experiment	Initial [NO], *M*	Initial [H_2], *M*	Initial Rate of Disappearance of NO (mol/L sec)
1	6.4×10^{-3}	2.2×10^{-3}	2.7×10^{-5}
2	12.8×10^{-3}	2.2×10^{-3}	1.1×10^{-4}
3	6.4×10^{-3}	4.5×10^{-3}	5.4×10^{-5}

24. What is the rate law for this reaction?
A) Rate = $k[NO]$
B) Rate = $k[NO]^2$
C) Rate = $k[NO]^2[H_2]$
D) Rate = $k[NO][H_2]$
E) Rate = $k[N_2O][H_2O]$

ANS: C PTS: 1 DIF: Easy REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | determining the rate law MSC: Conceptual

25. What is the magnitude of the rate constant for this reaction?
A) 0.66
B) 4.2×10^{-3}
C) 870
D) 1.9
E) 300

ANS: E PTS: 1 DIF: Moderate REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration MSC: Quantitative

26. What are the units for the rate constant for this reaction?
A) L/mol·s
B) $L^2/mol^2 \cdot s$
C) mol/L·s
D) s^{-2}
E) L^{-2}

ANS: B PTS: 1 DIF: Moderate REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration MSC: Conceptual

27. What is the order of this reaction?
A) 3
B) 2
C) 1
D) 0
E) cannot be determined from the data

ANS: A PTS: 1 DIF: Moderate REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | reaction order MSC: Conceptual

The reaction $H_2SeO_3(aq)$ $6I^-(aq) + 4H^+(aq) \rightarrow 2I_3^-(aq) + 3H_2O(l) + Se(s)$ was studied at 0°C by the method of initial rates:

$[H_2SeO_3]_0$	$[H^+]_0$	$[I^-]_0$	Rate (mol/L s)
1.0×10^{-4}	2.0×10^{-2}	2.0×10^{-2}	1.66×10^{-7}
2.0×10^{-4}	2.0×10^{-2}	2.0×10^{-2}	3.33×10^{-7}
3.0×10^{-4}	2.0×10^{-2}	2.0×10^{-2}	4.99×10^{-7}
1.0×10^{-4}	4.0×10^{-2}	2.0×10^{-2}	6.66×10^{-7}
1.0×10^{-4}	1.0×10^{-2}	2.0×10^{-2}	0.41×10^{-7}
1.0×10^{-4}	2.0×10^{-2}	4.0×10^{-2}	13.4×10^{-7}
1.0×10^{-4}	4.0×10^{-2}	4.0×10^{-2}	5.33×10^{-6}

28. The rate law is
A) Rate = $k[H_2SeO_3][H^+][I^-]$
B) Rate = $k[H_2SeO_3][H^+]^2[I^-]$
C) Rate = $k[H_2SeO_3][H^+][I^-]^2$
D) Rate = $k[H_2SeO_3]^2[H^+][I^-]$
E) Rate = $k[H_2SeO_3][H^+]^2[I^-]^3$

ANS: E PTS: 1 DIF: Moderate REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | determining the rate law MSC: Conceptual

29. The numerical value of the rate constant is

A) 5.2×10^5
B) 2.1×10^2
C) 4.2
D) 1.9×10^{-6}
E) none of these

ANS: A PTS: 1 DIF: Difficult REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration MSC: Quantitative

The following questions refer to the reaction shown below:

Experiment	Initial [A] (mol/L)	Initial [B] (mol/L)	Initial Rate of Disappearance of A (mol/L·s)
1	0.16	0.15	0.08
2	0.16	0.30	0.30
3	0.08	0.30	0.08

30. What is the rate law for this reaction?
A) Rate = k[A][B]
B) Rate = k[A]^2[B]
C) Rate = k[A][B]^2
D) Rate = k[A]^2[B]^2
E) Rate = k[B]

ANS: D PTS: 1 DIF: Moderate REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | determining the rate law MSC: Conceptual

31. What is the magnitude of the rate constant for the reaction?
A) 140
B) 79
C) 119
D) 164
E) 21

ANS: A PTS: 1 DIF: Moderate REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration MSC: Quantitative

32. What are the units for the rate constant for this reaction?
A) L/mol·s
B) L^2/mol^2·s
C) mol/L·s
D) L^3/mol^3·s
E) mol^3/L

ANS: D PTS: 1 DIF: Moderate REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate

on concentration MSC: Conceptual

33. What is the order of this reaction?
A) 4
B) 3
C) 2
D) 1
E) 0

ANS: A PTS: 1 DIF: Moderate REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | reaction order MSC: Conceptual

34. Initial rate data have been determined at a certain temperature for the gaseous reaction

$2NO + 2H_2 \rightarrow N_2 + 2H_2O$

$[NO]_0$	$[H_2]_0$	Initial Rate (M/s)
0.10	0.20	0.0150
0.10	0.30	0.0225
0.20	0.20	0.0600

What is the value of the rate constant?
A) 7.5
B) 3.0×10^{-3}
C) 380
D) 0.75
E) 3.0×10^{-4}

ANS: A PTS: 1 DIF: Moderate REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration MSC: Quantitative

35. The following data were obtained at 25°C:

$[A]_0$	$[B]_0$	$[C]_0$	Rate
0.1	0.2	0.3	0.063
0.3	0.4	0.2	0.084
0.6	0.4	0.2	0.168
0.3	0.4	0.1	0.021
0.6	0.2	0.2	0.168

What is the correct rate law?
A) Rate = k[A][B][C]
B) Rate = k[A][B][C]^2
C) Rate = k[A][C]
D) Rate = k[A]^3[B]^2[C]
E) Rate = k[A][C]^2

ANS: E PTS: 1 DIF: Easy REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | determining the rate law MSC: Conceptual

The oxidation of Cr^{3+} to CrO_4^{2-} can be accomplished using Ce^{4+} in a buffered solution. The following data were obtained:

Relative Initial Rate	$[Ce^{4+}]_0$	$[Ce^{3+}]_0$	$[Cr^{3+}]_0$
1	2.0×10^{-3}	1.0×10^{-2}	3.0×10^{-2}
2	4.0×10^{-3}	2.0×10^{-2}	3.0×10^{-2}
4	4.0×10^{-3}	1.0×10^{-2}	3.0×10^{-2}
16	8.0×10^{-3}	2.0×10^{-2}	6.0×10^{-2}

36. Determine the order in the rate law of the species Ce^{4+}.
A) 1
B) 2
C) 3
D) –1
E) –2

ANS: B PTS: 1 DIF: Moderate REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | reaction order MSC: Conceptual

37. Determine the order in the rate law of the species Ce^{3+}.
A) 1
B) 2
C) 3
D) –1
E) –2

ANS: D PTS: 1 DIF: Moderate REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | reaction order MSC: Conceptual

38. Determine the order in the rate law of the species Cr^{3+}.
A) 1
B) 2
C) 3
D) –1
E) –2

ANS: A PTS: 1 DIF: Moderate REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | reaction order MSC: Conceptual

39. The rate expression for a particular reaction is rate = $k[A][B]^2$. If the initial concentration of B is increased from 0.1 *M* to 0.3 *M*, the initial rate will increase by which of the following factors?
A) 2
B) 6
C) 12
D) 3
E) 9

ANS: E PTS: 1 DIF: Easy REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | reaction order MSC: Conceptual

40. The following data were obtained for the reaction $2A + B \rightarrow C$ where rate = $\Delta[C]/\Delta t$

[A](*M*)	[B](*M*)	Initial Rate (*M*/s)
0.100	0.0500	2.13×10^{-4}
0.200	0.0500	1.70×10^{-2}
0.400	0.100	1.36×10^{-1}

What is the value of the rate constant?
A) 2.13
B) 0.213
C) 0.426
D) 1.70
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws
MSC: Quantitative

41. The reaction $2A + 5B \rightarrow$ products is second order in A and first order in B. What is the rate law for this reaction?
A) rate = $k[A]^2[B]^5$
B) rate = $k[A]^1[B]^2$
C) rate = $k[A]^2[B]^1$
D) rate = $k[A]^5[B]^2$
E) rate = $k[A]^{2/7}[B]^{5/7}$

ANS: C PTS: 1 DIF: Easy REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | reaction order MSC: Conceptual

42. The reaction $3A + 4B \rightarrow$ products is second order in A and second order in B. What is the overall order of the reaction?
A) 0
B) 7
C) 2
D) 4
E) 6

ANS: D PTS: 1 DIF: Easy REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | reaction order MSC: Conceptual

43. The reactants A and B are mixed, and the reaction is timed until a color change occurs. The data are as follows:

[A]	**[B]**	**Time (s)**

0.100	0.140	25
0.050	0.140	50
0.100	0.070	100

The order of the reaction in terms of B is

A) 2.
B) $\frac{1}{2}$.
C) 0.
D) $-\frac{1}{2}$.
E) 1.

ANS: A PTS: 1 DIF: Easy REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | determining the rate law MSC: Quantitative

44. The reaction $2\mathrm{NO} \rightarrow \mathrm{N_2} + \mathrm{O_2}$ has the following rate law:

$$-\frac{\Delta[\mathrm{NO}]}{\Delta t} = 2k[\mathrm{NO}]^2.$$

After a period of 2.7×10^3 s, the concentration of NO falls from an initial value of 2.8×10^{-3} mol/L to 2.0×10^{-3} mol/L. What is the rate constant, *k*?

A) $1.5 \times 10^{-7}\ M^{-1} \cdot s^{-1}$
B) $5.3 \times 10^{-2}\ M^{-1} \cdot s^{-1}$
C) $3.2 \times 10^{-1}\ M^{-1} \cdot s^{-1}$
D) $1.2 \times 10^{-4}\ M^{-1} \cdot s^{-1}$
E) $2.6 \times 10^{-2}\ M^{-1} \cdot s^{-1}$

ANS: E PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | second-order reaction MSC: Quantitative

45. The following data were collected for the decay of HO_2 radicals:

Time	$[HO_2]$	Time	$[HO_2]$
0 s	1.0×10^{11} molec/cm^3	14 s	1.25×10^{10} molec/cm^3
2 s	5.0×10^{10} molec/cm^3	30 s	6.225×10^{9} molec/cm^3
6 s	2.5×10^{10} molec/cm^3		

Which of the following best describes the reaction?

A) The decay of HO_2 occurs by a first-order process.
B) The half-life of the reaction is 2 ms.
C) A plot of ln $[HO_2]$ versus time is linear with a slope of $-k$.
D) The rate of the reaction increases with time.
E) A plot of $1/[HO_2]$ versus time gives a straight line.

ANS: E PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | graphing of kinetic data MSC: Conceptual

46. A first-order reaction is 45% complete at the end of 43 minutes. What is the length of the half-life of this reaction?
A) 50. min
B) 37 min
C) 2.7 h
D) 62 min
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | first-order reaction MSC: Quantitative

The following questions refer to the gas-phase decomposition of ethylene chloride.

$C_2H_5Cl \rightarrow$ products

Experiment shows that the decomposition is first order.
The following data show kinetics information for this reaction:

Time (s)	ln [C_2H_5Cl] (M)
1.0	–1.625
2.0	–1.735

47. What is the rate constant for this decomposition?
A) 0.29/s
B) 0.35/s
C) 0.11/s
D) 0.02/s
E) 0.22/s

ANS: C PTS: 1 DIF: Easy REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | first-order reaction MSC: Quantitative

48. What was the initial concentration of the ethylene chloride?
A) 0.29 M
B) 0.35 M
C) 0.11 M
D) 0.02 M
E) 0.22 M

ANS: E PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | first-order reaction MSC: Quantitative

49. What would the concentration be after 5.0 seconds?
A) 0.13 M
B) 0.08 M
C) 0.02 M
D) 0.19 M
E) 0.12 M

ANS: A PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | first-order reaction MSC: Quantitative

50. What is the half-life time for this reaction?
A) 0.7 s
B) 1.3 s
C) 8.9 s
D) 6.3 s
E) 2.2 s

ANS: D PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | half-life of a reaction MSC: Quantitative

51. For a reaction: $aA \rightarrow Products$, $[A]_0 = 4.2\ M$, and the first two half-lives are 56 and 28 minutes, respectively. Calculate k (without units).
A) 7.5×10^{-2}
B) 4.3×10^{-3}
C) 3.7×10^{-2}
D) 8.5×10^{-3}
E) none of these

ANS: C PTS: 1 DIF: Difficult REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | half-life of a reaction MSC: Quantitative

52. For a reaction: $aA \rightarrow Products$, $[A]_0 = 6.0\ M$, and the first two half-lives are 56 and 28 minutes, respectively. Calculate [A] at $t = 105.9$ minutes.
A) 5.7 *M*
B) 12 *M*
C) 0.68 *M*
D) 0.33 *M*
E) none of these

ANS: D PTS: 1 DIF: Difficult REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | zero-order reaction MSC: Quantitative

53. For which order reaction is the half-life of the reaction proportional to $1/k$ (k is the rate constant)?
A) zero order
B) first order
C) second order
D) all of the above
E) none of the above

ANS: D PTS: 1 DIF: Easy REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | half-life of a reaction MSC: Conceptual

The kinetics of the reaction $A + 3B \rightarrow C + 2D$ were studied and the following results obtained, where the rate law is:

$$-\frac{\Delta[A]}{\Delta t} = k[A]^n[B]^m$$

For a run where $[A]_0 = 1.0 \times 10^{-3}$ *M* and $[B]_0 = 5.0$ *M*, a plot of ln [A] versus *t* was found to give a straight line with slope = -5.0×10^{-2} s^{-1}.
For a run where $[A]_0 = 1.0 \times 10^{-3}$ *M* and $[B]_0 = 10.0$ *M*, a plot of ln [A] versus *t* was found to give a straight line with slope = -7.1×10^{-2} s^{-1}.

54. What is the value of *n*?
A) 0
B) 0.5
C) 1
D) 1.5
E) 2

ANS: C PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | graphing of kinetic data MSC: Conceptual

55. What is the value of *m*?
A) 0
B) 0.5
C) 1
D) 1.5
E) 2

ANS: B PTS: 1 DIF: Difficult REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | graphing of kinetic data MSC: Conceptual

56. Calculate the value of *k* (ignore units).
A) 22
B) 10
C) 50
D) 1.1
E) none of these

ANS: A PTS: 1 DIF: Difficult REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | graphing of kinetic data MSC: Quantitative

For the reaction $2N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$, the following data were collected:

t (minutes)	$[N_2O_5]$ (mol/L)
0	1.24×10^{-2}
10.	0.92×10^{-2}
20.	0.68×10^{-2}

30. 0.50×10^{-2}
40. 0.37×10^{-2}
50. 0.28×10^{-2}
70. 0.15×10^{-2}

57. The order of this reaction in N_2O_5 is
A) 0
B) 1
C) 2
D) 3
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | graphing of kinetic data MSC: Conceptual

58. The concentration of O_2 at t = 10. minutes is
A) 2.0×10^{-4} mol/L
B) 0.32×10^{-2} mol/L
C) 0.16×10^{-2} mol/L
D) 0.64×10^{-2} mol/L
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | graphing of kinetic data MSC: Quantitative

59. The initial rate of production of NO_2 for this reaction is approximately
A) 7.4×10^{-4} mol/L·min
B) 3.2×10^{-4} mol/L·min
C) 1.24×10^{-2} mol/L·min
D) 1.6×10^{-4} mol/L·min
E) none of these

ANS: A PTS: 1 DIF: Difficult REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | graphing of kinetic data MSC: Quantitative

60. The half-life of this reaction is approximately
A) 15 minutes
B) 18 minutes
C) 23 minutes
D) 36 minutes
E) 45 minutes

ANS: C PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | half-life of a reaction MSC: Quantitative

61. The concentration N_2O_5 at 100 minutes will be approximately

A) 0.03×10^{-2} mol/L
B) 0.06×10^{-2} mol/L
C) 0.10×10^{-2} mol/L
D) 0.01×10^{-2} mol/L
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | graphing of kinetic data MSC: Quantitative

The following questions refer to the hypothetical reaction A + B → products. The kinetics data given can be analyzed to answer the questions.

$[A]_0$ (mol/L)	$[B]_0$ (mol/L)	Rate of decrease of [A] (*M*/s)
5.0	5.0	X
10.0	5.0	2X
5.0	10.0	2X

Time (s)	[B] (mol/L)
10.0	100
20.0	100
30.0	100

62. The rate law for the reaction is Rate = $k[A]^x[B]^y$. What are the values of *x* and *y*?
A) $x = 0$ $y = 1$
B) $x = 1$ $y = 0$
C) $x = 1$ $y = 1$
D) $x = 2$ $y = 1$
E) $x = 1$ $y = 2$

ANS: C PTS: 1 DIF: Easy REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | determining the rate law MSC: Conceptual

63. What form will the pseudo-rate law have?
A) Rate = $k'[A]^x$
B) Rate = $k'[B]^y$
C) Rate = $k'[A]^x[B]^y$
D) Rate = $kk'[A]^x$
E) Rate = $kk'[B]^y$

ANS: A PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | determining the rate law MSC: Conceptual

64. Determine the magnitude of the pseudo-rate constant (*k*') if the magnitude of X in the rate data is 0.00905.
A) 4.3×10^{-3}
B) 1.2×10^{-2}
C) 0.86

D) 0.31
E) 1.81×10^{-3}

ANS: E PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration MSC: Quantitative

The reaction $A \rightarrow B + C$ is known to be zero order in A with a rate constant of 5.0×10^{-2} mol/L·s at 25°C. An experiment was run at 25°C where $[A]_0 = 1.0 \times 10^{-3}$ *M*.

65. The integrated rate law is
A) $[A] = kt$
B) $[A] - [A]_0 = kt$
C) $\frac{[A]}{[A]_0} = kt$
D) $\ln \frac{[A]}{[A]_0} = kt$
E) $[A]_0 - [A] = kt$

ANS: E PTS: 1 DIF: Easy REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | zero-order reaction MSC: Conceptual

66. What is the concentration of B after 5×10^{-3} sec?
A) 5.0×10^{-5} *M*
B) 5.0×10^{-4} *M*
C) 7.5×10^{-4} *M*
D) 2.5×10^{-4} *M*
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | zero-order reaction MSC: Quantitative

67. The reaction $A \rightarrow B + C$ is known to be zero order in A with a rate constant of 5.0×10^{-2} mol/L s at 25°C. An experiment was run at 25°C where $[A]_0 = 2.0 \times 10^{-3}$ *M*. After 5.0 minutes, the rate is
A) 5.0×10^{-2} mol/L·s
B) 2.5×10^{-2} mol/L·s
C) 1.3×10^{-2} mol/L·s
D) 2.0×10^{-3} mol/L·s
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | zero-order reaction MSC: Quantitative

68. The reaction $A \rightarrow B + C$ is known to be zero order in A with a rate constant of 5.0×10^{-2} mol/L s at 25°C. An experiment was run at 25°C where $[A]_0 = 2.7 \times 10^{-3}$ *M*. The half-life for the reaction is

A) 2.7×10^{-2} s
B) 2.7×10^{2} s
C) 5.0×10^{-2} s
D) 5.4×10^{-4} s
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | half-life of a reaction MSC: Quantitative

69. The reaction

$2NOBr \rightarrow 2NO + Br_2$

exhibits the rate law

$$\text{Rate} = k[NOBr]^2 = -\frac{\Delta[NOBr]}{\Delta t}$$

where $k = 1.0 \times 10^{-5}\ M^{-1}\ s^{-1}$ at 25°C. This reaction is run where the initial concentration of NOBr ($[NOBr]_0$) is 0.11 *M*. What is one half-life for this experiment?

A) 1.1 s
B) 0.6×10^{-5} s
C) 6.9×10^{-4} s
D) 9.1×10^{5} s
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction mechanism | integrated rate laws | half-life of a reaction MSC: Quantitative

70. The reaction

$2NOBr \rightarrow 2NO + Br_2$

exhibits the rate law

$$\text{Rate} = k[NOBr]^2 = -\frac{\Delta[NOBr]}{\Delta t}$$

where $k = 1.0 \times 10^{-5}\ M^{-1} \cdot s^{-1}$ at 25°C. This reaction is run where the initial concentration of NOBr ($[NOBr]_0$) is 1.00×10^{-1} *M*.
The [NO] after 1.00 hour has passed is

A) $3.6 \times 10^{-4}\ M$
B) $9.9 \times 10^{-3}\ M$
C) $9.7 \times 10^{-3}\ M$
D) $1.0 \times 10^{-3}\ M$
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | second-order reaction MSC: Quantitative

For the reaction A → Products, successive half-lives are observed to be 10.0 min and 40.0 min.

71. The reaction follows the integrated rate law
A) $[\mathrm{A}] = -kt + [\mathrm{A}]_0$
B) $\ln[\mathrm{A}] = kt + \ln[\mathrm{A}]_0$
C) $\frac{1}{[\mathrm{A}]} = kt + \frac{1}{[\mathrm{A}]_0}$
D) $\frac{1}{[\mathrm{A}]^2} = kt + \frac{1}{[\mathrm{A}]_0^2}$
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | half-life of a reaction MSC: Conceptual

72. At the beginning of the reaction, [A] was 0.71 *M*. The numerical value of the rate constant is
A) 0.069
B) 0.14
C) 10.
D) 0.036
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | half-life of a reaction MSC: Quantitative

73. The reaction

$$2\mathrm{N_2O_5}(g) \rightarrow \mathrm{O_2}(g) + 4\mathrm{NO_2}(g)$$

is first order in N_2O_5. For this reaction at 45°C, the rate constant $k = 1.0 \times 10^{-5}\ s^{-1}$, where the rate law is defined as

$$\text{Rate} = -\frac{\Delta[\mathrm{N_2O_5}]}{\Delta t} = k[\mathrm{N_2O_5}]$$

For a particular experiment ($[N_2O_5]_0 = 1.0 \times 10^{-3}\ M$), calculate $[N_2O_5]$ after 3.5×10^5 seconds.
A) 3.5 *M*
B) $1.0 \times 10^{-3}\ M$
C) $3.0 \times 10^{-5}\ M$
D) 0 *M*
E) 10 *M*

ANS: C PTS: 1 DIF: Easy REF: 12.4

KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | first-order reaction MSC: Quantitative

Consider the reaction $3A + B + C \rightarrow D + E$ where the rate law is defined as

$$-\frac{\Delta[A]}{\Delta t} = k[A]^2[B][C].$$

An experiment is carried out where $[B]_0 = [C]_0 = 1.00\ M$ and $[A]_0 = 1.00 \times 10^{-4}\ M$.

74. After 3.00 minutes, $[A] = 3.26 \times 10^{-5}\ M$. The value of k is
A) $6.23 \times 10^{-3}\ L^3/mol^3 \cdot s$
B) $3.26 \times 10^{-5}\ L^3/mol^3 \cdot s$
C) $1.15 \times 10^{2}\ L^3/mol^3 \cdot s$
D) $1.00 \times 10^{8}\ L^3/mol^3 \cdot s$
E) none of these

ANS: C PTS: 1 DIF: Difficult REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws
MSC: Quantitative

75. The half-life for this experiment is
A) 1.11×10^{2} s
B) 87.0 s
C) 6.03×10^{-3} s
D) 117 s
E) none of these

ANS: B PTS: 1 DIF: Difficult REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | half-life of a reaction MSC: Quantitative

76. The concentration of C after 10.0 minutes is
A) 1.00 *M*
B) $1.10 \times 10^{-5}\ M$
C) 0.330 *M*
D) 0.100 *M*
E) none of these

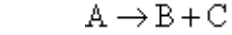
ANS: A PTS: 1 DIF: Easy REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | experimental determination of rate MSC: Conceptual

77. The concentration of A after 10.0 minutes is
A) $1.06 \times 10^{-9}\ M$
B) $2.38 \times 10^{-6}\ M$
C) $9.80 \times 10^{-6}\ M$
D) $1.27 \times 10^{-5}\ M$
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 12.4

KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws
MSC: Quantitative

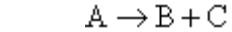
78. The reaction



is second order in A. When $[A]_0 = 0.100\ M$, the reaction is 20.0% complete in 35.9 minutes. Calculate the value of the rate constant (in L/min·mol).
A) 6.96×10^{-2}
B) 5.57×10^{-4}
C) 1.57
D) 1.11
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | second-order reaction MSC: Quantitative

79. The reaction

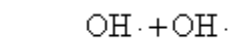


is second order in A. When $[A]_0 = 0.100\ M$, the reaction is 20.0% complete in 43.2 minutes. Calculate the half-life for the reaction.
A) 1.73×10^2 min
B) 10.8 min
C) 2.16×10^4 min
D) 7.68 min
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | half-life of a reaction MSC: Quantitative

80. A first-order reaction is 40.0% complete at the end of 48.1 minutes. What is the value of the rate constant (in min^{-1})?
A) 1.90×10^{-2}
B) 1.06×10^{-2}
C) 94.2
D) 52.5
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | first-order reaction MSC: Quantitative

81. The OH· radical disproportionates according to the elementary chemical reaction  This reaction is second order in OH·. The rate constant for the reaction is 2.0×10^{-12} cm^3/molecules at room temperature. If the initial OH concentration is 1.3×10^{13} molecules/cm^3, what is the first half-life for the reaction?
A) 3.5×10^{11} s

B) 2.6×10^{1} s
C) 3.8×10^{-2} s
D) 7.7×10^{-14} s
E) 1.9×10^{-2} s

ANS: C PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | half-life of a reaction MSC: Quantitative

82. At a particular temperature, N_2O_5 decomposes according to a first-order rate law with a half-life of 3.0 s. If the initial concentration of N_2O_5 is 1.0×10^{16} molecules/cm^3, what will be the concentration in molecules/cm^3 after 16.1 s?
A) 2.4×10^{14}
B) 3.3×10^{1}
C) 1.0×10^{16}
D) 1.4×10^{14}
E) 2.3×10^{-1}

ANS: A PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | first-order reaction MSC: Quantitative

83. At a given temperature, a first-order reaction has a rate constant of 3.4×10^{-3} s^{-1}. The time required for the reaction to be 44% completed is
A) 4.0 min
B) 1.2 min
C) 20 min
D) 2.8 min
E) 19 min

ANS: D PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | first-order reaction MSC: Quantitative

84. A chemical reaction that is first order in *X* is observed to have a rate constant of 1.7×10^{-2}s^{-1}. If the initial concentration of *X* is 1.0 *M*, what is the concentration of *X* after 190 s?
A) 25 *M*
B) 0.68 *M*
C) 0.24 *M*
D) 0.96 *M*
E) 0.040 *M*

ANS: E PTS: 1 DIF: Easy REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | first-order reaction MSC: Quantitative

85. A particular first-order reaction has a rate constant of 0.0107 s^{-1}. What is the half-life for this reaction?
A) 1.00 s

B) 64.6 s
C) 93.2 s
D) 0.0155 s
E) 0.0107 s

ANS: B PTS: 1 DIF: Easy REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | half-life of a reaction MSC: Quantitative

86. The reaction A $\rightarrow$ products is first order. If the initial concentration of A is 0.528 *M* and, after 16.3 seconds have elapsed, the concentration of A has fallen to 0.0122 *M*, what is the rate constant of the reaction?
A) 0.231 s^{-1}
B) 0.0425 s^{-1}
C) 0.0316 s^{-1}
D) 4.91 s^{-1}
E) 0.0613 s^{-1}

ANS: A PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | first-order reaction MSC: Quantitative

87. The reaction A $\rightarrow$ products is second order. If the initial concentration of A is 0.436 *M* and, after 52.8 seconds have elapsed, the concentration of A has fallen to 0.0476 *M*, what is the rate constant of the reaction?
A) 0.0419 M^{-1} s^{-1}
B) 0.354 M^{-1} s^{-1}
C) 0.0131 M^{-1} s^{-1}
D) 0.00736 M^{-1} s^{-1}
E) 0.0189 M^{-1} s^{-1}

ANS: B PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | second-order reaction MSC: Quantitative

88. The radioactive nuclide ^{178}Ta undergoes first-order decay with a half-life of 9.31 min. If a quantity of ^{178}Ta is produced, what fraction remains after 82.5 seconds?
A) 0.113
B) 0.00215
C) 0.148
D) 0.903
E) 0.0973

ANS: D PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | first-order reaction MSC: Quantitative

89. ^{63}Ni decays by a first-order process via the emission of a beta particle. The ^{63}Ni isotope has a half-life of 100. years. How long will it take for 67% of the nickel to undergo decay?
A) 58 years

B) 0.77 years
C) 69 years
D) 25 years
E) 160 years

ANS: E PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | first-order reaction MSC: Quantitative

Two isomers (A and B) of a given compound dimerize as follows:

$$2A \rightarrow A_2$$

$$2B \rightarrow B_2$$

Both processes are known to be second order in reactant, and k_1 is known to be 0.25 L/mol·s at 25°C, where

$$\text{Rate} = -\frac{\Delta[A]}{\Delta t} = k_1[A]^2$$

In a particular experiment, A and B were placed in separate containers at 25°, where $[A]_0 = 1.0 \times 10^{-2}$ *M* and $[B]_0 = 2.5 \times 10^{-2}$ *M*. It was found that [A] = 3[B] after the reactions progressed for 3.0 minutes.

90. Calculate the concentration of A_2 after 3.0 minutes.
A) 2.8×10^{-22} *M*
B) 6.9×10^{-3} *M*
C) 3.1×10^{-3} *M*
D) 1.6×10^{-3} *M*
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | second-order reaction MSC: Quantitative

91. Calculate the value of k_2 where

$$\text{Rate} = -\frac{\Delta[B]}{\Delta t} = k_2[B]^2$$

A) 2.2 L/mol·s
B) 0.75 L/mol·s
C) 1.9 L/mol·s
D) 0.21 L/mol·s
E) none of these

ANS: A PTS: 1 DIF: Difficult REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | second-order reaction MSC: Quantitative

92. Two isomers (A and B) of a given compound dimerize as follows:

$2A \rightarrow A_2$

$2B \rightarrow B_2$

Both processes are known to be second order in reactant, and k_1 is known to be 0.24 L/mol s at 25°C, where:

$$\text{Rate} = -\frac{\Delta[A]}{\Delta t} = k_1[A]^2$$

In a particular experiment, A and B were placed in separate containers at 25°C, where $[A]_0 = 1.0 \times 10^{-2}$ *M* and $[B]_0 = 2.5 \times 10^{-2}$ *M*. It was found that [A] = 3[B] after the reactions progressed for 3.0 minutes. Calculate the half-life for the reaction involving A.

A) 4.2×10^2 s
B) 1.0×10^2 s
C) 1.8×10^2 s
D) 2.4×10^3 s
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | half-life of a reaction MSC: Quantitative

93. The decomposition of $N_2O_5(g)$ to $NO_2(g)$ and $O_2(g)$ obeys first-order kinetics. Assuming the form of the rate law is:

$$\text{Rate} = -\frac{\Delta[N_2O_5]}{\Delta t} = k[N_2O_5]$$

where $k = 3.4 \times 10^{-5}$ s^{-1} at 25°C, what is the initial rate of reaction at 25°C where $[N_2O_5]_0 = 8.2 \times 10^{-2}$ *M*?

A) 3.4×10^{-5} mol/L·s
B) 2.8×10^{-6} mol/L·s
C) 4.1×10^{-4} mol/L·s
D) 8.2×10^{-2} mol/L·s
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | first-order reaction MSC: Quantitative

94. The decomposition of $N_2O_5(g)$ to $NO_2(g)$ and $O_2(g)$ obeys first-order kinetics. Assuming the form of the rate law is:

$$\text{Rate} = -\frac{\Delta[N_2O_5]}{\Delta t} = k[N_2O_5]$$

where $k = 5.4 \times 10^{-5}$ s^{-1} at 25°C, what is the half-life for the reaction described?

A) 1.9×10^4 s
B) 1.3×10^4 s

C) 3.4×10^{8} s
D) 7.8×10^{-5} s
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | half-life of a reaction MSC: Quantitative

95. Consider a reaction of the type aA → Products in which the rate law is found to be rate = $k[A]^3$ (yes, a termolecular reaction is improbable but possible). If the first half-life of the reaction is found to be 40 seconds, what is the time for the second half-life?
A) 10 seconds
B) 20 seconds
C) 80 seconds
D) 160 seconds
E) 320 seconds

ANS: D PTS: 1 DIF: Difficult REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | half-life of a reaction MSC: Quantitative

96. The reaction $2NO_2 \rightarrow 2NO + O_2$ obeys the rate law:

$$\frac{\Delta[O_2]}{\Delta t} = \left(1.40 \times 10^{-2}\ \text{sec}\right)[NO_2]^2 \text{ at 500. K.}$$

If the initial concentration of NO_2 is 1.00 *M*, how long will it take for the $[NO_2]$ to decrease to 35.8% of its initial value?
A) 45.9 s
B) 73 s
C) 128 s
D) 1.40×10^{-2} s
E) cannot be determined from this data

ANS: C PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | second-order reaction MSC: Quantitative

97. If the reaction $2HI \rightarrow H_2 + I_2$ is second order, which of the following will yield a linear plot?
A) log [HI] vs time
B) 1/[HI] vs time
C) [HI] vs time
D) ln [HI] vs time
E) None of these.

ANS: B PTS: 1 DIF: Easy REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | graphing of kinetic data MSC: Conceptual

98. The reaction $3NO \rightarrow N_2O + NO_2$ is found to obey the rate law, Rate = $k[NO]^2$. If the first half-life of the reaction is found to be 2.0 s, what is the length of the fourth half-life?
A) 2.0 s
B) 4.0 s
C) 8.0 s
D) 12.0 s
E) 16.0 s

ANS: E PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | half-life of a reaction MSC: Conceptual

99. In 6 *M* HCl, the complex ion $Ru(NH_3)_6^{3+}$ decomposes to a variety of products. The reaction is first order in $Ru(NH_3)_6^{3+}$ and has a half-life of 14 hours at 25°C. Under these conditions, how long will it take for the $[Ru(NH_3)_6^{3+}]$ to decrease to 23.5% of its initial value?
A) 5.4 hours
B) 9.7 hours
C) 3.3 hours
D) 14 hours
E) 29 hours

ANS: E PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | first-order reaction MSC: Quantitative

100. The elementary chemical reaction $O + ClO \rightarrow Cl + O_2$ is made pseudo-first order in oxygen atoms by using a large excess of ClO radicals. The rate constant for the reaction is 2.7 cm^3/molecule·s. If the initial concentration of ClO is 1.0×10^{11} molecules/cm^3, how long will it take for the oxygen atoms to decrease to 10.% of their initial concentration?
A) 1.2 s
B) 0.039 s
C) 0.26 s
D) 0.85 s
E) 2.6 s

ANS: D PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | first-order reaction MSC: Quantitative

101. Determine the molecularity of the following elementary reaction: $O_3 \rightarrow O_2 + O$.
A) unimolecular
B) bimolecular
C) termolecular
D) quadmolecular
E) molecularity cannot be determined

ANS: A PTS: 1 DIF: Easy REF: 12.5
KEY: Chemistry | general chemistry | rates of reaction | reaction mechanism | elementary reaction | molecularity MSC: Conceptual

102. The decomposition of ozone may occur through the two-step mechanism shown:

step 1 $O_3 \rightarrow O_2 + O$

step 2 $O_3 + O \rightarrow 2O_2$

The oxygen atom is considered to be a(n)
A) reactant
B) product
C) catalyst
D) reaction intermediate
E) activated complex

ANS: D PTS: 1 DIF: Easy REF: 12.5
KEY: Chemistry | general chemistry | rates of reaction | reaction mechanism | elementary reaction MSC: Conceptual

103. The rate law for a reaction is found to be Rate = $k[A]^2[B]$. Which of the following mechanisms gives this rate law?

I. $A + B \rightleftharpoons E$ (fast)
$E + B \rightarrow C + D$ (slow)
II. $A + B \rightleftharpoons E$ (fast)
$E + A \rightarrow C + D$ (slow)
III. $A + A \rightarrow E$ (slow).
$E + B \rightarrow C + D$ (fast)

A) I
B) II
C) III
D) two of these
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 12.5
KEY: Chemistry | general chemistry | rates of reaction | reaction mechanism | the rate law and the mechanism MSC: Conceptual

104. The experimental rate law for the decomposition of nitrous oxide (N_2O) to N_2 and O_2 is Rate = $k[N_2O]^2$. Two mechanisms are proposed:

I. $N_2O \rightarrow N_2 + O$
$N_2O + O \rightarrow N_2 + O_2$
II. $2N_2O \rightleftharpoons N_4O_2$
$N_4O_2 \rightarrow 2N_2 + O_2$

Which of the following could be a correct mechanism?
A) Mechanism I, with the first step as the rate-determining step.
B) Mechanism I, with the second step as the rate-determining step as long as the first step is a fast equilibrium step.
C) Mechanism II, with the second step as the rate-determining step if the first step is a fast equilibrium step.

D) None of the choices (A-C) could be correct.
E) At least two of the above choices (A-C) could be correct.

ANS: C PTS: 1 DIF: Easy REF: 12.5
KEY: Chemistry | general chemistry | rates of reaction | reaction mechanism | the rate law and the mechanism MSC: Conceptual

105. Consider the reaction $2O_3(g) \rightarrow 3O_2(g)$. The following mechanism is proposed:

$$O_3 \rightleftharpoons O_2 + O$$
$$O_3 + O \rightarrow 2O_2$$

If we assume the second step of the mechanism is the rate determining step and the first step is a fast equilibrium step, which of the following rate laws is predicted by this mechanism?
A) rate = $k[O_3]$
B) rate = $k[O_3]^2[O_2]$
C) rate = $k[O_3]^2[O_2]^{-1}$
D) rate = $k[O_3]^2$
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 12.5
KEY: Chemistry | general chemistry | rates of reaction | reaction mechanism | the rate law and the mechanism MSC: Conceptual

106. Of what use is it to find a rate law for a reaction?
A) We can use the rate law to directly determine coefficients in the balanced equation.
B) From the rate law we can evaluate potential reaction mechanisms.
C) The rate law gives us a good indication of the thermodynamic stability of the products.
D) The rate law can lead us to determine the equilibrium constant for the reaction.
E) None of these.

ANS: B PTS: 1 DIF: Easy REF: 12.5
KEY: Chemistry | general chemistry | rates of reaction | reaction mechanism | the rate law and the mechanism MSC: Conceptual

The following questions refer to the reaction $2A_2 + B_2 \rightarrow 2C$. The following mechanism has been proposed:

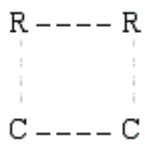
step 1 (very slow) $A_2 + B_2 \rightarrow R + C$
step 2 (slow) $A_2 + R \rightarrow C$

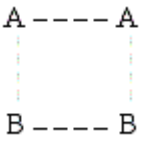
107. What is the molecularity of step 2?
A) unimolecular
B) bimolecular
C) termolecular
D) quadmolecular
E) molecularity cannot be determined

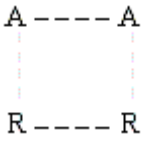
ANS: B PTS: 1 DIF: Easy REF: 12.5
KEY: Chemistry | general chemistry | rates of reaction | reaction mechanism | elementary reaction | molecularity MSC: Conceptual

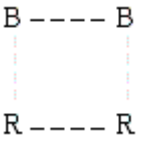
108. Which step is rate determining?
A) both steps
B) step 1
C) step 2
D) a step that is intermediate to step 1 and step 2
E) none of these

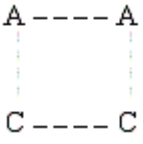
ANS: B PTS: 1 DIF: Easy REF: 12.5
KEY: Chemistry | general chemistry | rates of reaction | reaction mechanism | the rate law and the mechanism | rate determining step MSC: Conceptual

109. According to collision theory, the activated complex that forms in step 1 could have which of the following structures? (The dotted lines represent partial bonds.)
A)


B)


C)


D)


E)


ANS: B PTS: 1 DIF: Moderate REF: 12.6
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | collision theory | activated complex MSC: Conceptual

110. According to the proposed mechanism, what should the overall rate law be?
A) rate = $k[A_2]^2$
B) rate = $k[A_2]$
C) rate = $k[A_2][B_2]$
D) rate = $k[A_2][R]$
E) rate = $k[R]^2$

ANS: C PTS: 1 DIF: Easy REF: 12.5
KEY: Chemistry | general chemistry | rates of reaction | reaction mechanism | the rate law

and the mechanism MSC: Conceptual

Under certain conditions the reaction $H_2O_2 + 3I^- + 2H^+ \rightarrow I_3^- + 2H_2O$ occurs by the following series of steps:

Step 1. $H_2O_2 + H^+ \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} H_3O_2^+$

$$\left(\text{rapid equilibrium constant } K = \frac{k_1}{k_{-1}} \right)$$

Step 2. $H_3O_2^+ + I^- \rightarrow H_2O + HOI$ (slow, rate constant k_2)
Step 3. $HOI + I^- \rightarrow OH^- + I_2$ (fast, rate constant k_3)
Step 4. $OH^- + H^+ \rightarrow H_2O$ (fast, rate constant k_4)
Step 5. $I_2 + I^- \rightarrow I_3^-$ (fast, rate constant k_5)

111. Which of the steps would be called the rate-determining step?
A) 1
B) 2
C) 3
D) 4
E) 5

ANS: B PTS: 1 DIF: Easy REF: 12.5
KEY: Chemistry | general chemistry | rates of reaction | reaction mechanism | the rate law and the mechanism | rate determining step MSC: Conceptual

112. The rate constant k for the reaction would be given by
A) $k = k_2$
B) $k = k_2k_3$
C) $k = k_2K$
D) $k = k_5$
E) $k = Kk_2k_3k_4k_5$

ANS: C PTS: 1 DIF: Easy REF: 12.5
KEY: Chemistry | general chemistry | rates of reaction | reaction mechanism | the rate law and the mechanism MSC: Conceptual

113. The rate law for the reaction would be:
A) $\Delta[I_3]/\Delta t = k[H_2O_2]$
B) $\Delta[I_3]/\Delta t = k[H_2O_2][H^+][I^-]$
C) $\Delta[I_3]/\Delta t = k[H_2O_2][H^+]$
D) $\Delta[I_3]/\Delta t = k[H_2O_2][I^-]$
E) $\Delta[I_3]/\Delta t = k[H_2O_2][H^+]^2[I^-]^{-3}$

ANS: B PTS: 1 DIF: Easy REF: 12.5
KEY: Chemistry | general chemistry | rates of reaction | reaction mechanism | the rate law and the mechanism MSC: Conceptual

114. The reaction:

$2A + B \rightarrow C$

has the following proposed mechanism:

Step 1: $A + B \rightleftharpoons D$ (fast equilibrium)
Step 2: $D + B \rightarrow E$
Step 3: $E + A \rightarrow C + B$

If step 2 is the rate-determining step, then the rate of formation of C should equal:
A) $k[A]$
B) $k[A]^2[B]$
C) $k[A]^2[B]^2$
D) $k[A][B]$
E) $k[A][B]^2$

ANS: E PTS: 1 DIF: Easy REF: 12.5
KEY: Chemistry | general chemistry | rates of reaction | reaction mechanism | the rate law and the mechanism | rate determining step MSC: Conceptual

115. The reaction $2NO + O_2 \rightarrow 2NO_2$ obeys the rate law $-\frac{\Delta[O_2]}{\Delta t} = k_{obsd}[NO]^2[O_2]$.

Which of the following mechanisms is consistent with the experimental rate law?
A) $NO + NO \rightarrow N_2O_2$ (slow)
$N_2O_2 + O_2 \rightarrow 2NO_2$ (fast)
B) $NO + O_2 \rightleftharpoons NO_3$ (fast equilibrium)
$NO_3 + NO \rightarrow 2NO_2$ (slow)
C) $2NO \rightleftharpoons N_2O_2$ (fast equilibrium)
$N_2O_2 \rightarrow NO_2 + O$ (slow)
$NO + O \rightarrow NO_2$ (fast)
D) $O_2 + O_2 \rightarrow O_2 + O_2$ (slow)
$O_2 + NO \rightarrow NO_2 + O$ (fast)
$O + NO \rightarrow NO_2$ (fast)
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 12.5
KEY: Chemistry | general chemistry | rates of reaction | reaction mechanism | the rate law and the mechanism MSC: Conceptual

116. The rate constant *k* is dependent on

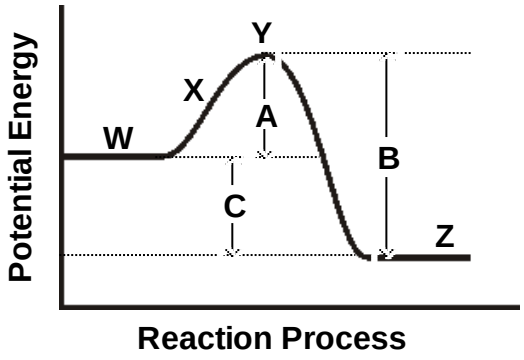
I. the concentration of the reactant
II. the nature of the reactants
III. the temperature
IV. the order of the reaction

A) none of these
B) one of these
C) two of these
D) three of these

E) all of these

ANS: C PTS: 1 DIF: Easy REF: 12.6
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | collision theory
MSC: Conceptual

The questions below refer to the following diagram:



117. Why is this reaction considered to be exothermic?
A) Because energy difference B is greater than energy difference C.
B) Because energy difference B is greater than energy difference A.
C) Because energy difference A is greater than energy difference C.
D) Because energy difference B is greater than energy difference C plus energy difference A.
E) Because energy difference A and energy difference C are about equal.

ANS: B PTS: 1 DIF: Easy REF: 12.6
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | collision theory
MSC: Conceptual

118. At what point on the graph is the activated complex present?
A) point W
B) point X
C) point Y
D) point Z
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 12.6
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | collision theory | activated complex MSC: Conceptual

119. If the reaction were reversible, would the forward or the reverse reaction have a higher activation energy?
A) The diagram shows no indication of any activation energy.
B) The forward and reverse activation energies are equal.
C) The forward activation energy would be greater.
D) The reverse activation energy would be greater.
E) None of these.

ANS: D PTS: 1 DIF: Easy REF: 12.6

KEY: Chemistry | general chemistry | rates of reaction | reaction rate | collision theory | activation energy MSC: Conceptual

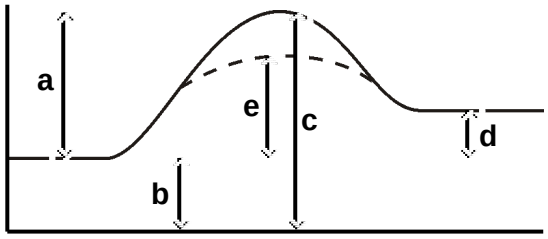
120. What would happen if the kinetic energy of the reactants was not enough to provide the needed activation energy?
A) The products would be produced at a lower energy state.
B) The rate of the reaction would tend to increase.
C) The activated complex would convert into products.
D) The reactants would continue to exist in their present form.
E) The products would form at an unstable energy state.

ANS: D PTS: 1 DIF: Easy REF: 12.6
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | collision theory | activation energy MSC: Conceptual

121. The rate constant for a reaction at 40.0°C is exactly 3 times that at 20.0°C. Calculate the Arrhenius energy of activation for the reaction.
A) 9.13 kJ/mol
B) 5.04 kJ/mol
C) 41.9 kJ/mol
D) 3.00 kJ/mol
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 12.6
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | Arrhenius equation
MSC: Quantitative

Use the potential energy diagram shown to answer the following:



122. Which letter shows the activation energy (without use of a catalyst)?
A) a
B) b
C) c
D) d
E) e

ANS: A PTS: 1 DIF: Easy REF: 12.6
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | collision theory | activation energy MSC: Conceptual

123. Which letter shows the change in energy for the overall reaction?
A) a

B) b
C) c
D) d
E) e

ANS: D PTS: 1 DIF: Easy REF: 12.6
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | collision theory
MSC: Conceptual

124. Which letter shows the activation energy using a catalyst?
A) a
B) b
C) c
D) d
E) e

ANS: E PTS: 1 DIF: Easy REF: 12.7
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | collision theory | activation energy MSC: Conceptual

The questions below refer to the following information: The rate constant *k* for the reaction shown below is 2.6×10^{-8} L/mol · s when the reaction proceeds at 300.0 K. The activation energy is 98000 J/mol. (The universal gas constant, *R*, is 8.314 J/mol·K)

$2NOCl \rightarrow 2NO + Cl_2$

125. Determine the magnitude of the frequency factor for the reaction.
A) 1.2×10^8
B) 4.6×10^9
C) 3.0×10^9
D) 2.7×10^8
E) 9.1×10^9

ANS: C PTS: 1 DIF: Moderate REF: 12.6
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | Arrhenius equation
MSC: Quantitative

126. If the temperature changed to 310 K, the rate constant *k* would change. The ratio of *k* at 310 K to *k* at 300.0 K is closest to what whole number?
A) 1
B) 2
C) 3
D) 4
E) 5

ANS: D PTS: 1 DIF: Difficult REF: 12.6
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | Arrhenius equation
MSC: Quantitative

127. Use the following information to determine the activation energy for the reaction shown here:

$2NO \rightarrow N_2 + O_2$

Temperature (K)	Rate Constant (L/mol·s)
1400	0.143
1500	0.685

A) 6.6×10^4 J/mol
B) 1.3×10^1 J/mol
C) 9.4×10^3 J/mol
D) 3.3×10^4 J/mol
E) 2.7×10^5 J/mol

ANS: E PTS: 1 DIF: Moderate REF: 12.6
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | Arrhenius equation
MSC: Quantitative

128. When ethyl chloride, CH_3CH_2Cl, is dissolved in 1.0 *M* NaOH, it is converted into ethanol, CH_3CH_2OH, by the reaction:

$CH_3CH_2Cl + OH^- \rightarrow CH_3CH_2OH + Cl^-$

At 25°C the reaction is first order in CH_3CH_2Cl, and the rate constant is $3.1 \times 10^{-3}\ s^{-1}$. If the activation parameters are $A = 3.4 \times 10^{14}\ s^{-1}$ and E_a = 100.0 kJ/mol, what will the rate constant be at 40.°C?

A) $2.1 \times 10^{-2}\ s^{-1}$
B) $4.5 \times 10^{-4}\ s^{-1}$
C) $2.2 \times 10^{3}\ s^{-1}$
D) $6.0 \times 10^{-3}\ s^{-1}$
E) $1.6 \times 10^{-3}\ s^{-1}$

ANS: A PTS: 1 DIF: Moderate REF: 12.6
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | Arrhenius equation
MSC: Quantitative

129. Which of the following statements best describes the condition(s) needed for a successful formation of a product according to the collision model?

A) The collision must involve a sufficient amount of energy, provided from the motion of the particles, to overcome the activation energy.
B) The relative orientation of the particles has little or no effect on the formation of the product.
C) The relative orientation of the particles has an effect only if the kinetic energy of the particles is below some minimum value.
D) The relative orientation of the particles must allow for formation of the new bonds in the product.
E) The energy of the incoming particles must be above a certain minimum value, and the relative orientation of the particles must allow for formation of new bonds in the product.

ANS: E PTS: 1 DIF: Easy REF: 12.6

KEY: Chemistry | general chemistry | rates of reaction | reaction rate | collision theory
MSC: Conceptual

130. The rate constant for a reaction is 1.5×10^{-2} s^{-1} at 734 K and 3.9×10^{-2} s^{-1} at 878 K. What is the activation energy?
A) 15 kJ/mol
B) 36 kJ/mol
C) 440 kJ/mol
D) 4300 kJ/mol
E) This can't be solved without knowing the frequency factor.

ANS: B PTS: 1 DIF: Moderate REF: 12.6
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | Arrhenius equation
MSC: Quantitative

131. For the second-order reaction $NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g)$, the rate constant has been measured to be 1.08×10^7 M^{-1} s^{-1} at 298 K and the activation energy has been measured to be 11.4 kJ/mol over the temperature range 195 K to 304 K. What is the rate constant at 233 K? (R = 8.3145 J K^{-1} mol^{-1})
A) 1.08×10^7 M^{-1} s^{-1}
B) 1.08×10^9 M^{-1} s^{-1}
C) 2.99×10^6 M^{-1} s^{-1}
D) 3.90×10^7 M^{-1} s^{-1}
E) 9.51×10^5 M^{-1} s^{-1}

ANS: C PTS: 1 DIF: Difficult REF: 12.6
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | Arrhenius equation
MSC: Quantitative

132. The reaction $2H_2O_2 \rightarrow 2H_2O + O_2$ has the following mechanism:

$H_2O_2 + I^- \rightarrow H_2O + IO^-$
$H_2O_2 + IO^- \rightarrow H_2O + O_2 + I^-$

The catalyst in the reaction is:
A) H_2O
B) I^-
C) H_2O_2
D) IO^-
E) There is no catalyst in this reaction.

ANS: B PTS: 1 DIF: Easy REF: 12.7
KEY: Chemistry | general chemistry | rates of reaction | reaction mechanism | catalysis
MSC: Conceptual

133. Which of the following statements is typically true for a catalyst?

I. The concentration of the catalyst will go down as a reaction proceeds.
II. The catalyst provides a new pathway in the reaction mechanism.
III. The catalyst speeds up the reaction.

A) I only
B) II only
C) III only
D) I and III
E) II and III

ANS: E PTS: 1 DIF: Easy REF: 12.7
KEY: Chemistry | general chemistry | rates of reaction | reaction mechanism | catalysis
MSC: Conceptual

134. The catalyzed pathway in a reaction mechanism has a _____ activation energy and thus causes a _____ reaction rate.
A) higher, lower
B) higher, higher
C) lower, higher
D) lower, steady
E) higher, steady

ANS: C PTS: 1 DIF: Easy REF: 12.7
KEY: Chemistry | general chemistry | rates of reaction | reaction mechanism | catalysis
MSC: Conceptual

135. Which of the following statements about enzymes is incorrect?
A) They are proteins that catalyze specific biologic reactions.
B) Several hundred are now known.
C) The molecules they react with are called substrates.
D) They are equal to inorganic catalysts in efficiency.
E) All of these are correct.

ANS: D PTS: 1 DIF: Moderate REF: 12.7
KEY: Chemistry | general chemistry | rates of reaction | reaction mechanism | catalysis | enzyme catalysis MSC: Conceptual

136. Determine (a) the rate equation and (b) the rate constant for the hypothetical reaction $A + B \rightarrow C$ given the following initial concentrations and initial rate data.

Run #	$[A]_0$ (mol/L)	$[B]_0$ (mol/L)	Initial Rate (mol/L·s)
(1)	0.100	0.100	0.18
(2)	0.100	0.200	0.36
(3)	0.200	0.200	1.44

ANS:
a) rate = $k[A]^2[B]$ (b) 1.8×10^2 L^2/mol^2s

a) Use method of initial rates to solve for exponents:

$$\frac{rate3}{rate2} = \frac{1.44}{0.36} = \frac{[0.200]^n[0.200]^m}{[0.100]^n[0.200]^m}$$

$4 = [2]^n$; $n = 2$

$$\frac{rate2}{rate1} = \frac{0.36}{0.18} = \frac{[0.100]^n[0.200]^m}{[0.100]^n[0.100]^m}$$

$2 = [2]^m$; $m = 1$
Therefore the rate law is: rate = $k[A]^2[B]$

b) To solve for k, use any set of experimental conditions in the rate law:
$0.18 \text{ mol/L·s} = k(0.100 \text{ mol/L})^2(0.100 \text{ mol/L})$
$k = 0.18 \text{ mol/L·s} / (0.100)^3 \text{ mol}^3/\text{L}^3$; $k = 1.8 \times 10^2 \text{ L}^2/\text{mol}^2\text{s}$

PTS: 1 DIF: Moderate REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration MSC: Quantitative

A reaction represented by the equation was studied at a specific temperature and the following data were collected:

$$3O_2\,(g) \rightarrow 2O_3\,(g)$$

Time (seconds)	Total pressure (atm)
0	1.000
46.89	0.9500
98.82	0.9033
137.9	0.8733
200.0	0.8333
286.9	0.7900
337.9	0.7700
511.3	0.7233

137. What is the rate law for this reaction?

ANS:
rate = $k[O_2]$

Data given represents "total pressure," so it must be adjusted to consider only P_{O_2}.

	$3O_2 \rightarrow$	$2O_3$
Before	1.000	0
Change	$-3x$	$+2x$
After	$1.000 - 3x$	$2x$

Total P = $1.000 - 3x + 2x = 1.000 - x$
At t=46.89, P = $1.000 - x = 0.9500$; $x = 0.0500$
Thus, $P_{O2} = 1.000 - 3(0.0500) = 0.0850$

The corrected table is:

Time (seconds)	Total pressure (atm)
0	1.000
46.89	0.850
98.82	0.710

137.9	0.620
200.0	0.500
286.9	0.370
337.9	0.310
511.3	0.170

This data will give a straight-line plot for $\ln\left(P_{O_2}\right)$ versus time, indicating the reaction is first-order in O_2.

PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | graphing of kinetic data MSC: Conceptual

138. What is the value of the rate constant?

ANS:
$k = 3.47 \times 10^{-3}$ sec^{-1}

This is the slope of the straight line resulting from graph of $\ln\left(P_{O_2}\right)$ versus time (see answer to previous problem).

PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | graphing of kinetic data MSC: Quantitative

139. How many seconds would it take for the total pressure to be 0.7133 atm?

ANS:
567 s

Total pressure of 0.7133 atm must be corrected to reflect P_{O_2} only (see answer to #123).

1.000-x = 0.7133; x = 0.287
1.000-3(0.287) = 0.140 atm
(k = 0.00347 sec^{-1} from previous problem)
ln(0.140) = –0.00347t + ln(1.000); t = 567 s

PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | graphing of kinetic data MSC: Quantitative

For the reaction aA $\rightarrow$ Products, use the following choices

a) zero order in A
b) first order in A
c) second order in A
d) a, b, c
e) none of the above

140. The half-life is constant.

ANS:
b

For a first-order reaction, the half-life is not dependent on concentration, but it is for zero-order and second-order reactions.
See Sec 12.4, Zumdahl *Chemistry*.

PTS: 1 DIF: Easy REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | half-life of a reaction MSC: Conceptual

141. A plot of [A] vs. *t* is a straight line.

ANS:
a

The integrated rate law for a zero-order reaction is: $[A] = -kt + [A]_0$
See Sec 12.4, Zumdahl *Chemistry*.

PTS: 1 DIF: Moderate REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | graphing of kinetic data MSC: Conceptual

142. [A] is constant.

ANS:
e

[A] is the amount of reactant at any time during the reaction. If [A] is constant then there is no reaction occurring.
See Sec. 12.4, Zumdahl *Chemistry*.

PTS: 1 DIF: Easy REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws
MSC: Conceptual

143. The rate is constant over time.

ANS:
a

For a zero-order reaction, the rate law only depends on *k*, and not at all on the amount of reactant present, so it is constant.
See Sec. 12.4, Zumdahl *Chemistry*.

PTS: 1 DIF: Easy REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws

MSC: Conceptual

144. Consider the reaction, 3 A + 5 B → 4 C + 7 D. If C is being produced at a rate of 2.43 mol/L s, at what rate is [A] decreasing?
A) 1.82 mol/L s
B) 3.24 mol/L s
C) 3.6 mol/L s
D) –1.82 mol/L s
E) 2.43 mol/L s

ANS: A PTS: 1 DIF: Easy REF: 12.1
KEY: Chemistry | general chemistry | rates of reaction | reaction rate
MSC: Quantitative

145. Consider the reaction, 3 A + 5 B → 4 C + 7 D. If C is being produced at a rate of 1.96 mol/L s, at what rate is [D] increasing?
A) 3.43 mol/L s
B) 1.12 mol/L s
C) 2.1 mol/L s
D) –3.43 mol/L s
E) 1.96 mol/L s

ANS: A PTS: 1 DIF: Easy REF: 12.1
KEY: Chemistry | general chemistry | rates of reaction | reaction rate
MSC: Quantitative

146. The rate law of a particular reaction is found to be, rate = $k[A]^2[B]$. Which of the following statements is FALSE?
A) The reaction is third order overall.
B) The units of k could be (L^2/mol^2 s)
C) Tripling the concentration of A will result in a nine-fold increase in the rate.
D) The actual value of k will depend on the temperature
E) The actual value of k will depend on the concentrations of A and B.

ANS: E PTS: 1 DIF: Easy REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | rate law MSC: Conceptual

147. The following data were obtained for the reaction, C + D + E → products. Determine the rate law.

Initial [C] mol/L	Initial [D] mol/L	Initial [E] mol/L	Initial rate (mol/Ls)
0.15	0.22	0.34	5.11×10^{-3}
0.30	0.22	0.34	1.02×10^{-2}
0.45	0.33	0.34	2.30×10^{-2}
0.30	0.22	0.68	1.03×10^{-2}

A) rate = $k[C][D][E]$
B) rate = $k[C]^2[D]$

C) rate = k[C][D]
D) rate = k[C][E]
E) rate = k[E][D]

ANS: C PTS: 1 DIF: Easy REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | determining rate law MSC: Conceptual

148. The following data were obtained for the reaction, C + D + E → products. Determine the value of k (do not include units)

Initial [C] mol/L	Initial [D] mol/L	Initial [E] mol/L	Initial rate (mol/Ls)
0.15	0.22	0.34	5.11×10^{-3}
0.30	0.22	0.34	1.02×10^{-2}
0.45	0.33	0.34	2.30×10^{-2}
0.30	0.22	0.68	1.03×10^{-2}

A) 0.46
B) 0.23
C) 0.15
D) 0.10
E) 0.068

ANS: C PTS: 1 DIF: Easy REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | determining rate law MSC: Quantitative

149. The following data were obtained for the reaction, C + D + E → products. Determine the units of k.

Initial [C] mol/L	Initial [D] mol/L	Initial [E] mol/L	Initial rate (mol/Ls)
0.15	0.22	0.34	5.11×10^{-3}
0.30	0.22	0.34	1.02×10^{-2}
0.45	0.33	0.34	2.30×10^{-2}
0.30	0.22	0.68	1.03×10^{-2}

A) mol/L
B) mol/L·s
C) 1/s
D) L/mol·s
E) $L^2/mol^2 \cdot s$

ANS: D PTS: 1 DIF: Easy REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | determining rate law MSC: Conceptual

150. Determine the rate law for the reaction: $C_2H_4Br_2 + 3KI \rightarrow C_2H_4 + 2KBr + KI_3$, given the initial rate data below?

$[C_2H_4Br_2]$, M	[KI], M	$\Delta[KI_3]/\Delta t$ (M min^{-1})
0.500	1.80	0.269
0.500	7.20	1.08
1.50	1.80	0.807

A) rate = k[KI]
B) rate = $k[C_2H_4Br_2]$
C) rate = $k[KI]^2$
D) rate = $k[KI][C_2H_4Br_2]$
E) rate = $k[KI][C_2H_4Br_2]^2$

ANS: D PTS: 1 DIF: Easy REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | determining rate law MSC: Conceptual

151. Determine the value of k (without units) for the reaction: $C_2H_4Br_2 + 3KI \rightarrow C_2H_4 + 2KBr + KI_3$, given the initial rate data below?

$[C_2H_4Br_2]$, M	[KI], M	$\Delta[KI_3]/\Delta t$ (M min^{-1})
0.500	1.80	0.269
0.500	7.20	1.08
1.50	1.80	0.807

A) 0.149
B) 0.538
C) 0.0830
D) 0.299
E) 0.598

ANS: D PTS: 1 DIF: Easy REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | determining rate law MSC: Quantitative

152. Determine the units of k for the reaction: $C_2H_4Br_2 + 3KI \rightarrow C_2H_4 + 2KBr + KI_3$, given the initial rate data below?

$[C_2H_4Br_2]$, M	[KI], M	$\Delta[KI_3]/\Delta t$ (M s^{-1})
0.500	1.80	0.269
0.500	7.20	1.08
1.50	1.80	0.807

A) mol/L
B) mol/L·s
C) 1/s
D) L/mol·s
E) $L^2/mol^2 \cdot s$

ANS: D PTS: 1 DIF: Easy REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | determining rate law MSC: Conceptual

153. Which statement is true about the reaction $2A \rightarrow B + C$ which is first order in A and first order overall?
A) The rate of the reaction will decrease at higher concentrations of B and C.
B) The time required for one half of A to react is directly proportional to the quantity

of A.
C) The rate of formation of C is twice the rate of reaction of A.
D) The rate of formation of B is the same as the rate of reaction of A.
E) The concentration of A will decrease exponentially.

ANS: E PTS: 1 DIF: Easy REF: 12.3
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | dependence of rate on concentration | rate law MSC: Conceptual

154. The first-order decomposition of H_2O_2 at -30 °C occurs with a half-life of 42.0 seconds. What will be the residual concentration of 10.2 mol/L H_2O_2 after 3 minutes?
A) 0.326 mol/L
B) 0.523 mol/L
C) 8.73 mol/L
D) 9.71 mol/L
E) 11.9 mol/L

ANS: B PTS: 1 DIF: Difficult REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | first-order reaction MSC: Quantitative

155. The dimerization of NO_2 has a rate constant at 25 °C of 2.45×10^{-2} L/mol min. What will be the concentration of NO_2 after 120. seconds, given a starting concentration of NO_2 of 11.5 mol/L?
A) 0.331 mol/L
B) 0.608 mol/L
C) 7.36 mol/L
D) 10.95 mol/L
E) 12.1 mol/L

ANS: C PTS: 1 DIF: Difficult REF: 12.4
KEY: Chemistry | general chemistry | rates of reaction | reaction rate | integrated rate laws | second-order reaction MSC: Quantitative

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Chapter 13: Chemical Equilibrium

MULTIPLE CHOICE

1. Which of the following is true about a system at equilibrium?
   A) The concentration(s) of the reactant(s) is equal to the concentration(s) of the product(s).
   B) No new product molecules are formed.
   C) The concentration(s) of reactant(s) is constant over time.
   D) The rate of the reverse reaction is equal to the rate of the forward reaction and both rates are equal to zero.
   E) None of the above (A-D) is true.

   ANS: C PTS: 1 DIF: Easy REF: 13.1
   KEY: Chemistry | general chemistry | chemical equilibrium MSC: Conceptual

2. Which of the following is true about chemical equilibrium?
   A) It is microscopically and macroscopically static.
   B) It is microscopically and macroscopically dynamic.
   C) It is microscopically static and macroscopically dynamic.
   D) It is microscopically dynamic and macroscopically static.
   E) None of these are true about chemical equilibrium.

   ANS: D PTS: 1 DIF: Easy REF: 13.1
   KEY: Chemistry | general chemistry | chemical equilibrium MSC: Conceptual

3. Equilibrium is reached in chemical reactions when:
   A) The rates of the forward and reverse reactions become equal.
   B) The concentrations of reactants and products become equal.
   C) The temperature shows a sharp rise.
   D) All chemical reactions stop.
   E) The forward reaction stops.

   ANS: A PTS: 1 DIF: Easy REF: 13.1
   KEY: Chemistry | general chemistry | chemical equilibrium MSC: Conceptual

4. For a particular system at a particular temperature there _____ equilibrium constant(s) and there _____ equilibrium position(s).
   A) are infinite; is one
   B) is one; are infinite
   C) is one; is one
   D) are infinite; are infinite
   E) none of these

   ANS: B PTS: 1 DIF: Easy REF: 13.2
   KEY: Chemistry | general chemistry | chemical equilibrium MSC: Conceptual

5. For the reaction given below, 2.00 moles of A and 3.00 moles of B are placed in a 6.00-L container.

$$A(g) + 2B(g) \rightleftharpoons C(g)$$

At equilibrium, the concentration of A is 0.246 mol/L. What is the concentration of B at equilibrium?

A) 0.246 mol/L
B) 0.325 mol/L
C) 0.500 mol/L
D) 0.492 mol/L
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 13.2
KEY: Chemistry | general chemistry | chemical equilibrium MSC: Quantitative

6. The value of the equilibrium constant, *K*, is dependent on:
   I. the temperature of the system
   II. the nature of the reactants and products
   III. the concentration of the reactants
   IV. the concentration of the products

   A) I, II
   B) II, III
   C) III, IV
   D) It is dependent on three of the above choices.
   E) It is not dependent on any of the above choices.

   ANS: A PTS: 1 DIF: Easy REF: 13.2
   KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant
   MSC: Conceptual

7. If the equilibrium constant for $A + B \rightleftharpoons C$ is 0.208, then the equilibrium constant for $2C \rightleftharpoons 2A + 2B$ is
   A) 0.584
   B) 4.81
   C) 0.416
   D) 23.1
   E) 0.208

   ANS: D PTS: 1 DIF: Easy REF: 13.2
   KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant
   MSC: Conceptual

8. Indicate the mass action expression for the following reaction: $2X(g) + Y(g) \rightleftharpoons 3W(g) + V(g)$
   A) $[X]^2[Y][W]^3[V]$
   B) $\dfrac{[W]^3[V]}{[X]^2[Y]}$
   C) $\dfrac{[3W][V]}{[2X][Y]}$

D) $\frac{[X]^2[Y]}{[W]^3[V]}$

E) none of these

ANS: B PTS: 1 DIF: Easy REF: 13.2
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | definition of equilibrium constant Kc MSC: Conceptual

9. If, at a given temperature, the equilibrium constant for the reaction $H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$ is K_p, then the equilibrium constant for the reaction $HCl(g) \rightarrow \frac{1}{2}H_2(g) + \frac{1}{2}Cl_2(g)$ can be represented as:

A) $\frac{1}{K_p^2}$

B) K_p^2

C) $\frac{1}{\sqrt{K_p}}$

D) $\sqrt{K_p}$

E) none of these

ANS: C PTS: 1 DIF: Easy REF: 13.2
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | definition of equilibrium constant Kc MSC: Conceptual

10. Apply the law of mass action to determine the equilibrium expression for $2NO_2Cl(aq) \rightleftharpoons 2NO_2(aq) + Cl_2(aq)$.

A) $K = 2[NO_2][Cl_2]/2[NO_2Cl]$

B) $K = 2[NO_2Cl]/2[NO_2][Cl_2]$

C) $K = [NO_2Cl]^2/[NO_2]^2[Cl_2]$

D) $K = [NO_2]^2[Cl_2]/[NO_2Cl]^2$

E) $K = [NO_2Cl]^2[NO_2]^2[Cl_2]$

ANS: D PTS: 1 DIF: Easy REF: 13.2
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | definition of equilibrium constant Kc MSC: Conceptual

11. At a given temperature, $K = 0.017$ for the equilibrium:

$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

What is K for:

$Cl_2(g) + PCl_3(g) \rightleftharpoons PCl_5(g)$?

A) 0.017

B) 59

C) 0.00029

D) 17

E) 3500

ANS: B PTS: 1 DIF: Easy REF: 13.2

KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | equilibrium constant for the sum of reactions MSC: Quantitative

12. Given the equilibrium constants for the following reactions:

$4Cu(s) + O_2(g) \rightleftharpoons 2Cu_2O(s)$, K_1
$2CuO(s) \rightleftharpoons Cu_2O(s) + \frac{1}{2}O_2(g)$, K_2

what is K for the system

$2Cu(s) + O_2(g) \rightleftharpoons 2CuO(s)$

equivalent to?

A) $(K_1)(K_2)$
B) $(K_2)^{1/2} / (K_1)$
C) $(K_1)^{1/2} / (K_2)$
D) $(K_2)(K_1)^{1/2}$
E) $(K_1)(K_2)^{1/2}$

ANS: C PTS: 1 DIF: Moderate REF: 13.2
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | equilibrium constant for the sum of reactions MSC: Conceptual

13. Which expression correctly describes the equilibrium constant for the following reaction?

$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$
A) $K = (4[NH_3] + 5[O_2]) / (4[NO] + 6[H_2O])$
B) $K = (4[NO] + 6[H_2O]) / (4[NH_3] + 5[O_2])$
C) $K = ([NO][H_2O]) / ([NH_3][O_2])$
D) $K = ([NO]^4[H_2O]^6) / ([[NH_3]^4[O_2]^5)$
E) $K = ([NH_3]^4[O_2]^5) / ([NO]^4[H_2O]^6)$

ANS: D PTS: 1 DIF: Easy REF: 13.2
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | definition of equilibrium constant Kc MSC: Conceptual

Consider the chemical system $CO + Cl_2 \rightleftharpoons COCl_2$; $K = 4.6 \times 10^9$ L/mol.

14. How do the equilibrium concentrations of the reactants compare to the equilibrium concentration of the product?
A) They are much smaller.
B) They are much bigger.
C) They are about the same.
D) They have to be exactly equal.
E) You can't tell from the information given.

ANS: A PTS: 1 DIF: Easy REF: 13.2
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant | qualitatively interpreting the equilibrium constant MSC: Conceptual

15. If the concentration of the product were to double, what would happen to the equilibrium constant?
    A) It would double its value.
    B) It would become half its current value.
    C) It would quadruple its value.
    D) It would not change its value.
    E) It would depend on the initial conditions of the product.

    ANS: D PTS: 1 DIF: Easy REF: 13.2
    KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | definition of equilibrium constant Kc MSC: Conceptual

16. Determine the equilibrium constant for the system $N_2O_4 \rightleftharpoons 2NO_2$ at 25°C. The concentrations are shown here: $[N_2O_4] = 2.32 \times 10^{-2}$ *M*, $[NO_2] = 1.41 \times 10^{-2}$ *M*.
    A) 0.608
    B) 1.65
    C) 1.17×10^{2}
    D) 0.369
    E) 8.57×10^{-3}

    ANS: E PTS: 1 DIF: Easy REF: 13.2
    KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | definition of equilibrium constant Kc MSC: Quantitative

17. If $K = 0.144$ for $A_2 + 2B \rightleftharpoons 2AB$, then for $4AB \rightleftharpoons 2A_2 + 4B$, *K* would equal:
    A) 0.288
    B) 0.144
    C) –0.144
    D) 3.47
    E) 48.2

    ANS: E PTS: 1 DIF: Easy REF: 13.2
    KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | equilibrium constant for the sum of reactions MSC: Conceptual

18. Consider the gaseous reaction $CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$. What is the expression for K_p in terms of *K*?
    A) $K(RT)$
    B) $K/(RT)$
    C) $K(RT)^2$
    D) $K/(RT)^2$
    E) $1/K(RT)$

    ANS: B PTS: 1 DIF: Easy REF: 13.3
    KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | the equilibrium constant Kp MSC: Conceptual

19. For the reaction $N_2O_4(g) \rightleftharpoons 2NO_2(g)$, $K_p = 0.148$ at a temperature of 298 K. What is K_p for the following reaction?

$10NO_2(g) \rightleftharpoons 5N_2O_4(g)$

A) 6.76
B) 0.74
C) 1.35
D) 1.41×10^{4}
E) 7.10×10^{-5}

ANS: D PTS: 1 DIF: Easy REF: 13.3
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | equilibrium constant for the sum of reactions MSC: Conceptual

20. For the reaction $H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$, $K_c = 1.22 \times 10^{33}$ at a temperature of 301 K. What is K_p at this temperature?

A) 1.22×10^{33}
B) 3.01×10^{34}
C) 4.93×10^{31}
D) 7.43×10^{35}
E) 2.00×10^{30}

ANS: A PTS: 1 DIF: Easy REF: 13.3
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | the equilibrium constant Kp MSC: Quantitative

21. For the reaction $NO(g) + \frac{1}{2}O_2(g) \rightleftharpoons NO_2(g)$ at 750°C, the equilibrium constant K_c equals:

A) 1.0
B) K_p
C) $K_p(RT)^{-1/2}$
D) $K_p(RT)^{3/4}$
E) $K_p(RT)^{1/2}$

ANS: E PTS: 1 DIF: Easy REF: 13.3
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | the equilibrium constant Kp MSC: Conceptual

22. An equilibrium reaction, $A_2(g) + 3B_2(g) \rightleftharpoons 2C(g)$, has a K_p at 225°C of 2.6×10^{-3} /atm^2. What is K for this reaction at that temperature?

A) 1.6×10^{-6}
B) 7.6×10^{-6}
C) 4.3
D) 6.4×10^{-5}
E) 0.89

ANS: A PTS: 1 DIF: Easy REF: 13.3
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | the equilibrium constant Kp MSC: Conceptual

23. Find the value of the equilibrium constant (K) (at 500 K) for $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$. The value for K_p at 500 K is $1.5 \times 10^{-5}/atm^2$.
A) 7.5×10^{-2}
B) 1.3×10^{-2}
C) 9.6×10^{-2}
D) 2.5×10^{-2}
E) 6.0×10^{-2}

ANS: D PTS: 1 DIF: Easy REF: 13.3
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | the equilibrium constant Kp MSC: Conceptual

24. Consider the following reaction: $CS_2(g) + 4H_2(g) \rightleftharpoons CH_4(g) + 2H_2S(g)$. The equilibrium constant K is about 0.31 at 900.°C. What is K_p at this temperature?
A) 2.9×10^{3}
B) 3.2×10^{-3}
C) 3.3×10^{-5}
D) 3.0×10^{1}
E) 1.1×10^{-3}

ANS: C PTS: 1 DIF: Easy REF: 13.3
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | the equilibrium constant Kp MSC: Quantitative

25. Given the equation $2NOCl_2(g) \rightleftharpoons 2NO(g) + Cl_2(g)$, the equilibrium constant is about 0.0196 at 115°C. Calculate K_p.
A) 0.0196
B) 0.624
C) 0.185
D) 19.9
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 13.3
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | the equilibrium constant Kp MSC: Quantitative

26. Calculate K_p for $H_2O(g) + \frac{1}{2}O_2(g) \rightleftharpoons H_2O_2(g)$ using the following data:

$H_2(g) + O_2(g) \rightleftharpoons H_2O_2(g)$ $K_p = 2.3 \times 10^{6}$
$2H_2(g) + O_2(g) \rightleftharpoons 2H_2O(g)$ $K_p = 1.8 \times 10^{37}$

A) 4.1×10^{43}
B) 2.1×10^{43}
C) 2.9×10^{-25}
D) 5.4×10^{-13}
E) 9.8×10^{-13}

ANS: D PTS: 1 DIF: Easy REF: 13.3
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant |

equilibrium constant for the sum of reactions MSC: Conceptual

27. Consider the reaction:

$CaCl_2(s) + 2H_2O(g) \rightleftharpoons CaCl_2 \cdot 2H_2O(s)$

The equilibrium constant for the reaction as written is:

A) $K = \dfrac{[CaCl_2 \cdot 2H_2O]}{[CaCl_2][H_2O]^2}$

B) $K = \dfrac{1}{[H_2O]^2}$

C) $K = \dfrac{1}{2[H_2O]}$

D) $K = [H_2O]^2$

E) $K = \dfrac{[CaCl_2 \cdot 2H_2O]}{[H_2O]^2}$

ANS: B PTS: 1 DIF: Easy REF: 13.4
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | heterogeneous and homogeneous equilibrium MSC: Conceptual

28. Consider the reaction $C(s) + CO_2(g) \rightleftharpoons 2CO(g)$. At 1273 K, the K_p value is 167.5. What is the P_{CO} at equilibrium if the P_{CO_2} is 0.17 atm at this temperature?

A) 2.7 atm
B) 0.085 atm
C) 11 atm
D) 5.3 atm
E) 7.5 atm

ANS: D PTS: 1 DIF: Easy REF: 13.4
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant
MSC: Quantitative

Consider the following equilibrium: $H_2(g) + I_2(s) \rightleftharpoons 2HI(g)$

29. The proper K_{eq} expression is:

A) $\dfrac{[H_2][I_2]}{[HI]}$

B) $\dfrac{\sqrt{([H_2][I_2])}}{[HI]^2}$

C) $\dfrac{[HI]}{\sqrt{([H_2])}}$

D) $\dfrac{[HI]^2}{[H_2][I_2]}$

E) $\dfrac{[HI]^2}{[H_2]}$

ANS: E PTS: 1 DIF: Easy REF: 13.4
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | heterogeneous and homogeneous equilibrium MSC: Conceptual

30. Which of the following statements about the equilibrium is false?
A) If the system is heated, the right side is favored.
B) This is a heterogeneous equilibrium.
C) If the pressure on the system is increased by changing the volume, the left side is favored.
D) Adding more $H_2(g)$ increases the equilibrium constant.
E) Removing HI as it forms forces the equilibrium to the right.

ANS: D PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle
MSC: Conceptual

31. Consider the reaction: $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ at constant temperature. Initially a container is filled with pure $SO_3(g)$ at a pressure of 2 atm, after which equilibrium is reached. If y is the partial pressure of O_2 at equilibrium, the value of K_p is:
A) $\dfrac{(2-2y)^2}{(y^2)(2y)}$
B) $\dfrac{(2-y)^2}{(y^2)(y/2)}$
C) $\dfrac{(2-y)^2}{(2y)^2(y)}$
D) $\dfrac{(2-2y)^2}{(2y)^2(y)}$
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant
MSC: Conceptual

32. Which of the following is true for a system whose equilibrium constant is relatively small?
A) It will take a short time to reach equilibrium.
B) It will take a long time to reach equilibrium.
C) The equilibrium lies to the left.
D) The equilibrium lies to the right.
E) Two of these.

ANS: C PTS: 1 DIF: Easy REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant | qualitatively interpreting the equilibrium constant MSC: Conceptual

33. The reaction quotient for a system is 7.2×10^2. If the equilibrium constant for the system is 36, what will happen as equilibrium is approached?
A) There will be a net gain in product.
B) There will be a net gain in reactant.

C) There will be a net gain in both product and reactant.
D) There will be no net gain in either product or reactant.
E) The equilibrium constant will decrease until it equals the reaction quotient.

ANS: B PTS: 1 DIF: Easy REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant | predicting the direction of reaction MSC: Conceptual

34. Consider the following reaction:

$$2HF(g) \rightleftharpoons H_2(g) + F_2(g) \qquad (K = 1.00 \times 10^{-2})$$

Given 1.00 mole of HF(g), 0.362 mole of H_2(g), and 0.750 mole of F_2(g) are mixed in a 5.00 L flask, determine the reaction quotient, Q.
A) $Q = 0.0543$
B) $Q = 0.272$
C) $Q = 0.0679$
D) $Q = 2.11$
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant | predicting the direction of reaction MSC: Quantitative

Nitric oxide, an important pollutant in air, is formed from the elements nitrogen and oxygen at high temperatures, such as those obtained when gasoline burns in an automobile engine. At 2000°C, K for the reaction $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ is 0.01.

35. Predict the direction in which the system will move to reach equilibrium at 2000°C if 0.4 moles of N_2, 0.1 moles of O_2, and 0.08 moles of NO are placed in a 1.0-liter container.
A) The system remains unchanged.
B) The concentration of NO will decrease; the concentrations of N_2 and O_2 will increase.
C) The concentration of NO will increase; the concentrations of N_2 and O_2 will decrease.
D) The concentration of NO will decrease; the concentrations of N_2 and O_2 will remain unchanged.
E) More information is necessary.

ANS: B PTS: 1 DIF: Easy REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant | predicting the direction of reaction MSC: Conceptual

36. A 1-L container originally holds 0.4 mol of N_2, 0.1 mol of O_2, and 0.08 mole of NO. If the volume of the container holding the equilibrium mixture of N_2, O_2, and NO is decreased to 0.5 L without changing the quantities of the gases present, how will their concentrations change?
A) The concentration of NO will increase; the concentrations of N_2 and O_2 will decrease.
B) The concentrations of N_2 and O_2 will increase; and the concentration of NO will decrease.

C) The concentrations of N_2, O_2, and NO will increase.
D) The concentrations of N_2, O_2, and NO will decrease.
E) There will be no change in the concentrations of N_2, O_2, and NO.

ANS: C PTS: 1 DIF: Moderate REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle
MSC: Conceptual

37. Consider the following equilibrated system: $2NO_2(g) \rightleftharpoons 2NO(g) + O_2(g)$. If the K_p value is 0.604, find the equilibrium pressure of the O_2 gas if the NO_2 gas pressure is 0.520 atm and the P_{NO} is 0.300 atm at equilibrium.
A) 1.05 atm
B) 24.8 atm
C) 0.348 atm
D) 0.201 atm
E) 1.81 atm

ANS: E PTS: 1 DIF: Moderate REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant
MSC: Quantitative

38. For the reaction given below, 2.00 moles of A and 3.00 moles of B are placed in a 6.00-L container.

$$A(g) + 2B(g) \rightleftharpoons C(g)$$

At equilibrium, the concentration of A is 0.213 mol/L. What is the value of K?
A) 2.18
B) 1.79
C) 0.213
D) 8.40
E) 0.565

ANS: D PTS: 1 DIF: Moderate REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant
MSC: Quantitative

39. A 10.0-g sample of solid NH_4Cl is heated in a 5.00-L container to 900.°C. At equilibrium the pressure of $NH_3(g)$ is 1.51 atm.

$$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$$

The equilibrium constant, K_p, for the reaction is:
A) 1.51
B) 2.28
C) 3.02
D) 8.21
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | heterogeneous and homogeneous equilibrium MSC: Quantitative

40. Consider the reaction $H_2 + I_2 \rightleftharpoons 2HI$ for which $K = 44.8$ at a high temperature. If an equimolar mixture of reactants gives the concentration of the product to be 0.50 *M* at equilibrium, determine the equilibrium concentration of the hydrogen.
A) $1.1 \times 10^{-1}\ M$
B) $7.5 \times 10^{-2}\ M$
C) $3.7 \times 10^{-2}\ M$
D) $1.3 \times 10^{1}\ M$
E) $5.6 \times 10^{-3}\ M$

ANS: B PTS: 1 DIF: Moderate REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant | calculating equilibrium concentrations MSC: Quantitative

41. Consider the equation $A(aq) + 2B(aq) \rightleftharpoons 3C(aq) + 2D(aq)$. In one experiment, 45.0 mL of 0.050 *M* A is mixed with 25.0 mL 0.100 *M* B. At equilibrium the concentration of C is 0.0410 *M*. Calculate *K*.
A) 7.3
B) 0.34
C) 0.040
D) 0.14
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant
MSC: Quantitative

42. The reaction:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

has $K_p = 45.9$ at 763 K. A particular equilibrium mixture at that temperature contains gaseous HI at a partial pressure of 4.00 atm and hydrogen gas at a partial pressure of 0.213 atm. What is the partial pressure of I_2?
A) 0.213 atm
B) 0.409 atm
C) 1.64 atm
D) 10.9 atm
E) 75.1 atm

ANS: C PTS: 1 DIF: Easy REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant | calculating equilibrium concentrations MSC: Quantitative

43. For the equilibrium system:

$CO_2(g) + H_2(g) \rightleftharpoons CO(g) + H_2O(g)$ $\quad \Delta H = +42$ kJ/mol

K equals 1.6 at 1260 K. If 0.15 mol each of CO_2, H_2, CO, and H_2O (all at 1260 K) were placed in a 1.0-L thermally insulated vessel that was also at 1260 K, then as the system came to equilibrium:
A) The temperature would decrease and the mass of CO_2 would increase.
B) The temperature would decrease and the mass of CO_2 would decrease.

C) The temperature would remain constant and the mass of CO_2 would increase.
D) The temperature would increase and the mass of CO_2 would increase.
E) The temperature would increase and the mass of CO_2 would decrease.

ANS: B PTS: 1 DIF: Easy REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant | predicting the direction of reaction MSC: Conceptual

44. $CS_2(g) + 3Cl_2(g) \rightleftharpoons CCl_4(g) + S_2Cl_2(g)$

At a given temperature, the reaction above is at equilibrium when $[CS_2] = 0.050\ M$, $[Cl_2] = 0.25\ M$, $[CCl_4] = 0.15\ M$, and $[S_2Cl_2] = 0.35\ M$. What would be the direction of the reaction when the reactants and products have the following concentrations: $CS_2 = 0.15\ M$, $Cl_2 = 0.18\ M$, $CCl_4 = 0.29\ M$, and $S_2Cl_2 = 0.21\ M$?
A) to the right
B) to the left
C) no change
D) cannot predict unless we know the temperature
E) cannot predict unless we know whether the reaction is endothermic or exothermic

ANS: B PTS: 1 DIF: Easy REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant | predicting the direction of reaction MSC: Conceptual

45. A mixture of nitrogen and hydrogen was allowed to come to equilibrium at a given temperature.

$3H_2 + N_2 \rightleftharpoons 2NH_3$

An analysis of the mixture at equilibrium revealed 2.1 mol N_2, 3.2 mol H_2, and 1.8 mol NH_3. How many moles of H_2 were present at the beginning of the reaction?
A) 3.2
B) 4.8
C) 5.0
D) 5.9
E) 4.4

ANS: D PTS: 1 DIF: Moderate REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium MSC: Quantitative

46. Carbon disulfide and chlorine react according to the following equation:

$CS_2(g) + 3Cl_2(g) \rightleftharpoons S_2Cl_2(g) + CCl_4(g)$

When 2.14 mol of CS_2 and 5.85 mol of Cl_2 are placed in a 2.00-L container and allowed to come to equilibrium, the mixture is found to contain 0.620 mol of CCl_4. How many moles of Cl_2 are present at equilibrium?
A) 1.520 mol
B) 0.620 mol
C) 3.99 mol
D) 4.61 mol
E) 2.00 mol

ANS: C PTS: 1 DIF: Moderate REF: 13.5

KEY: Chemistry | general chemistry | chemical equilibrium MSC: Quantitative

47. Initially 2.0 moles of $N_2(g)$ and 4.0 moles of $H_2(g)$ were added to a 1.0-liter container and the following reaction then occurred:

$$3H_2(g) + N_2(g) \rightleftharpoons 2NH_3(g)$$

The equilibrium concentration of $NH_3(g)$ = 0.55 moles/liter at 700.°C. The value for K at 700.°C for the formation of ammonia is:

A) 1.0×10^{-1}
B) 5.5×10^{-2}
C) 5.5×10^{-3}
D) 3.0×10^{-1}
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant
MSC: Quantitative

Consider the following reaction (assume an ideal gas mixture): $2NOBr(g) \rightleftharpoons 2NO(g) + Br_2(g)$ A 1.0-liter vessel was initially filled with pure NOBr, at a pressure of 4.0 atm, at 300 K.

48. After equilibrium was established, the partial pressure of NOBr was 3.1 atm. What is K_p for the reaction?

A) 0.26
B) 0.038
C) 0.13
D) 0.45
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant
MSC: Quantitative

49. After equilibrium was reached, the volume was increased to 2.0 liters, while the temperature was kept at 300 K. The result of this change was

A) an increase in K_p
B) a decrease in K_p
C) a shift in the equilibrium position to the right
D) a shift in the equilibrium position to the left
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle
MSC: Conceptual

50. Nitrogen gas (N_2) reacts with hydrogen gas (H_2) to form ammonia (NH_3). At 200°C in a closed container, 1.0 atm of nitrogen gas is mixed with 2.0 atm of hydrogen gas. At equilibrium, the total pressure is 2.2 atm. Calculate the partial pressure of hydrogen gas at equilibrium.

A) 2.2 atm
B) 0.80 atm
C) 1.4 atm
D) 0.0 atm
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium MSC: Quantitative

51. The following reaction is investigated (assume an ideal gas mixture):

$$2N_2O(g) + N_2H_4(g) \rightleftharpoons 3N_2(g) + 2H_2O(g)$$

Initially there are 0.10 moles of N_2O and 0.25 moles of N_2H_4, in a 10.0-L container. If there are 0.048 moles of N_2O at equilibrium, how many moles of N_2 are present at equilibrium?
A) 2.6×10^{-2}
B) 5.2×10^{-2}
C) 7.8×10^{-2}
D) 1.6×10^{-1}
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium MSC: Quantitative

52. A 3.00-liter flask initially contains 3.00 mol of gas A and 1.50 mol of gas B. Gas A decomposes according to the following reaction:

$$3A \rightleftharpoons 2B + C$$

The equilibrium concentration of gas C is 0.115 mol/L. Determine the equilibrium concentration of gas A.
A) 0.115 *M*
B) 0.655 *M*
C) 0.730 *M*
D) 0.885 *M*
E) 0.345 *M*

ANS: B PTS: 1 DIF: Easy REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium MSC: Quantitative

53. A 3.00-liter flask initially contains 3.00 mol of gas A and 1.50 mol of gas B. Gas A decomposes according to the following reaction:

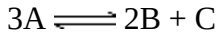
$$3A \rightleftharpoons 2B + C$$

The equilibrium concentration of gas C is 0.119 mol/L. Determine the equilibrium concentration of gas B.
A) 0.119 *M*
B) 0.619 *M*
C) 0.738 *M*
D) 0.262 *M*
E) 0.238 *M*

ANS: C PTS: 1 DIF: Easy REF: 13.5

KEY: Chemistry | general chemistry | chemical equilibrium MSC: Quantitative

54. A 3.00-liter flask initially contains 3.00 mol of gas A and 1.50 mol of gas B. Gas A decomposes according to the following reaction:

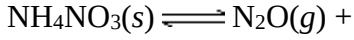


The equilibrium concentration of gas C is 0.146 mol/L. Determine the value of the equilibrium constant, *K*.

A) 0.206
B) 0.163
C) 3.84×10^{-3}
D) 0.516
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant
MSC: Quantitative

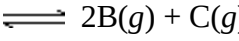
55. A sample of solid NH_4NO_3 was placed in an evacuated container and then heated so that it decomposed explosively according to the following equation:



At equilibrium the total pressure in the container was found to be 2.63 atm at a temperature of 500.°C. Calculate K_p.

A) 0.769
B) 1.54
C) 0.674
D) 2.70
E) 72.8

ANS: D PTS: 1 DIF: Moderate REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant
MSC: Quantitative

Given the equation  At a particular temperature, $K = 1.6 \times 10^4$.

56. If you mixed 5.0 mol B, 0.10 mol C, and 0.0010 mol A in a one-liter container, which direction would the reaction initially proceed?

A) To the left.
B) To the right.
C) The above mixture is the equilibrium mixture.
D) Cannot tell from the information given.
E) None of these (A-D).

ANS: A PTS: 1 DIF: Moderate REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant | predicting the direction of reaction MSC: Conceptual

57. Addition of chemical B to an equilibrium mixture of the above will

A) cause [A] to increase

B) cause [C] to increase
C) have no effect
D) cannot be determined
E) none of the above

ANS: A PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle | removing products or adding reactants MSC: Conceptual

58. At a higher temperature, $K = 1.8 \times 10^{-5}$. Placing the equilibrium mixture in an ice bath (thus lowering the temperature) will
A) cause [A] to increase
B) cause [B] to increase
C) have no effect
D) cannot be determined
E) none of the above

ANS: B PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle | temperature change MSC: Conceptual

59. Raising the pressure by lowering the volume of the container will
A) cause [A] to increase
B) cause [B] to increase
C) have no effect
D) cannot be determined
E) none of the above

ANS: A PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle | pressure change MSC: Conceptual

Consider the following equilibrium: $2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$ with $K = 1.6 \times 10^{-5}$. In an experiment, 1.00 mole of pure NOCl and 1.00 mole of pure Cl_2 are placed in a 1.00-L container.

60. If x moles of NOCl react, what is the equilibrium concentration of NO?
A) x
B) $2x$
C) $-x$
D) $-2x$
E) x^2

ANS: A PTS: 1 DIF: Easy REF: 13.6
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant | calculating equilibrium concentrations MSC: Conceptual

61. If x moles of NOCl react, what is the equilibrium concentration of Cl_2?
A) x
B) $\frac{1}{2}\ x$

C) $1 + x$
D) $1 + \frac{1}{2}\ x$
E) $1 + 2x$

ANS: D PTS: 1 DIF: Easy REF: 13.6
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant | calculating equilibrium concentrations MSC: Conceptual

62. At a certain temperature K for the reaction $2NO_2 \rightleftharpoons N_2O_4$ is 7.5 liters/mole. If 2.0 moles of NO_2 are placed in a 2.0-liter container and permitted to react at this temperature, calculate the concentration of N_2O_4 at equilibrium.
A) 0.39 moles/liter
B) 0.65 moles/liter
C) 0.82 moles/liter
D) 7.5 moles/liter
E) none of these

ANS: A PTS: 1 DIF: Difficult REF: 13.6
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant | calculating equilibrium concentrations MSC: Quantitative

63. Exactly 1.0 mol N_2O_4 is placed in an empty 1.0-L container and is allowed to reach equilibrium described by the equation $N_2O_4(g) \rightleftharpoons 2NO_2(g)$
If at equilibrium the N_2O_4 is 37% dissociated, what is the value of the equilibrium constant, K_c, for the reaction under these conditions?
A) 1.2
B) 0.87
C) 1.2
D) 0.55
E) 0.22

ANS: B PTS: 1 DIF: Moderate REF: 13.6
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant
MSC: Quantitative

64. At 500.0 K, one mole of gaseous ONCl is placed in a one-liter container. At equilibrium it is 5.3% dissociated according to the equation shown here: $2ONCl \rightleftharpoons 2NO + Cl_2$. Determine the equilibrium constant.
A) 8.3×10^{-5}
B) 1.6×10^{-3}
C) 5.6×10^{-2}
D) 9.5×10^{-1}
E) 1.2×10^{4}

ANS: A PTS: 1 DIF: Difficult REF: 13.6
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant
MSC: Quantitative

65. Consider the following equilibrium:

$$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$$

with $K = 1.6 \times 10^{-5}$. 1.00 mole of pure NOCl and 0.958 mole of pure Cl_2 are placed in a 1.00-L container. Calculate the equilibrium concentration of NO(g).

A) $2.04 \times 10^{-3}\ M$
B) $9.58 \times 10^{-1}\ M$
C) $1.04\ M$
D) $5.78 \times 10^{-3}\ M$
E) $4.09 \times 10^{-3}\ M$

ANS: E PTS: 1 DIF: Difficult REF: 13.6
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant | calculating equilibrium concentrations MSC: Quantitative

66. Consider the following equilibrium:

$$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$$

with $K = 1.6 \times 10^{-5}$. 1.00 mole of pure NOCl and 0.964 mole of pure Cl_2 are placed in a 1.00-L container. Calculate the equilibrium concentration of Cl_2(g).

A) $1.6 \times 10^{-5}\ M$
B) $0.966\ M$
C) $0.483\ M$
D) $2.04 \times 10^{-3}\ M$
E) $4.07 \times 10^{-3}\ M$

ANS: B PTS: 1 DIF: Difficult REF: 13.6
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant | calculating equilibrium concentrations MSC: Quantitative

67. For the reaction below, $K_p = 1.16$ at 800.°C.

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$$

If a 31.3-gram sample of $CaCO_3$ is put into a 10.0-L container and heated to 800.°C, what percent of the $CaCO_3$ will react to reach equilibrium?

A) 21.8%
B) 42.1%
C) 56.5%
D) 100.0%
E) none of these

ANS: B PTS: 1 DIF: Difficult REF: 13.6
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant | calculating equilibrium concentrations MSC: Quantitative

68. At –80°C, K for the reaction

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

is 4.66×10^{-8}. We introduce 0.047 mole of N_2O_4 into a 1.0-L vessel at –80°C and let equilibrium be established. The total pressure in the system at equilibrium will be:

A) 0.31 atm
B) 0.74 atm
C) 1.4 atm

D) 0.047 atm
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 13.6
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant | calculating equilibrium concentrations MSC: Quantitative

69. The equilibrium system $2A \rightleftharpoons 2B + C$ has a very small equilibrium constant: $K = 2.6 \times 10^{-6}$.
Initially 3.0 moles of A are placed in a 1.5-L flask. Determine the concentration of C at equilibrium.
A) 0.011 *M*
B) 0.024 *M*
C) 0.032 *M*
D) 0.048 *M*
E) 2.0 *M*

ANS: A PTS: 1 DIF: Moderate REF: 13.6
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant | calculating equilibrium concentrations MSC: Quantitative

70. Which of the following statements concerning equilibrium is *not* true?
A) A system that is disturbed from an equilibrium condition responds in a manner to restore equilibrium.
B) Equilibrium in molecular systems is dynamic, with two opposing processes balancing one another.
C) The value of the equilibrium constant for a given reaction mixture is the same regardless of the direction from which equilibrium is attained.
D) A system moves spontaneously toward a state of equilibrium.
E) The equilibrium constant is independent of temperature.

ANS: E PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium MSC: Conceptual

The questions below refer to the following system:

$$\underset{\text{(pink)}}{Co(H_2O)_6^{2+}} + 4\,Cl^- \rightleftharpoons \underset{\text{(blue)}}{CoCl_4^{2-}} + 6H_2O$$

When cobalt(II) chloride is added to pure water, the Co^{2+} ions hydrate. The hydrated form then reacts with the Cl^- ions to set up the equilibrium shown here.

71. Which statement below describes the change that the system will undergo if hydrochloric acid is added?
A) It should become more blue.
B) It should become more pink.
C) The equilibrium will shift to the right.
D) The equilibrium will shift to the left.
E) Two of these.

ANS: E PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle
MSC: Conceptual

72. Which statement below describes the change that the system will undergo if water is added?
A) More chloride ions will be produced.
B) More water will be produced.
C) The equilibrium will shift to the right.
D) The color will become more blue.
E) There will be less of the hydrated cobalt ion at the new equilibrium position.

ANS: A PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle
MSC: Conceptual

73. Which statement below describes the change that the system will undergo if silver nitrate is added?
A) It should become more blue.
B) It should become more pink.
C) Water will be produced.
D) The silver ion will react with the $CoCl_4^{2-}$.
E) Nothing will change.

ANS: B PTS: 1 DIF: Moderate REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle
MSC: Conceptual

The following questions refer to the equilibrium shown here: $4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$

74. What would happen to the system if oxygen were added?
A) More ammonia would be produced.
B) More oxygen would be produced.
C) The equilibrium would shift to the right.
D) The equilibrium would shift to the left.
E) Nothing would happen.

ANS: C PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle | removing products or adding reactants MSC: Conceptual

75. What would happen to the system if the pressure were decreased?
A) Nothing would happen.
B) More oxygen would be produced.
C) The water vapor would become liquid water.
D) The ammonia concentration would increase.
E) The NO concentration would increase.

ANS: E PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle | pressure change MSC: Conceptual

76. For a certain reaction at 25.0°C, the value of K is 1.2×10^{-3}. At 50.0°C the value of K is 3.4×10^{-1}. This means that the reaction is

A) exothermic
B) endothermic
C) never favorable
D) more information needed
E) none of these (A-D)

ANS: B PTS: 1 DIF: Moderate REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle | temperature change MSC: Conceptual

77. Ammonia is prepared industrially by the reaction: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ for the reaction: $\Delta H° = -92.2$ kJ and K (at 25°C) = 4.0×10^8. When the temperature of the reaction is increased to 500°C, which of the following is true?
A) K for the reaction will be larger at 500°C than at 25°C.
B) At equilibrium, more NH_3 is present at 500°C than at 25°C.
C) Product formation (at equilibrium) is not favored as the temperature is raised.
D) The reaction of N_2 with H_2 to form ammonia is endothermic.
E) None of the above is true.

ANS: C PTS: 1 DIF: Moderate REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle | temperature change MSC: Conceptual

Consider the following equilibrium: $2H_2(g) + X_2(g) \rightleftharpoons 2H_2X(g)$ + energy

78. Addition of X_2 to a system described by the above equilibrium
A) will cause $[H_2]$ to decrease
B) will cause $[X_2]$ to decrease
C) will cause $[H_2X]$ to decrease
D) will have no effect
E) cannot possibly be carried out

ANS: A PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle | removing products or adding reactants MSC: Conceptual

79. Addition of argon to the above equilibrium
A) will cause $[H_2]$ to decrease
B) will cause $[X_2]$ to increase
C) will cause $[H_2X]$ to increase
D) will have no effect
E) cannot possibly be carried out

ANS: D PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle
MSC: Conceptual

80. Increasing the pressure by decreasing the volume will cause
A) the reaction to occur to produce H_2X
B) the reaction to occur to produce H_2 and X_2
C) the reaction to occur to produce H_2 but no more X_2

D) no reaction to occur
E) X_2 to dissociate

ANS: A PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle | pressure change MSC: Conceptual

81. Increasing the temperature will cause
A) the reaction to occur to produce H_2X
B) the reaction to occur to produce H_2 and X_2
C) the reaction to occur to produce H_2 but no more X_2
D) no reaction to occur
E) an explosion

ANS: B PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle | temperature change MSC: Conceptual

82. Which of the following statements is true?
A) When two opposing processes are proceeding at identical rates, the system is at equilibrium.
B) Catalysts are an effective means of changing the position of an equilibrium.
C) The concentration of the products equals that of reactants and is constant at equilibrium.
D) An endothermic reaction shifts toward reactants when heat is added to the reaction.
E) None of the above statements is true.

ANS: A PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium MSC: Conceptual

83. Consider the following system at equilibrium: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) + 92.94$ kJ
Which of the following changes will shift the equilibrium to the right?
I. increasing the temperature
II. decreasing the temperature
III. increasing the volume
IV. decreasing the volume
V. removing some NH_3
VI. adding some NH_3
VII. removing some N_2
VIII. adding some N_2

A) I, IV, VI, VII
B) II, III, V, VIII
C) I, VI, VIII
D) I, III, V, VII
E) II, IV, V, VIII

ANS: E PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle
MSC: Conceptual

84. Consider the reaction $A(g) + B(g) \rightleftharpoons C(g) + D(g)$. You have the gases A, B, C, and D at equilibrium. Upon adding gas A, the value of *K*:
A) increases, because by adding A more products are made, increasing the product to reactant ratio
B) decreases, because A is a reactant so the product to reactant ratio decreases
C) does not change, because A does not figure into the product to reactant ratio
D) does not change, as long as the temperature is constant
E) depends on whether the reaction is endothermic or exothermic

ANS: D PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle
MSC: Conceptual

85. Consider the combustion of methane (as represented by the following equation). This is the reaction that occurs for a Bunsen burner, which is a source of heat for chemical reactions in the laboratory.
$CH_4(g) + 2O_2(g) \rightleftharpoons CO_2(g) + 2H_2O(g)$
For the system at chemical equilibrium, which of the following explains what happens if the temperature is raised?
A) The equilibrium position is shifted to the right and the value for *K* increases.
B) The equilibrium position is shifted to the right and the value for *K* decreases.
C) The equilibrium position is shifted to the left and the value for *K* decreases.
D) The equilibrium position is shifted to the left and the value for *K* increases.
E) The equilibrium position is shifted but the value for *K* stays constant.

ANS: C PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle | temperature change MSC: Conceptual

86. Consider the reaction represented by the equation $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$. For the system at chemical equilibrium, which of the following explains what happens after the addition of oxygen gas (assume constant temperature)?
A) The amount of $SO_3(g)$ increases and the value for *K* increases.
B) The amount of $SO_3(g)$ decreases and the value for *K* increases.
C) The amount of $SO_3(g)$ stays the same and the value for *K* decreases.
D) The amount of $SO_3(g)$ decreases and the value for *K* stays the same.
E) The amount of $SO_3(g)$ increases and the value for *K* stays the same.

ANS: E PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle | removing products or adding reactants MSC: Conceptual

87. Consider the reaction represented by the equation: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$. What happens to the equilibrium position when an inert gas is added to this system (as represented above) at equilibrium?
A) If the container is rigid, nothing happens to the equilibrium position. If the container is fitted with a moveable piston, the equilibrium position shifts.
B) If the container is rigid, the equilibrium position shifts. If the container is fitted with a moveable piston, nothing happens to the equilibrium position.
C) The equilibrium position shifts no matter what the container is like.

D) Nothing happens to the equilibrium position no matter what the container is like.
E) The value of the equilibrium constant must be known to answer this question.

ANS: A PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle
MSC: Conceptual

88. Which of the following are true at equilibrium for the reaction A ⇆ B?

I. [A] is no longer changing.
II. The overall rate of change of [B] is zero.
III. No new molecules of A are converting into B.
IV. The value of [B]/[A] is changing in time.
A) I, II, III
B) I, II
C) I, II, IV
D) I, IV
E) II, III

ANS: B PTS: 1 DIF: Moderate REF: 13.1
KEY: Chemistry | general chemistry | chemical equilibrium MSC: Conceptual

89. Which of the following statements is FALSE:
A) At equilibrium, the concentrations of all species are constant
B) The value of the equilibrium constant depends on the temperature
C) At equilibrium, the reaction has stopped
D) At equilibrium, the forward and reverse reactions are happening at the same rate
E) Pure solids are not included in the equilibrium constant expression.

ANS: C PTS: 1 DIF: Easy REF: 13.1 to 13.4
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | heterogenous equilibria MSC: Conceptual

90. Which of the following statements is true?
A) At equilibrium <u>BOTH</u> the rate of the forward reaction equals that of the reverse reaction <u>AND</u> the rate constant for the forward reaction equals that of the reverse.
B) The equilibrium state is dynamic even though there is no change in concentrations.
C) The equilibrium constant for a particular reaction is constant under all conditions.
D) Starting with different initial concentrations will yield different individual equilibrium concentrations and a different relationship of equilibrium concentrations.
E) None of these is true.

ANS: B PTS: 1 DIF: Easy REF: 13.2
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant
MSC: Conceptual

91. Which of the following statements concerning equilibrium is TRUE?
A) Catalysts effectively change the position of an equilibrium.
B) The concentration of the products equals the concentration of reactants for a reaction at equilibrium.

C) The equilibrium constant may be expressed in terms of pressure or in terms of concentration for **any** reaction.
D) When two opposing processes proceed at the same rate, the system is at equilibrium.
E) A system at equilibrium cannot be disturbed.

ANS: D PTS: 1 DIF: Easy REF: 13.2 to 13.4
KEY: Chemistry | general chemistry | chemical equilibrium | heteroegenous equilibria
MSC: Conceptual

92. In general, the value of the equilibrium constant for a chemical reaction does NOT depend on
A) The temperature of the reaction vessel.
B) The initial amounts of reactants present.
C) The total pressure of the reaction vessel.
D) The volume of the reaction vessel.
E) The rate constants of the forward and reverse reactions.

ANS: B PTS: 1 DIF: Easy REF: 13.2
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant
MSC: Conceptual

93. Which of the following statements is true?

I. The concentration of a pure liquid does not appear in the mass-action expression
II. If Q > K, the reaction will produce more products and less reactants to reach equilibrium
III. The equilibrium constant of an overall reaction is the product of the equilibrium constants of the individual reactions that add up to the overall reaction
IV. If A ⇆ B has a reaction quotient, Q, then n A ⇆ n B has a reaction quotient, Q^n
V. An equilibrium constant expressed in terms of concentrations can be greater than the corresponding equilibrium constant expressed in terms of pressure, depending on the reaction

A) II, III, IV and V
B) I, III, IV and V
C) III and IV
D) III, IV and V
E) All are true

ANS: B PTS: 1 DIF: Moderate REF: 13.2 to 13.5
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | heterogeneous equilibria | preidicting the direction of a reaction MSC: Conceptual

94. For the gaseous reaction, $2\ H_2 + 2\ NO <=> 2\ H_2O + N_2$, K_p at 120°C = 2.42. At a given moment, it is found that the partial pressures of H_2, NO, H_2O and N_2 are 1.1, 1.3, 0.78 and 2.2 atm, respectively. Which of the following statements describes the situation?
A) $Q_p = 1.2$ so the reaction goes to the right
B) $Q_p = 1.2$ so the reaction goes to the left
C) $Q_p = 0.65$ so the reaction goes to the right
D) $Q_p = 0.65$ so the reaction goes to the left

E) The reaction is at equilibrium

ANS: C PTS: 1 DIF: Easy REF: 13.5
KEY: Chemistry | general chemistry | chemical equilibrium | using the equilibrium constant | predicting the direction of reaction MSC: Quantitative

95. What effect does a) increasing the total pressure and b) increasing the temperature have on the equilibrium $H_2(g) + CO_2(g) \leftrightarrows H_2O(g) + CO(g)$, $\Delta H^o = 41.2$ kJ/mol.

A) a) equilibrium shifts towards products, b) equilibrium shifts towards products.
B) a) equilibrium shifts towards reactants, b) equilibrium shifts towards products.
C) a) equilibrium shifts towards products, b) equilibrium shifts towards reactants.
D) a) no change in the equilibrium, b) equilibrium shifts towards products.
E) a) no change in the equilibrium, b) equilibrium shifts towards reactants.

ANS: D PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle
MSC: Conceptual

96. Consider the endothermic reaction $2\ BrCl(g) \leftrightarrows Br_2(g) + Cl_2(g)$. What will be the effect on the equilibrium of
a) changing the volume at constant temperature?
b) increasing the temperature at constant volume
A) a) equilibrium shifts towards products, b) equilibrium shifts towards products.
B) a) equilibrium shifts towards reactants, b) equilibrium shifts towards products.
C) a) equilibrium shifts towards products, b) equilibrium shifts towards reactants.
D) a) no change in the equilibrium, b) equilibrium shifts towards products.
E) a) no change in the equilibrium, b) equilibrium shifts towards reactants.

ANS: D PTS: 1 DIF: Easy REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle
MSC: Conceptual

97. Consider the reaction, which is exothermic as written, $PCl_5(g) \leftrightarrows PCl_3(g) + Cl_2(g)$. Which of the following changes would result in the production of MORE $Cl_2(g)$?

I. adding $PCl_3(g)$
II. removing $PCl_3(g)$
III. reducing the volume of the container
IV. removing $PCl_5(g)$

V. increasing the temperature
VI. increasing the volume of the container
VII. adding $PCl_5(g)$
VIII. reducing the temperature
IX. adding a suitable catalyst
A) I, IV, V, VI
B) II, VI, VII, VIII
C) II, III, VII, VIII
D) II, V, VI, VII
E) II, VI, VII, VIII, IX

ANS: B PTS: 1 DIF: Moderate REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle
MSC: Conceptual

98. Consider the reaction, which is exothermic as written, $PCl_5(g) \leftrightarrows PCl_3(g) + Cl_2(g)$. Which of the following changes would result in the production of LESS $Cl_2(g)$?

I. adding $PCl_3(g)$
II. removing $PCl_3(g)$
III. reducing the volume of the container
IV. removing $PCl_5(g)$
V. increasing the temperature
VI. increasing the volume of the container
VII. adding $PCl_5(g)$
VIII. reducing the temperature
IX. adding a suitable catalyst
A) II, III, VII, VIII
B) I, III, IV, V
C) I, III, IV, VIII
D) I, V, VI, VII
E) I, III, IV, V, IX

ANS: B PTS: 1 DIF: Moderate REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle
MSC: Conceptual

99. The following reaction is allowed to reach equilibrium is a glass bulb at a given temperature. $2\ HgO(s) \Leftrightarrow 2\ Hg(l) + O_2(g)$ $\Delta H = 43.4$ kcal/mol. The mass of HgO in the bulb could be increased by:
A) removing some Hg
B) reducing the volume of the bulb
C) adding more Hg
D) increasing the temperature
E) removing some O

ANS: B PTS: 1 DIF: Moderate REF: 13.7
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle
MSC: Conceptual

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Chapter 14: Acids and Bases

1. For the equilibrium that exists in an aqueous solution of nitrous acid (HNO_2, a weak acid), the equilibrium constant expression is:
   A) $K = \dfrac{[H^+][NO_2^-]}{[HNO_2]}$
   B) $K = \dfrac{[H^+][N^{3+}][O^{2-}]^2}{[HNO_2]}$
   C) $K = [H^+][NO_2^-]$
   D) $K = \dfrac{[H^+]^2[NO_2^-]}{[HNO_2]}$
   E) none of these

   ANS: A PTS: 1 DIF: Easy REF: 14.1
   KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria MSC: Conceptual

2. Which of the following is a conjugate acid/base pair?
   A) HCl/OCl^-
   B) H_2SO_4/SO_4^{2-}
   C) NH_4^+/NH_3
   D) H_3O^+/OH^-
   E) more than one of these

   ANS: C PTS: 1 DIF: Easy REF: 14.1
   KEY: Chemistry | general chemistry | acids and bases | acid-base concepts | Bronsted-Lowry concept of acids and bases MSC: Conceptual

3. The equilibrium constant for the reaction $A^- + H^+ \rightleftharpoons HA$ is called:
   A) K_a
   B) K_b
   C) $\dfrac{1}{K_a}$
   D) $\dfrac{K_w}{K_b}$
   E) K_wK_a

   ANS: C PTS: 1 DIF: Easy REF: 14.1
   KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria MSC: Conceptual

4. What is the equilibrium constant for the following reaction? $N_3^- + H_3O^+ \rightleftharpoons HN_3 + H_2O$ The K_a value for $HN_3 = 1.9 \times 10^{-5}$.
   A) 5.3×10^{-10}
   B) 1.9×10^{-9}
   C) 1.9×10^{-5}
   D) 5.3×10^{4}

E) 1.9×10^9

ANS: D PTS: 1 DIF: Easy REF: 14.1
KEY: Chemistry | general chemistry | acids and bases | acid-base concepts | Bronsted-Lowry concept of acids and bases MSC: Conceptual

5. The hydrogen sulfate or bisulfate ion HSO_4^- can act as either an acid or a base in water solution. In which of the following equations does HSO_4^- act as an acid?
A) $HSO_4^- + H_2O \rightarrow H_2SO_4 + OH^-$
B) $HSO_4^- + H_3O^+ \rightarrow SO_3 + 2H_2O$
C) $HSO_4^- + OH^- \rightarrow H_2SO_4 + O^{2-}$
D) $HSO_4^- + H_2O \rightarrow SO_4^{2-} + H_3O^+$
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 14.1
KEY: Chemistry | general chemistry | acids and bases | acid-base concepts | Bronsted-Lowry concept of acids and bases MSC: Conceptual

6. Which of the following is the equilibrium constant expression for the dissociation of the weak acid HOCl?
A) $K = \dfrac{[H^+][OCl^-]}{[HOCl]}$
B) $K = [H^+][OCl^-]$
C) $K = \dfrac{[HOCl]}{[H^+][OCl^-]}$
D) $K = \dfrac{[H^+][O^{2-}][Cl^-]}{[HOCl]}$
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 14.1
KEY: Chemistry | general chemistry | acids and bases | acid-base concepts | Bronsted-Lowry concept of acids and bases MSC: Conceptual

7. Consider the reaction $HNO_2(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + NO_2^-(aq)$. Which species is a conjugate base?
A) $HNO_2(aq)$
B) $H_2O(l)$
C) $H_3O^+(aq)$
D) $NO_2^-(aq)$
E) two of these

ANS: E PTS: 1 DIF: Easy REF: 14.1
KEY: Chemistry | general chemistry | acids and bases | acid-base concepts | Bronsted-Lowry concept of acids and bases MSC: Conceptual

8. In which of the following reactions does the $H_2PO_4^-$ ion act as an acid?
A) $H_3PO_4 + H_2O \rightarrow H_3O^+ + H_2PO_4^-$
B) $H_2PO_4^- + H_2O \rightarrow H_3O^+ + HPO_4^{2-}$
C) $H_2PO_4^- + OH^- \rightarrow H_3PO_4 + O^{2-}$

D) The ion cannot act as an acid.
E) Two of these.

ANS: B PTS: 1 DIF: Easy REF: 14.1
KEY: Chemistry | general chemistry | acids and bases | acid-base concepts | Bronsted-Lowry concept of acids and bases MSC: Conceptual

Consider the following reactions:
a) $Al^{3+} + 6H_2O \rightleftharpoons Al(OH_2)_6^{3+}$
b) $Al(OH_2)_6^{3+} \rightleftharpoons Al(OH)(OH_2)_5^{2+} + H^+$
c) $OCl^- + H_2O \rightleftharpoons HOCl + OH^-$
d) $CN^- + H^+ \rightleftharpoons HCN$
e) none of these

9. Which is associated with the definition of K_a?
A) a
B) b
C) c
D) d
E) e

ANS: B PTS: 1 DIF: Easy REF: 14.1
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria MSC: Conceptual

10. Which is associated with the definition of K_b?
A) a
B) b
C) c
D) d
E) e

ANS: C PTS: 1 DIF: Easy REF: 14.6
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | base-ionization equilibria MSC: Conceptual

11. Using the following K_a values, indicate the correct order of base strength.
HNO_2 $K_a = 4.0 \times 10^{-4}$
HF $K_a = 7.2 \times 10^{-4}$
HCN $K_a = 6.2 \times 10^{-10}$

A) $CN^- > NO_2^- > F^- > H_2O > Cl^-$
B) $Cl^- > H_2O > F^- > NO_2^- > CN^-$
C) $CN^- > F^- > NO_2^- > Cl^- > H_2O$
D) $H_2O > CN^- > NO_2^- > F^- > Cl^-$
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 14.2
KEY: Chemistry | general chemistry | acids and bases | acid and base strength | relative strengths of acids and bases MSC: Conceptual

12. The equilibrium constants (K_a) for HCN and HF in H_2O at 25°C are 6.2×10^{-10} and 7.2×10^{-4}, respectively. The relative order of base strengths is:
A) $F^- > H_2O > CN^-$
B) $H_2O > F^- > CN^-$
C) $CN^- > F^- > H_2O$
D) $F^- > CN^- > H_2O$
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 14.2
KEY: Chemistry | general chemistry | acids and bases | acid and base strength | relative strengths of acids and bases MSC: Conceptual

13. Given the following acids and K_a values:

$HClO_4$	HOAc	HCN	HF
1×10^{7}	1.76×10^{-5}	4.93×10^{-10}	3.53×10^{-4}

What is the order of increasing base strength?
A) CN^-, F^-, OAc^-, ClO_4^-
B) CN^-, OAc^-, F^-, ClO_4^-
C) CN^-, ClO_4^-, F^-, OAc^-
D) ClO_4^-, OAc^-, CN^-, F^-
E) ClO_4^-, F^-, OAc^-, CN^-

ANS: E PTS: 1 DIF: Moderate REF: 14.2
KEY: Chemistry | general chemistry | acids and bases | acid and base strength | relative strengths of acids and bases MSC: Conceptual

14. Which of the following is *not* true for a solution at 25°C that has a hydroxide concentration of 2.5×10^{-6} *M*?
A) $K_w = 1 \times 10^{-14}$
B) The solution is acidic.
C) The solution is basic.
D) The $[H^+]$ is 4.0×10^{-9} *M*.
E) The K_w is independent of what the solution contains.

ANS: B PTS: 1 DIF: Easy REF: 14.2
KEY: Chemistry | general chemistry | acids and bases MSC: Conceptual

Consider the reaction $HOCl + F^- \rightleftharpoons HF + OCl^-$

15. Given that K_a for HOCl is 3.5×10^{-8} and the K_a for HF is 7.2×10^{-4} (both at 25°C), which of the following is true concerning *K* for the above reaction at 25°C?
A) *K* is greater than 1.
B) *K* is less than 1.
C) *K* is equal to 1.
D) Cannot be determined with the above information.
E) None of these (A-D).

ANS: B PTS: 1 DIF: Moderate REF: 14.2
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant |

equilibrium constant for the sum of reactions MSC: Conceptual

16. Assuming that the value for *K* in the above reaction is greater than 1, this means that HF is a stronger acid than HOCl.

ANS: F PTS: 1 DIF: Moderate REF: 14.2
KEY: Chemistry | general chemistry | acids and bases | acid and base strength | relative strengths of acids and bases MSC: Conceptual

17. HA and HB are both weak acids in water, and HA is a stronger acid than HB. Which of the following statements is correct?
A) A^- is a stronger base than B^-, which is a stronger base than H_2O, which is a stronger base than Cl^-.
B) B^- is a stronger base than A^-, which is a stronger base than H_2O, which is a stronger base than Cl^-.
C) B^- is a stronger base than A^-, which is a stronger base than Cl^-, which is a stronger base than H_2O.
D) Cl^- is a stronger base than A^-, which is a stronger base than B^-, which is a stronger base than H_2O.
E) None of these (A-D) is correct.

ANS: B PTS: 1 DIF: Easy REF: 14.2
KEY: Chemistry | general chemistry | acids and bases | acid and base strength | relative strengths of acids and bases MSC: Conceptual

18. True or false: The species Cl^- is not a good base in aqueous solution.
A) True. This is because Cl^- is the conjugate base of a weak acid.
B) False. The species Cl^- is a good base in aqueous solution because it is the conjugate base of a strong acid.
C) True. This is because Cl^- is a good proton donor.
D) False. The species Cl^- is a good base in aqueous solution because of its high electronegativity.
E) True. This is because water has a stronger attraction for protons than does Cl^-.

ANS: E PTS: 1 DIF: Easy REF: 14.2
KEY: Chemistry | general chemistry | acids and bases | acid and base strength
MSC: Conceptual

19. The autoionization of water, as represented by the below equation, is known to be endothermic. Which of the following correctly states what occurs as the temperature of water is raised? $H_2O(l) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$
A) The pH of the water does not change, and the water remains neutral.
B) The pH of the water decreases, and the water becomes more acidic.
C) The pH of the water decreases, and the water remains neutral.
D) The pH of the water increases, and the water becomes more acidic.
E) The pH of the water increases and the water remains neutral.

ANS: C PTS: 1 DIF: Moderate REF: 14.2
KEY: Chemistry | general chemistry | acids and bases | self-ionization of water and pH | self-ionization of water MSC: Conceptual

The following three equations represent equilibria that lie far to the right.

$HNO_3(aq) + CN^-(aq) \rightleftharpoons HCN(aq) + NO_3^-(aq)$

$HCN(aq) + OH^-(aq) \rightleftharpoons H_2O(l) + CN^-(aq)$

$H_2O(l) + CH_3O^-(aq) \rightleftharpoons CH_3OH(aq) + OH^-(aq)$

20. Identify the strongest acid.
    A) HCN
    B) HNO_3
    C) H_2O
    D) OH^-
    E) CH_3OH

    ANS: B PTS: 1 DIF: Moderate REF: 14.2
    KEY: Chemistry | general chemistry | acids and bases | acid and base strength | relative strengths of acids and bases MSC: Conceptual

21. Identify the strongest base.
    A) CH_3O^-
    B) CH_3OH
    C) CN^-
    D) H_2O
    E) NO_3^-

    ANS: A PTS: 1 DIF: Moderate REF: 14.2
    KEY: Chemistry | general chemistry | acids and bases | acid and base strength | relative strengths of acids and bases MSC: Conceptual

22. A solution in which the pOH is 12.1 would be described as
    A) very acidic
    B) slightly acidic
    C) neutral
    D) very basic
    E) slightly basic

    ANS: A PTS: 1 DIF: Easy REF: 14.3
    KEY: Chemistry | general chemistry | acids and bases | solutions of a strong acid or base | pH of a solution MSC: Conceptual

23. Calculate the $[H^+]$ in a solution that has a pH of 9.88.
    A) 4.1 *M*
    B) 9.9 *M*
    C) 7.6×10^{-5} *M*
    D) 1.3×10^{-10} *M*
    E) none of these

    ANS: D PTS: 1 DIF: Easy REF: 14.3
    KEY: Chemistry | general chemistry | acids and bases | solutions of a strong acid or base | pH of a solution MSC: Quantitative

24. Calculate the $[H^+]$ in a solution that has a pH of 2.73.

A) 2.7 M
B) 11.3 M
C) $1.9 \times 10^{-3}\,M$
D) $5.4 \times 10^{-12}\,M$
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 14.3
KEY: Chemistry | general chemistry | acids and bases | solutions of a strong acid or base | pH of a solution MSC: Quantitative

25. Calculate the $[H^+]$ in a solution that has a pH of 8.73.
A) $1.9 \times 10^{-9}\,M$
B) $5.4 \times 10^{-6}\,M$
C) $8.7 \times 10^{-9}\,M$
D) $9.4 \times 10^{-1}\,M$
E) $7.2 \times 10^{-1}\,M$

ANS: A PTS: 1 DIF: Easy REF: 14.3
KEY: Chemistry | general chemistry | acids and bases | solutions of a strong acid or base | pH of a solution MSC: Quantitative

26. The pH of a solution at 25°C in which $[OH^-] = 3.9 \times 10^{-5}\,M$ is:
A) 4.41
B) 3.90
C) 9.59
D) 4.80
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 14.3
KEY: Chemistry | general chemistry | acids and bases | solutions of a strong acid or base | pH of a solution MSC: Quantitative

27. In deciding which of two acids is the stronger, one must know:
A) the concentration of each acid solution
B) the pH of each acid solution
C) the equilibrium constant of each acid
D) all of the above
E) both A and C must be known

ANS: C PTS: 1 DIF: Easy REF: 14.3
KEY: Chemistry | general chemistry | acids and bases | acid and base strength | relative strengths of acids and bases MSC: Conceptual

28. Solid calcium hydroxide is dissolved in water until the pH of the solution is 11.44. The hydroxide ion concentration $[OH^-]$ of the solution is:
A) $3.6 \times 10^{-12}\,M$
B) $5.5 \times 10^{-3}\,M$
C) $2.8 \times 10^{-3}\,M$
D) $1.4 \times 10^{-3}\,M$
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 14.3
KEY: Chemistry | general chemistry | acids and bases | solutions of a strong acid or base | pH of a solution MSC: Quantitative

29. As water is heated, its pH decreases. This means that:
A) The water is no longer neutral.
B) $[H^+] > [OH^-]$
C) $[OH^-] > [H^+]$
D) A and B are correct.
E) None of these.

ANS: E PTS: 1 DIF: Easy REF: 14.3
KEY: Chemistry | general chemistry | acids and bases | self-ionization of water and pH
MSC: Conceptual

30. As water is heated, its pH decreases. This means that:
A) The water is no longer neutral.
B) The K_w value is decreasing.
C) The water has a lower $[OH^-]$ than cooler water.
D) The dissociation of water is an endothermic process.
E) None of these.

ANS: D PTS: 1 DIF: Easy REF: 14.3
KEY: Chemistry | general chemistry | acids and bases | self-ionization of water and pH
MSC: Conceptual

31. At 65°C, the ion-product constant of water, K_w, is 1.20×10^{-13}. The pH of pure water at 65°C is:
A) 7.000
B) 6.560
C) 5.880
D) 6.460
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 14.3
KEY: Chemistry | general chemistry | acids and bases | self-ionization of water and pH | self-ionization of water MSC: Quantitative

32. What is the pOH of pure water at 65°C? (K_w at 65°C = 1.20×10^{-13})
A) 7.540
B) 7.000
C) 14.000
D) 12.921
E) 6.460

ANS: E PTS: 1 DIF: Moderate REF: 14.3
KEY: Chemistry | general chemistry | acids and bases | self-ionization of water and pH | self-ionization of water MSC: Quantitative

33. Which of the following indicates the most basic solution?

A) $[H^+] = 1 \times 10^{-10}\ M$
B) pOH = 6.7
C) $[OH^-] = 7 \times 10^{-5}\ M$
D) pH = 4.2
E) At least two of the solutions are equally basic.

ANS: A PTS: 1 DIF: Easy REF: 14.3
KEY: Chemistry | general chemistry | acids and bases | acid and base strength
MSC: Conceptual

34. Calculate the pH of 0.203 *M* $HNO_3(aq)$.
A) 0.693
B) 2.030
C) –1.140
D) 13.797
E) 1.595

ANS: A PTS: 1 DIF: Easy REF: 14.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a strong acid or base | pH of a solution MSC: Quantitative

35. Calculate the pOH of a 4.9 *M* solution of HCl.
A) –0.69
B) 13.31
C) 14.69
D) 0.69
E) –0.96

ANS: C PTS: 1 DIF: Moderate REF: 14.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a strong acid or base | pH of a solution MSC: Quantitative

36. You have 100.0 mL of a solution of hydrochloric acid that has a pH of 3.00. You add 100.0 mL of water to this solution. What is the resulting pH of the solution?
A) The pH = 5.00 (the average of 3.00 and 7.00).
B) The pH = 10.00 (3.00 + 7.00 = 10.00).
C) The pH = 3.00 (water is neutral and does not affect the pH).
D) None of the above is correct, but the pH must be greater than 3.00.
E) None of the above is correct, but the pH must be less than 3.00.

ANS: D PTS: 1 DIF: Easy REF: 14.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a strong acid or base | pH of a solution MSC: Conceptual

37. What volume of water must be added to 11.1 mL of a pH 2.0 solution of HNO_3 in order to change the pH to 4.0?
A) 11.1 mL
B) 89 mL
C) 110 mL
D) 1.10×10^3 mL
E) 28 mL

ANS: D PTS: 1 DIF: Moderate REF: 14.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a strong acid or base | pH of a solution MSC: Quantitative

38. Calculate the pH of a 0.031 *M* strong acid solution.
A) –1.51
B) 1.51
C) 12.49
D) 15.51
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 14.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a strong acid or base | pH of a solution MSC: Quantitative

39. For nitrous acid, HNO_2, $K_a = 4.0 \times 10^{-4}$. Calculate the pH of 0.27 *M* HNO_2.
A) 1.98
B) 0.57
C) 3.97
D) 12.02
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | calculations with Ka MSC: Quantitative

40. The pK_a of HOCl is 7.5. Calculate the pH of a 0.31 *M* solution of HOCl.
A) 7.50
B) 6.50
C) 4.00
D) 10.00
E) 0.31

ANS: C PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | calculations with Ka MSC: Quantitative

41. For weak acid, HX, $K_a = 6.9 \times 10^{-6}$. Calculate the pH of a 0.13 *M* solution of HX.
A) 0.89
B) 3.02
C) 6.05
D) 10.98
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | calculations with Ka MSC: Quantitative

42. Calculate the pH of a 0.13 *M* solution of HOCl, $K_a = 3.5 \times 10^{-8}$.
A) 4.17

B) 8.34
C) 9.83
D) 1.00
E) 3.76

ANS: A PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | calculations with Ka MSC: Quantitative

43. Calculate the pOH of a 0.12 *M* solution of acetic acid ($K_a = 1.8 \times 10^{-5}$).
A) 2.83
B) 8.33
C) 5.67
D) 11.17
E) 1.91

ANS: D PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria MSC: Quantitative

44. Acetic acid, ($HC_2H_3O_2$) is a weak acid ($K_a = 1.8 \times 10^{-5}$). Calculate the pH of a 15.1 *M* $HC_2H_3O_2$ solution.
A) –1.18
B) 3.57
C) 1.78
D) 1.18
E) 12.22

ANS: C PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | calculations with Ka MSC: Quantitative

45. Calculate the $[H^+]$ in a 0.068 *M* solution of HCN, $K_a = 6.2 \times 10^{-10}$.
A) $1.0 \times 10^{-7}\ M$
B) $6.5 \times 10^{-6}\ M$
C) $4.2 \times 10^{-11}\ M$
D) $1.3 \times 10^{-5}\ M$
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | calculations with Ka MSC: Quantitative

46. Determine the concentration of a solution of the weak acid $HClO_2$ ($K_a = 1.10 \times 10^{-2}$) if it has a pH of 1.075.
A) 0.644 *M*
B) 0.0841 *M*
C) 7.65 *M*
D) 12.9 *M*
E) 1.287 *M*

ANS: A PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | calculations with Ka MSC: Quantitative

47. How many moles of benzoic acid, a monoprotic acid with $K_a = 6.4 \times 10^{-5}$, must be dissolved in 250. mL of H_2O to produce a solution with pH = 2.04?
A) 1.3
B) 0.00228
C) 0.32
D) 36
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | calculations with Ka MSC: Quantitative

48. What concentration of acetic acid ($K_a = 1.80 \times 10^{-5}$) has the same pH as that of 5.33×10^{-3} *M* HCl?
A) 17.2 *M*
B) 12.4 *M*
C) 1.58 *M*
D) 5.33×10^{-3} *M*
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | calculations with Ka MSC: Quantitative

49. Calculate the pH of the following aqueous solution:
0.66 *M* HOCl ($pK_a = 7.46$)
A) 10.18
B) 3.82
C) 7.64
D) 6.36
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | calculations with Ka MSC: Quantitative

50. Hypobromous acid, HOBr, has an acid dissociation constant of 2.5×10^{-9} at 25°C. What is the pOH of a 0.075 *M* HOBr solution?
A) 2.80
B) 4.27
C) 4.86
D) 9.14
E) 11.20

ANS: D PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base |

acid-ionization equilibria | calculations with Ka MSC: Quantitative

51. In a solution prepared by dissolving 0.100 mole of propanoic acid in enough water to make 1.00 L of solution, the pH is observed to be 2.832. The K_a for propanoic acid ($HC_3H_5O_2$) is:
A) 1.47×10^{-3}
B) 2.20×10^{-5}
C) 1.49×10^{-2}
D) 4.55×10^{-10}
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | calculations with Ka MSC: Quantitative

52. The pH of a 0.118 *M* solution of an aqueous weak acid (HA) is 3.20. The K_a for the weak acid is:
A) 5.4×10^{-3}
B) 4.0×10^{-7}
C) 3.4×10^{-6}
D) 3.2
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | calculations with Ka MSC: Quantitative

53. Saccharin is a monoprotic acid. If the pH of a 4.41×10^{-3} *M* solution of this acid is 2.53, what is the K_a of saccharin?
A) 8.7×10^{-6}
B) 2.0×10^{-3}
C) 6.0×10^{-3}
D) 2.9×10^{-3}
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | calculations with Ka MSC: Quantitative

54. When 2.5×10^{-2} mol of nicotinic acid (a monoprotic acid) is dissolved in 350 mL of water, the pH is 3.05. Calculate the K_a of nicotinic acid.
A) 1.3×10^{-2}
B) 1.1×10^{-5}
C) 7.1×10^{-2}
D) 3.3×10^{-5}
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | calculations with Ka MSC: Quantitative

55. Approximately how much water should be added to 10.0 mL of 11.1 *M* HCl so that it has the same pH as 0.90 *M* acetic acid ($K_a = 1.8 \times 10^{-5}$)?
A) 28 mL
B) 276 mL
C) 3 L
D) 28 L
E) 276 L

ANS: D PTS: 1 DIF: Difficult REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | calculations with Ka MSC: Quantitative

56. The pH of a 0.17 *M* solution of a weak monoprotic acid, HA, is 2.92. Calculate the K_a for this acid.
A) 0.17
B) 1.2×10^{-3}
C) 7.1×10^{-3}
D) 8.6×10^{-6}
E) 7.3×10^{-11}

ANS: D PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | calculations with Ka MSC: Quantitative

57. A monoprotic weak acid when dissolved in water is 0.75% dissociated and produces a solution with a pH of 3.11. Calculate the K_a of the acid.
A) 7.6×10^{-3}
B) 1.0×10^{-1}
C) 5.9×10^{-6}
D) Need to know the initial concentration of the acid.
E) None of these.

ANS: C PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | experimental determination of Ka MSC: Quantitative

58. A 8.5×10^{-3} *M* solution of a weak acid is 4.6% dissociated at 25°C. In a 8.5×10^{-4} *M* solution, the percentage of dissociation would be
A) the same
B) > 4.6%
C) < 4.6%
D) zero
E) need to know the K_a of the acid to answer this

ANS: B PTS: 1 DIF: Easy REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria MSC: Conceptual

59. A solution of 2.9 *M* weak acid is 0.52% ionized. What is the K_a value of this acid?
A) 7.9×10^{-5}

B) 1.5
C) 1.5×10^{-2}
D) 5.2×10^{-3}
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | experimental determination of Ka MSC: Quantitative

60. A solution of 8.01 *M* formic acid (HCOOH) is 0.47% ionized. What is the K_a value of formic acid?
A) 3.8×10^{-2}
B) 1.8×10^{-4}
C) 4.7×10^{-3}
D) 3.8
E) more data is needed

ANS: B PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | experimental determination of Ka MSC: Quantitative

61. If an acid, HA, is 14.7% dissociated in a 1.0 *M* solution, what is the K_a for this acid?
A) 1.7×10^{-1}
B) 2.5×10^{-2}
C) 1.5×10^{-1}
D) 3.9×10^{1}
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | experimental determination of Ka MSC: Quantitative

62. Determine the percent dissociation of a 0.18 *M* solution of hypochlorous acid, HClO. The K_a for the acid is 3.5×10^{-8}.
A) 3.5×10^{-6} %
B) 6.3×10^{-9} %
C) 7.9×10^{-3} %
D) 4.4×10^{-2} %
E) 1.1×10^{-2} %

ANS: D PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | experimental determination of Ka MSC: Quantitative

63. The following question refers to a solution that contains 1.59 *M* hydrofluoric acid, HF ($K_a = 7.2 \times 10^{-4}$), and 3.00 *M* hydrocyanic acid, HCN ($K_a = 6.2 \times 10^{-10}$).
What is the pH of this mixture of weak acids?
A) 1.47
B) 2.94
C) 4.50

D) 9.01
E) 12.53

ANS: A PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | calculations with Ka MSC: Quantitative

64. The following question refers to a solution that contains 1.99 *M* hydrofluoric acid, HF ($K_a = 7.2 \times 10^{-4}$), and 3.00 *M* hydrocyanic acid, HCN ($K_a = 6.2 \times 10^{-10}$).
Determine the [CN^-] at equilibrium.
A) $1.9 \times 10^{-9}\ M$
B) $3.8 \times 10^{-2}\ M$
C) $4.9 \times 10^{-8}\ M$
D) $6.2 \times 10^{-10}\ M$
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | calculations with Ka MSC: Quantitative

65. Consider a 0.70 *M* solution of HOCl. If the molarity was decreased to 0.3 *M*, which of the following statements would be true?
A) The percent dissociation would not change.
B) The percent dissociation would increase.
C) The percent dissociation would decrease.
D) The equilibrium constant would stay the same.
E) Two of these.

ANS: E PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria MSC: Conceptual

66. Consider a solution made by mixing HCN ($K_a = 6.2 \times 10^{-10}$) with $HC_2H_3O_2$ ($K_a = 1.8 \times 10^{-5}$) in aqueous solution. What are the major species in solution?
A) H^+, CN^-, H^+, $C_2H_3O_2^-$, H_2O
B) HCN, H^+, $C_2H_3O_2^-$, H_2O
C) H^+, CN^-, $HC_2H_3O_2$, H_2O
D) H^+, CN^-, H^+, $C_2H_3O_2^-$, OH^-, H_2O
E) HCN, $HC_2H_3O_2$, H_2O

ANS: E PTS: 1 DIF: Moderate REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria MSC: Conceptual

67. Which of the following solutions contains the strongest acid?
A) 5.00 *M* HCN ($K_a = 6.2 \times 10^{-10}$)
B) 3.50 *M* $H_2C_6H_6O_6$ ($K_{a1} = 7.9 \times 10^{-5}$, $K_{a2} = 1.6 \times 10^{-12}$).
C) 2.50 *M* $HC_2H_3O_2$ ($K_a = 1.8 \times 10^{-5}$)
D) 4.00 *M* HOCl ($K_a = 3.5 \times 10^{-8}$)
E) 1.00 *M* HF ($K_a = 7.2 \times 10^{-4}$)

ANS: E PTS: 1 DIF: Easy REF: 14.5
KEY: Chemistry | general chemistry | acids and bases | acid and base strength | relative strengths of acids and bases MSC: Conceptual

68. Which of the following statements are true?
A) The pH of a strong acid is always lower than the pH of a weak acid.
B) The pH of a solution can never be negative.
C) For a conjugate acid-base pair, $K_a = 1/K_b$.
D) At least two of the statements A-C are true.
E) All of the statements A-C are false.

ANS: E PTS: 1 DIF: Easy REF: 14.5
KEY: Chemistry | general chemistry | acids and bases MSC: Conceptual

69. Which of the following reactions is associated with the definition of K_b?
A) $Zn(OH_2)_6^{2+} \rightleftharpoons [Zn(OH_2)_5OH]^+ + H^+$
B) $CN^- + H^+ \rightleftharpoons HCN$
C) $F^- + H_2O \rightleftharpoons HF + OH^-$
D) $Cr^{3+} + 6H_2O \rightleftharpoons Cr(OH_2)_6^{3+}$
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 14.6
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | base-ionization equilibria MSC: Conceptual

70. Calculate the pH of a 0.02 *M* solution of KOH.
A) 1.7
B) 15.7
C) 14.0
D) 12.3
E) cannot calculate answer unless a volume is given

ANS: D PTS: 1 DIF: Moderate REF: 14.6
KEY: Chemistry | general chemistry | acids and bases | solutions of a strong acid or base | pH of a solution MSC: Quantitative

71. Calculate the pH of a 0.51 *M* solution of KOH.
A) 14.00
B) 13.71
C) 0.29
D) 0.51
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 14.6
KEY: Chemistry | general chemistry | acids and bases | solutions of a strong acid or base | pH of a solution MSC: Quantitative

72. Calculate the pH of a 0.059 *M* solution of $Ca(OH)_2$.
A) 13.07
B) 12.77

C) 0.93
D) 1.23
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 14.6
KEY: Chemistry | general chemistry | acids and bases | solutions of a strong acid or base | pH of a solution MSC: Quantitative

73. Calculate the pOH of a 0.32 *M* solution of $Ba(OH)_2$.
A) 0.49
B) 0.19
C) 13.81
D) 13.51
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 14.6
KEY: Chemistry | general chemistry | acids and bases | solutions of a strong acid or base | pH of a solution MSC: Quantitative

74. A 0.372-g sample of NaOH(*s*) is added to enough water to make 250.0 mL of solution. The pH of this solution is:
A) 1.429
B) 0.429
C) 11.968
D) 12.571
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 14.6
KEY: Chemistry | general chemistry | acids and bases | solutions of a strong acid or base | pH of a solution MSC: Quantitative

75. Calculate the pH of a 2.3×10^{-3} *M* KOH solution.
A) 2.64
B) 12.36
C) 11.36
D) 1.64
E) 10.36

ANS: C PTS: 1 DIF: Moderate REF: 14.6
KEY: Chemistry | general chemistry | acids and bases | solutions of a strong acid or base | pH of a solution MSC: Quantitative

76. Calculate the pH of a 2.28 *M* solution of NaOH.
A) 0.358
B) 13.642
C) 14.358
D) 2.28
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 14.6
KEY: Chemistry | general chemistry | acids and bases | solutions of a strong acid or base |

pH of a solution MSC: Quantitative

77. The pain killer morphine is a weak base when added to water. The K_b is 1.6×10^{-6}. What is the pH of a 4.33×10^{-3} *M* solution of morphine?
A) 4.08
B) 9.92
C) 5.84
D) 9.77
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 14.6
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | base-ionization equilibria MSC: Quantitative

78. The $[OH^-]$ in a 0.87 *M* pyridine (C_5H_5N; $K_b = 1.7 \times 10^{-9}$) solution is
A) 1.5×10^{-9} *M*
B) 3.8×10^{-5} *M*
C) 0.87 *M*
D) 4.4×10^{-5} *M*
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 14.6
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | base-ionization equilibria MSC: Quantitative

79. Calculate the pH of a 5.7 *M* solution of aniline ($C_6H_5NH_2$; $K_b = 3.8 \times 10^{-10}$):
A) 4.33
B) 9.67
C) 5.34
D) 8.66
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 14.6
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | base-ionization equilibria MSC: Quantitative

80. Calculate the pH of a 0.69 *M* solution of pyridine (C_5H_5N; $K_b = 1.7 \times 10^{-9}$):
A) 4.47
B) 5.07
C) 9.53
D) 8.93
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 14.6
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | base-ionization equilibria MSC: Quantitative

81. Calculate the percentage of pyridine (C_5H_5N) that forms pyridinium ion, $C_5H_6N^+$, in a 0.72 *M* aqueous solution of pyridine ($K_b = 1.7 \times 10^{-9}$).
A) 1.7×10^{-7} %

B) 3.5×10^{-3} %
C) 2.4×10^{-7} %
D) 6.7×10^{-3} %
E) 4.9×10^{-3} %

ANS: E PTS: 1 DIF: Moderate REF: 14.6
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | base-ionization equilibria MSC: Quantitative

82. Which of the following aqueous solutions will have the highest pH? For NH_3, $K_b = 1.8 \times 10^{-5}$; for $C_2H_3O_2^-$, $K_b = 5.6 \times 10^{-10}$.
A) 2.0 *M* NaOH
B) 2.0 *M* NH_3
C) 2.0 *M* $HC_2H_3O_2$
D) 2.0 *M* HCl
E) all the same

ANS: A PTS: 1 DIF: Moderate REF: 14.6
KEY: Chemistry | general chemistry | acids and bases | acid and base strength | relative strengths of acids and bases MSC: Conceptual

83. Calculate the pH of a 0.47 *M* NH_3 ($K_b = 1.8 \times 10^{-5}$) solution.
A) 2.54
B) 8.93
C) 5.07
D) 0.47
E) 11.46

ANS: E PTS: 1 DIF: Moderate REF: 14.6
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | base-ionization equilibria MSC: Quantitative

84. The equilibrium constant for the reaction $NH_4^+ + OH^- \rightleftharpoons NH_3 + H_2O$ is:
A) $\dfrac{1}{K_b(NH_3)}$
B) $\dfrac{1}{K_a(NH_4^+)}$
C) $\dfrac{K_w}{K_a(NH_4^+)}$
D) $\dfrac{K_w}{K_b(NH_3)}$
E) $\dfrac{K_b(NH_3)}{K_w}$

ANS: A PTS: 1 DIF: Easy REF: 14.6
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | base-ionization equilibria MSC: Conceptual

85. The pH of a 0.150 *M* solution of a weak base is 10.98. Calculate the pH of a 0.0603 *M* solution of the base.
A) 3.22
B) 10.78
C) 7.57
D) 6.43
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 14.6
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | base-ionization equilibria MSC: Quantitative

86. Calculate the pH of the following aqueous solution:
0.52 *M* aniline ($pK_b = 9.42$)
A) 4.85
B) 4.30
C) 9.70
D) 9.15
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 14.6
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | base-ionization equilibria MSC: Quantitative

87. Calculate the pH of the following aqueous solution:
0.62 *M* H_2S ($pK_{a1} = 7.00$; $pK_{a2} = 12.89$)
A) 10.40
B) 3.60
C) 7.21
D) 6.79
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 14.7
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | polyprotic acids MSC: Quantitative

88. Determine the pH of a 0.034 *M* solution of H_2SO_4. The dissociation occurs in two steps. K_{a1} is extremely large; K_{a2} is 1.2×10^{-2}.
A) 12.66
B) 1.47
C) 1.92
D) 1.38
E) 2.12

ANS: D PTS: 1 DIF: Moderate REF: 14.7
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | polyprotic acids MSC: Quantitative

89. Calculate the pH of the following aqueous solution: 0.5 *M* H_2CO_3 ($pK_{a1} = 6.37$; $pK_{a2} = 10.25$). Choose your answer from the following pH ranges:

A) pH 0.00–2.99
B) pH 3.00–5.99
C) pH 6.00–8.99
D) pH 9.00 –10.99
E) pH 11.00–14.00

ANS: B PTS: 1 DIF: Moderate REF: 14.7
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | polyprotic acids MSC: Quantitative

90. A 0.33-mol sample of a diprotic acid, H_2A, is dissolved in 250 mL of water. The K_{a1} of this acid is 1.0×10^{-5} and K_{a2} is 1.0×10^{-10}. Calculate the concentration of A^{2-} in this solution.
A) 1.0×10^{-5} *M*
B) 1.8×10^{-3} *M*
C) 3.6×10^{-3} *M*
D) 1.0×10^{-10} *M*
E) 1.32 *M*

ANS: D PTS: 1 DIF: Moderate REF: 14.7
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | polyprotic acids MSC: Quantitative

91. For the stepwise dissociation of aqueous H_3PO_4, which of the following is not a conjugate acid–base pair?
A) HPO_4^{2-} and PO_4^{3-}
B) H_3PO_4 and $H_2PO_4^-$
C) $H_2PO_4^-$ and HPO_4^{2-}
D) $H_2PO_4^-$ and PO_4^{3-}
E) H_3O^+ and H_2O

ANS: D PTS: 1 DIF: Easy REF: 14.7
KEY: Chemistry | general chemistry | acids and bases | acid-base concepts | Bronsted-Lowry concept of acids and bases MSC: Conceptual

92. The pH of a solution of 1.9 *M* H_2A ($K_{a1} = 1.0 \times 10^{-6}$ and K_{a2} is 1.0×10^{-10}) is:
A) 10.00
B) 5.72
C) 11.14
D) 2.86
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 14.7
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | polyprotic acids MSC: Quantitative

93. Calculate the pH of a 0.04 *M* solution of ascorbic acid ($K_{a1} = 7.9 \times 10^{-5}$; K_{a2} is 1.6×10^{-12}).
A) 11.2
B) 2.8
C) 5.5
D) 8.5

E) 11.8

ANS: B PTS: 1 DIF: Moderate REF: 14.7
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | polyprotic acids MSC: Quantitative

94. The dihydrogenphosphate ion, $H_2PO_4^-$, has both a conjugate acid and a conjugate base. These are, respectively:
A) H_3PO_4, PO_4^{3-}
B) H_3PO_4, HPO_4^{2-}
C) $H_2PO_4^-$, HPO_4^{2-}
D) HPO_4^{2-}, PO_4^{3-}
E) HPO_4^{2-}, H_3PO_4

ANS: B PTS: 1 DIF: Easy REF: 14.7
KEY: Chemistry | general chemistry | acids and bases | acid-base concepts | Bronsted-Lowry concept of acids and bases MSC: Conceptual

95. For which of the following 0.10 *M* diprotic acids would the second dissociation affect the pH significantly?
A) H_2A; $K_{a1} = 4.2 \times 10^{-2}$, $K_{a2} = 1.8 \times 10^{-7}$
B) H_2B; $K_{a1} = 2.4 \times 10^{-4}$, $K_{a2} = 6.1 \times 10^{-8}$
C) H_2C; $K_{a1} = 1.3 \times 10^{-4}$, $K_{a2} = 5.2 \times 10^{-9}$
D) H_2D; $K_{a1} = 1.8 \times 10^{-3}$, $K_{a2} = 9.3 \times 10^{-4}$
E) The second dissociation never affects the pH significantly.

ANS: D PTS: 1 DIF: Easy REF: 14.7
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | polyprotic acids MSC: Conceptual

96. The conjugate acid and conjugate base of bicarbonate ion, HCO_3^-, are, respectively:
A) H_3O^+ and OH^-
B) H_3O^+ and CO_3^{2-}
C) H_2CO_3 and OH^-
D) H_2CO_3 and CO_3^{2-}
E) CO_3^{2-} and OH^-

ANS: D PTS: 1 DIF: Easy REF: 14.7
KEY: Chemistry | general chemistry | acids and bases | acid-base concepts | Bronsted-Lowry concept of acids and bases MSC: Conceptual

97. Which of the following species is present in the greatest concentration in a 0.100 M H_2SO_4 solution in H_2O?
A) H_3O^+
B) HSO_4^-
C) H_2SO_4
D) All species are in equilibrium and therefore have the same concentration.
E) SO_4^{2-}

ANS: A PTS: 1 DIF: Easy REF: 14.7
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base

|acid-ionization equilibria | polyprotic acids MSC: Conceptual

98. Which of the following is true about the pH of a solution of sulfuric acid?
A) If the solution is dilute the pH can not be calculated.
B) If the solution is dilute the pH is completely controlled by the first dissociation.
C) If the solution is dilute the pH is completely controlled by the second dissociation.
D) If the solution is concentrated the pH is partially controlled by the second dissociation.
E) If the solution is dilute the pH is partially controlled by the second dissociation.

ANS: E PTS: 1 DIF: Easy REF: 14.7
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | polyprotic acids MSC: Conceptual

99. What is the equilibrium concentration of PO_4^{3-} in a 0.511 *M* solution of $H_3PO_4(aq)$? ($K_{a1} = 7.5 \times 10^{-3}$, $K_{a2} = 6.2 \times 10^{-8}$, $K_{a3} = 4.8 \times 10^{-13}$)
A) 5.8×10^{-2} *M*
B) 1.8×10^{-4} *M*
C) 4.8×10^{-13} *M*
D) 5.0×10^{-7} *M*
E) 6.2×10^{-8} *M*

ANS: C PTS: 1 DIF: Moderate REF: 14.7
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | polyprotic acids MSC: Quantitative

100. What is the equilibrium concentration of HPO_4^{2-} in a 0.528 *M* solution of $H_3PO_4(aq)$? ($K_{a1} = 7.5 \times 10^{-3}$, $K_{a2} = 6.2 \times 10^{-8}$, $K_{a3} = 4.8 \times 10^{-13}$)
A) 1.8×10^{-4} *M*
B) 5.9×10^{-2} *M*
C) 4.8×10^{-13} *M*
D) 6.2×10^{-8} *M*
E) 5.0×10^{-7} *M*

ANS: D PTS: 1 DIF: Moderate REF: 14.7
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | polyprotic acids MSC: Quantitative

101. What is the equilibrium concentration of $H_2PO_4^-$ in a 0.202 *M* solution of $H_3PO_4(aq)$? ($K_{a1} = 7.5 \times 10^{-3}$, $K_{a2} = 6.2 \times 10^{-8}$, $K_{a3} = 4.8 \times 10^{-13}$)
A) 1.1×10^{-4} *M*
B) 3.5×10^{-2} *M*
C) 3.9×10^{-2} *M*
D) 7.5×10^{-3} *M*
E) 6.2×10^{-8} *M*

ANS: B PTS: 1 DIF: Difficult REF: 14.7
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | polyprotic acids MSC: Quantitative

102. What is the equilibrium pH of a 0.835 *M* solution of $H_3PO_4(aq)$? ($K_{a1} = 7.5 \times 10^{-3}$, $K_{a2} = 6.2 \times 10^{-8}$, $K_{a3} = 4.8 \times 10^{-13}$)
A) 1.12
B) 3.64
C) 12.32
D) 6.20
E) 7.21

ANS: A PTS: 1 DIF: Difficult REF: 14.7
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | polyprotic acids MSC: Quantitative

103. Carbonic acid is a diprotic acid, H_2CO_3, with $K_{a1} = 4.2 \times 10^{-7}$ and $K_{a2} = 4.8 \times 10^{-11}$ at 25°C. The ion product for water is $K_w = 1.0 \times 10^{-14}$ at 25°C. What is the OH^- concentration of a solution that is 0.18 *M* in Na_2CO_3?
A) 6.1×10^{-3} *M*
B) 2.1×10^{-4} *M*
C) 6.5×10^{-5} *M*
D) 2.9×10^{-6} *M*
E) 2.7×10^{-4} *M*

ANS: A PTS: 1 DIF: Difficult REF: 14.7
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | polyprotic acids MSC: Quantitative

104. The two acid dissociation constants for carbonic acid, H_2CO_3, are 4.3×10^{-7} and 4.8×10^{-11} at 25°C. The base constant, K_b, or hydrolysis constant for HCO_3^- is:
A) 4.3×10^{-7}
B) 4.8×10^{-11}
C) 2.1×10^{-17}
D) 2.3×10^{-8}
E) 6.2×10^{-22}

ANS: D PTS: 1 DIF: Difficult REF: 14.7
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-ionization equilibria | polyprotic acids MSC: Quantitative

105.

HOAc	$K_a = 1.8 \times 10^{-5}$
H_2CO_3	$K_{a1} = 4.3 \times 10^{-7}$
	$K_{a2} = 5.6 \times 10^{-11}$

Which of the following 0.01 *M* solutions has the highest pH?
A) HOAc
B) NaOAc
C) Na_2CO_3
D) H_2CO_3
E) $NaHCO_3$

ANS: C PTS: 1 DIF: Easy REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base |

acid-base properties of salt solutions MSC: Conceptual

106. The sodium salt, NaA, of a weak acid is dissolved in water; no other substance is added. Which of these statements (to a close approximation) is true?
A) $[H^+] = [A^-]$
B) $[H^+] = [OH^-]$
C) $[A^-] = [OH^-]$
D) $[HA] = [OH^-]$
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions | prediction of salt solution acid-base properties
MSC: Conceptual

107. Which of the following would give the highest pH when dissolved in water to form a 0.10 *M* solution?
A) a strong acid
B) a weak acid
C) the potassium salt of a weak acid
D) the potassium salt of a strong acid
E) the ammonium salt of a strong acid

ANS: C PTS: 1 DIF: Easy REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions | prediction of salt solution acid-base properties
MSC: Conceptual

Select the answer that best describes an aqueous solution made from each of the following substances:

108. solid sodium nitrate ($NaNO_3$)
A) acidic
B) basic
C) neutral
D) cannot tell
E) none of these (A-D)

ANS: C PTS: 1 DIF: Easy REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions | prediction of salt solution acid-base properties
MSC: Conceptual

109. solid aluminum chloride ($AlCl_3$)
A) acidic
B) basic
C) neutral
D) cannot tell
E) none of these (A-D)

ANS: A PTS: 1 DIF: Easy REF: 14.8

KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions | prediction of salt solution acid-base properties
MSC: Conceptual

110. solid sodium carbonate (Na_2CO_3)
A) acidic
B) basic
C) neutral
D) cannot tell
E) none of these (A-D)

ANS: B PTS: 1 DIF: Easy REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions | prediction of salt solution acid-base properties
MSC: Conceptual

111. solid ammonium acetate ($NH_4C_2H_3O_2$). For NH_4^+, $K_a = 5.6 \times 10^{-10}$; for $C_2H_3O_2^-$, $K_b = 5.6 \times 10^{-10}$.
A) acidic
B) basic
C) neutral
D) cannot tell
E) none of these (A-D)

ANS: C PTS: 1 DIF: Easy REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions | prediction of salt solution acid-base properties
MSC: Conceptual

112. solid ammonium perchlorate (NH_4ClO_4) For NH_4^+, $K_a = 5.6 \times 10^{-10}$; for ClO_4^-, $K_b \approx 10^{-21}$.
A) acidic
B) basic
C) neutral
D) cannot tell
E) none of these (A-D)

ANS: A PTS: 1 DIF: Easy REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions | prediction of salt solution acid-base properties
MSC: Conceptual

113. Which of the following correctly labels the salts?
HF ($K_a = 7.2 \times 10^{-4}$) NH_3 ($K_b = 1.8 \times 10^{-5}$) HCN ($K_a = 6.2 \times 10^{-10}$)

A) NaCN = acidic, NH_4F = basic, KCN = neutral
B) NaCN = acidic, NH_4F = neutral, KCN = basic
C) NaCN = basic, NH_4F = basic, KCN= neutral
D) NaCN = basic, NH_4F = neutral, KCN = basic
E) NaCN = basic, NH_4F = acidic, KCN = basic

ANS: E PTS: 1 DIF: Easy REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions | prediction of salt solution acid-base properties
MSC: Conceptual

114. The pH of a 1.0 *M* aqueous solution of NaCl is:
A) 7.0
B) greater than 7.0
C) less than 7.0
D) not enough information given
E) none of these (A-D)

ANS: A PTS: 1 DIF: Easy REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions | prediction of salt solution acid-base properties
MSC: Conceptual

115. The pH of a 1.0 *M* sodium acetate solution is:
A) 7.0
B) greater than 7.0
C) less than 7.0
D) not enough information given
E) none of these (A-D)

ANS: B PTS: 1 DIF: Easy REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions | prediction of salt solution acid-base properties
MSC: Conceptual

116. Calculate the pH of the following aqueous solution:
0.35 *M* NaF (pK_a for HF = 3.14)
A) 5.66
B) 2.68
C) 8.34
D) 11.32
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions | pH of a salt solution MSC: Quantitative

117. Calculate the pH of the following aqueous solution:
0.39 *M* NH_4Cl (pK_b for NH_3 = 4.74)
A) 9.17
B) 4.83
C) 9.67
D) 4.33
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base |

acid-base properties of salt solutions | pH of a salt solution MSC: Quantitative

118. Calculate the $[H^+]$ in 1.0 *M* solution of Na_2CO_3 (for H_2CO_3, $K_{a1} = 4.3 \times 10^{-7}$; $K_{a2} = 5.6 \times 10^{-11}$).
A) 7.5×10^{-6} *M*
B) 6.6×10^{-4} *M*
C) 1.3×10^{-2} *M*
D) 7.5×10^{-13} *M*
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions | pH of a salt solution MSC: Quantitative

119. The $[H_3O^+]$ of a 0.49 *M* solution of NH_4Cl in H_2O at 25°C is (K_b for $NH_3 = 1.8 \times 10^{-5}$):
A) 2.7×10^{-10} *M*
B) 3.0×10^{-3} *M*
C) 1.6×10^{-5} *M*
D) 0.49 *M*
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions | pH of a salt solution MSC: Quantitative

120. Calculate the pH of a 0.59 *M* solution of NH_4Cl. (K_b for $NH_3 = 1.8 \times 10^{-5}$)
A) 9.26
B) 4.74
C) 9.48
D) 4.52
E) 0.23

ANS: B PTS: 1 DIF: Moderate REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions | pH of a salt solution MSC: Quantitative

121. What is the pH of a 0.73 *M* KCl solution?
A) 0.14
B) 7.00
C) 13.86
D) 3.65
E) 9.20

ANS: B PTS: 1 DIF: Easy REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions | pH of a salt solution MSC: Conceptual

122. Calculate the pH of a 0.49 *M* solution of $NaC_2H_3O_2$ (for $HC_2H_3O_2$ $K_a = 1.8 \times 10^{-5}$).
A) 4.78
B) 9.22

C) 8.95
D) 5.05
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions | pH of a salt solution MSC: Quantitative

123. Given that the K_a for HOCl is 3.45×10^{-8}, calculate the K value for the reaction of HOCl with OH^-.
A) 3.45×10^{6}
B) 3.45
C) 3.45×10^{-22}
D) 2.90×10^{-7}
E) 2.90×10^{21}

ANS: A PTS: 1 DIF: Moderate REF: 14.8
KEY: Chemistry | general chemistry | chemical equilibrium | equilibrium constant | equilibrium constant for the sum of reactions MSC: Quantitative

124. Which of the following is the correct order for increasing pHs for equimolar solutions of HNO_3, KCl, NH_4Cl, KOH, and $NaC_2H_3O_2$? (K_a for $HC_2H_3O_2$ is 1.80×10^{-5}, K_a for NH_4^+ is 5.56×10^{-10}).
A) KCl, NH_4Cl, HNO_3, KOH, $NaC_2H_3O_2$
B) HNO_3, KCl, NH_4Cl, KOH, $NaC_2H_3O_2$
C) NH_4Cl, HNO_3, KCl, KOH, $NaC_2H_3O_2$
D) HNO_3, NH_4Cl, KCl, $NaC_2H_3O_2$, KOH
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions MSC: Conceptual

125. Which of the following is the strongest base? (K_b for NH_3 is 1.8×10^{-5}, K_{a2} for H_2SO_4 is 1.2×10^{-2}, K_{a3} for H_3PO_4 is 4.8×10^{-13})
NH_3, HSO_4^-, PO_4^{3-}, or NO_3^-
A) NH_3
B) HSO_4^-
C) NO_3^-
D) PO_4^{3-}
E) Two of these are equally strong.

ANS: D PTS: 1 DIF: Moderate REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | acid and base strength | relative strengths of acids and bases MSC: Conceptual

126. The salt BX, when dissolved in water, produces an acidic solution. Which of the following could be true?
A) HX is a weak acid.
B) HX is a strong acid.

C) The cation B^+ is a weak acid.
D) All of the above could be true.
E) Only A and C could be true.

ANS: D PTS: 1 DIF: Easy REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions MSC: Conceptual

127. Calculate the K_a for an unknown monoprotic acid HX, given that a solution of 0.28 *M* LiX has a pH of 8.90.
A) 2.3×10^{-10}
B) 3.5×10^{-10}
C) 1.8×10^{3}
D) 8.9×10^{-5}
E) 4.4×10^{-5}

ANS: E PTS: 1 DIF: Moderate REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions MSC: Quantitative

128. If K_a for HCN is 6.17×10^{-10}, what is K_b for CN^-?

Note: $CN^- + H_2O \rightleftharpoons HCN + OH^-$ $\qquad K_b = \dfrac{[HCN][OH^-]}{[CN^-]}$

A) 6.17×10^{-24}
B) 6.17×10^{4}
C) 1.62×10^{-5}
D) 1.23×10^{-9}
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | base-ionization equilibria MSC: Quantitative

129. A 0.186 *M* solution of the salt NaA has a pH of 8.40. Calculate the K_a value of the acid HA.
A) 3.4×10^{-11}
B) 7.4×10^{-10}
C) 2.9×10^{-4}
D) 1.2×10^{2}
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions MSC: Quantitative

130. If you know K_b for ammonia, NH_3, you can calculate the equilibrium constant, K_a, for the following reaction: $NH_4^+ \rightleftharpoons NH_3 + H^+$ by the equation:
A) $K_a = K_w \times K_b$
B) $K_a = K_w / K_b$
C) $K_a = 1 / K_b$

D) $K_a = K_b / K_w$
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | base-ionization equilibria MSC: Conceptual

131. The hydrogen halides (HF, HCl, HBr, and HI) are all polar molecules. The strength of the acid each forms in water is based on which of the following?
A) the polarity of the molecule
B) the size of the molecule
C) the strength of the bond
D) two of these
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 14.9
KEY: Chemistry | general chemistry | acids and bases | acid and base strength | molecular structure and acid strength MSC: Conceptual

132. Which factor listed below is most important in determining the strength of an oxyacid?
A) the size of the molecule
B) the ability of the molecule to change atomic orientation
C) the identity of the central atom in the molecule
D) the number of oxygen atoms present in the molecule
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 14.9
KEY: Chemistry | general chemistry | acids and bases | acid and base strength | molecular structure and acid strength MSC: Conceptual

133. Which is the strongest acid of the following?
A) $HClO_2$
B) HClO
C) HBrO
D) HIO
E) HOAt

ANS: A PTS: 1 DIF: Easy REF: 14.9
KEY: Chemistry | general chemistry | acids and bases | acid and base strength | molecular structure and acid strength MSC: Conceptual

134. Which of the following would produce a basic aqueous solution?
A) P_4O_{10}
B) KCl
C) CO_2
D) NH_4Cl
E) none of these

ANS: E PTS: 1 DIF: Easy REF: 14.1
KEY: Chemistry | general chemistry | acids and bases MSC: Conceptual

135. Calculate the pH of a 0.005 *M* solution of potassium oxide, K_2O.
A) 12.0
B) 11.7
C) 7.0
D) 2.3
E) 2.0

ANS: A PTS: 1 DIF: Moderate REF: 14.1
KEY: Chemistry | general chemistry | acids and bases MSC: Quantitative

136. Which of the species below, when dissolved in H_2O, will not produce a basic solution?
A) SO_2
B) NH_3
C) BaO
D) $Ba(OH)_2$
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 14.1
KEY: Chemistry | general chemistry | acids and bases MSC: Conceptual

137. Which of the following species cannot act as a Lewis base?
A) O^{2-}
B) OH^-
C) CH_4
D) H_2S
E) NH_3

ANS: C PTS: 1 DIF: Easy REF: 14.11
KEY: Chemistry | general chemistry | acids and bases | acid-base concepts | Lewis concept of acids and bases MSC: Conceptual

138. Which of the following species cannot act as a Lewis base?
A) Al^{3+}
B) O^{2-}
C) OH^-
D) H_2O
E) H_2O_2

ANS: A PTS: 1 DIF: Easy REF: 14.11
KEY: Chemistry | general chemistry | acids and bases | acid-base concepts | Lewis concept of acids and bases MSC: Conceptual

139. Which of the following species cannot act as a Lewis base?
A) N^{3-}
B) NH^{2-}
C) NH_2^-
D) NH_3
E) NH_4^+

ANS: E PTS: 1 DIF: Easy REF: 14.11
KEY: Chemistry | general chemistry | acids and bases | acid-base concepts | Lewis concept

of acids and bases MSC: Conceptual

140. Which of the following species cannot act as a Lewis acid?
A) K^+
B) Mg^{2+}
C) Al^{3+}
D) H^+
E) H^-

ANS: E PTS: 1 DIF: Easy REF: 14.11
KEY: Chemistry | general chemistry | acids and bases | acid-base concepts | Lewis concept of acids and bases MSC: Conceptual

141. Which of the following species cannot act as a Lewis acid?
A) NH_4^+
B) H^+
C) BF_3
D) $BeCl_2$
E) Ag^+

ANS: A PTS: 1 DIF: Easy REF: 14.11
KEY: Chemistry | general chemistry | acids and bases | acid-base concepts | Lewis concept of acids and bases MSC: Conceptual

142. In the reaction:
$CaO(s) + SO_2(g) \rightarrow CaSO_3(s)$
A) Ca^{2+} acts as a Lewis acid and SO_3^{2-} acts as a Lewis base.
B) O^{2-} acts as a Lewis base and SO_2 acts as a Lewis acid.
C) O^{2-} acts as a Lewis base and Ca^{2+} acts as a Lewis acid.
D) CaO is the Lewis acid and $CaSO_3$ is its conjugate base.
E) SO_2 is the Lewis acid and $CaSO_3$ is its conjugate base.

ANS: B PTS: 1 DIF: Easy REF: 14.11
KEY: Chemistry | general chemistry | acids and bases | acid-base concepts | Lewis concept of acids and bases MSC: Conceptual

143. Consider the following reaction:
$AgBr(s) + 2CN^-(aq) \rightarrow Ag(CN)_2^-(aq) + Br^-(aq)$
The species that are acting as a Lewis acid and Lewis base, respectively, are
A) AgBr and $Ag(CN)_2^-$
B) $Ag(CN)_2^-$ and Ag^+
C) Ag^+ and Br^-
D) Br^- and CN^-
E) Ag^+ and CN^-

ANS: E PTS: 1 DIF: Easy REF: 14.11
KEY: Chemistry | general chemistry | acids and bases | acid-base concepts | Lewis concept of acids and bases MSC: Conceptual

144. Define amphoteric substance.

ANS:
A substance that can behave either as an acid or a base is amphoteric. Water is a common example of an amphoteric substance.

See Sec. 14.2 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Easy REF: 14.2
KEY: Chemistry | general chemistry | acids and bases | acid-base concepts | Bronsted-Lowry concept of acids and bases MSC: Conceptual

145. Explain why 0.1 *M* NaCN is basic while 0.1 *M* $NaNO_3$ is neutral.

ANS:
When NaCN dissolves in water, it produces Na^+ and CN^- ions. The Na^+ ion is the cation of a strong base, and so does not have any effect on the $[H^+]$ or $[OH^-]$ in water. The CN^- ion, however, is the anion of a weak acid. It will react with water to produce OH^- and the conjugate acid, HCN. Since $[OH^-]$ increases by this reaction, the solution is basic.
When $NaNO_3$ dissolves in water, the solvated ions are Na^+ and NO_3^-. Again, Na^+ does not affect $[H^+]$ or $[OH^-]$. Neither does NO_3^- since it is the anion of a strong acid, and so it does not act as a base, and does not affect $[H^+]$ or $[OH^-]$.

See Sec. 14.8 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Easy REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions | prediction of salt solution acid-base properties
MSC: Conceptual

146. Explain why $Al_2(SO_4)_3$ produces an acidic solution when it is dissolved in water.

ANS:
The ions from this salt are: Al^{3+} and SO_4^{2-}. The sulfate ion is the anion of a strong acid. It is the anion from the second ionization of H_2SO_4, for which $K_{a2} = 1.2 \times 10^{-2}$. The aluminum ion reacts with water to produce $Al(OH)_3$ (which is actually only slightly soluble), thus increasing $[H^+]$.

See Sec. 14.8 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Easy REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions MSC: Conceptual

Determine whether the following oxides produce an acidic, basic, or neutral solution when dissolved in water:

147. K_2O

ANS:
basic

$K_2O(s) + H_2O(l) \rightarrow 2KOH(aq)$; see Sec 14.10, Zumdahl *Chemistry*.

PTS: 1 DIF: Easy REF: 14.1
KEY: Chemistry | general chemistry | acids and bases MSC: Conceptual

148. NO_2

ANS:
acidic

$2NO_2(g) + H_2O(l) \rightarrow HNO_3(aq) + HNO_2(aq)$; see Sec 14.10, Zumdahl *Chemistry*.

PTS: 1 DIF: Easy REF: 14.1
KEY: Chemistry | general chemistry | acids and bases MSC: Conceptual

149. Cl_2O

ANS:
acidic

$Cl_2O(g) + H_2O(l) \rightarrow 2HClO(aq)$; see Sec 14.10, Zumdahl *Chemistry*.

PTS: 1 DIF: Easy REF: 14.1
KEY: Chemistry | general chemistry | acids and bases MSC: Conceptual

150. CaO

ANS:
basic

$CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$; see Sec 14.10, Zumdahl *Chemistry*.

PTS: 1 DIF: Easy REF: 14.1
KEY: Chemistry | general chemistry | acids and bases MSC: Conceptual

151. SO_2

ANS:
acidic

$SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$; see Sec 14.10, Zumdahl *Chemistry*.

PTS: 1 DIF: Easy REF: 14.1
KEY: Chemistry | general chemistry | acids and bases MSC: Conceptual

152. Given the following values of pK_a, determine which is the weakest base of the answers listed.

Acid	pK_a
$HClO_2$	1.95
HClO	7.54
HCOOH	3.74
HF	3.17
HNO_2	3.15

A) ClO_2^-
B) ClO^-
C) $HCOO^-$
D) F^-
E) Cl^-

ANS: E PTS: 1 DIF: Easy REF: 14.2
KEY: Chemistry | general chemistry | acids and bases | acid and base strength | relative strengths of acids and bases MSC: Conceptual

153. Which of the following solutions is incorrectly described?
A) 0.25 M NaH would be basic
B) 0.15 M KBr would be neutral
C) 0.25 M NH_4Cl would be acidic
D) 0.15 M HN_3 would be acidic
E) 0.20 M ClOH would be basic

ANS: E PTS: 1 DIF: Moderate REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions | prediction of salt solution acid-base properties
MSC: Conceptual

154. Which of the following statements is incorrect?
A) A solution of ammonium chloride will have a pH less than 7.
B) A solution of potassium bromide will have a pH of 7.
C) A solution of cobalt(II) chloride will have a pH less than 7.
D) Given that the K_b of ammonia is 1.8×10^{-5} and the K_a of hydrofluoric acid is 6.8×10^{-4}, a solution of ammonium fluoride will have a pH of less than 7.
E) A solution of sodium phosphate will have a pH of less than 7.

ANS: E PTS: 1 DIF: Moderate REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions | prediction of salt solution acid-base properties
MSC: Conceptual

155. Which of the following solutions is INCORRECTLY described?

I. 0.2 M NaCN has a pH > 7.
II. 0.2 M $FeBr_3$ is acidic
III. 0.25 M NH_4Cl is acidic
A) II only
B) II and III only
C) I and II only
D) I and III only

E) All are correctly described

ANS: E PTS: 1 DIF: Moderate REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions | prediction of salt solution acid-base properties
MSC: Conceptual

156. Describe the pH of the following salts? NaF, NH_4Cl, KI, NH_4F
A) acidic, basic, neutral, cannot tell without further information
B) neutral, acidic, neutral, cannot tell without further information
C) neutral, acidic, neutral, neutral
D) basic, acidic, neutral, cannot tell without further information
E) basic, acidic, neutral, neutral

ANS: D PTS: 1 DIF: Moderate REF: 14.8
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base properties of salt solutions | prediction of salt solution acid-base properties
MSC: Conceptual

157. For each group of compounds listed, which is the strongest acid?
I. HIO_2, HIO_3, HIO_4
II. H_2Se, H_2S, H_3As
III. HPO_2, $HClO_2$, $HBrO_2$
A) I. HIO_2, H_2Se, $HBrO_2$
B) I. HIO_4, H_2Se, $HBrO_2$
C) I. HIO_2, H_3As, HPO_2
D) I. HIO_3, H_3As, $HClO_2$
E) I. HIO_4, H_2Se, $HClO_2$

ANS: E PTS: 1 DIF: Moderate REF: 14.9
KEY: Chemistry | general chemistry | acids and bases | acid and base strength | molecular structure and acid strength MSC: Conceptual

158. Select the stronger acid from each pair:

I. HBr, HI
II $HClO_2$, $HClO_3$
III H_2SO_3, $HClO_3$

A)	HI	$HClO_2$	$HClO_3$
B)	HBr	$HClO_3$	H_2SO_3
C)	HI	$HClO_3$	H_2SO_3
D)	HBr	$HClO_2$	$HClO_3$
E)	HI	$HClO_3$	$HClO_3$

ANS: E PTS: 1 DIF: Moderate REF: 14.9
KEY: Chemistry | general chemistry | acids and bases | acid and base strength | molecular structure and acid strength MSC: Conceptual

159. Which is the stronger acid in each of the following pairs?

I. $HClO_2$ or $HClO_3$

II. H_2S or H_2Se
III. H_3AsO_4 or H_2SeO_4

A) I. $HClO_3$ II. H_2S III. H_2SeO_4
B) I.$HClO_2$ II. H_2S III. H_2SeO_4
C) I. $HClO_3$ II. H_2Se III. H_3AsO_4
D) I. $HClO_2$ II. H_2Se III. H_3AsO_4
E) I. $HClO_3$ II. H_2Se III. H_2SeO_4

ANS: E PTS: 1 DIF: Moderate REF: 14.9
KEY: Chemistry | general chemistry | acids and bases | acid and base strength | molecular structure and acid strength MSC: Conceptual

160. Which of the following statements is false?
A) $HBrO_3$ is a stronger acid than $HBrO_2$
B) H_2S is a stronger acid than H_2O
C) nitrite is a stronger base than nitrate
D) $HClO_3$ is a weaker acid than H_2SO_3
E) SbH_3 is a weaker acid than H_2Te

ANS: D PTS: 1 DIF: Moderate REF: 14.9
KEY: Chemistry | general chemistry | acids and bases | acid and base strength | molecular structure and acid strength MSC: Conceptual

161. Which of the following statements is false?
A) $HClO_3$ is a weaker acid than HBr
B) H_3PO_3 is a weaker acid than H_3PO_4
C) $HClO_3$ is a stronger acid than H_3PO_3
D) F^- is a weaker base than Br^-
E) The anion ClO_3^- is a weaker base than the anion $H_2PO_3^-$

ANS: D PTS: 1 DIF: Moderate REF: 14.9
KEY: Chemistry | general chemistry | acids and bases | acid and base strength | molecular structure and acid strength MSC: Conceptual

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1. Calculate the $[H^+]$ in a solution that is 0.16 *M* in NaF and 0.25 *M* in HF. ($K_a = 7.2 \times 10^{-4}$)
   A) $7.2 \times 10^{-4}\ M$
   B) $1.6\ M$
   C) $1.1 \times 10^{-3}\ M$
   D) $0.20\ M$
   E) $4.6 \times 10^{-4}\ M$

   ANS: C PTS: 1 DIF: Moderate REF: 15.1
   KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | common-ion effect MSC: Quantitative

2. For a solution equimolar in HCN and NaCN, which statement is *false*?
   A) This is an example of the common ion effect.
   B) The $[H^+]$ is larger than it would be if only the HCN was in solution.
   C) The $[H^+]$ is equal to the K_a.
   D) Addition of more NaCN will shift the acid dissociation equilibrium of HCN to the left.
   E) Addition of NaOH will increase $[CN^-]$ and decrease [HCN].

   ANS: B PTS: 1 DIF: Easy REF: 15.1
   KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | common-ion effect MSC: Conceptual

3. What will happen if a small amount of hydrochloric acid is added to a 0.1 *M* solution of HF?
   A) The percent ionization of HF will increase.
   B) The percent ionization of HF will decrease.
   C) The percent ionization of HF will remain unchanged.
   D) K_a for HF will increase.
   E) K_a for HF will decrease.

   ANS: B PTS: 1 DIF: Easy REF: 15.1
   KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | common-ion effect MSC: Conceptual

4. What will happen if a small amount of sodium hydroxide is added to a 0.1 *M* solution of ammonia?
   A) K_b for ammonia will increase.
   B) K_b for ammonia will decrease.
   C) The percent ionization of ammonia will increase.
   D) The percent ionization of ammonia will decrease.
   E) The percent ionization of ammonia will remain unchanged.

   ANS: D PTS: 1 DIF: Easy REF: 15.1
   KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | common-ion effect MSC: Conceptual

5. 15.0 mL of 0.50 *M* HCl is added to a 100.-mL sample of 0.456 *M* HNO_2 (K_a for $HNO_2 = 4.0 \times 10^{-4}$). What is the equilibrium concentration of NO_2^- ions?

A) $2.4 \times 10^{-3}\,M$
B) $1.6 \times 10^{-4}\,M$
C) $4.0 \times 10^{-1}\,M$
D) $4.9 \times 10^{-2}\,M$
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 15.1
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | common-ion effect MSC: Quantitative

6. 15.0 mL of 0.50 *M* NaOH is added to a 100.-mL sample of 0.457 *M* NH_3 (K_b for $NH_3 = 1.8 \times 10^{-5}$). What is the equilibrium concentration of NH_4^+ ions?
A) $1.0 \times 10^{-2}\,M$
B) $7.2 \times 10^{-6}\,M$
C) $4.0 \times 10^{-1}\,M$
D) $1.1 \times 10^{-4}\,M$
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 15.1
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | common-ion effect MSC: Quantitative

7. What is the percent dissociation of HNO_2 when 0.064 g of sodium nitrite is added to 120.0 mL of a 0.057 *M* HNO_2 solution? K_a for HNO_2 is 4.0×10^{-4}.
A) 13%
B) 0.30%
C) 5.2%
D) 0.075%
E) 8.4%

ANS: C PTS: 1 DIF: Moderate REF: 15.1
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | common-ion effect MSC: Quantitative

8. Which of the following mixtures would result in a buffered solution?
A) Mixing 100.0 mL of 0.100 *M* HCl with 100.0 mL of 0.100 *M* NaOH.
B) Mixing 100.0 mL of 0.100 *M* NH_3 ($K_b = 1.8 \times 10^{-5}$) with 100.0 mL of 0.100 *M* NaOH.
C) Mixing 100.0 mL of 0.100 *M* HCl with 100.0 mL of 0.100 *M* NH_3 ($K_b = 1.8 \times 10^{-5}$).
D) Mixing 50.0 mL of 0.100 *M* HCl with 100.0 mL of 0.100 *M* NH_3 ($K_b = 1.8 \times 10^{-5}$).
E) At least two of the above mixtures would result in a buffered solution.

ANS: D PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer MSC: Conceptual

9. Which of the following will not produce a buffered solution?
A) 100 mL of 0.1 *M* Na_2CO_3 and 50 mL of 0.1 *M* HCl
B) 100 mL of 0.1 *M* $NaHCO_3$ and 25 mL of 0.2 *M* HCl

C) 100 mL of 0.1 *M* Na_2CO_3 and 75 mL of 0.2 *M* HCl
D) 50 mL of 0.2 *M* Na_2CO_3 and 5 mL of 1.0 *M* HCl
E) 100 mL of 0.1 *M* Na_2CO_3 and 50 mL of 0.1 *M* NaOH

ANS: E PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer MSC: Conceptual

10. What combination of substances will give a buffered solution that has a pH of 5.05? (Assume each pair of substances is dissolved in 5.0 L of water.) (K_b for $NH_3 = 1.8 \times 10^{-5}$; K_b for $C_5H_5N = 1.7 \times 10^{-9}$)
A) 1.0 mole NH_3 and 1.5 mole NH_4Cl
B) 1.5 mole NH_3 and 1.0 mole NH_4Cl
C) 1.0 mole C_5H_5N and 1.5 mole C_5H_5NHCl
D) 1.5 mole C_5H_5N and 1.0 mole C_5H_5NHCl
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer MSC: Conceptual

11. Suppose a buffer solution is made from formic and ($HCHO_2$) and sodium formate ($NaCHO_2$). What is the net ionic equation for the reaction that occurs when a small amount of hydrochloric acid is added to the buffer?
A) $H_3O^+(aq) + OH^-(aq) \rightarrow 2H_2O(l)$
B) $H_3O^+(aq) + HCHO_2(aq) \rightarrow H_2O(l) + H_2CHO_2^+(aq)$
C) $HCl(aq) + OH^-(aq) \rightarrow H_2O(l) + Cl^-(aq)$
D) $HCl(aq) + CHO_2^-(aq) \rightarrow HCHO_2(aq) + Cl^-(aq)$
E) $H_3O^+(aq) + CHO_2^-(aq) \rightarrow HCHO_2(aq) + H_2O(l)$

ANS: E PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | adding an acid or base to a buffer MSC: Conceptual

12. Suppose a buffer solution is made from formic acid, $HCHO_2$, and sodium formate, $NaCHO_2$. What is the net ionic equation for the reaction that occurs when a small amount of sodium hydroxide is added to the buffer?
A) $NaOH(aq) + H_3O^+(aq) \rightarrow Na^+(aq) + 2H_2O(l)$
B) $H_3O^+(aq) + OH^-(aq) \rightarrow 2H_2O(l)$
C) $OH^-(aq) + HCHO_2(aq) \rightarrow CHO_2^-(aq) + H_2O(l)$
D) $NaOH(aq) + HCHO_2(aq) \rightarrow NaCHO_2(aq) + H_2O(l)$
E) $Na^+(aq) + HCHO_2(aq) \rightarrow NaH(aq) + HCO_2^+(aq)$

ANS: C PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | adding an acid or base to a buffer MSC: Conceptual

13. A weak acid, HF, is in solution with dissolved sodium fluoride, NaF. If HCl is added, which ion will react with the extra hydrogen ions from the HCl to keep the pH from changing?
A) OH^-

B) Na^+
C) F^-
D) Na^-
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | adding an acid or base to a buffer MSC: Conceptual

14. Which of the following is true for a buffered solution?
A) The solution resists change in its $[H^+]$.
B) The solution will not change its pH very much even if a concentrated acid is added.
C) The solution will not change its pH very much even if a strong base is added.
D) Any H^+ ions will react with a conjugate base of a weak acid already in solution.
E) All of these.

ANS: E PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer MSC: Conceptual

15. A 100. mL sample of 0.10 *M* HCl is mixed with 50. mL of 0.11 *M* NH_3. What is the resulting pH? (K_b for $NH_3 = 1.8 \times 10^{-5}$)
A) 3.09
B) 10.91
C) 12.48
D) 1.35
E) 1.52

ANS: E PTS: 1 DIF: Moderate REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | pH of a buffer MSC: Quantitative

16. The following question refers to a 2.0-liter buffered solution created from 0.72 *M* NH_3 ($K_b = 1.8 \times 10^{-5}$) and 0.26 *M* NH_4F. What is the pH of this solution?
A) 9.26
B) 9.70
C) 4.30
D) 5.18
E) 8.81

ANS: B PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | pH of a buffer MSC: Quantitative

17. The following question refers to a 2.0-liter buffered solution created from 0.31 *M* NH_3 ($K_b = 1.8 \times 10^{-5}$) and 0.26 *M* NH_4F. When 0.10 mol of H^+ ions is added to the solution what is the pH?
A) 4.82
B) 4.66
C) 10.53

D) 9.18
E) 7.88

ANS: D PTS: 1 DIF: Moderate REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | adding an acid or base to a buffer MSC: Quantitative

18. You have a 250.-mL sample of 1.250 *M* acetic acid ($K_a = 1.8 \times 10^{-5}$). Assuming no volume change, how much NaOH must be added to make the best buffer?
A) 6.25 g
B) 12.5 g
C) 16.3 g
D) 21.3 g
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer MSC: Quantitative

19. You have a 250.-mL sample of 1.28 *M* acetic acid ($K_a = 1.8 \times 10^{-5}$). Calculate the pH of the best buffer.
A) 7.00
B) 4.74
C) 4.25
D) 9.26
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | pH of a buffer MSC: Quantitative

20. You have a 250.0-mL sample of 1.00 *M* acetic acid ($K_a = 1.8 \times 10^{-5}$). Calculate the pH after adding 0.0050 mol of NaOH to 1.0 liter of the best buffer.
A) 7.05
B) 2.41
C) 3.54
D) 4.78
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | adding an acid or base to a buffer MSC: Quantitative

21. You have a 250.0-mL sample of 1.00 *M* acetic acid ($K_a = 1.8 \times 10^{-5}$). Calculate the pH after adding 0.0040 mol HCl to 1.0 liter of the best buffer.
A) 4.72
B) 2.35
C) 3.12
D) 6.98
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | adding an acid or base to a buffer MSC: Quantitative

22. You have solutions of 0.200 *M* HNO_2 and 0.200 *M* KNO_2 (K_a for $HNO_2 = 4.00 \times 10^{-4}$). A buffer of pH 3.000 is needed. What volumes of HNO_2 and KNO_2 are required to make 1 liter of buffered solution?
A) 500 mL of each
B) 286 mL HNO_2; 714 mL KNO_2
C) 413 mL HNO_2; 587 mL KNO_2
D) 714 mL HNO_2; 286 mL KNO_2
E) 587 mL HNO_2; 413 mL KNO_2

ANS: D PTS: 1 DIF: Difficult REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | Henderson-Hasselbalch equation MSC: Quantitative

23. A solution contains 0.250 *M* HA ($K_a = 1.0 \times 10^{-6}$) and 0.45 *M* NaA. What is the pH after 0.17 mole of HCl is added to 1.00 L of this solution?
A) 0.77
B) 7.82
C) 5.82
D) 1.97
E) 8.18

ANS: C PTS: 1 DIF: Moderate REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | adding an acid or base to a buffer MSC: Quantitative

24. The following question refers to the following system: A 1.0-liter solution contains 0.25 *M* HF and 0.83 *M* NaF (K_a for HF is 7.2×10^{-4}).
What is the pH of this solution?
A) 3.14
B) 3.66
C) 2.62
D) 0.52
E) 10.34

ANS: B PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | pH of a buffer MSC: Quantitative

25. The following question refers to the following system: A 1.0-liter solution contains 0.25 *M* HF and 0.32 *M* NaF (K_a for HF is 7.2×10^{-4}).
If one adds 0.30 liters of 0.020 *M* KOH to the solution, what will be the change in pH?
A) 0.02
B) 3.27
C) 0.13
D) –0.11
E) –0.28

ANS: A PTS: 1 DIF: Moderate REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | adding an acid or base to a buffer MSC: Quantitative

26. How many moles of HCl need to be added to 150.0 mL of 0.50 *M* NaZ to have a solution with a pH of 6.50? (K_a of HZ is 2.3×10^{-5})? Assume negligible volume of the HCl.
A) 6.8×10^{-3}
B) 7.5×10^{-2}
C) 5.0×10^{-1}
D) 1.0×10^{-3}
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | Henderson-Hasselbalch equation MSC: Quantitative

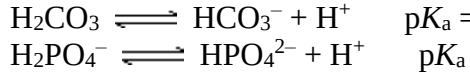
27. Calculate the pH of a solution that is 0.50 *M* in HF ($K_a = 7.2 \times 10^{-4}$) and 0.95 *M* in NaF.
A) 3.14
B) 3.42
C) 0.28
D) 10.58
E) 2.86

ANS: B PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | Henderson-Hasselbalch equation MSC: Quantitative

28. Calculate the pH of a solution that is 2.00 *M* HF, 1.00 *M* NaOH, and 0.642 *M* NaF. ($K_a = 7.2 \times 10^{-4}$)
A) 3.14
B) 3.36
C) 2.65
D) 2.93
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | adding an acid or base to a buffer MSC: Quantitative

29. Consider a solution consisting of the following two buffer systems:



At pH 6.4, which one of the following is true of the relative amounts of acid and conjugate base present?
A) $[H_2CO_3] > [HCO_3^-]$ and $[H_2PO_4^-] > [HPO_4^{2-}]$
B) $[H_2CO_3] = [HCO_3^-]$ and $[H_2PO_4^-] > [HPO_4^{2-}]$
C) $[H_2CO_3] = [HCO_3^-]$ and $[HPO_4^{2-}] > [H_2PO_4^-]$
D) $[HCO_3^-] > [H_2CO_3]$ and $[HPO_4^{2-}] > [H_2PO_4^-]$
E) $[H_2CO_3] > [HCO_3^-]$ and $[HPO_4^{2-}] > [H_2PO_4^-]$

ANS: B PTS: 1 DIF: Moderate REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | Henderson-Hasselbalch equation MSC: Conceptual

30. Given 100.0 mL of a buffer that is 0.50 *M* in HOCl and 0.77 *M* in NaOCl, what is the pH after 10.0 mL of 1.0 *M* NaOH has been added? (K_a for HOCl = 3.5×10^{-8})
A) 7.68
B) 7.74
C) 7.46
D) 7.12
E) 7.79

ANS: E PTS: 1 DIF: Moderate REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | adding an acid or base to a buffer MSC: Quantitative

31. How many moles of solid NaF would have to be added to 1.0 L of 2.39 *M* HF solution to achieve a buffer of pH 3.35? Assume there is no volume change. (K_a for HF = 7.2×10^{-4})
A) 3.9
B) 0.50
C) 0.67
D) 1.0
E) 1.6

ANS: A PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | Henderson-Hasselbalch equation MSC: Quantitative

32. What is the pH of a solution that results when 0.010 mol HNO_3 is added to 500. mL of a solution that is 0.10 *M* in aqueous ammonia and 0.55 *M* in ammonium nitrate. Assume no volume change. (The K_b for NH_3 = 1.8×10^{-5}.)
A) 9.26
B) 5.05
C) 10.11
D) 8.40
E) 8.71

ANS: D PTS: 1 DIF: Moderate REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | adding an acid or base to a buffer MSC: Quantitative

33. How many mmoles of HCl must be added to 100 mL of a 0.100 *M* solution of methylamine (pK_b = 3.36) to give a buffer having a pH of 10.00?
A) 8.1
B) 18.7
C) 20.0
D) 41.5
E) 12.7

ANS: A PTS: 1 DIF: Moderate REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base

with another solute | buffer | Henderson-Hasselbalch equation MSC: Quantitative

34. Calculate the pH of a solution made by mixing 100.0 mL of 0.635 *M* NH_3 with 100.0 mL of 0.100 *M* HCl. (K_b for $NH_3 = 1.8 \times 10^{-5}$)
A) 9.98
B) 4.02
C) 8.53
D) 9.26
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | pH of a buffer MSC: Quantitative

35. A solution contains 0.500 *M* HA ($K_a = 1.0 \times 10^{-8}$) and 0.432 *M* NaA. What is the $[H^+]$ after 0.10 mole of HCl is added to 1.00 L of this solution?
A) $1.0 \times 10^{-8}\ M$
B) $3.0 \times 10^{-8}\ M$
C) $5.5 \times 10^{21}\ M$
D) $1.8 \times 10^{-8}\ M$
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | adding an acid or base to a buffer MSC: Quantitative

36. Consider a solution of 2.0 *M* HCN and 1.0 *M* NaCN (K_a for $HCN = 6.2 \times 10^{-10}$). Which of the following statements is true?
A) The solution is not a buffer because [HCN] is not equal to $[CN^-]$.
B) The pH will be below 7.00 because the concentration of the acid is greater than that of the base.
C) $[OH^-] > [H^+]$
D) The buffer will be more resistant to pH changes from addition of strong acid than of strong base.
E) All of the above are false.

ANS: C PTS: 1 DIF: Easy REF: 15.3
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer MSC: Conceptual

37. Which of the following solutions will be the best buffer at a pH of 9.26? (K_a for $HC_2H_3O_2$ is 1.8×10^{-5}, K_b for NH_3 is 1.8×10^{-5}).
A) 0.10 *M* $HC_2H_3O_2$ and 0.10 *M* Na $C_2H_3O_2$
B) 5.0 *M* $HC_2H_3O_2$ and 5.0 *M* Na $C_2H_3O_2$
C) 0.10 *M* NH_3 and 0.10 *M* NH_4Cl
D) 5.0 *M* NH_3 and 5.0 *M* NH_4Cl
E) 5.0 *M* $HC_2H_3O_2$ and 5.0 *M* NH_3

ANS: D PTS: 1 DIF: Easy REF: 15.3
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base

with another solute | buffer MSC: Conceptual

You have two buffered solutions. Buffered solution 1 consists of 5.0 *M* HOAc and 5.0 *M* NaOAc; buffered solution 2 is made of 0.050 *M* HOAc and 0.050 *M* NaOAc.

38. How do the pHs of the buffered solutions compare?
A) The pH of buffered solution 1 is greater than that of buffered solution 2.
B) The pH of buffered solution 2 is greater than that of buffered solution 1.
C) The pH of buffered solution 1 is equal to that of buffered solution 2.
D) Cannot be determined without the K_a values.
E) None of these (A-D).

ANS: C PTS: 1 DIF: Easy REF: 15.3
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | pH of a buffer MSC: Conceptual

39. Buffered solution 1 has a greater buffering capacity than buffered solution 2.

ANS: T PTS: 1 DIF: Easy REF: 15.3
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer MSC: Conceptual

40. In titrating 0.20 *M* hydrochloric acid, HCl, with 0.20 *M* NaOH at 25°C, the solution at the equivalence point is
A) 0.20 *M* NaCl
B) very acidic
C) slightly acidic
D) 0.10 *M* HCl and 0.20 *M* NaOH
E) 0.10 *M* NaCl

ANS: E PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a strong acid by a strong base
MSC: Conceptual

41. One milliliter (1.00 mL) of acid taken from a lead storage battery is pipetted into a flask. Water and phenolphthalein indicator are added, and the solution is titrated with 0.55 *M* NaOH until a pink color appears; 12.0 mL are required. The number of grams of H_2SO_4 (formula weight = 98) present in one liter of the battery acid is:
A) 647
B) 323
C) 30
D) 1294
E) 54

ANS: B PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a strong acid by a strong base
MSC: Quantitative

42. You are given 5.00 mL of an H_2SO_4 solution of unknown concentration. You divide the 5.00-mL sample into five 1.00-mL samples and titrate each separately with 0.1000 *M* NaOH. In each titration the H_2SO_4 is completely neutralized. The average volume of NaOH solution used to reach the endpoint is 15.6 mL. What was the concentration of H_2SO_4 in the 5.00-mL sample?
A) 1.56 *M*
B) 3.90 *M*
C) 0.780 *M*
D) 0.156 *M*
E) 7.80 *M*

ANS: C PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a strong acid by a strong base
MSC: Quantitative

43. What is the molarity of a sodium hydroxide solution if 28.7 mL of this solution reacts exactly with 22.30 mL of 0.253 *M* sulfuric acid?
A) 0.197 *M*
B) 0.786 *M*
C) 7.26 *M*
D) 0.393 *M*
E) 0.221 *M*

ANS: D PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a strong acid by a strong base
MSC: Quantitative

44. If 25.0 mL of 0.451 *M* NaOH solution is titrated with 0.253 *M* H_2SO_4, the flask at the endpoint will contain (besides the indicator phenolphthalein) as the principal components:
A) sodium hydroxide, sulfuric acid, and water
B) dissolved sodium sulfate and water
C) sodium hydroxide, sodium sulfate, and water
D) dissolved sodium sulfate, sulfuric acid, and water
E) precipitated sodium sulfate and water

ANS: B PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a strong acid by a strong base
MSC: Conceptual

45. A 19.0-mL sample of tartaric acid is titrated to a phenolphthalein endpoint with 20. mL of 1.0 *M* NaOH. Assuming tartaric acid is diprotic, what is the molarity of the acid?
A) 1.0 *M*
B) 0.53 *M*
C) 2.0 *M*
D) 1.05 *M*
E) impossible to determine

ANS: B PTS: 1 DIF: Moderate REF: 15.4

KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Quantitative

46. If 25 mL of 0.750 *M* HCl are added to 100. mL of 0.352 *M* NaOH, what is the final pH?
A) 13.12
B) 0.88
C) 13.45
D) 0.55
E) 7.00

ANS: A PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a strong acid by a strong base
MSC: Quantitative

47. A 50.00-mL sample of 0.100 *M* KOH is titrated with 0.202 *M* HNO_3. Calculate the pH of the solution after 52.00 mL of HNO_3 is added.
A) 12.73
B) 0.99
C) 1.27
D) 13.01
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a strong acid by a strong base
MSC: Quantitative

48. A solution of hydrochloric acid of unknown concentration was titrated with 0.23 *M* NaOH. If a 100.-mL sample of the HCl solution required exactly 10. mL of the NaOH solution to reach the equivalence point, what was the pH of the HCl solution?
A) 12.4
B) 1.6
C) –0.4
D) 3.3
E) 6.6

ANS: B PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a strong acid by a strong base
MSC: Quantitative

49. A titration of 200.0 mL of 1.32 *M* H_2A was done with 1.00 *M* NaOH. For the diprotic acid H_2A, $K_{a1} = 2.5 \times 10^{-5}$, $K_{a2} = 3.1 \times 10^{-9}$. Calculate the pH before any 1.00 M NaOH has been added.
A) 11.76
B) 4.48
C) 9.52
D) 8.96

E) 2.24

ANS: E PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Quantitative

50. A titration of 200.0 mL of 1.00 *M* H_2A was done with 1.38 *M* NaOH. For the diprotic acid H_2A, $K_{a1} = 2.5 \times 10^{-5}$, $K_{a2} = 3.1 \times 10^{-9}$. Calculate the pH after 100.0 mL of 1.38 *M* NaOH have been added.
A) 9.05
B) 8.86
C) 5.14
D) 9.90
E) 4.95

ANS: E PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Quantitative

51. A titration of 200.0 mL of 1.00 *M* H_2A was done with 1.02 *M* NaOH. For the diprotic acid H_2A, $K_{a1} = 2.5 \times 10^{-5}$, $K_{a2} = 3.1 \times 10^{-9}$. Calculate the pH after 600.0 mL of 1.02 *M* NaOH have been added.
A) 13.423
B) 0.577
C) 13.712
D) 0.288
E) 9.423

ANS: A PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Quantitative

52. Consider the titration of 300.0 mL of 0.577 *M* NH_3 ($K_b = 1.8 \times 10^{-5}$) with 0.500 *M* HNO_3. After 150.0 mL of 0.500 *M* HNO_3 have been added, the pH of the solution is:
A) 4.63
B) 11.37
C) 6.37
D) 9.37
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a weak base by a strong acid
MSC: Quantitative

53. Consider the titration of 300.0 mL of 0.450 *M* NH_3 ($K_b = 1.8 \times 10^{-5}$) with 0.450 *M* HNO_3. How many milliliters of 0.450 *M* HNO_3 are required to reach the stoichiometric point of the reaction?
A) 3.50×10^2 mL
B) 4.00×10^2 mL
C) 4.50×10^2 mL
D) 3.00×10^2 mL
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a weak base by a strong acid
MSC: Quantitative

54. Consider the titration of 300.0 mL of 0.450 *M* NH_3 ($K_b = 1.8 \times 10^{-5}$) with 0.450 *M* HNO_3. At the stoichiometric point of this titration, the pH is:
A) 4.80
B) 2.70
C) 4.95
D) 4.74
E) 7.00

ANS: C PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a weak base by a strong acid
MSC: Quantitative

55. Consider the titration of 500.0 mL of 0.200 *M* NaOH with 0.800 *M* HCl. How many milliliters of 0.800 *M* HCl must be added to reach a pH of 13.000?
A) 55.6 mL
B) 24.6 mL
C) 18.5 mL
D) 12.9 mL
E) 4.32 mL

ANS: A PTS: 1 DIF: Difficult REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a strong acid by a strong base
MSC: Quantitative

56. What quantity of NaOH(*s*) must be added to 2.00 L of 0.434 *M* HCl to achieve a pH of 13.00? (Assume no volume change.)
A) 0.67 mol
B) 1.07 mol
C) 0.20 mol
D) 1.00×10^{-13} mol
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base

with another solute | acid-base titration curve | titration of a strong acid by a strong base
MSC: Quantitative

57. A 50.0-mL sample of 0.10 *M* HNO_2 ($K_a = 4.0 \times 10^{-4}$) is titrated with 0.12 M NaOH. The pH after 25.0 mL of NaOH have been added is
A) 10.43
B) 7.00
C) 6.57
D) 3.57
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a weak acid by a strong base
MSC: Quantitative

58. The pH at the equivalence point of the titration of a strong acid with a strong base is:
A) 3.9
B) 4.5
C) 7.0
D) 8.2
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a strong acid by a strong base
MSC: Quantitative

59. The pH at the equivalence point of a titration of a weak acid with a strong base will be
A) less than 7.00
B) equal to 7.00
C) greater than 7.00
D) equal to the pK_a of the acid
E) more data needed to answer this question

ANS: C PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a weak acid by a strong base
MSC: Quantitative

60. A 75.0-mL sample of 0.0650 *M* HCN ($K_a = 6.2 \times 10^{-10}$) is titrated with 0.65 *M* NaOH. What volume of 0.65 *M* NaOH is required to reach the stoichiometric point?
A) 750. mL
B) 7.50 mL
C) 3.75 mL
D) 75.0 mL
E) cannot determine without knowing the pH at the stoichiometric point

ANS: B PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a weak acid by a strong base

MSC: Quantitative

61. A 75.0-mL sample of 0.0500 *M* HCN ($K_a = 6.2 \times 10^{-10}$) is titrated with 0.277 *M* NaOH. What is the $[H^+]$ in the solution after 3.0 mL of 0.277 *M* NaOH have been added?
A) 4.6×10^{-6} *M*
B) 1.0×10^{-7} *M*
C) 3.5 *M*
D) 2.2×10^{-9} *M*
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a weak acid by a strong base
MSC: Quantitative

62. A student titrates an unknown weak acid, HA, to a pale pink phenolphthalein endpoint with 25.0 mL of 0.100 *M* NaOH. The student then adds 13.0 mL of 0.100 *M* HCl. The pH of the resulting solution is 4.7. Which of the following is true?
A) At pH 4.7, half the conjugate base, A^-, has been converted to HA.
B) The pK_a of the acid is 4.7.
C) The pK_a of the acid is less than 4.7.
D) The pK_a of the acid is greater than 4.7.
E) More than one of the above is correct.

ANS: D PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a weak acid by a strong base
MSC: Conceptual

63. How many moles of HCl(*g*) must be added to 1.0 L of 2.4 *M* NaOH to achieve a pH of 0.00? (Neglect any volume change.)
A) 1.4 moles
B) 4.4 moles
C) 3.4 moles
D) 5.4 moles
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a strong acid by a strong base
MSC: Quantitative

64. A 50.0-mL sample of a 1.50 *M* NaOH solution is titrated with a 1.86 *M* HCl solution. What will be the final volume of solution when the NaOH has been completely neutralized by the HCl?
A) 90.3 mL
B) 40.3 mL
C) 75.3 mL
D) 190. mL
E) 94.3 mL

ANS: A PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a strong acid by a strong base
MSC: Quantitative

65. You have 75.0 mL of 0.11 *M* HA. After adding 30.0 mL of 0.10 *M* NaOH, the pH is 5.50. What is the K_a value of HA?
A) 3.2×10^{-6}
B) 1.8×10^{-6}
C) 0.57
D) 1.1×10^{-6}
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a weak acid by a strong base
MSC: Quantitative

66. Consider the titration of 100.0 mL of 0.10 *M* H_2A ($K_{a1} = 1.50 \times 10^{-4}$; $K_{a2} = 3.89 \times 10^{-7}$) with 0.20 *M* NaOH. Calculate the $[H^+]$ after 75.0 mL of 0.20 *M* NaOH has been added.
A) $7.8 \times 10^{-7}\ M$
B) $2.6 \times 10^{-8}\ M$
C) $1.9 \times 10^{-7}\ M$
D) $3.9 \times 10^{-7}\ M$
E) none of these

ANS: D PTS: 1 DIF: Difficult REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Quantitative

67. Consider the titration of 100.0 mL of 0.10 *M* H_2A ($K_{a1} = 1.5 \times 10^{-4}$; $K_{a2} = 8.0 \times 10^{-7}$) with 0.20 *M* NaOH. Calculate the volume of 0.20 *M* NaOH required to reach an $[H^+]$ of $6.0 \times 10^{-4}\ M$.
A) 0 mL
B) 10. mL
C) 25. mL
D) 50. mL
E) 65. mL

ANS: B PTS: 1 DIF: Difficult REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Quantitative

68. A 50.00-mL sample of a 1.00 *M* solution of the diprotic acid H_2A ($K_{a1} = 1.0 \times 10^{-6}$ and $K_{a2} = 1.0 \times 10^{-10}$) is titrated with 2.00 *M* NaOH. How many mL of 2.00 *M* NaOH must be added to reach a pH of 10?
A) 0 mL

B) 12.5 mL
C) 25.0 mL
D) 37.5 mL
E) none of these

ANS: D PTS: 1 DIF: Difficult REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base | acid-base titration curve | titration of polyprotic acids MSC: Quantitative

69. Consider the titration of 100.0 mL of 0.100 *M* H_2A ($K_{a1} = 1.50 \times 10^{-4}$; $K_{a2} = 1.00 \times 10^{-8}$). How many milliliters of 0.100 *M* NaOH must be added to reach a pH of 5.000?
A) 41.9 mL
B) 93.8 mL
C) 100. mL
D) 200. mL
E) 60.0 mL

ANS: B PTS: 1 DIF: Difficult REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Quantitative

70. A 100.0-mL sample of 0.503 *M* H_2A (diprotic acid) is titrated with 0.200 *M* NaOH. After 125.0 mL of 0.200 *M* NaOH has been added, the pH of the solution is 4.50. Calculate K_{a1} for H_2A.
A) 3.2×10^{-10}
B) 4.5
C) 3.1×10^{-5}
D) not enough information to calculate
E) none of these

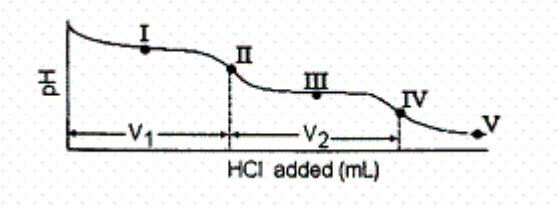
ANS: C PTS: 1 DIF: Difficult REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Quantitative

Consider the following information about the diprotic acid, ascorbic acid. (H_2As for short, molar mass 176.1)

$H_2As \rightleftharpoons HAs^- + H^+$ $pK_{a1} = 4.10$ ($K_{a1} = 7.9 \times 10^{-5}$)

$HAs^- \rightleftharpoons As^{2-} + H^+$ $pK_{a2} = 11.79$ ($K_{a2} = 1.6 \times 10^{-12}$)

The titration curve for disodium ascorbate, Na_2As, with standard HCl is shown below:



71. What major species is (are) present at point III?
A) As^{2-} and HAs^-

B) HAs^- only
C) HAs^- and H_2As
D) H_2As only
E) H_2As and H^+

ANS: C PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Conceptual

72. What is the pH at point I (V_1/2 HCl added)?
A) 4.10
B) 7.95
C) 11.79
D) 12.39
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Quantitative

73. What is the pH at point III?
A) 4.10
B) 7.95
C) 11.79
D) 12.39
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Quantitative

74. Which of the following is a major species present at point IV?
A) H_2As
B) HAs^-
C) As^{2-}
D) H^+
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Conceptual

75. A solution contains 10. mmol of H_3PO_4 and 5.0 mmol of NaH_2PO_4. How many milliliters of 0.10 *M* NaOH must be added to reach the second equivalence point of the titration of the H_3PO_4 with NaOH?
A) 250
B) 150

C) 1.0×10^2
D) 50
E) 2.0×10^2

ANS: A PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Quantitative

76. A solution contains 25 mmol of H_3PO_4 and 10. mmol of NaH_2PO_4. What volume of 2.0 *M* NaOH must be added to reach the second equivalence point of the titration of the H_3PO_4 with NaOH?
A) 5.0 mL
B) 12 mL
C) 25 mL
D) 30. mL
E) 60. mL

ANS: D PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Quantitative

77. A 100.-mL sample of a 0.10 *M* solution of H_3PO_4 is titrated with 0.20 *M* NaOH. What volume of base must be added to reach the third equivalence point?
A) 50. mL
B) 1.0×10^2
C) 150 mL
D) 2.0×10^2
E) 250 mL

ANS: C PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Quantitative

78. For carbonic acid (H_2CO_3), $K_{a1} = 4.30 \times 10^{-7}$ and $K_{a2} = 5.62 \times 10^{-11}$. Calculate the pH of a 0.56 *M* solution of Na_2CO_3.
A) 2.00
B) 10.06
C) 3.94
D) 12.00
E) 9.00

ANS: D PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Quantitative

79. A solution containing 10. mmol of CO_3^{2-} and 5.0 mmol of HCO_3^- is titrated with 1.8 *M* HCl. What volume of HCl must be added to reach the first equivalence point?
A) 2.8 mL
B) 5.6 mL
C) 10.6 mL
D) 15.6 mL
E) 20.6 mL

ANS: B PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Quantitative

80. A solution containing 10. mmol of CO_3^{2-} and 5.0 mmol of HCO_3^- is titrated with 1.7 *M* HCl. What total volume of HCl must be added to reach the second equivalence point?
A) 8.8 mL
B) 5.9 mL
C) 2.9 mL
D) 14.7 mL
E) 19.7 mL

ANS: D PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Quantitative

81. You dissolve 1.15 grams of an unknown diprotic acid in 200.0 mL of H_2O. This solution is just neutralized by 5.00 mL of a 1.00 *M* NaOH solution. What is the molar mass of the unknown acid?
A) 230
B) 115
C) 28.8
D) 460
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Quantitative

82. A 2.36-g sample of an acid, H_2X, requires 45.0 mL of a 0.500 *M* NaOH solution for complete reaction (removing both protons). The molar mass of the acid is:
A) 105
B) 255
C) 232
D) 210
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base

with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Quantitative

83. A 0.210-g sample of an acid (molar mass = 192 g/mol) is titrated with [$X] mL of [$Y] *M* NaOH to a phenolphthalein endpoint. The formula of the acid is:
A) HA
B) H_2A
C) H_3A
D) H_4A
E) not enough information given

ANS: C PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Quantitative

84. Consider the titration of 100.0 mL of 0.250 *M* aniline ($K_b = 3.82 \times 10^{-10}$) with 0.500 *M* HCl. Calculate the pH of the solution at the stoichiometric point.
A) 5.10
B) 9.42
C) 2.68
D) 11.32
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a weak base by a strong acid
MSC: Quantitative

85. Consider the titration of 100.0 mL of 0.250 *M* aniline ($K_b = 3.8 \times 10^{-10}$) with 0.500 *M* HCl. For calculating the volume of HCl required to reach a pH of 8.0, which of the following expressions is correct? (x = volume in mL of HCl required to reach a pH of 8.0)
A) $\frac{0.5x(100)(0.25)}{100+x}$ = [aniline]
B) $[H^+] = x$
C) $\frac{05x}{100+x}$ = [aniline]
D) $\frac{25-0.5x}{100+x} - 10^{-6}$ = [aniline]
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a weak base by a strong acid
MSC: Quantitative

86. A 100.0-mL sample of 0.2 *M* $(CH_3)_3N$ ($K_b = 5.33 \times 10^{-5}$) is titrated with 0.2 *M* HCl. What is the pH at the equivalence point?
A) 2.6

B) 8.6
C) 10.7
D) 5.4
E) 7.0

ANS: D PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a weak base by a strong acid
MSC: Quantitative

87. Calculate the pH at the equivalence point for the titration of 1.0 *M* ethylamine, $C_2H_5NH_2$, by 1.0 *M* perchloric acid, $HClO_4$. (pK_b for $C_2H_5NH_2$ = 3.25)
A) 6.05
B) 2.24
C) 5.53
D) 2.09
E) 5.38

ANS: C PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a weak base by a strong acid
MSC: Quantitative

88. What volume of 0.0100 *M* NaOH must be added to 1.00 L of 0.0500 *M* HOCl to achieve a pH of 8.00? The K_a for HOCl is 3.5×10^{-8}.
A) 1.0 L
B) 5.0 L
C) 1.2 L
D) 3.9 L
E) none of these

ANS: D PTS: 1 DIF: Difficult REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a weak acid by a strong base
MSC: Quantitative

89. Which of the following is the net ionic equation for the reaction that occurs during the titration of nitric acid with potassium hydroxide?
A) $HNO_3 + K^+ OH^- \rightarrow KNO_3 + H_2O$
B) $HNO_3 + H_2O \rightarrow NO3^- + H_3O^+$
C) $HNO_3 + KOH \rightarrow K^+ + NO_3^- + H_2O$
D) $HNO_3 + OH^- \rightarrow NO_3^- + H_2O$
E) $H^+ + OH^- \rightarrow H_2O$

ANS: E PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a strong acid by a strong base
MSC: Conceptual

90. In titrating 100 mL of 0.10 *M* HCl (*aq*) with 0.10 *M* NaOH, the pH does not change a great deal initially. Why is this?
A) The amount of OH^- has no affect on the pH of aqueous solutions.
B) The H^+ from the HCl (*aq*) acts like a buffer.
C) The major species when the acid and base are mixed form a buffered solution.
D) The statement "In titrating 100 mL of 0.10 *M* HCl (*aq*) with 0.10 *M* NaOH, the pH does not change a great deal initially." is not true.
E) None of these.

ANS: E PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a strong acid by a strong base
MSC: Conceptual

91. You have 100.0 mL of 0.100 *M* aqueous solutions of each of the following acids: HCN, HF, HCl, and $HC_2H_3O_2$. You titrate each with 0.100 *M* NaOH (*aq*). Rank the pHs of each of the solutions when each are titrated to the equivalence point, from highest to lowest pH.

K_a for HCN = 6.2×10^{-10}
K_a for HF = 7.2×10^{-4}
K_a for $HC_2H_3O_2$ = 1.8×10^{-5}

A) HCN, $HC_2H_3O_2$, HF, HCl
B) HCl, HF, HCN, $HC_2H_3O_2$
C) HF, HCN, $HC_2H_3O_2$, HCl
D) $HC_2H_3O_2$, HCl, HCN, HF
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a weak acid by a strong base
MSC: Conceptual

92. How many of the following will raise the pH of a weak acid HA in aqueous solution?

I. addition of water
II. making a buffered solution by adding NaA(*s*)
III. addition of NaCl(*s*)
IV. addition of HNO_3
V. titrating with KOH

A) 1
B) 2
C) 3
D) 4
E) 5

ANS: C PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases MSC: Conceptual

93. A 25.00-mL sample of propanoic acid, CH_3CH_2COOH, of unknown concentration was titrated with 0.111 *M* KOH. The equivalence point was reached when 44.54 mL of base had been added.What is the concentration of the propanoate ion at the equivalence point?
A) 0.111 *M*
B) 0.0711 *M*
C) 0.198 *M*
D) 0.128 *M*
E) 0.147 *M*

ANS: B PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a weak acid by a strong base
MSC: Quantitative

94. A 50.00-mL solution of 0.0350 *M* hydrocyanic acid ($K_a = 6.2 \times 10^{-10}$) is titrated with a 0.0333 *M* solution of sodium hydroxide as the titrant. What is the pH of the acid solution after 15.00 mL of titrant have been added? ($K_w = 1.00 \times 10^{-14}$)
A) 1.46
B) 5.33
C) 8.81
D) 10.60
E) 9.21

ANS: C PTS: 1 DIF: Difficult REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a weak acid by a strong base
MSC: Quantitative

95. A 50.00-mL solution of 0.0304 *M* ethanolamine ($K_b = 3.2 \times 10^{-5}$) is titrated with a 0.0282 *M* solution of hydrochloric acid as the titrant. What is the pH of the base solution after 23.24 mL of titrant have been added? ($K_w = 1.00 \times 10^{-14}$)
A) 10.99
B) 12.48
C) 4.49
D) 9.62
E) 4.38

ANS: D PTS: 1 DIF: Difficult REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a weak base by a strong acid
MSC: Quantitative

96. A 50.00-mL solution of 0.0217 *M* butyric acid ($K_a = 1.5 \times 10^{-5}$) is titrated with a 0.0302 *M* solution of sodium hydroxide as the titrant. What is the pH of at the equivalence point? ($K_w = 1.00 \times 10^{-14}$)
A) 8.46
B) 5.54
C) 4.82
D) 10.64
E) 9.18

ANS: A PTS: 1 DIF: Moderate REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a weak base by a strong acid
MSC: Quantitative

97. A 50.00-mL solution of 0.0350 *M* aniline ($K_b = 3.8 \times 10^{-10}$) is titrated with a 0.0127 *M* solution of hydrochloric acid as the titrant. What is the pH at the equivalence point? ($K_w = 1.0 \times 10^{-14}$)
A) 4.58
B) 10.69
C) 5.73
D) 9.42
E) 3.31

ANS: E PTS: 1 DIF: Difficult REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a weak base by a strong acid
MSC: Quantitative

Consider the titration of 100.0 mL of the weak diprotic acid H_2A (0.10 *M*) with 0.20 *M* NaOH. What are the major species at each of the following points in the titration? (Water is always assumed to be a major species.)

98. Before any NaOH is added
A) HA^-
B) H_2A, HA^-
C) HA^-, A^{2-}
D) H_2A
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Conceptual

99. After 25.0 mL of 0.20 *M* NaOH is added
A) HA^-
B) H_2A, HA^-
C) HA^-, A^{2-}
D) H_2A
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Conceptual

100. After 50.0 mL of 0.20 *M* NaOH is added
A) HA^-
B) H_2A, HA^-

C) HA^-, A^{2-}
D) H_2A
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Conceptual

101. After 75.0 mL of 0.20 *M* NaOH is added
A) HA^-
B) H_2A, HA^-
C) HA^-, A^{2-}
D) H_2A
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Conceptual

102. After 200.0 mL of 0.20 *M* NaOH is added
A) HA^-
B) H_2A, HA^-
C) HA^-, A^{2-}
D) H_2A
E) none of these

ANS: E PTS: 1 DIF: Easy REF: 15.4
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of polyprotic acids
MSC: Conceptual

103. Consider the following indicators and their pH ranges:

Methyl orange	3.2-4.4
Methyl red	4.8-6.0
Bromothymol blue	6.0-7.6
Phenolphthalein	8.2-10.0
Alizarin yellow	10.1-12.0

Assume an indicator works best when the equivalence point of a titration comes in the middle of the indicator range. For which of the following titrations would methyl red be the best indicator?
A) 0.100 *M* HNO_3 + 0.100 *M* KOH
B) 0.100 *M* aniline ($K_b = 3.8 \times 10^{-10}$) + 0.100 *M* HCl
C) 0.100 *M* NH_3 ($K_b = 1.8 \times 10^{-5}$) + 0.100 *M* HCl
D) 0.100 *M* HF ($K_a = 7.2 \times 10^{-4}$) + 0.100 *M* NaOH
E) 0.100 *M* acetic acid ($K_a = 1.8 \times 10^{-5}$) + 0.100 *M* NaOH

ANS: C PTS: 1 DIF: Moderate REF: 15.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base

with another solute | acid-base titration curve MSC: Conceptual

104. Assume an indicator works best when the equivalence point of a titration comes in the middle of the indicator range. Which indicator would be best for the following titration?

0.100 *M* HOCl ($K_a = 3.5 \times 10^{-8}$) + 0.100 *M* NaOH
A) crystal violet (0.2 - 1.8)
B) phenolphthalien (8.2 - 10.0)
C) methyl orange (3.2 - 4.4)
D) thymolphthalein (9.5 - 10.5)
E) cresol red (7.0 - 8.8)

ANS: D PTS: 1 DIF: Moderate REF: 15.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve MSC: Quantitative

105. In the titration of a weak acid HA with 0.100 *M* NaOH, the stoichiometric point is known to occur at a pH value of approximately 10. Which of the following indicator acids would be best to use to mark the endpoint of this titration?
A) indicator A, $K_a = 10^{-14}$
B) indicator B, $K_a = 10^{-11}$
C) indicator C, $K_a = 10^{-8}$
D) indicator D, $K_a = 10^{-6}$
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 15.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve MSC: Conceptual

106. In the titration of a weak acid, HA, with a sodium hydroxide solution of approximately the same concentration, the stoichiometric point occurs at pH = 9.5. Which of the following weak acid indicators would be best suited to mark the endpoint of this titration?
A) indicator A, $K_a = 10^{-11}$
B) indicator B, $K_a = 10^{-13}$
C) indicator C, $K_a = 10^{-9}$
D) indicator D, $K_a = 10^{-7}$
E) indicator E, $K_a = 10^{-5}$

ANS: A PTS: 1 DIF: Easy REF: 15.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve MSC: Conceptual

107. In the titration of a weak acid HA with 0.100 *M* NaOH, the stoichiometric point is known to occur at a pH value of approximately 11. Which of the following indicators would be best to use to mark the endpoint of this titration?
A) an indicator with $K_a = 10^{-10}$
B) an indicator with $K_a = 10^{-8}$
C) an indicator with $K_a = 10^{-14}$
D) an indicator with $K_a = 10^{-11}$
E) an indicator with $K_a = 10^{-12}$

ANS: E PTS: 1 DIF: Easy REF: 15.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve MSC: Conceptual

108. A certain indicator HIn has a pK_a of 9.00 and a color change becomes visible when 7.00% of it is In^-. At what pH is this color change visible?
A) 10.2
B) 3.85
C) 6.15
D) 7.88
E) none of these

ANS: D PTS: 1 DIF: Difficult REF: 15.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve MSC: Quantitative

109. Methyl orange is an indicator with a K_a of 1×10^{-4}. Its acid form, HIn, is red, while its base form, In^-, is yellow. At pH 6.0, the indicator will be
A) red
B) orange
C) yellow
D) blue
E) not enough information

ANS: C PTS: 1 DIF: Easy REF: 15.5
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve MSC: Conceptual

110. Which of the following pairs of 0.100 mol L^{-1} solutions, when mixed, will produce a buffer solution?
A) 50 mL of aqueous CH_3COONa and 25 mL aqueous NaOH
B) 50 mL of aqueous CH_3COOH and 25 mL aqueous HCl
C) 50 mL of aqueous CH_3COOH and 25 mL aqueous CH_3COONa
D) 50 mL of aqueous CH_3COOH and 100 mL aqueous NaOH
E) 50 mL of aqueous NaOH and 25 mL aqueous HCl

ANS: C PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer MSC: Conceptual

111. Equal volumes of the following pairs of solutions are mixed. Which pair will produce a buffer solution?
A) 0.10 mol L^{-1} HCl and 0.05 mol L^{-1} NaOH
B) 0.10 mol L^{-1} HCl and 0.15 mol L^{-1} NH_3
C) 0.10 mol L^{-1} HCl and 0.05 mol L^{-1} NH_3
D) 0.10 mol L^{-1} HCl and 0.20 mol L^{-1} CH_3COOH
E) 0.10 mol L^{-1} HCl and 0.20 mol L^{-1} NaCl

ANS: B PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer MSC: Conceptual

112. Which of the following solutions would be described as a buffer solution?
A) 0.25 M CH_3COOH and 0.20 M HCl
B) 0.25 M CH_3COOH and 0.20 M NaOH
C) 0.15 M NaBr and 0.20 M HBr
D) 0.25 M NH_3 and 0.15 M NaOH
E) 0.25 M HCl and 0.10 M NaOH

ANS: B PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer MSC: Conceptual

113. Which of the following mixtures would be classified as a buffer solution?
A) 50 mL of 0.100 M HCl and 50 mL of 0.100 M KCl
B) 50 mL of 0.100 M CH_3COOH and 55 mL of 0.100 M NaOH
C) 50 mL of 0.100 M CH_3COOH and 25 mL of 0.100 M NaOH
D) 50 mL of 0.100 M CH_3COOH and 0.500 mL of 0.000100 M NaOH
E) 50 mL of 0.100 M CH_3COOH and 55 mL of 0.100 M HCl

ANS: C PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer MSC: Conceptual

114. Which of the following mixtures would NOT be described as a buffer solution?
A) 0.15 M NH_4Cl and 0.25 M NH_3
B) 0.20 M NaOH and 0.40 M CH_3COOH
C) 0.25 M HNO_2 and 0.15 M KNO_2
D) 0.25 M HNO_3 and 0.15 M KNO_3
E) 0.30 M NH_3 and 0.15 M HCl

ANS: D PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer MSC: Conceptual

115. 100 mL of a buffer that consists of 0.20 M NH_3 and 0.20 M NH_4Cl is titrated with 25 mL of 0.20 M HCl. Calculate the pH of the resulting solution given that the K_b for NH_3 is 1.8×10^{-5}.
A) 4.74
B) 4.97
C) 9.03
D) 9.26
E) 9.48

ANS: C PTS: 1 DIF: Moderate REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | adding an acid or base to a buffer MSC: Quantitative

116. What is the pH for a buffer that consists of 0.45 M CH_3COOH and 0.35 M CH_3COONa? K_a of $CH_3COOH = 1.8 \times 10^{-5}$
A) 2.55
B) 4.63

C) 9.15
D) 4.85
E) 9.37

ANS: B PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | pH of a buffer MSC: Quantitative

117. What is the pH for a buffer that consists of 0.25 M CH_3COOH and 0.10 M CH_3COONa? K_a of $CH_3COOH = 1.8 \times 10^{-5}$
A) 2.67
B) 4.34
C) 8.86
D) 5.14
E) 9.66

ANS: B PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | pH of a buffer MSC: Quantitative

118. What is the pH for a buffer that consists of 0.45 M CH_3CH_2COOH and 0.10 M CH_3CH_2COOK? K_a of $CH_3CH_2COOH = 1.3 \times 10^{-5}$
A) 2.62
B) 4.24
C) 8.46
D) 5.54
E) 9.76

ANS: B PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | pH of a buffer MSC: Quantitative

119. What is the pH for a buffer that consists of 0.25 M CH_3CH_2COOH and 0.10 M CH_3CH_2COONa? K_a of $CH_3CH_2COOH = 1.3 \times 10^{-5}$
A) 2.74
B) 4.49
C) 8.71
D) 5.29
E) 9.51

ANS: B PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | pH of a buffer MSC: Quantitative

120. What is the pH for a buffer that consists of 0.45 M benzoic acid, C_6H_5COOH and 0.40 M potassium benzoate C_6H_5COOK? K_a of $C_6H_5COOH = 6.4 \times 10^{-5}$
A) 2.27
B) 4.14
C) 9.76
D) 4.24
E) 9.86

ANS: B PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | pH of a buffer MSC: Quantitative

121. What is the pH for a buffer that consists of 0.25 M benzoic acid, C_6H_5COOH and 0.40 M potassium benzoate C_6H_5COOK? K_a of $C_6H_5COOH = 6.4 \times 10^{-5}$
A) 2.40
B) 4.39
C) 10.01
D) 3.99
E) 9.61

ANS: B PTS: 1 DIF: Easy REF: 15.2
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | buffer | pH of a buffer MSC: Quantitative

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1. The molar solubility of PbI_2 is 1.52×10^{-3} *M*. Calculate the value of K_{sp} for PbI_2.
   A) 3.51×10^{-9}
   B) 4.62×10^{-6}
   C) 1.40×10^{-8}
   D) 1.52×10^{-3}
   E) none of these

   ANS: C PTS: 1 DIF: Easy REF: 16.1
   KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

2. The concentration of OH^- in a saturated solution of $Mg(OH)_2$ is 3.63×10^{-4} *M*. The K_{sp} of $Mg(OH)_2$ is
   A) 6.6×10^{-8}
   B) 4.8×10^{-11}
   C) 1.3×10^{-7}
   D) 3.6×10^{-4}
   E) 2.4×10^{-11}

   ANS: E PTS: 1 DIF: Easy REF: 16.1
   KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

3. The solubility of $CaSO_4$ in pure water at 0^oC is 1.14 gram(s) per liter. The value of the solubility product is
   A) 8.37×10^{-3}
   B) 1.14×10^{-3}
   C) 9.15×10^{-2}
   D) 7.01×10^{-5}
   E) none of these

   ANS: D PTS: 1 DIF: Moderate REF: 16.1
   KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

4. It is observed that 7.50 mmol of BaF_2 will dissolve in 1.0 L of water. Use these data to calculate the value of K_{sp} for barium fluoride.
   A) 1.1×10^{-4}
   B) 4.2×10^{-7}
   C) 1.7×10^{-6}
   D) 2.2×10^{-4}
   E) 5.6×10^{-5}

   ANS: C PTS: 1 DIF: Easy REF: 16.1
   KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

5. The solubility in mol/L of Ag_2CrO_4 is 1.8×10^{-4} *M*. Calculate the K_{sp} for this compound.
   A) 6.5×10^{-8}
   B) 1.8×10^{-4}
   C) 2.3×10^{-11}
   D) 5.8×10^{-12}
   E) 3.6×10^{-4}

   ANS: C PTS: 1 DIF: Easy REF: 16.1
   KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

6. The solubility of $Cd(OH)_2$ in water is 1.67×10^{-5} mol/L. The K_{sp} value for $Cd(OH)_2$ is
   A) 1.86×10^{-14}
   B) 4.66×10^{-15}
   C) 5.58×10^{-10}
   D) 1.67×10^{-5}
   E) none of these

   ANS: A PTS: 1 DIF: Easy REF: 16.1
   KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

7. The solubility of silver phosphate, Ag_3PO_4, at 25°C is 1.60×10^{-5} mol/L. What is the K_{sp} for the silver phosphate at 25°C?
   A) 1.11×10^{-13}
   B) 1.77×10^{-18}
   C) 7.68×10^{-10}
   D) 6.55×10^{-20}
   E) none of these

   ANS: B PTS: 1 DIF: Easy REF: 16.1
   KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

8. The solubility of an unknown salt, M_3Z_2, at 25°C is 3.1×10^{-7} mol/L. What is the K_{sp} for M_3Z_2 at 25°C?
   A) 4.2×10^{-23}
   B) 1.0×10^{-24}
   C) 7.7×10^{-32}
   D) 3.1×10^{-31}
   E) none of these

   ANS: D PTS: 1 DIF: Easy REF: 16.1
   KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

9. The solubility of an unknown salt, MZ_2, at 25°C is 3.9×10^{-4} mol/L. What is the K_{sp} for MZ_2 at 25°C?

A) 3.8×10^{-9}
B) 1.5×10^{-7}
C) 1.6×10^{-9}
D) 6.1×10^{-7}
E) none of these

ANS: E PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

10. The solubility of an unknown salt, MZ_3, at 25°C is 3.1×10^{-5} mol/L. What is the K_{sp} for MZ_3 at 25°C?
A) 5.9×10^{-10}
B) 2.5×10^{-17}
C) 8.0×10^{-13}
D) 1.2×10^{-13}
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

11. Barium carbonate has a measured solubility of 4.03×10^{-5} at 25°C. Determine the K_{sp}.
A) 4.03×10^{-5}
B) 8.06×10^{-5}
C) 6.35×10^{-3}
D) 2.62×10^{-13}
E) 1.62×10^{-9}

ANS: E PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

12. A 300.0-mL saturated solution of copper(II) peroidate, $Cu(IO_4)_2$, contains 0.30 grams of dissolved salt. Determine the K_{sp}.
A) 1.0×10^{-5}
B) 2.0×10^{-5}
C) 2.2×10^{-3}
D) 4.5×10^{-8}
E) 1.2×10^{-9}

ANS: D PTS: 1 DIF: Moderate REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

13. The $\left[IO_3^-\right]$ in a saturated solution of $Ce(IO_3)_3$ is 5.93×10^{-3} *M*. Calculate the K_{sp} for $Ce(IO_3)_3$.

A) 4.12×10^{-10}
B) 3.71×10^{-9}
C) 2.09×10^{-7}
D) 1.98×10^{-3}
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

14. The correct mathematical expression for finding the molar solubility (s) of $Sn(OH)_2$ is:
A) $2s^2 = K_{sp}$
B) $2s^3 = K_{sp}$
C) $108s^5 = K_{sp}$
D) $4s^3 = K_{sp}$
E) $8s^3 = K_{sp}$

ANS: D PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Conceptual

15. Find the solubility (in mol/L) of lead(II) chloride, $PbCl_2$, at 25°C. $K_{sp} = 1.59 \times 10^{-5}$.
A) 1.58×10^{-2}
B) 2.51×10^{-2}
C) 6.28×10^{-17}
D) 1.99×10^{-3}
E) 2.00×10^{-2}

ANS: A PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

16. Calculate the concentration of chromate ion, CrO_4^{2-}, in a saturated solution of $CaCrO_4$ ($K_{sp} = 7.08 \times 10^{-4}$).
A) 2.66×10^{-2} M
B) 1.42×10^{-3} M
C) 7.08×10^{-4} M
D) 5.01×10^{-7} M
E) 3.54×10^{-4} M

ANS: A PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

17. Calculate the concentration of the silver ion in a saturated solution of silver chloride, AgCl ($K_{sp} = 1.57 \times 10^{-10}$).
A) 1.57×10^{-10}
B) 1.25×10^{-5}
C) 2.46×10^{-20}

D) 3.14×10^{-10}
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

18. Silver chromate, Ag_2CrO_4, has a K_{sp} of 8.96×10^{-12}. Calculate the solubility in mol/L of silver chromate.
A) 1.31×10^{-4} *M*
B) 1.65×10^{-4} *M*
C) 2.25×10^{-12} *M*
D) 2.08×10^{-4} *M*
E) 1.50×10^{-6} *M*

ANS: A PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

19. An unknown salt, M_2Z, has a K_{sp} of 3.3×10^{-9}. Calculate the solubility in mol/L of M_2Z.
A) 2.9×10^{-5} *M*
B) 5.7×10^{-5} *M*
C) 9.4×10^{-4} *M*
D) 3.7×10^{-4} *M*
E) none of the above

ANS: C PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

20. An unknown salt, M_3Z, has a K_{sp} of 1.2×10^{-17}. Calculate the solubility in mol/L of M_3Z.
A) 2.6×10^{-5} *M*
B) 3.5×10^{-9} *M*
C) 1.4×10^{-6} *M*
D) 2.2×10^{-6} *M*
E) none of the above

ANS: A PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

21. Calculate the concentration of Al^{3+} in a saturated aqueous solution of $Al(OH)_3$ ($K_{sp} = 2.2 \times 10^{-32}$).
A) 7.0×10^{-9}
B) 2.0×10^{-34}
C) 1.2×10^{-8}
D) 8.1×10^{-34}
E) 5.3×10^{-9}

ANS: E PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

22. In a solution prepared by adding excess PbI_2 ($K_{sp} = 1.44 \times 10^{-8}$) to water, the $[I^-]$ at equilibrium is:
A) 1.53×10^{-3} mol/L
B) 7.20×10^{-9} mol/L
C) 1.20×10^{-4} mol/L
D) 9.33×10^{-26} mol/L
E) 3.07×10^{-3} mol/L

ANS: E PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

23. The solubility of silver phosphate, Ag_3PO_4, at 25°C is 1.55×10^{-5} mol/L. Determine the concentration of the Ag^+ ion in a saturated solution.
A) 1.55×10^{-5} *M*
B) 5.17×10^{-6} *M*
C) 4.65×10^{-5} *M*
D) 1.94×10^{5} *M*
E) 3.72×10^{-15} *M*

ANS: C PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Quantitative

24. Which of the following compounds has the lowest solubility in mol/L in water at 25°C?
A) Ag_3PO_4 $K_{sp} = 1.8 \times 10^{-18}$
B) $Sn(OH)_2$ $K_{sp} = 3 \times 10^{-27}$
C) CdS $K_{sp} = 1.0 \times 10^{-28}$
D) $CaSO_4$ $K_{sp} = 6.1 \times 10^{-5}$
E) $Al(OH)_3$ $K_{sp} = 2 \times 10^{-33}$

ANS: C PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant | relative solubilities MSC: Conceptual

25. Solubility Products (K_{sp})

$BaSO_4$	1.5×10^{-9}
CoS	5.0×10^{-22}
$PbSO_4$	1.3×10^{-8}
AgBr	5.0×10^{-13}
$BaCO_3$	1.6×10^{-9}

Which of the following compounds is the most soluble (in moles/liter)?
A) $BaSO_4$

B) CoS
C) $PbSO_4$
D) AgBr
E) $BaCO_3$

ANS: C PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant | relative solubilities MSC: Conceptual

26. Which of the following compounds has the lowest solubility in mol/L in water?
A) $Al(OH)_3$ $K_{sp} = 2 \times 10^{-32}$
B) CdS $K_{sp} = 1.0 \times 10^{-28}$
C) $PbSO_4$ $K_{sp} = 1.3 \times 10^{-8}$
D) $Sn(OH)_2$ $K_{sp} = 3 \times 10^{-27}$
E) MgC_2O_4 $K_{sp} = 8.6 \times 10^{-5}$

ANS: B PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant | relative solubilities MSC: Conceptual

27. Which of the following salts shows the lowest solubility in water? (K_{sp} values: $Ag_2S = 1.6 \times 10^{-49}$; $Bi_2S_3 = 1.0 \times 10^{-72}$; $HgS = 1.6 \times 10^{-54}$; $Mg(OH)_2 = 8.9 \times 10^{-12}$; $MnS = 2.3 \times 10^{-13}$)
A) Bi_2S_3
B) Ag_2S
C) MnS
D) HgS
E) $Mg(OH)_2$

ANS: D PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant | relative solubilities MSC: Conceptual

28. How many moles of $Fe(OH)_2$ [$K_{sp} = 1.8 \times 10^{-15}$] will dissolve in 1.0 liter of water buffered at pH = 10.37?
A) 3.3×10^{-8}
B) 2.3×10^{-4}
C) 5.5×10^{-8}
D) 3.1×10^{7}
E) 7.7×10^{-12}

ANS: A PTS: 1 DIF: Moderate REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility and the common-ion effect MSC: Quantitative

29. The molar solubility of $BaCO_3$ ($K_{sp} = 1.6 \times 10^{-9}$) in 0.10 *M* $BaCl_2$ solution is:
A) 1.6×10^{-10}
B) 4.0×10^{-5}
C) 7.4×10^{-4}
D) 0.10

E) none of these

ANS: E PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility and the common-ion effect MSC: Quantitative

30. The K_{sp} of AgI is 1.5×10^{-16}. Calculate the solubility in mol/L of AgI in a 0.30 *M* NaI solution.
A) 4.5×10^{-17}
B) 0.30
C) 1.5×10^{-16}
D) 1.2×10^{-8}
E) 5.0×10^{-16}

ANS: E PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility and the common-ion effect MSC: Quantitative

31. The molar solubility of AgCl ($K_{sp} = 1.6 \times 10^{-10}$) in 0.0035 *M* sodium chloride at 25°C is:
A) 0.0035
B) 5.6×10^{-13}
C) 4.6×10^{-8}
D) 1.6×10^{-10}
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility and the common-ion effect MSC: Quantitative

32. The K_{sp} of $PbSO_4$ is 1.3×10^{-8}. Calculate the solubility (in mol/L) of $PbSO_4$ in a 0.0037 *M* solution of Na_2SO_4.
A) 4.8×10^{-11} *M*
B) 1.2×10^{-11} *M*
C) 3.5×10^{-6} *M*
D) 1.3×10^{-8} *M*
E) 1.9×10^{-3} *M*

ANS: C PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility and the common-ion effect MSC: Quantitative

33. The K_{sp} for PbF_2 is 4.0×10^{-8}. If a 0.040 *M* NaF solution is saturated with PbF_2, what is the $[Pb^{2+}]$ in the solution?
A) 1.0×10^{-6} *M*
B) 6.4×10^{-11} *M*
C) 6.3×10^{-4} *M*
D) 2.5×10^{-5} *M*
E) 1.6×10^{-9} *M*

ANS: D PTS: 1 DIF: Moderate REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility and the common-ion effect MSC: Quantitative

34. The K_{sp} of an unknown salt, MZ_2, is 1.9×10^{-14}. Calculate the solubility (in mol/L) of MZ_2 in a 0.0230 *M* solution of CaZ_2.
A) 1.7×10^{-5} *M*
B) 1.4×10^{-7} *M*
C) 4.1×10^{-13} *M*
D) 3.6×10^{-11} *M*
E) 9.0×10^{-12} *M*

ANS: E PTS: 1 DIF: Moderate REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility and the common-ion effect MSC: Quantitative

35. The solubility of $La(IO_3)_3$ in a 0.42 *M* KIO_3 solution is 5.6×10^{-12} mol/L. Calculate the K_{sp} for $La(IO_3)_3$.
A) 1.1×10^{-11}
B) 7.6×10^{-11}
C) 4.2×10^{-13}
D) 7.4×10^{-35}
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility and the common-ion effect MSC: Quantitative

36. The solubility of an unknown salt, M_2Z, in a 0.0768 *M* CaZ solution is 5.6×10^{-10} mol/L. Calculate the K_{sp} for M_2Z.
A) 9.6×10^{-20}
B) 2.4×10^{-20}
C) 1.7×10^{-12}
D) 7.0×10^{-28}
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility and the common-ion effect MSC: Quantitative

37. Chromate ion is added to a saturated solution of Ag_2CrO_4 to reach 0.78 *M* CrO_4^{2-}. Calculate the final concentration of silver ion at equilibrium (K_{sp} for Ag_2CrO_4 is 9.0×10^{-12}).
A) 1.7×10^{-6} *M*
B) 3.4×10^{-6} *M*
C) 4.8×10^{-6} *M*
D) 5.8×10^{-12} *M*
E) 2.4×10^{-6} *M*

ANS: B PTS: 1 DIF: Moderate REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility and the common-ion effect MSC: Quantitative

38. Calculate the solubility of Ag_2CrO_4 ($K_{sp} = 9.0 \times 10^{-12}$) in a 0.049 *M* $AgNO_3$ solution.
A) 1.8×10^{-10} mol/L
B) 9.2×10^{-11} mol/L
C) 3.7×10^{-9} mol/L
D) 1.9×10^{-9} mol/L
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility and the common-ion effect MSC: Quantitative

39. The solubility of $Mg(OH)_2$ ($K_{sp} = 8.9 \times 10^{-12}$) in 1.0 L of a solution buffered (with large capacity) at pH 9.73 is:
A) 2.6×10^{8} moles
B) 3.1×10^{-3} moles
C) 1.7×10^{-7} moles
D) 5.4×10^{-5} moles
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility and the common-ion effect MSC: Quantitative

40. Calculate the solubility of $Ca_3(PO_4)_2$ ($K_{sp} = 1.3 \times 10^{-32}$) in a 0.048 *M* $Ca(NO_3)_2$ solution.
A) 5.4×10^{-15} mol/L
B) 1.1×10^{-14} mol/L
C) 2.6×10^{-16} mol/L
D) 2.9×10^{-29} mol/L
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility and the common-ion effect MSC: Quantitative

41. Calculate the solubility of $Cu(OH)_2$ in a solution buffered at pH = 7.59. ($K_{sp} = 1.6 \times 10^{-19}$)
A) 3.9×10^{-7} *M*
B) 4.1×10^{-13} *M*
C) 1.1×10^{-6} *M*
D) 1.5×10^{-13} *M*
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility and the common-ion effect MSC: Quantitative

42. How many moles of CaF_2 will dissolve in 3.0 liters of 0.089 *M* NaF solution? (K_{sp} for $CaF_2 = 4.0 \times 10^{-11}$)
A) 5.0×10^{-9}
B) 1.5×10^{-10}
C) 1.5×10^{-8}
D) 1.7×10^{-9}
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility and the common-ion effect MSC: Quantitative

43. The solubility in mol/L of $M(OH)_2$ in 0.053 *M* KOH is 1.0×10^{-5} mol/L. What is the K_{sp} for $M(OH)_2$?
A) 2.8×10^{-8}
B) 5.3×10^{-7}
C) 2.8×10^{-3}
D) 4.0×10^{-15}
E) 2.3×10^{-6}

ANS: A PTS: 1 DIF: Moderate REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility and the common-ion effect MSC: Quantitative

44. The two salts AgX and AgY exhibit very similar solubilities in water. It is known that the salt AgX is much more soluble in acid than is AgY. What can be said about the relative strengths of the acids HX and HY?
A) Nothing.
B) HY is stronger than HX.
C) HX is stronger than HY.
D) The acids are weak acids and have equal values for K_a.
E) Both acids are strong.

ANS: B PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | effect of pH on solubility | qualitative effect of pH MSC: Conceptual

45. You have two salts, AgX and AgY, with very similar K_{sp} values. You know that K_a for HX is much greater than K_a for HY. Which salt is more soluble in acidic solution?
A) AgX
B) AgY
C) They are equally soluble in acidic solution.
D) Cannot be determined by the information given.
E) None of these (A-D).

ANS: B PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | effect of pH on solubility | qualitative effect of pH MSC: Conceptual

46. The solubility of AgCl in water is _____ the solubility of AgCl in strong acid at the same temperature.
A) greater than
B) less than
C) about the same as
D) cannot be determined
E) much different from

ANS: C PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | effect of pH on solubility | qualitative effect of pH MSC: Conceptual

47. Which of the following solid salts is more soluble in 1.0 M H^+ than in pure water?
A) NaCl
B) $CaCO_3$
C) KCl
D) AgCl
E) KNO_3

ANS: B PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | effect of pH on solubility | qualitative effect of pH MSC: Conceptual

48. Which of the following solid salts is more soluble in 1.0 M H^+ than in pure water?
A) NaCl
B) KCl
C) $FePO_4$
D) AgCl
E) KNO_3

ANS: C PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | effect of pH on solubility | qualitative effect of pH MSC: Conceptual

49. Given the following K_{sp} values, which statement about solubility in mol/L in water is correct?

	K_{sp}		K_{sp}
$PbCrO_4$	2.0×10^{-16}	$Pb(OH)_2$	1.2×10^{-15}
$Zn(OH)_2$	4.5×10^{-17}	MnS	2.3×10^{-13}

A) $PbCrO_4$, $Zn(OH)_2$, and $Pb(OH)_2$ have equal solubilities in water.
B) $PbCrO_4$ has the lowest solubility in water.
C) The solubility of MnS in water will not be pH dependent.
D) MnS has the highest molar solubility in water.
E) A saturated $PbCrO_4$ solution will have a higher $[Pb^{2+}]$ than a saturated $Pb(OH)_2$ solution.

ANS: B PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant | relative solubilities MSC: Conceptual

50. The best explanation for the dissolution of ZnS in dilute HCl is that:
A) The zinc ion is amphoteric.
B) The sulfide-ion concentration is decreased by the formation of H_2S.
C) the sulfide-ion concentration is decreased by oxidation to sulfur.
D) the zinc-ion concentration is decreased by the formation of a chloro complex.
E) The solubility product of $ZnCl_2$ is less than that of ZnS.

ANS: B PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | effect of pH on solubility MSC: Conceptual

51. What is the best way to ensure complete precipitation of SnS from a saturated H_2S solution?
A) Add more H_2S.
B) Add a strong acid.
C) Add a weak acid.
D) Add a strong base.
E) Add a weak base.

ANS: D PTS: 1 DIF: Moderate REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | effect of pH on solubility MSC: Conceptual

52. The K_{sp} of $Al(OH)_3$ is 2×10^{-32}. At what pH will a 0.5 *M* Al^{3+} solution begin to show precipitation of $Al(OH)_3$?
A) 3.5
B) 10.5
C) 1.0
D) 6.0
E) 3.1

ANS: A PTS: 1 DIF: Moderate REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | criterion for precipitation MSC: Quantitative

53. You have a solution consisting of 0.10 *M* Cl^- and 0.10 *M* CrO_4^{2-}. You add 0.10 *M* silver nitrate dropwise to this solution. Given that the K_{sp} for Ag_2CrO_4 is 9.0×10^{-12}, and that for AgCl is 1.6×10^{-10}, which of the following will precipitate first?
A) silver chloride
B) silver chromate
C) silver nitrate
D) cannot be determined by the information given
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | criterion for precipitation MSC: Conceptual

The following questions refer to the following system: 3.5×10^2 mL of 3.2 *M* $Pb(NO_3)_2$ and 2.0×10^2 mL of 0.020 *M* NaCl are added together. K_{sp} for the lead chloride is 1.6×10^{-5}.

54. Determine the ion product.
A) 1.1×10^{-4}
B) 1.5×10^{-2}
C) 7.8×10^{-3}
D) 8.1×10^{-4}
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | criterion for precipitation MSC: Quantitative

55. Will precipitation occur?
A) Yes.
B) No.
C) Maybe, it depends on the temperature.
D) Maybe, it depends on the limiting reagent concentration.
E) None of these.

ANS: A PTS: 1 DIF: Moderate REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | criterion for precipitation MSC: Conceptual

56. What is the limiting reagent in the formation of the lead chloride?
A) Pb^{2+}
B) Cl^{-}
C) $(NO_3)^{-}$
D) $PbCl_2$
E) $Pb(NO_3)_2$

ANS: B PTS: 1 DIF: Easy REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | criterion for precipitation MSC: Conceptual

57. Determine the equilibrium concentration of the chloride ion.
A) 3.9×10^{-4}
B) 8.0×10^{-6}
C) 2.8×10^{-3}
D) 6.1×10^{-2}
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations MSC: Quantitative

58. The K_{sp} for BaF_2 is 2.4×10^{-5}. When 10 mL of 0.01 *M* NaF is mixed with 10 mL of 0.01 *M* $BaNO_3$, will a precipitate form?
A) No, because Q is 1×10^{-12} and since it is less than K_{sp} no precipitate will form.
B) Yes, because Q is 1×10^{-12} and since it is less than K_{sp} a precipitate will form.
C) No, because Q is 1.25×10^{-7} and since it is less than K_{sp} no precipitate will form.
D) Yes, because Q is 1.25×10^{-7} and since it is less than K_{sp} a precipitate will form.

E) None of the above.

ANS: C PTS: 1 DIF: Easy REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | criterion for precipitation MSC: Conceptual

59. How many moles of $Ca(NO_3)_2$ must be added to 1.0 L of a 0.182 *M* KF solution to begin precipitation of CaF_2? For CaF_2, $K_{sp} = 4.0 \times 10^{-11}$.
A) 6.0×10^{-10}
B) 2.2×10^{-10}
C) 1.3×10^{-12}
D) 1.2×10^{-9}
E) 3.5×10^{-5}

ANS: D PTS: 1 DIF: Easy REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | criterion for precipitation MSC: Quantitative

60. A 50.0-mL sample of 0.100 *M* $Ca(NO_3)_2$ is mixed with 50.00 mL of 0.200 *M* NaF. When the system has come to equilibrium, which of the following sets of conditions will hold? The K_{sp} for CaF_2 is 4.0×10^{-11}.

	Moles Solid CaF_2 Formed	$[Ca^{2+}]$	$[F^-]$
A)	5.0×10^{-3}	$3.5 \times 10^{-4}\ M$	$7.0 \times 10^{-4}\ M$
B)	5.0×10^{-3}	$3.4 \times 10^{-9}\ M$	$0.5\ M$
C)	5.0×10^{-3}	$2.2 \times 10^{-4}\ M$	$4.3 \times 10^{-4}\ M$
D)	5.0×10^{-3}	$3.5 \times 10^{-4}\ M$	$4.3 \times 10^{-4}\ M$
E)	10.0×10^{-3}	$1.3 \times 10^{-5}\ M$	$1.3 \times 10^{-5}\ M$

ANS: C PTS: 1 DIF: Moderate REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations MSC: Conceptual

61. The K_{sp} for $Mn(OH)_2$ is 2.0×10^{-13}. At what pH will $Mn(OH)_2$ begin to precipitate from a solution in which the initial concentration of Mn^{2+} is 0.10 *M*?
A) 6.47
B) 13.3
C) 5.85
D) 7.03
E) 8.15

ANS: E PTS: 1 DIF: Moderate REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | criterion for precipitation MSC: Quantitative

62. Sodium chloride is added slowly to a solution that is 0.010 *M* in Cu^+, Ag^+, and Au^+. The K_{sp} values for the chloride salts are 1.9×10^{-7}, 1.6×10^{-10}, and 2.0×10^{-13}, respectively. Which compound will precipitate first?
A) CuCl
B) AgCl
C) AuCl
D) All will precipitate at the same time.
E) Cannot be determined.

ANS: C PTS: 1 DIF: Easy REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | criterion for precipitation MSC: Conceptual

63. A 0.012-mol sample of Na_2SO_4 is added to 400 mL of each of two solutions. One solution contains 1.5×10^{-3} *M* $BaCl_2$; the other contains 1.5×10^{-3} *M* $CaCl_2$. Given that K_{sp} for $BaSO_4 = 1.5 \times 10^{-9}$ and K_{sp} for $CaSO_4 = 6.1 \times 10^{-5}$:
A) $BaSO_4$ would precipitate but $CaSO_4$ would not.
B) $CaSO_4$ would precipitate but $BaSO_4$ would not.
C) Both $BaSO_4$ and $CaSO_4$ would precipitate.
D) Neither $BaSO_4$ nor $CaSO_4$ would precipitate.
E) Not enough information is given to determine if precipitation would occur.

ANS: A PTS: 1 DIF: Easy REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | criterion for precipitation MSC: Conceptual

64. If 30 mL of 5.0×10^{-4} *M* $Ca(NO_3)_2$ are added to 70 mL of 2.0×10^{-4} *M* NaF, will a precipitate occur? (K_{sp} of $CaF_2 = 4.0 \times 10^{-11}$)
A) No, because the ion product is greater than K_{sp}.
B) Yes, because the ion product is less than K_{sp}.
C) No, because the ion product is less than K_{sp}.
D) Not enough information is given.
E) Yes, because the ion product is greater than K_{sp}.

ANS: C PTS: 1 DIF: Easy REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | criterion for precipitation MSC: Conceptual

65. The concentration of Mg^{2+} in seawater is 0.052 *M*. At what pH will 99% of the Mg^{2+} be precipitated as the hydroxide? [K_{sp} for $Mg(OH)_2 = 8.9 \times 10^{-12}$]
A) 8.35
B) 9.22
C) 6.50
D) 10.12
E) 4.86

ANS: D PTS: 1 DIF: Moderate REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | fractional precipitation MSC: Quantitative

66. A precipitate forms when a solution that is 0.10 *M* in Cu^{2+}, Pb^{2+}, and Ni^{2+} is saturated with H_2S and adjusted to pH = 1. What sulfides are present in the precipitate?

$[H_2S]$ = 0.10 *M*; for H_2S, $K_{a1} \times K_{a2} = 1.1 \times 10^{-24}$
K_{sp}: CuS = 8.5×10^{-45}, PbS = 7.0×10^{-29}, NiS = 3.0×10^{-21}

A) CuS, PbS, and NiS
B) PbS and NiS
C) NiS
D) CuS and PbS
E) CuS

ANS: D PTS: 1 DIF: Difficult REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | fractional precipitation MSC: Quantitative

67. A solution is 0.010 *M* in each of $Pb(NO_3)_2$, $Mn(NO_3)_2$, and $Zn(NO_3)_2$. Solid NaOH is added until the pH of the solution is 8.50. Which of the following statements is true?

Salt	***K*$_{sp}$**
$Pb(OH)_2$	1.4×10^{-20}
$Mn(OH)_2$	2.0×10^{-13}
$Zn(OH)_2$	2.1×10^{-16}

A) No precipitate will form.
B) Only $Pb(OH)_2$ will precipitate.
C) Only $Mn(OH)_2$ will precipitate.
D) Only $Zn(OH)_2$ and $Pb(OH)_2$ will precipitate.
E) All three hydroxides will precipitate.

ANS: D PTS: 1 DIF: Moderate REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | fractional precipitation MSC: Quantitative

68. An industrial plant processes its waste water through a sedimentation tank that removes hazardous metals by precipitating them as insoluble carbonate salts. If sodium carbonate is gradually added to the tank, what would be the order of precipitation of the metals, Pb^{2+}, Cu^{2+}, Hg_2^{2+}, and Zn^{2+} if each is $\approx 1.0 \times 10^{-4}$ *M*? (K_{sp} $PbCO_3 = 7.4 \times 10^{-14}$, K_{sp} $CuCO_3 = 1.4 \times 10^{-10}$, K_{sp} $Hg_2CO_3 = 8.9 \times 10^{-17}$, and K_{sp} $ZnCO_3 = 1.4 \times 10^{-11}$)
A) Pb^{2+}, Hg_2^{2+}, Zn^{2+}, Cu^{2+}
B) Hg_2^{2+}, Pb^{2+}, Zn^{2+}, Cu^{2+}
C) Cu^{2+}, Zn^{2+}, Pb^{2+}, Hg_2^{2+}
D) Cu^{2+}, Zn^{2+}, Hg_2^{2+}, Pb^{2+}
E) All metal ions will precipitate at the same time.

ANS: B PTS: 1 DIF: Easy REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | fractional precipitation MSC: Quantitative

69. A solution contains 0.018 moles each of I^-, Br^-, and Cl^-. When the solution is mixed with 200 mL of 0.24 *M* $AgNO_3$, how much AgCl(*s*) precipitates out?

*K*sp AgI $= 1.5 \times 10^{-16}$

Ksp AgBr $= 5.0 \times 10^{-13}$
Ksp AgCl $= 1.6 \times 10^{-10}$

A) 0.0 g
B) 1.7 g
C) 2.6 g
D) 3.3 g
E) 5.0 g

ANS: B PTS: 1 DIF: Moderate REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | fractional precipitation MSC: Conceptual

70. A 100.-mL sample of solution contains 10.0 mmol of Ca^{2+} ion. How many mmol of solid Na_2SO_4 must be added in order to cause precipitation of 99.9% of the calcium as $CaSO_4$? The K_{sp} of $CaSO_4$ is 6.1×10^{-5}. Assume the volume remains constant.
A) 17.4
B) 10.0
C) 61.0
D) 71.0
E) 6.1

ANS: C PTS: 1 DIF: Moderate REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | fractional precipitation MSC: Quantitative

71. What is the maximum concentration of carbonate ions that will precipitate $BaCO_3$ but not $MgCO_3$ from a solution that is 1.9×10^{-3} M each in Mg^{2+} and Ba^{2+}? For $MgCO_3$, $K_{sp} = 1.0 \times 10^{-15}$ and for $BaCO_3$, $K_{sp} = 2.6 \times 10^{-9}$.
A) 5.3×10^{-13} M
B) 1.4×10^{-6} M
C) 3.2×10^{-8} M
D) 5.1×10^{-5} M
E) None of these; $MgCO_3$ will always precipitate before $BaCO_3$.

ANS: E PTS: 1 DIF: Moderate REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | criterion for precipitation MSC: Quantitative

72. What is the maximum concentration of iodide ions that will precipitate AgI but not PbI_2 from a solution that is 1.5×10^{-3} M each in Ag^+ and Pb^{2+}? For AgI, $K_{sp} = 1.5 \times 10^{-16}$ and for PbI_2, $K_{sp} = 1.4 \times 10^{-8}$.
A) 3.1×10^{-3} M
B) 1.0×10^{-13} M
C) 9.3×10^{-6} M
D) 1.2×10^{-8} M
E) None of these; PbI_2 will always precipitate before AgI.

ANS: A PTS: 1 DIF: Moderate REF: 16.2

KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | criterion for precipitation MSC: Quantitative

73. In the qualitative analysis scheme for metal ions, how are the Analytical Group I cations separated from the other cations?
A) by addition of HCl, forming insoluble metal chlorides
B) by addition of H_2SO_4, forming insoluble metal sulfates
C) by addition of H_2S in acidic solution, forming insoluble metal sulfides
D) by addition of H_2S in basic solution, forming insoluble metal sulfides or hydroxides
E) by addition of $(NH_4)_2CO_3$ or $(NH_4)_3PO_4$, forming insoluble metal carbonates or phosphates

ANS: A PTS: 1 DIF: Easy REF: 16.2
KEY: Chemistry | general chemistry | solubility | applications of solubility equilibria | qualitative analysis of metal ions MSC: Conceptual

74. In the qualitative analysis scheme for metal ions, how are the Analytical Group II cations separated from the cations of Analytical Groups III–V?
A) by addition of HCl, forming insoluble metal chlorides
B) by addition of H_2SO_4, forming insoluble metal sulfates
C) by addition of H_2S in acidic solution, forming insoluble metal sulfides
D) by addition of H_2S in basic solution, forming insoluble metal sulfides or hydroxides
E) by addition of $(NH_4)_2CO_3$ or $(NH_4)_3PO_4$, forming insoluble metal carbonates or phosphates

ANS: C PTS: 1 DIF: Easy REF: 16.2
KEY: Chemistry | general chemistry | solubility | applications of solubility equilibria | qualitative analysis of metal ions MSC: Conceptual

75. In the qualitative analysis scheme for metal ions, how are the Analytical Group III cations separated from the cations of Analytical Groups IV and V?
A) by addition of HCl, forming insoluble metal chlorides
B) by addition of H_2SO_4, forming insoluble metal sulfates
C) by addition of H_2S in acidic solution, forming insoluble metal sulfides
D) by addition of H_2S in basic solution, forming insoluble metal sulfides or hydroxides
E) by addition of $(NH_4)_2CO_3$ or $(NH_4)_3PO_4$, forming insoluble metal carbonates or phosphates

ANS: D PTS: 1 DIF: Easy REF: 16.2
KEY: Chemistry | general chemistry | solubility | applications of solubility equilibria | qualitative analysis of metal ions MSC: Conceptual

76. When a mixture containing cations of Analytical Groups I–III is treated with H_2S in acidic solution, which cations are expected to precipitate?
A) Analytical Group I only
B) Analytical Group II only
C) Analytical Group III only

D) Analytical Groups I and II
E) Analytical Groups II and III

ANS: D PTS: 1 DIF: Moderate REF: 16.2
KEY: Chemistry | general chemistry | solubility | applications of solubility equilibria | qualitative analysis of metal ions MSC: Conceptual

77. In the classic scheme for qualitative analysis, the cations of Analytical Group IV are precipitated as phosphates or carbonates. Analytical Group IV consists of
A) alkali metals
B) alkaline earth elements
C) the halogens
D) transition metals having +2 ions
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 16.2
KEY: Chemistry | general chemistry | solubility | applications of solubility equilibria | qualitative analysis of metal ions MSC: Conceptual

78. Consider a solution containing the following cations: Na^+, Hg^{2+}, Mn^{2+}, Al^{3+} and Ag^+. Treatment of the solution with dilute HCl followed by saturation with H_2S results in formation of precipitate(s). Which ions still remain in solution (i.e., did not precipitate)?
A) Ag^+ only
B) Na^+, Hg^{2+}, Al^{3+}
C) Ag^+ and Hg^{2+}
D) Na^+, Al^{3+}, and Mn^{2+}
E) Na^+ only

ANS: D PTS: 1 DIF: Moderate REF: 16.2
KEY: Chemistry | general chemistry | solubility | applications of solubility equilibria | qualitative analysis of metal ions MSC: Conceptual

79. Which of the following solid salts should be more soluble in 1.0 *M* NH_3 than in water?
A) Na_2CO_3
B) KCl
C) AgBr
D) KNO_3
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 16.3
KEY: Chemistry | general chemistry | solubility | complex ion equilibria | complex ion formation MSC: Conceptual

80. The overall K_f for the complex ion $Ag(NH_3)_2^+$ is 1.7×10^7. The K_{sp} for AgI is 1.5×10^{-16}. What is the molar solubility of AgI in a solution that is 2.0 *M* in NH_3?
A) 1.5×10^{-9}
B) 1.3×10^{-3}
C) 1.0×10^{-4}
D) 5.8×10^{-12}
E) 8.4×10^{-5}

ANS: C PTS: 1 DIF: Moderate REF: 16.3
KEY: Chemistry | general chemistry | solubility | complex ion equilibria | complex ions and solubility MSC: Quantitative

81. The K_f for the complex ion $Ag(NH_3)_2^+$ is 1.7×10^7. The K_{sp} for AgCl is 1.6×10^{-10}. Calculate the molar solubility of AgCl in 1.0 *M* NH_3.
A) 5.2×10^{-2}
B) 4.7×10^{-2}
C) 2.9×10^{-3}
D) 1.3×10^{-5}
E) 1.7×10^{-10}

ANS: B PTS: 1 DIF: Difficult REF: 16.3
KEY: Chemistry | general chemistry | solubility | complex ion equilibria | complex ions and solubility MSC: Quantitative

82. Given the following values of equilibrium constants:

$Cu(OH)_2(s) \rightleftharpoons Cu^{2+}(aq) + 2OH^-(aq)$ $K_{sp} = 1.60 \times 10^{-19}$
$Cu(NH_3)_4^{2+}(aq) \rightleftharpoons Cu^{2+}(aq) + 4NH_3(aq)$ $K = 1.0 \times 10^{-13}$

What is the value of the equilibrium constant for the following reaction?

$Cu(OH)_2(s) + 4NH_3(aq) \rightleftharpoons Cu(NH_3)_4^{2+}(aq) + 2OH^-(aq)$

A) 1.60×10^{-19}
B) 1.6×10^{-32}
C) 1.6×10^{-6}
D) 6.25×10^{18}
E) 1.0×10^{13}

ANS: C PTS: 1 DIF: Easy REF: 16.3
KEY: Chemistry | general chemistry | solubility | complex ion equilibria | complex ion formation MSC: Quantitative

Consider a solution made by mixing 500.0 mL of 4.0 *M* NH_3 and 500.0 mL of 0.40 *M* $AgNO_3$. Ag^+ reacts with NH_3 to form $AgNH_3^+$ and $Ag(NH_3)_2^+$:

$Ag^+ + NH_3 \rightleftharpoons AgNH_3^+$ $K_1 = 2.1 \times 10^3$
$AgNH_3^+ + NH_3 \rightleftharpoons Ag(NH_3)_2^+$ $K_2 = 8.2 \times 10^3$

83. The concentration of $Ag(NH_3)_2^+$ at equilibrium is:
A) 2.0 *M*
B) 0.40 *M*
C) 0.20 *M*
D) 1.0×10^{-3} *M*
E) none of these

ANS: C PTS: 1 DIF: Difficult REF: 16.3
KEY: Chemistry | general chemistry | solubility | complex ion equilibria | complex ion formation | equilibrium calculations with Kf MSC: Quantitative

84. The concentration of Ag^+ at equilibrium is:
A) 2.0 *M*
B) 1.2×10^{-8} *M*
C) 4.5×10^{-9} *M*
D) 1.6 *M*
E) none of these

ANS: C PTS: 1 DIF: Difficult REF: 16.3
KEY: Chemistry | general chemistry | solubility | complex ion equilibria | complex ion formation | equilibrium calculations with Kf MSC: Quantitative

The following questions refer to the following system: 500.0 mL of 0.020 *M* $Mn(NO_3)_2$ are mixed with 1.0 L of 1.0 *M* $Na_2C_2O_4$. The oxalate ion, C_2O_4, acts as a ligand to form a complex ion with the Mn^{2+} ion with a coordination number of two.

$Mn^{2+} + C_2O_4^{2-} \rightleftharpoons MnC_2O_4$ $K_1 = 7.9 \times 10^3$
$[Mn(C_2O_4)_2]^{2-} \rightleftharpoons MnC_2O_4 + C_2O_4^{2-}$ $K_2 = 1.26 \times 10^{-2}$

85. What is the equilibrium constant for the following formation?

$Mn^{2+} + 2C_2O_4^{2-} \rightleftharpoons [Mn(C_2O_4)_2]^{2-}$

A) 1.0
B) 3.7×10^2
C) 2.1×10^{-1}
D) 6.3×10^5
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 16.3
KEY: Chemistry | general chemistry | solubility | complex ion equilibria | complex ion formation MSC: Quantitative

86. Find the equilibrium concentration of the $[Mn(C_2O_4)_2]^{2-}$ ion.
A) 9.2×10^{-5} *M*
B) 0.01 *M*
C) 2.5×10^{-8} *M*
D) 1.3×10^{-4} *M*
E) 6.7×10^{-3} *M*

ANS: E PTS: 1 DIF: Difficult REF: 16.3
KEY: Chemistry | general chemistry | solubility | complex ion equilibria | complex ion formation | equilibrium calculations with Kf MSC: Quantitative

87. Find the equilibrium concentration of $Mn(C_2O_4)$ in the system.
A) 9.2×10^{-5} *M*
B) 0.01 *M*
C) 2.5×10^{-8} *M*
D) 1.3×10^{-4} *M*
E) 6.7×10^{-3} *M*

ANS: D PTS: 1 DIF: Difficult REF: 16.3

KEY: Chemistry | general chemistry | solubility | complex ion equilibria | complex ion formation | equilibrium calculations with Kf MSC: Quantitative

88. Find the equilibrium concentration of the Mn^{2+} ion.
A) 9.2×10^{-5} *M*
B) 0.01 *M*
C) 2.5×10^{-8} *M*
D) 1.3×10^{-4} *M*
E) 6.7×10^{-3} *M*

ANS: C PTS: 1 DIF: Difficult REF: 16.3
KEY: Chemistry | general chemistry | solubility | complex ion equilibria | complex ion formation | equilibrium calculations with Kf MSC: Quantitative

89. Silver acetate, $AgC_2H_3O_2$, is a sparingly soluble salt with $K_{sp} = 1.9 \times 10^{-3}$. Consider a saturated solution in equilibrium with the solid salt. Compare the effects on the solubility of adding to the solution either the acid HNO_3 or the base NH_3.
A) Either substance would decrease the solubility.
B) NH_3 would increase the solubility, but HNO_3 would decrease it.
C) NH_3 would increase the solubility, but HNO_3 would have virtually no effect.
D) Either substance would increase the solubility.
E) NH_3 would decrease the solubility, but HNO_3 would increase it.

ANS: D PTS: 1 DIF: Moderate REF: 16.3
KEY: Chemistry | general chemistry | solubility | complex ion equilibria | complex ions and solubility MSC: Conceptual

90. Calculate the molar concentration of uncomplexed Zn^{2+} in a solution that contains 0.20 mole of $Zn(NH_3)_4^{2+}$ per liter and 0.0116 M NH_3 at equilibrium. The overall K_f for $Zn(NH_3)_4^{2+}$ is 3.8×10^9.
A) 2.9×10^{-3} *M*
B) 8.8×10^{-3} *M*
C) 6.7×10^{-4} *M*
D) 2.0×10^{-13} *M*
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 16.3
KEY: Chemistry | general chemistry | solubility | complex ion equilibria | complex ion formation | equilibrium calculations with Kf MSC: Quantitative

91. The cation M^{2+} reacts with NH_3 to form a series of complex ions as follows:

$M^{2+} + NH_3 \rightleftharpoons M(NH_3)^{2+}$ $K_1 = 10^2$
$M(NH_3)^{2+} + NH_3 \rightleftharpoons M(NH_3)_2^{2+}$ $K_2 = 10^3$
$M(NH_3)_2^{2+} + NH_3 \rightleftharpoons M(NH_3)_3^{2+}$ $K_3 = 10^2$

A 1.0×10^{-3} mol sample of $M(NO_3)_2$ is added to 1.0 L of 15.0 *M* NH_3 ($K_b = 1.8 \times 10^{-5}$). Choose the dominant species in this solution.
A) M^{2+}
B) $M(NH_3)^{2+}$

C) $M(NH_3)_2^{2+}$
D) $M(NH_3)_3^{2+}$
E) $M(NO_3)_2$

ANS: D PTS: 1 DIF: Moderate REF: 16.3
KEY: Chemistry | general chemistry | solubility | complex ion equilibria | complex ion formation MSC: Conceptual

92. What is the molar solubility of lead(II) chromate in 0.055 *M* $Na_2S_2O_3$? For $PbCrO_4$, $K_{sp} = 2.0 \times 10^{-16}$; for $Pb(S_2O_3)_3^{4-}$, $K_f = 2.2 \times 10^6$.
A) 2.7×10^{-7} *M*
B) 4.9×10^{-6} *M*
C) 4.4×10^{-10} *M*
D) 6.1×10^{2} *M*
E) 1.7×10^{-4} *M*

ANS: A PTS: 1 DIF: Difficult REF: 16.3
KEY: Chemistry | general chemistry | solubility | complex ion equilibria | complex ions and solubility MSC: Quantitative

93. Consider the following three complex ions of Ag^+ and their formation constants, K_f.

$Ag(NH_3)_2^+$ $K_f = 1.7 \times 10^7$
$Ag(CN)_2^-$ $K_f = 5.6 \times 10^{18}$
$AgBr_2^-$ $K_f = 1.0 \times 10^{11}$

Which of the following responses are *true*?

1. $Ag(NH_3)_2^+$ is more stable than $Ag(CN)_2^-$.

2. Adding a strong acid (HNO_3) to a solution that is 0.010 *M* in $Ag(NH_3)_2^+$ would tend to dissociate the complex ion.

3. Adding a strong acid (HNO_3) to a solution that is 0.010 *M* in $AgBr_2^-$ would tend to dissociate the complex ion.

4. To dissolve AgI add either NaCN *or* HCN, fewer moles of NaCN would be required.

A) 1 and 2
B) 1 and 3
C) 1 and 4
D) 2 and 4
E) 2 and 3

ANS: D PTS: 1 DIF: Moderate REF: 16.3
KEY: Chemistry | general chemistry | solubility | complex ion equilibria
MSC: Conceptual

94. What is the concentration of $Ni^{2+}(aq)$ ion in a 0.045 *M* $Ni(NO_3)_2$ solution that is also 1.0 *M* NH_3? [K_f for $Ni(NH_3)_6^{2+} = 5.5 \times 10^8$]
A) 5.4×10^{-10} *M*
B) 1.1×10^{-10} *M*
C) 8.2×10^{-11} *M*

D) 4.5×10^{-2} *M*
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 16.3
KEY: Chemistry | general chemistry | solubility | complex ion equilibria | complex ion formation | equilibrium calculations with Kf MSC: Quantitative

95. What is the concentration of the $Cd^{2+}(aq)$ ion in a 0.030 *M* $Cd(NO_3)_2$ solution that is also 1.0 *M* NH_3? At this temperature, K_f for $Cd(NH_3)_4^{2+} = 1.0 \times 10^7$.
A) 3.0×10^{-9} *M*
B) 5.0×10^{-9} *M*
C) 3.0×10^{-30} *M*
D) 1.0×10^{-7} *M*
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 16.3
KEY: Chemistry | general chemistry | solubility | complex ion equilibria | complex ion formation | equilibrium calculations with Kf MSC: Quantitative

96. The correct mathematical expression for finding the molar solubility (*s)* of silver chloride is:
A) $s^2 = K_{sp}$
B) $2s^3 = K_{sp}$
C) $108s^5 = K_{sp}$
D) $4s^3 = K_{sp}$
E) $27s^4 = K_{sp}$

ANS: A PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Conceptual

97. The correct mathematical expression for finding the molar solubility (*s)* of barium chloride is:
A) $s^2 = K_{sp}$
B) $2s^3 = K_{sp}$
C) $108s^5 = K_{sp}$
D) $4s^3 = K_{sp}$
E) $27s^4 = K_{sp}$

ANS: D PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Conceptual

98. The correct mathematical expression for finding the molar solubility (*s)* of iron(III) hydroxide is:
A) $s^2 = K_{sp}$
B) $2s^3 = K_{sp}$
C) $108s^5 = K_{sp}$
D) $4s^3 = K_{sp}$
E) $27s^4 = K_{sp}$

ANS: E PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Conceptual

99. The correct mathematical expression for finding the molar solubility (*s)* of silver(I)phosphide is:
A) $s^2 = K_{sp}$
B) $2s^3 = K_{sp}$
C) $108s^5 = K_{sp}$
D) $4s^3 = K_{sp}$
E) $27s^4 = K_{sp}$

ANS: E PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Conceptual

100. The correct mathematical expression for finding the molar solubility (*s)* of silver(I)sulfide is:
A) $s^2 = K_{sp}$
B) $2s^3 = K_{sp}$
C) $108s^5 = K_{sp}$
D) $4s^3 = K_{sp}$
E) $27s^4 = K_{sp}$

ANS: D PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Conceptual

101. The correct mathematical expression for finding the molar solubility (*s)* of aluminum sulfide is:
A) $s^2 = K_{sp}$
B) $2s^3 = K_{sp}$
C) $108s^5 = K_{sp}$
D) $4s^3 = K_{sp}$
E) $27s^4 = K_{sp}$

ANS: C PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Conceptual

102. The correct mathematical expression for finding the molar solubility (*s)* of calcium phosphate is:
A) $s^2 = K_{sp}$
B) $2s^3 = K_{sp}$
C) $108s^5 = K_{sp}$
D) $4s^3 = K_{sp}$
E) $27s^4 = K_{sp}$

ANS: C PTS: 1 DIF: Easy REF: 16.1
KEY: Chemistry | general chemistry | solubility | solubility equilibria | solubility product constant MSC: Conceptual

103. Given that the K_{sp} for calcium fluoride [CaF_2] is 3.2×10^{-15}, which of the following describes a solution that is 2.00×10^{-5} M NaF and 2.00×10^{-5} M $Ca(NO_3)_2$?
A) $Q = 4 \times 10^{-10}$ and there will be a precipitate formed
B) $Q = 8 \times 10^{-10}$ and there will be a precipitate formed
C) $Q = 8 \times 10^{-15}$ and there will be no precipitate formed
D) $Q = 1.3 \times 10^{-13}$ and there will be a precipitate formed
E) $Q = 8 \times 10^{-15}$ and there will be a precipitate formed

ANS: E PTS: 1 DIF: Moderate REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | criterion for precipitation MSC: Quantitative

104. A solution is 2.00×10^{-3} M $Ba(NO_3)_2$ and 0.0500 M KF. Given that the K_{sp} of barium fluoride is 1.5×10^{-6},
A) $Q_{sp} = 1 \times 10^{-4}$ so a precipitate will be observed.
B) $Q_{sp} = 2 \times 10^{-4}$ so a precipitate will be observed.
C) $Q_{sp} = 1 \times 10^{-6}$ so no precipitate will be observed
D) $Q_{sp} = 2 \times 10^{-5}$ so a precipitate will be observed.
E) $Q_{sp} = 5 \times 10^{-6}$ so a precipitate will be observed.

ANS: E PTS: 1 DIF: Moderate REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | criterion for precipitation MSC: Quantitative

105. Which, if any of the following mixtures will result in a precipitate. You might need to know that the K_{sp} for AgCN is 2.2×10^{-16} and that for PbI_2 is 7.9×10^{-9}.
I. a mixture that is 1.2×10^{-6} M $AgNO_3$ and 2.4×10^{-10} M NaCN
II. a mixture that is 2.3×10^{-4} M $Pb(ClO_4)_2$ and 4.6×10^{-3} M KI
A) both will produce precipitates
B) Neither will produce precipitates
C) I will precipitate but II will not precipitate
D) II will precipitate but I will not precipitate
E) More information is required to come to a conclusion.

ANS: C PTS: 1 DIF: Moderate REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | criterion for precipitation MSC: Quantitative

106. Which of the following leads to the formation of a precipitate?
A) $Q = K_{sp}$
B) $Q < K_{sp}$
C) $Q > K_{sp}$
D) Q = 1
E) K = 1

ANS: C PTS: 1 DIF: Easy REF: 16.2
KEY: Chemistry | general chemistry | solubility | solubility equilibria | precipitation calculations | criterion for precipitation MSC: Quantitative

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Chapter 17: Spontaneity, Entropy, and Free Energy

1. For which process is ΔS negative?
   A) evaporation of 1 mol of $CCl_4(l)$
   B) mixing 5 mL ethanol with 25 mL water
   C) compressing 1 mol Ne at constant temperature from 1.5 L to 0.5 L
   D) raising the temperature of 100 g Cu from 275 K to 295 K
   E) grinding a large crystal of KCl to powder

   ANS: C PTS: 1 DIF: Easy REF: 17.1
   KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

2. Ten identical coins are shaken vigorously in a cup and then poured out onto a table top. Which of the following distributions has the highest probability of occurrence? (T = Tails, H = Heads)
   A) $T_{10}H_0$
   B) T_8H_2
   C) T_7H_3
   D) T_5H_5
   E) T_4H_6

   ANS: D PTS: 1 DIF: Easy REF: 17.1
   KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

3. If two pyramid-shaped dice (with numbers 1 through 4 on the sides) were tossed, which outcome has the highest entropy?
   A) The sum of the dice is 3.
   B) The sum of the dice is 4.
   C) The sum of the dice is 5.
   D) The sum of the dice is 6.
   E) The sum of the dice is 7.

   ANS: C PTS: 1 DIF: Easy REF: 17.1
   KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

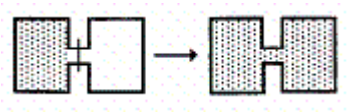
4. A two-bulbed flask contains 5 particles. What is the probability of finding all 5 particles on the left side?
   A) 2.50%
   B) 2.24%
   C) 3.13%
   D) 0.20%
   E) 6.25%

   ANS: C PTS: 1 DIF: Moderate REF: 17.1
   KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

5. Which of the following shows a decrease in entropy?
   A) precipitation
   B) gaseous reactants forming a liquid
   C) a burning piece of wood
   D) melting ice
   E) two of these

   ANS: E PTS: 1 DIF: Easy REF: 17.1
   KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

6. Which of the following result(s) in an increase in the entropy of the system?

   I. 

   II. $Br_2(g) \rightarrow Br_2(l)$
   III. $NaBr(s) \rightarrow Na^+(aq) + Br^-(aq)$
   IV. $O_2(298\ K) \rightarrow O_2(373\ K)$
   V. $NH_3(1\ atm, 298\ K) \rightarrow NH_3(3\ atm, 298\ K)$

   A) I
   B) II, V
   C) I, III, IV
   D) I, II, III, IV
   E) I, II, III, V

   ANS: C PTS: 1 DIF: Easy REF: 17.1
   KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

7. Consider the following processes:
   I. condensation of a liquid
   II increasing the volume of 1.0 mol of an ideal gas at constant temperature
   III. dissolving sugar in water
   IV. heating 1.0 mol of an ideal gas at constant volume
   For how many of these is ΔS positive?
   A) 0
   B) 1
   C) 2
   D) 3
   E) 4

   ANS: D PTS: 1 DIF: Easy REF: 17.1
   KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | third law of thermodynamics | entropy change for a reaction MSC: Conceptual

8. The second law of thermodynamics states that:
   A) The entropy of a perfect crystal is zero at 0 K.
   B) The entropy of the universe is constant.

C) The energy of the universe is increasing.
D) The entropy of the universe is increasing.
E) The energy of the universe is constant.

ANS: D PTS: 1 DIF: Easy REF: 17.2
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics MSC: Conceptual

9. Which of the following statements is true?
A) The total energy and entropy of the universe are both increasing.
B) The total energy of the universe is increasing, but the entropy is constant.
C) The total energy of the universe increases, while the entropy decreases.
D) The total energy of the universe is constant, but the entropy is increasing.
E) None of these.

ANS: D PTS: 1 DIF: Easy REF: 17.2
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics MSC: Conceptual

10. A 100-mL sample of water is placed in a coffee cup calorimeter. When 1.0 g of an ionic solid is added, the temperature decreases from 21.5°C to 20.8°C as the solid dissolves. For the dissolving of the solid
A) $\Delta H < 0$
B) $\Delta S_{univ} > 0$
C) $\Delta S_{sys} < 0$
D) $\Delta S_{surr} > 0$
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 17.3
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

11. A chemical reaction is most likely to be spontaneous if it is accompanied by
A) increasing energy and increasing entropy
B) lowering energy and increasing entropy
C) increasing energy and decreasing entropy
D) lowering energy and decreasing entropy
E) none of these (A-D)

ANS: B PTS: 1 DIF: Easy REF: 17.3
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy | spontaneity MSC: Conceptual

12. Assume that the enthalpy of fusion of ice is 6020 J/mol and does not vary appreciably over the temperature range 270-290 K. If one mole of ice at 0°C is melted by heat supplied from surroundings at 276 K, what is the entropy change in the surroundings, in J/K?
A) 22.1
B) 21.8
C) 0.0
D) –21.8

E) –22.1

ANS: D PTS: 1 DIF: Easy REF: 17.3
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy change for a phase transition MSC: Quantitative

13. If the change in entropy of the surroundings for a process at 431 K and constant pressure is –326 J/K, what is the heat flow absorbed by for the system?
A) 326 kJ
B) 1.32 kJ
C) –141 kJ
D) 105 kJ
E) 141 kJ

ANS: E PTS: 1 DIF: Moderate REF: 17.3
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy change for a phase transition MSC: Quantitative

14. The heat of vaporization for 1.0 mole of water at 100.°C and 1.0 atm is 40.56 kJ/mol. Calculate ΔS for the process $H_2O(l) \rightarrow H_2O(g)$ at 100.°C.
A) 109 J/K mol
B) –109 J/K mol
C) 406 J/K mol
D) –406 J/K mol
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 17.3
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy change for a phase transition MSC: Quantitative

15. A change of state that occurs in a system is accompanied by 52.3 kJ of heat, which is transferred to the surroundings at a constant pressure and a constant temperature of 300. K. For this process ΔS_{surr} is:
A) 52.3 kJ/K
B) –52.3 kJ/K
C) –174 J/K
D) 174 J/K
E) 248 kJ/K

ANS: D PTS: 1 DIF: Easy REF: 17.3
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy change for a phase transition MSC: Quantitative

16. The enthalpy of vaporization of ammonia is 23.35 kJ/mol at its boiling point (–33.4°C). Calculate the value of ΔS_{surr} when 1.00 mole of ammonia is vaporized at –33.4°C and 1.00 atm.
A) 0
B) -6.99×10^2 J/K mol
C) 9.74×10^1 J/K mol
D) -9.74×10^1 J/K mol

E) 6.99×10^2 J/K mol

ANS: D PTS: 1 DIF: Easy REF: 17.3
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy change for a phase transition MSC: Quantitative

17. ΔS_{surr} is _____ for exothermic reactions and _____ for endothermic reactions.
A) favorable, unfavorable
B) unfavorable, favorable
C) favorable, favorable
D) unfavorable, unfavorable
E) cannot tell

ANS: A PTS: 1 DIF: Easy REF: 17.3
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

18. Which of the following is true for exothermic processes?
A) $\Delta S_{surr} < 0$
B) $\Delta S_{surr} = -\Delta H/T$
C) $\Delta S_{surr} = 0$
D) $\Delta S_{surr} > 0$
E) two of these

ANS: E PTS: 1 DIF: Easy REF: 17.3
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

At 1 atm, liquid water is heated above 100°C.

19. ΔS_{surr} for this process is
A) greater than zero
B) less than zero
C) equal to zero
D) more information needed to answer this question
E) none of these (A-D)

ANS: B PTS: 1 DIF: Easy REF: 17.3
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

20. ΔS_{sys} for this process is
A) greater than zero
B) less than zero
C) equal to zero
D) more information needed to answer this question
E) none of these (A-D)

ANS: A PTS: 1 DIF: Easy REF: 17.3
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

21. ΔS_{univ} for this process is
    A) greater than zero
    B) less than zero
    C) equal to zero
    D) more information needed to answer this question
    E) none of these (A-D)

    ANS: A PTS: 1 DIF: Easy REF: 17.3
    KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

22. Given that ΔH_{vap} is 58.2 kJ/mol, and the boiling point is 83.4°C, 1 atm, if one mole of this substance is vaporized at 1 atm, calculate ΔS_{surr}.
    A) –163 J/K mol
    B) 163 J/K mol
    C) 698 J/K mol
    D) –698 J/K mol
    E) 0

    ANS: A PTS: 1 DIF: Easy REF: 17.3
    KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy change for a phase transition MSC: Quantitative

23. As long as the disorder of the surroundings is increasing, a process will be spontaneous.

    ANS: F PTS: 1 DIF: Easy REF: 17.3
    KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics MSC: Conceptual

24. For any given process, ΔS_{surr} and ΔS_{sys} have opposite signs.

    ANS: F PTS: 1 DIF: Easy REF: 17.3
    KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

25. If $\Delta S_{surr} = -\Delta S_{sys}$, the process is at equilibrium.

    ANS: T PTS: 1 DIF: Easy REF: 17.3
    KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

26. Which of the following is true?
    A) By *spontaneous* we mean that the reaction or process will always proceed to the right (as written) even if very slowly. Increasing the temperature may speed up the reaction, but it does not affect the spontaneity of the reaction.
    B) By *spontaneous* we mean that the reaction or process will always proceed to the left (as written) even if very slowly. Increasing the temperature may speed up the reaction, but it does not affect the spontaneity of the reaction.
    C) By *spontaneous* we mean that the reaction or process will always proceed to the

left (as written) even if very slowly. Increasing the temperature may speed up the reaction and it generally affects the spontaneity of the reaction.

D) By *spontaneous* we mean that the reaction or process will always proceed to the right (as written) even if very slowly. Increasing the temperature may speed up the reaction, and it generally affects the spontaneity of the reaction.

E) None of the above is true.

ANS: D PTS: 1 DIF: Easy REF: 17.3
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | temperature dependence of free energy | spontaneity and temperature change MSC: Conceptual

27. Substance X has a heat of vaporization of 55.9 kJ/mol at its normal boiling point (423°C). For the process $X(l) \rightarrow X(g)$ at 1 atm and 423°C calculate the value of ΔS_{univ}.

A) 0
B) 80.3 J/K mol
C) 132 J/K mol
D) –80.3 J/K mol
E) –132 J/K mol

ANS: A PTS: 1 DIF: Easy REF: 17.3
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy change for a phase transition MSC: Conceptual

28. Substance X has a heat of vaporization of 58.4 kJ/mol at its normal boiling point (423°C). For the process $X(l) \rightarrow X(g)$ at 1 atm and 423°C calculate the value of ΔS_{surr}.

A) 0
B) 83.9 J/K mol
C) 138 J/K mol
D) –83.9 J/K mol
E) –138 J/K mol

ANS: D PTS: 1 DIF: Easy REF: 17.3
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy change for a phase transition MSC: Quantitative

29. Substance X has a heat of vaporization of 47.1 kJ/mol at its normal boiling point (423°C). For the process $X(l) \rightarrow X(g)$ at 1 atm and 423°C calculate the value of ΔS.

A) 0
B) 67.7 J/K mol
C) 111 J/K mol
D) –67.7 J/K mol
E) –111 J/K mol

ANS: B PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy change for a phase transition MSC: Quantitative

30. Substance X has a heat of vaporization of 64.4 kJ/mol at its normal boiling point (423°C). For the process $X(l) \rightarrow X(g)$ at 1 atm and 423°C calculate the value of ΔG.

A) 0 J

B) 92.5 J
C) 152 J
D) –92.5 J
E) –152 J

ANS: A PTS: 1 DIF: Moderate REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy | spontaneity MSC: Conceptual

31. The enthalpy of vaporization of ammonia is 23.35 kJ/mol at its boiling point (–33.4°C). Calculate the value of ΔS when 1.00 mole of ammonia is vaporized at –33.4°C and 1.00 atm.
A) 0
B) -6.99×10^2 J/K mol
C) 9.74×10^1 J/K mol
D) -9.74×10^1 J/K mol
E) 6.99×10^2 J/K mol

ANS: C PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy change for a phase transition MSC: Quantitative

32. ΔS is _____ for exothermic reactions and _____ for endothermic reactions.
A) favorable, unfavorable
B) unfavorable, favorable
C) favorable, favorable
D) unfavorable, unfavorable
E) cannot tell

ANS: E PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

33. For the process $CHCl_3(s) \rightarrow CHCl_3(l)$, $\Delta H° = 9.19$ kJ/mol and $\Delta S° = 43.9$ J/mol/K. What is the melting point of chloroform?
A) –64 °C
B) 209 °C
C) 130 °C
D) 64 °C
E) –130 °C

ANS: A PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy change for a phase transition MSC: Quantitative

34. Given that ΔH_{vap} is 60.3 kJ/mol, and the boiling point is 83.4°C, 1 atm, if one mole of this substance is vaporized at 1 atm, calculate ΔS.
A) –169 J/K mol
B) 169 J/K mol
C) 723 J/K mol

D) –723 J/K mol
E) 0

ANS: B PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy change for a phase transition MSC: Quantitative

35. $\Delta H°$ is zero for a chemical reaction at constant temperature.

ANS: F PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | enthalpy
MSC: Conceptual

Consider two perfectly insulated vessels. Vessel #1 initially contains an ice cube at 0°C and water at 0°C. Vessel #2 initially contains an ice cube at 0°C and a saltwater solution at 0°C. In each vessel, consider the "system" to be the ice, and the "surroundings" to be the liquid.

36. Determine the sign of ΔS_{sys}, ΔS_{surr}, and ΔS_{univ} for the contents of Vessel #1.

	ΔS_{sys}	ΔS_{surr}	ΔS_{univ}
A)	0	0	0
B)	+	–	0
C)	+	+	+
D)	+	–	+
E)	+	0	+

ANS: B PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

37. Determine the sign of ΔS_{sys}, ΔS_{surr}, and ΔS_{univ} for the system (ice/saltwater) in Vessel #2.

	ΔS_{sys}	ΔS_{surr}	ΔS_{univ}
A)	0	0	0
B)	+	–	0
C)	+	+	+
D)	+	–	+
E)	+	0	+

ANS: D PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

38. The melting point of water is 0°C at 1 atm pressure because under these conditions:
A) ΔS for the process $H_2O(s) \rightarrow H_2O(l)$ is positive.
B) ΔS and ΔS_{surr} for the process $H_2O(s) \rightarrow H_2O(l)$ are both positive.
C) ΔS and ΔS_{surr} for the process $H_2O(s) \rightarrow H_2O(l)$ are equal in magnitude and opposite

in sign.

D) ΔG is positive for the process $H_2O(s) \rightarrow H_2O(l)$.

E) None of these is correct.

ANS: C PTS: 1 DIF: Moderate REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy change for a phase transition MSC: Conceptual

39. For the vaporization of a liquid at a given pressure:

A) ΔG is positive at all temperatures.

B) ΔG is negative at all temperatures.

C) ΔG is positive at low temperatures, but negative at high temperatures (and zero at some temperature).

D) ΔG is negative at low temperatures, but positive at high temperatures (and zero at some temperature).

E) None of these (A-D).

ANS: C PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy change for a phase transition MSC: Conceptual

40. Which of the following statements is always true for a spontaneous process?

I. $\Delta S\text{sys} > 0$

II. $\Delta S\text{surr} > 0$

III. $\Delta S\text{univ} > 0$

IV. $\Delta G\text{sys} > 0$

A) I

B) III

C) IV

D) I and III

E) III and IV

ANS: B PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy | spontaneity MSC: Conceptual

41. For a spontaneous exothermic process, which of the following must be true?

A) ΔG must be positive.

B) ΔS must be positive.

C) ΔS must be negative.

D) Two of the above must be true.

E) None of the above (A-C) must be true.

ANS: E PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy | spontaneity MSC: Conceptual

42. A mixture of hydrogen and chlorine remains unreacted until it is exposed to ultraviolet light from a burning magnesium strip. Then the following reaction occurs very rapidly:

$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$ $\Delta G = -45.54$ kJ
$\Delta H = -44.12$ kJ
$\Delta S = -4.76$ J/K

Which of the following is consistent with this information?

A) The reactants are thermodynamically more stable than the products.
B) The reaction has a small equilibrium constant.
C) The ultraviolet light raises the temperature of the system and makes the reaction more favorable.
D) The negative value for ΔS slows down the reaction.
E) The reaction is spontaneous, but the reactants are kinetically stable.

ANS: E PTS: 1 DIF: Moderate REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy
MSC: Conceptual

43. For a particular chemical reaction $\Delta H = 4.3$ kJ and $\Delta S = -19$ J/K. Under what temperature condition is the reaction spontaneous?

A) When $T < -226$ K.
B) When $T < 226$ K.
C) The reaction is spontaneous at all temperatures.
D) The reaction is not spontaneous at any temperature.
E) When $T > 226$ K.

ANS: D PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy | spontaneity MSC: Conceptual

44. For a certain process at 355 K, $\Delta G = -11.8$ kJ and $\Delta H = -9.2$ kJ. Therefore, ΔS for the process is

A) 0 J/K mol
B) 7.3 J/K mol
C) –7.3 J/K mol
D) –25.9 J/K mol
E) 25.9 J/K mol

ANS: B PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy
MSC: Quantitative

45. Consider the freezing of liquid water at –10°C. For this process what are the signs for ΔH, ΔS, and ΔG?

	ΔH	ΔS	ΔG
A)	+	–	0
B)	+	–	–
C)	–	+	0
D)	–	+	–
E)	–	–	–

ANS: E PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy
MSC: Conceptual

46. For the process of a certain liquid vaporizing at 1 atm, $\Delta H°_{vap}$ = 54.2 kJ/mol and $\Delta S°_{vap}$= 74.1 J/mol K. Assuming these values are independent of *T*, what is the normal boiling point of this liquid?
A) 731 °C
B) 1004 °C
C) 458 °C
D) 0.731 °C
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy
MSC: Quantitative

47. For the reaction A + B → C + D, $\Delta H°$ = +40 kJ and $\Delta S°$ = +50 J/K. Therefore, the reaction under standard conditions is
A) spontaneous at temperatures less than 10 K
B) spontaneous at temperatures greater than 800 K
C) spontaneous only at temperatures between 10 K and 800 K
D) spontaneous at all temperatures
E) nonspontaneous at all temperatures

ANS: B PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy | spontaneity MSC: Conceptual

48. In which case must a reaction be spontaneous at all temperatures?
A) ΔH is positive, ΔS is positive.
B) ΔH = 0, ΔS is negative.
C) ΔS = 0, ΔH is positive.
D) ΔH is negative, ΔS is positive.
E) None of these.

ANS: D PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy | spontaneity MSC: Conceptual

49. For the process S_8 (rhombic) → S_8 (monoclinic) at 110°C, ΔH = 3.21 kJ/mol and ΔS = 8.70 J/K · mol (at 110°C).
Which of the following is correct?
A) This reaction is spontaneous at 110°C (S_8 (monoclinic) is stable).
B) This reaction is spontaneous at 110°C (S_8 (rhombic) is stable).
C) This reaction is nonspontaneous at 110°C (S_8 (rhombic) is stable).
D) This reaction is nonspontaneous at 110°C (S_8 (monoclinic) is stable).
E) Need more data.

ANS: A PTS: 1 DIF: Easy REF: 17.4

KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy | spontaneity MSC: Conceptual

50. As $O_2(l)$ is cooled at 1 atm, it freezes at 54.5 K to form Solid I. At a lower temperature, Solid I rearranges to Solid II, which has a different crystal structure. Thermal measurements show that ΔH for the I $\rightarrow$II phase transition is –743.07 J/mol, and ΔS for the same transition is -17.0 J/K mol. At what temperature are Solids I and II in equilibrium?
A) 13.6 K
B) 43.7 K
C) 19.8 K
D) 98.2 K
E) They can never be in equilibrium because they are both solids.

ANS: B PTS: 1 DIF: Moderate REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy change for a phase transition MSC: Quantitative

51. At constant pressure, the following reaction $2NO_2(g) \rightarrow N_2O_4(g)$ is exothermic. The reaction (as written) is
A) always spontaneous
B) spontaneous at low temperatures, but not high temperatures
C) spontaneous at high temperatures, but not low temperatures
D) never spontaneous
E) cannot tell

ANS: B PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy | spontaneity MSC: Conceptual

52. Given that ΔH_{vap} is 53.3 kJ/mol, and the boiling point is 83.4°C, 1 atm, if one mole of this substance is vaporized at 1 atm, calculate ΔG.
A) –150 J
B) 150 J
C) 639 J
D) –639 J
E) 0 J

ANS: E PTS: 1 DIF: Moderate REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy
MSC: Quantitative

The following questions refer to the following reaction at constant 25°C and 1 atm.

$2Fe(s) + (3/2)O_2(g) + 3H_2O(l) \rightarrow 2Fe(OH)_3(s)$ $\Delta H = -789$ kJ/mol

Substance	$S°$ (J/mol K)
$Fe(OH)_3(s)$	107
$Fe(s)$	27
$O_2(g)$	205
$H_2O(l)$	70

53. Determine ΔS_{surr} for the reaction (in kJ/mol K)

A) 3.14
B) 0.937
C) 0.378
D) 1.31
E) 2.65

ANS: E PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Quantitative

54. Determine ΔS_{univ} for the reaction (in kJ/mol K)
A) 0.23
B) 2.3
C) 0.36
D) 2.8
E) 3.6

ANS: B PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Quantitative

55. What must be true about ΔG for this reaction?
A) $\Delta G = \Delta H$
B) $\Delta G = 0$
C) $\Delta G > 0$
D) $\Delta G < 0$
E) $\Delta G = \Delta S_{univ}$

ANS: D PTS: 1 DIF: Easy REF: 17.5
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy
MSC: Conceptual

56. Given the following data, calculate the normal boiling point for formic acid (HCOOH).

	$\Delta H_f°$(kJ/mol)	$S°$(J/mol K)
HCOOH(l)	-410.	130.0
HCOOH(g)	-363	251.1

A) 0.39 °C
B) 388 °C
C) 661 °C
D) 279 °C
E) 115 °C

ANS: E PTS: 1 DIF: Moderate REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy
MSC: Quantitative

57. The following reaction takes place at 120°C: $H_2O(l) \rightarrow H_2O(g)$ ΔH = 44.0 kJ/mol
ΔS = 0.119 kJ/mol K
Which of the following must be true?

A) The reaction is not spontaneous.
B) The reaction is spontaneous.
C) $\Delta G = 0$
D) $\Delta G < 0$
E) Two of these.

ANS: E PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy | spontaneity MSC: Conceptual

When ignited, solid ammonium dichromate decomposes in a fiery display. This is the reaction for a "volcano" demonstration. The decomposition produces nitrogen gas, water vapor, and chromium(III) oxide. The temperature is constant at 25°C.

Substance	$\Delta H_f°$ (kJ/mol)	$S°$ (kJ/mol K)
$Cr_2O_3(g)$	–1147	0.08118
$H_2O(l)$	–242	0.1187
$N_2(g)$	0	0.1915
$(NH_4)_2Cr_2O_7(s)$	–22.5	0.1137

58. Determine $\Delta S_{univ}°$ (in kJ/mol K).
A) 7.66
B) 6.39
C) 84.3
D) 5.22
E) 6.03

ANS: A PTS: 1 DIF: Difficult REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics
MSC: Quantitative

59. Determine $\Delta S°$ reaction (in kJ/mol K).
A) 0.2777
B) 0.8612
C) 0.7475
D) 0.6338
E) 0.1590

ANS: D PTS: 1 DIF: Easy REF: 17.5
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | third law of thermodynamics | entropy change for a reaction MSC: Quantitative

60. Determine $\Delta G°$ (in kJ/mol).
A) –191.4
B) –2281.4
C) –38.9
D) 1903.6
E) –1555.4

ANS: B PTS: 1 DIF: Moderate REF: 17.6
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy |

standard free energy change MSC: Quantitative

61. The third law of thermodynamics states:
A) The entropy of the universe is increasing.
B) The entropy of the universe is constant.
C) The entropy is zero at 0 K for a perfect crystal.
D) The absolute entropy of a substance decreases with increasing temperature.
E) The entropy of the universe equals the sum of the entropy of system and surroundings.

ANS: C PTS: 1 DIF: Easy REF: 17.5
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | third law of thermodynamics MSC: Conceptual

62. For which of the following processes would $\Delta S°$ be expected to be most positive?
A) $O_2(g) + 2H_2(g) \rightarrow 2H_2O(g)$
B) $H_2O(l) \rightarrow H_2O(s)$
C) $NH_3(g) + HCl(g) \rightarrow NH_4Cl(g)$
D) $2NH_4NO_3(s) \rightarrow 2N_2(g) + O_2(g) + 4H_2O(g)$
E) $N_2O_4(g) \rightarrow 2NO_2(g)$

ANS: D PTS: 1 DIF: Easy REF: 17.5
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | third law of thermodynamics | entropy change for a reaction MSC: Conceptual

63. Which of the following statements is (are) always true?
I. In order for a process to be spontaneous, the entropy of the universe must increase.
II. A system cannot have both energy disorder and positional disorder.
III. $\Delta S_{univ} = \frac{\Delta G}{T}$
IV. $S°$ is zero for elements in their standard states.

A) I
B) I, IV
C) I, III, IV
D) II, IV
E) II

ANS: A PTS: 1 DIF: Easy REF: 17.5
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics
MSC: Conceptual

64. In which process is ΔS expected to be positive?
A) a reaction that forms a solid precipitant from aqueous solutions
B) an ideal gas being compressed at a constant temperature and against a constant pressure
C) water freezing below its normal freezing point
D) a spontaneous endothermic process at a constant temperature and pressure
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 17.5
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

65. In which reaction is $\Delta S°$ expected to be positive?
A) $I_2(g) \rightarrow I_2(s)$
B) $H_2O(l) \rightarrow H_2O(s)$
C) $CH_3OH(g) + \frac{3}{2}O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$
D) $2O_2(g) + 2SO(g) \rightarrow 2SO_3(g)$
E) none of these

ANS: E PTS: 1 DIF: Easy REF: 17.5
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

66. For the dissociation reaction of the acid HF:

$$HF(aq) \rightleftharpoons H^+(aq) + F^-(aq)$$

ΔS is observed to be negative. The best explanation is:
A) This is the expected result since each HF molecule produces two ions when it dissociates.
B) Hydration of the ions produces the negative value of ΔS.
C) The reaction is expected to be exothermic and thus ΔS should be negative.
D) The reaction is expected to be endothermic and thus ΔS should be negative.
E) None of these can explain the negative value of ΔS.

ANS: B PTS: 1 DIF: Moderate REF: 17.5
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics
MSC: Conceptual

67. Consider the dissociation of hydrogen:

$$H_2(g) \rightleftharpoons 2H(g)$$

One would expect that this reaction:
A) will be spontaneous at any temperature
B) will be spontaneous at high temperatures
C) will be spontaneous at low temperatures
D) will not be spontaneous at any temperature
E) will never happen

ANS: B PTS: 1 DIF: Easy REF: 17.5
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics
MSC: Conceptual

68. When a stable diatomic molecule spontaneously forms from its atoms, what are the signs of $\Delta H°$, $\Delta S°$, and $\Delta G°$?

	ΔH	ΔS	ΔG
A)	+	+	+
B)	+	–	–

C) – + +
D) – – +
E) – – –

ANS: E PTS: 1 DIF: Easy REF: 17.5
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy
MSC: Conceptual

Consider the reaction

$$2N_2O_5(g) \rightleftharpoons 4NO_2(g) + O_2(g)$$

at 25°C for which the following data are relevant:

	$\Delta H_f°$	$S°$
N_2O_5	11.289 kJ/mol	355.32 J/K mol
NO_2	33.150 kJ/mol	239.90 J/K mol
O_2	0 kJ/mol	204.80 J/K mol

69. Calculate $\Delta S°$ for the reaction.
A) 809.08 J/K
B) 89.38 J/K
C) 453.76 J/K
D) –265.94 J/K
E) 1164.40 J/K

ANS: C PTS: 1 DIF: Easy REF: 17.5
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | third law of thermodynamics | entropy change for a reaction MSC: Quantitative

70. Calculate $\Delta H°$ for the reaction.
A) 110.022 kJ
B) 10.572 kJ
C) 121.311 kJ
D) 21.861 kJ
E) 155.178 kJ

ANS: A PTS: 1 DIF: Easy REF: 17.6
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | standard enthalpies of formation MSC: Quantitative

71. Calculate $\Delta G°$ for the reaction at 25°C.
A) -1.35×10^5 kJ
B) 98.7 kJ
C) –25.2 kJ
D) 135 kJ
E) 0

ANS: C PTS: 1 DIF: Moderate REF: 17.6
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy | standard free energy change MSC: Quantitative

72. The reaction is allowed to proceed until all substances involved have reached their equilibrium concentrations. Under those conditions, what is ΔG for the reaction?
A) -1.35×10^5 kJ
B) 98.7 kJ
C) –25.2 kJ
D) 135 kJ
E) 0

ANS: E PTS: 1 DIF: Easy REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy
MSC: Conceptual

73. Which of the following is true for this reaction?
A) Both $\Delta H°$ and $\Delta S°$ favor the reaction's spontaneity.
B) Both $\Delta H°$ and $\Delta S°$ oppose the reaction's spontaneity.
C) $\Delta H°$ favors the reaction, but $\Delta S°$ opposes it.
D) $\Delta H°$ opposes the reaction, but $\Delta S°$ favors it.
E) The reaction cannot occur at room temperature.

ANS: D PTS: 1 DIF: Moderate REF: 17.6
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy | spontaneity MSC: Conceptual

74. Which of the following is not a state function?
A) q
B) G
C) H
D) E
E) P

ANS: A PTS: 1 DIF: Easy REF: 17.6
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy
MSC: Conceptual

75. The standard free energy of formation of KCl(s) is –408.8 kJ/mol. $\Delta G°$ for the reaction $2KCl(s) \rightarrow 2K(s) + Cl_2(g)$ is:
A) –408.8 kJ
B) 817.6 kJ
C) 408.8 kJ
D) –817.6 kJ
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 17.6
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy | standard free energy change MSC: Quantitative

76. Consider the following hypothetical reaction at 310 K. Standard free energies of formation are given in parentheses.

B C $\Delta G° = -32.6$ kJ/mol
$\rightarrow$

(?) (176.4 kJ/mol)

Calculate the standard free energy of formation of compound B.

A) 209.0 kJ/mol
B) –209.0 kJ/mol
C) 143.8 kJ/mol
D) –143.8 kJ/mol
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 17.6
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy | standard free energies of formation MSC: Quantitative

77. For the reaction $Cl_2O(g) + \frac{3}{2}O_2(g) \rightarrow 2ClO_2(g)$, $\Delta H°$ = 126.4 kJ/mol and $\Delta S°$ = –74.9 J/K mol.

At 361°C, what is ΔG ?

A) 153.4 kJ/mol
B) 47.6 kJ/mol
C) 173.9 kJ/mol
D) 78.9 kJ/mol
E) 155.0 kJ/mol

ANS: C PTS: 1 DIF: Moderate REF: 17.6
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy
MSC: Quantitative

78. Determine $\Delta G°$ for the following reaction:

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$$

Substance	$\Delta G_f°$(kJ/mol)
$CH_4(g)$	–50.69
$O_2(g)$	0
$CO_2(g)$	–394.4
$H_2O(l)$	–237.4

A) –581.1 kJ
B) –919.9 kJ
C) –818.5 kJ
D) –682.5 kJ
E) 131.1 kJ

ANS: C PTS: 1 DIF: Easy REF: 17.6
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy | standard free energy change MSC: Quantitative

79. Of ΔS, ΔS_{surr}, ΔS_{univ}, and ΔG, which are state functions?

A) ΔS, ΔS_{surr}, ΔS_{univ}, and ΔG are all state functions.
B) Only ΔS, ΔS_{univ}, and ΔG are state functions.
C) Only ΔS and ΔG are state functions.
D) Only ΔS, ΔS_{surr}, and ΔS_{univ} are state functions.

E) Only ΔS_{univ} and ΔG are state functions.

ANS: C PTS: 1 DIF: Easy REF: 17.6
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics
MSC: Conceptual

80. At 699 K, $\Delta G° = -23.25$ kJ for the reaction $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$. Calculate ΔG for this reaction if the reagents are both supplied at 10.0 atm pressure and the product is at 1.76 atm pressure.
A) –20.2 kJ
B) 20.2 kJ
C) 3.1 kJ
D) –43.4 kJ
E) 43.4 kJ

ANS: D PTS: 1 DIF: Moderate REF: 17.7
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free-energy dependence on pressure MSC: Quantitative

81. The standard molar free energies of formation of $NO_2(g)$ and $N_2O_4(g)$ at 25°C are 51.84 and 98.00 kJ/mol, respectively. What is the value of ΔG for the reaction written as follows at 25°C if the pressures of both gases are 1.33 atm?

$$2NO_2 \rightleftharpoons N_2O_4$$

A) –4.97
B) 4.97
C) –6.39
D) –5.68
E) –5.74

ANS: C PTS: 1 DIF: Moderate REF: 17.7
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free-energy dependence on pressure MSC: Quantitative

82. Elemental sulfur exists in two crystalline forms, rhombic and monoclinic. From the following data, calculate the equilibrium temperature at which monoclinic sulfur and rhombic sulfur are in equilibrium.

	$\Delta H_f°$ (kJ/mol)	$S°$ (J/K mol)
S (rhombic)	0	31.880
S (monoclinic)	0.30	32.552

A) 446 K
B) 202 K
C) –202 K
D) –446 K
E) 0 K

ANS: A PTS: 1 DIF: Moderate REF: 17.7
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy
MSC: Quantitative

83. Given the following data (ΔH_f, $S°$, respectively) for $N_2O_4(l)$ -20. kJ/mol, 209.0 J/K mol, and $N_2O_4(g)$ 10. kJ/mol, 304.2 J/K mol. Above what temperature (in °C) is the vaporization of N_2O_4 liquid spontaneous?
A) Above –178 °C.
B) Above –231 °C.
C) Above 3 °C.
D) Above 30. °C.
E) Above 42 °C.

ANS: E PTS: 1 DIF: Easy REF: 17.7
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | third law of thermodynamics | entropy change for a reaction MSC: Quantitative

84. The reaction $2H_2O(g) \rightarrow 2H_2(g) + O_2(g)$ has a positive value of $\Delta G°$. Which of the following statements must be true?
A) The reaction is slow.
B) The reaction will not occur. (When $H_2O(g)$ is introduced into a flask, no O_2 or H_2 will form even over a long period of time.)
C) The reaction is exothermic.
D) The equilibrium lies far to the right.
E) None of these is true.

ANS: E PTS: 1 DIF: Easy REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Conceptual

85. Given the following free energies of formation:

	$\Delta G_f°$
$C_2H_2(g)$	209.2 kJ/mol
$C_2H_6(g)$	–32.92 kJ/mol

calculate K_p at 298 K for $C_2H_2(g) + 2H_2(g) \rightleftharpoons C_2H_6(g)$
A) 97.7
B) 1.10
C) 7.95×10^{30}
D) 2.76×10^{42}
E) None of these is within a factor of 10 of the correct answer.

ANS: D PTS: 1 DIF: Moderate REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

86. The acid dissociation constant for a weak acid HX at 25°C is 4.3×10^{-8}. Calculate the free energy of formation for $X^-(aq)$ at 25°C. The standard free energies of $HX(aq)$ and $H^+(aq)$ at 25°C are –208.3 kJ/mol and 0, respectively.
A) –205 kJ/mol
B) 250 kJ/mol
C) 0
D) –166 kJ/mol
E) –250 kJ/mol

ANS: D PTS: 1 DIF: Moderate REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

87. The standard molar free energies of formation of $NO_2(g)$ and $N_2O_4(g)$ at 25°C are 51.840 and 98.035 kJ/mol, respectively. What is the value of K_p (in atm) for the reaction written as follows at 25°C?

$$2NO_2 \rightleftharpoons N_2O_4$$

A) 6.24×10^{11}
B) 1.00
C) 9.76
D) 4.38×10^{-36}
E) 7.99×10^{-9}

ANS: C PTS: 1 DIF: Moderate REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

88. Given that $\Delta G_f°$ for NH_3 = –16.668 kJ/mol, calculate the equilibrium constant for the following reaction at 298 K:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

A) 6.97×10^{5}
B) 8.35×10^{2}
C) 1.01
D) 4.51×10^{69}
E) 5.82×10^{8}

ANS: A PTS: 1 DIF: Easy REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

89. Calculate K_{sp} for the salt NaCl at 25°C.

Substance	$\Delta G_f°$(in kJ/mol)
$Na^+(aq)$	–262.0
$Cl^-(aq)$	–131.0
$NaCl(s)$	383.8

A) 41
B) 1.7×10^{19}
C) 9.2
D) 4.1
E) 0.41

ANS: A PTS: 1 DIF: Easy REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

90. Determine $\Delta G°$ for the weak acid, HF, at 25°C. ($K_a = 7.16 \times 10^{-4}$)
A) 1.5 kJ
B) 177 kJ

C) 7.79 kJ
D) 1.77 kJ
E) 17.9 kJ

ANS: E PTS: 1 DIF: Easy REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

91. Assume that the reaction:

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

occurs in an ideal mixture of ideal gases. At 700. K, $K_p = 3.24$. At this temperature, $\Delta G°$ equals:
A) 0 kJ
B) 6.84 kJ
C) –3.42 kJ
D) –6.84 kJ
E) –2.97 kJ

ANS: D PTS: 1 DIF: Easy REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

92. Consider the reaction:

$$2SO_2(g) \rightleftharpoons 2SO_3(g)$$

for which $\Delta H° = -200.$ kJ and $\Delta S° = -187.1$ J/K at 25°C. Assuming that $\Delta H°$ and $\Delta S°$ are independent of temperature, calculate the temperature where $K_p = 1$.
A) 969. K
B) 2069 K
C) 200. K
D) 1069 K
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

93. For the following reaction, $CO_2(g) + 2H_2O(g) \rightleftharpoons CH_4(g) + 2O_2(g)$, $\Delta H° = 803$ kJ which of the following will increase K?
A) decrease number of moles of methane
B) increase volume of system
C) increase the temperature of system
D) all of the above
E) none of the above

ANS: C PTS: 1 DIF: Easy REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Conceptual

94. For a particular reaction the equilibrium constant is 0.0122 at 370.°C and $\Delta H°$ is +16.0 kJ at 25°C. Assuming $\Delta H°$ and $\Delta S°$ are temperature independent, calculate $\Delta S°$ for the reaction.

A) 6.61 J/K
B) –6.61 J/K
C) –11.8 J/K
D) 11.8 J/K
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

95. Calculate $\Delta G°$ for $H_2O(g) + \frac{1}{2}O_2(g) \rightleftharpoons H_2O_2(g)$ at 600.1 K, using the following data:

$H_2(g) + O_2(g) \rightleftharpoons H_2O_2(g)$ $K_p = 2.3 \times 10^6$ at 600.1 K
$2H_2(g) + O_2(g) \rightleftharpoons 2H_2O(g)$ $K_p = 1.8 \times 10^{37}$ at 600.1 K

A) 141 kJ
B) –501 kJ
C) 501 kJ
D) –287 kJ
E) 287 kJ

ANS: A PTS: 1 DIF: Moderate REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

96. Consider the following hypothetical reaction (at 307.8 K). Standard free energies in kJ/mol are given in parentheses.

A $\rightleftharpoons$ B + C

$\Delta G° = ?$

(-32.2) (207.8) (-237.0)

What is the value of the equilibrium constant for the reaction at 307.8 K?
A) 0.31
B) 1.0
C) 9.0×10^4
D) 273
E) 0.43

ANS: A PTS: 1 DIF: Moderate REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

97. The equilibrium constant K for the dissociation reaction of a molecule X_2

$X_2(g) \rightleftharpoons 2X(g)$

was measured as a function of temperature (in K). A graph of ln K versus $1/T$ for this reaction gives a straight line with a slope of -1.352×10^4 and an intercept of 15.59 K. The value of ΔS for this dissociation reaction is:
A) 1.875 J/K mol
B) 259.2 J/K mol
C) 129.6 J/K mol
D) 64.81 J/K mol
E) none of these

ANS: C PTS: 1 DIF: Difficult REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

98. The following reaction has a $\Delta G°$ value of 48.47 kJ/mol at 25°C.

$$HB(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + B^-(aq)$$

Calculate the K_a for the acid HB.

A) 0.981
B) –19.6
C) 3.19×10^{-9}
D) 4.85×10^{-5}
E) –233

ANS: C PTS: 1 DIF: Easy REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

99. The standard free energy of formation of nitric oxide, NO, at 1000. K (roughly the temperature in an automobile engine during ignition) is 77.9 kJ/mol. Calculate the equilibrium constant for the reaction

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$$

at 1000. K.

A) 1.56×10^{5}
B) 8.53×10^{-5}
C) –14.7
D) 7.27×10^{-9}
E) 0.948

ANS: D PTS: 1 DIF: Easy REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

100. Consider the reaction $2NO_2(g) \rightleftharpoons N_2O_4(g)$; $\Delta H° = -56.8$ kJ and $\Delta S° = -175$ J/K. In a container (at 298 K) $N_2O_4(g)$ and $NO_2(g)$ are mixed with initial partial pressures of 2.4 atm and 0.42 atm, respectively. Which of the following statements is correct?

A) Some $N_2O_4(g)$ will decompose into $NO_2(g)$.
B) Some $NO_2(g)$ will dimerize to form $N_2O_4(g)$.
C) The system is at equilibrium at these initial pressures.
D) The final total pressure must be known to answer this question.
E) None of these.

ANS: A PTS: 1 DIF: Moderate REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Conceptual

Consider the gas phase reaction $NO + \frac{1}{2}O_2 \rightleftharpoons NO_2$ for which $\Delta H° = -56.91$ kJ and $K = 1.46 \times 10^{6}$ at 25°C.

101. Calculate $\Delta H°$ at 25°C for the following reaction:

$2NO + O_2 \rightleftharpoons 2NO_2$

A) 56.91 kJ
B) –113.8 kJ
C) –28.5 kJ
D) 3239 kJ
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | Hess's law
MSC: Quantitative

102. Calculate *K* for the following reaction at 25°C:

$2NO + O_2 \rightleftharpoons 2NO_2$

A) 2.92×10^{6}
B) 2.13×10^{12}
C) 7.30×10^{5}
D) 1.21×10^{3}
E) 1.46×10^{6}

ANS: B PTS: 1 DIF: Moderate REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

103. Calculate $\Delta G°$ at 25°C for the following reaction:

$2NO + O_2 \rightleftharpoons 2NO_2$

A) –70.3 kJ
B) –5.90 kJ
C) –35.2 kJ
D) 5.90 kJ
E) 70.3 kJ

ANS: A PTS: 1 DIF: Easy REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

104. Calculate $\Delta S°$ at 25°C for the following reaction:

$2NO + O_2 \rightleftharpoons 2NO_2$

A) 236 J/K
B) –146 J/K
C) –236 J/K
D) –264 J/K
E) 264 J/K

ANS: B PTS: 1 DIF: Easy REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | heats of reaction | Hess's law
MSC: Quantitative

105. For this system at equilibrium, how will raising the temperature affect the amount of NO present?

A) The amount of NO will increase.

B) The amount of NO will decrease.
C) The amount of NO will remain the same.
D) Cannot be determined.
E) Answer depends on the value of *K*.

ANS: A PTS: 1 DIF: Easy REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | temperature dependence of free energy MSC: Conceptual

106. What would be the effect on the amount of NO present of compressing the equilibrium system to a smaller volume, while keeping the temperature constant?
A) The amount of NO will increase.
B) The amount of NO will decrease.
C) The amount of NO will remain the same.
D) Cannot be determined.
E) Answer depends on the value of *K*.

ANS: B PTS: 1 DIF: Easy REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free-energy dependence on pressure MSC: Conceptual

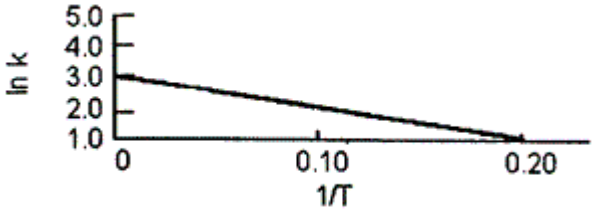
107. Given $CH_3CO_2H(aq) \rightleftharpoons H^+(aq) + CH_3CO_2^-(aq)$ at 25°C, $K_a = 1.84 \times 10^{-5}$. What is $\Delta G°$ at 25°C?
A) –27.0 kJ
B) 27.0 kJ
C) 2.27 kJ
D) –2.27 kJ
E) 27.0 J

ANS: B PTS: 1 DIF: Easy REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

108. Given $CH_3CO_2H(aq) \rightleftharpoons H^+(aq) + CH_3CO_2^-(aq)$ at 25°C, $K_a = 1.75 \times 10^{-5}$. What is ΔG at 25°C for a solution in which the initial concentrations are:
$[CH_3CO_2H]_0 = 0.10\ M$
$[H^+]_0 = 4.8 \times 10^{-8}\ M$
$[CH_3CO_2^-]_0 = 0.010\ M$
A) –74.6 kJ
B) 74.6 kJ
C) 20.3 kJ
D) –20.3 kJ
E) 27.1 kJ

ANS: D PTS: 1 DIF: Moderate REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

109. The equilibrium constant of a certain reaction was measured at various temperatures to give the plot shown below. What is $\Delta S°$ for the reaction in J/mol · K?



A) 0.20
B) 3.0
C) 25
D) –50.
E) -8.3×10^3

ANS: C PTS: 1 DIF: Moderate REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | temperature dependence of free energy | spontaneity and temperature change MSC: Conceptual

110. Consider a weak acid, HX. If a 0.10 *M* solution of HX has a pH of 5.64 at 25°C, what is $\Delta G°$ for the acid's dissociation reaction at 25°C?
A) –58.6 kJ
B) 4.92 kJ
C) 0
D) –4.92 kJ
E) 58.6 kJ

ANS: E PTS: 1 DIF: Moderate REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

111. For the reaction $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$ $\Delta G°_{700K} = -13.462$ kJ. The K_p for this reaction at 700. K is:
A) 10.1
B) 1.00
C) 1.54
D) 2.31
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

112. For the reaction $2HF(g) \rightleftharpoons H_2(g) + F_2(g)$, $\Delta G° = 38.3$ kJ, at 1000 K. If, at this temperature, 5.00 moles of HF(*g*), 0.500 moles of H_2(*g*), and 0.75 moles of F_2(*g*) are mixed in a 1.00-L container:
A) Some HF will decompose (to yield H_2 and F_2).
B) The system is at equilibrium.
C) Some HF will be formed (from H_2 and F_2).
D) Not enough data are given to answer this question.
E) None of these (A-D).

ANS: C PTS: 1 DIF: Moderate REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Conceptual

Consider the following system at equilibrium at 25°C:
$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$
for which $\Delta H° = -92.5$kJ at 25°C.

113. If the temperature of the system is raised, the ratio of the partial pressure of PCl_5 to the partial pressure of PCl_3 will
A) increase
B) decrease
C) stay the same
D) impossible to tell without more information
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 17.8
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle
MSC: Conceptual

114. When some $Cl_2(g)$ is added at constant volume and temperature, the ratio of the partial pressure of PCl_5 to the partial pressure of PCl_3 will
A) increase
B) decrease
C) stay the same
D) impossible to tell without more information
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 17.8
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle
MSC: Conceptual

115. When the volume is decreased at constant temperature, the ratio of the partial pressure of PCl_5 to the partial pressure of PCl_3 will
A) increase
B) decrease
C) stay the same
D) impossible to tell without more information
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 17.8
KEY: Chemistry | general chemistry | chemical equilibrium | Le Chatelier's principle
MSC: Conceptual

116. Water gas, a commercial fuel, is made by the reaction of hot coke carbon with steam.
$$C(s) + H_2O(g) \rightleftharpoons CO(g) + H_2(g)$$
When equilibrium is established at 844°C the concentrations of CO, H_2, and H_2O are 4.00×10^{-2}, 4.00×10^{-2}, and 1.00×10^{-2} mole/liter, respectively. Calculate the value of $\Delta G°$ for this reaction at 844°C.
A) 12.9 kJ

B) –12.87 kJ
C) 55.64 kJ
D) 17.02 kJ
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

The equilibrium constant K_p (in atm) for the dissociation reaction of $Cl_2 \rightleftharpoons 2Cl$ was measured as a function of temperature (in K). A graph of ln K_p versus $1/T$ for this reaction gives a straight line with a slope of -1.651×10^4 and an intercept of 14.51.

117. From these data, which of the following statements is true?
A) The reaction is exothermic.
B) The reaction is endothermic.
C) The reaction rate is high
D) The reaction is not spontaneous.
E) None of these.

ANS: B PTS: 1 DIF: Moderate REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | temperature dependence of free energy | spontaneity and temperature change MSC: Conceptual

118. The value of ΔH for this dissociation reaction is:
A) –137.3 kJ
B) 137.3 kJ
C) 1.986 kJ
D) –1.986 kJ
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 17.8
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | thermodynamic equilibrium constant (K) MSC: Quantitative

119. For a certain process, at 300. K, $\Delta G = -10.4$ kJ and $\Delta H = -7.0$ kJ. If the process is carried out reversibly, the amount of useful work that can be performed is
A) –17.4 kJ
B) –7.0 kJ
C) –3.4 kJ
D) –10.4 kJ
E) 3.4 kJ

ANS: D PTS: 1 DIF: Moderate REF: 17.9
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | reversible and irreversible processes MSC: Conceptual

120. For a certain process, at 300. K, $\Delta G = -12.2$ kJ and $\Delta H = -7.0$ kJ. If the process is carried out so that no useful work is performed, ΔG is
A) 12.2 kJ

B) 7.0 kJ
C) 0
D) –7.0 kJ
E) –12.2 kJ

ANS: E PTS: 1 DIF: Moderate REF: 17.9
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy and work MSC: Conceptual

121. Which statement is true?
A) All real processes are irreversible.
B) A thermodynamically reversible process takes place infinitely fast.
C) In a reversible process, the state functions of the system are always much greater than those of the surroundings.
D) There is always more heat given off to the surroundings in a reversible process than in an unharnessed one.
E) All statements (A–D) are true.

ANS: A PTS: 1 DIF: Easy REF: 17.9
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | reversible and irreversible processes MSC: Conceptual

Would you predict an increase or decrease in entropy for each of the following?

122. The freezing of water

ANS:
decrease in entropy

Positional entropy relates to the phase of the substance: $S_{solid} < S_{liquid} < S_{gas}$.
See Sec. 17.1, Zumdahl, *Chemistry*.

PTS: 1 DIF: Easy REF: 17.1
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy and molecular disorder MSC: Conceptual

123. $He(g)$ at 3 atm $\rightarrow$ $He(g)$ at 1 atm

ANS:
increase in entropy

At constant temperature, a decrease in pressure corresponds to an increase in volume, which imparts greater positional entropy.
See Sec. 17.1, Zumdahl, *Chemistry*.

PTS: 1 DIF: Easy REF: 17.1
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy and molecular disorder MSC: Conceptual

124. $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

ANS:
decrease in entropy

The change in positional entropy is dominated by the relative numbers of molecules in the gas phase.
See Sec. 17.5, Zumdahl, *Chemistry*.

PTS: 1 DIF: Easy REF: 17.5
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy change for a reaction MSC: Conceptual

125. $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$

ANS:
increase in entropy

The change in positional entropy is dominated by the relative numbers of molecules in the gas phase.
See Sec. 17.5, Zumdahl, *Chemistry*.

PTS: 1 DIF: Easy REF: 17.5
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy change for a reaction MSC: Conceptual

126. Which of the following statements is FALSE?
A) Increasing the temperature of a system increases the entropy.
B) 2 moles of a gas at one atmosphere pressure has a greater entropy than 2 moles of the same gas at 1000 mmHg pressure.
C) The reaction of O_3(g) to produce O_2(g) has a negative entropy change.
D) The S° of methane (CH_4) is less than that of ethane (C_2H_6).
E) A substance can only have zero entropy at absolute zero in a perfect crystal.

ANS: C PTS: 1 DIF: Easy REF: 17.1 | 17.5
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

127. Which item (a, b or c) in each of the three groups below has the lowest entropy?

I. (a) 10 g ice (b) 10 g water vapor (c) 10 g liquid water
II. (a) 1 mole NaCl solid (b) 1 mol NaCl in 1 M aqueous solution (c) 1 mol molten NaCl
III. (a) 1 mole C_2H_6(g), (b) 1 mole CH_4(g), (c) 1 mol C_3H_8(g) all at 25 °C and 1 atm
A) a, a, b
B) c, b, c
C) b, b, c
D) a, b, c
E) a, a, c

ANS: A PTS: 1 DIF: Easy REF: 17.5

KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

128. In which of the following pairs is the substance with the HIGHER entropy listed first?

I. NaCl(s), NaCl(aq)
II. $CO(g)$, $CO_2(g)$
III. 1 mole of $H_2(g)$ at 25°C; 1 mole of $H_2(g)$ at 50°C
A) I only
B) II only
C) III only
D) all of them
E) none of them

ANS: E PTS: 1 DIF: Easy REF: 17.5
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics | entropy MSC: Conceptual

129. Predict the sign of $\Delta S°$ for each of the following processes:

I. $2\ K(s) + Cl_2(g) \rightarrow 2\ KCl(s)$
II. $CH_4(g) \rightarrow C(s) + 2\ H_2(g)$
III. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
A) negative, negative, positive
B) negative, negative, negative
C) positive, negative, negative
D) negative, positive, positive
E) positive, positive, positive

ANS: D PTS: 1 DIF: Easy REF: 17.5
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | third law of thermodynamics | entropy change for a reaction MSC: Conceptual

130. Which of the following reactions will have a positive value of $\Delta S°$?

I. $Pb(s) + Cl_2(g) \rightarrow PbCl_2(s)$
II. $2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(g) + 2SO_2(g)$
III. $K_2SO_4(s) \rightarrow 2K^+(aq) + SO_4^{2-}(aq)$
A) I only
B) II only
C) III only
D) I and II
E) II and III

ANS: C PTS: 1 DIF: Easy REF: 17.5
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | third law of thermodynamics | entropy change for a reaction MSC: Conceptual

131. Which of the following processes should show the greatest increase in entropy?
A) $C_6H_6(l) + 15/2\ O_2(g) \rightarrow 6\ CO_2(g) + 3\ H_2O(g)$

B) $2\ NO_2(g) \rightarrow N_2O_4(g)$
C) $C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$
D) $BaS(s) + 2\ NaNO_3(s) \rightarrow Ba(NO_3)_2(s) + Na_2S(s)$
E) This cannot be predicted without additional information.

ANS: A PTS: 1 DIF: Easy REF: 17.5
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | third law of thermodynamics | entropy change for a reaction MSC: Conceptual

132. In which of the following reactions do you expect to have the largest increase in entropy?
A) $I_2(s) \rightarrow I_2(g)$
B) $2IF(g) \rightarrow I_2(g) + F_2(g)$
C) $Mn(s) + O_2(g) \rightarrow MnO_2(s)$
D) $Hg(l) + S(s) \rightarrow HgS(s)$
E) $CuSO_4(s) + 5H_2O(l) \rightarrow CuSO_4 \cdot H_2O(s)$

ANS: A PTS: 1 DIF: Easy REF: 17.5
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | third law of thermodynamics | entropy change for a reaction MSC: Conceptual

133. The exothermic reaction, $2\ Cu(s) + O_2(g) \rightarrow 2\ CuO(s)$, is spontaneous
A) At high temperatures
B) At low temperatures
C) At all temperatures
D) The reaction is nonspontaneous at all temperatures
E) Cannot be determined with the available information

ANS: B PTS: 1 DIF: Easy REF: 17.5
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy | spontaneity MSC: Conceptual

134. For the reaction, $X + Y \rightarrow A + B$, ΔG^o is –1324 kJ. Which one of the following statements is NOT valid concerning the reaction?
A) The reaction is thermodynamically favorable.
B) The reaction is spontaneous as written.
C) The products are more stable than the reactants.
D) The reaction will proceed rapidly from left to right.
E) Three of these statements are valid.

ANS: D PTS: 1 DIF: Easy REF: 17.4
KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | free energy | spontaneity MSC: Conceptual

135. The Second Law of Thermodynamics states that
A) energy is conserved in a spontaneous process.
B) the entropy of the universe increases during a spontaneous process.
C) the heat content of the universe increases during a spontaneous process.
D) all of these are valid components of the second law.
E) none of these is correct.

ANS: B PTS: 1 DIF: Easy REF: 17.3

KEY: Chemistry | general chemistry | thermochemistry | thermodynamics | second law of thermodynamics MSC: Conceptual

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Chapter 18: Electrochemistry

1. Given the following reaction in acidic media:

$$Fe^{2+} + Cr_2O_7^{2-} \rightarrow Fe^{3+} + Cr^{3+}$$

answer the following question: The coefficient for water in the balanced reaction is:
A) 1
B) 3
C) 5
D) 7
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions | half-reaction method MSC: Conceptual

2. For the reaction of sodium bromide with chlorine gas to form sodium chloride and bromine, the appropriate half-reactions are (ox = oxidation and re = reduction):
A) ox: $Cl_2 + 2e^- \rightarrow 2Cl^-$; re: $2Br^- \rightarrow Br_2 + 2e^-$
B) ox: $2Br^- \rightarrow Br_2 + 2e^-$; re: $Cl_2 + 2e^- \rightarrow 2Cl^-$
C) ox: $Cl + e^- \rightarrow Cl^-$; re: $Br \rightarrow Br^- + e^-$
D) ox: $Br + 2e^- \rightarrow Br^{2-}$; re: $2Cl^- \rightarrow Cl_2 + 2e^-$
E) ox: $2Na^+ + 2e^- \rightarrow 2Na$; re: $2Cl^- \rightarrow Cl_2 + 2e^-$

ANS: B PTS: 1 DIF: Easy REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions MSC: Conceptual

3. How many electrons are transferred in the following reaction when it is balanced in acidic solution? $SO_3^{2-}(aq) + MnO_4^-(aq) \rightarrow SO_4^{2-}(aq) + Mn^{2+}(aq)$
A) 6
B) 2
C) 10
D) 5
E) 3

ANS: C PTS: 1 DIF: Easy REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions | half-reaction method MSC: Conceptual

4. Ammonium metavandate reacts with sulfur dioxide in acidic solution as follows (hydrogen ions and H_2O omitted):

$$xVO_3^- + ySO_2 \rightarrow xVO^{2+} + ySO_4^{2-}$$

The ratio x : y is
A) 1 : 1
B) 1 : 2
C) 2 : 1
D) 1 : 3

E) 3 : 1

ANS: C PTS: 1 DIF: Easy REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions | half-reaction method MSC: Conceptual

The following reaction occurs in aqueous acid solution:

$$NO_3^- + I^- \rightarrow IO_3^- + NO_2$$

5. In the balanced equation the coefficient of NO_3^- is:
A) 2
B) 3
C) 4
D) 5
E) 6

ANS: E PTS: 1 DIF: Easy REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions | half-reaction method MSC: Conceptual

6. In the balanced equation the coefficient of water is:
A) 1
B) 2
C) 3
D) 4
E) 5

ANS: C PTS: 1 DIF: Easy REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions | half-reaction method MSC: Conceptual

7. When the equation $Cl_2 \rightarrow Cl^- + ClO_3^-$ (basic solution) is balanced using the smallest whole-number coefficients, the coefficient of OH^- is:
A) 1
B) 12
C) 3
D) 4
E) 6

ANS: E PTS: 1 DIF: Moderate REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions | half-reaction method MSC: Conceptual

8. The following reaction occurs in basic solution:

$$F_2 + H_2O \rightarrow O_2 + F^-$$

When the equation is balanced, the sum of the coefficients is:
A) 10
B) 11
C) 12

D) 13
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions | half-reaction method MSC: Conceptual

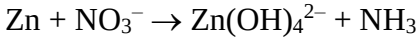
9. When the equation for the following reaction in basic solution is balanced, what is the sum of the coefficients?

$$MnO_2 + HO_2^- \rightarrow MnO_4^-$$

A) 11
B) 31
C) 14
D) 9
E) 18

ANS: D PTS: 1 DIF: Moderate REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions | half-reaction method MSC: Conceptual

10. The reaction below occurs in basic solution. In the balanced equation, what is the sum of the coefficients?



$$Zn + NO_3^- \rightarrow Zn(OH)_4^{2-} + NH_3$$

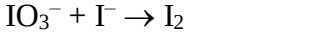
A) 12
B) 15
C) 19
D) 23
E) 27

ANS: D PTS: 1 DIF: Easy REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions | half-reaction method MSC: Conceptual

11. The following reaction occurs in basic solution: $Ag^+ + Cu \rightarrow Ag + Cu^{2+}$ When the equation is balanced, the sum of the coefficients is:
A) 4
B) 5
C) 6
D) 7
E) none of the above

ANS: C PTS: 1 DIF: Easy REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions MSC: Conceptual

12. When the following reaction is balanced in acidic solution, what is the coefficient of I_2?



$$IO_3^- + I^- \rightarrow I_2$$

A) 1
B) 2

C) 3
D) 4
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions | half-reaction method MSC: Conceptual

13. Balance the following oxidation–reduction reaction using the half-reaction method.

$$Cr_2O_7^{2-} + I_2 \rightarrow Cr^{3+} + IO_3^-$$

In the balanced equation, the coefficient of water is:
A) 4
B) 17
C) 11
D) 7
E) 6

ANS: B PTS: 1 DIF: Easy REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions | half-reaction method MSC: Conceptual

14. For the redox reaction $2Fe^{2+} + Cl_2 \rightarrow 2Fe^{3+} + 2Cl^-$ which of the following are the correct half-reactions?

I. $Cl_2 + 2e– \rightarrow 2Cl–$
II. $Cl \rightarrow Cl– + e–$
III. $Cl_2 \rightarrow 2Cl– + 2e–$
IV. $Fe^{2+} \rightarrow Fe^{3+} + e–$
V. $Fe^{2+} + e– \rightarrow Fe^{3+}$

A) I and IV
B) I and V
C) II and IV
D) II and V
E) III and IV

ANS: A PTS: 1 DIF: Easy REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction
MSC: Conceptual

15. What is the oxidation state of Hg in Hg_2Cl_2?
A) +2
B) –1
C) –2
D) +1
E) 0

ANS: D PTS: 1 DIF: Easy REF: 18.1
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions | oxidation-reduction reaction | assigning oxidation number MSC: Conceptual

16. How many electrons are transferred in the following reaction?

$$2ClO_3^- + 12H^+ + 10I^- \rightarrow 5I_2 + Cl_2 + 6H_2O$$

A) 12
B) 5
C) 2
D) 30
E) 10

ANS: E PTS: 1 DIF: Easy REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing chemical equation MSC: Conceptual

17. How many electrons are transferred in the following reaction?

$$Sn + 2HCl \rightarrow SnCl_2 + H_2$$

A) 0
B) 1
C) 2
D) 4
E) not enough information given

ANS: C PTS: 1 DIF: Easy REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions MSC: Conceptual

18. When the equation for the following reaction in basic solution is balanced, what is the sum of the coefficients?

$$MnO_4^-(aq) + CN^-(aq) \rightarrow MnO_2(s) + CNO^-(aq)$$

A) 13
B) 8
C) 10
D) 20
E) 11

ANS: A PTS: 1 DIF: Easy REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions | half-reaction method MSC: Conceptual

19. The following unbalanced equation represents a reaction that occurs in basic solution:

$$MnO_4^{2-} + C_2O_4^{2-} \rightarrow MnO_2 + CO_3^{2-}$$

How many moles of MnO_4^{2-} are required to produce 1 mole of CO_3^{2-}?
A) 4
B) 3
C) 2
D) 1
E) none of these

ANS: E PTS: 1 DIF: Easy REF: 18.1

KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions | half-reaction method MSC: Conceptual

20. The following questions refer to a galvanic cell that utilizes the following reaction (unbalanced):

$$(AuCl_4)^-(aq) + Cu(s) \rightarrow Au(s) + Cl^-(aq) + Cu^{2+}(aq)$$

Determine the number of electrons transferred during the reaction (when balanced).
A) 2
B) 3
C) 4
D) 6
E) 9

ANS: D PTS: 1 DIF: Easy REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions MSC: Conceptual

Consider a galvanic cell based in the reaction $Fe^{2+} + Cr_2O_7^{2-} \rightarrow Fe^{3+} + Cr^{3+}$ in acidic solution.

21. What is the coefficient of Fe^{3+} in the balanced equation?
A) 6
B) 2
C) 3
D) 4
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions | half-reaction method MSC: Conceptual

22. Calculate the voltage of the standard cell carrying out this reaction.
A) 0
B) 0.21 V
C) –0.21 V
D) 0.56 V
E) –0.56 V

ANS: D PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | calculating cell emfs MSC: Quantitative

23. Which energy conversion shown below takes place in a galvanic cell?
A) electrical to chemical
B) chemical to electrical
C) mechanical to chemical
D) chemical to mechanical
E) mechanical to electrical

ANS: B PTS: 1 DIF: Easy REF: 18.2

KEY: Chemistry | general chemistry | electrochemistry | voltaic cells
MSC: Conceptual

24. Which of the following reactions is possible at the anode of a galvanic cell?
A) $Zn \rightarrow Zn^{2+} + 2e^-$
B) $Zn^{2+} + 2e^- \rightarrow Zn$
C) $Zn^{2+} + Cu \rightarrow Zn + Cu^{2+}$
D) $Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$
E) two of these

ANS: A PTS: 1 DIF: Easy REF: 18.2
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | construction of voltaic cells MSC: Conceptual

25. Which of the following is true for the cell shown here? $Zn(s) \mid Zn^{2+}(aq) \parallel Cr^{3+}(aq) \mid Cr(s)$
A) The electrons flow from the cathode to the anode.
B) The electrons flow from the zinc to the chromium.
C) The electrons flow from the chromium to the zinc.
D) The chromium is oxidized.
E) The zinc is reduced.

ANS: B PTS: 1 DIF: Moderate REF: 18.2
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | construction of voltaic cells MSC: Conceptual

26. The anode in a voltaic cell and in an electrolytic cell is
A) positive in both cells
B) the site of oxidation and of reduction, respectively
C) the site of reduction and of oxidation, respectively
D) the site of oxidation in both cells
E) the site of reduction in both cells

ANS: D PTS: 1 DIF: Easy REF: 18.2
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | construction of voltaic cells MSC: Conceptual

27. Which statement is <u>always</u> true of the cathode in an electrochemical cell?
A) It is considered the "negative" electrode.
B) It is considered the "positive" electrode.
C) Reduction occurs here.
D) Metal is plated out here.
E) Negative ions flow toward the cathode.

ANS: C PTS: 1 DIF: Easy REF: 18.2
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | construction of voltaic cells MSC: Conceptual

28. A strip of copper is placed in a 1 *M* solution of copper nitrate and a strip of silver is placed in a 1 *M* solution of silver nitrate. The two metal strips are connected to a voltmeter by wires and a salt bridge connects the solutions. The following standard reduction potentials apply:

$Ag^+(aq) + e^- \rightarrow Ag(s)$ $\varepsilon^\circ = +0.80$ V
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ $\varepsilon^\circ = +0.34$ V

Which of the following statements is *false*?
A) Electrons flow in the external circuit from the copper electrode to the silver electrode.
B) The silver electrode increases in mass as the cell operates.
C) There is a net general movement of silver ions through the salt bridge to the copper half-cell.
D) Negative ions pass through the salt bridge from the silver half-cell to the copper half-cell.
E) Some positive copper ions pass through the salt bridge from the copper half-cell to the silver half-cell.

ANS: C PTS: 1 DIF: Moderate REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | construction of voltaic cells MSC: Conceptual

29. You are told that metal X is a better reducing agent than metal Y. This must mean that:
A) X^+ is a better oxidizing agent than Y^+.
B) X^+ is a better reducing agent than Y^+.
C) Y is a better oxidizing agent than X.
D) Y^+ is a better reducing agent than X^+.
E) Y^+ is a better oxidizing agent than X^+.

ANS: E PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | strength of oxidizing and reducing agents
MSC: Conceptual

30. Which of the following species cannot function as an oxidizing agent?
A) $S(s)$
B) $NO_3^-(aq)$
C) $Cr_2O_7^{2-}(aq)$
D) $I^-(aq)$
E) $MnO_4^-(aq)$

ANS: D PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials MSC: Conceptual

31. Which of the following is the strongest oxidizing agent?

$MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O$ $\varepsilon^\circ = 1.68$ V
$I_2 + 2e^- \rightarrow 2I^-$ $\varepsilon^\circ = 0.54$ V
$Zn^{2+} + 2e^- \rightarrow Zn$ $\varepsilon^\circ = -0.76$ V

A) MnO_4^-
B) I_2
C) Zn^{2+}
D) Zn

E) MnO_2

ANS: A PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | strength of oxidizing and reducing agents
MSC: Conceptual

32. Which metal, Al or Ni could reduce Zn^{2+} to Zn(*s*) if placed in a Zn^{2+}(*aq*) solution?

$Zn^{2+} + 2e^- \rightarrow Zn$ $\quad\quad$ $\mathcal{E}^\circ = -0.76$ V
$Al^{3+} + 3e^- \rightarrow Al$ $\quad\quad$ $\mathcal{E}^\circ = -1.66$ V
$Ni^{2+} + 2e^- \rightarrow Ni$ $\quad\quad$ $\mathcal{E}^\circ = -0.23$ V

A) Al
B) Ni
C) Both Al and Ni would work.
D) Neither Al nor Ni would work.
E) Cannot be determined.

ANS: A PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | tabulating standard electrode potentials
MSC: Conceptual

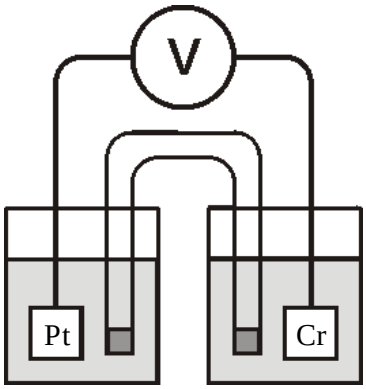
33. Which of the following is the best reducing agent?

$Cl_2 + 2e^- \rightarrow 2Cl^-$ $\quad\quad$ $\mathcal{E}^\circ = 1.36$ V
$Mg^{2+} + 2e^- \rightarrow Mg$ $\quad\quad$ $\mathcal{E}^\circ = -2.37$ V
$2H^+ + 2e^- \rightarrow H_2$ $\quad\quad$ $\mathcal{E}^\circ = 0.00$ V

A) Cl_2
B) H_2
C) Mg
D) Mg^{2+}
E) Cl^-

ANS: C PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | strength of oxidizing and reducing agents
MSC: Conceptual

34. Consider the galvanic cell shown below (the contents of each half-cell are written beneath each compartment):



0.50 *M* Br_2 0.20 *M* Cr^{3+}
0.10 *M* Br^-

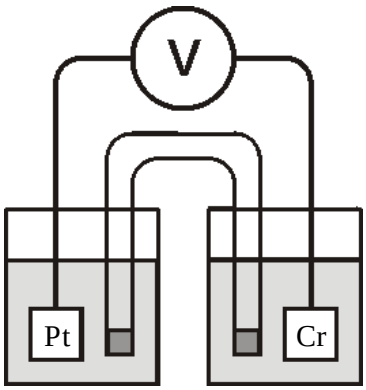
The standard reduction potentials are as follows:

$Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$ $\varepsilon^\circ = -0.727$ V
$Br_2(aq) + 2e^- \rightarrow 2Br^-(aq)$ $\varepsilon^\circ = +1.090$ V

What is ε° for this cell?
A) 1.817 V
B) 0.363 V
C) –0.363 V
D) 4.724 V
E) 1.316 V

ANS: A PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | calculating cell emfs MSC: Quantitative

35. Consider the galvanic cell shown below (the contents of each half-cell are written beneath each compartment):



0.50 *M* Br_2 0.20 *M* Cr^{3+}
0.10 *M* Br^-

The standard reduction potentials are as follows:

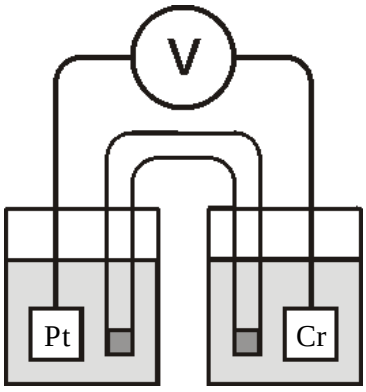
$Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$ $\varepsilon^\circ = -0.73$ V
$Br_2(aq) + 2e^- \rightarrow 2Br^-(aq)$ $\varepsilon^\circ = +1.09$ V

Which of the following statements about this cell is false?

A) This is a galvanic cell.
B) Electrons flow from the Pt electrode to the Cr electrode.
C) Reduction occurs at the Pt electrode.
D) The cell is not at standard conditions.
E) To complete the circuit, cations migrate into the left half-cell and anions migrate into the right half-cell from the salt bridge.

ANS: B PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | construction of voltaic cells MSC: Conceptual

36. Refer to the galvanic cell below (the contents of each half-cell are written beneath each compartment):



0.10 *M* MnO_4^- 0.40 *M* Cr^{3+}
0.20 *M* Mn^{2+} 0.30 *M* $Cr_2O_7^{2-}$
0.010 *M* H^+ 0.010 *M* H^+

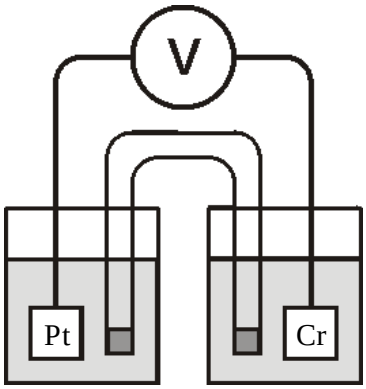
The standard reduction potentials are as follows:

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$, $\mathcal{E}^\circ = 1.506$ V
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$, $\mathcal{E}^\circ = 1.330$ V

What is the value of $\mathcal{E}^\circ_{cell}$?
A) –0.176
B) 2.836
C) 0.176
D) 0.676
E) 6.200

ANS: C PTS: 1 DIF: Moderate REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration | Nernst equation MSC: Quantitative

Refer to the galvanic cell below (the contents of each half-cell are written beneath each compartment):



0.10 *M* MnO_4^- 0.40 *M* Cr^{3+}
0.20 *M* Mn^{2+} 0.30 *M* $Cr_2O_7^{2-}$
0.010 *M* H^+ 0.010 *M* H^+

The standard reduction potentials are as follows:

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$, $\mathcal{E}^\circ = 1.51$ V
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$, $\mathcal{E}^\circ = 1.33$ V

37. When current is allowed to flow, which species is oxidized?
A) $Cr_2O_7^{2-}$
B) Cr^{3+}
C) MnO_4^-
D) Mn^{2+}
E) H^+

ANS: B PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | construction of voltaic cells MSC: Conceptual

38. When current is allowed to flow, which species is reduced?
A) $Cr_2O_7^{2-}$
B) Cr^{3+}
C) MnO_4^-
D) Mn^{2+}
E) H^+

ANS: C PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | construction of voltaic cells MSC: Conceptual

39. What is the oxidation state of Cr in $Cr_2O_7^{2-}$?
A) +7
B) +6
C) +12
D) –1
E) –2

ANS: B PTS: 1 DIF: Easy REF: 18.1
KEY: Chemistry | general chemistry | chemical reactions | types of chemical reactions |

oxidation-reduction reaction | assigning oxidation number MSC: Conceptual

40. What is the value of *Q*, the reaction quotient, for this cell reaction?
A) 6.7×10^{40}
B) 1.5×10^{-41}
C) 1.5×10^{-4}
D) 6.7×10^{3}
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration MSC: Quantitative

41. In which direction do electrons flow in the external circuit?
A) left to right
B) right to left
C) no current flows; the cell is at equilibrium
D) cannot be determined.
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | construction of voltaic cells MSC: Conceptual

42. In the balanced cell reaction, what is the stoichiometric coefficient for H^+?
A) 5
B) 6
C) 30
D) 22
E) 2

ANS: D PTS: 1 DIF: Moderate REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions | half-reaction method MSC: Conceptual

43. How many electrons are transferred in the balanced reaction (i.e., what will be the value of *n* in the Nernst equation)?
A) 5
B) 6
C) 30
D) 22
E) 2

ANS: C PTS: 1 DIF: Easy REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions MSC: Conceptual

44. What is the cell potential at 25°C as read on the digital voltmeter?
A) 0.18 V
B) 2.58 V

C) 0.10 V
D) 0.59 V
E) 0.26 V

ANS: E PTS: 1 DIF: Moderate REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration | Nernst equation MSC: Quantitative

45. A cell is set up with copper and lead electrodes in contact with $CuSO_4(aq)$ and $Pb(NO_3)_2(aq)$, respectively, at 25°C. The standard reduction potentials are:

$$Pb^{2+} + 2e^- \rightarrow Pb \qquad \varepsilon^\circ = -0.13 \text{ V}$$
$$Cu^{2+} + 2e^- \rightarrow Cu \qquad \varepsilon^\circ = +0.34 \text{ V}$$

If the Pb^{2+} and Cu^{2+} are each 1.0 *M*, the potential of the cell, in volts, is:
A) 0.47 V
B) 0.92 V
C) 0.22 V
D) 0.58 V
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | calculating cell emfs MSC: Quantitative

46. Consider an electrochemical cell with a zinc electrode immersed in 1.0 *M* Zn^{2+} and a silver electrode immersed in 1.0 *M* Ag^+.

$$Zn^{2+} + 2e^- \rightarrow Zn \qquad \varepsilon^\circ = -0.755 \text{ V}$$
$$Ag^+ + e^- \rightarrow Ag \qquad \varepsilon^\circ = 0.800 \text{ V}$$

Calculate ε° for this cell.
A) 0.045 V
B) –0.045 V
C) 1.555 V
D) –1.555 V
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | calculating cell emfs MSC: Quantitative

47. The galvanic cell described by $Zn(s) \mid Zn^{2+}(aq) \mid Cu^{2+}(aq) \mid Cu(s)$ has a standard cell potential of 1.101 volts. Given that $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$ has an oxidation potential of 0.764 volts, determine the reduction potential for Cu^{2+}.
A) 1.865 V
B) –1.865 V
C) –0.337 V
D) 0.337 V
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 18.3

KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials MSC: Quantitative

48. The following question refers to a galvanic cell that utilizes the following reaction (unbalanced):

$$(AuCl_4)^-(aq) + Cu(s) \rightarrow Au(s) + Cl^-(aq) + Cu^{2+}(aq)$$

Given the following information, determine the standard cell potential:

Species	Standard Reduction Potential (V)
$Au^{3+}(aq)$	1.4980
$Cu^{2+}(aq)$	−0.3390

A) 1.1590 V
B) 1.8370 V
C) 3.8160 V
D) 0.8200 V
E) 4.1550 V

ANS: A PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | calculating cell emfs MSC: Quantitative

49. Choose the correct statement given the following information:

$$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq) \qquad \varepsilon^\circ = 0.77\,V$$
$$Fe(CN)_6^{3-}(aq) + e^- \rightarrow Fe(CN)_6^{4-}(aq) \qquad \varepsilon^\circ = 0.36\,V$$

A) $Fe^{2+}(aq)$ is more likely to be oxidized than Fe^{2+} complexed to CN^-.
B) $Fe^{3+}(aq)$ is more likely to be reduced than Fe^{3+} complexed to CN^-.
C) Both A and B are true.
D) Complexation of Fe ions with CN^- has no effect on their tendencies to become oxidized or reduced.
E) None of these is true.

ANS: B PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | strength of oxidizing and reducing agents
MSC: Conceptual

50. The following question refers to the following system:

$$3Ag(s) + NO_3^-(aq) + 4H^+(aq) \rightarrow 3Ag^+(aq) + NO(g) + 2H_2O(l)$$

Anode reaction: $Ag \rightarrow Ag^+(aq) + e^-$ $\varepsilon^\circ = -0.7990$ V
Cathode reaction: $NO_3^-(aq) + 4H^+(aq) + 3e^- \rightarrow NO(g) + 2H_2O(l)$ $\varepsilon^\circ = 0.9644$ V

Determine the standard cell potential.
A) –1.7634 V
B) 0.1654 V
C) 2.0942 V
D) 3.5268 V

E) 0.5878 V

ANS: B PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | calculating cell emfs MSC: Quantitative

51. Which of the following would be the best oxidizing agent?
A) Cl_2
B) Fe
C) Na
D) Na^+
E) F^-

ANS: A PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | strength of oxidizing and reducing agents
MSC: Conceptual

52. Copper will spontaneously reduce which of the following?
A) Fe^{2+} and Ag^+
B) Fe^{2+}
C) Ag^+
D) Al^{3+}
E) Fe^{2+} and Al^{3+}

ANS: C PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | tabulating standard electrode potentials
MSC: Conceptual

53. Determine the standard potential, ε°, of a cell that employs the reaction:

$Fe + Cu^{2+} \rightarrow Cu + Fe^{2+}$.

Reaction	ε° **(volts)**
$Fe^{2+} + 2e^- \rightarrow Fe$	–0.441
$Cu^{2+} + 2e^- \rightarrow Cu$	+0.340

A) –0.101
B) –0.781
C) 0.101
D) 0.781
E) –0.202

ANS: D PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | calculating cell emfs MSC: Quantitative

54. Of Sn^{2+}, Ag^+, and/or Zn^{2+}, which could be reduced by Cu?
A) Sn^{2+}
B) Ag^+

C) Zn^{2+}
D) Two of them could be reduced by Cu.
E) All of them could be reduced by Cu.

ANS: B PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | tabulating standard electrode potentials
MSC: Conceptual

55. You wish to plate out zinc metal from a zinc nitrate solution. Which metal, Al or Ni, could you place in the solution to accomplish this?
A) Al
B) Ni
C) Both Al and Ni would work.
D) Neither Al nor Ni would work.
E) Cannot be determined.

ANS: A PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | tabulating standard electrode potentials
MSC: Conceptual

56. Which of the following is the best reducing agent?
A) Cl_2
B) H_2
C) Mg
D) Mg^{2+}
E) Cl^-

ANS: C PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | strength of oxidizing and reducing agents
MSC: Conceptual

57. What is the cell reaction for the voltaic cell $Cr(s) \mid Cr^{3+}(aq) \parallel Cl^-(aq) \mid Cl_2(g) \mid Pt$?
A) $Cr(s) + 2Cl^-(aq) \rightleftharpoons Cl_2(g) + Cr^{3+}(aq)$
B) $2Cr^{3+}(aq) + 6Cl^-(aq) \rightleftharpoons 2Cr(s) + 3Cl_2(g)$
C) $Cr(s) + 3Cl_2(g) \rightleftharpoons Cr^{3+}(s) + 2Cl^-(aq)$
D) $2Cr(s) + 3Cl_2(g) \rightleftharpoons 2Cr^{3+}(aq) + 6Cl^-(aq)$
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | cell notation
MSC: Conceptual

58. What is the balanced chemical equation corresponding to the following cell diagram?

$Na(s) \mid Na^+(aq) \parallel Cu^{2+}(aq) \mid Cu(s)$

A) $2Na(s) + 2Na^+(aq) \rightarrow Cu^{2+}(aq) + Cu(s)$
B) $Cu(s) + 2Na^+(aq) \rightarrow 2Na(s) + Cu^{2+}(aq)$

C) $2Na(s) + Cu(s) \rightarrow 2Na^+(aq) + Cu^{2+}(aq)$
D) $Cu^{2+}(aq) + Cu(s) \rightarrow 2Na(s) + 2Na^+(aq)$
E) $2Na(s) + Cu^{2+}(aq) \rightarrow 2Na^+(aq) + Cu(s)$

ANS: E PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | cell notation
MSC: Conceptual

59. Which of the following cell diagrams represents a galvanic cell? ($\varepsilon^\circ_{red}(Sn^{2+}/Sn) = -0.138V$, $\varepsilon^\circ_{red}(H^+/H_2) = 0.00$ V)
A) $Pt(s), H_2(g) \mid H^+(aq) \parallel Sn^{2+}(aq) \mid Sn(s)$
B) $Sn(s) \mid Sn^{2+}(aq) \parallel H^+(aq) \mid H_2(g), Pt(s)$
C) $Sn(s), H_2(g) \mid H^+(aq) \parallel Sn^{2+}(aq) \mid Pt(s)$
D) $Pt(s) \mid Sn^{2+}(aq) \parallel H^+(aq) \mid H_2(g), Sn(s)$
E) $Sn(s) \mid Pt(s) \parallel H^+(aq), Sn^{2+}(aq) \mid H_2(g)$

ANS: B PTS: 1 DIF: Moderate REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | cell notation
MSC: Conceptual

60. The following has a potential of 0.92 V:

$$2Hg^{2+}(aq) + H_2(g) \rightarrow 2H^+(aq) + Hg_2^{2+}(aq)$$

If the concentrations of the ions were 1.0 *M* and the pressure of H_2 were 1.0 atm, then ε° for the half-reaction $2Hg^{2+}(aq) + 2e^- \rightarrow Hg_2^{2+}(aq)$ would be

A) –0.92 V
B) –0.46 V
C) 0.46 V
D) 0.92 V
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials MSC: Conceptual

61. Consider the following electrode potentials:

$Mg^{2+} + 2e^- \rightarrow Mg$ $\quad \varepsilon^\circ = -2.37$ V
$V^{2+} + 2e^- \rightarrow V$ $\quad \varepsilon^\circ = -1.19$ V
$Cu^{2+} + e^- \rightarrow Cu^+$ $\quad \varepsilon^\circ = 0.16$ V

Which one of the reactions below will proceed spontaneously from left to right?
A) $Mg^{2+} + V \rightarrow V^{2+} + Mg$
B) $Mg^{2+} + 2Cu^+ \rightarrow 2Cu^{2+} + Mg$
C) $V^{2+} + 2Cu^+ \rightarrow V + 2Cu^{2+}$
D) $V + 2Cu^{2+} \rightarrow V^{2+} + 2Cu^+$
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs

and standard electrode potentials MSC: Conceptual

62. What is $\mathcal{E}^\circ_{cell}$ for the following electrochemical equation? ($\mathcal{E}^\circ_{red}(Li^+/Li) = -3.04$ V, $\mathcal{E}^\circ_{red}(Cu^{2+}/Cu) = 0.342$ V)

$2Li(s) + Cu^{2+}(aq) \rightarrow 2Li^+(aq) + Cu(s)$

A) –5.738 V
B) 6.422 V
C) 3.382 V
D) –3.382 V
E) –6.422 V

ANS: C PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | calculating cell emfs MSC: Quantitative

63. Which of the following cell reactions would require the use of an inert electrode?
A) $Co(s) + 2Ag^+(aq) \rightarrow Co^{2+}(aq) + 2Ag(s)$
B) $3Sr(s) + 2Au^{3+}(aq) \rightarrow 3Sr^{2+} + 2Au(s)$
C) $3Rb^+(aq) + Al(s) \rightarrow 3Rb(s) + Al^{3+}(aq)$
D) $Ba(s) + 2MnO_2(s) + 2NH_4^+(aq) \rightarrow Ba^{2+}(aq) + Mn_2O_3(s) + 2NH_3(aq) + H_2O(l)$
E) $Sr(s) + 2Ag^+(aq) \rightarrow 2Ag(s) + Sr^{2+}(aq)$

ANS: D PTS: 1 DIF: Moderate REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | construction of voltaic cells MSC: Conceptual

64. Given:

$2H^+(aq) + 2e^- \rightarrow H_2(g)$; 0.00 V
$K^+(aq) + e^- \rightarrow K(s)$; –2.93 V
$F_2(g) + 2e^- \rightarrow 2F^-(aq)$; 2.87 V
$Al^{3+}(aq) + 3e^- \rightarrow Al(s)$; –1.66 V
$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$; –0.13 V

Under standard-state conditions, which is the strongest reducing agent?
A) H^+
B) K
C) F^-
D) Al^{3+}
E) Pb^{2+}

ANS: B PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | strength of oxidizing and reducing agents
MSC: Conceptual

65. Which of the following statements is true concerning the electrochemical cell depicted below?

$Mg \mid Mg^{2+}(aq) \parallel Cu^{2+}(aq) \mid Cu$

$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$; $\varepsilon^\circ = -2.38$ V
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$; $\varepsilon^\circ = 0.34$ V

A) The cell reaction is spontaneous with a standard cell potential of 2.72 V.
B) The cell reaction is spontaneous with a standard cell potential of 2.04 V.
C) The cell reaction is nonspontaneous with a standard cell potential of –2.72 V.
D) The cell reaction is nonspontaneous with a standard cell potential of –2.04 V.
E) The cell is at equilibrium.

ANS: A PTS: 1 DIF: Moderate REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | calculating cell emfs MSC: Conceptual

66. Which of the following statements is true concerning the electrochemical cell depicted below?

Ca | $Ca^{2+}(aq)$ || $K^+(aq)$ | K
$Ca^{2+}(aq) + 2e^- \rightarrow Ca(s)$; $\varepsilon^\circ = -2.87$ V
$K^+(aq) + e^- \rightarrow K(s)$; $\varepsilon^\circ = -2.93$ V

A) The cell reaction is spontaneous with a standard cell potential of 0.06 V.
B) The cell reaction is nonspontaneous with a standard cell potential of –5.80 V.
C) The cell reaction is nonspontaneous with a standard cell potential of –0.06 V.
D) The cell reaction is spontaneous with a standard cell potential of 5.80 V.
E) The cell is at equilibrium.

ANS: C PTS: 1 DIF: Moderate REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | calculating cell emfs MSC: Conceptual

67. The reduction potentials for Au^{3+} and Ni^{2+} are as follows:

$Au^{3+} + 3e^- \rightarrow Au$, $\varepsilon^\circ = +1.50$ V
$Ni^{2+} + 2e^- \rightarrow Ni$, $\varepsilon^\circ = -0.229$ V

Calculate ΔG° (at 25°C) for the reaction:

$2Au^{3+} + 2Ni \rightarrow 3Ni^{2+} + 2Au$

A) 1.00×10^3 kJ
B) -7.36×10^2 kJ
C) 7.36×10^2 kJ
D) -1.67×10^2 kJ
E) -1.00×10^3 kJ

ANS: E PTS: 1 DIF: Moderate REF: 18.4
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells
MSC: Quantitative

68. Tables of standard reduction potentials are usually given at 25°C. ε° depends on temperature. Which of the following equations describes the temperature dependence of ε°?
A) $\varepsilon^\circ = \frac{nF}{RT} = \ln k$

B) $\varepsilon^\circ = \Delta H^\circ - T\Delta S^\circ$
C) $\varepsilon^\circ = \frac{\Delta H^\circ}{nF} + \frac{T\Delta S^\circ}{nF}$
D) $\ln \varepsilon^\circ = -\frac{\Delta H^\circ}{RT} + \frac{\Delta S^\circ}{R}$
E) none of these

ANS: C PTS: 1 DIF: Difficult REF: 18.4
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells
MSC: Conceptual

69. For a reaction in a voltaic cell both ΔH° and ΔS° are positive. Which of the following statements is true?
A) ε°_{cell} will increase with an increase in temperature.
B) ε°_{cell} will decrease with an increase in temperature.
C) ε°_{cell} will not change when the temperature increases.
D) $\Delta G^\circ > 0$ for all temperatures.
E) None of the above statements is true.

ANS: A PTS: 1 DIF: Moderate REF: 18.4
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells
MSC: Conceptual

70. For a certain reaction, $\Delta H^\circ = -74.4$ kJ and $\Delta S^\circ = -227$ J/K. If $n = 3$, calculate ε° for the reaction at 25°C.
A) 0.0233 V
B) 0.491 V
C) 0.277 V
D) 0.0700 V
E) 0.237 V

ANS: A PTS: 1 DIF: Moderate REF: 18.4
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells
MSC: Quantitative

71. The standard free energies of formation of several species are:

	kJ/mol
$H^+(aq)$	0
$H_2O(l)$	–237.0
$CH_3OH(aq)$	–163.0
$HCOOH(aq)$	–351.2
e^-	0

What is the standard reduction potential of methanoic acid in aqueous solution (i.e., for $HCOOH + 4H^+ + 4e^- \rightarrow CH_3OH + H_2O$)?

A) 0.126 V
B) 0.506 V
C) –0.718 V
D) –0.126 V
E) 1.946 V

ANS: A PTS: 1 DIF: Moderate REF: 18.4
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells
MSC: Quantitative

72. A fuel cell designed to react grain alcohol with oxygen has the following net reaction:

$C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

The maximum work one mole of alcohol can yield by this process is 1320 kJ. What is the theoretical maximum voltage this cell can achieve?
A) 0.760 V
B) 1.14 V
C) 2.01 V
D) 2.28 V
E) 13.7 V

ANS: B PTS: 1 DIF: Difficult REF: 18.4
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells
MSC: Quantitative

73. Consider the following reduction potentials:

$Cu^{2+} + 2e^- \rightarrow Cu$ $\varepsilon^\circ = 0.342$ V
$Pb^{2+} + 2e^- \rightarrow Pb$ $\varepsilon^\circ = -0.130$ V

For a galvanic cell employing the Cu, Cu^{2+} and Pb, Pb^{2+} couples, calculate the maximum amount of work that would accompany the reaction of one mole of lead under standard conditions.
A) –40.9 kJ
B) –45.5 kJ
C) –91.1 kJ
D) No work can be done. The system is at equilibrium.
E) None of these.

ANS: C PTS: 1 DIF: Moderate REF: 18.4
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells
MSC: Quantitative

74. Determine ΔG° for a cell that utilizes the following reaction:

$Cl_2(g) + 2Br^-(aq) \rightarrow 2Cl^-(aq) + Br_2(l)$

The standard reduction for the chlorine gas is 1.360 volts and the standard reduction for the bromine liquid is about 1.078 volts.
A) –470 kJ
B) –27.2 kJ
C) –235 kJ
D) –54.4 kJ
E) –23.9 kJ

ANS: D PTS: 1 DIF: Moderate REF: 18.4
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells
MSC: Quantitative

75. For a particular reaction in a galvanic (voltaic) cell $\Delta S°$ is negative. Which of the following statements is true?
A) ε will increase with an increase in temperature.
B) ε will decrease with an increase in temperature.
C) ε will not change when the temperature increases.
D) $\Delta G° > 0$ for all temperatures.
E) None of the above statements is true.

ANS: B PTS: 1 DIF: Difficult REF: 18.4
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells
MSC: Conceptual

76. Under standard conditions, which of the following operations results in a spontaneous chemical reaction taking place?
A) A piece of aluminum metal is placed in an aqueous solution of potassium nitrate.
B) Iodine crystals are added to an aqueous solution of sodium chloride.
C) A piece of silver metal is placed in an aqueous solutions of copper(II) nitrate.
D) Chlorine gas is bubbled through an aqueous solution of sodium bromide.
E) At least two of the above (A-D) result in a spontaneous chemical reaction.

ANS: D PTS: 1 DIF: Moderate REF: 18.4
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells
MSC: Conceptual

77. A common car battery consists of six identical cells, each of which carries out the reaction:

$Pb + PbO_2 + 2HSO_4^- + 2H^+ \rightarrow 2PbSO_4 + 2H_2O$

The value of ε° for such a cell is 2.039 V. Calculate $\Delta G°$ at 25 °C for the reaction.
A) –196.7 kJ
B) –98.37 kJ
C) –393.5 kJ
D) –786.9 kJ
E) –590.2 kJ

ANS: C PTS: 1 DIF: Moderate REF: 18.4
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells
MSC: Quantitative

78. What is $\Delta G°$ for the following electrochemical equation? ($\varepsilon^\circ_{red}(Ag^+/Ag) = 0.800$ V, $\varepsilon^\circ_{red}(Cd^{2+}/Cd) = -0.403$ V)

$2Ag(s) + Cd^{2+}(aq) \rightarrow 2Ag^+(aq) + Cd(s)$

A) –232 kJ/mol
B) 116 kJ/mol
C) 232 kJ/mol
D) 464 kJ/mol
E) –464 kJ/mol

ANS: C PTS: 1 DIF: Moderate REF: 18.4

KEY: Chemistry | general chemistry | electrochemistry | voltaic cells
MSC: Quantitative

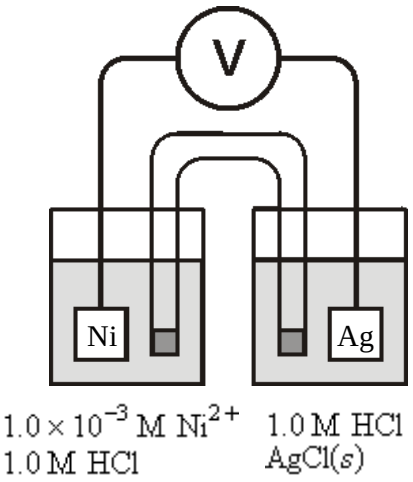
Consider an electrochemical cell with a zinc electrode immersed in 1.0 *M* Zn^{2+} and a nickel electrode immersed in 0.10 *M* Ni^{2+}.

$Zn^{2+} + 2e^- \rightarrow Zn$ $\quad \varepsilon^\circ = -0.76$ V
$Ni^{2+} + 2e^- \rightarrow Ni$ $\quad \varepsilon^\circ = -0.23$ V

79. Calculate the concentration of Ni^{2+} if the cell is allowed to run to equilibrium at 25°C.
A) 1.10 *M*
B) 0.20 *M*
C) 0.10 *M*
D) 0 *M*
E) none of these

ANS: E PTS: 1 DIF: Moderate REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration | Nernst equation MSC: Quantitative

80. Calculate ε at 25°C for the cell shown below, given the following data:



K_{sp} for AgCl = 1.6×10^{-10}

A) 0.83 V
B) 0.54 V
C) 1.01 V
D) 2.98 V
E) cannot be determined from the data given

ANS: B PTS: 1 DIF: Difficult REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | construction of voltaic cells | Nernst equation MSC: Quantitative

81. The following question refers to the following system:

$$3Ag(s) + NO_3^-(aq) + 4H^+(aq) \rightarrow 3Ag^+(aq) + NO(g) + 2H_2O(l)$$

Anode reaction: $Ag \rightarrow Ag^+(aq) + 1e^-$ $\varepsilon^\circ = -0.7990$ V
Cathode reaction: $NO_3^-(aq) + 4H^+(aq) + 3e^- \rightarrow NO(g) + 2H_2O(l)$ $\varepsilon^\circ = 0.9636$ V

Determine the equilibrium constant at 25°C.

A) 6.097×10^2
B) 2.965×10^{89}
C) 4.412×10^{-9}
D) 2.266×10^8
E) 3.117

ANS: D PTS: 1 DIF: Moderate REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | equilibrium constants from emfs MSC: Quantitative

82. A galvanic cell consists of a left compartment with a tin electrode in contact with 0.1 *M* $Sn(NO_3)_2(aq)$ and a right compartment with a lead electrode in contact with 1×10^{-3} *M* $Pb(NO_3)_2(aq)$. The relevant reduction potentials are:

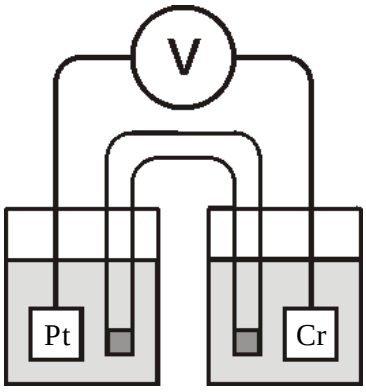
$Pb^{2+} + 2e^- \rightarrow Pb$ $\varepsilon^\circ = -0.13$ V
$Sn^{2+} + 2e^- \rightarrow Sn$ $\varepsilon^\circ = -0.14$ V

When this cell is allowed to discharge spontaneously at 25°C, which of the following statements is true?

A) Electrons will flow from left to right through the wire.
B) Pb^{2+} ions will be reduced to Pb metal.
C) The concentration of Sn^{2+} ions in the left compartment will increase.
D) The tin electrode will be the cathode.
E) No noticeable change will occur, because the cell is at equilibrium.

ANS: D PTS: 1 DIF: Moderate REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells
MSC: Conceptual

83. Consider the galvanic cell shown below (the contents of each half-cell are written beneath each compartment):



0.50 *M* Br_2 0.20 *M* Cr^{3+}
0.10 *M* Br^-

The standard reduction potentials are as follows:

$Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$ $\quad \varepsilon^\circ = -0.733$ V
$Br_2(aq) + 2e^- \rightarrow 2Br^-(aq)$ $\quad \varepsilon^\circ = +1.090$ V

What is the value of ε for this cell at 25°C?
A) 1.759 V
B) 1.823 V
C) 1.837 V
D) 1.887 V
E) 2.207 V

ANS: D PTS: 1 DIF: Moderate REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration | Nernst equation MSC: Quantitative

84. Consider an electrochemical cell with a zinc electrode immersed in a solution of Zn^{2+} and a silver electrode immersed in a solution of Ag^+.

$Zn^{2+} + 2e^- \rightarrow Zn$ $\quad \varepsilon^\circ = -0.76$ V
$Ag^+ + e^- \rightarrow Ag$ $\quad \varepsilon^\circ = 0.80$ V

If $\left[Zn^{2+}\right]_0$ is 0.050 *M* and $\left[Ag^+\right]_0$ is 11.26 *M*, calculate ε.
A) 1.46 V
B) 1.76 V
C) 1.36 V
D) 1.66 V
E) 1.63 V

ANS: D PTS: 1 DIF: Moderate REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration | Nernst equation MSC: Quantitative

85. Consider an electrochemical cell with a zinc electrode immersed in 1.0 *M* Zn^{2+} and a nickel electrode immersed in 0.39 *M* Ni^{2+}.

$Zn^{2+} + 2e^- \rightarrow Zn$ $\quad \varepsilon^\circ = -0.76$ V
$Ni^{2+} + 2e^- \rightarrow Ni$ $\quad \varepsilon^\circ = -0.23$ V

Calculate ε for this cell.
A) 0.54 V
B) 0.52 V
C) 0.51 V
D) 0.53 V
E) 0.98 V

ANS: B PTS: 1 DIF: Easy REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration | Nernst equation MSC: Quantitative

86. A cell is set up with copper and lead electrodes in contact with $CuSO_4(aq)$ and $Pb(NO_3)_2(aq)$, respectively, at 25°C. The standard reduction potentials are:

$Pb^{2+} + 2e^- \rightarrow Pb$ $\varepsilon^\circ = -0.13$ V
$Cu^{2+} + 2e^- \rightarrow Cu$ $\varepsilon^\circ = +0.34$ V

If sulfuric acid is added to the $Pb(NO_3)_2$ solution, forming a precipitate of $PbSO_4$, the cell potential:
A) increases
B) decreases
C) is unchanged
D) can't tell what will happen
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration | Nernst equation MSC: Conceptual

87. A concentration cell is constructed using two Ni electrodes with Ni^{2+} concentrations of 1.0 *M* and 1.00×10^{-4} *M* in the two half-cells. The reduction potential of Ni^{2+} is –0.23 V. Calculate the potential of the cell at 25°C.
A) –0.368 V
B) +0.132 V
C) –0.132 V
D) +0.118 V
E) +0.0592 V

ANS: D PTS: 1 DIF: Moderate REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration | Nernst equation MSC: Quantitative

88. The standard potential for the reaction $A + B \rightleftharpoons C + D$ is 1.50 volts. The equilibrium constant *K* for this reaction at 25°C is:
A) 2.5×10^{25}
B) 4.0×10^{-26}
C) 25.4
D) –25.4
E) not enough information given

ANS: E PTS: 1 DIF: Easy REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | equilibrium constants from emfs MSC: Quantitative

89. The reduction potentials for Ni^{2+} and Sn^{2+} are as follows:

$Ni^{2+} + 2e^- \rightarrow Ni$, $\varepsilon^\circ = -0.231$ V
$Sn^{2+} + 2e^- \rightarrow Sn$, $\varepsilon^\circ = -0.140$ V

Calculate the equilibrium constant at 25 °C for the reaction:

$Sn^{2+} + Ni \rightleftharpoons Sn + Ni^{2+}$

A) 3.6×10^{12}
B) 35
C) 5.9

D) 8.3×10^{-4}
E) 1.2×10^{3}

ANS: E PTS: 1 DIF: Moderate REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | equilibrium constants from emfs MSC: Quantitative

90. An excess of finely divided iron is stirred up with a solution that contains Cu^{2+} ion, and the system is allowed to come to equilibrium. The solid materials are then filtered off and electrodes of solid copper and solid iron are inserted into the remaining solution. What is the value of the ratio $[Fe^{2+}]/[Cu^{2+}]$ at 25°C?

The following standard reduction potentials apply:

$Fe^{2+}(aq) + 2e^{-} \rightarrow Fe(s)$ $\mathcal{E}^{\circ} = -0.44$ V
$Cu^{2+}(aq) + 2e^{-} \rightarrow Cu(s)$ $\mathcal{E}^{\circ} = +0.34$ V

A) 1
B) 0
C) 2.5×10^{26}
D) 4.4×10^{-27}
E) none of these

ANS: C PTS: 1 DIF: Difficult REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration | Nernst equation MSC: Conceptual

91. An excess of finely divided iron is stirred up with a solution that contains Cu^{2+} ion, and the system is allowed to come to equilibrium. The solid materials are then filtered off and electrodes of solid copper and solid iron are inserted into the remaining solution. What potential develops between these two electrodes at 25°C?
A) 0
B) –0.78 V
C) 0.592 V
D) 0.296 V
E) not enough information given

ANS: A PTS: 1 DIF: Difficult REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells
MSC: Conceptual

92. The equilibrium constant at 25°C for the reaction $Al + 3Cu^{2+} \rightleftharpoons 2Al^{3+} + 3Cu$ is approximately
A) 10^{203}
B) 10^{34}
C) 10^{68}
D) 10^{-203}
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | equilibrium

constants from emfs MSC: Quantitative

93. A concentration cell is constructed with copper electrodes and Cu^{2+} in each compartment. In one compartment, the $[Cu^{2+}] = 1.0 \times 10^{-3}$ *M* and in the other compartment, the $[Cu^{2+}] = 2.0$ *M*. Calculate the potential for this cell at 25°C. The standard reduction potential for Cu^{2+} is +0.34 V.
A) 0.44 V
B) –0.44 V
C) 0.098 V
D) –0.098 V
E) 0.78 V

ANS: C PTS: 1 DIF: Moderate REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration | Nernst equation MSC: Quantitative

94. Calculate the solubility product of silver iodide at 25°C given the following data:

	$\varepsilon°$(V)
$AgI(s) + e^- \rightarrow Ag(s) + I^-$	–0.15
$I_2(s) + 2e^- \rightarrow 2I^-$	+0.54
$Ag^+ + e^- \rightarrow Ag(s)$	+0.80

A) 2.9×10^{-3}
B) 1.9×10^{-4}
C) 2.1×10^{-12}
D) 8.4×10^{-17}
E) 6.1×10^{-26}

ANS: D PTS: 1 DIF: Difficult REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | equilibrium constants from emfs MSC: Quantitative

95. Using the following data to calculate K_{sp} for $PbSO_4$.

	$\varepsilon°$
$PbO_2 + 4H^+ + SO_4^{2-} + 2e^- \rightarrow PbSO_4(s) + 2H_2O$	+1.69
$PbO_2 + 4H^+ + 2e^- \rightarrow Pb^{2+} + 2H_2O$	+1.46

A) 4.0×10^{106}
B) 2.5×10^{-107}
C) 5.9×10^{7}
D) 1.7×10^{-8}
E) None of these is within 5% of the correct answer.

ANS: D PTS: 1 DIF: Moderate REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells
MSC: Quantitative

96. In which of the following cases must ε be equal to zero?

A) In any cell at equilibrium.
B) In a concentration cell.
C) ε can never be equal to zero.
D) Choices A and B are both correct.
E) None of these.

ANS: A PTS: 1 DIF: Easy REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | electromotive force
MSC: Conceptual

97. Which of the following statements is/are correct?
A) The value of ε° is equal to zero in a concentration cell, and the value of ε is equal to zero in any cell at equilibrium.
B) The value of ε° can be equal to zero in a concentration cell, and the value of ε must be equal to zero in a concentration cell.
C) The values of ε° and ε are equal to zero in any cell at equilibrium.
D) ε° can never be equal to zero.
E) At least two of the above choice (A-D) are correct.

ANS: A PTS: 1 DIF: Moderate REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells
MSC: Conceptual

98. Which of the following statements is true about a voltaic cell for which $\varepsilon^\circ_{\text{cell}} = 1.00$ V?
A) It has $\Delta G^\circ > 0$.
B) The system is at equilibrium.
C) It has $K = 1$.
D) The cathode is at a higher energy than the anode.
E) The reaction is spontaneous.

ANS: E PTS: 1 DIF: Easy REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells
MSC: Conceptual

99. If a reducing agent M reacts with an oxidizing agent N^+ to give M^+ and N, and the equilibrium constant for the reaction is 1.6, then what is the ε° value for the oxidation-reduction reaction?
A) 0.012 V
B) –0.012 V
C) 0.0060 V
D) –0.0060 V
E) 0.024 V

ANS: A PTS: 1 DIF: Moderate REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | equilibrium constants from emfs MSC: Quantitative

You make a cell with an aluminum electrode in a solution of aluminum nitrate and a zinc electrode in a solution of zinc nitrate.

100. If you could increase the concentration of Zn^{2+}, which of the following is true about the cell potential?
A) It would increase.
B) It would decrease.
C) It would remain constant.
D) Cannot be determined.
E) None of these (A-D).

ANS: A PTS: 1 DIF: Easy REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration MSC: Conceptual

101. If you could increase the concentration of Al^{3+}, which of the following is true about the cell potential?
A) It would increase.
B) It would decrease.
C) It would remain constant.
D) Cannot be determined.
E) None of these (A-D).

ANS: B PTS: 1 DIF: Easy REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration MSC: Conceptual

102. A concentration cell is constructed using two metal (M) electrodes with M^{2+} concentrations of 0.10 *M* and 1.00×10^{-5} *M* in the two half-cells. Determine the reduction potential of M^{2+} given that the potential of the cell at 25°C is 0.118 V.
A) 0 V
B) +0.118 V
C) –0.118 V
D) Cannot be determined with the information given.
E) None of the above.

ANS: D PTS: 1 DIF: Moderate REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration | Nernst equation MSC: Quantitative

103. What is ε of the following cell reaction at 25°C? $\varepsilon^{\circ}_{cell} = 0.460$ V.

$Cu(s) \mid Cu^{2+}(0.014\ M) \parallel Ag^{+}(0.20\ M) \mid Ag(s)$

A) 0.282 V
B) 0.491 V
C) 0.460 V
D) 0.473 V
E) 0.494 V

ANS: D PTS: 1 DIF: Easy REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration | Nernst equation MSC: Quantitative

104. For the cell $Cu(s) \mid Cu^{2+} \parallel Ag^{+} \mid Ag(s)$, the standard cell potential is 0.46 V. A cell using these reagents was made, and the observed potential was 0.16 V at 25°C. What is a possible explanation for the observed voltage?
A) The Ag^{+} concentration was larger than the Cu^{2+} concentration.
B) The Cu^{2+} concentration was larger than the Ag^{+} concentration.
C) The Ag electrode was twice as large as the Cu electrode.
D) The volume of the Cu^{2+} solution was larger than the volume of the Ag^{+} solution.
E) The volume of the Ag^{+} solution was larger than the volume of the Cu^{2+} solution.

ANS: B PTS: 1 DIF: Moderate REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration | Nernst equation MSC: Conceptual

105. What is the value of the reaction quotient, *Q*, for the voltaic cell constructed from the following two half-reactions when the Zn^{2+} concentration is 0.0103 *M* and the Ag^{+} concentration is 1.35 *M*?

$Zn^{2+}(aq) + 2e^{-} \rightarrow Zn(s)$; $\varepsilon^{\circ} = -0.76$ V
$Ag^{+}(aq) + e^{-} \rightarrow Ag(s)$; $\varepsilon^{\circ} = 0.80$ V

A) 177
B) 131
C) 1.25×10^{-2}
D) 7.63×10^{-3}
E) 5.65×10^{-3}

ANS: E PTS: 1 DIF: Moderate REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration MSC: Quantitative

106. In order to determine the identity of a particular lanthanide metal Sm, a voltaic cell is constructed at 25°C with the anode consisting of the lanthanide metal as the electrode immersed in a solution of 0.0819 *M* $SmCl_3$, and the cathode consisting of a copper electrode immersed in a 1.00 *M* $Cu(NO_3)_2$ solution. The two half-reactions are as follows:

$Sm(s) \rightarrow Sm^{3+}(aq) + 3e^{-}$
$Cu^{2+}(aq) + 2e^{-} \rightarrow Cu(s)$

The potential measured across the cell is 2.67 V. What is the identity of the metal?

Reduction Half-Reaction	ε° **(V)**
$Cu^{2+}(aq) + 2e^{-} \rightarrow Cu(s)$	0.34
$Ce^{3+}(aq) + 3e^{-} \rightarrow Ce(s)$	–2.336
$Dy^{3+}(aq) + 3e^{-} \rightarrow Dy(s)$	–2.295
$Eu^{3+}(aq) + 3e^{-} \rightarrow Eu(s)$	–1.991
$Gd^{3+}(aq) + 3e^{-} \rightarrow Gd(s)$	–2.279
$Sm^{3+}(aq) + 3e^{-} \rightarrow Sm(s)$	–2.304

A) Ce
B) Eu
C) Dy
D) Sm

E) Gd

ANS: D PTS: 1 DIF: Difficult REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration | Nernst equation MSC: Quantitative

107. Which of the following statements is true concerning the electrochemical cell described below at 25°C?

$Cu \mid Cu^{2+}(0.816\ M) \parallel Cu^{2+}(0.843]\ M) \mid Cu$
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s);\ \varepsilon^\circ = 0.34$ V

A) The cell reaction is spontaneous with a cell potential of 4.81 mV.
B) The cell reaction is spontaneous with a cell potential of 0.418 mV.
C) The cell reaction is nonspontaneous with a cell potential of –0.418 mV.
D) The cell reaction is nonspontaneous with a cell potential of –4.81 mV.
E) The cell reaction is spontaneous with a cell potential of 0.340 V.

ANS: B PTS: 1 DIF: Difficult REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration | Nernst equation MSC: Quantitative

108. What is the potential at 25°C for the following cell?

$Cr \mid Cr^{3+}(0.015\ M) \parallel Ag^+(0.00025\ M) \mid Ag$

$Cr^{3+} + 3e^- \rightleftharpoons Cr \qquad \varepsilon^\circ = -0.73$ V
$Ag^+ + e^- \rightleftharpoons Ag \qquad \varepsilon^\circ = 0.80$ V

A) 2.09 V
B) 1.35 V
C) 0.95 V
D) 1.71 V
E) 1.49 V

ANS: B PTS: 1 DIF: Moderate REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration | Nernst equation MSC: Quantitative

109. Concentration cells work because standard reduction potentials are dependent on concentration.

ANS: F PTS: 1 DIF: Easy REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration MSC: Conceptual

110. Consider the hydrogen–oxygen fuel cell where:

$H_2(g) + O_2(g) \rightleftharpoons H_2O(l) \qquad \Delta G^\circ = -237.18$ kJ/mol H_2

Which of the following statements is true?
A) At standard conditions, the maximum work the fuel cell could do on the surroundings is 237.18 kJ/mol.

B) In the real world, the actual amount of useful work the cell can do is less than 237.18 kJ.
C) More energy is dissipated as waste heat in the fuel cell than in the reversible pathway.
D) A, B, and C are all true.
E) A, B, and C are all false.

ANS: D PTS: 1 DIF: Easy REF: 18.6
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells
MSC: Conceptual

111. Which type of battery has been designed for use in space vehicles?
A) lead storage
B) alkaline dry cell
C) mercury cells
D) fuel cells
E) silver cells

ANS: D PTS: 1 DIF: Easy REF: 18.6
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells
MSC: Conceptual

112. Which of the following statements about batteries is false?
A) A battery is a group of galvanic cells connected in series.
B) Lead storage batteries contain lead at the anode and lead coated with lead dioxide at the cathode.
C) The alkaline dry cell battery can last longer than a nickel-cadmium battery.
D) A fuel cell is a galvanic cell for which the reactants are continuously supplied.
E) Dry cell batteries are used in tape players and portable radios.

ANS: C PTS: 1 DIF: Easy REF: 18.6
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells
MSC: Conceptual

113. Which of the following statements about corrosion is false?
A) Patina is the layer of tarnish that gives silver a richer appearance.
B) The oxidation of most metals by oxygen is spontaneous.
C) Most metals will develop a thin oxide coating, which protects their internal atoms from oxidation.
D) A car exposed to the elements will rust faster in the Midwest than in Arizona.
E) All of these are true.

ANS: A PTS: 1 DIF: Easy REF: 18.7
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | corrosion
MSC: Conceptual

114. Which of the following statements is false?
A) Stainless steel contains chromium and nickel, which form protective oxide coatings.
B) Galvanized steel is coated with zinc to form an oxide coating.
C) Cathodic protection is a method used to protect steel in buried tanks and pipelines.

D) Chromium and tin are often used to plate steel by forming a durable oxide coating.
E) All of these are true.

ANS: B PTS: 1 DIF: Easy REF: 18.7
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | corrosion
MSC: Conceptual

115. How many faradays are involved in conversion of a mole of Fe_2O_3 to FeO_2?

A) 1
B) 2
C) 3
D) 4
E) 5

ANS: A PTS: 1 DIF: Easy REF: 18.8
KEY: Chemistry | general chemistry | electrochemistry | electrolytic cells | stoichiometry of electrolysis MSC: Conceptual

116. How many moles of electrons are produced from a current of 14.4 A in 3.20 hours?

A) 4.78×10^{-4} mol
B) 1.72 mol
C) 46.1 mol
D) 3.35 mol
E) 9.33×10^{3} mol

ANS: B PTS: 1 DIF: Easy REF: 18.8
KEY: Chemistry | general chemistry | electrochemistry | electrolytic cells | stoichiometry of electrolysis MSC: Quantitative

117. A common car battery consists of six identical cells each of which carries out the reaction:

$$Pb + PbO_2 + 2HSO_4^- + 2H^+ \rightarrow 2PbSO_4 + 2H_2O$$

Suppose that in starting a car on a cold morning a current of 125 amperes is drawn for 18.4 seconds from a cell of the type described above. How many grams of Pb would be consumed? (The atomic weight of Pb is 207.19.)

A) 4.94 g
B) 2.47 g
C) 7.29×10^{-3} g
D) 1.58×10^{-4} g
E) 1.19×10^{-2} g

ANS: B PTS: 1 DIF: Moderate REF: 18.8
KEY: Chemistry | general chemistry | electrochemistry | electrolytic cells | stoichiometry of electrolysis MSC: Quantitative

An antique automobile bumper is to be chrome plated. The bumper, which is dipped into an acidic $Cr_2O_7^{2-}$ solution, serves as a cathode of an electrolytic cell. The atomic mass of Cr is 51.996; 1 faraday = 96,485 coulombs.

118. If oxidation of H_2O occurs at the anode, how many moles of oxygen gas will evolve for every 151 grams of Cr(*s*) deposited?
A) 4.36
B) 0.726
C) 17.4
D) 11.6
E) 3.87

ANS: A PTS: 1 DIF: Difficult REF: 18.8
KEY: Chemistry | general chemistry | electrochemistry | electrolytic cells | stoichiometry of electrolysis MSC: Quantitative

119. If the current is 10.0 amperes, how long will it take to deposit 105 grams of Cr(*s*) onto the bumper?
A) 5.41 h
B) 1.35 days
C) 54.1 min
D) 2.02 min
E) 2 mo, 25 days, 14 h, and 6 s

ANS: B PTS: 1 DIF: Easy REF: 18.8
KEY: Chemistry | general chemistry | electrochemistry | electrolytic cells | stoichiometry of electrolysis MSC: Quantitative

120. Copper is electroplated from $CuSO_4$ solution. A constant current of 3.19 amp is applied by an external power supply. How long will it take to deposit 1.00×10^2 g of Cu? The atomic mass of copper is 63.546.
A) 26.4 h
B) 13.2 min
C) 2.03 days
D) 9.57 s
E) 3.78 h

ANS: A PTS: 1 DIF: Easy REF: 18.8
KEY: Chemistry | general chemistry | electrochemistry | electrolytic cells | stoichiometry of electrolysis MSC: Quantitative

121. What quantity of charge is required to reduce 27.8 g of $CrCl_3$ to chromium metal?
(1 faraday = 96,485 coulombs)
A) 1.69×10^4 C
B) 5.08×10^4 C
C) 8.05×10^2 C
D) 2.68×10^2 C
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 18.8
KEY: Chemistry | general chemistry | electrochemistry | electrolytic cells | stoichiometry of electrolysis MSC: Quantitative

122. Electrolysis of a molten salt with the formula MCl, using a current of 3.86 amp for 16.2 min, deposits 1.52 g of metal. Identify the metal. (1 faraday = 96,485 coulombs)
A) Li
B) Na
C) K
D) Rb
E) Ca

ANS: C PTS: 1 DIF: Moderate REF: 18.8
KEY: Chemistry | general chemistry | electrochemistry | electrolytic cells | electrolysis of molten salts MSC: Quantitative

123. If a constant current of 5.0 amperes is passed through a cell containing Cr^{3+} for 1.0 hour, how many grams of Cr will plate out onto the cathode? (The atomic mass of Cr is 51.996.)
A) 9.7 g
B) 9.0×10^{-4} g
C) 3.2 g
D) 29 g
E) 6.2×10^{-2} g

ANS: C PTS: 1 DIF: Easy REF: 18.8
KEY: Chemistry | general chemistry | electrochemistry | electrolytic cells | stoichiometry of electrolysis MSC: Quantitative

124. If an electrolysis plant operates its electrolytic cells at a total current of 1.8×10^6 amp, how long will it take to produce one metric ton (one million grams) of Mg(*s*) from seawater containing Mg^{2+}? (1 faraday = 96,485 coulombs)
A) 1.2 h
B) 1.2 days
C) 37 min
D) 0.61 h
E) 0.31 year

ANS: A PTS: 1 DIF: Easy REF: 18.8
KEY: Chemistry | general chemistry | electrochemistry | electrolytic cells | stoichiometry of electrolysis MSC: Quantitative

125. Nickel is electroplated from a $NiSO_4$ solution. A constant current of 5.50 amp is applied by an external power supply. How long will it take to deposit 100. g of Ni? The atomic mass of Ni is 58.69.
A) 16.6 h
B) 8.30 h
C) 18.2 min
D) 55.4 s
E) 1.09 s

ANS: A PTS: 1 DIF: Easy REF: 18.8
KEY: Chemistry | general chemistry | electrochemistry | electrolytic cells | stoichiometry of electrolysis MSC: Quantitative

126. A solution of MnO_4^{2-} is electrolytically reduced to Mn^{3+}. A current of 8.07 amp is passed through the solution for 15.0 minutes. What is the number of moles of Mn^{3+} produced in this process? (1 faraday = 96,485 coulombs)
A) 0.0753
B) 0.226
C) 4.18×10^{-4}
D) 0.0251
E) 1.67×10^{-3}

ANS: D PTS: 1 DIF: Easy REF: 18.8
KEY: Chemistry | general chemistry | electrochemistry | electrolytic cells | stoichiometry of electrolysis MSC: Quantitative

127. How many seconds would it take to deposit 18.2 g of Ag (atomic mass = 107.87) from a solution of $AgNO_3$ using a current of 10.00 amp?
A) 3.26×10^3 s
B) 8.14×10^2 s
C) 4.88×10^3 s
D) 1.63×10^3 s
E) 5.43×10^2 s

ANS: D PTS: 1 DIF: Easy REF: 18.8
KEY: Chemistry | general chemistry | electrochemistry | electrolytic cells | stoichiometry of electrolysis MSC: Quantitative

128. Gold (atomic mass = 197.0) is plated from a solution of chloroauric acid, $HAuCl_4$; it deposits on the cathode. Calculate the time it takes to deposit 0.30 gram of gold, passing a current of 0.10 amperes. (1 faraday = 96,485 coulombs)
A) 12 hours
B) 1.2 hours
C) 24 minutes
D) 8.2 minutes
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 18.8
KEY: Chemistry | general chemistry | electrochemistry | electrolytic cells | stoichiometry of electrolysis MSC: Quantitative

129. An unknown metal (M) is electrolyzed. It took 74.1 s for a current of 2.00 amp to plate 0.107 g of the metal from a solution containing $M(NO_3)_3$. Identify the metal.
A) La
B) Bi
C) Ga
D) Cu
E) Rh

ANS: B PTS: 1 DIF: Moderate REF: 18.8
KEY: Chemistry | general chemistry | electrochemistry | electrolytic cells | stoichiometry of electrolysis MSC: Quantitative

130. Gold is produced electrochemically from an aqueous solution of $Au(CN)_2^-$ containing an excess of CN^-. Gold metal and oxygen gas are produced at the electrodes. How many moles of O_2 will be produced during the production of 1.00 mole of gold?
A) 0.25
B) 0.50
C) 1.00
D) 3.56
E) 4.00

ANS: A PTS: 1 DIF: Difficult REF: 18.8
KEY: Chemistry | general chemistry | electrochemistry | electrolytic cells | aqueous electrolysis MSC: Conceptual

131. What mass of Ti(*s*) may be deposited from an aqueous $TiCl_2$ solution if a current of 2.50 A is applied to the solution for 365 s? ($\mathcal{E}^\circ_{red}(Ti^{2+}/Ti) = -1.63$ V, $F = 96485$ *C*/mol)
A) 0.453 g
B) 0.906 g
C) 0.369 g
D) 0.226 g
E) 0.139 g

ANS: D PTS: 1 DIF: Moderate REF: 18.8
KEY: Chemistry | general chemistry | electrochemistry | electrolytic cells | stoichiometry of electrolysis MSC: Quantitative

132. What mass of chromium could be deposited by electrolysis of an aqueous solution of $Cr_2(SO_4)_3$ for 145 minutes using a constant current of 11.0 amperes?
A) 0.187 g
B) 154.7 g
C) 0.287 g
D) 25.8 g
E) 17.2 g

ANS: E PTS: 1 DIF: Moderate REF: 18.8
KEY: Chemistry | general chemistry | electrochemistry | electrolytic cells | stoichiometry of electrolysis MSC: Quantitative

133. Which of the following are incorrectly paired?
A) Alumina – pure aluminum oxide
B) Downs cell – electrolyzes molten sodium chloride
C) Mercury cell – used in preventing contamination of NaOH by NaCl
D) Hall-Heroult process – uses cryolite in production of aluminum
E) All of these are correct.

ANS: E PTS: 1 DIF: Easy REF: 18.9
KEY: Chemistry | general chemistry | electrochemistry | electrolytic cells | commercial electrolytic processes MSC: Conceptual

134. Which of the following used to be more precious than gold or silver, due to difficulties refining it?
A) copper

B) aluminum
C) tin
D) zinc
E) iron

ANS: B PTS: 1 DIF: Easy REF: 18.9
KEY: Chemistry | general chemistry | electrochemistry | electrolytic cells | commercial electrolytic processes MSC: Conceptual

135. What are the products of the chlor-alkali process?
A) sodium and sodium chloride
B) sodium chloride and chlorine
C) sodium and chlorine
D) sodium hydroxide and chlorine
E) aluminum and cryolite

ANS: D PTS: 1 DIF: Easy REF: 18.9
KEY: Chemistry | general chemistry | electrochemistry | electrolytic cells | commercial electrolytic processes MSC: Conceptual

136. Balance the following equation: $Cr_2O_7^{2-} + I^- \rightarrow Cr^{3+} + IO_3^-$ (acid)

ANS:
$8H^+ + Cr_2O_7^{2-} + I^- \rightarrow 2Cr^{3+} + IO_3^- + 4H_2O$

Balanced half-reactions:
$6e^- + 14H^+ + Cr_2O_7^{2-} \rightarrow 2Cr^{3+} + 7H_2O$
$3H_2O + I^- \rightarrow IO_3^- + 6H^+ + 6e^-$

PTS: 1 DIF: Moderate REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions | half-reaction method MSC: Conceptual

137. Balance the following equation: $Zn + As_2O_3 \rightarrow AsH_3 + Zn^{2+}$ (acid)

ANS:
$12H^+ + 6Zn + As_2O_3 \rightarrow 2AsH_3 + 6Zn^{2+} + 3H_2O$

Balanced half-reactions:
$Zn \rightarrow Zn^{2+} + 2e^-$
$12e^- + 12H^+ + As_2O_3 \rightarrow 2AsH_3 + 3H_2O$

PTS: 1 DIF: Moderate REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions | half-reaction method MSC: Conceptual

138. Balance the following equation: $MnO_4^- + Br^- \rightarrow MnO_2 + BrO_3^-$ (base)

ANS:

$H_2O + 2MnO_4^- + Br^- \rightarrow 2MnO_2 + BrO_3^- + 2OH^-$

Balanced half-reactions:
$3e^- + 4H^+ + MnO_4^- \rightarrow MnO_2 + 2H_2O$
$3H_2O + Br^- \rightarrow BrO_3^- + 6H^+ + 6e^-$
Combine to give (in acid):
$2H^+ + 2MnO_4^- + Br^- \rightarrow BrO_3^- + 2MnO_2 + H_2O$

PTS: 1 DIF: Moderate REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions | half-reaction method MSC: Conceptual

139. Balance the following equation: $Bi(OH)_3 + SnO_2^{2-} \rightarrow Bi + SnO_3^{2-}$ (base)

ANS:
$2Bi(OH)_3 + 3SnO_2^{2-} \rightarrow 2Bi + 3SnO_3^{2-} + 3H_2O$

Balanced half-reactions:
$3e^- + 3H^+ + Bi(OH)_3 \rightarrow Bi + 3H_2O$
$H_2O + SnO_2^{2-} \rightarrow SnO_3^{2-} + 2H^+ + 2e^-$

PTS: 1 DIF: Moderate REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions | half-reaction method MSC: Conceptual

140. Consider a galvanic cell with a zinc electrode immersed in 1.0 *M* Zn^{2+} and a silver electrode immersed in 1.0 *M* Ag^+.

$Zn^{2+} + 2e^- \rightarrow Zn$ $\varepsilon^\circ = -0.76$ V
$Ag^+ + e^- \rightarrow Ag$ $\varepsilon^\circ = 0.80$ V

Which of the electrodes is the anode?

ANS:
The zinc electrode.

To give a positive cell potential, the overall reaction will be: $Zn + 2Ag^+ \rightarrow 2Ag + Zn^{2+}$.
Oxidation occurs at the anode, and zinc is being oxidized.
See Sec. 18.3 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | construction of voltaic cells MSC: Conceptual

141. Balance the following redox equation in acidic solution. What is the coefficient of the water? $CH_3OH(aq) + Cr_2O_7^{2-}(aq) \rightarrow CH_2O(aq) + Cr^{3+}(aq)$
A) 1
B) 2
C) 4

D) 6
E) 7

ANS: E PTS: 1 DIF: Moderate REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions MSC: Conceptual

142. Balance the following redox equation in acidic solution. What is the coefficient of the H^+ ion? $CH_3OH(aq) + Cr_2O_7^{2-}(aq) \rightarrow CH_2O(aq) + Cr^{3+}(aq)$
A) 1
B) 2
C) 3
D) 4
E) 8

ANS: E PTS: 1 DIF: Moderate REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions MSC: Conceptual

143. Balance the following redox equation in acidic solution. What is the coefficient of the water? $MnO_4^-(aq) + H_2O_2(aq) \rightarrow Mn^{2+}(aq) + O_2(g)$
A) 2
B) 4
C) 6
D) 8
E) 16

ANS: D PTS: 1 DIF: Moderate REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions MSC: Conceptual

144. Balance the following redox equation in acidic solution. What is the coefficient of the H^+ ion? $MnO_4^-(aq) + H_2O_2(aq) \rightarrow Mn^{2+}(aq) + O_2(g)$
A) 2
B) 4
C) 6
D) 8
E) 16

ANS: C PTS: 1 DIF: Moderate REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions MSC: Conceptual

145. Balance the following redox equation in basic solution. What is the coefficient of the water? $NO_2^-(aq) + Al(s) \rightarrow NH_3(g) + AlO_2^-(aq)$
A) 1
B) 2
C) 4
D) 6
E) 7

ANS: A PTS: 1 DIF: Moderate REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions MSC: Conceptual

146. Balance the following redox equation in basic solution. What is the coefficient of the hydroxide ion? $NO_2^-(aq) + Al(s) \rightarrow NH_3(g) + AlO_2^-(aq)$
A) 1
B) 2
C) 4
D) 6
E) 7

ANS: A PTS: 1 DIF: Moderate REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions MSC: Conceptual

147. Balance the following redox equation in basic solution. What is the coefficient of the water? $MnO_4^-(aq) + HCOOH(aq) \rightarrow Mn^{2+}(aq) + CO_2(g)$
A) 2
B) 4
C) 6
D) 8
E) 16

ANS: A PTS: 1 DIF: Moderate REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions MSC: Conceptual

148. Balance the following redox equation in basic solution. What is the coefficient of the hydroxide ion? $MnO_4^-(aq) + HCOOH(aq) \rightarrow Mn^{2+}(aq) + CO_2(g)$
A) 2
B) 4
C) 6
D) 8
E) 16

ANS: C PTS: 1 DIF: Moderate REF: 18.1
KEY: Chemistry | general chemistry | electrochemistry | half-reaction | balancing oxidation-reduction reactions MSC: Conceptual

149. The reduction potential to the metal of Ba^{2+} is -1.57 V. Given that the cell potential for the reaction $3\ Ba(s) + 2\ La^{3+}(aq) \rightarrow 3\ Ba^{2+}(aq) + 2\ La(s)$ is 0.52 V, the reduction potential for $La^{3+}(aq)$ is:
A) (0.52 – (3 x -1.57)) / 2
B) (0.52) – (-1.57)
C) (+1.57) + (0.52)
D) 0.52 – (+1.57)
E) (-1.57) - (0.52)

ANS: D PTS: 1 DIF: Easy REF: 18.3

KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | calculating cell emfs MSC: Quantitative

150. A voltaic cell consists of a Cu^{2+}/Cu electrode ($\mathcal{E}^{\circ}_{red}$ = 0.34 V) and an Au^{3+}/Au electrode ($\mathcal{E}^{\circ}_{red}$ = 1.50 V). Calculate $[Au^{3+}]$ if $[Cu^{2+}]$ = 1.20 M and $\mathcal{E}_{cell}$ = 1.13 V
A) 0.001 M
B) 0.002 M
C) 0.04 M
D) 0.2 M
E) 5.0 M

ANS: C PTS: 1 DIF: Moderate REF: 18.5
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | dependence of emf on concentration | Nernst equation MSC: Quantitative

151. The reduction potential to the metal of Ba^{2+} is -1.57 V and that of Cu^{2+} is +0.34 V. The cell potential for the reaction $Ba(s) + Cu^{2+}(aq) \rightarrow Ba^{2+}(aq) + Cu(s)$ is therefore:
A) (-1.57) + (0.34)
B) 2 x (-1.57) + 2 x (0.34)
C) (+1.57) + (-0.34)
D) (-1.57) + (+0.34)
E) (+1.57) + (+0.34)

ANS: E PTS: 1 DIF: Easy REF: 18.3
KEY: Chemistry | general chemistry | electrochemistry | voltaic cells | standard cell emfs and standard electrode potentials | calculating cell emfs MSC: Quantitative

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1. Identify the missing particle in the following equation:

$$^{238}_{92}\text{U} \rightarrow {}^{4}_{2}\text{He} + ?$$

A) $^{242}_{94}$Pu
B) $^{234}_{90}$Th
C) $^{242}_{90}$Th
D) $^{234}_{92}$U
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactivity | nuclear equation MSC: Conceptual

2. The ratio of the atomic radius to the nuclear radius is approximately:
A) 10^{-5}
B) 10^{5}
C) 10^{2}
D) 10^{15}
E) 10^{-15}

ANS: B PTS: 1 DIF: Easy REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry MSC: Conceptual

3. An unstable isotope of rhenium, ^{191}Re, has a half-life of 9.8 minutes and is a beta producer. What is the other product of the reaction?
A) ^{191}Os
B) ^{191}W
C) ^{192}Pt
D) ^{190}W
E) ^{190}Os

ANS: A PTS: 1 DIF: Easy REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactivity | nuclear equation MSC: Conceptual

4. The nuclide $^{232}_{92}$Th is radioactive. When one of these atoms decays, a series of α and β-particle emissions occurs, taking the atom through many transformations to end up as an atom of $^{208}_{82}$Pb. How many α particles are emitted in converting $^{232}_{92}$Th into $^{208}_{82}$Pb?
A) 6
B) 8
C) 2
D) 214
E) 4

ANS: A PTS: 1 DIF: Moderate REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear

bombardment reactions | radioactive decay series MSC: Conceptual

5. It is desired to determine the concentration of arsenic in a lake sediment sample by means of neutron activation analysis. The nuclide $^{75}_{33}As$ captures a neutron to form $^{76}_{33}As$, which in turn undergoes β decay. The daughter nuclide produces the characteristic γ rays used for the analysis. What is the daughter nuclide?
   A) $^{75}_{34}Se$
   B) $^{76}_{32}Ge$
   C) $^{74}_{31}Ga$
   D) $^{76}_{34}Se$
   E) $^{74}_{34}Se$

   ANS: D PTS: 1 DIF: Moderate REF: 19.1
   KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactive decay | beta emission MSC: Conceptual

6. Which of the following is a product of α decay of $^{238}_{92}U$?
   A) $^{234}_{90}Th$
   B) $^{238}_{93}Np$
   C) $^{238}_{91}Pa$
   D) $^{235}_{92}U$
   E) $^{235}_{92}Pu$

   ANS: A PTS: 1 DIF: Moderate REF: 19.1
   KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactive decay | alpha emission MSC: Conceptual

7. Electron capture transforms $^{40}_{19}K$ into what nuclide?
   A) $^{40}_{20}Ca$
   B) $^{40}_{18}Ar$
   C) $^{4}_{2}He$
   D) $^{40}_{19}K^{-}$
   E) $^{39}_{20}Ca$

   ANS: B PTS: 1 DIF: Moderate REF: 19.1
   KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactive decay | electron capture MSC: Conceptual

8. Which of the following processes decreases the atomic number by one?
   A) gamma-ray production
   B) electron capture
   C) beta-particle production
   D) positron production
   E) at least two of the above processes

ANS: E PTS: 1 DIF: Moderate REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactive decay MSC: Conceptual

9. If $^{214}_{82}$Pb undergoes a beta decay and the product of this decay undergoes another beta decay, which nuclide is produced?
A) $^{212}_{82}$Bi
B) $^{214}_{82}$Pb
C) $^{214}_{84}$Po
D) $^{212}_{83}$Bi
E) $^{206}_{82}$Pb

ANS: C PTS: 1 DIF: Moderate REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactivity | beta emission MSC: Conceptual

10. Electron capture transforms $^{7}_{4}$Be into what nuclide?
A) $^{6}_{3}$Li
B) $^{7}_{5}$B
C) $^{7}_{3}$Li
D) $^{6}_{5}$B
E) $^{12}_{6}$C

ANS: C PTS: 1 DIF: Moderate REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactive decay | electron capture MSC: Conceptual

11. A radioactive isotope of vanadium, $^{53}_{23}$V, decays by producing a β particle and gamma ray. The nuclide formed has the atomic number:
A) 22
B) 21
C) 23
D) 24
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactive decay | beta emission MSC: Conceptual

12. The nuclide $^{208}_{81}$Tl is the daughter nuclide resulting from the α decay of what parent nuclide?
A) $^{210}_{82}$Pb
B) $^{204}_{79}$Au
C) $^{297}_{80}$Hg

D) $^{212}_{83}\text{Bi}$

E) $^{4}_{2}\text{He}$

ANS: D PTS: 1 DIF: Moderate REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactive decay | alpha emission MSC: Conceptual

13. The nuclide $^{12}_{7}\text{N}$ is unstable. What type of radioactive decay would be expected?

A) $^{0}_{-1}\text{e}$

B) $^{0}_{1}\text{e}$

C) σ

D) α

E) $^{4}_{2}\text{n}$

ANS: B PTS: 1 DIF: Easy REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactivity | nuclear stability MSC: Conceptual

14. Nuclides with too many neutrons to be in the band of stability are most likely to decay by what mode?

A) alpha emission
B) fission
C) positron production
D) electron capture
E) beta emission

ANS: E PTS: 1 DIF: Easy REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactivity | nuclear stability MSC: Conceptual

15. The most likely decay mode (or modes) of the unstable nuclide $^{11}_{6}\text{C}$ would be:

A) positron production
B) α-particle production
C) electron capture
D) β-particle production
E) either positron production or electron capture, or both.

ANS: E PTS: 1 DIF: Easy REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactivity | nuclear stability MSC: Conceptual

16. When $^{238}_{93}\text{Np}$ undergoes β^- emission, the products are:

A) $^{238}_{92}\text{U} + e^-$

B) $^{238}_{94}\text{Pu} + e^-$

C) $^{238}_{92}\text{U} + e^-$

D) $^{238}_{91}\text{Pa} + \text{He}$

E) $^{238}_{94}\text{Np} + e^-$

ANS: B PTS: 1 DIF: Moderate REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactive decay | beta emission MSC: Conceptual

17. Which reaction will produce an isotope of the parent nuclide?
A) $^{210}_{84}\text{Po} \rightarrow \text{He} + ?$
B) $^{88}_{35}\text{Br} \rightarrow \text{n} + ?$
C) $^{227}_{89}\text{Ac} \rightarrow e^- + ?$
D) $^{13}_{7}\text{N} \rightarrow e^- + ?$
E) $^{73}_{33}\text{As} + e^- \rightarrow ?$

ANS: B PTS: 1 DIF: Moderate REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactive decay MSC: Conceptual

The Fe-56 nucleus is known to be stable. Answer the following questions.

18. What is the most likely decay for the Fe-53 nucleus?
A) β decay
B) positron emission
C) α decay
D) γ-ray emission
E) two of these

ANS: E PTS: 1 DIF: Easy REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactivity | nuclear stability MSC: Conceptual

19. What is the most likely decay for the Fe-59 nucleus?
A) β decay
B) positron emission
C) α decay
D) γ-ray emission
E) two of these

ANS: A PTS: 1 DIF: Easy REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactivity | nuclear stability MSC: Conceptual

The U-238 nucleus decays to form Pb-206 by α and β decays.

20. Calculate the number of α decays.
A) 2
B) 4
C) 6
D) 8

E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactive decay series MSC: Conceptual

21. Calculate the number of β decays.
A) 2
B) 4
C) 6
D) 8
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactive decay series MSC: Conceptual

22. Which types of processes are likely when the neutron-to-proton ratio in a nucleus is too low?
I. α decay
II. β decay
III. positron production
IV. electron capture

A) I, II
B) II, III
C) III, IV
D) II, III, IV
E) II, IV

ANS: C PTS: 1 DIF: Easy REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactivity | nuclear stability MSC: Conceptual

23. The so-called "magic numbers" of protons and neutrons produce special chemical stability.

ANS: F PTS: 1 DIF: Easy REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactivity | nuclear stability MSC: Conceptual

24. As atomic mass increases, the proton/neutron ratio of stable nuclides decreases.

ANS: T PTS: 1 DIF: Easy REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactivity | nuclear stability MSC: Conceptual

25. The rate constant for the beta decay of thorium-234 is 2.882×10^{-2} / day. What is the half-life of this nuclide?
A) 48.09 days
B) 1.218 days

C) 0.693 days
D) 24.05 days
E) 96.18 days

ANS: D PTS: 1 DIF: Easy REF: 19.2
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay | half-life MSC: Quantitative

26. Consider a certain type of nucleus that has a rate constant of 2.95×10^{-2} min^{-1}. Calculate the time required for the sample to decay to one-fourth of its initial value.
A) 2.95 min
B) 0.0590 min
C) 23.5 min
D) 29.4 min
E) 47.0 min

ANS: E PTS: 1 DIF: Moderate REF: 19.2
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay MSC: Quantitative

27. Consider a certain type of nucleus that has a half-life of 32 min. Calculate the percent of original sample of nuclides remaining after 2.5 hours have passed.
A) 96%
B) 40%
C) 6.9%
D) 3.9%
E) 3.2%

ANS: D PTS: 1 DIF: Moderate REF: 19.2
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay MSC: Quantitative

28. Consider a certain type of nucleus that has a half-life of 32 min. Calculate the time required for 52% of the nuclides to decompose.
A) 30 min
B) 21 min
C) 49 min
D) 42 min
E) 34 min

ANS: E PTS: 1 DIF: Moderate REF: 19.2
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay MSC: Quantitative

29. The number of a certain radioactive nuclide present in a sample decays from 160. to 20. in 39 minutes. What is the half-life of this radioactive species?
A) 8 minutes
B) 13 minutes
C) 18 minutes
D) 23 minutes
E) 28 minutes

ANS: B PTS: 1 DIF: Easy REF: 19.2
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay | half-life MSC: Quantitative

30. The half-life of ^{90}Sr is 28 years. How long will it take for a given sample of ^{90}Sr to be 89% decomposed?
A) 9.0 half-lives
B) 5 years
C) 89 years
D) 2.2 years
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 19.2
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay MSC: Quantitative

31. The number of half-lives needed for a radioactive element to decay to about 6% of its original activity is (choose nearest number):
A) 2
B) 3
C) 4
D) 5
E) 6

ANS: C PTS: 1 DIF: Easy REF: 19.2
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay | half-life MSC: Conceptual

32. The Br-82 nucleus has a half-life of about 1.0×10^3 minutes. If you wanted 2.2 g of Br-82 and the delivery time was three days, about how much NaBr should you order (assuming all of the Br in the NaBr was Br-82)?
A) 2.2 g
B) 4.4 g
C) 4.0 g
D) 57 g
E) 7.8 g

ANS: D PTS: 1 DIF: Difficult REF: 19.2
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay MSC: Quantitative

33. A radioactive sample has an initial activity of 2.00×10^6 cpm (counts per minute), and after 4.0 days, its activity is 9.0×10^5 cpm. What is its activity after 29 days?
A) 8.7 cpm
B) 6.1×10^3 cpm
C) 3.3×10^2 cpm
D) 1.5×10^{-9} cpm
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 19.2

KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay MSC: Quantitative

A certain radioactive sample contains 2.4×10^3 nuclides at a certain time ($t = 0$); 3.0 h later the sample contains 6.0×10^2 nuclides.

34. For this sample the ratio of the decay rates at $t = 0$ to $t = 3.0$ h is:
A) 1.0
B) 8.0
C) 4.0
D) 16
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 19.2
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay MSC: Quantitative

35. The value of the rate constant for this process is:
A) $2.2\ h^{-1}$
B) $4.6 \times 10^{-1}\ h^{-1}$
C) $1.6\ h^{-1}$
D) $3.0\ h^{-1}$
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 19.2
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay MSC: Quantitative

36. The half-life of ^{90}Sr is 28.1 years. How long will it take a 10.0-g sample of ^{90}Sr to decompose to 0.23 g?
A) 102 years
B) 306 years
C) 153 years
D) 229 years
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 19.2
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay MSC: Quantitative

37. The rate constant for the decay of $^{45}_{20}Ca$ is 4.234×10^{-3} / day. What is the half-life of $^{45}_{20}Ca$?
A) 81.84 days
B) 163.7 days
C) 327.4 days
D) 409.2 days
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 19.2
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay | half-life MSC: Quantitative

38. A radioactive element has a half-life of 1.6 hours. How many hours will it take for the number of atoms present to decay to one-sixteenth of the initial value?
A) 26
B) 13
C) 6.4
D) 0.15
E) 16

ANS: C PTS: 1 DIF: Easy REF: 19.2
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay | half-life MSC: Quantitative

39. The half-life of a sample has been defined as the time it takes for half of a sample to decay. The fifth-life can be defined as the time it takes for one-fifth of a sample to decay. Given these definitions, calculate the fifth-life of a sample that has a half-life of 26 years.
A) 8.4 years
B) 60 years
C) 17 years
D) 29 years
E) 42 years

ANS: A PTS: 1 DIF: Difficult REF: 19.2
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay | half-life MSC: Quantitative

40. The Cs-131 nuclide has a half-life of 30. years. After 144 years, about 3.0 grams remain. The original mass of the Cs-131 sample is closest to
A) 167 g
B) 42 g
C) 84 g
D) 292 g
E) 100 g

ANS: C PTS: 1 DIF: Moderate REF: 19.2
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay MSC: Quantitative

41. The I-131 nuclide has a half-life of 8.0 days. If you originally have a 1.8-kg sample, after 1.4 months you will have approximately
A) 95 g
B) 62 g
C) 71 g
D) 47 g
E) less than 1 g

ANS: D PTS: 1 DIF: Moderate REF: 19.2
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay MSC: Quantitative

42. Use the following table to assist in answering the question below.

Nuclide	Half-Life
Uranium-238	4.51×10^9 years
Uranium-234	2.48×10^5 years
Thorium-230	8.0×10^4 years
Radium-226	1.62×10^3 years
Lead-210	20.4 years

The rate constant for the decay of unstable nuclide X by alpha-particle emission is 4.21×10^{-13} / day. What is the identity of X?

A) Radium-226
B) Thorium-230
C) Uranium-234
D) Uranium-238
E) Lead-210

ANS: D PTS: 1 DIF: Easy REF: 19.2
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay | half-life MSC: Quantitative

43. The half-life for electron capture for $^{40}_{19}\mathrm{K}$ is 1.30×10^9 years. What percent of the original $^{40}_{19}\mathrm{K}$ remains after 3.24×10^9 years?

A) 82.2%
B) 17.8%
C) 75.7%
D) 24.3%
E) 44.4%

ANS: B PTS: 1 DIF: Moderate REF: 19.2
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay | half-life MSC: Quantitative

44. Identify the missing particle in the following nuclear equation:

$$^{241}_{95}\mathrm{Am} + {}^{4}_{2}\mathrm{He} \rightarrow _____ + 2\,{}^{1}_{0}\mathrm{n}$$

A) $^{245}_{97}\mathrm{Bk}$
B) $^{246}_{97}\mathrm{Bk}$
C) $^{247}_{97}\mathrm{Bk}$
D) $^{244}_{97}\mathrm{Bk}$
E) $^{243}_{97}\mathrm{Bk}$

ANS: E PTS: 1 DIF: Easy REF: 19.3
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | nuclear bombardment reactions | transmutation
MSC: Conceptual

45. In the following nuclear equation, identify the missing product:

$$^{43}_{20}\mathrm{Ca} + \alpha \rightarrow _____ + {}^{1}_{1}\mathrm{H}$$

A) $^{46}_{22}\mathrm{Ti}$

B) $^{46}_{21}\text{Sc}$

C) $^{44}_{22}\text{Ti}$

D) $^{42}_{18}\text{Ar}$

E) none of these

ANS: B PTS: 1 DIF: Easy REF: 19.3
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | nuclear bombardment reactions | transmutation
MSC: Conceptual

46. Identify the missing particle in the following nuclear equation:

$$^{27}_{13}\text{Al} + _____ \rightarrow {}^{24}_{11}\text{Na} + \alpha$$

A) $^{1}_{0}\text{n}$

B) $^{-1}_{0}\text{n}$

C) $^{0}_{-1}\text{e}$

D) $^{0}_{1}\text{e}$

E) $2\ {}^{1}_{0}\text{n}$

ANS: A PTS: 1 DIF: Moderate REF: 19.3
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactivity | nuclear equation MSC: Conceptual

47. When the Pd-106 nucleus is struck with an alpha particle, a proton is produced along with a new element. What is this new element?

A) Cd-112
B) Cd 109
C) Ag-108
D) Ag-109
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 19.3
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | nuclear bombardment reactions | transmutation
MSC: Conceptual

48. An archaeological sample contains 0.743 g of lead-206 and 2.145 g of uranium-238. Assume that all the lead now present in the rock came from the radioactive decay of the uranium and that no appreciable amounts of other radioactive nuclides are present in the sample. The decay rate constant for the uranium is 1.537×10^{-10}/ year. Determine the half-life of the uranium.

A) 4.509×10^{9} years
B) 1.065×10^{-10} years
C) depends on the age of the sample
D) depends on the organic content of the sample
E) two of these

ANS: A PTS: 1 DIF: Easy REF: 19.4

KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay | half-life MSC: Quantitative

49. An archaeological sample contains 0.739 g of lead-206 and 2.328 g of uranium-238. Assume that all the lead now present in the rock came from the radioactive decay of the uranium and that no appreciable amounts of other radioactive nuclides are present in the sample. The decay rate constant for the uranium is 1.54×10^{-10}/year. What is the age of the sample?
A) 8.54×10^{9} years
B) 8.81×10^{8} years
C) 2.03×10^{9} years
D) 6.51×10^{9} years
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 19.4
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay | radioactive dating
MSC: Quantitative

50. Use the following data to determine the expected ^{14}C activity in the Shroud of Turin. The atmospheric activity of ^{14}C is 15 cpm/gC (counts per minute per gram of carbon). Assume that the cloth was made in the year 24 A.D. The half-life of ^{14}C is 5730 years.
A) 28 cpm/gC
B) 7.3 cpm/gC
C) 5.1 cpm/gC
D) 11 cpm/gC
E) 12 cpm/gC

ANS: E PTS: 1 DIF: Moderate REF: 19.4
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay | radioactive dating
MSC: Quantitative

51. A sample of wood from an Egyptian mummy case gives a ^{14}C count of 7.8 cpm/gC (counts per minute per gram of carbon). How old is the wood? (The initial decay rate of ^{14}C is 15.3 cpm/g C, and its half-life is 5730 years.)
A) 2785 yr
B) 8071 yr
C) 5571 yr
D) 6621 yr
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 19.4
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay | radioactive dating
MSC: Quantitative

52. If a tree dies and the trunk remains undisturbed for 13,261 years, what percentage of original ^{14}C is still present? (half-life of ^{14}C = 5730 years)
A) 79.9%

B) 20.1%
C) 40.2%
D) 30.2%
E) 2.31%

ANS: B PTS: 1 DIF: Moderate REF: 19.4
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay | radioactive dating
MSC: Quantitative

53. The half-life for electron capture for $^{40}_{19}\mathrm{K}$ is 1.3 billion years. What will be the $^{40}_{19}\mathrm{K}$/$^{40}_{18}\mathrm{Ar}$ ratio in a rock that is 5.1 billion years old?
A) 0.066
B) 14
C) 0.071
D) 3.9
E) 15

ANS: C PTS: 1 DIF: Easy REF: 19.4
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | rate of radioactive decay | radioactive dating
MSC: Quantitative

54. It is desired to determine the blood volume of a live mouse. To do this, 0.10 mL of a saline suspension of red blood cells labeled with $^{59}_{26}\mathrm{Fe}$ is injected into the tail vein. Before injection, the gamma rays were counted for this 0.10-mL solution and the count rate found to be 1.0×10^4 cpm. After a sufficient time for the blood to be thoroughly mixed, 0.10 mL of blood is removed and counted. The sample is found to have a count rate of 539 cpm. What is the approximate blood volume of the mouse?
A) 0.54 mL
B) 19 mL
C) 5.4 mL
D) 5.3 mL
E) 1.9 mL

ANS: E PTS: 1 DIF: Moderate REF: 19.4
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | applications of radioactive isotopes | chemical anaylsis
MSC: Quantitative

55. A 0.20-mL sample of a solution containing $^{3}_{1}\mathrm{H}$ that produces 3.7×10^3 cps is injected into the bloodstream of an animal. After allowing circulatory equilibrium to be established, a 0.20-mL sample of blood is found to have an activity of 37 cps. Calculate the blood volume of the animal.
A) 0.50 L
B) 20 mL
C) 10 mL
D) 100 mL
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 19.4
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | applications of radioactive isotopes | chemical anaylsis
MSC: Quantitative

56. Radioactive tracers are useful in studying very low concentrations of chemical species. A chemist has a sample of HgI_2 in which part of the iodine is the radioactive nuclide of mass 131, so that the count rate is 5.0×10^{11} counts per minute per mole of I. The solid mercuric iodide is placed in water and allowed to come to equilibrium. Then 100 mL of the solution is withdrawn, and its radioactivity is measured and found to give 22 counts per minute. What is the molar concentration of iodide ion in the solution?
A) 1.1×10^{-9}
B) 4.4×10^{-10}
C) 1.1×10^{-10}
D) 1.1×10^{-11}
E) 4.4×10^{-11}

ANS: B PTS: 1 DIF: Moderate REF: 19.4
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | applications of radioactive isotopes | chemical anaylsis
MSC: Quantitative

57. Which statement is true about the following reaction?

${}^{14}_{7}\mathrm{N}$	+	${}^{4}_{2}\mathrm{He}$	→	${}^{17}_{8}\mathrm{O}$	+	${}^{1}_{1}\mathrm{H}$
13.992 amu		4.0015 amu		16.9986 amu		1.0073 amu

A) Energy is absorbed in the reaction.
B) Energy is released in the reaction.
C) No energy change is associated with the reaction.
D) Not enough information is given to determine the energy change.
E) None of these.

ANS: A PTS: 1 DIF: Moderate REF: 19.5
KEY: Chemistry | general chemistry | nuclear chemistry | energy of nuclear reactions | mass-energy calculations MSC: Conceptual

58. One of the hopes for solving the world's energy problem is to make use of the fusion reaction:

$${}^{2}_{1}\mathrm{H} + {}^{3}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He} + {}^{1}_{0}\mathrm{n} + \text{energy}$$

How much energy is released when one mole of deuterium is fused with one mole of tritium according to the above reaction? The masses of the atoms and the neutrons are:

${}^{2}_{1}\mathrm{H} = 2.0140$ amu ${}^{3}_{1}\mathrm{H} = 3.01605$ amu
${}^{4}_{2}\mathrm{He} = 4.002603$ amu ${}^{1}_{0}\mathrm{n} = 1.008665$ amu

The speed of light is 2.9979×10^{8} m/s
A) 5.63×10^{8} J
B) 56.3 J

C) 1.69×10^{12} J
D) 7.84×10^{44} J
E) 8.44×10^{11} J

ANS: C PTS: 1 DIF: Moderate REF: 19.5
KEY: Chemistry | general chemistry | nuclear chemistry | energy of nuclear reactions | mass-energy calculations MSC: Quantitative

59. Consider the following process:

$$^{14}_{7}\text{N} + {}^{4}_{2}\text{He} \rightarrow {}^{17}_{8}\text{O} + {}^{1}_{1}\text{H}$$

Masses (amu): 14.003074 4.002603 16.999133 1.007825

Which statement describes ΔE for the process?

A) 1.15×10^{11} J/mol are released.
B) 1.15×10^{14} J/mol are released.
C) 1.15×10^{18} J/mol are absorbed.
D) 1.15×10^{11} J/mol are absorbed.
E) None of these.

ANS: D PTS: 1 DIF: Moderate REF: 19.5
KEY: Chemistry | general chemistry | nuclear chemistry | energy of nuclear reactions | mass-energy calculations MSC: Quantitative

60. Calculate ΔE in kilojoules per mole for the following reaction:

$$^{230}_{90}\text{Th} \rightarrow {}^{4}_{2}\text{He} + {}^{236}_{88}\text{Ra}$$

Atomic masses: ^{230}Th = 230.0332, ^{4}He = 4.00260, ^{226}Ra = 226.02544.

A) -4.6×10^{8} kJ/mol
B) -2.4×10^{6} kJ/mol
C) 0
D) $+2.4 \times 10^{6}$ kJ/mol
E) $+4.6 \times 10^{8}$ kJ/mol

ANS: A PTS: 1 DIF: Moderate REF: 19.5
KEY: Chemistry | general chemistry | nuclear chemistry | energy of nuclear reactions | mass-energy calculations MSC: Quantitative

61. Calculate the change in energy in kJ/mol for the transmutation of radium from the given molar masses:

$$^{226}_{88}\text{Ra} \rightarrow {}^{4}_{2}\text{He} + {}^{222}_{86}\text{Rn}$$

226.0254 g/mol 4.0026 g/mol 222.0176 g/mol

A) –5.2 kJ/mol
B) –1.6 kJ/mol
C) -4.7×10^{14} kJ/mol
D) -4.7×10^{8} kJ/mol
E) $+1.6 \times 10^{8}$ kJ/mol

ANS: D PTS: 1 DIF: Moderate REF: 19.5
KEY: Chemistry | general chemistry | nuclear chemistry | energy of nuclear reactions | mass-energy calculations MSC: Quantitative

62. If one mole of oxygen-16 were formed from protons and neutrons, 0.1366 g of mass would be lost. What can best account for this loss?
    A) When fission occurs, the nuclei remaining always has a smaller mass.
    B) Converting from the atomic scale (in amu's) to the macroscopic scale (in grams) can often cause minor errors to occur.
    C) The process was so exothermic, the system lost energy, which meant that it also lost mass.
    D) This is impossible because of the Law of Conservation of Matter (so mass must be conserved).
    E) Both A and C are correct.

    ANS: C PTS: 1 DIF: Easy REF: 19.5
    KEY: Chemistry | general chemistry | nuclear chemistry | energy of nuclear reactions | mass-energy calculations MSC: Conceptual

63. Iron-56 ($^{56}_{26}$Fe) has a binding energy per nucleon of 8.79 MeV. (1MeV is 1.60×10^{-13} J). Determine the difference in mass between one mole of iron-56 nuclei and the component nucleons of which it is made.
    A) 9.41×10^{-6} kg
    B) 2.43×10^{-5} kg
    C) 6.65×10^{-5} kg
    D) 5.27×10^{-4} kg
    E) 7.21×10^{-4} kg

    ANS: D PTS: 1 DIF: Moderate REF: 19.5
    KEY: Chemistry | general chemistry | nuclear chemistry | energy of nuclear reactions | mass-energy calculations MSC: Quantitative

64. The bismuth-209 nucleus has a binding energy per nucleon of 7.6514 MeV. (1 MeV is 1.60×10^{-13} J). Determine the difference in mass between one mole of bismuth-209 nuclei and the component nucleons of which it is made.
    A) 1.71×10^{-3} kg
    B) 3.92×10^{-8} kg
    C) 8.20×10^{-6} kg
    D) 2.56×10^{-10} kg
    E) 6.81×10^{-4} kg

    ANS: A PTS: 1 DIF: Moderate REF: 19.5
    KEY: Chemistry | general chemistry | nuclear chemistry | energy of nuclear reactions | mass-energy calculations MSC: Quantitative

65. The lead-208 nucleus has a mass defect of 1.714 g/mol.
    Determine the binding energy per nucleon for lead-208 nuclei. (1 MeV is 1.602×10^{-13} J).
    A) 1.597×10^{-4} MeV
    B) 1.597×10^{3} MeV
    C) 19.47 MeV
    D) 24.68 MeV
    E) 7.677 MeV

ANS: E PTS: 1 DIF: Moderate REF: 19.5
KEY: Chemistry | general chemistry | nuclear chemistry | energy of nuclear reactions | mass-energy calculations MSC: Quantitative

66. The mass defect arises because the sum of masses of the component nucleons is less than that of the nucleus.

ANS: F PTS: 1 DIF: Easy REF: 19.5
KEY: Chemistry | general chemistry | nuclear chemistry | energy of nuclear reactions | mass-energy calculations | nuclear binding energy MSC: Conceptual

67. In the following fission reaction, identify the other product:

$$^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{139}_{53}\text{I} + 2\,{}^{1}_{0}\text{n} + _____$$

A) $^{89}_{39}\text{Y}$
B) $^{95}_{39}\text{Y}$
C) $^{95}_{42}\text{Mo}$
D) $^{94}_{42}\text{Mo}$
E) $^{95}_{40}\text{Zr}$

ANS: B PTS: 1 DIF: Moderate REF: 19.6
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactive decay series | nuclear equation
MSC: Conceptual

68. What nuclide is necessary to balance the following fission reaction?

$$^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow 3\,{}^{1}_{0}\text{n} + {}^{139}_{56}\text{Ba} + _____$$

A) $^{96}_{35}\text{Br}$
B) $^{96}_{36}\text{Kr}$
C) $^{94}_{37}\text{Rb}$
D) $^{94}_{36}\text{Kr}$
E) $^{90}_{38}\text{Sr}$

ANS: D PTS: 1 DIF: Moderate REF: 19.6
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactivity | nuclear equation MSC: Conceptual

69. Which of the following balanced equations is labeled incorrectly?
A) fission: $^{209}_{83}\text{Bi} + {}^{4}_{2}\text{He} \rightarrow {}^{211}_{85}\text{At} + 2\,{}^{1}_{0}\text{n}$
B) fusion: $^{2}_{1}\text{H} + {}^{2}_{1}\text{H} \rightarrow {}^{3}_{1}\text{H} + {}^{1}_{1}\text{H}$
C) bombardment: $^{239}_{94}\text{Pu} + {}^{1}_{0}\text{n} \rightarrow {}^{240}_{95}\text{Am} + {}^{0}_{-1}\text{e}$
D) beta production: $^{239}_{92}\text{U} \rightarrow {}^{239}_{93}\text{Np} + {}^{0}_{-1}\text{e}$
E) all correctly labeled

ANS: A PTS: 1 DIF: Moderate REF: 19.6

KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions MSC: Conceptual

70. Breeder reactors are used to convert the nonfissionable nuclide $^{238}_{92}\text{U}$ to a fissionable product. Neutron capture of the $^{238}_{92}\text{U}$ is followed by two successive beta decays. What is the final fissionable product?
A) $^{239}_{94}\text{Pu}$
B) $^{235}_{88}\text{Ra}$
C) $^{235}_{92}\text{U}$
D) $^{238}_{94}\text{Pu}$
E) $^{239}_{93}\text{Np}$

ANS: A PTS: 1 DIF: Moderate REF: 19.6
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactivity | nuclear equation MSC: Conceptual

When the U-235 nucleus is struck with a neutron, the Ce-144 and Sr-90 nuclei are produced along with some neutrons and electrons.

71. How many neutrons are emitted?
A) 2
B) 3
C) 4
D) 5
E) 6

ANS: A PTS: 1 DIF: Moderate REF: 19.6
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactivity | nuclear equation MSC: Conceptual

72. How many electrons are emitted?
A) 2
B) 3
C) 4
D) 5
E) 6

ANS: C PTS: 1 DIF: Moderate REF: 19.6
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactivity | nuclear equation MSC: Conceptual

73. When the U-235 nucleus is struck with a neutron, the Zn-72 and Sm-160 nuclei are produced along with some neutrons. How many neutrons are emitted?
A) 2
B) 3
C) 4
D) 5
E) 6

ANS: C PTS: 1 DIF: Moderate REF: 19.6
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactivity | nuclear equation MSC: Conceptual

74. The smallest amount of radioactive material that will support a self-sustained fission reaction is called the
A) molar mass
B) moderator
C) supercritical mass
D) subcritical mass
E) critical mass

ANS: E PTS: 1 DIF: Easy REF: 19.6
KEY: Chemistry | general chemistry | nuclear chemistry | energy of nuclear reactions | nuclear fission MSC: Conceptual

75. How much energy is released when 5.00 metric tons of $^{2}H_2$ gas undergoes nuclear fusion? (1 metric ton = 1000 kg, $c = 2.9979 \times 10^{8}$ m/s, 1 amu = 1.66054×10^{-27} kg)
$^{2}H + {}^{2}H \rightarrow {}^{3}He + {}^{1}n$

Particle	Mass (amu)
$^{1}_{0}n$	1.008665
$^{2}_{1}H$	2.01400
$^{3}_{2}He$	3.01603

A) 7.37×10^{17} J
B) 2.71×10^{-18} J
C) 5.39×10^{64} J
D) 3.69×10^{17} J
E) 2.67×10^{71} J

ANS: D PTS: 1 DIF: Difficult REF: 19.6
KEY: Chemistry | general chemistry | nuclear chemistry | energy of nuclear reactions | nuclear fusion MSC: Quantitative

76. Which of the following is true for the fission of uranium-235?
A) The electron is captured by the nucleus, which becomes unstable.
B) The products include neutrons.
C) The nuclides produced are individually heavier than the uranium nuclide.
D) The nuclides produced are more stable than the uranium nuclide.
E) Two of these.

ANS: E PTS: 1 DIF: Easy REF: 19.6
KEY: Chemistry | general chemistry | nuclear chemistry | energy of nuclear reactions | nuclear fission MSC: Conceptual

77. If more than one neutron from each fission event causes another fission event, the fission situation is described as
A) critical

B) subcritical
C) supercritical
D) moderated
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 19.6
KEY: Chemistry | general chemistry | nuclear chemistry | energy of nuclear reactions | nuclear fission MSC: Conceptual

78. Which of the following statements (A-D) is false?
A) The process of splitting a heavy nucleus into two nuclei with smaller mass numbers is called fission.
B) A beta particle is a particle with the same mass as the electron but opposite charge.
C) Nitrogen can be changed into oxygen by bombarding it with alpha particles.
D) Archaeologists use radioactivity to determine the age of some artifacts and rocks.
E) All of the above statements are true.

ANS: B PTS: 1 DIF: Easy REF: 19.6
KEY: Chemistry | general chemistry | nuclear chemistry MSC: Conceptual

79. Radioactivity is not useful for:
A) Dating artifacts and rocks.
B) Producing electricity.
C) Tracing pathways in biological systems.
D) Making chemicals like sulfuric acid.
E) Radioactivity is useful for all of the above.

ANS: D PTS: 1 DIF: Easy REF: 19.6
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactivity MSC: Conceptual

80. Which statement about fusion is incorrect?
A) Fusion requires starting nuclides that are difficult to find on Earth, which is a problem for scientists.
B) Studying fusion is a worthwhile research endeavor because this process could be used as an alternative energy source.
C) Fusion requires a very high temperature in order to begin, which is a problem for scientists.
D) In fusion, two nuclei must be traveling fast enough to overcome the electrostatic repulsion and “fuse” the particles into a new nucleus.
E) Both A and C are incorrect.

ANS: A PTS: 1 DIF: Easy REF: 19.6
KEY: Chemistry | general chemistry | nuclear chemistry | energy of nuclear reactions | nuclear fusion MSC: Conceptual

81. What component of a nuclear reactor moderates the rate of the reaction?
A) steam turbine
B) control rods
C) cooling water
D) containment shell

E) cyclotron

ANS: B PTS: 1 DIF: Easy REF: 19.6
KEY: Chemistry | general chemistry | nuclear chemistry | energy of nuclear reactions | nuclear fission MSC: Conceptual

82. Which of the following is not a factor in determining the biological effects of radiation exposure?
A) the energy of the radiation
B) the age of the organism at which the exposure occurs
C) the penetrating ability of the radiation
D) the chemical properties of the radiation source
E) the ionizing ability of the radiation

ANS: B PTS: 1 DIF: Easy REF: 19.7
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radiation and matter MSC: Conceptual

83. The greatest radiation exposure for Americans comes from which of the following?
A) medical x-rays
B) nuclear power plants
C) electrical transmission wires
D) industrial waste
E) a combination of the natural causes of radiation including cosmic rays

ANS: E PTS: 1 DIF: Easy REF: 19.7
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radiation and matter MSC: Conceptual

84. Which unit takes into account the relative ability of radiation to cause damage?
A) rem
B) rad
C) curie
D) becquerel
E) cpm

ANS: A PTS: 1 DIF: Easy REF: 19.7
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radiation and matter MSC: Conceptual

85. Which type of radiation has the lowest penetrating ability?
A) gamma ray
B) beta particle
C) alpha particle
D) positron
E) more than one of these

ANS: C PTS: 1 DIF: Easy REF: 19.7
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radiation and matter MSC: Conceptual

86. Which of the following nuclides would be most expected to undergo α-decay?
A) ^{86}As
B) ^{127}I
C) ^{252}Es
D) ^{9}C
E) ^{171}Ir

ANS: C PTS: 1 DIF: Easy REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactive decay MSC: Conceptual

87. Which of the following nuclides would be most expected to undergo β-decay?
A) ^{200}Ta
B) ^{209}Bi
C) ^{257}Fm
D) ^{18}Na
E) ^{121}Xe

ANS: A PTS: 1 DIF: Easy REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactive decay MSC: Conceptual

88. Which of the following nuclides would be most expected to undergo positron emission?
A) ^{86}As
B) ^{127}I
C) ^{252}Es
D) ^{9}C
E) ^{171}Ir

ANS: D PTS: 1 DIF: Easy REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactive decay MSC: Conceptual

89. Which of the following nuclides is most likely to be unstable?
A) ^{35}Cl
B) ^{234}Th
C) ^{2}H
D) ^{4}He
E) ^{52}Cr

ANS: B PTS: 1 DIF: Easy REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactive decay MSC: Conceptual

90. Which of the following nuclides is most likely to be stable?
A) ^{41}Cl
B) ^{234}Th
C) ^{3}H
D) ^{221}Pb
E) ^{52}Cr

ANS: E PTS: 1 DIF: Easy REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactive decay MSC: Conceptual

91. ^{232}Th decays to ^{208}Pb. How many alpha decays are involved in this decay series?
A) 6
B) 1
C) 4
D) 2
E) 5

ANS: A PTS: 1 DIF: Moderate REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactive decay | decay series MSC: Conceptual

92. ^{237}Np decays to ^{209}Bi. . How many alpha decays are involved in this decay series?
A) 6
B) 7
C) 4
D) 2
E) 5

ANS: B PTS: 1 DIF: Moderate REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactive decay | decay series MSC: Conceptual

93. ^{232}Th decays to ^{208}Pb. How many beta decays are involved in this decay series?
A) 6
B) 1
C) 4
D) 2
E) 5

ANS: C PTS: 1 DIF: Moderate REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactive decay | decay series MSC: Conceptual

94. ^{237}Np decays to ^{209}Bi. How many beta decays are involved in this decay series?
A) 6
B) 1
C) 4
D) 2
E) 5

ANS: C PTS: 1 DIF: Moderate REF: 19.1
KEY: Chemistry | general chemistry | nuclear chemistry | radioactivity and nuclear bombardment reactions | radioactive decay | decay series MSC: Conceptual

95. An atom of ^{186}Ta has a mass of 185.958540 amu. Calculate the mass defect (deficit) in amu/atom.
A) 1.591

B) 0
C) 1482
D) 7.97
E) 1.442

ANS: A PTS: 1 DIF: Moderate REF: 19.5
KEY: Chemistry | general chemistry | nuclear chemistry | energy of nuclear reactions | mass-energy calculations MSC: Quantitative

96. An atom of ^{131}I has a mass of 130.906114 amu. Calculate the binding energy per MOLE in kJ.
A) 1.06×10^{14}
B) 1.18
C) 1.06×10^{17}
D) 1.06×10^{11}
E) 1097

ANS: D PTS: 1 DIF: Moderate REF: 19.5
KEY: Chemistry | general chemistry | nuclear chemistry | energy of nuclear reactions | mass-energy calculations MSC: Quantitative

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Chapter 20: The Representative Elements

1. In a given period this group has the element with the largest atomic radius.
   A) Group 1A
   B) Group 2A
   C) Group 3A
   D) Group 4A
   E) Group 5A

   ANS: A PTS: 1 DIF: Easy REF: 20.1
   KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group I alkali metal MSC: Conceptual

2. Which of the following is a metalloid?
   A) carbon
   B) oxygen
   C) hydrogen
   D) copper
   E) silicon

   ANS: E PTS: 1 DIF: Easy REF: 20.1
   KEY: Chemistry | general chemistry | main group chemistry MSC: Conceptual

3. Which of the following exhibits the greatest metallic character?
   A) Cs
   B) Rb
   C) K
   D) Na
   E) All are equally metallic.

   ANS: A PTS: 1 DIF: Easy REF: 20.1
   KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group I alkali metal MSC: Conceptual

4. What is the most abundant element found in the human body?
   A) carbon
   B) hydrogen
   C) calcium
   D) oxygen
   E) water

   ANS: D PTS: 1 DIF: Easy REF: 20.1
   KEY: Chemistry | general chemistry | main group chemistry MSC: Conceptual

5. Hydrogen and lithium react very differently, although they are both members of Group 1. What is the primary reason for this difference?
   A) The metallic character increases going down a group.
   B) The ionization energy increases going down a group.
   C) Electron affinity increases going down a group.
   D) Electronegativity increases going down a group.

E) There is a very large difference in the atomic radii of H and Li.

ANS: E PTS: 1 DIF: Easy REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group I alkali metal MSC: Conceptual

6. All of the following are semimetals except
A) At
B) Ge
C) Al
D) Sb
E) Si

ANS: C PTS: 1 DIF: Easy REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry MSC: Conceptual

7. Which oxide of a Group 2A element is amphoteric?
A) Be
B) Mg
C) Ca
D) Sr
E) Ba

ANS: A PTS: 1 DIF: Easy REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIA alkaline earth metal MSC: Conceptual

8. Which oxide of a Group 2A element is not highly ionic?
A) Be
B) Mg
C) Ca
D) Sr
E) Ba

ANS: A PTS: 1 DIF: Moderate REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIA alkaline earth metal MSC: Conceptual

9. Choose the metal with the largest first ionization energy.
A) Na
B) Mg
C) Al
D) K
E) Ca

ANS: C PTS: 1 DIF: Moderate REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry MSC: Conceptual

10. Which group shows the correct order of first ionization energy?
A) Na > P > Cl
B) Cs > Na > K

C) K > Ca > Ge
D) Cs < Rb < Na
E) Al > Si > P

ANS: D PTS: 1 DIF: Moderate REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry MSC: Conceptual

11. Which element of Group 3A behaves as a nonmetal or semimetal?
A) B
B) Al
C) Ga
D) In
E) B and Al

ANS: A PTS: 1 DIF: Easy REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry MSC: Conceptual

12. What reason is given for the stability of C–C, N–N, and O–O bonds, compared to the instability of Si–Si, P–P, and S–S bonds?
A) Their metallic character varies greatly.
B) Large differences in their ionization energies.
C) Large differences in their electronegativities.
D) Large differences in their abilities to form strong pi bonds.
E) None of these.

ANS: D PTS: 1 DIF: Moderate REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry MSC: Conceptual

13. What are the most abundant metals in the earth's crust, oceans, and atmosphere?
A) titanium and silicon
B) aluminum and iron
C) manganese and nickel
D) tin and lead
E) iron and lead

ANS: B PTS: 1 DIF: Easy REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry MSC: Conceptual

14. Which of the following oxides is amphoteric?
A) BeO
B) MgO
C) CaO
D) SrO
E) BaO

ANS: A PTS: 1 DIF: Easy REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIA alkaline earth metal MSC: Conceptual

15. True or false: Hydrogen is a nonmetal while lithium is an active metal, even though they are in the same group.

A) True. Such differences are common for elements in the same group.
B) False. Because the elements are in the same group, they have similar metallic qualities.
C) True. This can be explained because of the very large difference in atomic radii between hydrogen and lithium.
D) False. Both hydrogen and lithium are nonmetals
E) None of these.

ANS: C PTS: 1 DIF: Easy REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group I alkali metal MSC: Conceptual

16. Choose the metal with the smallest radius.
A) Ca
B) Na
C) K
D) Mg
E) Al

ANS: E PTS: 1 DIF: Moderate REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry MSC: Conceptual

17. Within a group, as the atomic numbers of the elements increase, the
A) ionization energies decrease
B) atomic masses decrease
C) elements become less metallic
D) atomic radii decrease
E) metallic character decreases

ANS: A PTS: 1 DIF: Easy REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry MSC: Conceptual

18. Choose the element with the largest atomic radius.
A) Li
B) B
C) N
D) O
E) Ne

ANS: A PTS: 1 DIF: Easy REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry MSC: Conceptual

19. Choose the element with the smallest atomic radius.
A) Li
B) Na
C) K
D) Rb
E) Cs

ANS: A PTS: 1 DIF: Easy REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry MSC: Conceptual

20. Choose the element obtained from liquification of air.
    A) N
    B) P
    C) As
    D) Sb
    E) Bi

    ANS: A PTS: 1 DIF: Easy REF: 20.1
    KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal
    MSC: Conceptual

21. Which of the following is the second most abundant (by mass) element in the earth's crust, oceans, and atmosphere?
    A) hydrogen
    B) oxygen
    C) carbon
    D) aluminum
    E) silicon

    ANS: E PTS: 1 DIF: Easy REF: 20.1
    KEY: Chemistry | general chemistry | main group chemistry MSC: Conceptual

22. The compound SiO_2 does not exist as a discrete molecule while CO_2 does. This can be explained because:
    A) The Si—O bond is unstable.
    B) The Lewis structure of SiO_2 has an even number of electrons.
    C) The SiO_2 is a solid while CO_2 is a gas.
    D) The 3p orbital of the Si has little overlap with the 2p of the O.
    E) None of these.

    ANS: D PTS: 1 DIF: Moderate REF: 20.1
    KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group IV nonmetal MSC: Conceptual

23. Both CO_2 and SiO_2 appear to have valid Lewis structures. Using the molecular orbital model, why then are CO_2 molecules stable and SiO_2 molecules not stable?
    A) CO_2 is able to form sigma bonds and SiO_2 is not.
    B) The silicon 3p valence orbitals do not overlap very effectively with the smaller oxygen 2p orbitals.
    C) The carbon atom is larger than the silicon atom, giving carbon a higher electron density and thus better pi bonding.
    D) Silicon prefers to bond to other silicon atoms over oxygen atoms.
    E) At least two of the above are correct.

    ANS: B PTS: 1 DIF: Moderate REF: 20.1
    KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal
    MSC: Conceptual

24. The elements in this group are termed alkali metals.
    A) Group 1A

B) Group 2A
C) Group 3A
D) Group 4A
E) Group 5A

ANS: A PTS: 1 DIF: Easy REF: 20.2
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group I alkali metal MSC: Conceptual

25. Which group contains the most active metals?
A) Group 1A
B) Group 3A
C) Group 2A
D) Group 4A
E) Group 7A

ANS: A PTS: 1 DIF: Easy REF: 20.2
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group I alkali metal MSC: Conceptual

26. Choose the element that is the strongest reducing agent.
A) Li
B) Na
C) K
D) Rb
E) Cs

ANS: A PTS: 1 DIF: Easy REF: 20.2
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group I alkali metal MSC: Conceptual

27. Choose the element with the highest melting point.
A) Li
B) Na
C) K
D) Rb
E) Cs

ANS: A PTS: 1 DIF: Easy REF: 20.2
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group I alkali metal MSC: Conceptual

28. Choose the element whose ion has the largest concentration *inside* a human cell.
A) Li
B) Na
C) K
D) Rb
E) Cs

ANS: C PTS: 1 DIF: Easy REF: 20.2
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group I

alkali metal MSC: Conceptual

29. Choose the metal with the lowest melting point.
A) Li
B) Na
C) K
D) Rb
E) Cs

ANS: E PTS: 1 DIF: Difficult REF: 20.2
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group I alkali metal MSC: Conceptual

30. What ions are very important for the proper functioning of biologic systems, such as nerves and muscles?
A) alkaline earth metal ions
B) alkali metal ions
C) oxygen ions
D) hydrogen ions
E) nitrogen ions

ANS: B PTS: 1 DIF: Moderate REF: 20.2
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group I alkali metal MSC: Conceptual

31. The strongest reducing agent in the alkali metals is:
A) K
B) Na
C) Cs
D) Fr
E) Li

ANS: E PTS: 1 DIF: Easy REF: 20.2
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group I alkali metal MSC: Conceptual

32. Which of the following is the best explanation as to why lithium is the strongest reducing agent of the alkali metals?
A) The ionization energy of lithium is the highest of the alkali metals.
B) The ionization energy of lithium is the lowest of the alkali metals.
C) The standard reduction potential of lithium is the most positive of the alkali metals.
D) The relatively high charge density of lithium compared to the other alkali metals.
E) None of these.

ANS: D PTS: 1 DIF: Easy REF: 20.2
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group I alkali metal MSC: Conceptual

33. Because Li is the strongest reducing agent of the alkali metals, it reacts most quickly with water of the alkali metals.

ANS: F PTS: 1 DIF: Moderate REF: 20.2
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group I alkali metal MSC: Conceptual

34. Ionic hydrides are formed when hydrogen combines with elements from:
I. Group 1A
II. Group 2A
III Group 3A

A) I, II, and III
B) I and II
C) I and III
D) II and III
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 20.3
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | hydrogen | reactions and compounds MSC: Conceptual

35. _____ are formed when hydrogen combines with other nonmetals.
A) Covalent hydrides
B) Nonmetallic hydrides
C) Active hydrides
D) Interstitial hydrides
E) Ionic hydrides

ANS: A PTS: 1 DIF: Easy REF: 20.3
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | hydrogen | reactions and compounds MSC: Conceptual

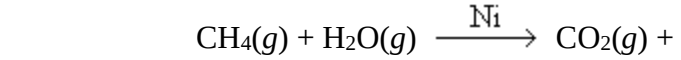
36. _____ are formed when transition metal crystals are treated with hydrogen gas.
A) Covalent hydrides
B) Metallic hydrides
C) Active hydrides
D) Saltlike hydrides
E) Ionic hydrides

ANS: B PTS: 1 DIF: Easy REF: 20.3
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | hydrogen | reactions and compounds MSC: Conceptual

37. Ionic hydrides are formed with hydrogen combined with elements from
A) group 1A
B) group 2A
C) group 3A
D) all of the above
E) two of the above

ANS: E PTS: 1 DIF: Easy REF: 20.3
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | hydrogen | reactions and compounds MSC: Conceptual

38. The major industrial source of hydrogen gas is the reaction of methane and water at high temperatures (800 – 1000°C) and high pressures (10 – 15 atm) with nickel as a catalyst.



If 171.5 g of CH_4 and 171.5 g of H_2O are reacted at 945°C and 11.0 atm, how much hydrogen should be available for industrial use?

A) 201 L
B) 291 L
C) 259 L
D) 28.8 L
E) 86.5 L

ANS: C PTS: 1 DIF: Moderate REF: 20.3
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | hydrogen | preparation MSC: Quantitative

39. Which statements about hydrogen are true?

I. H has a lower ionization energy than He.
II. H^- is smaller than H.
III. H bonds with the halogens to form polar covalent compounds.
IV. H is always a metal.
V. H does not have a second ionization energy.

A) I, V
B) II, IV
C) I, III, V
D) II, IV, V
E) I, III, IV, V

ANS: C PTS: 1 DIF: Moderate REF: 20.3
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | hydrogen MSC: Conceptual

40. Salts can consist of hydrogen.

ANS: T PTS: 1 DIF: Easy REF: 20.3
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | hydrogen | reactions and compounds MSC: Conceptual

41. Choose the metal that reacts least vigorously with water.

A) Mg
B) Ca
C) Sr
D) Ba
E) All of these react equally vigorously with water.

ANS: A PTS: 1 DIF: Easy REF: 20.4

KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIA alkaline earth metal MSC: Conceptual

42. Choose the metal that is produced by electrolysis of its molten chloride salt.
A) Mg
B) Ca
C) Sr
D) Ba
E) all of these

ANS: E PTS: 1 DIF: Easy REF: 20.4
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIA alkaline earth metal MSC: Conceptual

43. Choose the group that matches the following description: reacts with H_2 to form compounds with the general formula MH_2.
A) Group 1A
B) Group 2A
C) Group 3A
D) Group 4A
E) Group 5A

ANS: B PTS: 1 DIF: Easy REF: 20.4
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIA alkaline earth metal MSC: Conceptual

44. Choose the group that matches the following description: reacts with F_2 to form compounds with the general formula MF_2.
A) Group 1A
B) Group 2A
C) Group 3A
D) Group 4A
E) Group 5A

ANS: B PTS: 1 DIF: Easy REF: 20.4
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIA alkaline earth metal MSC: Conceptual

45. Elements in this group lose two valence electrons to non-metals to form ionic compounds.
A) Group 1A
B) Group 2A
C) Group 3A
D) Group 4A
E) Group 5A

ANS: B PTS: 1 DIF: Easy REF: 20.4
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIA alkaline earth metal MSC: Conceptual

46. Choose the solid that has the smallest ionization energy.
A) Be

B) Mg
C) Ca
D) Sr
E) Ba

ANS: E PTS: 1 DIF: Easy REF: 20.4
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIA alkaline earth metal MSC: Conceptual

47. Which of the following ions interferes with the action of detergents in hard water?
A) Na^+
B) Ca^{2+}
C) Mg^{2+}
D) Ca^{2+} and Mg^{2+}
E) Na^+, Ca^{2+}, and Mg^{2+}

ANS: D PTS: 1 DIF: Easy REF: 20.4
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIA alkaline earth metal MSC: Conceptual

48. What element is found in the structural minerals that make up our bones and teeth?
A) strontium
B) barium
C) calcium
D) silicon
E) magnesium

ANS: C PTS: 1 DIF: Easy REF: 20.4
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIA alkaline earth metal | calcium MSC: Conceptual

49. In cation-exchange resins, what ion replaces Ca^{2+} and Mg^{2+} in the hard water that is passed over the resin?
A) H^+
B) Li^+
C) Na^+
D) K^+
E) Ba^{2+}

ANS: C PTS: 1 DIF: Easy REF: 20.4
KEY: Chemistry | general chemistry | main group chemistry | main-group metal
MSC: Conceptual

50. Arrange the following Group 2A elements (in their ionic form) from *largest to smallest* atomic radius.
A) $Ra^{2+} > Ba^{2+} > Sr^{2+} > Ca^{2+} > Mg^{2+}$
B) $Sr^{2+} > Ca^{2+} > Ba^{2+} > Mg^{2+} > Ra^{2+}$
C) $Ba^{2+} > Ra^{2+} > Ca^{2+} > Sr^{2+} > Mg^{2+}$
D) $Mg^{2+} > Ca^{2+} > Sr^{2+} > Ba^{2+} > Ra^{2+}$
E) $Ra^{2+} > Mg^{2+} > Ba^{2+} > Ca^{2+} > Sr^{2+}$

ANS: A PTS: 1 DIF: Easy REF: 20.4
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIA alkaline earth metal MSC: Conceptual

51. Which of the following is the *best* explanation for how a water softener works?
A) When hard water passes over a resin in the softener, the Ca^{2+} and Mg^{2+} ions in the water bind to the resin in place of Na^{+} ions.
B) The softener releases an acid to interact with the Ca^{2+} and Mg^{2+} ions in the hard water to neutralize them.
C) When hard water passes through the softener, the Ca^{2+} and Mg^{2+} ions are removed through electrolysis.
D) The softener releases K^{+} ions to counteract the Ca^{2+} and Mg^{2+} ions in the hard water.
E) When hard water passes through the softener, the Ca^{2+} and Mg^{2+} ions precipitate out as $Mg(OH)_2$ and $Ca(OH)_2$.

ANS: A PTS: 1 DIF: Easy REF: 20.4
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIA alkaline earth metal MSC: Conceptual

52. Alkaline earth metals react less vigorously with water than do the alkali metals.

ANS: T PTS: 1 DIF: Easy REF: 20.4
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIA alkaline earth metal MSC: Conceptual

53. Which of these Group 2A elements reacts least vigorously with water?
A) Mg
B) Sr
C) Ca
D) Ba
E) All of these react in the same manner.

ANS: A PTS: 1 DIF: Easy REF: 20.4
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIA alkaline earth metal MSC: Conceptual

54. The element with the lowest melting point is:
A) B
B) Al
C) Ga
D) Tl
E) All have the same melting point.

ANS: C PTS: 1 DIF: Easy REF: 20.5
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIIA metal MSC: Conceptual

55. The element with the widest liquid range is:
A) B

B) Al
C) Ga
D) Tl
E) All are the same.

ANS: C PTS: 1 DIF: Easy REF: 20.5
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIIA metal MSC: Conceptual

56. The ion that aluminum is most likely to form is isoelectronic with:
A) Ar
B) Na
C) Ne
D) Mg
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 20.5
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIIA metal | aluminum MSC: Conceptual

57. Which of the following metals has the highest melting point?
A) Na
B) Mg
C) Al
D) Ca
E) K

ANS: C PTS: 1 DIF: Moderate REF: 20.5
KEY: Chemistry | general chemistry | main group chemistry | main-group metal
MSC: Conceptual

58. An element that exhibits the oxidation states +1 and +3 is:
A) B
B) Al
C) Ga
D) In
E) all of these

ANS: D PTS: 1 DIF: Easy REF: 20.5
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIIA metal MSC: Conceptual

59. The Group 3A element with the highest ionization energy is:
A) B
B) Al
C) Ga
D) Tl
E) All are the same.

ANS: A PTS: 1 DIF: Easy REF: 20.5
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group

IIIA metal MSC: Conceptual

60. The element found in bauxite is:
A) B
B) Al
C) Ga
D) Tl
E) all of these

ANS: B PTS: 1 DIF: Easy REF: 20.5
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIIA metal | aluminum MSC: Conceptual

61. The element that reacts with N_2 to form a compound of the general formula MN is:
A) B
B) Al
C) Ga
D) Tl
E) all of these

ANS: B PTS: 1 DIF: Easy REF: 20.5
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIIA metal | aluminum MSC: Conceptual

62. The Group 3A elements are all metals.

ANS: F PTS: 1 DIF: Easy REF: 20.5
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIIA metal MSC: Conceptual

63. Choose the group that matches the following description: contains two of the most important elements found on earth.
A) Group 1A
B) Group 2A
C) Group 3A
D) Group 4A
E) Group 5A

ANS: D PTS: 1 DIF: Moderate REF: 20.6
KEY: Chemistry | general chemistry | main group chemistry MSC: Conceptual

64. Order the following bonds from highest to lowest bond energy: carbon–carbon, silicon–silicon, silicon–oxygen.
A) C—C, Si—Si, S—O
B) Si—O, C—C, Si—Si
C) Si—Si, Si—O, C—C
D) Si—O, Si—Si, C—C
E) C—C, Si—O, Si—Si

ANS: B PTS: 1 DIF: Moderate REF: 20.6
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal

MSC: Conceptual

65. Which group contains two elements that exhibit +2 and +4 oxidation states?
A) Group 1A
B) Group 3A
C) Group 4A
D) Group 5A
E) Group 7A

ANS: C PTS: 1 DIF: Easy REF: 20.6
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IVA metal MSC: Conceptual

66. What are the forms of elemental carbon?
A) graphite and diamond
B) graphite, diamond, and fullerenes
C) graphite and fullerenes
D) diamond and fullerenes
E) diamond, graphite, and carbonite

ANS: B PTS: 1 DIF: Easy REF: 20.6
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group IV nonmetal | carbon MSC: Conceptual

67. The solid substance with the empirical formula SiO_2 is commonly called:
A) silicon
B) silica
C) silicate
D) silicone
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 20.6
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group IV nonmetal | silicon MSC: Conceptual

68. How many of the following statements are false?
I. The group 3A elements are all metals.
II Alkaline earth metals react less vigorously with water than do the alkali metals.
III. Salts can consist of hydrogen.
IV. Because Li is the strongest reducing agent of the alkali metals, it reacts most quickly with water of the alkali metals.

A) 0
B) 1
C) 2
D) 3
E) 4

ANS: C PTS: 1 DIF: Easy REF: 20.5
KEY: Chemistry | general chemistry | main group chemistry | main-group metal

MSC: Conceptual

69. Which of the following is the most abundant metal on earth?
A) calcium
B) iron
C) copper
D) aluminum
E) zinc

ANS: D PTS: 1 DIF: Easy REF: 20.5
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIIA metal | aluminum MSC: Conceptual

70. Which element is found in the ore galena?
A) tin
B) lead
C) aluminum
D) silicon
E) germanium

ANS: B PTS: 1 DIF: Easy REF: 20.6
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IVA metal | lead MSC: Conceptual

71. The largest commercial use of lead is in
A) gasoline
B) protective coatings for steel
C) semiconductors
D) paints
E) batteries used in automobiles

ANS: E PTS: 1 DIF: Easy REF: 20.6
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IVA metal | lead MSC: Conceptual

72. With which of the following elements does silicon form the strongest bonds?
A) Si
B) C
C) H
D) O
E) B

ANS: D PTS: 1 DIF: Moderate REF: 20.6
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IV nonmetal | silicon MSC: Conceptual

73. The chemistry of silicon is dominated by its bonding with
A) Cl
B) S
C) Al
D) F

E) none of these

ANS: E PTS: 1 DIF: Easy REF: 20.6
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IV nonmetal | silicon MSC: Conceptual

74. Which element in Group 4A has the strongest metallic character?
A) Pb
B) C
C) Si
D) Ge
E) None of these are metals.

ANS: A PTS: 1 DIF: Easy REF: 20.6
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IVA metal MSC: Conceptual

75. Choose the element with the largest electronegativity.
A) N
B) P
C) As
D) Sb
E) Bi

ANS: A PTS: 1 DIF: Easy REF: 20.7
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA MSC: Conceptual

76. Choose the most metallic element.
A) N
B) P
C) As
D) Sb
E) Bi

ANS: E PTS: 1 DIF: Easy REF: 20.7
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA MSC: Conceptual

77. Choose the element with the largest ionization energy.
A) N
B) P
C) As
D) Sb
E) Bi

ANS: A PTS: 1 DIF: Moderate REF: 20.7
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA MSC: Conceptual

78. Which Group 5A element cannot form molecules with five covalent bonds?

A) N
B) P
C) As
D) Sb
E) Bi

ANS: A PTS: 1 DIF: Easy REF: 20.7
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

79. Why is nitrogen *not* able to form molecules with five covalent bonds?
A) Because nitrogen can only form a trigonal bipyramidal shape when it bonds with other elements.
B) Because nitrogen has such a high ionization energy that having five covalent bonds is not possible.
C) Because nitrogen only exists as N_2 gas at room temperature.
D) Because of nitrogen's small size and lack of available d orbitals for electrons.
E) At least two of the above are correct.

ANS: D PTS: 1 DIF: Easy REF: 20.7
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

80. The ability of the Group 5A elements to form _____ greatly decreases after nitrogen.
A) molecules with five covalent bonds
B) pi bonds
C) larger molecules with single bonds
D) molecules with four covalent bonds
E) all of these

ANS: B PTS: 1 DIF: Easy REF: 20.7
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA MSC: Conceptual

81. Compounds containing bismuth in the +5 oxidation state tend to be _____, and compounds containing bismuth in the +3 oxidation state tend to be _____.
A) ionic, ionic
B) ionic, molecular
C) molecular, molecular
D) molecular, ionic
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 20.7
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA MSC: Conceptual

82. Choose the correct molecular structure for $AsCl_5$.
A) trigonal bipyramidal
B) trigonal planar
C) tetrahedral
D) octahedral

E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 20.7
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA MSC: Conceptual

83. Choose the correct molecular structure for PCl_3.
A) trigonal bipyramidal
B) trigonal planar
C) tetrahedral
D) octahedral
E) none of these

ANS: E PTS: 1 DIF: Moderate REF: 20.7
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA MSC: Conceptual

84. Pi bonding tends to be important in all elements of Group 5A.

ANS: F PTS: 1 DIF: Easy REF: 20.7
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA MSC: Conceptual

85. Choose the correct molecular structure for NH_4^+.
A) trigonal bipyramidal
B) trigonal planar
C) tetrahedral
D) octahedral
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

86. The strength of the N≡N bond in nitrogen is important
A) Because it allows N_2 gas to serve as a medium for experiments involving oxygen or water.
B) Both thermodynamically and kinetically.
C) In the use of nitrogen-based explosives.
D) In the exothermic decomposition of binary compounds containing nitrogen.
E) All of these.

ANS: E PTS: 1 DIF: Moderate REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

87. The process of transforming N_2 to a form usable by animals and plants is called
A) nitrogen fixation
B) fertilization
C) denitrification
D) the Ostwald process

E) nitrogenation

ANS: A PTS: 1 DIF: Easy REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

88. In which of the following compounds does N have its maximum oxidation state?
A) N_2O_5
B) N_2O
C) NO
D) N_2O_3
E) NO_2

ANS: A PTS: 1 DIF: Easy REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

89. The strength of the triple bond in the N_2 molecule is important
A) both kinetically and thermodynamically
B) kinetically but not thermodynamically
C) thermodynamically but not kinetically
D) neither thermodynamically nor kinetically
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

90. Which of the following is not a possible oxidation state of nitrogen?
A) +2
B) +1
C) 0
D) -2
E) -4

ANS: E PTS: 1 DIF: Easy REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

91. The Ostwald process
A) is used to manufacture ammonia
B) transforms nitrogen to other nitrogen-containing compounds
C) is used to recover sulfur from underground deposits
D) is used to produce nitric acid
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

92. The Haber process

A) is used to manufacture ammonia
B) transforms nitrogen to other nitrogen-containing compounds
C) is used to recover sulfur from underground deposits
D) is used to produce nitric acid
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

93. All of the following contribute to nitrogen-fixation except
A) lightning
B) bacteria on the roots of legumes
C) the combustion process in car engines
D) the Haber process
E) the Ostwald process

ANS: E PTS: 1 DIF: Moderate REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

94. Recent studies indicate that lightning may be responsible for as much as _____% of the total fixed nitrogen available on earth.
A) 5
B) 25
C) 50
D) 75
E) 95

ANS: C PTS: 1 DIF: Easy REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

95. The most important hydride of nitrogen is
A) ammonia
B) hydrazine
C) styrofoam
D) agricultural pesticides
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

96. What nitrogen-containing compound is used as rocket fuel?
A) nitrous oxide
B) ammonia
C) nitric oxide
D) hydrazine
E) nitrogen dioxide

ANS: D PTS: 1 DIF: Easy REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

97. Which of the following is not a use of hydrazine?
A) Blowing agent.
B) Fungicides.
C) Herbicides.
D) Insecticides.
E) All are uses of hydrazine.

ANS: E PTS: 1 DIF: Easy REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

98. Dinitrogen monoxide is more commonly known as
A) nitric oxide
B) laughing gas
C) hydrazine
D) nitrous oxide
E) two of these

ANS: E PTS: 1 DIF: Easy REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

99. What nitrogen-containing compound has a role in controlling the earth's temperature?
A) N_2O
B) nitric oxide
C) nitrogen oxide
D) ammonia
E) N_2

ANS: A PTS: 1 DIF: Moderate REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

100. What nitrogen-containing compound is produced commercially in the Ostwald process?
A) hydrazine
B) nitric acid
C) nitrous acid
D) ammonia
E) nitrous oxide

ANS: B PTS: 1 DIF: Easy REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

101. Nitroglycerin, the main component of dynamite, decomposes very rapidly and exothermically according to the equation:

$$4C_3H_5N_3O_9(l) \rightarrow 6N_2(g) + 12CO_2(g) + 10H_2O(g) + O_2(g) + \text{energy}$$

What is the total volume of products that would be produced from 595 g of nitroglycerin? Assume the heat released caused the temperature to become 233°C and the pressure to be 10.0 atm.

A) 36.3 L
B) 78.9 L
C) 16.3 L
D) 58.7 L
E) 93.9 L

ANS: B PTS: 1 DIF: Moderate REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Quantitative

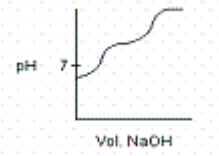
102. Which of the following are reasons why the chemical properties of phosphorus are quite different from those of nitrogen, even though they are located very closely on the periodic table?

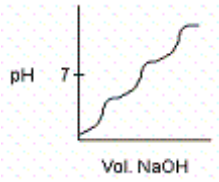
I. the greater electronegativity of nitrogen
II. the larger size of the phosphorus atom
III. nitrogen's ability to form stronger pi bonds
IV. the empty valence d orbitals on phosphorus

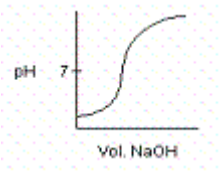
A) I, II
B) I, II, IV
C) II only
D) III, IV
E) I, II, III, IV

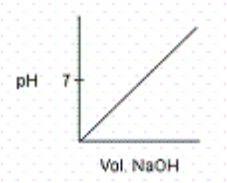
ANS: E PTS: 1 DIF: Moderate REF: 20.9
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA MSC: Conceptual

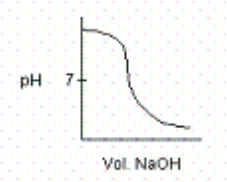
103. Which of the following titration curves best represents phosphorous acid, H_3PO_3, being titrated with a strong base?

A)


B)


C)


D) 

E) 

ANS: A PTS: 1 DIF: Moderate REF: 20.9
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | phosphorus MSC: Conceptual

104. Which is the most reactive form of phosphorus?
A) Black phosphorus.
B) White phosphorus.
C) Red phosphorus.
D) Two of these are equally reactive.
E) All of these (A-C) are equally reactive.

ANS: B PTS: 1 DIF: Easy REF: 20.9
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | phosphorus MSC: Conceptual

105. Which form of phosphorus is highly toxic?
A) white phosphorus
B) red phosphorus
C) black phosphorus
D) tetraphosphorus decaoxide
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 20.9
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | phosphorus MSC: Conceptual

106. Phosphorus is found in nature
A) as white phosphorus
B) as red phosphorus
C) as black phosphorus
D) usually as the PO_4^{3-} ion in phosphate rock
E) in gypsum

ANS: D PTS: 1 DIF: Moderate REF: 20.9
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | phosphorus MSC: Conceptual

107. Why is phosphorus added to soil as a fertilizer?

A) It is essential for plant growth.
B) It is often found in an inaccessible form in the soil.
C) Most soils do not have large amounts of phosphorus.
D) Two of these.
E) All of these.

ANS: D PTS: 1 DIF: Easy REF: 20.9
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | phosphorus MSC: Conceptual

108. What Group 6A element has been studied for its ability to protect against cancer?
A) sulfur
B) polonium
C) selenium
D) tellurium
E) oxygen

ANS: C PTS: 1 DIF: Easy REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIA MSC: Conceptual

109. What Group 6A element was discovered in pitchblende by the Curies?
A) sulfur
B) polonium
C) selenium
D) tellurium
E) oxygen

ANS: B PTS: 1 DIF: Easy REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIA MSC: Conceptual

110. What Group 6A element has 27 isotopes and is highly toxic and very radioactive?
A) sulfur
B) polonium
C) selenium
D) tellurium
E) oxygen

ANS: B PTS: 1 DIF: Easy REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIA MSC: Conceptual

111. What Group 6A elements are semiconductors?
A) selenium and polonium
B) tellurium and polonium
C) sulfur and selenium
D) selenium and tellurium
E) sulfur and tellurium

ANS: D PTS: 1 DIF: Easy REF: 20.1

KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIA MSC: Conceptual

112. Choose the correct molecular structure for $SeBr_4$.
A) trigonal bipyramidal
B) trigonal planar
C) tetrahedral
D) octahedral
E) none of these

ANS: E PTS: 1 DIF: Moderate REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIA MSC: Conceptual

113. Choose the correct molecular structure for SeF_6.
A) trigonal bipyramidal
B) trigonal planar
C) tetrahedral
D) octahedral
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIA MSC: Conceptual

114. All of the following are true about ozone *except*:
A) It causes skin cancer.
B) It is formed in the pollution from car exhaust.
C) It can be used to purify water.
D) It exists naturally in the upper atmosphere.
E) It prevents UV light from reaching the earth.

ANS: A PTS: 1 DIF: Easy REF: 20.11
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIA | oxygen MSC: Conceptual

115. What process is used to recover sulfur?
A) the Haber process
B) the Ostwald process
C) the Frasch process
D) the contact process
E) the wet process

ANS: C PTS: 1 DIF: Easy REF: 20.12
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIA | sulfur MSC: Conceptual

116. The fact that the SO molecule is very unstable while O_2 is stable can be best explained because:
A) The S-O bond is inherently unstable.
B) Sulfur lacks the ability to form double bonds.

C) The difference in electronegativity between the sulfur atom and the oxygen atom makes it unlikely for the S-O bond to form.
D) There exists much stronger pi bonding between oxygen atoms than between a sulfur atom and oxygen atom.
E) None of these.

ANS: D PTS: 1 DIF: Moderate REF: 20.12
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIA | sulfur MSC: Conceptual

117. Choose the species with the largest bond strength.
A) F_2
B) Cl_2
C) Br_2
D) I_2
E) All are the same.

ANS: B PTS: 1 DIF: Moderate REF: 20.13
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIIA: halogen MSC: Conceptual

118. Choose the species with the largest ionization energy.
A) F
B) Cl
C) Br
D) I
E) All are the same.

ANS: A PTS: 1 DIF: Moderate REF: 20.13
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIIA: halogen MSC: Conceptual

119. Choose the species with the largest radius.
A) F
B) F^-
C) Cl
D) Cl^-
E) All are the same.

ANS: D PTS: 1 DIF: Moderate REF: 20.13
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIIA: halogen MSC: Conceptual

120. Of F, Cl, Br, and I, which of the following correctly lists the largest radius of the anion, the element with the highest electronegativity, and the highest bond energy of the diatomic molecule, respectively?
A) I^-, Cl, F_2
B) I^-, F, Br_2
C) Br^-, Br, I_2
D) I^-, F, Cl_2
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 20.13
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIIA: halogen MSC: Conceptual

121. Choose the species with the smallest hydration energy (absolute value).
A) F^-
B) Cl^-
C) Br^-
D) I^-
E) all the same

ANS: D PTS: 1 DIF: Easy REF: 20.13
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIIA: halogen MSC: Conceptual

122. Choose the species that is the most reactive.
A) F_2
B) Cl_2
C) Br_2
D) I_2
E) all are the same.

ANS: A PTS: 1 DIF: Easy REF: 20.13
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIIA: halogen MSC: Conceptual

123. Choose the correct molecular structure for ClO_2^-.
A) trigonal bipyramidal
B) trigonal planar
C) tetrahedral
D) octahedral
E) none of these

ANS: E PTS: 1 DIF: Moderate REF: 20.13
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIIA: halogen MSC: Conceptual

124. Choose the correct molecular structure for ClO_4^-.
A) trigonal bipyramidal
B) trigonal planar
C) tetrahedral
D) octahedral
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 20.13
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIIA: halogen MSC: Conceptual

125. Choose the group containing the most reactive nonmetals.
A) Group 1A

B) Group 3A
C) Group 5A
D) Group 7A
E) Group 8A

ANS: D PTS: 1 DIF: Easy REF: 20.13
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIIA: halogen MSC: Conceptual

126. For the process $X^-(g) \rightarrow X^-(aq)$, select the ion with the most negative value of ΔH.
A) F^-
B) Cl^-
C) Br^-
D) I^-
E) all the same

ANS: A PTS: 1 DIF: Moderate REF: 20.13
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIIA: halogen MSC: Conceptual

127. For the process $X^-(g) \rightarrow X^-(aq)$, select the ion with the most negative value of ΔS.
A) F^-
B) Cl^-
C) Br^-
D) I^-
E) all the same

ANS: A PTS: 1 DIF: Moderate REF: 20.13
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIIA: halogen MSC: Conceptual

128. Within the halogen family, as atomic number increases:
A) Covalent radius decreases.
B) Ionic radius increases.
C) Melting point decreases.
D) Electronegativity increases.
E) None of these.

ANS: B PTS: 1 DIF: Easy REF: 20.13
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIIA: halogen MSC: Conceptual

129. The bond strength of HCl is greater than that of HF.

ANS: F PTS: 1 DIF: Easy REF: 20.13
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIIA: halogen MSC: Conceptual

130. The acid $HClO_4$ is a stronger acid than $HClO_2$.

ANS: T PTS: 1 DIF: Easy REF: 20.13

KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIIA: halogen MSC: Conceptual

131. All of the following statements about helium are true *except*:
A) It forms no compounds.
B) It is used as a coolant.
C) The major sources on earth are natural gas deposits.
D) It is used in luminescent lighting.
E) It is a component of the sun.

ANS: D PTS: 1 DIF: Easy REF: 20.14
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIIIA: noble gas | helium MSC: Conceptual

132. Of the following, which form compounds?
I. Ne
II. Kr
III. Xe
IV. Rn

A) I, II
B) II, III
C) I, II, III
D) II, III, IV
E) III, IV

ANS: D PTS: 1 DIF: Moderate REF: 20.14
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIIIA: noble gas MSC: Conceptual

133. Choose the correct molecular structure for XeF_4.
A) trigonal bipyramidal
B) trigonal planar
C) tetrahedral
D) square planar
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 20.14
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIIIA: noble gas MSC: Conceptual

134. Which of the following noble gases have been observed to form compounds?
A) He and Ar
B) Kr and Xe
C) Xe
D) Ar, Kr, and Xe
E) The noble gases never form compounds since they have filled outer shells.

ANS: D PTS: 1 DIF: Easy REF: 20.14
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIIIA: noble gas MSC: Conceptual

135. Which of the following is *not* a known compound?
A) XeF_4
B) KrF_2
C) $ArBr_4$
D) XeO_3
E) At least two of the above are not compounds.

ANS: C PTS: 1 DIF: Easy REF: 20.14
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIIIA: noble gas MSC: Conceptual

Write a balanced equation for each of the following reactions:

136. Lithium metal with excess $O_2(g)$.

ANS:
$4Li(s) + O_2(g) \rightarrow 2Li_2O(s)$

PTS: 1 DIF: Moderate REF: 20.2
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group I alkali metal MSC: Conceptual

137. Rubidium metal with $O_2(g)$.

ANS:
$Rb(s) + O_2(g) \rightarrow RbO_2(s)$

PTS: 1 DIF: Moderate REF: 20.2
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group I alkali metal MSC: Conceptual

138. Cesium metal with $Cl_2(g)$.

ANS:
$2Cs(s) + Cl_2(g) \rightarrow 2CsCl(s)$

PTS: 1 DIF: Moderate REF: 20.2
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group I alkali metal MSC: Conceptual

139. Sodium metal with $H_2(g)$.

ANS:
$2Na(s) + H_2(g) \rightarrow 2NaH(s)$

PTS: 1 DIF: Moderate REF: 20.2
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group I alkali metal MSC: Conceptual

140. Lithium metal with $H_2O(l)$.

ANS:
$2Li(s) + 2H_2O(l) \rightarrow 2Li^+(aq) + 2OH^-(aq) + H_2(g)$

PTS: 1 DIF: Moderate REF: 20.2
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group I alkali metal MSC: Conceptual

141. Magnesium metal with $O_2(g)$.

ANS:
$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

PTS: 1 DIF: Moderate REF: 20.4
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIA alkaline earth metal MSC: Conceptual

142. Strontium metal with $Br_2(l)$.

ANS:
$Sr(s) + Br_2(l) \rightarrow SrBr_2(s)$

PTS: 1 DIF: Moderate REF: 20.4
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIA alkaline earth metal MSC: Conceptual

143. Aluminum metal with $O_2(g)$ at high temperatures.

ANS:
$2Al + 3O_2 \rightarrow 2Al_2O_3$

PTS: 1 DIF: Moderate REF: 20.5
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIIA metal MSC: Conceptual

144. Gallium metal with $I_2(s)$.

ANS:
$2Ga(s) + 3I_2(s) \rightarrow 2GaI_3(s)$

PTS: 1 DIF: Moderate REF: 20.5
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IIIA metal MSC: Conceptual

145. Tin metal with $O_2(g)$.

ANS:

$Sn(s) + O_2(g) \rightarrow SnO_2(s)$

PTS: 1 DIF: Moderate REF: 20.6
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IVA metal MSC: Conceptual

146. Lead metal with $Br_2(l)$.

ANS:
$Pb(s) + Br_2(l) \rightarrow PbBr_2(s)$

PTS: 1 DIF: Moderate REF: 20.6
KEY: Chemistry | general chemistry | main group chemistry | main-group metal | group IVA metal MSC: Conceptual

Write a balanced equation for each of the following:

147. The reaction of hydrazine with $O_2(g)$

ANS:
$N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2H_2O(g)$

PTS: 1 DIF: Moderate REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

148. The oxidation of copper metal by 6 *M* nitric acid

ANS:
$8H^+(aq) + 2NO_3^-(aq) + 3Cu(s) \rightarrow 3Cu^{2+}(aq) + 4H_2O(l) + 2NO(g)$

PTS: 1 DIF: Moderate REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

149. The thermal decomposition of $NO(g)$

ANS:
$3NO(g) \rightarrow N_2O(g) + NO_2(g)$

PTS: 1 DIF: Moderate REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

150. The decomposition of nitric acid in sunlight

ANS:
$4HNO_3(aq) \rightarrow 4NO_2(aq) + 2H_2O(l) + O_2(g)$

PTS: 1 DIF: Moderate REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | nitrogen MSC: Conceptual

151. The reaction of sodium phosphide with water

ANS:
$2Na_3P(s) + 6H_2O(l) \rightarrow 2PH_3(g) + 6Na^+(aq) + 6OH^-(aq)$

PTS: 1 DIF: Moderate REF: 20.9
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | phosphorus MSC: Conceptual

152. The reaction of $P_4O_{10}(s)$ with water

ANS:
$P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(aq)$

PTS: 1 DIF: Moderate REF: 20.9
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VA | phosphorus MSC: Conceptual

153. The oxidation of sulfur dioxide by oxygen gas

ANS:
$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

PTS: 1 DIF: Moderate REF: 20.12
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIA | sulfur MSC: Conceptual

154. The reaction of chlorine gas with cold water

ANS:
$Cl_2(g) + H_2O(l) \rightarrow HOCl(aq) + H^+(aq) + Cl^-(aq)$

PTS: 1 DIF: Moderate REF: 20.13
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIIA: halogen MSC: Conceptual

155. The reaction of xenon hexafluoride with *excess* water

ANS:
$XeF_6(s) + 3H_2O(l) \rightarrow XeO_3(aq) + 6HF(aq)$

PTS: 1 DIF: Moderate REF: 20.14
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | group VIIIA: noble gas MSC: Conceptual

156. The smallest ionization energies are found in the _____ _____ region of the periodic table.
A) upper left
B) upper right
C) lower left
D) lower right
E) impossible to tell

ANS: C PTS: 1 DIF: Easy REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry MSC: Conceptual

157. The largest electron affinities are found in the _____ _____ region of the periodic table.
A) upper left
B) upper right
C) lower left
D) lower right
E) impossible to tell

ANS: B PTS: 1 DIF: Easy REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry MSC: Conceptual

158. All of the following are semimetals except
A) B
B) Ge
C) Se
D) Sb
E) Si

ANS: C PTS: 1 DIF: Easy REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry MSC: Conceptual

159. Which of the following elements has the highest electronegativity?
A) Al
B) In
C) S
D) Ba
E) O

ANS: E PTS: 1 DIF: Easy REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry MSC: Conceptual

160. Bromine will form compounds with each of the other elements in Period 4 of the periodic table. How does the type of bonding in the compounds change as one moves from potassium bromide to selenium bromide?
A) polar covalent to ionic
B) ionic to polar covalent
C) polar covalent to non-polar covalent
D) coordinate covalent to polar covalent
E) all are polar covalent

ANS: B PTS: 1 DIF: Easy REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry MSC: Conceptual

161. What is the overall reaction for the production of hydrogen from methane and water?
A) $CH_4(g) + H_2O(g) \rightarrow CO(g) + 3\ H_2(g)$
B) $CO(g) + H_2O(g) \rightarrow CO_2(g) + H_2(g)$
C) $CH_4(g) + 2\ H_2O(g) \rightarrow CO_2(g) + 4\ H_2(g)$
D) $2\ CH_4(g) + 3\ H_2O(g) \rightarrow CO(g) + CO_2(g) + 5\ H_2(g)$
E) $2\ H_2O(g) \rightarrow O_2(g) + 2\ H_2(g)$

ANS: A PTS: 1 DIF: Easy REF: 20.3
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | hydrogen MSC: Conceptual

162. The alkali metal hydrides are excellent _____
A) oxidizing agents
B) reducing agents
C) oxidants
D) acids
E) energy sources

ANS: B PTS: 1 DIF: Easy REF: 20.3
KEY: Chemistry | general chemistry | main group chemistry | main-group nonmetal | hydrogen MSC: Conceptual

163. Which of the following oxides will give the most basic solution when dissolved in water?
A) SO_2
B) CO_2
C) K_2O
D) P_4O_{10}
E) BeO

ANS: C PTS: 1 DIF: Easy REF: 20.1
KEY: Chemistry | general chemistry | main group chemistry | main-group metal
MSC: Conceptual

164. Borane, B_2H_6, forms dimers in which 2 hydrogen atoms bridge between the boron atoms forming 3-center bonds. How many electrons are shared in such a 3-center bond?
A) 1
B) 2
C) 3
D) 4
E) 6

ANS: B PTS: 1 DIF: Moderate REF: 20.5
KEY: Chemistry | general chemistry | main group chemistry | group IIIA
MSC: Conceptual

165. Which Group 3A element has the most stable +1 oxidation state?
A) B
B) Al

C) Ga
D) In
E) Tl

ANS: E PTS: 1 DIF: Easy REF: 20.5
KEY: Chemistry | general chemistry | main group chemistry | group IIIA metal
MSC: Conceptual

166. In which of the following compounds does N have its maximum oxidation state?
A) NH_3
B) N_2O
C) N_2
D) $NaNO_3$
E) HN_3

ANS: D PTS: 1 DIF: Moderate REF: 20.8
KEY: Chemistry | general chemistry | main group chemistry | group VA | nitrogen
MSC: Conceptual

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Chapter 21: Transition Metals and Coordination Chemistry

1. Transition metals display great similarities
   A) within a given period
   B) within a given vertical group
   C) with the semimetals
   D) all of these
   E) A and B only

   ANS: E PTS: 1 DIF: Easy REF: 21.1
   KEY: Chemistry | general chemistry | transition elements | periodic trends
   MSC: Conceptual

2. Which of the transition metals is the best conductor of heat and electric current?
   A) copper
   B) silver
   C) gold
   D) tungsten
   E) titanium

   ANS: B PTS: 1 DIF: Easy REF: 21.1
   KEY: Chemistry | general chemistry | transition elements | periodic trends
   MSC: Conceptual

3. Why do transition metals show a lot of chemical similarities within a given period?
   A) The valence *s* and *p* electrons affect their chemistry more so than the inner *d* and *f* electrons, which do not participate in bonding as easily.
   B) The number of electrons within a given period varies only slightly and is sometimes identical because these metals have more than one ionic form.
   C) All elements in a given period, including the representative elements, have a lot of chemical similarities due to the gradual increase in atomic number.
   D) The transition metals always fill their *s* and *p* orbitals first before filling their *d* orbitals, which affects their chemistry.
   E) None of the above is correct.

   ANS: A PTS: 1 DIF: Easy REF: 21.1
   KEY: Chemistry | general chemistry | transition elements | periodic trends
   MSC: Conceptual

4. Which of the following is incorrect concerning the 3*d*, 4*d*, and 5*d* transition series?
   A) There is a significant increase in radius in going from the 3*d* to the 4*d* metals, but the 4*d* and 5*d* metals are similar in size.
   B) There is a general decrease in size going from left to right for each of these series due to the increasing nuclear charge.
   C) The separation of hafnium and zirconium found together in nature is difficult due to their similarities in chemistry, which is attributed to their virtually identical sizes.
   D) Cerium through lutetium exhibits what is referred to as the lanthanide contraction.
   E) All of the above are correct.

ANS: E PTS: 1 DIF: Moderate REF: 21.1
KEY: Chemistry | general chemistry | transition elements | periodic trends
MSC: Conceptual

5. The reducing abilities of the first-row transition metals generally _____ going from left to right across the period.
   A) decrease
   B) increase
   C) stay the same
   D) none of these
   E) remain at 1.0 V

   ANS: A PTS: 1 DIF: Moderate REF: 21.1
   KEY: Chemistry | general chemistry | transition elements | periodic trends
   MSC: Conceptual

6. Which metal ion has a d^5 electron configuration?
   A) Cr^{2+}
   B) Ag^{+}
   C) Mn^{2+}
   D) Os^{2+}
   E) Co^{2+}

   ANS: C PTS: 1 DIF: Easy REF: 21.1
   KEY: Chemistry | general chemistry | transition elements | periodic trends | electron configuration MSC: Conceptual

7. Which of the following is a d^7 ion?
   A) Co(II)
   B) Cu(II)
   C) Mn(II)
   D) Mn(IV)
   E) At least two of the above (a-d) are d^7 ions.

   ANS: A PTS: 1 DIF: Easy REF: 21.1
   KEY: Chemistry | general chemistry | transition elements | periodic trends | electron configuration MSC: Conceptual

8. What is the maximum oxidation state expected for manganese?
   A) +2
   B) +8
   C) +6
   D) +5
   E) +7

   ANS: E PTS: 1 DIF: Easy REF: 21.1
   KEY: Chemistry | general chemistry | transition elements | periodic trends | oxidation state
   MSC: Conceptual

9. What is the electron configuration of the Sc(I) ion?
   A) [Ar] $4s^1 4d^1$

B) [Ar] $4s^1 3d^1$
C) [Ar] $3s^1 3d^1$
D) [Ar] $4s^2$
E) [Ar] $3d^2$

ANS: E PTS: 1 DIF: Moderate REF: 21.1
KEY: Chemistry | general chemistry | transition elements | periodic trends | electron configuration MSC: Conceptual

10. What is the electron configuration of the Ni(II) ion?
A) [Ar] $4s^2 3d^6$
B) [Ar] $4s^1 3d^7$
C) [Ar] $4s^2 3d^8$
D) [Ar] $3d^8$
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements | periodic trends | electron configuration MSC: Conceptual

11. What is the electron configuration of the Mn(II) ion?
A) [Ar] $4s^2 3d^5$
B) [Ar] $4s^1 3d^5$
C) [Ar] $4s^2 3d^3$
D) [Ar] $3d^5$
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements | periodic trends | electron configuration MSC: Conceptual

12. The electron configuration of Cr^{3+} is
A) [Ar] $4s^2 3d^1$
B) [Ar] $4s^1 3d^2$
C) [Ar] $3d^3$
D) [Ar] $4s^2 3d^4$
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements | periodic trends | electron configuration MSC: Conceptual

13. The electron configuration for Cr^{2+} is
A) [Ar] $4s^2 3d^4$
B) [Ar] $4s^1 3d^5$
C) [Ar] $3d^4$
D) [Ar] $4s^2 3d^2$
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements | periodic trends | electron

configuration MSC: Conceptual

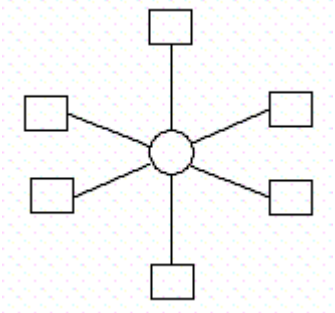
14. The electron configuration of Ti^{2+} is
    A) [Ar] $4s^2$
    B) [Ar] $4s^1 3d^1$
    C) [Ar] $3d^2$
    D) [Ar] $4s^2 3d^2$
    E) none of these

    ANS: C PTS: 1 DIF: Easy REF: 21.1
    KEY: Chemistry | general chemistry | transition elements | periodic trends | electron configuration MSC: Conceptual

15. A complex ion is a charged species consisting of a metal ion surrounded by
    A) other transition metals
    B) hydrogen ions
    C) ligands
    D) ligands and counter ions
    E) none of these

    ANS: C PTS: 1 DIF: Easy REF: 21.1
    KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure and isomerism in coordination compounds | basic definitions
    MSC: Conceptual

16. How many ligands are in this representative drawing of a complex ion?



    A) 1
    B) 3
    C) 6
    D) 7
    E) 8

    ANS: C PTS: 1 DIF: Easy REF: 21.1
    KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure of complex | basic definitions MSC: Conceptual

17. Which of the following transition metals is most likely to form an oxide?
    A) gold
    B) silver
    C) platinum

D) palladium
E) copper

ANS: E PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements | periodic trends | oxidation state
MSC: Conceptual

18. The phenomenon called _____ contraction is responsible for the great similarity in atomic size and chemistry of 4*d* and 5*d* elements.
A) transition
B) coordination
C) lanthanide
D) isomeric
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements | periodic trends | atomic radii
MSC: Conceptual

19. Which of the following is true?
A) The first ionization energy for Zn is significantly higher than that of Sc.
B) The first ionization energy for Zn is significantly lower than that of Sc.
C) The third ionization energy for Zn is significantly higher than that of Sc.
D) The third ionization energy for Zn is significantly lower than that of Sc.
E) Two of these are correct.

ANS: C PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements | periodic trends | ionization energy MSC: Conceptual

20. Which of the following transition metals are important to the U.S. economy and defense?
A) chromium and cobalt
B) manganese
C) platinum and palladium
D) all of these
E) A and B only

ANS: D PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements MSC: Conceptual

21. Which metal is most widely used in the electrical systems of homes and factories?
A) copper
B) silver
C) gold
D) tungsten
E) titanium

ANS: A PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements MSC: Conceptual

22. What transition metal is used in stainless steel?

A) nickel
B) titanium
C) chromium
D) iridium
E) niobium

ANS: C PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements MSC: Conceptual

23. What transition metal is used in magnets, catalysts, and drill bits?
A) nickel
B) copper
C) platinum
D) cobalt
E) titanium

ANS: D PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements MSC: Conceptual

24. True or false: Transition metals show great similarities both within a given period and within a given vertical group.

ANS: T PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements | periodic trends
MSC: Conceptual

25. The metals with the highest ionization energies are most likely to be found in nature in the elemental state.

ANS: T PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements | periodic trends | ionization energy MSC: Conceptual

26. Metals usually have higher melting points than nonmetals.

ANS: T PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements | periodic trends | melting point and boiling point MSC: Conceptual

27. Co^{2+} in water is blue.

ANS: F PTS: 1 DIF: Moderate REF: 21.1
KEY: Chemistry | general chemistry | transition elements MSC: Conceptual

28. The expected electron configuration of Cu^{+} is [Ar] $3s^1 3d^9$.

ANS: F PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements | periodic trends | electron configuration MSC: Conceptual

29. The electron configuration of Mn^{2+} is [Ar] $4s^2 3d^3$.

ANS: F PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements | periodic trends | electron configuration MSC: Conceptual

30. What transition metal has the combination of toughness, stretchability, and resilience that makes it ideal for use in bicycle frames?
A) titanium
B) platinum
C) tungsten
D) nickel
E) aluminum

ANS: A PTS: 1 DIF: Easy REF: 21.2
KEY: Chemistry | general chemistry | transition elements MSC: Conceptual

31. This transition metal is used in the production of a hard steel used for rock crushers and bank vaults, and can be found in nodules on the ocean floor.
A) iron
B) manganese
C) magnesium
D) cobalt
E) nickel

ANS: B PTS: 1 DIF: Easy REF: 21.2
KEY: Chemistry | general chemistry | transition elements MSC: Conceptual

32. What heavy metal is the most abundant and most important to our civilization?
A) iron
B) gold
C) magnesium
D) cobalt
E) copper

ANS: A PTS: 1 DIF: Easy REF: 21.2
KEY: Chemistry | general chemistry | transition elements MSC: Conceptual

33. An element that is a significant component of both brass and bronze is:
A) nickel
B) tin
C) copper
D) iron
E) zinc

ANS: C PTS: 1 DIF: Easy REF: 21.2
KEY: Chemistry | general chemistry | transition elements MSC: Conceptual

34. Which 3*d* transition metal is mixed with concentrated sulfuric acid to give a powerful cleaning solution for removing organic materials from analytical glassware?
A) chromium

B) iron
C) cobalt
D) scandium
E) manganese

ANS: A PTS: 1 DIF: Easy REF: 21.2
KEY: Chemistry | general chemistry | transition elements MSC: Conceptual

35. Which transition metal is valued for its high electrical conductivity and resistance to corrosion, and is widely used for plumbing?
A) iron
B) manganese
C) magnesium
D) cobalt
E) copper

ANS: E PTS: 1 DIF: Easy REF: 21.2
KEY: Chemistry | general chemistry | transition elements MSC: Conceptual

36. What transition metal is mainly used for galvanizing steel?
A) iron
B) zinc
C) copper
D) cobalt
E) nickel

ANS: B PTS: 1 DIF: Easy REF: 21.2
KEY: Chemistry | general chemistry | transition elements MSC: Conceptual

37. How many *d* electrons are present on the metal ion in the complex ion $PtCl_6^{2-}$?
A) 8
B) 6
C) 4
D) 3
E) 2

ANS: B PTS: 1 DIF: Easy REF: 21.3
KEY: Chemistry | general chemistry | transition elements | periodic trends | electron configuration MSC: Conceptual

38. Which of the metal ions in the following complex ions has a d^5 electron configuration?
A) $V(H_2O)_6^{2+}$
B) $Mo(NH_3)_6^{3+}$
C) $Co(CN)_4^-$
D) $Fe(CN)_6^{3-}$
E) $RhCl_6^{4-}$

ANS: D PTS: 1 DIF: Easy REF: 21.3
KEY: Chemistry | general chemistry | transition elements | periodic trends | electron configuration MSC: Conceptual

39. What are the oxidation numbers of each central metal atom in the following coordination compounds?
$K_3[Fe(CN)_6]$, $[Cr(NH_3)_4Br_2]Br$, $[Ni(H_2O)_6]Cl_2$, $Na_2[TaF_7]$
A) 3, 3, 3, 5
B) 3, 3, 2, 7
C) –3, 3, 2, 5
D) –3, 1, 2, 5
E) 3, 3, 2, 5

ANS: E PTS: 1 DIF: Easy REF: 21.3
KEY: Chemistry | general chemistry | transition elements | periodic trends | oxidation state
MSC: Conceptual

40. The coordination theory was proposed by:
A) Bailar
B) Jorgensen
C) Blomstrand
D) Werner
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 21.3
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds MSC: Conceptual

41. Ethylenediamine (en) is a bidentate ligand. What is the coordination number of cobalt in $[Co(en)_2Cl_2]Cl$?
A) four
B) five
C) seven
D) eight
E) six

ANS: E PTS: 1 DIF: Easy REF: 21.3
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure of complex MSC: Conceptual

42. Which of the following coordination compounds will form a precipitate when treated with an aqueous solution of $AgNO_3$?
A) $[Cr(NH_3)_3Cl_3]$
B) $[Cr(NH_3)_6]Cl_3$
C) $[Cr(NH_3)Cl]NO_3$
D) $Na_3[Cr(CN)_6]$
E) $Na_3[CrCl_6]$

ANS: B PTS: 1 DIF: Moderate REF: 21.3
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure of complex MSC: Conceptual

43. When 6.3 moles of $[Co(NH_3)_5Cl]Cl_2$ is dissolved in water, how many moles of ions are in solution?
A) 3.3

B) 4.3
C) 2.1
D) 19
E) 57

ANS: D PTS: 1 DIF: Easy REF: 21.3
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure of complex MSC: Conceptual

44. A coordination compound of Cu^{2+} can be described as $Cu(NH_3)_xSO_4$ and is known to contain 29.92% NH_3 by mass. The value of *x* is:
A) 2
B) 3
C) 4
D) 6
E) none of these

ANS: C
Alert to Publisher: All answer choices remain the same regardless of x value when rounded to 0 decimal places.

PTS: 1 DIF: Moderate REF: 21.3
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure of complex | formula of a complex MSC: Quantitative

45. The empirical formula of a compound with a mass percent composition of 6.78% H, 31.43% N, 39.76% Cl, and 22.03% Co is consistent with which of the following complexes?
A) $[Co(NH_3)_3Cl_3]$
B) $[Co(NH_3)_4Cl_2]Cl$
C) $[Co(NH_3)_5Cl]Cl_2$
D) $[Co(NH_3)_6]Cl_3$
E) none of these

ANS: D PTS: 1 DIF: Moderate REF: 21.3
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure of complex | formula of a complex MSC: Quantitative

Suppose you are studying coordination compounds of Co(II) with the ligand pyridine (py, C_5H_5N, molar mass = 79.10). You isolate a crystalline compound, and since the only available anions are Cl^- and NO_3^-, you hypothesize the empirical formula of the coordination compound must be $Co_w(py)_x(Cl)_y(NO_3)_z$.

46. You discover that the complex decomposes in water. You dissolve 0.1000 g of the complex in H_2O and add excess $NaHg(SCN)_4$, which precipitates Co(II) as $CoHg(SCN)_4(s)$. After the precipitate is washed and dried, its mass is 0.1102 g. How many grams of cobalt are contained in 0.1000 g of the complex?
A) 0.1102
B) 0.0396
C) 0.0132
D) 0.437

E) 0.0548

ANS: C PTS: 1 DIF: Moderate REF: 21.3
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure of complex | formula of a complex MSC: Conceptual

47. You analyze for pyridine (K_b is approximately 10^{-9}) by dissolving 0.1000 g of complex in 10 mL of H_2O and titrating with a 0.01 *M* HCl solution. Which of the following indicators should be used to detect the endpoint? (Assume that the initial concentration of pyridine is approximately 0.01 *M*.)
A) bromophenol blue, pH range of color change = 3.0–4.6
B) methyl red, pH range of color change = 4.8–6.0
C) bromothymol blue, pH range of color change = 6.0–7.6
D) thymol blue, pH range of color change = 8.0 –9.6
E) alizarin yellow, pH range of color change = 10.1–12.0

ANS: A PTS: 1 DIF: Moderate REF: 21.3
KEY: Chemistry | general chemistry | acids and bases | solutions of a weak acid or base with another solute | acid-base titration curve | titration of a weak base by a strong acid
MSC: Conceptual

48. Addition of $AgNO_3$ to aqueous solutions of the complex results in a cloudy white precipitate, presumably AgCl. You dissolve 0.1000 g of the complex in H_2O and perform a precipitation titration with 0.0500 *M* $AgNO_3$ as the titrant. Using an electrode that is sensitive to $[Ag^+]$, you reach the endpoint after 9.00 mL of titrant are added. How many grams of chloride ion were present in the 0.1000-g sample?
A) 4.50×10^{-4}
B) 5.00×10^{-3}
C) 1.77×10^{-3}
D) 6.38×10^{-2}
E) 1.60×10^{-2}

ANS: E PTS: 1 DIF: Moderate REF: 21.3
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure of complex | formula of a complex MSC: Quantitative

49. Analysis of the data from a titration indicates that a 0.1190-g sample of the complex contains 0.0844 g of py. Further analysis shows that 0.1190 g of the complex contains a 0.0157 g of cobalt and 0.0189 g of chloride. What is the empirical formula of the complex?
A) $Co(py)_6(Cl)(NO_3)$
B) $Co(py)_4Cl_2$
C) $Co_2(py)_5(Cl)_2(NO_3)_2$
D) $Co_3(py)_8(Cl)_2(NO_3)_4$
E) $Co(py)_4(NO_3)_2$

ANS: B PTS: 1 DIF: Moderate REF: 21.3
KEY: Chemistry | general chemistry | transition elements | complex ion equilibria | structure of complex | formula of a complex MSC: Quantitative

50. In which of the following complexes does the transition metal have a d^8 configuration?

A) $PtCl_4^{2-}$
B) $Cu(H_2O)_6^{2+}$
C) $Ni(CO)_4$
D) $Zn(NH_3)_4^{2+}$
E) $Fe(CN)_6^{3-}$

ANS: A PTS: 1 DIF: Easy REF: 21.3
KEY: Chemistry | general chemistry | transition elements | periodic trends | electron configuration MSC: Conceptual

51. What is the correct formula for sodium tetrachlorocuprate(II)?
A) $Na_2(CuCl_6)$
B) $Na_4(CuCl_4)$
C) $Na(CuCl_4)$
D) $Na_2(CuCl_4)$
E) $Na_3(CuCl_4)$

ANS: D PTS: 1 DIF: Easy REF: 21.3
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | naming coordination compounds MSC: Conceptual

52. What is the correct IUPAC name for $[AuCl_4(H_2O)_2]^-$?
A) diaquatetrachloroaurate(0) ion
B) diaquatetrachloroaurate(III) ion
C) diaquatetrachloroaurate(I) ion
D) diaquatetrachlorogold(III) ion
E) diaquatetrachlorogold(I) ion

ANS: B PTS: 1 DIF: Easy REF: 21.3
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | naming coordination compounds MSC: Conceptual

53. What is the formula for the hexaaquachromium(II) ion?
A) $[Cr(H_2O)_6]^{2+}$
B) $[Cr_2(H_2O)_6]^{4+}$
C) $[Cr(H_2O)_4]^{2+}$
D) $[Cr_2(H_2O)_6]^{2+}$
E) $[Cr(H_2O)_6]^{4-}$

ANS: A PTS: 1 DIF: Easy REF: 21.3
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | naming coordination compounds MSC: Conceptual

54. What is the formula for the pentaamminehydroxocopper(II) ion?
A) $[Cu(NH_3)(OH)_5]^{3-}$
B) $[Cu(NH_3)_5(OH)_5]^{2+}$
C) $[Cu(NH_3)_5(OH)]^{2+}$
D) $[Cu(NH_3)_5(OH)_5]^{3-}$
E) $[Cu(NH_3)_5(OH)]^{+}$

ANS: E PTS: 1 DIF: Easy REF: 21.3

KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | naming coordination compounds MSC: Conceptual

55. The coordination theory was proposed by Alfred Packer.

ANS: F PTS: 1 DIF: Easy REF: 21.3
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure of complex | basic definitions MSC: Conceptual

56. Consider the following complexes:
I. $Pt(NH_3)_2Cl_2$ (square planar)
II. $Rh(en)_3^{2+}$ (en = $H_2N–CH_2–CH_2–NH_2$ and is bidentate)
III. $CoCl_4^{2–}$ (tetrahedral)
Which can exhibit *cis*-*trans* isomerism?
A) I
B) II
C) III
D) I, II
E) I, II, III

ANS: A PTS: 1 DIF: Moderate REF: 21.4
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure and isomerism in coordination compounds
MSC: Conceptual

57. Which of the following complexes can exhibit optical isomerism?
(en = $H_2N–CH_2–CH_2–NH_2$ and is bidentate)
A) *cis*–$Co(NH_3)_4Cl_2$
B) *trans*–$Co(en)_2Br_2$
C) *cis*–$Co(en)_2Cl_2$
D) $Co(NH_3)_3Cl_3$
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 21.4
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure and isomerism in coordination compounds | stereoisomerism
MSC: Conceptual

58. Because they have the same atoms, bonds, and formulas, geometrical isomers have the same color.

ANS: F PTS: 1 DIF: Easy REF: 21.4
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure and isomerism in coordination compounds | stereoisomerism
MSC: Conceptual

59. Which of the following complexes shows geometrical isomerism?
A) $[Co(NH_3)_5Cl]SO_4$
B) $[Co(NH_3)_6]Cl_3$

C) $[Co(NH_3)_5Cl]Cl_2$
D) $K[Co(NH_3)_2Cl_4]$
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 21.4
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure and isomerism in coordination compounds | stereoisomerism
MSC: Conceptual

60. What is the sum of all isomers (geometrical and optical) that the complex ion $Co(en)_2Cl_2^+$ exhibits?
A) 0
B) 1
C) 2
D) 3
E) 4

ANS: D PTS: 1 DIF: Moderate REF: 21.4
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure and isomerism in coordination compounds | stereoisomerism
MSC: Conceptual

61. Which complex ion shape is not capable of showing *cis–trans* isomerism?
A) octahedral
B) square planar
C) tetrahedral
D) two of these
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 21.4
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure and isomerism in coordination compounds | stereoisomerism
MSC: Conceptual

62. Give the number of geometrical isomers for the octahedral compound $[MA_2B_2C_2]$, where A, B, and C represent ligands.
A) 1
B) 2
C) 3
D) 5
E) none of these

ANS: D PTS: 1 DIF: Difficult REF: 21.4
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure and isomerism in coordination compounds | stereoisomerism
MSC: Conceptual

63. For the process $Co(NH_3)_5Cl^{2+} + Cl^- \rightarrow Co(NH_3)_4Cl_2^+ + NH_3$ what would be the ratio of *cis* to *trans* isomer in the product?
A) 1 : 1
B) 1 : 2

C) 1 : 4
D) 4 : 1
E) 2 : 1

ANS: D PTS: 1 DIF: Moderate REF: 21.4
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure and isomerism in coordination compounds | stereoisomerism
MSC: Conceptual

64. The ____ isomer of the complex $Ni(en)_2Cl_2$ exhibits optical isomers, but the _____ isomer does not.
A) *cis*, *trans*
B) *trans*, *cis*
C) Both isomers exhibit optical isomers.
D) Neither isomers exhibit optical isomers.
E) Depends on the wavelength of plane-polarized light used.

ANS: A PTS: 1 DIF: Easy REF: 21.4
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure and isomerism in coordination compounds | stereoisomerism
MSC: Conceptual

65. How many of the following compounds exhibit geometric isomers?
I. $Pt(NH_3)_2Cl_2$ (square planar)
II. $[Co(H_2O)_2]Cl_3$
III. $Ni(NH_3)_4(NO_2)_2$
IV. $K_2[CoCl_4]$

A) 0
B) 1
C) 2
D) 3
E) 4

ANS: C PTS: 1 DIF: Easy REF: 21.4
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure and isomerism in coordination compounds | stereoisomerism
MSC: Conceptual

66. Which of the following ligands might give linkage isomers?
A) NO_2^-
B) SCN^-
C) $H_2NHC_2CH_2NH_2$
D) A and B
E) A, B, and C

ANS: D PTS: 1 DIF: Easy REF: 21.4
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure and isomerism in coordination compounds | constitutional isomerism
MSC: Conceptual

67. Which of the following are structural isomers?
    I. coordination isomers
    II. linkage isomers
    III. geometrical isomers
    IV. optical isomers

    A) I, III
    B) II, IV
    C) I, III, IV
    D) II, III
    E) I, II

    ANS: E PTS: 1 DIF: Easy REF: 21.4
    KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure and isomerism in coordination compounds | constitutional isomerism
    MSC: Conceptual

68. Which of the following statements concerning the complex ion $Co(en)_2Cl_2^+$ is true? (en = ethylenediamine, $NH_2CH_2CH_2NH_2$)?
    A) The complex ion contains Co(I).
    B) The complex ion exhibits *cis* and *trans* geometrical isomers, but no optical isomers.
    C) The complex ion exhibits two geometrical isomers (*cis* and *trans*) and two optical isomers.
    D) Since en is a strong field ligand (large Δ), the complex ion is paramagnetic.
    E) The geometric isomers of the complex ion have identical chemical properties.

    ANS: C PTS: 1 DIF: Moderate REF: 21.6
    KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds MSC: Conceptual

69. Which of the following is true about coordination complexes?
    A) The metal is a Lewis base and the ligands are Lewis acids.
    B) Only complexes with coordination number six are found in nature.
    C) When the ligands approach a transition metal ion in an octahedral field, the d_{xz}, d_{yz}, and d_{xy} atomic orbitals are affected the least by the ligands.
    D) None of the above is true.
    E) All of the above are true.

    ANS: C PTS: 1 DIF: Moderate REF: 21.6
    KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds MSC: Conceptual

70. Which of the following is paramagnetic?
    A) $Zn(H_2O)_6^{2+}$
    B) $Co(NH_3)_6^{3+}$ (strong field)
    C) $Cu(CN)_3^{2-}$
    D) $Mn(CN)_6^{2-}$ (strong field)
    E) none of these

    ANS: D PTS: 1 DIF: Moderate REF: 21.6

KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

71. The complex ions of Zn^{2+} are all colorless. The most likely explanation for this is:
A) Zn^{2+} is paramagnetic.
B) Zn^{2+} exhibits "*d* orbital" splittings in its complexes such that they absorb all wavelengths in the visible region.
C) Since Zn^{2+} is a d^{10} ion, it does not absorb visible light even though the "*d* orbital" splittings are correct for absorbing visible wavelengths.
D) Zn^{2+} is not a transition metal ion.
E) None of these is correct.

ANS: C PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory MSC: Conceptual

72. Copper(I) complexes would be expected to be colorless.

ANS: T PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | visible spectra of transition-metal complexes
MSC: Conceptual

73. Calculate the total number of unpaired electrons in the following complex ions: $Zn(OH_2)_6^{2+}$, $Ni(CN)_4^{2-}$ (square planar), $Co(NH_3)_6^{3+}$ (strong field).
A) 0
B) 1
C) 2
D) 3
E) 4

ANS: A PTS: 1 DIF: Difficult REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

74. The complex FeL_6^{2+}, where L is a neutral ligand, is known to be diamagnetic. The number of *d* electrons in this complex ion is:
A) 4
B) 5
C) 6
D) 7
E) 8

ANS: C PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | octahedral complex MSC: Conceptual

75. The geometry of a coordination compound with a coordination number of 4 is

A) tetrahedral, in order to minimize repulsions between the ligands
B) octahedral, since there are two different positions possible for each ligand
C) square planar, to allow room for the counterion because the ligands take up so much space
D) linear, since there are two ligands on each side of the transition metal
E) tetrahedral or square planar, but too difficult to predict based on the information given

ANS: E PTS: 1 DIF: Easy REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure of complex MSC: Conceptual

76. Which of the following statements is true about the octahedral complexes of Ni^{2+}?
A) Both strong- and weak-field complexes are diamagnetic.
B) The strong-field complex is diamagnetic and the weak-field complex is paramagnetic.
C) The strong-field complex is paramagnetic and the weak-field complex is diamagnetic.
D) Both strong- and weak-field complexes are paramagnetic.
E) There are no octahedral complexes of Ni.

ANS: D PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | octahedral complex MSC: Conceptual

Specify the number of unpaired electrons.

77. $CuCl_2^-$ (linear)
A) 0
B) 1
C) 2
D) 4
E) 5

ANS: A PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

78. $Ni(NH_3)_6^{2+}$
A) 0
B) 1
C) 2
D) 4
E) 5

ANS: C PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

79. $NiCl_4^{2-}$ (tetrahedral)
A) 0
B) 1
C) 2
D) 4
E) 5

ANS: C PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

80. CoF_6^{3-} (weak field)
A) 0
B) 1
C) 2
D) 4
E) 5

ANS: D PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

81. $Co(en)_3^{3+}$ (strong field)
A) 0
B) 1
C) 2
D) 4
E) 5

ANS: A PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

82. $Mn(H_2O)_4^{3+}$ (tetrahedral)
A) 0
B) 1
C) 2
D) 4
E) 5

ANS: D PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

83. Fluoride ion ranks low in the spectrochemical series and produces a weak crystal field in complex ions. Based on this information, predict the number of unpaired electrons in CoF_6^{4-}.

A) 0
B) 1
C) 2
D) 3
E) 4

ANS: D PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

84. According to crystal field theory, how many unpaired electrons are present in the complex ion $[Fe(H_2O)_6]^{2+}$? The water molecules are weak field ligands.
A) 1
B) 2
C) 3
D) 4
E) 5

ANS: D PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

85. How many unpaired electrons are present in the tetrahedral complex $[CoCl_4]^-$?
A) 1
B) 2
C) 3
D) 4
E) 5

ANS: D PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

86. Which has the greatest number of unpaired electrons?
A) The square planar complex $Ni(CN)_4^{2-}$.
B) The tetrahedral complex $FeCl_4^-$.
C) Neither of the above have any unpaired electrons.
D) Both (A and B) have the same number (non-zero) of unpaired electrons.
E) More information is needed.

ANS: B PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

87. A d^6 ion (Fe^{2+}) is complexed with six strong-field ligands (for example, SCN^-). What is the number of unpaired electrons in this complex?
A) 0

B) 1
C) 2
D) 3
E) 4

ANS: A PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

88. How many unpaired electrons are there in $Ir(Br)_6^{4-}$? (Br^- is a weak-field ligand.)
A) 4
B) 3
C) 2
D) 1
E) 0

ANS: B PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

89. The complex ion $NiCl_4^{2-}$ is tetrahedral. The number of unpaired electrons in the complex is:
A) 0
B) 1
C) 2
D) 3
E) 4

ANS: C PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

90. How many unpaired electrons are there in the tetrahedral complex ion $[FeCl_4]^-$?
A) 1
B) 2
C) 3
D) 4
E) 5

ANS: E PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | tetrahedral and square planar complexes
MSC: Conceptual

91. A metal ion in a high-spin octahedral complex has two more unpaired electrons than the same ion does in a low-spin octahedral complex. The metal ion could be:
A) V^{2+}
B) Cu^{2+}
C) Mn^{2+}

D) Cr^{3+}
E) Co^{2+}

ANS: E PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

92. For which of the following metal ions would there be no low-spin versus high-spin distinction in octahedral complexes?
A) Cr^{2+}
B) V^{2+}
C) Fe^{3+}
D) Mn^{2+}
E) Co^{3+}

ANS: B PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

93. How many unpaired electrons are there in a complex ion having a d^5 electron configuration and an octahedral geometry in the weak field case?
A) 1
B) 2
C) 3
D) 4
E) 5

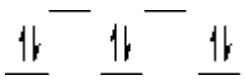
ANS: E PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

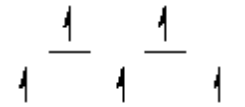
94. The spectrochemical series is $I^- < Br^- < Cl^- < F^- < OH^- < H_2O < NH_3 < en < NO_2^- < CN^-$ Which of the following complexes will absorb visible radiation of the highest energy (shortest wavelength)?
A) $[Co(H_2O)_6]^{3+}$
B) $[Co(I)_6]^{3-}$
C) $[Co(OH)_6]^{3-}$
D) $[Co(en)_3]^{3+}$
E) $[Co(NH_3)_6]^{3+}$

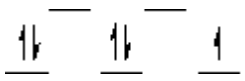
ANS: D PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | visible spectra of transition-metal complexes
MSC: Conceptual

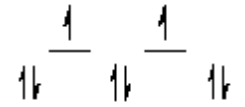
Here are some crystal field representations of *d* electrons in an octahedral complex:

I)

II) 

III) 

IV) 

V) 

Choose the representation that fits the transition metal atom in the following species:

95. $Fe(OH_2)_6^{3+}$ (assume weak field)
A) representation I
B) representation II
C) representation III
D) representation IV
E) representation V

ANS: C PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | octahedral complex MSC: Conceptual

96. $[Co(NH_3)_4Br_2]^+$
A) representation I
B) representation II
C) representation III
D) representation IV
E) representation V

ANS: B PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | octahedral complex MSC: Conceptual

97. $K_4Mn(CN)_6$ (assume strong field)
A) representation I
B) representation II
C) representation III
D) representation IV
E) representation V

ANS: D PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination

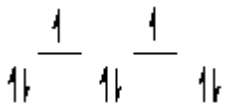
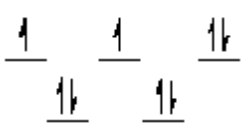
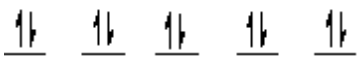
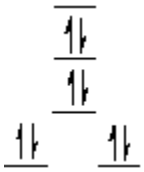
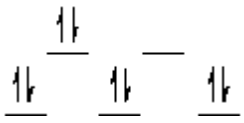
compounds | crystal field theory | octahedral complex MSC: Conceptual

98. $K_4Fe(CN)_6$
A) representation I
B) representation II
C) representation III
D) representation IV
E) representation V

ANS: B PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | octahedral complex MSC: Conceptual

99. $[Cr(NH_3)_5Cl]SO_4$
A) representation I
B) representation II
C) representation III
D) representation IV
E) representation V

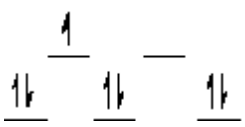
ANS: A PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | octahedral complex MSC: Conceptual

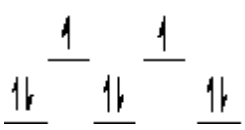
100. A complex ion is a square planar complex. It has a d^8 electron configuration. What is the most reasonable *d* orbital scheme for this complex?
A) 
B) 
C) 
D) 
E) 

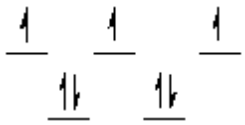
ANS: D PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | tetrahedral and square planar complexes
MSC: Conceptual

101. Which of the following crystal field diagrams is correct for $Co(CN)_6^{4-}$ where CN^- is a strong field ligand?

A)

B) 

C) 

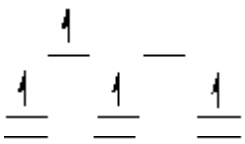
D) 

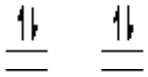
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory MSC: Conceptual

102. Which of the following crystal field diagrams is correct for $Mn(CN)_6^{3-}$ (CN^- is a strong field ligand)?

A)

B) 

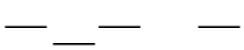
C) 

D)

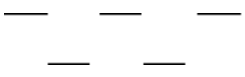
E) none of these

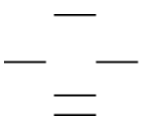
ANS: A PTS: 1 DIF: Easy REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory MSC: Conceptual

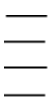
103. Choose the most likely pattern for the crystal field diagram for the complex *trans*–$[Ni(NH_3)_2(CN)_4]^{2-}$ where CN^- produces a much stronger crystal field than does NH_3.

A) 

B)

C) 

D) 

E) 

ANS: B PTS: 1 DIF: Difficult REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory MSC: Conceptual

104. Which of the following is true in describing the crystal field model?
A) The metal ion and ligand interaction is treated as a Lewis acid–base interaction.
B) The ligands are treated as negative point charges.
C) The metal ion–ligand bonds are considered to be completely ionic.
D) The electrons are assumed to be localized.
E) None of the above is true.

ANS: B PTS: 1 DIF: Easy REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory MSC: Conceptual

105. Which model(s) accounts for the magnetism and color of coordination compounds?
I. Lewis model
II. localized electron model
III. crystal field model

A) I
B) II
C) III
D) I, II
E) none accounts for both phenomena

ANS: C PTS: 1 DIF: Easy REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory MSC: Conceptual

106. Which of the following complexes would be diamagnetic (all electrons paired)? Assume the strong-field case for all complexes.
A) $[Ni(CN)_6]^{4-}$
B) $[Ti(CN)_6]^{3-}$
C) $[Co(CN)_6]^{3-}$
D) $[Cr(CN)_6]^{3-}$
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

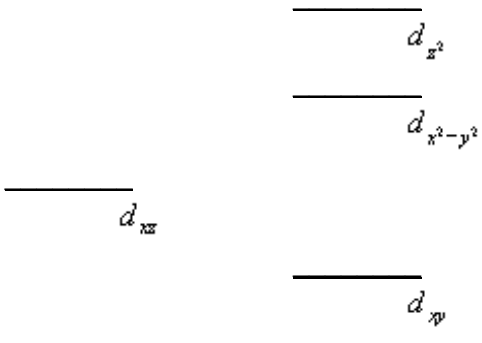
107. How many unpaired electrons are there in the complex ion $[Co(NO_3)_6]^{4-}$? For this ion the nitrate ligands produce a very strong crystal field.

A) 1
B) 2
C) 3
D) 4
E) 5

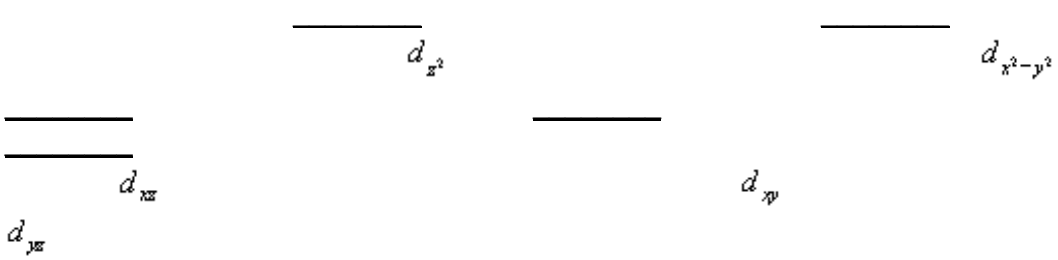
ANS: A PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

108. A certain complex ion has a distorted octahedral structure in which the ligands along the plus and minus *z* axes are compressed (pushed in closer to the central metal ion). The *d* orbital splitting diagram for this complex ion would be:

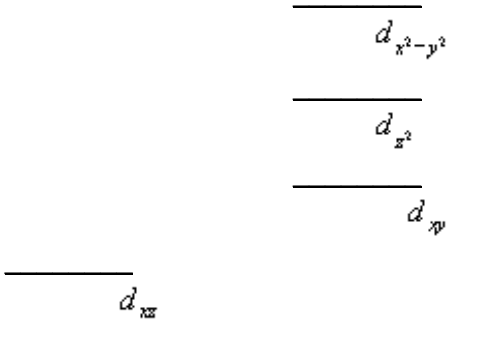
A)



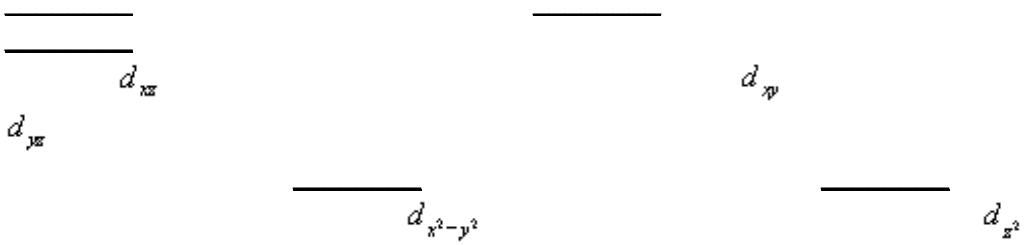
B)

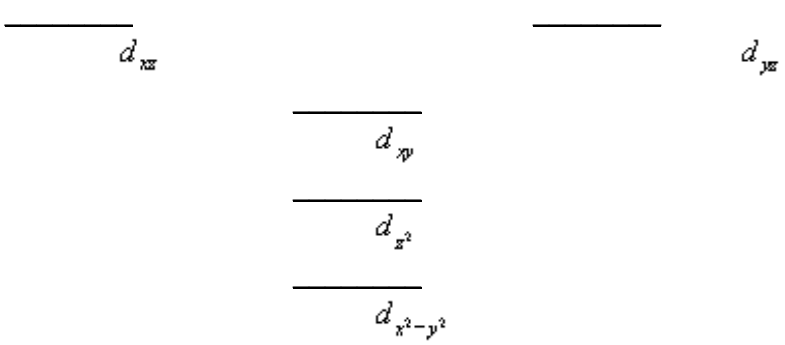


C)



D)



E) 

ANS: A PTS: 1 DIF: Difficult REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | octahedral complex MSC: Conceptual

109. The color of a transition metal complex results from:
A) bending vibrations
B) stretching vibrations
C) transition of an electron between *d* orbitals
D) transition of an electron between an *s* and a *p* orbital
E) nuclear magnetic resonance

ANS: C PTS: 1 DIF: Easy REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | visible spectra of transition-metal complexes
MSC: Conceptual

110. The complex ion $Fe(CN)_6^{4-}$ (no unpaired electrons) is classified as:
A) weak field
B) strong field
C) no way to tell

ANS: B PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

111. The complex ion $Co(NH_3)_6^{2+}$ (three unpaired electrons) is classified as:
A) weak field
B) strong field
C) no way to tell

ANS: A PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

112. The complex ion $Ni(NH_3)_6^{2+}$ (two unpaired electrons) is classified as:
A) weak field
B) strong field
C) no way to tell

ANS: C PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

113. All tetrahedral complex ions are high spin.

ANS: T PTS: 1 DIF: Easy REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | tetrahedral and square planar complexes
MSC: Conceptual

114. The complex ions containing Zn^{2+} are intensely colored.

ANS: F PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | visible spectra of transition-metal complexes
MSC: Conceptual

115. The complexes of Zn^{2+} are all diamagnetic.

ANS: T PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

116. In the crystal field model, ligands are treated as negative point charges.

ANS: T PTS: 1 DIF: Easy REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory MSC: Conceptual

117. Cytochromes consist of two main parts:
A) myoglobin and heme
B) heme and porphyrin
C) heme and a protein
D) myoglobin and porphyrin
E) an iron ion and porphyrin

ANS: C PTS: 1 DIF: Easy REF: 21.7
KEY: Chemistry | general chemistry | transition elements MSC: Conceptual

118. Hemoglobin is a complex of
A) Co^{3+}
B) Mg^{2+}
C) Fe^{2+}
D) Sc^{3+}
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 21.7

KEY: Chemistry | general chemistry | transition elements MSC: Conceptual

119. The iron in hemoglobin is _____ when carrying oxygen to cells, and _____ after releasing the oxygen.
A) diamagnetic Fe^{2+}, paramagnetic Fe^{3+}
B) diamagnetic Fe^{2+}, paramagnetic Fe^{2+}
C) paramagnetic Fe^{2+}, diamagnetic Fe^{3+}
D) paramagnetic Fe^{3+}, diamagnetic Fe^{3+}
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 21.7
KEY: Chemistry | general chemistry | transition elements MSC: Conceptual

120. Oxygen is stored in mammalian tissue in which type of molecule?
A) hemoglobin
B) myoglobin
C) chlorophyll
D) cytochrome
E) prophyrin

ANS: B PTS: 1 DIF: Easy REF: 21.7
KEY: Chemistry | general chemistry | transition elements MSC: Conceptual

121. The transition metal _____ assists insulin in the control of blood sugar and may also be involved in the control of cholesterol.
A) scandium
B) titanium
C) iron
D) nickel
E) chromium

ANS: E PTS: 1 DIF: Easy REF: 21.7
KEY: Chemistry | general chemistry | transition elements MSC: Conceptual

122. The transition metal _____ is present in vitamin B_{12}.
A) nickel
B) titanium
C) cobalt
D) zinc
E) chromium

ANS: C PTS: 1 DIF: Easy REF: 21.7
KEY: Chemistry | general chemistry | transition elements MSC: Conceptual

123. This molecule is toxic because it has about 200 times the affinity for the Fe^{2+} in hemoglobin as oxygen does, causing asphyxiation if enough of it is present in the air.
A) CN^-
B) CO
C) CO_2
D) NH_3
E) CH_4

ANS: B PTS: 1 DIF: Easy REF: 21.7
KEY: Chemistry | general chemistry | transition elements MSC: Conceptual

124. Carboxyhemoglobin is formed when _____ prevents the normal uptake of oxygen in the blood.
A) CN^-
B) CO
C) CO_2
D) NH_3
E) CH_4

ANS: B PTS: 1 DIF: Easy REF: 21.7
KEY: Chemistry | general chemistry | transition elements MSC: Conceptual

125. When the body adapts to high altitudes, it makes more _____ to adapt to lower oxygen concentrations in the blood.
A) myoglobin
B) iron
C) protein
D) hemoglobin
E) fatty tissue

ANS: D PTS: 1 DIF: Easy REF: 21.7
KEY: Chemistry | general chemistry | transition elements MSC: Conceptual

126. Which of the following materials is added to the blast furnace to produce slag?
A) sulfur
B) carbon
C) silicon
D) limestone
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 21.8
KEY: Chemistry | general chemistry | materials chemistry | metal | metallurgy
MSC: Conceptual

127. Name the careful heat treatment of metals that provides the proper combination of strength without too much brittleness.
A) tempering
B) core hardening
C) fire polishing
D) blast furnace
E) direct reduction

ANS: A PTS: 1 DIF: Easy REF: 21.8
KEY: Chemistry | general chemistry | materials chemistry | metal | metallurgy
MSC: Conceptual

128. Which of the following is not a typical step in metallurgy?
A) reduction

B) refining
C) alloying
D) roasting
E) transmutation

ANS: E PTS: 1 DIF: Easy REF: 21.8
KEY: Chemistry | general chemistry | materials chemistry | metal | metallurgy
MSC: Conceptual

129. Pig iron usually contains about 5%:
A) aluminum
B) oxygen
C) sodium
D) sulfur
E) carbon

ANS: E PTS: 1 DIF: Easy REF: 21.8
KEY: Chemistry | general chemistry | materials chemistry | metal | alloy
MSC: Conceptual

130. The strength of steel is due to the effect of what substance with the iron?
A) copper
B) carbon monoxide
C) sulfur
D) carbon
E) zinc

ANS: D PTS: 1 DIF: Easy REF: 21.8
KEY: Chemistry | general chemistry | materials chemistry | metal | alloy
MSC: Conceptual

131. Which of the following ligands are capable of linkage isomerism?
N^-
NO_2^-
NH_3
$NH_2CH_2CH_2NH_2$
OCN^-
Cl^-
H_2O
SCN^-

ANS:
SCN^-, NO_2^-, and OCN^-

PTS: 1 DIF: Easy REF: 21.4
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure and isomerism in coordination compounds | constitutional isomerism
MSC: Conceptual

132. Define stereoisomerism.

ANS:
Stereoisomers have the same bonds, but different spatial arrangements of the atoms. Types of stereoisomers include geometrical (*cis-trans*) and optical isomers.

See Sec. 21.4 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Easy REF: 21.4
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure and isomerism in coordination compounds | stereoisomerism
MSC: Conceptual

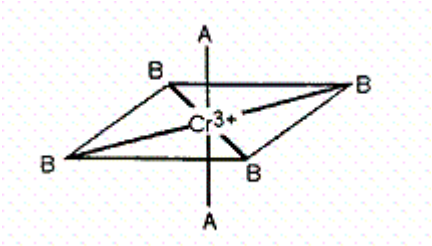
133. Define optical isomerism.

ANS:
Optical isomerism occurs when stereoisomers have opposite effects on plane-polarized light. Such steroisomers are nonsuperimposable mirror images.

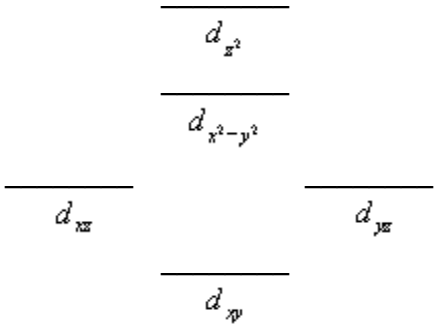
See Sec. 21.4 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Easy REF: 21.4
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure and isomerism in coordination compounds | stereoisomerism
MSC: Conceptual

134. Consider the pseudo-octahedral complex of Cr^{3+} shown below, where A and B represent Lewis bases and where A produces a stronger crystal field than B. Draw an appropriate crystal field diagram for this complex (include the electrons).



ANS:



The orbitals with lobes pointed in the *z*-direction will be affected. Strong field interactions result in higher energy of the affected *d*-orbitals. Thus, the normal octahedral crystal field diagram will be distorted, with d_{z^2}, d_{xz}, and d_{yz} at raised energy levels.
See Sec. 21.6 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Difficult REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | octahedral complex MSC: Conceptual

135. The 3*d* electrons in $Co(NH_3)_6^{3+}$ are all paired but $Fe(H_2O)_6^{3+}$ has unpaired electrons (is paramagnetic). Explain.

ANS:
Both complex ions have six 3*d* electrons. $Co(NH_3)_6^{3+}$ is low spin because NH_3 produces a strong field when it coordinates with CO^{3+}. $Fe(H_2O)_6^{2+}$ is high spin because H_2O produces a weak field when it coordinates with Fe^{2+}.
See Sec. 21.6 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

How many unpaired electrons are found in each of the following complex ions?

136. $CoBr_4^-$ (tetrahedral)

ANS:
4

PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

137. $Fe(CN)_6^{4-}$

ANS:
0

PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

138. $[Zn(CN)_6]^{4-}$

ANS:
0

PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

139. $NiCl_4^{2-}$

ANS:
0

PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

140. $FeCl_4^{2-}$

ANS:
4

PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

141. $[Ni(CN)_6]^{4-}$

ANS:
2

PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

142. $[Cr(CN)_4]^{2-}$

ANS:
4

PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

143. $[Co(NH_3)_4]^{2+}$

ANS:

PTS: 1 DIF: Moderate REF: 21.6
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | crystal field theory | high-spin and low-spin complex
MSC: Conceptual

144. Which of the following atoms has the smallest radius?
A) Sc
B) Ti
C) V
D) Cr
E) Fe

ANS: E PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements | periodic trends | atomic radii
MSC: Conceptual

145. Which of the following elements has the highest density?
A) Hg
B) W
C) Ta
D) Au
E) Ir

ANS: E PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements | periodic trends
MSC: Conceptual

146. Which of the following manganese species is likely to be the best oxidizing agent?
A) $MnO_4^{2-}(aq)$
B) $MnO_4^{-}(aq)$
C) $MnO_2(s)$
D) $Mn^{2+}(aq)$
E) Mn(s)

ANS: B PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements | periodic trends | reduction potential MSC: Conceptual

147. Which of the following metals (M) is mostly likely to form a chloride of the formula MCl_4?
A) Sc
B) Ti
C) Cr
D) Fe
E) Ni

ANS: B PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements | periodic trends | oxidation state
MSC: Conceptual

148. Which of the following metals (M) is mostly likely to form a chloride of the formula MCl_5?
A) Sc
B) Ti
C) Cr
D) V
E) Mn

ANS: D PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements | periodic trends | oxidation state
MSC: Conceptual

149. Which of the following metals (M) is mostly likely to form an oxide of the formula MO_3?
A) Sc
B) Ti
C) Cr
D) V
E) Mn

ANS: C PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements | periodic trends | oxidation state
MSC: Conceptual

150. Which 1st row transition metal demonstrates the most oxidation states?
A) Fe
B) Ti
C) Cr
D) V
E) Mn

ANS: E PTS: 1 DIF: Easy REF: 21.1
KEY: Chemistry | general chemistry | transition elements | periodic trends | oxidation state
MSC: Conceptual

151. How many oxygen atoms are present in the formula for triamminetriaquairon(II)sulfate?
A) 2
B) 3
C) 4
D) 6
E) 7

ANS: E PTS: 1 DIF: Easy REF: 21.3
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | structure of complex MSC: Conceptual

152. How many places on the ligand EDTA can simultaneously bind to a single metal atom?
A) 1
B) 2
C) 3
D) 4
E) 6

ANS: E PTS: 1 DIF: Easy REF: 21.3
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | polydentate ligand MSC: Conceptual

153. How many places on the ligand ethylene diamine can simultaneously bind to a single metal atom?
A) 1
B) 2
C) 3
D) 4
E) 6

ANS: B PTS: 1 DIF: Easy REF: 21.3
KEY: Chemistry | general chemistry | transition elements | complex ions and coordination compounds | polydentate ligand MSC: Conceptual

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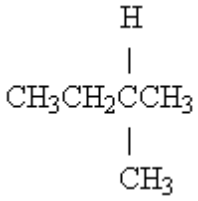
Chapter 22: Organic and Biological Molecules

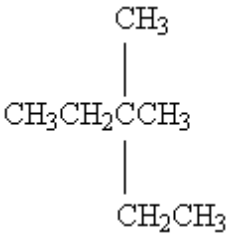
1. Name the following:



A) isopropane
B) methylpentane
C) methylbutane
D) *n*-pentane
E) dodecane

ANS: C PTS: 1 DIF: Easy REF: 22.1
KEY: Chemistry | organic chemistry | alkane | nomenclature MSC: Conceptual

2. Name the following:



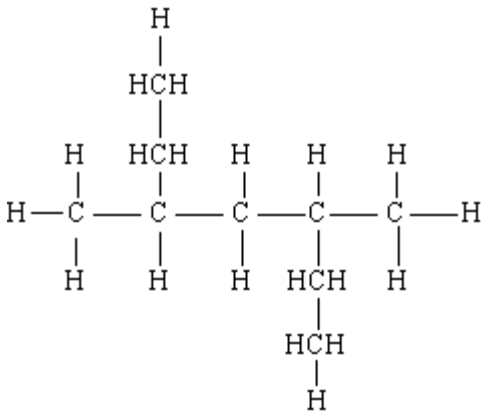
A) *n*-heptane
B) 2-methyl-2-ethylbutane
C) 3,3-dimethylpentane
D) 2,2-diethylpropane
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 22.1
KEY: Chemistry | organic chemistry | alkane | nomenclature | IUPAC nomenclature
MSC: Conceptual

3. Name the following: $CH_3–CH_2–CH_3$
A) ethane
B) propane
C) butane
D) pentane
E) hexane

ANS: B PTS: 1 DIF: Easy REF: 22.1
KEY: Chemistry | organic chemistry | alkane | nomenclature MSC: Conceptual

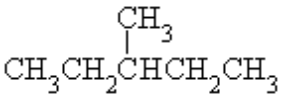
4. Name the following:



A) 2,4-diethylpentane
B) 3,5-dimethylheptane
C) secondary ethylpentane
D) 2,3-dimethyl-2,3-diethylpropane
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 22.1
KEY: Chemistry | organic chemistry | alkane | nomenclature | IUPAC nomenclature
MSC: Conceptual

5. Name the following:



A) *n*-hexane
B) isohexane
C) 1,2,3-trimethylpropane
D) methyl-diethylmethane
E) 3-methylpentane

ANS: E PTS: 1 DIF: Easy REF: 22.1
KEY: Chemistry | organic chemistry | alkane | nomenclature | IUPAC nomenclature
MSC: Conceptual

6. Name the following:

$CH_3–(CH_2)_6–CH_3$

A) pentane
B) hexane
C) heptane
D) octane
E) nonane

ANS: D PTS: 1 DIF: Easy REF: 22.1
KEY: Chemistry | organic chemistry | alkane | nomenclature MSC: Conceptual

7. A student gave a molecule the following name:

2-methyl-4-t-butylpentane

However, the teacher pointed out that, although the molecule could be correctly drawn from this name, the name violates the IUPAC rules. What is the correct (IUPAC) name of the molecule?

A) 2-t-butyl-4-methylpentane
B) 2,2,3,5-tetramethylhexane
C) 2,4,5,5-tetramethylhexane
D) 1-sec-butyl-1,2,2-trimethylpentane
E) none of these

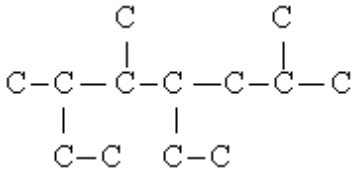
ANS: B PTS: 1 DIF: Easy REF: 22.1
KEY: Chemistry | organic chemistry | alkane | nomenclature | IUPAC nomenclature
MSC: Conceptual

8. Which of the following names is a correct one?

A) 3-methyl-4-isopropylpentane
B) 2-ethyl-4-tertiary-butylpentane
C) 2,2,3,5-tetramethylheptane
D) t-butylethane
E) *trans*-1,2-dimethylethane

ANS: C PTS: 1 DIF: Easy REF: 22.1
KEY: Chemistry | organic chemistry | alkane | nomenclature | IUPAC nomenclature
MSC: Conceptual

9. What is the compound whose carbon skeleton (minus any hydrogen atoms) appears below?



A) 2,4-diethyl-3,6-dimethylheptane
B) 2,5-dimethyl-4,6-diethylheptane
C) 1,4-diethyl-3,6-dimethyl-tridecane
D) 5-ethyl-3,6-trimethyloctane
E) 4-ethyl-2,5,6-trimethyloctane

ANS: E PTS: 1 DIF: Easy REF: 22.1
KEY: Chemistry | organic chemistry | alkane | nomenclature | IUPAC nomenclature
MSC: Conceptual

10. A student gave a molecule the following name: 2-ethyl-3-methyl-5-isopropylhexane
However, his TA pointed out that, although the molecule could be correctly drawn from this name, the name violates the systematic rules. What is the correct (systematic) name of the molecule?

A) 3,4-dimethyl-6-isopropylheptane
B) 2-isopropyl-4,5-dimethylheptane
C) 3,4,6,7-tetramethyloctane
D) 1,2-diethyl-3,6,7-trimethylheptane
E) 2,3,5,6-tetramethyloctane

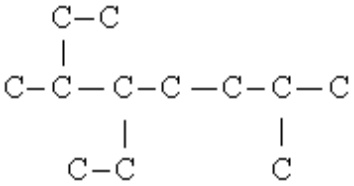
ANS: E PTS: 1 DIF: Easy REF: 22.1

KEY: Chemistry | organic chemistry | alkane | nomenclature | IUPAC nomenclature
MSC: Conceptual

11. In lecture, the professor named a molecule 4-ethylpentane. An alert student pointed out that although the correct structure could be drawn, the name did not follow systematic rules. What is the correct systematic name for the molecule?
A) 2-ethylpentane
B) 1-methyl-1-propylpropane
C) 3-methylhexane
D) 4-methylhexane
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 22.1
KEY: Chemistry | organic chemistry | alkane | nomenclature | IUPAC nomenclature
MSC: Conceptual

12. The compound below is the carbon skeleton (minus any hydrogen atoms) of



Which of these phrases could be used to describe this compound?
I. $C_{12}H_{26}$
II. a substituted octane
III. a compound with 3 tertiary carbons
IV. a compound with 3 secondary carbons
V. a compound with 2 isopropyl groups

A) I, II, III
B) II, III, IV
C) III, IV, V
D) II, IV, V
E) I, II, III, IV

ANS: A PTS: 1 DIF: Easy REF: 22.1
KEY: Chemistry | organic chemistry | carbon atom | classification of carbon in compounds
MSC: Conceptual

13. Which of the following pairs is incorrect?
A) ethane – C_2H_4
B) pentane – C_5H_{12}
C) hexane – C_6H_{14}
D) heptane – C_7H_{16}
E) octane – C_8H_{18}

ANS: A PTS: 1 DIF: Easy REF: 22.1
KEY: Chemistry | organic chemistry | alkane | structural characteristic
MSC: Conceptual

14. Why does octane have a higher boiling point than ethane, 126°C versus –89°C?
    A) Octane exhibits hydrogen bonding and ethane does not.
    B) Octane has a higher vapor pressure than ethane.
    C) Octane contains more double bonds than ethane.
    D) Octane has stronger London dispersion forces than ethane.
    E) At least two of the above are correct.

    ANS: D PTS: 1 DIF: Easy REF: 22.1
    KEY: Chemistry | organic chemistry | alkane | physical properties
    MSC: Conceptual

15. How many isomers of C_3H_8 are there?
    A) 1
    B) 2
    C) 3
    D) 5
    E) 6

    ANS: A PTS: 1 DIF: Easy REF: 22.1
    KEY: Chemistry | organic chemistry | alkane | isomerism MSC: Conceptual

16. Which is a possible product of the chlorination of butane in the presence of light?
    A) C_4H_9Cl
    B) C_4H_8Cl
    C) $C_4H_{10}Cl_2$
    D) $C_4H_6Cl_2$
    E) $C_4H_9Cl_2$

    ANS: A PTS: 1 DIF: Moderate REF: 22.1
    KEY: Chemistry | organic chemistry | alkane | chemical reaction | halogenation
    MSC: Conceptual

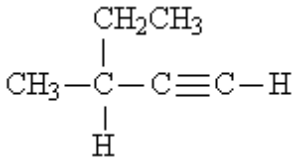
17. Which of the following, upon reacting with oxygen, would form the greatest amount of carbon dioxide?
    A) *n*-pentane
    B) isopentane
    C) neopentane
    D) Two of the above would form equal amounts.
    E) All (A-C) of the above would form equal amounts.

    ANS: E PTS: 1 DIF: Easy REF: 22.1
    KEY: Chemistry | organic chemistry | alkane | chemical reaction | combustion
    MSC: Conceptual

18. Cyclobutane has 109° bond angles like all alkanes.

    ANS: F PTS: 1 DIF: Easy REF: 22.1
    KEY: Chemistry | organic chemistry | cycloalkane | structural characteristic
    MSC: Conceptual

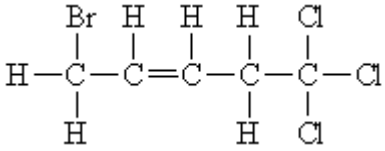
19. Name the following:



A) 1-hexyne
B) 2-ethynyl butane
C) 2-ethyl-3-butyne
D) 3-methyl-1-pentyne
E) 3-methyl-4-pentyne

ANS: D PTS: 1 DIF: Easy REF: 22.2
KEY: Chemistry | organic chemistry | alkyne | nomenclature | IUPAC nomenclature
MSC: Conceptual

20. Name the following:



A) 1,1,1-trichloro-5-bromo-3-pentene
B) 1-bromo-5,5,5-trichloro-2-pentene
C) 1,1,1-trichloro-5-bromo-2-pentene
D) 1,1,1-trichloro-5-bromo-3-pentyne
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 22.2
KEY: Chemistry | organic chemistry | alkene | nomenclature | IUPAC nomenclature
MSC: Conceptual

21. $CH_3C \equiv CCH_2CH_2Cl$ is named:
A) 1-chloro-3-pentyne
B) 5-chloro-2-pentene
C) 1-acetylenyl-3-chloropropane
D) 5-chloro-2-pentyne
E) 1-chloro-3-pentene

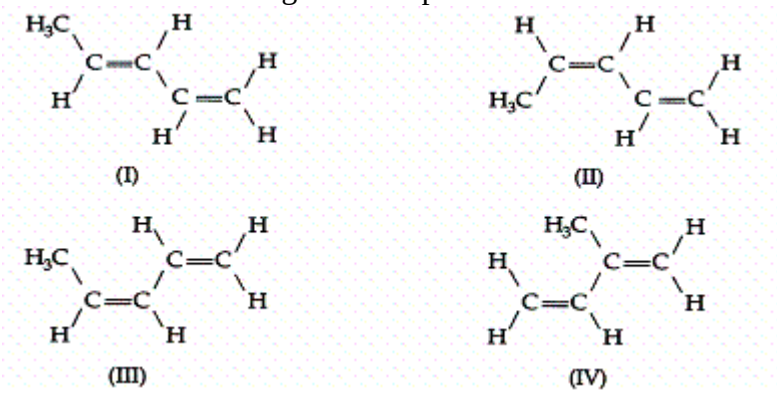
ANS: D PTS: 1 DIF: Easy REF: 22.2
KEY: Chemistry | organic chemistry | alkyne | nomenclature | IUPAC nomenclature
MSC: Conceptual

22. One of the ingredients on a margarine container is listed as "polyunsaturated corn oil." This means that:
A) All the carbon bonds in the oil are single bonds.
B) Many of the polymer bonds are unsaturated.
C) All the carbon–carbon bonds are triple bonds.
D) Many of the carbon–carbon bonds are multiple bonds.
E) None of these.

ANS: D PTS: 1 DIF: Easy REF: 22.2
KEY: Chemistry | organic chemistry | alkene | structural characteristic

MSC: Conceptual

23. Consider the following four compounds:



Which are the same molecule?
A) I and II
B) I and III
C) II and III
D) III and IV
E) I and IV

ANS: C PTS: 1 DIF: Easy REF: 22.2
KEY: Chemistry | organic chemistry | alkene MSC: Conceptual

24. Consider the molecule *trans*-2-butene. Which statement is true?
A) The molecule has two π bonds.
B) There is free rotation around every bond in the molecule.
C) *Cis*-2-butene is its structural isomer.
D) Carbon #2 exhibits sp^2 hybridization.
E) None of the above.

ANS: D PTS: 1 DIF: Moderate REF: 22.2
KEY: Chemistry | organic chemistry | alkene | structural characteristic
MSC: Conceptual

25. Hydrocarbons containing a carbon–carbon triple bond are called
A) alkynes
B) alkenes
C) cyclic alkanes
D) aldehydes
E) alkanes

ANS: A PTS: 1 DIF: Easy REF: 22.2
KEY: Chemistry | organic chemistry | alkyne | structural characteristic
MSC: Conceptual

26. How many of the following molecules exist?
I. methene
II. cycloethane
III. cyclopropyne

IV. neobutane

A) 0
B) 1
C) 2
D) 3
E) 4

ANS: A PTS: 1 DIF: Moderate REF: 22.2
KEY: Chemistry | organic chemistry | carbon atom | hydrocarbons and hydrocarbon derivative MSC: Conceptual

27. How many isomers are there of "dichloroethene"?
A) 2
B) 3
C) 4
D) 5
E) 6

ANS: B PTS: 1 DIF: Easy REF: 22.2
KEY: Chemistry | organic chemistry | alkene | isomerism MSC: Conceptual

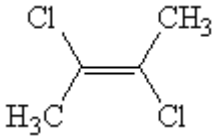
28. Propane undergoes dehydrogenation. The product of this is
A) 1-propene
B) 2-propene
C) *cis*-1-propene
D) *trans*-1-propene
E) *cis*-2-propene

ANS: A PTS: 1 DIF: Moderate REF: 22.2
KEY: Chemistry | organic chemistry | alkene | sources MSC: Conceptual

29. Chemical reactions involving alkanes in which hydrogen atoms are removed and the product is an unsaturated hydrocarbon are called
A) combustion reactions
B) dehydrogenation reactions
C) substitution reactions
D) addition reactions
E) polymerization reactions

ANS: B PTS: 1 DIF: Easy REF: 22.2
KEY: Chemistry | organic chemistry | alkene | sources MSC: Conceptual

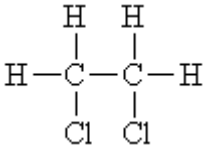
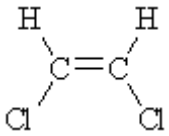
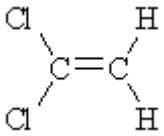
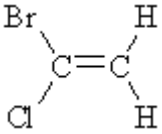
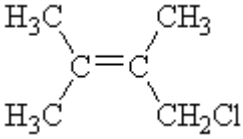
30. Name the following:



A) 2-chloro-3-chloro-*cis*-2-butene
B) 2,3-dichloro-*cis*-2-butene
C) 2,3-dichloro-*trans*-2-butene

D) 1-chloro-1-methyl-2-chloro-propene
E) 2,3-dichloro-1-methyl-propene

ANS: C PTS: 1 DIF: Moderate REF: 22.2
KEY: Chemistry | organic chemistry | alkene | isomerism | cis-trans isomer
MSC: Conceptual

31. Which of the following compounds can exhibit geometrical isomerism?
A) 
B) 
C) 
D) 
E) 

ANS: B PTS: 1 DIF: Easy REF: 22.2
KEY: Chemistry | organic chemistry | alkene | isomerism | cis-trans isomer
MSC: Conceptual

32. How many structural and geometrical isomers are there of chloropropene?
A) 2
B) 3
C) 4
D) 5
E) more than 5

ANS: C PTS: 1 DIF: Easy REF: 22.2
KEY: Chemistry | organic chemistry | alkene | isomerism MSC: Conceptual

33. How many geometric isomers can be drawn for the following compound:
$CH_3CH=CHCH_2CH=C(CH_3)_2$
A) 2
B) 3
C) 4
D) 5

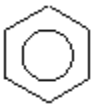
E) 6

ANS: A PTS: 1 DIF: Moderate REF: 22.2
KEY: Chemistry | organic chemistry | alkene | isomerism | cis-trans isomer
MSC: Conceptual

34. Which of the following is not a structural isomer of 1-pentene?
A) 2-pentene
B) 2-methyl-2-butene
C) cyclopentane
D) 3-methyl-1-butene
E) 1-methyl-cyclobutene

ANS: E PTS: 1 DIF: Easy REF: 22.2
KEY: Chemistry | organic chemistry | alkene | isomerism MSC: Conceptual

35. What is the compound represented by the following structure?



A) cyclohexene, C_6H_{10}
B) cyclohexane, C_6H_{12}
C) cyclohexatriene, C_6H_9
D) cyclohexatriene, C_6H_{12}
E) benzene, C_6H_6

ANS: E PTS: 1 DIF: Easy REF: 22.3
KEY: Chemistry | organic chemistry | aromatic hydrocarbons MSC: Conceptual

36. How many different possible dimethylbenzenes exist?
A) 2
B) 3
C) 4
D) 5
E) 6

ANS: B PTS: 1 DIF: Easy REF: 22.3
KEY: Chemistry | organic chemistry | aromatic hydrocarbons MSC: Conceptual

37. What is the most characteristic reaction of benzene?
A) oxidation
B) reduction
C) substitution
D) addition
E) addition and elimination

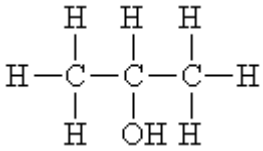
ANS: C PTS: 1 DIF: Easy REF: 22.3
KEY: Chemistry | organic chemistry | aromatic hydrocarbons | chemical reaction
MSC: Conceptual

38. Mothballs contain what aromatic hydrocarbon?

A) naphthalene
B) benzene
C) anthracene
D) phenanthrene
E) toluene

ANS: A PTS: 1 DIF: Easy REF: 22.3
KEY: Chemistry | organic chemistry | aromatic hydrocarbons | fused-ring aromatic compound MSC: Conceptual

39. Name the following:



A) methyl alcohol
B) ethyl alcohol
C) propyl alcohol
D) isopropyl alcohol
E) butanol

ANS: D PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | alcohol | nomenclature MSC: Conceptual

40. Which of the following is known as wood alcohol?
A) methanol
B) ethanol
C) propanol
D) isopropanol
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | alcohol | nomenclature | common name
MSC: Conceptual

41. Which of the following is known as rubbing alcohol?
A) methanol
B) ethanol
C) propanol
D) isopropanol
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | alcohol | nomenclature | common name
MSC: Conceptual

42. What alcohols have the greatest commercial value?
A) methanol and ethanol
B) methanol and phenol
C) ethanol and phenol
D) 1-propanol and ethanol

E) 1-propanol and methanol

ANS: A PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | alcohol MSC: Conceptual

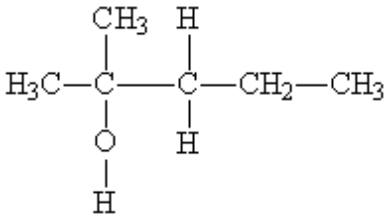
43. Which of the following has only one single C-O bond?
A) ketone
B) alcohol
C) ether
D) ester
E) aldehyde

ANS: B PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | alcohol | structural characteristic
MSC: Conceptual

44. The boiling point of methanol is much higher than that of ethane. This is primarily due to
A) the difference in molar masses of methanol and ethane
B) the hydrogen bonding in methanol
C) the significant molecular size difference between methanol and ethane
D) the carbon oxygen double bond in the methanol
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | alcohol | structural characteristic
MSC: Conceptual

45. Classify the following molecule:

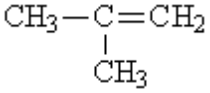


A) primary alcohol
B) secondary alcohol
C) tertiary alcohol
D) ether
E) phenol

ANS: C PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | alcohol | structural characteristic
MSC: Conceptual

46. Which of the following is found in beverages such as wine?
A) methanol
B) ethanol
C) propanol
D) isopropanol
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | alcohol | sources MSC: Conceptual

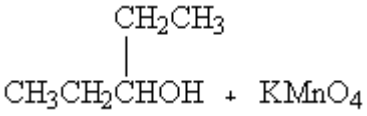
47. When C_4H_8 is treated with water and H_2SO_4, a tertiary alcohol is produced. Which of the following structures could represent C_4H_8 in this reaction?
A) $CH_3CH{=}CHCH_3$
B) $CH_3CH_2CH{=}CH_2$
C) 
D) $CH_3CH_2CH_2CH_3$
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 22.4
KEY: Chemistry | organic chemistry | alkene | chemical reaction | hydration
MSC: Conceptual

48. Oxidation of a primary alcohol results in a(n) _____ and oxidation of a secondary alcohol results in a(n) _____.
A) carboxylic acid, amine
B) aldehyde, ketone
C) ester, ether
D) ketone, aldehyde
E) amine, carboxylic acid

ANS: B PTS: 1 DIF: Moderate REF: 22.4
KEY: Chemistry | organic chemistry | alcohol | chemical reaction | oxidation
MSC: Conceptual

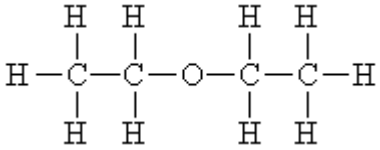
49. When the following organic compound is oxidized, what is the major organic product?



A) 3-pentanoic acid
B) 3-pentanol
C) 3-pentanone
D) 3-pentanal
E) No reaction takes place.

ANS: C PTS: 1 DIF: Moderate REF: 22.4
KEY: Chemistry | organic chemistry | alcohol | chemical reaction | oxidation
MSC: Conceptual

50. Name the following:

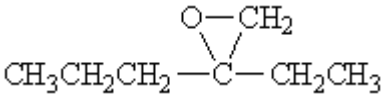


A) acetone
B) butyraldehyde

C) diethylketone
D) diethyl ether
E) none of these

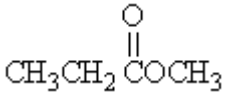
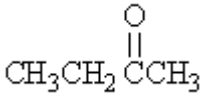
ANS: D PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | ethers | nomenclature | common name
MSC: Conceptual

51. Identify the functional group present in the following organic compound:



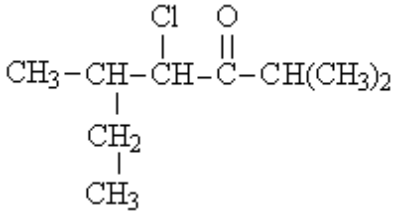
A) ester
B) aldehyde
C) ether
D) ketone
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 22.4
KEY: Chemistry | organic chemistry | ethers | cyclic ether MSC: Conceptual

52. Which molecule is an ether?
A) 
B) $CH_3CH_2OCH_3$
C) 
D) $CH_3CH_2NH_2$
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | ethers | structural characteristic
MSC: Conceptual

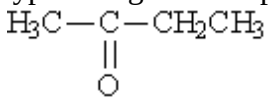
53. Name the following:



A) 2-chloro-3-ethyl-1-isopropylbutanone
B) isopropyl-chloro,methylbutyl ketone
C) 2-butyl,chloro,isobutanoyl methane
D) 4-chloro-2,5-dimethyl-3-heptanone
E) 3-methyl-4-chloro-1-isopropylpentanone

ANS: D PTS: 1 DIF: Moderate REF: 22.4
KEY: Chemistry | organic chemistry | ketone | nomenclature | IUPAC nomenclature
MSC: Conceptual

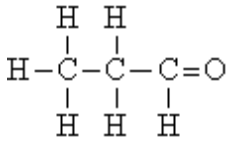
54. Identify the type of organic compound shown:



A) aldehyde
B) ester
C) amine
D) alcohol
E) none of these

ANS: E PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | ketone | structural characteristic
MSC: Conceptual

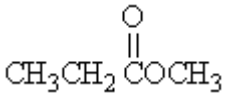
55. Identify the type of organic compound shown:



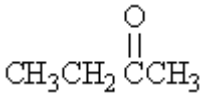
A) aldehyde
B) ester
C) amine
D) ketone
E) none of these

ANS: A PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | aldehyde | structural characteristic
MSC: Conceptual

56. Which molecule is a ketone?

A) 

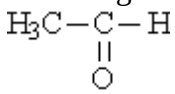
B) $CH_3CH_2OCH_3$

C) 

D) $CH_3CH_2NH_2$
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | ketone | structural characteristic
MSC: Conceptual

57. Classify the following molecule:

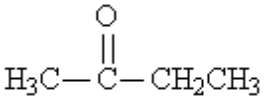


A) acid
B) aldehyde
C) amine

D) ketone
E) carbonyl

ANS: B PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | aldehyde | structural characteristic
MSC: Conceptual

58. Classify the following molecule:



A) acid
B) aldehyde
C) amine
D) ketone
E) carbonyl

ANS: D PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | ketone | structural characteristic
MSC: Conceptual

59. Which of the following yields a primary alcohol upon reduction?
A) a ketone
B) an alkene
C) an amine
D) an aldehyde
E) an ether

ANS: D PTS: 1 DIF: Difficult REF: 22.4
KEY: Chemistry | organic chemistry | aldehyde | chemical reaction | reduction
MSC: Conceptual

60. Which of the following becomes more soluble in water upon addition of NaOH?
A) an amine
B) a carboxylic acid
C) an aromatic hydrocarbon
D) an alkane
E) two of these

ANS: B PTS: 1 DIF: Moderate REF: 22.4
KEY: Chemistry | organic chemistry | carboxylic acids | carboxylic acid salt
MSC: Conceptual

61. Which of the following will yield a carboxylic acid upon oxidation?
A) a secondary alcohol
B) an aldehyde
C) a cycloalkane
D) a ketone
E) tertiary alcohol

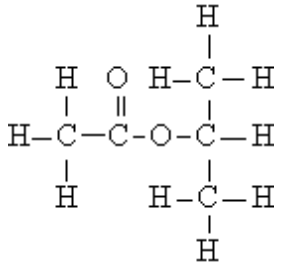
ANS: B PTS: 1 DIF: Moderate REF: 22.4

KEY: Chemistry | organic chemistry | carboxylic acids | preparation
MSC: Conceptual

62. What organic molecules have the general formula RCOOH?
A) esters
B) alcohols
C) carboxylic acids
D) ketones
E) aldehydes

ANS: C PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | carboxylic acids | structural characteristic
MSC: Conceptual

63. Name the following:



A) *n*-propyl acetate
B) isopropyl formate
C) isopropyl acetate
D) ethyl propanoate
E) none of these

ANS: C PTS: 1 DIF: Moderate REF: 22.4
KEY: Chemistry | organic chemistry | esters | nomenclature MSC: Conceptual

64. What is the common name for acetylsalicylic acid?
A) orange juice
B) aspirin
C) acetone
D) bananas
E) vinegar

ANS: B PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | esters | nomenclature | common name
MSC: Conceptual

65. What organic compounds often have pleasant fruity odors?
A) ethers
B) alkynes
C) carboxylic acids
D) esters
E) amines

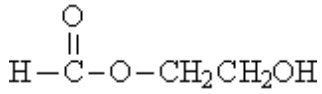
ANS: D PTS: 1 DIF: Moderate REF: 22.4

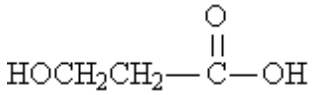
KEY: Chemistry | organic chemistry | esters | physical properties
MSC: Conceptual

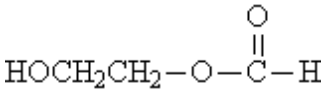
66. Which of the following has a double C-O bond and a single C-O bond?
A) ketone
B) ester
C) alcohol
D) amide
E) ether

ANS: B PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | esters | structural characteristic
MSC: Conceptual

67. Referring to the structures below, which statement is true?

I. 

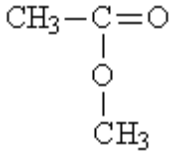
II. 

III. 

A) I and II have different molecular formulas.
B) I and III are structural isomers of each other.
C) II and III are stereoisomers of each other.
D) II and III are different conformations of the same compound.
E) I and III are the same compound.

ANS: E PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | esters MSC: Conceptual

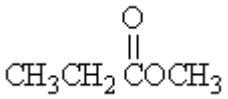
68. Identify the type of organic compound shown:



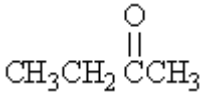
A) aldehyde
B) ester
C) amine
D) ketone
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | esters | structural characteristic
MSC: Conceptual

69. Which molecule is an ester?

A) 

B) $CH_3CH_2OCH_3$

C) 

D) $CH_3CH_2NH_2$

E) none of these

ANS: A PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | esters | structural characteristic
MSC: Conceptual

70. If you were to heat pentanoic acid and 2-butanol with a catalytic amount of strong acid, you would most likely discover in your flask:
A) a ketone
B) an ester
C) an amine
D) an alkane
E) an aldehyde

ANS: B PTS: 1 DIF: Moderate REF: 22.4
KEY: Chemistry | organic chemistry | esters | preparation | esterification reaction
MSC: Conceptual

71. A carboxylic acid will react with an alcohol to form a(n) _____ and a water molecule.
A) ester
B) amine
C) polymer
D) ketone
E) aldehyde

ANS: A PTS: 1 DIF: Moderate REF: 22.4
KEY: Chemistry | organic chemistry | esters | preparation | esterification reaction
MSC: Conceptual

72. Aspirin is formed via a(n) _____ reaction.
A) combustion
B) hydrogenation
C) addition
D) condensation
E) substitution

ANS: D PTS: 1 DIF: Moderate REF: 22.4
KEY: Chemistry | organic chemistry | esters | preparation | esterification reaction
MSC: Conceptual

73. Which of the following types of compounds must have an sp^2-hybridized carbon center?
A) cyclic ethers
B) aldehydes

C) alcohols
D) alkynes
E) amines

ANS: B PTS: 1 DIF: Moderate REF: 22.4
KEY: Chemistry | organic chemistry | carbon atom | bonding characteristics
MSC: Conceptual

74. Which of the following functional groups does *not* contain a doubly bonded oxygen (C=O)?
A) Aldehyde.
B) Carboxyl.
C) Ketone.
D) Carboxylic acid.
E) All contain a double bond.

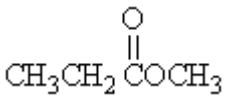
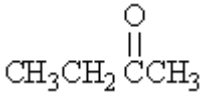
ANS: E PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry MSC: Conceptual

75. $H_2CCHCH_2N(CH_3)_2$ is
A) an alkyne and a secondary amine
B) an alkene and a primary amine
C) an alkene and a tertiary amine
D) an alkyne and a tertiary amine
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | amines | structural characteristic | classification
MSC: Conceptual

76. Identify the type of organic compound shown: $(CH_3)_3N$
A) aldehyde
B) ester
C) amine
D) ketone
E) none of these

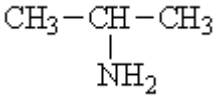
ANS: C PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | amines | structural characteristic
MSC: Conceptual

77. Which molecule is an amine?
A) 
B) $CH_3CH_2OCH_3$
C) 
D) $CH_3CH_2NH_2$
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 22.4

KEY: Chemistry | organic chemistry | amines | structural characteristic
MSC: Conceptual

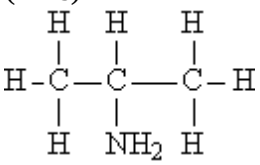
78. Classify the following molecule:



A) primary amine
B) secondary amine
C) tertiary amine
D) amino acid
E) peptide

ANS: A PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | amines | structural characteristic | classification
MSC: Conceptual

79. Identify the secondary amine.
A) CH_3NH_2
B) $(CH_3)_2NH$
C)



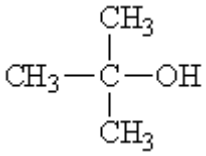
D) NH_3
E) $(CH_3)_3N$

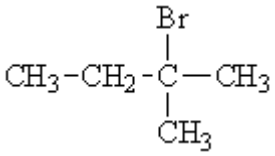
ANS: B PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | amines | structural characteristic | classification
MSC: Conceptual

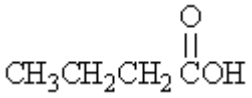
80. For which of the following compound(s) are *cis* and *trans* isomers possible?
A) 2,3-dimethyl-2-butene
B) 3-methyl-2-pentene
C) 4,4-dimethylcyclohexanol
D) *ortho*-chlorotoluene
E) All can exhibit *cis*/*trans* isomers.

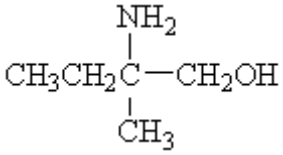
ANS: B PTS: 1 DIF: Moderate REF: 22.4
KEY: Chemistry | organic chemistry | stereochemistry | stereoisomer | geometric isomer
MSC: Conceptual

81. Which of the following has an optical isomer?
A)



B) 

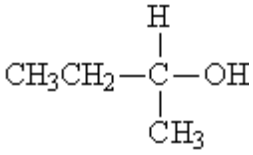
C) 

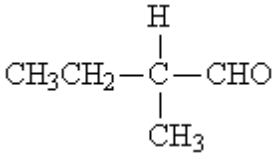
D) 

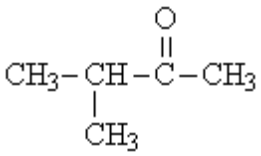
E) none of these

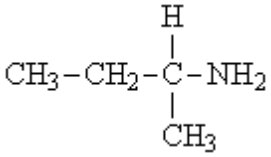
ANS: D PTS: 1 DIF: Moderate REF: 22.4
KEY: Chemistry | organic chemistry | stereochemistry | stereoisomer | chirality
MSC: Conceptual

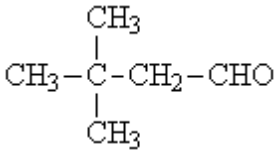
82. Which structure represents an optically active aldehyde?

A) 

B) 

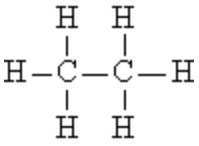
C) 

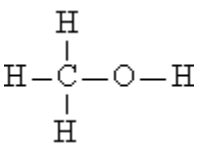
D) 

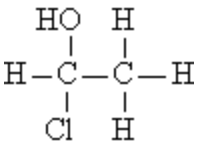
E) 

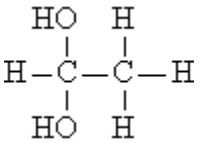
ANS: B PTS: 1 DIF: Moderate REF: 22.4
KEY: Chemistry | organic chemistry | stereochemistry | stereoisomer | chirality
MSC: Conceptual

83. Pick the optically active molecule from the following.

A)


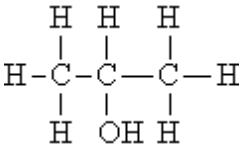
B)


C)


D)


E) none of these

ANS: C PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | stereochemistry | stereoisomer | chirality
MSC: Conceptual

84. Which of the following molecules exhibits chirality?
A) CH_4
B) CH_3OH
C) CH_3CH_2OH
D)


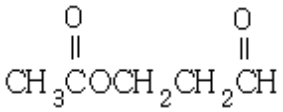
E) none of these

ANS: E PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | stereochemistry | stereoisomer | chirality
MSC: Conceptual

85. Which of the following is optically active (i.e., chiral)?
A) $HN(CH_3)_2$
B) CH_2Cl_2
C) 2-chloropropane
D) 2-chlorobutane
E) 3-chloropentane

ANS: D PTS: 1 DIF: Moderate REF: 22.4
KEY: Chemistry | organic chemistry | stereochemistry | stereoisomer | chirality
MSC: Conceptual

86. Identify all the functional groups present in the following organic compound: 1) ketone, 2) aldehyde, 3) acid, 4) alcohol, 5) ether, 6) ester, 7) amine.



A) 2,6
B) 2,5
C) 1,2
D) 1,2,5
E) 3,4

ANS: A PTS: 1 DIF: Moderate REF: 22.4
KEY: Chemistry | organic chemistry MSC: Conceptual

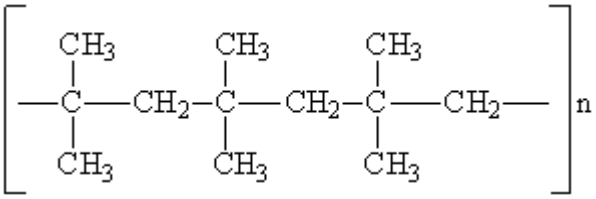
87. Teflon is an example of a
A) copolymer
B) homopolymer
C) dimer
D) two of these
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 22.5
KEY: Chemistry | organic chemistry | alkene | polymerization | addition polymer
MSC: Conceptual

88. Teflon is a type of
A) nylon
B) PVC
C) elastomer
D) polymer
E) synthetic rubber

ANS: D PTS: 1 DIF: Easy REF: 22.5
KEY: Chemistry | general chemistry | polymer MSC: Conceptual

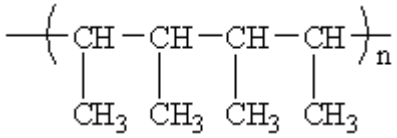
89. Consider the polymer drawn below:



What monomer(s) is (are) needed to produce the above polymer?
A) $CH_2 = CH_2$ and $CH_3CH = CH_2$
B) $CH_2 = C(CH_3)_2$
C) $CH_3CH = CHCH_3$
D) CO and $CH_2 = CH_2$
E) none of the above

ANS: B PTS: 1 DIF: Moderate REF: 22.5
KEY: Chemistry | organic chemistry | alkene | polymerization | addition polymer
MSC: Conceptual

90. The polymer



is formed by addition of

A) CH_2=CH-CH_3
B) $CH_3CH_2CH_3$
C) CH_3–CH=CH–CH_3
D) H_2C=CH–CH=CH_2
E) $CH_3CH=C(CH_3)_2$

ANS: C PTS: 1 DIF: Moderate REF: 22.5
KEY: Chemistry | organic chemistry | alkene | polymerization | addition polymer
MSC: Conceptual

91. Which of the following pairs of substances could form an addition copolymer?

A) $H_2C=CHCH_3 + HOCH_2CH_2COOH$
B) $HO(CH_2)_4COOH + HOCH_2CH=CHCH_3$
C) $H_2C=CHCH + H_2C=CHCH_3$
D) $HOCH_2CH_2OH + HOOCCOOH$
E) $H_2NCH_2COOH + H_2NCH_2CH_2COOH$

ANS: C PTS: 1 DIF: Moderate REF: 22.5
KEY: Chemistry | organic chemistry | alkene | polymerization | addition copolymer
MSC: Conceptual

92. The structure of the polymer used in a freezer wrap can mainly be described as follows:

$$[CCl_2 –CH_2 –CCl_2–CH_2 –CCl_2 –CH_2 –CCl_2 –CH_2]_n$$

The chief monomer of this wrap would have which structure?

A) $CCl_2=CH_2$
B) $Cl_2C–CH_2$
C) $Cl_2C=CH_2=CCl_2$
D) CCl_2
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 22.5
KEY: Chemistry | organic chemistry | alkene | polymerization | addition polymer
MSC: Conceptual

93. Which of the following polymers is not based on a substituted ethylene monomer?

A) nylon
B) polyvinylchloride
C) Teflon
D) polystyrene
E) polypropylene

ANS: A PTS: 1 DIF: Moderate REF: 22.5
KEY: Chemistry | organic chemistry | alkene | polymerization | addition copolymer
MSC: Conceptual

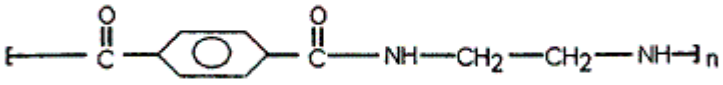
94. The greatest single use for PVC is
A) credit cards
B) table cloths and mats
C) pipe and pipe fittings
D) garden hose
E) toys

ANS: C PTS: 1 DIF: Easy REF: 22.5
KEY: Chemistry | organic chemistry | alkene | polymerization MSC: Conceptual

95. No atoms are lost from starting material in making which kind of polymer?
A) condensation polymer
B) polyester polymer
C) addition polymer
D) vulcanized polymer
E) branched polymer

ANS: C PTS: 1 DIF: Easy REF: 22.5
KEY: Chemistry | general chemistry | polymer | synthetic polymer | synthesis of organic polymer | addition polymer MSC: Conceptual

96. The formula below is the repeating unit of a



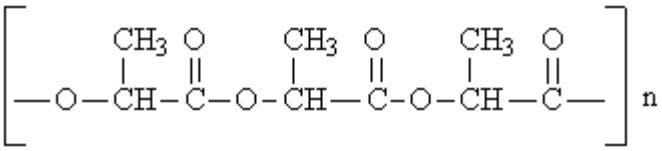
A) homopolymer formed by an addition reaction
B) homopolymer formed by a condensation reaction
C) copolymer formed by an addition reaction
D) copolymer formed by a condensation reaction
E) polyester formed by an addition reaction

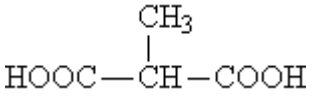
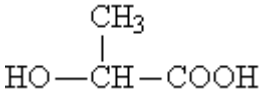
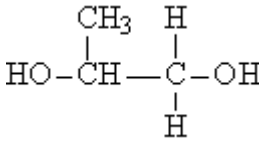
ANS: D PTS: 1 DIF: Moderate REF: 22.5
KEY: Chemistry | general chemistry | polymer | synthetic polymer | synthesis of organic polymer | condensation polymer MSC: Conceptual

97. Which of the following pairs of substances could form a polyester?
A) $H_2C{=}CHCH_3 + HOCH_2CH_2COOH$
B) $HO(CH_2)_4COOH + HOCH_2CH{=}CHCH_3$
C) $H_2C{=}CHCN + H_2C{=}CHCH_3$
D) $HOCH_2CH_2OH + HOOCCOOH$
E) $H_2NCH_2COOH + H_2NCH_2CH_2COOH$

ANS: D PTS: 1 DIF: Moderate REF: 22.5
KEY: Chemistry | organic chemistry | esters | polyester MSC: Conceptual

98. Which of the following monomers are used to produce the polymer:

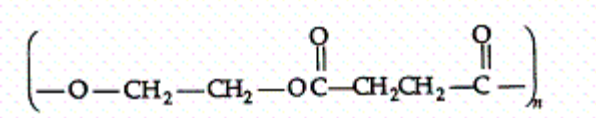


I.	
II.	
III.	

A) I
B) II
C) III
D) I and III
E) II and III

ANS: B PTS: 1 DIF: Moderate REF: 22.5
KEY: Chemistry | organic chemistry | esters | polyester MSC: Conceptual

99. What monomer(s) is (are) needed to make the polymer shown below?



I. $HOCH_2CH_2OH$
II $HOOCCH_2CH_2COOH$
III. $HOCH_2CH_2COOH$
IV. HOCH=CHOH
V. HOOCCH=CHCOOH

A) II
B) III
C) I and II
D) IV and V
E) II and III

ANS: C PTS: 1 DIF: Moderate REF: 22.5
KEY: Chemistry | organic chemistry | esters | polyester MSC: Conceptual

100. In condensation polymerization, a common by-product is:
A) ethylene
B) alcohol
C) aldehyde
D) water

E) none of these

ANS: D PTS: 1 DIF: Easy REF: 22.5
KEY: Chemistry | general chemistry | polymer | synthetic polymer | synthesis of organic polymer | condensation polymer MSC: Conceptual

101. Dacron is an example of a
A) copolymer
B) homopolymer
C) dimer
D) two of these
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 22.5
KEY: Chemistry | general chemistry | polymer | synthetic polymer | synthesis of organic polymer MSC: Conceptual

102. In each pair below the relative strength of the polymer types is indicated with the stronger polymer on the right. Which comparison is wrong?
A) low molecular weight < high molecular weight
B) polyamide (e.g., nylon) < polyhydrocarbon (e.g., polyethylene)
C) branched < linear
D) low density < high density
E) atactic < isotactic

ANS: B PTS: 1 DIF: Difficult REF: 22.5
KEY: Chemistry | general chemistry | polymer MSC: Conceptual

103. When sulfur is added to rubber and the mixture is heated, the resulting rubber is still elastic but much stronger. This process is called
A) addition polymerization
B) isomerization
C) oligomerization
D) vulcanization
E) halogenation

ANS: D PTS: 1 DIF: Easy REF: 22.5
KEY: Chemistry | general chemistry | polymer MSC: Conceptual

104. Which factor is not characteristic of a strong polymer?
A) high crystallinity
B) branching
C) strong intermolecular forces
D) high molecular weight
E) isotactic

ANS: B PTS: 1 DIF: Difficult REF: 22.5
KEY: Chemistry | general chemistry | polymer MSC: Conceptual

105. The major use for linear low-density polyethylene (LDPE) is in the manufacturing of
A) pipes

B) film for packaging
C) Teflon
D) rubber
E) carpets

ANS: B PTS: 1 DIF: Easy REF: 22.5
KEY: Chemistry | general chemistry | polymer MSC: Conceptual

106. HDPE, or high-density polyethylene, is a highly recyclable material because:
A) It has a high molecular weight (molar mass).
B) It is both strong and tough.
C) It is a thermoplastic polymer.
D) It is a thermoset polymer.
E) None of these.

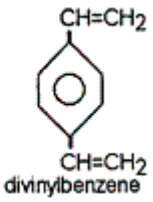
ANS: C PTS: 1 DIF: Easy REF: 22.5
KEY: Chemistry | general chemistry | polymer MSC: Conceptual

107. Which of the following will increase the rigidity of a polymer?
A) shorter polymer chains
B) making chains more branched
C) decreasing cross-linking
D) introducing the possibility of hydrogen bonding between chains
E) using atactic instead of isotactic chains

ANS: D PTS: 1 DIF: Easy REF: 22.5
KEY: Chemistry | general chemistry | polymer MSC: Conceptual

108. Polystyrene is an addition polymer of styrene. What would be the effect if some divinylbenzene was added to styrene and then polymerized?

styrene



divinylbenzene

A) The second polymer would be made less flammable than pure polystyrene.
B) The polymer would be more flexible. Divinylbenzene acts as a plasticizer.
C) Divinylbenzene would act as a cross-linking agent, making the polymer stronger.
D) There would be no effect on the properties of the polymer.
E) There would be an effect, but it cannot be predicted.

ANS: C PTS: 1 DIF: Moderate REF: 22.5
KEY: Chemistry | general chemistry | polymer | synthetic polymer | synthesis of organic polymer MSC: Conceptual

109. How many of the following apply to globular proteins?
I. Provide structural integrity and strength for many types of tissues.
II. Transport and store oxygen and nutrients.
III. Act as catalysts.
IV. Are the main components of muscle, hair, and cartilage.

V. Fight invasion of the body by foreign objects.

A) 1
B) 2
C) 3
D) 4
E) 5

ANS: C PTS: 1 DIF: Moderate REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | protein classification | globular
MSC: Conceptual

110. How many of the following apply to fibrous proteins?
I. Provide structural integrity and strength for many types of tissues.
II. Transport and store oxygen and nutrients.
III. Act as catalysts.
IV. Are the main components of muscle, hair, and cartilage.
V. Fight invasion of the body by foreign objects.

A) 1
B) 2
C) 3
D) 4
E) 5

ANS: B PTS: 1 DIF: Moderate REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | protein classification | fibrous
MSC: Conceptual

111. Which of the following is *not* a function of proteins?
A) Structure.
B) Catalysis.
C) Oxygen transport.
D) Energy transformation.
E) All of these are functions of proteins.

ANS: E PTS: 1 DIF: Moderate REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids MSC: Conceptual

112. Which one of the following statements about the structure of proteins is incorrect?
A) Disulfide bonds provide strong intrachain interactions.
B) Hydrogen bonding stabilizes the α-helix proteins.
C) Nonpolar groups tend to face the outside of a protein in an aqueous solution.
D) Ionized amino acid side chains can form salt bridges within a protein.
E) Heat can disrupt tertiary structure.

ANS: C PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | physical structure of protein
MSC: Conceptual

113. The building blocks of all proteins are

A) pleated sheets
B) alpha amino acids
C) alpha helices
D) tertiary structures
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | amino acid
MSC: Conceptual

114. What are the building blocks of proteins?
A) nucleotides
B) glucose and sucrose
C) lipids
D) amino acids
E) esters

ANS: D PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | amino acid
MSC: Conceptual

115. A polypeptide is
A) an addition polymer of amino acids
B) a condensation polymer of amino acids
C) a polymer of sugar molecules
D) a part of nucleic acids
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | amino acid | peptide formation
MSC: Conceptual

116. The condensation product of two amino acids is a(n)
A) dipeptide
B) glycol
C) ether
D) ester
E) diastereomer

ANS: A PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | amino acid | peptide formation
MSC: Conceptual

117. Nonpolar amino acid side chains contain substituents made mostly of what atoms?
A) carbon and hydrogen
B) nitrogen and oxygen
C) carbon and nitrogen
D) carbon and oxygen
E) nitrogen and hydrogen

ANS: A PTS: 1 DIF: Easy REF: 22.6

KEY: Chemistry | biochemistry | proteins and amino acids | amino acid | classification
MSC: Conceptual

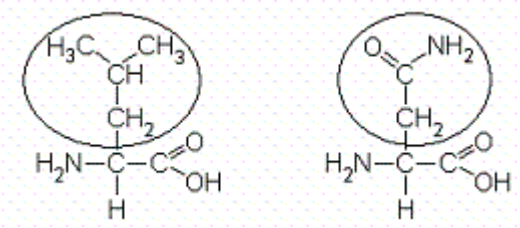
118. Polar amino acid side chains contain functional groups containing mostly what atoms?
A) carbon and hydrogen
B) nitrogen and oxygen
C) carbon and nitrogen
D) carbon and oxygen
E) nitrogen and hydrogen

ANS: B PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | amino acid | classification
MSC: Conceptual

119. Which of the following is incorrect?
A) Nonpolar amino acid side chains are hydrophobic.
B) Polar amino acid side chains are hydrophilic.
C) Nonpolar amino acid side chains contain hydrogen.
D) Polar amino acid side chains contain nitrogen.
E) Both polar and nonpolar amino acid side chains contain oxygen atoms.

ANS: E PTS: 1 DIF: Moderate REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | amino acid | classification
MSC: Conceptual

120. Consider the two amino acids below. The circled portion of each amino acid represents their R groups, or side chains.



Leucine Asparagine

Which of the following statements are true?
A) Leucine's side chain is polar and asparagine's side chain is nonpolar.
B) The side chain on asparagine is hydrophilic.
C) Asparagine is used to make polypeptides, but leucine is not.
D) Leucine's large side chain makes it very reactive and unstable.
E) At least two of the above statements are true.

ANS: B PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | amino acid
MSC: Conceptual

121. Which of the following is the best description of a protein?
A) an alternating chain of amino acids and nucleic acids
B) a chain of amino acids connected by ester bonds
C) two antiparallel chains of nucleic acids connected by hydrogen bonding
D) a chain of amino acids formed by condensation polymerization

E) a chain of nucleotides connected by phosphodiester bonds

ANS: D PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids MSC: Conceptual

122. The structures of proteins are partially determined by the order of various amino acids in the macromolecule. This level of structural determination is known as
A) primary structure
B) secondary structure
C) tertiary structure
D) quaternary structure
E) order of bases

ANS: A PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | physical structure of protein | primary structure MSC: Conceptual

123. The analysis of a protein for its amino acid content is valuable in determining the protein's
A) tertiary structure
B) secondary structure
C) quaternary structure
D) primary structure
E) main structure

ANS: D PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | physical structure of protein | primary structure MSC: Conceptual

124. The primary structure of a protein chain is
A) the order of amino acids
B) the arrangement of the chain in the long molecule
C) the overall shape of the protein
D) determined by the types of bonds it contains
E) determined by the side chains

ANS: A PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | physical structure of protein | primary structure MSC: Conceptual

125. How many possible sequences can be made for a polypeptide with five different amino acids?
A) 5
B) 25
C) 32
D) 120
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | amino acid | peptide formation
MSC: Conceptual

126. Hydrogen bonding between C=O groups and NH groups in the backbone of a protein determines the
A) primary structure
B) secondary structure
C) tertiary structure
D) quaternary structure
E) all of these

ANS: B PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | physical structure of protein | secondary structure MSC: Conceptual

127. The alpha helix of a protein is held in a coiled conformation partly because of
A) hydrogen bonding
B) optical activity
C) active sites
D) double bonding
E) ionization energies

ANS: A PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | physical structure of protein | secondary structure MSC: Conceptual

128. A pleated sheet arrangement of proteins
A) is found in muscle fibers
B) contains interchain hydrogen bonds
C) is found in silk fibers
D) results when hydrogen bonds occur between protein chains
E) all of these

ANS: E PTS: 1 DIF: Moderate REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | physical structure of protein | secondary structure MSC: Conceptual

129. An example of a secondary structure of a protein is
A) an alpha amino acid
B) a peptide linkage
C) a pleated sheet
D) serine
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | physical structure of protein | secondary structure MSC: Conceptual

130. In order to give someone a "permanent" (permanent waving of hair), these must be broken and reformed.
A) disulfide linkages
B) pleated sheets
C) alpha helices
D) alpha amino acids

E) globular proteins

ANS: A PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | physical structure of protein | tertiary structure MSC: Conceptual

131. The overall shape of a protein is maintained by
A) hydrogen bonding
B) ionic bonds
C) dipole-dipole bonding
D) covalent bonds
E) all of these

ANS: E PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | physical structure of protein | tertiary structure MSC: Conceptual

132. Which statement (A–D) is false with respect to proteins?
A) Primary structure refers to the sequence of nucleotides.
B) Secondary structure includes α-helixes.
C) Tertiary structure includes disulfide bonds.
D) The overall shape of a protein is related to the tertiary structure.
E) All are false.

ANS: A PTS: 1 DIF: Moderate REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | physical structure of protein
MSC: Conceptual

133. The secondary and tertiary structures of most biomolecules are determined by
A) hydrophobic bonding
B) hydrogen bonding
C) salt bridges
D) disulfide bonds
E) all of these

ANS: E PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | physical structure of protein
MSC: Conceptual

134. When heat is added to proteins, the hydrogen bonding in the secondary structure breaks apart. What are the algebraic signs of ΔH and ΔS for the denaturation process?
A) Both ΔH and ΔS are positive.
B) Both ΔH and ΔS are negative.
C) ΔH is positive and ΔS is negative.
D) ΔH is negative and ΔS is positive.
E) ΔH is positive and ΔS is 0.

ANS: A PTS: 1 DIF: Moderate REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | protein denaturation
MSC: Conceptual

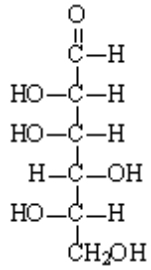
135. The process of breaking down the three-dimensional structure of a protein is called
A) degradation
B) denaturation
C) decomposition
D) fission
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | proteins and amino acids | protein denaturation
MSC: Conceptual

136. Which of the following is *not* a monosaccharide?
A) Sucrose.
B) Glucose.
C) Fructose.
D) Galactose.
E) All of these are monosaccharides.

ANS: A PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | carbohydrates | monosaccharide
MSC: Conceptual

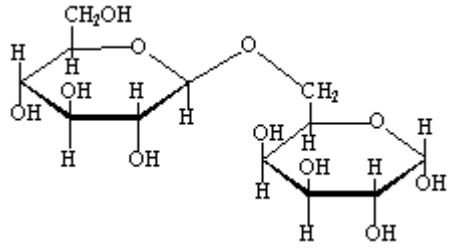
137. The following represents the structure of a carbohydrate. Which of the choices would more specifically classify this compound?



A) Hexose and ketose
B) Pentose and aldose
C) Hexose and aldose
D) Pentose and ketose
E) Tetrose and aldose

ANS: C PTS: 1 DIF: Moderate REF: 22.6
KEY: Chemistry | biochemistry | carbohydrates | monosaccharide | aldose
MSC: Conceptual

138. Which of the following would be the correct classification of the carbohydrate shown below?



A) monosaccharide
B) disaccharide
C) polysaccharide
D) starch
E) cellulose

ANS: B PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | carbohydrates | disaccharide MSC: Conceptual

139. The monomers that make up a starch molecule are:
I. optically active
II. not optically active
III. aldehydes
IV. ketones
and the polymer itself is formed primarily by:
V. addition.
VI. condensation.

A) I, III, V
B) II, IV, VI
C) I, III, VI
D) II, IV, V
E) I, IV, VI

ANS: C PTS: 1 DIF: Moderate REF: 22.6
KEY: Chemistry | biochemistry | carbohydrates | disaccharide | common disaccharide
MSC: Conceptual

140. Table sugar is a disaccharide formed from
A) alpha-D-glucose and fructose
B) beta-D-glucose and fructose
C) D-galactose and D-ribose
D) D-galactose and fructose
E) none of these

ANS: A PTS: 1 DIF: Moderate REF: 22.6
KEY: Chemistry | biochemistry | carbohydrates | disaccharide | common disaccharide
MSC: Conceptual

141. All of the following statements about carbohydrates are true except which one?
A) They serve as a food source for most organisms.
B) They are used as a structural material for plants.
C) Many have the empirical formula CH_2O.
D) Starch and cellulose are two important carbohydrates made of monosaccharides.
E) Fructose, a sugar found in fruit, has five carbon atoms.

ANS: E PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | carbohydrates MSC: Conceptual

142. Which of the following pairs is incorrect?
A) sucrose – disaccharide

B) starch – polysaccharide
C) glycogen – disaccharide
D) cellulose – polysaccharide
E) fructose – monosaccharide

ANS: C PTS: 1 DIF: Moderate REF: 22.6
KEY: Chemistry | biochemistry | carbohydrates MSC: Conceptual

143. What carbohydrate is the form in which plants store glucose for future use as cellular fuel?
A) starch
B) cellulose
C) glycogen
D) sucrose
E) fructose

ANS: A PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | carbohydrates | polysaccharide | common polysaccharide
MSC: Conceptual

144. Which of the following is a carbohydrate reservoir for animals?
A) starch
B) cellulose
C) glycogen
D) two of these
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | metabolism of carbohydrates MSC: Conceptual

145. What carbohydrate breaks down rapidly when energy is needed?
A) starch
B) cellulose
C) glycogen
D) sucrose
E) fructose

ANS: C PTS: 1 DIF: Moderate REF: 22.6
KEY: Chemistry | biochemistry | metabolism of carbohydrates MSC: Conceptual

146. Which of the following can be found both in DNA and RNA?
A) ribose
B) deoxyribose
C) uracil
D) phosphate
E) thymine

ANS: D PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | nucleic acids | nucleotide MSC: Conceptual

147. What does a nucleotide contain?
A) a sugar and a phosphate only

B) a sugar, a phosphate, and an organic base
C) amino acids
D) a sugar
E) four organic bases

ANS: B PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | nucleic acids | nucleotide MSC: Conceptual

148. Protein synthesis in a human occurs
A) in the nucleus
B) on the ribosomes in the cytoplasm
C) on the cell membranes
D) by reading pairs of tRNA nucleotides called codons
E) none of these

ANS: B PTS: 1 DIF: Moderate REF: 22.6
KEY: Chemistry | biochemistry | nucleic acids | DNA replication and repair | protein synthesis MSC: Conceptual

149. Which of the following is (are) not necessary for protein synthesis at the time and place where synthesis occurs?
A) amino acids
B) mRNA
C) DNA
D) tRNA
E) ribosomes

ANS: C PTS: 1 DIF: Moderate REF: 22.6
KEY: Chemistry | biochemistry | nucleic acids | DNA replication and repair | protein synthesis MSC: Conceptual

150. The complimentary nucleic acid sequence for the following DNA sequence—GAC TAC GTT AGC—is
A) GAC TAC GTT AGC
B) TCA GCA TGG CTA
C) CGA TTG CAT CAG
D) CTG ATG CAA TCG
E) none of these

ANS: D PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | nucleic acids | DNA structure and function
MSC: Conceptual

151. The complimentary nucleic acid sequence for the following DNA sequence—ATG GAC GTA TTC—is
A) ATG GAC GTA TTC
B) TAC CTG CAT AAG
C) CGT TCA TGC GGA
D) CTT ATG CAG GTA
E) none of these

ANS: B PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | nucleic acids | DNA structure and function
MSC: Conceptual

152. The complimentary nucleic acid sequence for the following DNA sequence—CTG ACT TAC GCT—is
A) AGT CAG GCA TAG
B) CTG ACT TAC GCT
C) GAC TGA ATG CGA
D) TCG CAT TCA GTC
E) none of these

ANS: C PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | nucleic acids | DNA structure and function
MSC: Conceptual

153. Which of the following organic bases is not found in RNA?
A) adenine
B) guanine
C) cytosine
D) thymine
E) uracil

ANS: D PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry | nucleic acids | RNA structure and function
MSC: Conceptual

154. What type of bonding occurs between two consecutive nucleotides in RNA?
A) ester
B) amide
C) hydrogen
D) ionic
E) hydrophobic

ANS: A PTS: 1 DIF: Moderate REF: 22.6
KEY: Chemistry | biochemistry | nucleic acids | RNA structure and function
MSC: Conceptual

155. Which of the following has the smallest molar mass?
A) mRNA
B) dRNA
C) rRNA
D) sRNA
E) tRNA

ANS: E PTS: 1 DIF: Moderate REF: 22.6
KEY: Chemistry | biochemistry | nucleic acids | RNA structure and function
MSC: Conceptual

156. An anticodon
A) is part of tRNA

B) complements the codon on mRNA
C) codes for a specific amino acid
D) is a sequence of three bases
E) all of the above

ANS: E PTS: 1 DIF: Moderate REF: 22.6
KEY: Chemistry | biochemistry | nucleic acids | RNA | anticodons and tRNA
MSC: Conceptual

157. Which of the following statements is correct?
A) No one has ever made a polymer using amide bonds.
B) Nucleic acids are made of nucleotides joined together with amide bonds.
C) The primary structure of DNA is determined by the order of amino acids.
D) All of the above (A-C) statements are true.
E) None of these.

ANS: E PTS: 1 DIF: Easy REF: 22.6
KEY: Chemistry | biochemistry MSC: Conceptual

158. Which statement is true?
A) Protein synthesis takes place in the cytoplasm of the cell.
B) Each gene in the DNA molecule codes for a specific protein.
C) Messenger RNA can be found in both the nucleus and the cytoplasm of each cell.
D) When a peptide bond is formed, H_2O is produced.
E) All of these.

ANS: E PTS: 1 DIF: Moderate REF: 22.6
KEY: Chemistry | biochemistry | nucleic acids MSC: Conceptual

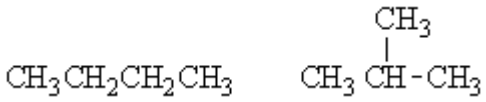
159. Indicate the total number of isomers in the following compound: C_4H_{10}

ANS:
2

PTS: 1 DIF: Easy REF: 22.1
KEY: Chemistry | organic chemistry | alkane | isomerism MSC: Conceptual

160. Draw the isomers for C_4H_{10}.

ANS:



See Sec. 22.1 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Easy REF: 22.1
KEY: Chemistry | organic chemistry | alkane | isomerism MSC: Conceptual

Write molecular equations for the following reactions:

161. halogenation of ethane

ANS:

$C_2H_6 + Cl_2 \xrightarrow{h\nu} C_2H_5Cl + HCl$

See Sec. 22.1 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Moderate REF: 22.1
KEY: Chemistry | organic chemistry | alkane | chemical reaction | halogenation
MSC: Conceptual

162. methyl substitution of benzene

ANS:

$C_6H_6 + CH_3Cl \xrightarrow{FeCl_3} C_6H_5CH_3 + HCl$

See Sec. 22.3 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Moderate REF: 22.3
KEY: Chemistry | organic chemistry | aromatic hydrocarbons | chemical reaction
MSC: Conceptual

163. formation of propyl propanoate

ANS:

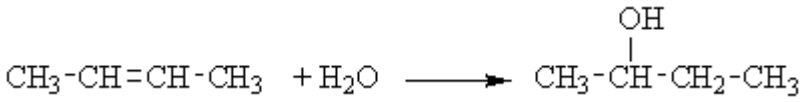
$CH_3CH_2COOH + CH_3CH_2CH_2OH \rightarrow CH_3CH_2COOCH_2CH_2CH_3 + H_2O$

See Sec. 22.4 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Moderate REF: 22.4
KEY: Chemistry | organic chemistry | esters | preparation | esterification reaction
MSC: Conceptual

164. hydration of 2-butene

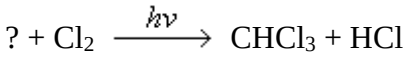
ANS:



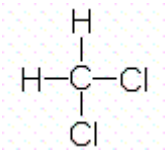
See Sec. 22.4 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Moderate REF: 22.4
KEY: Chemistry | organic chemistry | alkene | chemical reaction | hydration
MSC: Conceptual

165. Draw and name the missing reactant below.



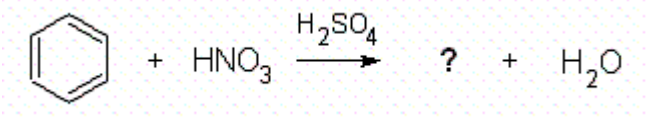
ANS:
dichloromethane, CH_2Cl_2



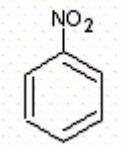
See Sec. 22.1 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Moderate REF: 22.1
KEY: Chemistry | organic chemistry | alkane | chemical reaction | halogenation
MSC: Conceptual

166. Draw and name the missing product below.



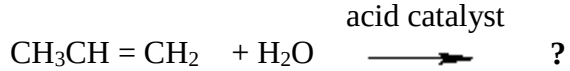
ANS:
nitrobenzene



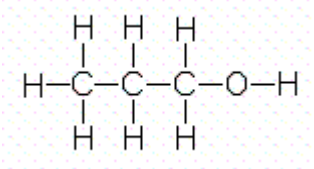
See Sec. 22.3 of Zumdahl, *Chemistry*.

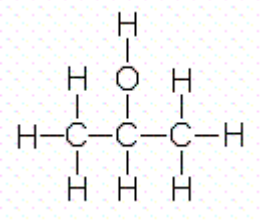
PTS: 1 DIF: Moderate REF: 22.3
KEY: Chemistry | organic chemistry | aromatic hydrocarbons | chemical reaction
MSC: Conceptual

167. Draw and name the two possible missing products below.



ANS:
1-propanol 2-propanol





See Sec. 22.4 of Zumdahl, *Chemistry*.

PTS: 1 DIF: Moderate REF: 22.4
KEY: Chemistry | organic chemistry | alkene | chemical reaction | hydration
MSC: Conceptual

168. Describe the relationship between pentane and 2-methylpentane
A) optical isomers
B) structural isomers
C) geometric isomers
D) not isomers but different compounds
E) same compound

ANS: D PTS: 1 DIF: Easy REF: 22.1
KEY: Chemistry | organic chemistry | alkane | isomerism MSC: Conceptual

169. Describe the relationship between hexane and 2-methylpentane
A) optical isomers
B) structural isomers
C) geometric isomers
D) not isomers but different compounds
E) same compound

ANS: B PTS: 1 DIF: Easy REF: 22.1
KEY: Chemistry | organic chemistry | alkane | isomerism MSC: Conceptual

170. Describe the relationship between 1,2-dimethylcyclohexane and 1,2-dimethylcycloheptane
A) optical isomers
B) structural isomers
C) geometric isomers
D) not isomers but different compounds
E) same compound

ANS: D PTS: 1 DIF: Easy REF: 22.1
KEY: Chemistry | organic chemistry | alkane | isomerism MSC: Conceptual

171. Describe the relationship between 1,2-dimethylcyclohexane and 1-octene:
A) optical isomers
B) structural isomers
C) geometric isomers
D) not isomers but different compounds
E) same compound

ANS: B PTS: 1 DIF: Easy REF: 22.1
KEY: Chemistry | organic chemistry | alkane | isomerism MSC: Conceptual

172. What type of reaction(s) are predominantly undergone by alkanes?
A) elimination
B) addition
C) substitution
D) reduction

E) both A and B

ANS: C PTS: 1 DIF: Moderate REF: 22.1
KEY: Chemistry | organic chemistry | alkane | chemical reaction
MSC: Conceptual

173. Which of the following is an ester?
A) R-O-R
B) R-COOH
C) R-CO-R
D) R-CONHR
E) RCOOR

ANS: E PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | esters | structural characteristic
MSC: Conceptual

174. 3-methyl-4-propyl-2-octanol is an example of a
A) primary alcohol
B) secondary alcohol
C) tertiary alcohol
D) ether
E) phenol

ANS: B PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | alcohol | structural characteristic
MSC: Conceptual

175. 3-ethyl-3-hexanol is an example of a
A) primary alcohol
B) secondary alcohol
C) tertiary alcohol
D) ether
E) phenol

ANS: C PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | alcohol | structural characteristic
MSC: Conceptual

176. 4-hydroxytoluene is an example of a
A) primary alcohol
B) secondary alcohol
C) tertiary alcohol
D) ether
E) phenol

ANS: E PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | phenol | structural characteristic
MSC: Conceptual

177. Which of the following compounds IS chiral (has optical isomers)?

A) 2,4-dimethylpentane
B) 2-methylhexane
C) 4-methylheptane
D) 3-methylpentane
E) None of these is chiral

ANS: E PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | stereochemistry | stereoisomer | chirality
MSC: Conceptual

178. Which of the following compounds is NOT chiral?
A) CHBrClF
B) CH_3CBrCl_2
C) 2,3-dimethylpentane
D) 3-methylhexane
E) They are all chiral

ANS: B PTS: 1 DIF: Easy REF: 22.4
KEY: Chemistry | organic chemistry | stereochemistry | stereoisomer | chirality
MSC: Conceptual