Chemistry, 11e (Brown)
Chapter 1: Introduction: Matter and Measurement

Multiple Choice and Bimodal

1) Solids have a __________ shape and are not appreciably __________.
A) definite, compressible
B) definite, incompressible
C) indefinite, compressible
D) indefinite, incompressible
E) sharp, convertible
Answer: A
Diff: 1 Page Ref: Sec. 1.2

2) __________ is the chemical symbol for elemental sodium.
A) S
B) W
C) So
D) Na
E) Sn
Answer: D
Diff: 1 Page Ref: Sec. 1.2

3) If matter is uniform throughout, cannot be separated into other substances by physical processes, but can be decomposed into other substances by chemical processes, it is called a (an) __________.
A) heterogeneous mixture
B) element
C) homogeneous mixture
D) compound
E) mixture of elements
Answer: D
Diff: 4 Page Ref: Sec. 1.2

4) The symbol for the element potassium is __________.
A) Pt
B) P
C) K
D) S
E) Ca
Answer: C
Diff: 1 Page Ref:Sec. 1.2

5) The symbol for the element magnesium is __________.
A) Rb
B) Mn
C) Ne
D) Si
E) Mg
Answer: E
Diff: 1 Page Ref:Sec. 1.2

6) The initial or tentative explanation of an observation is called a(n) __________.
A) law
B) theory
C) hypothesis
D) experiment
E) test
Answer: C
Diff: 2 Page Ref:Sec. 1.3

7) A concise verbal statement or mathematical equation that summarizes a broad variety of observations and experiences is called a(n) __________.
A) law
B) theory
C) hypothesis
D) experiment
E) test
Answer: A
Diff: 2 Page Ref:Sec. 1.3

8) A separation process that depends on differing abilities of substances to form gases is called __________.
A) filtration
B) solvation
C) distillation
D) chromatography
E) all of the above are correct
Answer: C
Diff: 3 Page Ref:Sec. 1.3

9) The SI unit for mass is __________.
A) kilogram
B) gram
C) pound
D) troy ounce
E) none of the above
Answer: A
Diff: 1 Page Ref:Sec. 1.4

10) A one degree of temperature difference is the smallest on the __________ temperature scale.
A) Kelvin
B) Celsius
C) Fahrenheit
D) Kelvin and Celsius
E) Fahrenheit and Celsius
Answer: C
Diff: 3 Page Ref:Sec. 1.4

11) A common English set of units for expressing velocity is miles/hour. The SI unit for velocity is __________?
A) km/hr
B) km/s
C) m/hr
D) m/s
E) cm/s
Answer: D
Diff: 3 Page Ref:Sec. 1.4

12) The unit of force in the English measurement system is $\frac{\text{lb} \bullet \text{ft}}{\text{s}^2}$. The SI unit of force is the Newton, which is __________ in base SI units.
A) $\frac{\text{g} \bullet \text{cm}}{\text{s}^2}$
B) $\frac{\text{kg} \bullet \text{m}}{\text{hr}^2}$
C) $\frac{\text{kg} \bullet \text{m}}{\text{s}^2}$
D) $\frac{\text{g} \bullet \text{m}}{\text{s}^2}$
E) $\frac{\text{g} \bullet \text{cm}}{\text{s}}$
Answer: C
Diff: 4 Page Ref:Sec. 1.4

13) Momentum is defined as the product of mass and velocity. The SI unit for momentum is __________?
A) $\frac{\text{kg} \bullet \text{m}}{\text{s}}$
B) $\frac{\text{kg} \bullet \text{m}}{\text{hr}}$
C) $\frac{\text{g} \bullet \text{m}}{\text{s}}$
D) $\frac{\text{g} \bullet \text{km}}{\text{s}}$
E) $\frac{\text{kg} \bullet \text{km}}{\text{hr}}$
Answer: A
Diff: 4 Page Ref:Sec. 1.4

14) The SI unit of temperature is __________.
A) K
B) °C
C) °F
D) t
E) T
Answer: A
Diff: 2 Page Ref:Sec. 1.4

15) The temperature of 25°C is __________ in Kelvins.
A) 103
B) 138
C) 166
D) 248
E) 298
Answer: E
Diff: 1 Page Ref:Sec. 1.4

16) The freezing point of water at 1 atm pressure is __________.
A) 0°F
B) 0 K
C) 0°C
D) -273°C
E) -32°F
Answer: C
Diff: 2 Page Ref:Sec. 1.4

17) A temperature of 400 K is the same as __________°F.
A) 261
B) 286
C) 88
D) 103
E) 127
Answer: A
Diff: 2 Page Ref:Sec. 1.4

18) A temperature of __________ K is the same as 63°F.
A) 17
B) 276
C) 290
D) 29
E) 336
Answer: C
Diff: 2 Page Ref:Sec. 1.4

19) 1 nanometer = __________ picometers
A) 1000
B) 0.1
C) 0.01
D) 1
E) 10
Answer: A
Diff: 2 Page Ref:Sec. 1.4

20) 1 picometer = __________ centimeters
A) 1×10^{10}
B) 1×10^{-10}
C) 1×10^{8}
D) 1×10^{-8}
E) 1×10^{-12}
Answer: B
Diff: 2 Page Ref:Sec. 1.4

21) 1 kilogram = __________ milligrams
A) 1×10^{-6}
B) 1,000
C) 10,000
D) 1,000,000
E) none of the above
Answer: D
Diff: 2 Page Ref:Sec. 1.4

22) "Absolute zero" refers to __________.
A) 0 Kelvin
B) 0° Fahrenheit
C) 0° Celsius
D) °C + 9/5(°F - 32)
E) 273.15°C
Answer: A
Diff: 1 Page Ref:Sec. 1.4

23) An object will sink in a liquid if the density of the object is greater than that of the liquid. The mass of a sphere is 9.83 g. If the volume of this sphere is less than __________ cm^3, then the sphere will sink in liquid mercury (density = 13.6 g/cm^3).
A) 0.723
B) 1.38
C) 134
D) 7.48
E) none of the above
Answer: A
Diff: 3 Page Ref:Sec. 1.4

24) The density (in g/cm^3) of a gold nugget that has a volume of 1.68 cm^3 and a mass of 32.4 g is __________.
A) 0.0519
B) 19.3
C) 54.4
D) 0.0184
E) 32.4
Answer: B
Diff: 1 Page Ref:Sec. 1.4

25) The density of silver is 10.5 g/cm^3. A piece of silver with a mass of 61.3 g would occupy a volume of __________ cm^3.
A) 0.171
B) 644
C) 10.5
D) 0.00155
E) 5.84
Answer: E
Diff: 2 Page Ref:Sec. 1.4

26) The density of silver is 10.5 g/cm^3. A piece of silver that occupies a volume of 23.6 cm^3 would have a mass of __________g.
A) 248
B) 0.445
C) 2.25
D) 112
E) 23.6
Answer: A
Diff: 2 Page Ref:Sec. 1.4

27) A certain liquid has a density of 2.67 g/cm^3. 1340 g of this liquid would occupy a volume of __________ L.

A) 1.99×10^{-3}
B) 50.2
C) 3.58
D) 35.8
E) 0.502
Answer: E
Diff: 2 Page Ref:Sec. 1.4

28) A certain liquid has a density of 2.67 g/cm^3. 30.5 mL of this liquid would have a mass of __________ Kg.

A) 81.4
B) 11.4
C) 0.0875
D) 0.0814
E) 0.0114
Answer: D
Diff: 2 Page Ref:Sec. 1.4

29) Osmium has a density of 22.6 g/cm^3. The mass of a block of osmium that measures 1.01 cm × 0.233 cm × 0.648 cm is __________ g.

A) 6.75×10^{-3}
B) 3.45
C) 148
D) 6.75×10^{3}
E) 34.5
Answer: B
Diff: 3 Page Ref:Sec. 1.4

30) 3.337 g/cm^3 = __________ kg/cm^3

A) 3.337×10^{-9}
B) 3.337×10^{-5}
C) 3337
D) 0.3337
E) 333.7
Answer: C
Diff: 2 Page Ref:Sec. 1.4

31) The number 0.00430 has __________ significant figures.

A) 2
B) 3
C) 5
D) 6
E) 4
Answer: B
Diff: 1 Page Ref:Sec. 1.4

32) The number 1.00430 has __________ significant figures.
A) 2
B) 3
C) 5
D) 6
E) 4
Answer: D
Diff: 1 Page Ref:Sec. 1.4

33) The correct answer (reported to the proper number of significant figures) to the following is __________.

$6.3 \times 3.25 =$ __________
A) 20.
B) 20.475
C) 20.48
D) 20.5
E) 21
Answer: A
Diff: 2 Page Ref:Sec. 1.4

34) One side of a cube measures 1.55 m. The volume of this cube is __________ cm^3.
A) 2.40×10^4
B) 3.72×10^6
C) 2.40
D) 3.72
E) 155
Answer: B
Diff: 4 Page Ref:Sec. 1.4

35) The length of the side of a cube (in cm) having a volume of 44.4 L is __________.
A) 875
B) 35.4
C) 6.66
D) 66.6
E) 0.354
Answer: B
Diff: 4 Page Ref:Sec. 1.4

36) 45 m/s = __________ km/hr
A) 2.7
B) 0.045
C) 1.6×10^2
D) 2.7×10^3
E) 1.6×10^5
Answer: C
Diff: 2 Page Ref:Sec. 1.4

37) If an object, beginning at rest, is moving at a speed of 700 m/s after 2.75 min, its rate of acceleration (in m/s^2) is __________. (Assume that the rate of acceleration is constant.)
A) 1.6×10^5
B) 255
C) 193
D) 4.24
E) 1.53×10^4
Answer: D
Diff: 4 Page Ref:Sec. 1.4

38) The correct result (indicating the proper number of significant figures) of the following addition is __________.

$$\begin{array}{r} 12 \\ 1.2 \\ 0.12 \\ \underline{+\ 0.012} \end{array}$$

A) 13
B) 13.3
C) 13.33
D) 13.332
E) none of the above
Answer: A
Diff: 2 Page Ref:Sec. 1.5

39) $\dfrac{(0.002843)(12.80184)}{0.00032} =$ __________
A) 113.73635
B) 113.736
C) 113.74
D) 113.7
E) 1.1×10^2
Answer: E
Diff: 3 Page Ref:Sec. 1.5

40) The correct result of the molecular mass calculation for H_2SO_4 is ________.

$$4 \times 15.9994 + 32.066 + 2 \times 1.0079$$

A) 98.08
B) 98.079
C) 98.074
D) 98.838
E) 98.84
Answer: B
Diff: 3 Page Ref:Sec. 1.5

41) The volume of a regular cylinder is $V = \pi r^2 h$. Using the value 3.1416 for the constant π, the volume $\left(cm^3\right)$ of a cylinder of radius 2.34 cm and height 19.91 cm expressed to the correct number of significant figures is __________.

A) 342.49471
B) 342.495
C) 342.49
D) 343
E) 342
Answer: E
Diff: 4 Page Ref:Sec. 1.5

42) There are __________ significant figures in the answer to the following computation:

$$\frac{(29.2 - 20.0)\,(1.79 \times 10^5)}{1.39}$$

A) 1
B) 2
C) 3
D) 4
E) 5
Answer: B
Diff: 1 Page Ref:Sec. 1.5

43) There should be __________ significant figures in the answer to the following computation.

$$\frac{(10.07 + 7.395)}{2.5}$$

A) 1
B) 2
C) 3
D) 4
E) 5
Answer: B
Diff: 2 Page Ref:Sec. 1.5

44) __________ significant figures should be retained in the result of the following calculation.

$$\frac{(11.13 - 2.6) \times 10^4}{(103.05 + 16.9) \times 10^{-6}}$$

A) 1
B) 2
C) 3
D) 4
E) 5
Answer: B
Diff: 2 Page Ref:Sec. 1.5

45) The output of a plant is 4335 pounds of ball bearings per week (five days). If each ball bearing weighs 0.0113 g, how many ball bearings does the plant make in a single day? (Indicate the number in proper scientific notation with the appropriate number of significant figures.)
A) 3.84×10^5
B) 7.67×10^4
C) 867
D) 3.84×10^7
E) 2.91×10^6
Answer: D
Diff: 4 Page Ref:Sec. 1.6

46) The density of mercury is 13.6 g/cm^3. The density of mercury is __________ kg/m^3.
A) 1.36×10^{-2}
B) 1.36×10^4
C) 1.36×10^8
D) 1.36×10^{-5}
E) 1.36×10^{-4}
Answer: B
Diff: 4 Page Ref:Sec. 1.6

47) The quantity 1.0 mg/cm^2 is the same as 1.0 × __________ kg/m^2.
A) 10^{-4}
B) 10^2
C) 10^{-6}
D) 10^{-2}
E) 10^4
Answer: D
Diff: 2 Page Ref:Sec. 1.6

48) The quantity __________ m is the same as 3 km.
A) 3000
B) 300
C) 0.003
D) 0.03
E) 30
Answer: A
Diff: 2 Page Ref:Sec. 1.6

49) There are __________ ng in a pg.
A) 0.001
B) 1000
C) 0.01
D) 100
E) 10
Answer: A
Diff: 2 Page Ref:Sec. 1.6

50) One edge of a cube is measured and found to be 13 cm. The volume of the cube in m^3 is __________.
A) 2.2×10^{-3}
B) 2.2×10^{-6}
C) 2.2
D) 2.2×10^{3}
E 2.2×10^{6}
Answer: A
Diff: 4 Page Ref:Sec. 1.6

51) The density of lead is $11.4\ g/cm^3$. The mass of a lead ball with a radius of 0.50 mm is __________ g. $\left(\text{Vsphere} = 4\pi r^3/3\right)$
A) 6.0
B) 4.6×10^{-2}
C) 4.6×10^{-5}
D) 6.0×10^{-3}
E) 4.6
Answer: D
Diff: 4 Page Ref:Sec. 1.6

Multiple-Choice

52) In the following list, only __________ is not an example of matter.
A) planets
B) light
C) dust
D) elemental phosphorus
E) table salt
Answer: B
Diff: 2 Page Ref:Sec. 1.1

53) What is the physical state in which matter has no specific shape but does have a specific volume?
A) gas
B) solid
C) liquid
D) salts
E) ice
Answer: C
Diff: 1 Page Ref:Sec. 1.2

54) The law of constant composition applies to __________.
A) solutions
B) heterogeneous mixtures
C) compounds
D) homogeneous mixtures
E) solids
Answer: C
Diff: 1 Page Ref:Sec. 1.2

55) A combination of sand, salt, and water is an example of a __________.
A) homogeneous mixture
B) heterogeneous mixture
C) compound
D) pure substance
E) solid
Answer: B
Diff: 1 Page Ref:Sec. 1.2

56) Which one of the following has the element name and symbol correctly matched?
A) P, potassium
B) C, copper
C) Mg, manganese
D) Ag, silver
E) Sn, silicon
Answer: D
Diff: 1 Page Ref:Sec. 1.2

57) Which one of the following has the element name and symbol correctly matched?
A) S, sodium
B) Tn, tin
C) Fe, iron
D) N, neon
E) B, bromine
Answer: C
Diff: 1 Page Ref:Sec. 1.2

58) Which one of the following elements has a symbol that is not derived from its foreign name?
A) tin
B) aluminum
C) mercury
D) copper
E) lead
Answer: B
Diff: 2 Page Ref:Sec. 1.2

59) Which one of the following is a pure substance?
A) concrete
B) wood
C) salt water
D) elemental copper
E) milk
Answer: D
Diff: 1 Page Ref:Sec. 1.2

60) Which one of the following is often easily separated into its components by simple techniques such as filtering or decanting?
A) heterogeneous mixture
B) compounds
C) homogeneous mixture
D) elements
E) solutions
Answer: A
Diff: 3 Page Ref:Sec. 1.2

61) Which states of matter are significantly compressible?
A) gases only
B) liquids only
C) solids only
D) liquids and gases
E) solids and liquids
Answer: A
Diff: 1 Page Ref:Sec. 1.2

62) For which of the following can the composition vary?
A) pure substance
B) element
C) both homogeneous and heterogeneous mixtures
D) homogeneous mixture
E) heterogeneous mixture
Answer: C
Diff: 2 Page Ref:Sec. 1.2

63) If matter is uniform throughout and cannot be separated into other substances by physical means, it is __________.
A) a compound
B) either an element or a compound
C) a homogeneous mixture
D) a heterogeneous mixture
E) an element
Answer: B
Diff: 2 Page Ref:Sec. 1.2

64) An element cannot __________.
A) be part of a heterogeneous mixture
B) be part of a homogeneous mixture
C) be separated into other substances by chemical means
D) interact with other elements to form compounds
E) be a pure substance
Answer: C
Diff: 2 Page Ref:Sec. 1.2

65) Homogeneous mixtures are also known as __________.
A) solids
B) compounds
C) elements
D) substances
E) solutions
Answer: E
Diff: 1 Page Ref:Sec. 1.2

66) The law of constant composition says __________.
A) that the composition of a compound is always the same
B) that all substances have the same composition
C) that the composition of an element is always the same
D) that the composition of a homogeneous mixture is always the same
E) that the composition of a heterogeneous mixture is always the same
Answer: A
Diff: 1 Page Ref:Sec. 1.2

67) Which of the following is an illustration of the law of constant composition?
A) Water boils at 100°C at 1 atm pressure.
B) Water is 11% hydrogen and 89% oxygen by mass.
C) Water can be separated into other substances by a chemical process.
D) Water and salt have different boiling points.
E) Water is a compound.
Answer: B
Diff: 4 Page Ref:Sec. 1.2

68) In the following list, only __________ is not an example of a chemical reaction.
A) dissolution of a penny in nitric acid
B) the condensation of water vapor
C) a burning candle
D) the formation of polyethylene from ethylene
E) the rusting of iron
Answer: B
Diff: 2 Page Ref:Sec. 1.3

69) Gases and liquids share the property of __________.
A) compressibility
B) definite volume
C) incompressibility
D) indefinite shape
E) definite shape
Answer: D
Diff: 1 Page Ref:Sec. 1.3

70) Of the following, only __________ is a chemical reaction.
A) melting of lead
B) dissolving sugar in water
C) tarnishing of silver
D) crushing of stone
E) dropping a penny into a glass of water
Answer: C
Diff: 1 Page Ref:Sec. 1.3

71) Which one of the following is not an intensive property?
A) density
B) temperature
C) melting point
D) mass
E) boiling point
Answer: D
Diff: 2 Page Ref:Sec. 1.3

72) Which one of the following is an intensive property?
A) mass
B) temperature
C) heat content
D) volume
E) amount
Answer: B
Diff: 2 Page Ref:Sec. 1.3

73) Of the following, only __________ is an extensive property.
A) density
B) mass
C) boiling point
D) freezing point
E) temperature
Answer: B
Diff: 2 Page Ref:Sec. 1.3

74) Which of the following are chemical processes?

1. rusting of a nail
2. freezing of water
3. decomposition of water into hydrogen and oxygen gases
4. compression of oxygen gas

A) 2, 3, 4
B) 1, 3, 4
C) 1, 3
D) 1, 2
E) 1, 4
Answer: C
Diff: 3 Page Ref:Sec. 1.3

75) Of the following, __________ is the smallest mass.
A) 25 kg
B) 2.5×10^{-2} mg
C) 2.5×10^{15} pg
D) 2.5×10^{9} fg
E) 2.5×10^{10} ng
Answer: D
Diff: 2 Page Ref:Sec. 1.4

76) Which one of the following is the highest temperature?
A) 38°C
B) 96°F
C) 302 K
D) none of the above
E) the freezing point of water
Answer: A
Diff: 3 Page Ref:Sec. 1.4

77) Which one of the following is true about the liter?
A) It is the SI base unit for volume.
B) It is equivalent to a cubic decimeter.
C) It is slightly smaller than a quart.
D) It contains 10^6 cubic centimeters.
E) It is slightly smaller than a gallon.
Answer: B
Diff: 4 Page Ref:Sec. 1.4

78) Of the objects below, __________ is the most dense.
A) an object with a volume of 2.5 L and a mass of 12.5 kg
B) an object with a volume of 139 mL and a mass of 93 g
C) an object with a volume of 0.00212 m^3 and a mass of 4.22×10^4mg
D) an object with a volume of $3.91 \times 10^{-24}nm^3$ and a mass of 7.93×10^{-1}ng
E) an object with a volume of 13 dm^3 and a mass of 1.29×10^3g
Answer: D
Diff: 4 Page Ref:Sec. 1.4

79) Which calculation clearly shows a conversion between temperatures in degrees Celsius, t(°C), and temperature in Kelvins, T(K)?
A) T(K) = t(°C) + 273
B) T(K) = 273 - t(°C)
C) T(K) = [t(°C) - 32] / 1.8
D) T(K) = [t(°C) + 32] × 1.8
E) T(K) = t(°C)
Answer: A
Diff: 1 Page Ref:Sec. 1.4

80) Express the temperature, 422.35 K, in degrees Celsius.
A) 792.23°C
B) 149.20°C
C) 695.50°C
D) 50.89°C
E) 22.78°C
Answer: B
Diff: 2 Page Ref:Sec. 1.4

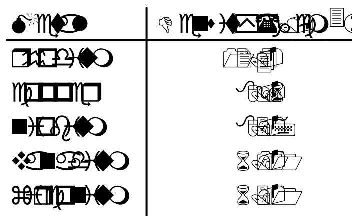
81) Which of the following liquids has the greatest density?
A) 13 cm^3 with a mass of 23 g
B) 3.5 cm^3 with a mass of 10 g
C) 0.022 cm^3 with a mass of 0.10 g
D) 54 cm^3 with a mass of 45 g
E) 210 cm^3 with a mass of 12 g
Answer: C
Diff: 2 Page Ref:Sec. 1.4

82) You have to calculate the mass of a 30.0 mL liquid sample with density of 1.52 g/mL, but you have forgotten the formula. Which way of reasoning would help you in finding the correct mass?
A) If 1 mL of a liquid has the mass of 1.52 g, then 30.0 mL has the mass of _____ g.
B) If 1.52 mL of a liquid has the mass of 1 g, then 30.0 mL has the mass of _____ g.
Answer: A
Diff: 2 Page Ref:Sec. 1.4

83) You have to calculate the volume of a gas sample with mass of 1.000×10^3g and density of 1.027 g/L , but you have forgotten the formula. Which way of reasoning would help you in finding the correct mass?
A) If 1.027 g of a gas takes up a volume of 1 L, then 1.000×10^3g of the same gas takes up a volume of _____.
B) If 1.027 L of gas has a mass of 1 g, then _____ L has the mass of 1.000×10^3g .
Answer: A
Diff: 2 Page Ref:Sec. 1.4

84) Osmium has a density of 22.6 g/cm^3. What volume (in cm^3) would be occupied by a 21.8 g sample of osmium?
A) 0.965
B) 1.04
C) 493
D) 2.03×10^{-3}
E) 2.03×10^{3}
Answer: A
Diff: 1 Page Ref:Sec. 1.4

85) A cube of an unknown metal measures 1.61 mm on one side. The mass of the cube is 36 mg. Which of the following is most likely the unknown metal?



A) copper
B) rhodium
C) niobium
D) vanadium
E) zirconium
Answer: C
Diff: 3 Page Ref:Sec. 1.4

86) Precision refers to __________.
A) how close a measured number is to other measured numbers
B) how close a measured number is to the true value
C) how close a measured number is to the calculated value
D) how close a measured number is to zero
E) how close a measured number is to infinity
Answer: A
Diff: 1 Page Ref:Sec. 1.4

87) Accuracy refers to __________.
A) how close a measured number is to zero
B) how close a measured number is to the calculated value
C) how close a measured number is to other measured numbers
D) how close a measured number is to the true value
E) how close a measured number is to infinity
Answer: D
Diff: 1 Page Ref:Sec. 1.4

88) Which of the following has the same number of significant figures as the number 1.00310?

A) 1×10^6
B) 199.791
C) 8.66
D) 5.119
E) 100
Answer: B
Diff: 2 Page Ref:Sec. 1.4

89) A wooden object has a mass of 10.782 g and occupies a volume of 13.72 mL. What is the density of the object determined to an appropriate number of significant figures?

A) 8×10^{-1}g/mL
B) 7.9×10^{-1}g/mL
C) 7.86×10^{-1}g/mL
D) 7.859×10^{-1}g/mL
E) 7.8586×10^{-1}g/mL
Answer: D
Diff: 2 Page Ref:Sec. 1.4, 1.5

90) Acceleration due to gravity of a free-falling object is 9.8 m/s^2. Express this in millimeters/millisecond^2.

A) 9.8×10^{-9}
B) 9.8×10^{3}
C) 9.8×10^{-6}
D) 9.8×10^{6}
E) 9.8×10^{-3}
Answer: E
Diff: 2 Page Ref:Sec. 1.4

91) If an object is accelerating at a rate of 25 m/s^2, how long (in seconds) will it take to reach a speed of 550 m/s? (Assume an initial velocity of zero.)

A) 22
B) 1.4×10^4
C) 0.045
D) 1.2×10^4
E) 2.3×10^2
Answer: A
Diff: 4 Page Ref:Sec. 1.4

92) If an object is accelerating at a rate of 25 m/s^2, how fast will it be moving (in m/s) after 1.50 min? (Assume an initial velocity of zero.)

A) 17
B) 3.6
C) 38
D) 2.3×10^3
E) 0.060
Answer: D
Diff: 4 Page Ref:Sec. 1.4

93) Expressing a number in scientific notation __________.
A) changes its value
B) removes ambiguity as to the significant figures
C) removes significant zeros
D) allows to increase the number's precision
E) all of the above
Answer: B
Diff: 2 Page Ref:Sec. 1.5

94) The number with the most significant zeros is __________.
A) 0.00002510
B) 0.02500001
C) 250000001
D) 2.501×10^{-7}
E) 2.5100000
Answer: C
Diff: 1 Page Ref:Sec. 1.5

95) How many significant figures should be retained in the result of the following calculation?

$$12.00000 \times 0.9893 + 13.00335 \times 0.0107$$

A) 2
B) 3
C) 4
D) 5
E) 6
Answer: C
Diff: 2 Page Ref:Sec. 1.5

96) In which one of the following numbers are all of the zeros significant?
A) 100.090090
B) 0.143290
C) 0.05843
D) 0.1000
E) 00.0030020
Answer: A
Diff: 1 Page Ref:Sec. 1.5

97) Round the number 0.007222 to three significant figures.
A) 0.007
B) 0.00722
C) 0.0072
D) 0.00723
E) 0.007225
Answer: B
Diff: 1 Page Ref:Sec. 1.5

98) Round the number 0.08535 to two significant figures.
A) 0.09
B) 0.086
C) 0.0854
D) 0.085
E) 0.08535
Answer: D
Diff: 1 Page Ref:Sec. 1.5

99) Which of the following is the same as 0.001 cm?
A) 0.01 mm
B) 0.01 dm
C) 0.01 m
D) 100 mm
E) 1 mm
Answer: A
Diff: 1 Page Ref:Sec. 1.6

100) One angstrom, symbolized Å, is 10^{-10}m. $1\ cm^3$ = __________ $Å^3$.
A) 10^{24}
B) 10^{-24}
C) 10^{30}
D) 10^{-30}
E) 10^{-9}
Answer: A
Diff: 3 Page Ref:Sec. 1.6

SHORT ANSWER.

1) Gases do not have a fixed __________ as they are able to be __________.
Answer: volume, compressed
Diff: 1 Page Ref:Sec. 1.2

2) The symbol for the element phosphorous is __________.
Answer: P
Diff: 1 Page Ref:Sec. 1.2

3) Sn is the symbol for the element __________.
Answer: Tin
Diff: 1 Page Ref:Sec. 1.2

4) Mass and volume are often referred to as __________ properties of substances.
Answer: extensive
Diff: 4 Page Ref:Sec. 1.3

5) 1 milligram = __________ micrograms
Answer: 1,000
Diff: 1 Page Ref:Sec. 1.4

6) 1.035×10^{-4}L = __________ mL
Answer: 0.1035
Diff: 1 Page Ref:Sec. 1.4

TRUE/FALSE.
1) Water is considered to be a diatomic molecule because it is composed of two different atoms.
Answer: FALSE
Diff: 1 Page Ref:Sec. 1.2

2) $3.2\ cm^3$ = 0.0032 L
Answer: TRUE
Diff: 2 Page Ref:Sec. 1.4

3) There are 6 significant figures in the number 0.003702
Answer: FALSE
Diff: 2 Page Ref:Sec. 1.4

4) A scientific theory is a concise statement or an equation that summarizes a broad variety of observations.
Answer: FALSE
Diff: 2 Page Ref:Sec. 1.4

5) Temperature is a physical property that determines the direction of heat flow.
Answer: TRUE
Diff: 3 Page Ref:Sec. 1.4

Algorithmic Questions

1) What decimal power does the abbreviation f represent?
A) 1×10^{6}
B) 1×10^{3}
C) 1×10^{-1}
D) 1×10^{-15}
E) 1×10^{-12}
Answer: D
Diff: 2 Page Ref:Sec. 1.4

2) What decimal power does the abbreviation Milli represent?
A) 1×10^{3}
B) 1×10^{6}
C) 1×10^{9}
D) 1×10^{-3}
E) 1×10^{-6}
Answer: D
Diff: 1 Page Ref:Sec. 1.4

3) How many significant figures are in the measurement 5.34 g?
A) 1
B) 2
C) 4
D) 3
E) 5
Answer: D
Diff: 1 Page Ref:Sec. 1.5

4) The width, length, and height of a large, custom-made shipping crate are 1.22 m, 3.22 m, and 0.83 m, respectively. The volume of the box using the correct number of significant figures is __________ m^3.
A) 3.26057
B) 3.3
C) 3.26
D) 3.261
E) 3.2606
Answer: B
Diff: 2 Page Ref:Sec. 1.5

5) The estimated costs for remodelling the interior of an apartment are: three 1-gallon cans of paint at \$13.22 each (including tax), two paint brushes at \$9.53 each (including tax), and \$135 for a helper. The total estimated cost with the appropriate significant figures is \$________.
A) 193.72
B) 1.9×10^2
C) 194
D) 2×10^2
E) 193.7
Answer: C
Diff: 3 Page Ref:Sec. 1.5

6) Round the following number to four significant figures and express the result in standard exponential notation:
229.613
A) 0.2296×10^3
B) 229.6
C) 2.296×10^{-2}
D) 2.296×10^2
E) 22.96×10^{-1}
Answer: D
Diff: 2 Page Ref:Sec. 1.5

7) How many liters of wine can be held in a wine barrel whose capacity is 26.0 gal? 1 gal = 4 qt = 3.7854 L.
A) 1.46×10^{-4}
B) 0.146
C) 98.4
D) 6.87×10^3
E) 6.87
Answer: C
Diff: 3 Page Ref:Sec. 1.6

8) The recommended adult dose of Elixophyllin®, a drug used to treat asthma, is 6.0 mg/kg of body mass. Calculate the dose in milligrams for a 115-lb person. 1 lb = 453.59 g.
A) 24
B) 1,521
C) 1.5
D) 313
E) 3.1×10^5
Answer: D
Diff: 3 Page Ref:Sec. 1.6

9) The density of air under ordinary conditions at 25°C is 1.19 g/L. How many kilograms of air is in a room that measures 11.0 ft × 11.0 ft and has an 10.0 ft ceiling? 1 in. = 2.54 cm. (exactly); 1 L = $10^3 cm^3$
A) 3.66
B) 0.152
C) 4.08×10^4
D) 0.0962
E) 40.8
Answer: E
Diff: 3 Page Ref:Sec. 1.6

10) How many liters of air are in a room that measures 10.0 ft × 11.0 ft and has an 8.00 ft ceiling?
1 in. = 2.54 cm (exactly); 1 L = $10^3 cm^3$
A) 2.49×10^4
B) 92.8
C) 26.8
D) 2.68×10^7
E) 8.84×10^5
Answer: A
Diff: 3 Page Ref:Sec. 1.6

11) What is the volume (in cm^3) of a 63.4 g piece of metal with a density of 12.86 g/cm^3?
A) 4.93
B) 19.5
C) .425
D) 6.65
E) none of the above
Answer: A
Diff: 2 Page Ref:Sec. 1.4

12) The correct answer (reported to the proper number of significant figures) to the following is __________.

11.5 × 8.78 = __________

Answer: 101
Diff: 2 Page Ref:Sec. 1.4

13) The correct answer (reported to the proper number of significant figures) to the following is __________.

(1815 - 1806) × (9.11 × 7.92) = __________

Answer: 600
Diff: 4 Page Ref:Sec. 1.4

14) 38.325 lbs = __________ grams.
Answer: 17400
Diff: 4 Page Ref:Sec 1.4, 1.5

Chemistry, 11e (Brown)
Chapter 2, Atoms, Molecules, and Ions

Multiple-Choice and Bimodal

1) A certain mass of carbon reacts with 13.6 g of oxygen to form carbon monoxide. __________ grams of oxygen would react with that same mass of carbon to form carbon dioxide, according to the law of multiple proportions?
A) 25.6
B) 6.8
C) 13.6
D) 136
E) 27.2
Answer: E
Diff: 3 Page Ref: Sec. 2.1

2) Methane and ethane are both made up of carbon and hydrogen. In methane, there are 12.0 g of carbon for every 4.00 g of hydrogen, a ratio of 3:1 by mass. In ethane, there are 24.0 g of carbon for every 6.00 g of hydrogen, a ratio of 4:1 by mass. This is a statement of the law of __________.
A) constant composition
B) multiple proportions
C) conservation of matter
D) conservation of mass
E) octaves
Answer: B
Diff: 2 Page Ref: Sec. 2.1

3) Which statement below correctly describes the responses of alpha, beta, and gamma radiation to an electric field?
A) Both beta and gamma are deflected in the same direction, while alpha shows no response.
B) Both alpha and gamma are deflected in the same direction, while beta shows no response.
C) Both alpha and beta are deflected in the same direction, while gamma shows no response.
D) Alpha and beta are deflected in opposite directions, while gamma shows no response.
E) Only alpha is deflected, while beta and gamma show no response.
Answer: D
Diff: 2 Page Ref: Sec. 2.2

4) __________ and __________ reside in the atomic nucleus.
A) Protons, electrons
B) Electrons, neutrons
C) Protons, neutrons
D) none of the above
E) Neutrons, only neutrons
Answer: C
Diff: 1 Page Ref: Sec. 2.2

5) 200 pm is the same as __________ Ă .
A) 2000
B) 20
C) 200
D) 2
E) 2×10^{-12}
Answer: D
Diff: 1 Page Ref: Sec. 2.3

6) The atomic number indicates __________.
A) the number of neutrons in a nucleus
B) the total number of neutrons and protons in a nucleus
C) the number of protons or electrons in a neutral atom
D) the number of atoms in 1 g of an element
E) the number of different isotopes of an element
Answer: C
Diff: 1   Page Ref: Sec. 2.3

7) Which pair of atoms constitutes a pair of isotopes of the same element?
A) $^{14}_{6}X$ $^{14}_{7}X$
B) $^{14}_{6}X$ $^{12}_{6}X$
C) $^{17}_{9}X$ $^{17}_{8}X$
D) $^{19}_{10}X$ $^{19}_{9}X$
E) $^{20}_{10}X$ $^{21}_{11}X$
Answer: B
Diff: 1   Page Ref: Sec. 2.3

8) The nucleus of an atom contains __________.
A) electrons
B) protons, neutrons, and electrons
C) protons and neutrons
D) protons and electrons
E) protons
Answer: C
Diff: 1   Page Ref: Sec. 2.3

9) In the periodic table, the rows are called __________ and the columns are called __________.
A) octaves, groups
B) staffs, families
C) periods, groups
D) cogeners, families
E) rows, groups
Answer: C
Diff: 1   Page Ref: Sec. 2.5

10) Which group in the periodic table contains only nonmetals?
A) 1A
B) 6A
C) 2B
D) 2A
E) 8A
Answer: E
Diff: 1   Page Ref: Sec. 2.5

11) The element __________ is the most similar to strontium in chemical and physical properties.
A) Li
B) At
C) Rb
D) Ba
E) Cs
Answer: D
Diff: 3 Page Ref: Sec. 2.5

12) Horizontal rows of the periodic table are known as __________.
A) periods
B) groups
C) metalloids
D) metals
E) nonmetals
Answer: A
Diff: 1 Page Ref: Sec. 2.5

13) Vertical columns of the periodic table are known as __________.
A) metals
B) periods
C) nonmetals
D) groups
E) metalloids
Answer: D
Diff: 1 Page Ref: Sec. 2.5

14) Elements in Group 1A are known as the __________.
A) chalcogens
B) alkaline earth metals
C) alkali metals
D) halogens
E) noble gases
Answer: C
Diff: 1 Page Ref: Sec. 2.5

15) Elements in Group 2A are known as the __________.
A) alkaline earth metals
B) alkali metals
C) chalcogens
D) halogens
E) noble gases
Answer: A
Diff: 1 Page Ref: Sec. 2.5

16) Elements in Group 6A are known as the __________.
A) alkali metals
B) chalcogens
C) alkaline earth metals
D) halogens
E) noble gases
Answer: B
Diff: 1 Page Ref: Sec. 2.5

17) Elements in Group 7A are known as the __________.
A) chalcogens
B) alkali metals
C) alkaline earth metals
D) halogens
E) noble gases
Answer: D
Diff: 1 Page Ref: Sec. 2.5

18) Elements in Group 8A are known as the __________.
A) halogens
B) alkali metals
C) alkaline earth metals
D) chalcogens
E) noble gases
Answer: E
Diff: 1 Page Ref: Sec. 2.5

19) Potassium is a __________ and chlorine is a __________.
A) metal, nonmetal
B) metal, metal
C) metal, metalloid
D) metalloid, nonmetal
E) nonmetal, metal
Answer: A
Diff: 1 Page Ref: Sec. 2.5

20) Lithium is a __________ and magnesium is a __________.
A) nonmetal, metal
B) nonmetal, nonmetal
C) metal, metal
D) metal, metalloid
E) metalloid, metalloid
Answer: C
Diff: 1 Page Ref: Sec. 2.5

21) Oxygen is a __________ and nitrogen is a __________.
A) metal, metalloid
B) nonmetal, metal
C) metalloid, metalloid
D) nonmetal, nonmetal
E) nonmetal, metalloid
Answer: D
Diff: 1 Page Ref: Sec. 2.5

22) Calcium is a __________ and silver is a __________.
A) nonmetal, metal
B) metal, metal
C) metalloid, metal
D) metal, metalloid
E) nonmetal, metalloid
Answer: B
Diff: 1 Page Ref: Sec. 2.5

23) __________ are found uncombined, as monatomic species in nature.
A) Noble gases
B) Chalcogens
C) Alkali metals
D) Alkaline earth metals
E) Halogens
Answer: A
Diff: 1   Page Ref: Sec. 2.6

24) When a metal and a nonmetal react, the __________ tends to lose electrons and the __________ tends to gain electrons.
A) metal, metal
B) nonmetal, nonmetal
C) metal, nonmetal
D) nonmetal, metal
E) None of the above, these elements share electrons.
Answer: C
Diff: 1   Page Ref: Sec. 2.6

25) The empirical formula of a compound with molecules containing 12 carbon atoms, 14 hydrogen atoms, and 6 oxygen atoms is __________.
A) $C_{12}H_{14}O_6$
B) CHO
C) CH_2O
D) $C_6H_7O_3$
E) C_2H_4O
Answer: D
Diff: 2   Page Ref: Sec. 2.6

26) __________ typically form ions with a 2+ charge.
A) Alkaline earth metals
B) Halogens
C) Chalcogens
D) Alkali metals
E) Transition metals
Answer: A
Diff: 2   Page Ref: Sec. 2.7

27) What is the formula of the compound formed between strontium ions and nitrogen ions?
A) SrN
B) Sr_3N_2
C) Sr_2N_3
D) SrN_2
E) SrN_3
Answer: B
Diff: 3   Page Ref: Sec. 2.7

28) Magnesium reacts with a certain element to form a compound with the general formula MgX. What would the most likely formula be for the compound formed between potassium and element X?
A) K_2X
B) KX_2
C) K_2X_3
D) K_2X_2
E) KX
Answer: A
Diff: 1   Page Ref: Sec. 2.7

29) The formula of a salt is XCl_2. The X-ion in this salt has 28 electrons. The metal X is __________.
A) Ni
B) Zn
C) Fe
D) V
E) Pd
Answer: B
Diff: 2   Page Ref: Sec. 2.7

30) The charge on the manganese in the salt MnF_3 is __________.
A) +1
B) -1
C) +2
D) -2
E) +3
Answer: E
Diff: 1   Page Ref: Sec. 2.7

31) Aluminum reacts with a certain nonmetallic element to form a compound with the general formula AlX. Element X is a diatomic gas at room temperature. Element X must be __________.
A) oxygen
B) fluorine
C) chlorine
D) nitrogen
E) sulfur
Answer: D
Diff: 2   Page Ref: Sec. 2.7

32) Sodium forms an ion with a charge of __________.
A) +1
B) -1
C) +2
D) -2
E) 0
Answer: A
Diff: 1   Page Ref: Sec. 2.7

33) Potassium forms an ion with a charge of __________.
A) +2
B) -1
C) +1
D) -2
E) 0
Answer: C
Diff: 1 Page Ref: Sec. 2.7

34) Calcium forms an ion with a charge of __________.
A) -1
B) -2
C) +1
D) +2
E) 0
Answer: D
Diff: 1 Page Ref: Sec. 2.7

35) Barium forms an ion with a charge of __________.
A) +1
B) -2
C) +3
D) -3
E) +2
Answer: E
Diff: 1 Page Ref: Sec. 2.7

36) Aluminum forms an ion with a charge of __________.
A) +2
B) -3
C) +1
D) +3
E) -1
Answer: D
Diff: 1 Page Ref: Sec. 2.7

37) Fluorine forms an ion with a charge of __________.
A) -1
B) +1
C) +2
D) +3
E) -3
Answer: A
Diff: 1 Page Ref: Sec. 2.7

38) Iodine forms an ion with a charge of __________.
A) -7
B) +1
C) -2
D) +2
E) -1
Answer: E
Diff: 1 Page Ref: Sec. 2.7

39) Oxygen forms an ion with a charge of __________.
A) -2
B) +2
C) -3
D) +3
E) +6
Answer: A
Diff: 1 Page Ref: Sec. 2.7

40) Sulfur forms an ion with a charge of __________.
A) +2
B) -2
C) +3
D) -6
E) +6
Answer: B
Diff: 2 Page Ref: Sec. 2.7

41) Predict the empirical formula of the ionic compound that forms from sodium and fluorine.
A) NaF
B) Na_2F
C) NaF_2
D) Na_2F_3
E) Na_3F_2
Answer: A
Diff: 1 Page Ref: Sec. 2.7

42) Predict the empirical formula of the ionic compound that forms from magnesium and fluorine.
A) Mg_2F_3
B) MgF
C) Mg_2F
D) Mg_3F_2
E) MgF_2
Answer: E
Diff: 1 Page Ref: Sec. 2.7

43) Predict the empirical formula of the ionic compound that forms from magnesium and oxygen.
A) Mg_2O
B) MgO
C) MgO_2
D) Mg_2O_2
E) Mg_3O_2
Answer: B
Diff: 1 Page Ref: Sec. 2.7

44) Predict the empirical formula of the ionic compound that forms from aluminum and oxygen.
A) AlO
B) Al_3O_2
C) Al_2O_3
D) AlO_2
E) Al_2O
Answer: C
Diff: 1 Page Ref: Sec. 2.7

45) The correct name for SrO is __________.
A) strontium oxide
B) strontium hydroxide
C) strontium peroxide
D) strontium monoxide
E) strontium dioxide
Answer: A
Diff: 1 Page Ref: Sec. 2.8

46) The correct name for K_2S is __________.
A) potassium sulfate
B) potassium disulfide
C) potassium bisulfide
D) potassium sulfide
E) dipotassium sulfate
Answer: D
Diff: 1 Page Ref: Sec. 2.8

47) The correct name for Al_2O_3 is __________.
A) aluminum oxide
B) dialuminum oxide
C) dialuminum trioxide
D) aluminum hydroxide
E) aluminum trioxide
Answer: A
Diff: 2 Page Ref: Sec. 2.8

48) The correct name for CaH_2 is __________.
A) hydrocalcium
B) calcium dihydride
C) calcium hydroxide
D) calcium dihydroxide
E) calcium hydride
Answer: E
Diff: 1 Page Ref: Sec. 2.8

49) The correct name for SO is __________.
A) sulfur oxide
B) sulfur monoxide
C) sulfoxide
D) sulfate
E) sulfite
Answer: B
Diff: 1 Page Ref: Sec. 2.8

50) The correct name for CCl_4 is __________.

A) carbon chloride
B) carbon tetrachlorate
C) carbon perchlorate
D) carbon tetrachloride
E) carbon chlorate
Answer: D
Diff: 1 Page Ref: Sec. 2.8

51) The correct name for N_2O_5 is __________.

A) nitrous oxide
B) nitrogen pentoxide
C) dinitrogen pentoxide
D) nitric oxide
E) nitrogen oxide
Answer: C
Diff: 1 Page Ref: Sec. 2.8

52) The correct name for H_2CO_3 is __________.

A) carbonous acid
B) hydrocarbonate
C) carbonic acid
D) carbohydrate
E) carbohydric acid
Answer: C
Diff: 1 Page Ref: Sec. 2.8

53) The correct name for H_2SO_3 is __________.

A) sulfuric acid
B) sulfurous acid
C) hydrosulfuric acid
D) hydrosulfic acid
E) sulfur hydroxide
Answer: B
Diff: 1 Page Ref: Sec. 2.8

54) The correct name for $HClO_3$ is __________.

A) hydrochloric acid
B) perchloric acid
C) chloric acid
D) chlorous acid
E) hydrochlorous acid
Answer: C
Diff: 1 Page Ref: Sec. 2.8

55) The correct name for $HClO_2$ is __________.

A) perchloric acid
B) chloric acid
C) hypochlorous acid
D) hypychloric acid
E) chlorous acid
Answer: E
Diff: 2 Page Ref: Sec. 2.8

56) The correct name of the compound Na_3N is __________.
A) sodium nitride
B) sodium azide
C) sodium trinitride
D) sodium(IX) nitride
E) trisodium nitride
Answer: A
Diff: 1 Page Ref: Sec. 2.8

57) The formula of bromic acid is __________.
A) HBr
B) $HBrO_4$
C) HBrO
D) $HBrO_3$
E) $HBrO_2$
Answer: D
Diff: 1 Page Ref: Sec. 2.8

58) The correct formula for molybdenum(IV) hypochlorite is __________.
A) $Mo(ClO_3)_4$
B) $Mo(ClO)_4$
C) $Mo(ClO_2)_4$
D) $Mo(ClO_4)_4$
E) $MoCl_4$
Answer: B
Diff: 2 Page Ref: Sec. 2.8

59) The name of PCl_3 is __________.
A) potassium chloride
B) phosphorus trichloride
C) phosphorous(III) chloride
D) monophosphorous trichloride
E) trichloro potassium
Answer: B
Diff: 1 Page Ref: Sec. 2.8

60) The ions Ca^{2+} and PO_4^{3-} form a salt with the formula __________.
A) $CaPO_4$
B) $Ca_2(PO_4)_3$
C) Ca_2PO_4
D) $Ca(PO_4)_2$
E) $Ca_3(PO_4)_2$
Answer: E
Diff: 1 Page Ref: Sec. 2.8

61) The correct formula of iron(III) bromide is __________.
A) $FeBr_2$
B) $FeBr_3$
C) FeBr
D) Fe_3Br_3
E) Fe_3Br
Answer: B
Diff: 1   Page Ref: Sec. 2.8

62) Element M reacts with fluorine to form an ionic compound with the formula MF_3. The M-ion has 18 electrons. Element M is __________.
A) P
B) Sc
C) Ar
D) Ca
E) Cr
Answer: B
Diff: 2   Page Ref: Sec. 2.8

63) Magnesium and sulfur form an ionic compound with the formula __________.
A) MgS
B) Mg_2S
C) MgS_2
D) Mg_2S_2
E) Mg_2S_3
Answer: A
Diff: 1   Page Ref: Sec. 2.8

64) The formula of ammonium carbonate is __________.
A) $(NH_4)_2CO_3$
B) NH_4CO_2
C) $(NH_3)_2CO_4$
D) $(NH_3)_2CO_3$
E) $N_2(CO_3)_3$
Answer: A
Diff: 1   Page Ref: Sec. 2.8

65) The formula of the chromate ion is __________.
A) CrO_4^{2-}
B) CrO_2^{3-}
C) CrO^-
D) CrO_3^{2-}
E) CrO^{2-}
Answer: A
Diff: 1   Page Ref: Sec. 2.8

66) The formula of the carbonate ion is __________.

A) CO_2^{2-}

B) CO_3^{2-}

C) CO_3^{3-}

D) CO_2^{-}

E) CO^{-}

Answer: B

Diff: 1 Page Ref: Sec. 2.8

67) The correct name for $Mg(ClO_3)_2$ is __________.

A) magnesium chlorate

B) manganese chlorate

C) magnesium chloroxide

D) magnesium perchlorate

E) manganese perchlorate

Answer: A

Diff: 1 Page Ref: Sec. 2.8

68) What is the correct formula for ammonium sulfide?

A) NH_4SO_3

B) $(NH_4)_2SO_4$

C) $(NH_4)_2S$

D) NH_3S

E) N_2S_3

Answer: C

Diff: 1 Page Ref: Sec. 2.8

69) When calcium reacts with sulfur the compound formed is __________.

A) Ca_2S_2

B) Ca_3S_2

C) CaS

D) CaS_2

E) Ca_2S_3

Answer: C

Diff: 1 Page Ref: Sec. 2.8

70) Chromium and chlorine form an ionic compound whose formula is $CrCl_3$. The name of this compound is __________.

A) chromium chlorine

B) chromium(III) chloride

C) monochromium trichloride

D) chromium(III) trichloride

E) chromic trichloride

Answer: B

Diff: 1 Page Ref: Sec. 2.8

71) The name of the binary compound N_2O_4 is __________.

A) nitrogen oxide
B) nitrous oxide
C) nitrogen(III) oxide
D) dinitrogen tetroxide
E) oxygen nitride
Answer: D
Diff: 2 Page Ref: Sec. 2.8

72) The formula for zinc phosphate is $Zn_3(PO_4)_2$. What is the formula for cadmium arsenate?

A) $Cd_4(AsO_2)_3$
B) $Cd_3(AsO_4)_2$
C) $Cd_3(AsO_3)_4$
D) $Cd_2(AsO_4)_3$
E) $Cd_2(AsO_4)_4$
Answer: B
Diff: 1 Page Ref: Sec. 2.8

73) The formula for aluminum hydroxide is __________.
A) AlOH
B) Al_3OH
C) $Al_2(OH)_3$
D) $Al(OH)_3$
E) Al_2O_3
Answer: D
Diff: 1 Page Ref: Sec. 2.8

74) The name of the ionic compound $KBrO_4$ is __________.

A) potassium perbromate
B) potassium bromate
C) potassium hypobromate
D) potassium perbromite
E) potassium bromide
Answer: A
Diff: 2 Page Ref: Sec. 2.8

75) The name of the ionic compound V_2O_3 is __________.

A) vanadium(III) oxide
B) vanadium oxide
C) vanadium(II) oxide
D) vanadium(III) trioxide
E) divanadium trioxide
Answer: A
Diff: 1 Page Ref: Sec. 2.8

76) The name of the ionic compound NH_4CN is __________.

A) nitrogen hydrogen cyanate
B) ammonium carbonitride
C) ammonium cyanide
D) ammonium hydrogen cyanate
E) cyanonitride
Answer: C
Diff: 1 Page Ref: Sec. 2.8

77) The name of the ionic compound $(NH_4)_3PO_4$ is __________.

A) ammonium phosphate
B) nitrogen hydrogen phosphate
C) tetrammonium phosphate
D) ammonia phosphide
E) triammonium phosphate
Answer: A
Diff: 1 Page Ref: Sec. 2.8

78) What is the formula for perchloric acid?
A) HClO
B) $HClO_3$
C) $HClO_4$
D) $HClO_2$
E) HCl
Answer: C
Diff: 1 Page Ref: Sec. 2.8

79) The correct name for HIO_2 is __________.

A) hypoiodic acid
B) hydriodic acid
C) periodous acid
D) iodous acid
E) periodic acid
Answer: D
Diff: 2 Page Ref: Sec. 2.8

80) What is the molecular formula for propane __________?
A) C_2H_8
B) C_3H_6
C) C_3H_8
D) C_4H_8
E) C_4H_{10}
Answer: C
Diff: 1 Page Ref: Sec. 2.9

81) What is the molecular formula for nonane __________?
A) C_9H_{18}
B) C_9H_{20}
C) $C_{10}H_{20}$
D) $C_{10}H_{22}$
E) $C_{10}H_{24}$
Answer: B
Diff: 2 Page Ref: Sec. 2.9

82) What is the molecular formula for heptane __________?
A) C_6H_{12}
B) C_6H_{14}
C) C_7H_{14}
D) C_7H_{16}
E) C_7H_{18}
Answer: D
Diff: 2 Page Ref: Sec. 2.9

83) What is the molecular formula for n-hexanol __________?
A) $C_6H_{12}OH$
B) $C_6H_{13}OH$
C) $C_6H_{14}OH$
D) $C_7H_{13}OH$
E) $C_7H_{14}OH$
Answer: B
Diff: 2 Page Ref: Sec. 2.9

Multiple-Choice

84) A molecule of water contains hydrogen and oxygen in a 1:8 ratio by mass. This is a statement of __________.
A) the law of multiple proportions
B) the law of constant composition
C) the law of conservation of mass
D) the law of conservation of energy
E) none of the above
Answer: B
Diff: 2 Page Ref: Sec. 2.1

85) Which one of the following is not one of the postulates of Dalton's atomic theory?
A) Atoms are composed of protons, neutrons, and electrons.
B) All atoms of a given element are identical; the atoms of different elements are different and have different properties.
C) Atoms of an element are not changed into different types of atoms by chemical reactions: atoms are neither created nor destroyed in chemical reactions.
D) Compounds are formed when atoms of more than one element combine; a given compound always has the same relative number and kind of atoms.
E) Each element is composed of extremely small particles called atoms.
Answer: A
Diff: 1 Page Ref: Sec. 2.1

86) Consider the following selected postulates of Dalton's atomic theory:
(i) Each element is composed of extremely small particles called atoms.
(ii) Atoms are indivisible.
(iii) Atoms of a given element are identical.
(iv) Atoms of different elements are different and have different properties.
Which of the postulates is(are) no longer valid?
A) (i) and (ii)
B) (ii) only
C) (ii) and (iii)
D) (iii) only
E) (iii) and (iv)
Answer: C
Diff: 2 Page Ref: Sec. 2.1

87) Which pair of substances could be used to illustrate the law of multiple proportions?
A) SO_2, H_2SO_4
B) CO, CO_2
C) H_2O, O_2
D) CH_4, $C_6H_{12}O_6$
E) NaCl, KCl
Answer: B
Diff: 1 Page Ref: Sec. 2.1

88) Which one of the following is not true concerning cathode rays?
A) They originate from the negative electrode.
B) They travel in straight lines in the absence of electric or magnetic fields.
C) They impart a negative charge to metals exposed to them.
D) They are made up of electrons.
E) The characteristics of cathode rays depend on the material from which they are emitted.
Answer: E
Diff: 2 Page Ref: Sec. 2.2

89) The charge on an electron was determined in the __________.
A) cathode ray tube, by J. J. Thompson
B) Rutherford gold foil experiment
C) Millikan oil drop experiment
D) Dalton atomic theory
E) atomic theory of matter
Answer: C
Diff: 1 Page Ref: Sec. 2.2

90) __________-rays consist of fast-moving electrons.
A) alpha
B) beta
C) gamma
D) X
E) none of the above
Answer: B
Diff: 1 Page Ref: Sec. 2.2

91) The gold foil experiment performed in Rutherford's lab __________.
A) confirmed the plum-pudding model of the atom
B) led to the discovery of the atomic nucleus
C) was the basis for Thompson's model of the atom
D) utilized the deflection of beta particles by gold foil
E) proved the law of multiple proportions
Answer: B
Diff: 1 Page Ref: Sec. 2.2

92) In the Rutherford nuclear-atom model, __________.
A) the heavy subatomic particles, protons and neutrons, reside in the nucleus
B) the three principal subatomic particles (protons, neutrons, and electrons) all have essentially the same mass
C) the light subatomic particles, protons and neutrons, reside in the nucleus
D) mass is spread essentially uniformly throughout the atom
E) the three principal subatomic particles (protons, neutrons, and electrons) all have essentially the same mass and mass is spread essentially uniformly throughout the atom
Answer: A
Diff: 1 Page Ref: Sec. 2.2

93) Cathode rays are __________.
A) neutrons
B) x-rays
C) electrons
D) protons
E) atoms
Answer: C
Diff: 1 Page Ref: Sec. 2.2

94) Cathode rays are deflected away from a negatively charged plate because __________.
A) they are not particles
B) they are positively charged particles
C) they are neutral particles
D) they are negatively charged particles
E) they are emitted by all matter
Answer: D
Diff: 1 Page Ref: Sec. 2.2

95) In the absence of magnetic or electric fields, cathode rays __________.
A) do not exist
B) travel in straight lines
C) cannot be detected
D) become positively charged
E) bend toward a light source
Answer: B
Diff: 1 Page Ref: Sec. 2.2

96) Of the three types of radioactivity characterized by Rutherford, which is/are electrically charged?
A) β-rays
B) α-rays and β-rays
C) α-rays, β-rays, and γ-rays
D) α-rays
E) α-rays and γ-rays
Answer: B
Diff: 1 Page Ref: Sec. 2.2

97) Of the three types of radioactivity characterized by Rutherford, which is/are not electrically charged?
A) α-rays
B) α-rays, β-rays, and γ-rays
C) γ-rays
D) α-rays and β-rays
E) α-rays and γ-rays
Answer: C
Diff: 1 Page Ref: Sec. 2.2

98) Of the three types of radioactivity characterized by Rutherford, which are particles?
A) β-rays
B) α-rays, β-rays, and γ-rays
C) γ-rays
D) α-rays and γ-rays
E) α-rays and β-rays
Answer: E
Diff: 1 Page Ref: Sec. 2.2

99) Of the three types of radioactivity characterized by Rutherford, which is/are not particles?
A) β-rays
B) α-rays and β-rays
C) α-rays
D) γ-rays
E) α-rays, β-rays, and γ-rays
Answer: D
Diff: 1 Page Ref: Sec. 2.2

100) Of the following, the smallest and lightest subatomic particle is the __________.
A) neutron
B) proton
C) electron
D) nucleus
E) alpha particle
Answer: C
Diff: 1 Page Ref: Sec. 2.3

101) All atoms of a given element have the same __________.
A) mass
B) number of protons
C) number of neutrons
D) number of electrons and neutrons
E) density
Answer: B
Diff: 1 Page Ref: Sec. 2.3

102) Which atom has the smallest number of neutrons?
A) carbon-14
B) nitrogen-14
C) oxygen-16
D) fluorine-19
E) neon-20
Answer: B
Diff: 1 Page Ref: Sec. 2.3

103) Which atom has the largest number of neutrons?
A) phosphorous-30
B) chlorine-37
C) potassium-39
D) argon-40
E) calcium-40
Answer: D
Diff: 3 Page Ref: Sec. 2.3

104) There are __________ electrons, __________ protons, and __________ neutrons in an atom of $^{132}_{54}$Xe.

A) 132, 132, 54
B) 54, 54, 132
C) 78, 78, 54
D) 54, 54, 78
E) 78, 78, 132
Answer: D
Diff: 2 Page Ref: Sec. 2.3

105) An atom of the most common isotope of gold, ^{197}Au, has __________ protons, __________ neutrons, and __________ electrons.
A) 197, 79, 118
B) 118, 79, 39
C) 79, 197, 197
D) 79, 118, 118
E) 79, 118, 79
Answer: E
Diff: 2 Page Ref: Sec. 2.3

106) Which combination of protons, neutrons, and electrons is correct for the isotope of copper, $^{63}_{29}$Cu?

A) 29 p^+, 34 n°, 29 e^-

B) 29 p^+, 29 n°, 63 e^-

C) 63 p^+, 29 n°, 63 e^-

D) 34 p^+, 29 n°, 34 e^-

E) 34 p^+, 34 n°, 29 e^-

Answer: A
Diff: 1 Page Ref: Sec. 2.3

107) Which isotope has 45 neutrons?
A) $^{80}_{36}\text{Kr}$
B) $^{80}_{35}\text{Br}$
C) $^{78}_{34}\text{Se}$
D) $^{34}_{17}\text{Cl}$
E) $^{103}_{45}\text{Rh}$
Answer: B
Diff: 1 Page Ref: Sec. 2.3

108) Which isotope has 36 electrons in an atom?
A) $^{80}_{36}\text{Kr}$
B) $^{80}_{35}\text{Br}$
C) $^{78}_{34}\text{Se}$
D) $^{34}_{17}\text{Cl}$
E) $^{36}_{80}\text{Hg}$
Answer: A
Diff: 1 Page Ref: Sec. 2.3

109) Isotopes are atoms that have the same number of __________ but differing number of __________.
A) protons, electrons
B) neutrons, protons
C) protons, neutrons
D) electrons, protons
E) neutrons, electrons
Answer: C
Diff: 1 Page Ref: Sec. 2.3

110) The nucleus of an atom does not contain __________.
A) protons
B) protons or neutrons
C) neutrons
D) subatomic particles
E) electrons
Answer: E
Diff: 1 Page Ref: Sec. 2.3

111) Different isotopes of a particular element contain the same number of __________.
A) protons
B) neutrons
C) protons and neutrons
D) protons, neutrons, and electrons
E) subatomic particles
Answer: A
Diff: 1 Page Ref: Sec. 2.3

112) Different isotopes of a particular element contain different numbers of __________.
A) protons
B) neutrons
C) protons and neutrons
D) protons, neutrons, and electrons
E) None of the above is correct.
Answer: B
Diff: 1 Page Ref: Sec. 2.3

113) In the symbol shown below, x = __________.

$$^{13}_{x}\mathrm{C}$$

A) 7
B) 13
C) 12
D) 6
E) not enough information to determine
Answer: D
Diff: 1 Page Ref: Sec. 2.3

114) In the symbol below, X = __________.

$$^{13}_{6}\mathrm{X}$$

A) N
B) C
C) Al
D) K
E) not enough information to determine
Answer: B
Diff: 1 Page Ref: Sec. 2.3

115) In the symbol below, x = __________.

$$^{x}_{6}\mathrm{C}$$

A) 19
B) 13
C) 6
D) 7
E) not enough information to determine
Answer: E
Diff: 2 Page Ref: Sec. 2.3

116) In the symbol below, x is __________.

$^{x}_{6}C$

A) the number of neutrons
B) the atomic number
C) the mass number
D) the isotope number
E) the elemental symbol
Answer: C
Diff: 1 Page Ref: Sec. 2.3

117) Which one of the following basic forces is so small that it has no chemical significance?
A) weak nuclear force
B) strong nuclear force
C) electromagnetism
D) gravity
E) Coulomb's law
Answer: D
Diff: 2 Page Ref: Sec. 2.3

118) Gravitational forces act between objects in proportion to their
A) volumes
B) masses
C) charges
D) polarizability
E) densities
Answer: B
Diff: 1 Page Ref: Sec. 2.3

119) Silver has two naturally occurring isotopes with the following isotopic masses:

$^{107}_{47}Ar$	$^{107}_{47}Ar$
106.90509	108.9047

The average atomic mass of silver is 107.8682 amu. The fractional abundance of the lighter of the two isotopes is __________.
A) 0.2422
B) 0.4816
C) 0.5184
D) 0.7578
E) 0.9047
Answer: C
Diff: 4Page Ref: Sec. 2.4

120) The atomic mass unit is presently based on assigning an exact integral mass (in amu) to an isotope of __________.
A) hydrogen
B) oxygen
C) sodium
D) carbon
E) helium
Answer: D
Diff: 1 Page Ref: Sec. 2.4

121) The element X has three naturally occurring isotopes. The masses (amu) and % abundances of the isotopes are given in the table below. The average atomic mass of the element is __________ amu.

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

A) 219.7
B) 220.4
C) 22042
D) 218.5
E) 221.0
Answer: B
Diff: 1 Page Ref: Sec. 2.4

122) Element X has three naturally occurring isotopes. The masses (amu) and % abundances of the isotopes are given in the table below. The average atomic mass of the element is __________ amu.

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

A) 41.54
B) 39.68
C) 39.07
D) 38.64
E) 33.33
Answer: A
Diff: 1 Page Ref: Sec. 2.4

123) The element X has three naturally occurring isotopes. The isotopic masses (amu) and % abundances of the isotopes are given in the table below. The average atomic mass of the element is __________ amu.

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

A) 161.75
B) 162.03
C) 162.35
D) 163.15
E) 33.33
Answer: C
Diff: 1 Page Ref: Sec. 2.4

124) The element X has three naturally occurring isotopes. The isotopic masses (amu) and % abundances of the isotopes are given in the table below. The average atomic mass of the element is __________ amu.

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

A) 33.33
B) 55.74
C) 56.11
D) 57.23
E) 56.29
Answer: C
Diff: 1 Page Ref: Sec. 2.4

125) The element X has two naturally occurring isotopes. The masses (amu) and % abundances of the isotopes are given in the table below. The average atomic mass of the element is __________ amu.

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

A) 30.20
B) 33.19
C) 34.02
D) 35.22
E) 32.73
Answer: B
Diff: 1 Page Ref: Sec. 2.4

126) The average atomic weight of copper, which has two naturally occurring isotopes, is 63.5. One of the isotopes has an atomic weight of 62.9 amu and constitutes 69.1% of the copper isotopes. The other isotope has an abundance of 30.9%. The atomic weight (amu) of the second isotope is __________ amu.
A) 63.2
B) 63.8
C) 64.1
D) 64.8
E) 28.1
Answer: D
Diff: 1 Page Ref: Sec. 2.4

127) The element X has three naturally occurring isotopes. The masses (amu) and % abundances of the isotopes are given in the table below. The average atomic mass of the element is __________ amu.

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

A) 17.20
B) 16.90
C) 17.65
D) 17.11
E) 16.90
Answer: A
Diff: 1   Page Ref: Sec. 2.4

128) Vanadium has two naturally occurring isotopes, ^{50}V with an atomic mass of 49.9472 amu and ^{51}V with an atomic mass of 50.9440. The atomic weight of vanadium is 50.9415. The percent abundances of the vanadium isotopes are __________% ^{50}V and __________% ^{51}V .
A) 0.2500, 99.750
B) 99.750, 0.2500
C) 49.00, 51.00
D) 1.000, 99.000
E) 99.000, 1.000
Answer: A
Diff: 1   Page Ref: Sec. 2.4

129) An unknown element is found to have three naturally occurring isotopes with atomic masses of 35.9675 (0.337%), 37.9627 (0.063%), and 39.9624 (99.600%). Which of the following is the unknown element?
A) Ar
B) K
C) Cl
D) Ca
E) None of the above could be the unknown element.
Answer: A
Diff: 2   Page Ref: Sec. 2.4

130) In the periodic table, the elements are arranged in __________.
A) alphabetical order
B) order of increasing atomic number
C) order of increasing metallic properties
D) order of increasing neutron content
E) reverse alphabetical order
Answer: B
Diff: 1   Page Ref: Sec. 2.5

131) Elements __________ exhibit similar physical and chemical properties.
A) with similar chemical symbols
B) with similar atomic masses
C) in the same period of the periodic table
D) on opposite sides of the periodic table
E) in the same group of the periodic table
Answer: E
Diff: 1   Page Ref: Sec. 2.5

132) Which pair of elements would you expect to exhibit the greatest similarity in their physical and chemical properties?
A) H, Li
B) Cs, Ba
C) Ca, Sr
D) Ga, Ge
E) C, O
Answer: C
Diff: 1 Page Ref: Sec. 2.5

133) Which pair of elements would you expect to exhibit the greatest similarity in their physical and chemical properties?
A) O, S
B) C, N
C) K, Ca
D) H, He
E) Si, P
Answer: A
Diff: 1 Page Ref: Sec. 2.5

134) Which one of the following is a nonmetal?
A) W
B) Sr
C) Os
D) Ir
E) Br
Answer: E
Diff: 1 Page Ref: Sec. 2.5

135) Of the following, only __________ is not a metalloid.
A) B
B) Al
C) Si
D) Ge
E) As
Answer: B
Diff: 1 Page Ref: Sec. 2.5

136) The elements in groups 1A, 6A, and 7A are called, __________, respectively.
A) alkaline earth metals, halogens, and chalcogens
B) alkali metals, chalcogens, and halogens
C) alkali metals, halogens, and noble gases
D) alkaline earth metals, transition metals, and halogens
E) halogens, transition metals, and alkali metals
Answer: B
Diff: 2 Page Ref: Sec. 2.5

137) Which pair of elements below should be the most similar in chemical properties?
A) C and O
B) B and As
C) I and Br
D) K and Kr
E) Cs and He
Answer: C
Diff: 1 Page Ref: Sec. 2.5

138) An element in the upper right corner of the periodic table __________.
A) is either a metal or metalloid
B) is definitely a metal
C) is either a metalloid or a non-metal
D) is definitely a non-metal
E) is definitely a metalloid
Answer: D
Diff: 1 Page Ref: Sec. 2.5

139) An element that appears in the lower left corner of the periodic table is __________.
A) either a metal or metalloid
B) definitely a metal
C) either a metalloid or a non-metal
D) definitely a non-metal
E) definitely a metalloid
Answer: B
Diff: 1 Page Ref: Sec. 2.5

140) Which one of the following does not occur as diatomic molecules in elemental form?
A) oxygen
B) nitrogen
C) sulfur
D) hydrogen
E) bromine
Answer: C
Diff: 1 Page Ref: Sec. 2.6

141) Which one of the following molecular formulas is also an empirical formula?
A) $C_6H_6O_2$
B) C_2H_6SO
C) H_2O_2
D) $H_2P_4O_6$
E) C_6H_6
Answer: B
Diff: 2 Page Ref: Sec. 2.6

142) Which compounds do not have the same empirical formula?
A) C_2H_2, C_6H_6
B) CO, CO_2
C) C_2H_4, C_3H_6
D) $C_2H_4O_2$, $C_6H_{12}O_6$
E) $C_2H_5COOCH_3$, CH_3CHO
Answer: B
Diff: 2 Page Ref: Sec. 2.6

143) Of the choices below, which one is <u>not</u> an ionic compound?
A) PCl_5
B) $MoCl_6$
C) RbCl
D) $PbCl_2$
E) NaCl
Answer: A
Diff: 1 Page Ref: Sec. 2.6

144) Which type of formula provides the most information about a compound?
A) empirical
B) molecular
C) simplest
D) structural
E) chemical
Answer: D
Diff: 1 Page Ref: Sec. 2.6

145) A molecular formula always indicates __________.
A) how many of each atom are in a molecule
B) the simplest whole-number ratio of different atoms in a compound
C) which atoms are attached to which in a molecule
D) the isotope of each element in a compound
E) the geometry of a molecule
Answer: A
Diff: 1 Page Ref: Sec. 2.6

146) An empirical formula always indicates __________.
A) which atoms are attached to which in a molecule
B) how many of each atom are in a molecule
C) the simplest whole-number ratio of different atoms in a compound
D) the isotope of each element in a compound
E) the geometry of a molecule
Answer: C
Diff: 1 Page Ref: Sec. 2.6

147) The molecular formula of a compound is always __________ the empirical formula.
A) more complex than
B) different from
C) an integral multiple of
D) the same as
E) simpler than
Answer: C
Diff: 1 Page Ref: Sec. 2.7

148) Of the following, __________ contains the greatest number of electrons.
A) P^{3+}
B) P
C) P^{2-}
D) P^{3-}
E) P^{2+}
Answer: D
Diff: 1 Page Ref: Sec. 2.7

149) Which one of the following is most likely to lose electrons when forming an ion?
A) F
B) P
C) Rh
D) S
E) N
Answer: C
Diff: 2 Page Ref: Sec. 2.7

150) Elements in the same group of the periodic table typically have __________.
A) similar mass numbers
B) similar physical properties only
C) similar chemical properties only
D) similar atomic masses
E) similar physical and chemical properties
Answer: E
Diff: 1 Page Ref: Sec. 2.5

151) Which species has 54 electrons?
A) $^{132}_{54}Xe^{+}$
B) $^{128}_{52}Te^{2-}$
C) $^{118}_{50}Sn^{2+}$
D) $^{112}_{48}Cd$
E) $^{132}_{54}Xe^{2+}$

Answer: B
Diff: 1 Page Ref: Sec. 2.7

152) Which species has 16 protons?
A) ^{31}P
B) $^{34}S^{2-}$
C) ^{36}Cl
D) $^{80}Br^{-}$
E) ^{16}O
Answer: B
Diff: 1 Page Ref: Sec. 2.7

153) The species __________ contains 16 neutrons.
A) ^{31}P
B) $^{34}S^{2-}$
C) ^{36}Cl
D) $^{80}Br^{-}$
E) ^{16}O
Answer: A
Diff: 1 Page Ref: Sec. 2.7

154) Which species is an isotope of ^{39}Cl?

A) $^{40}Ar^{+}$

B) $^{34}S^{2-}$

C) $^{36}Cl^{-}$

D) ^{80}Br

E) ^{39}Ar

Answer: C

Diff: 1 Page Ref: Sec. 2.7

155) Which one of the following species has as many electrons as it has neutrons?

A) ^{1}H

B) $^{40}Ca^{2+}$

C) ^{14}C

D) $^{19}F^{-}$

E) $^{14}C^{2+}$

Answer: D

Diff: 2 Page Ref: Sec. 2.7

156) There are __________ protons, __________ neutrons, and __________ electrons in $^{131}I^{-}$.

A) 131, 53, and 54

B) 131, 53, and 52

C) 53, 78, and 54

D) 53, 131, and 52

E) 78, 53, and 72

Answer: C

Diff: 2 Page Ref: Sec. 2.7

157) Which species has 48 electrons?

A) $^{118}_{50}Sn^{+2}$

B) $^{116}_{50}Sn^{+4}$

C) $^{112}_{48}Cd^{+2}$

D) $^{68}_{31}Ga$

E) $^{48}_{22}Ti$

Answer: A

Diff: 1 Page Ref: Sec. 2.7

158) Which of the following compounds would you expect to be ionic?

A) SF_6

B) H_2O

C) H_2O_2

D) NH_3

E) CaO

Answer: E

Diff: 1 Page Ref: Sec. 2.7

159) Which of the following compounds would you expect to be ionic?
A) H_2O
B) CO_2
C) $SrCl_2$
D) SO_2
E) H_2S
Answer: C
Diff: 1 Page Ref: Sec. 2.7

160) Which pair of elements is most apt to form an ionic compound with each other?
A) barium, bromine
B) calcium, sodium
C) oxygen, fluorine
D) sulfur, fluorine
E) nitrogen, hydrogen
Answer: A
Diff: 1 Page Ref: Sec. 2.7

161) Which pair of elements is most apt to form a molecular compound with each other?
A) aluminum, oxygen
B) magnesium, iodine
C) sulfur, fluorine
D) potassium, lithium
E) barium, bromine
Answer: C
Diff: 1 Page Ref: Sec. 2.7

162) Which formula/name pair is incorrect?
A) $Mn(NO_2)_2$ manganese(II) nitrite
B) $Mg(NO_3)_2$ magnesium nitrate
C) $Mn(NO_3)_2$ manganese(II) nitrate
D) Mg_3N_2 magnesium nitrite
E) $Mg(MnO_4)_2$ magnesium permanganate
Answer: D
Diff: 2 Page Ref: Sec. 2.8

163) Which species below is the nitride ion?
A) Na^+
B) NO_3^-
C) NO_2^-
D) NH_4^+
E) N^{3-}
Answer: E
Diff: 1 Page Ref: Sec. 2.7

164) Which species below is the sulfite ion?
A) SO_2^-
B) SO_3^-
C) S^{2-}
D) H_2SO_4
E) H_2S
Answer: A
Diff: 1 Page Ref: Sec. 2.7

165) Which species below is the nitrate ion?
A) NO_2^-
B) NH_4^+
C) NO_3^-
D) N_3^-
E) N^3-
Answer: C
Diff: 1 Page Ref: Sec. 2.7

166) Which formula/name pair is incorrect?
A) $FeSO_4$ iron(II) sulfate
B) $Fe_2(SO_3)_3$ iron(III) sulfite
C) FeS iron(II) sulfide
D) $FeSO_3$ iron(II) sulfite
E) $Fe_2(SO_4)_3$ iron(III) sulfide
Answer: E
Diff: 1 Page Ref: Sec. 2.8

167) Which one of the following is the formula of hydrochloric acid?
A) $HClO_3$
B) $HClO_4$
C) HClO
D) HCl
E) $HClO_2$
Answer: D
Diff: 1 Page Ref: Sec. 2.8

168) The suffix -ide is used __________.
A) for monatomic anion names
B) for polyatomic cation names
C) for the name of the first element in a molecular compound
D) to indicate binary acids
E) for monoatomic cations
Answer: A
Diff: 1 Page Ref: Sec. 2.8

169) Which one of the following compounds is chromium(III) oxide?
A) Cr_2O_3
B) CrO_3
C) Cr_3O_2
D) Cr_3O
E) Cr_2O_4
Answer: A
Diff: 1 Page Ref: Sec. 2.8

170) Which one of the following compounds is copper(I) chloride?
A) CuCl
B) $CuCl_2$
C) Cu_2Cl
D) Cu_2Cl_3
E) Cu_3Cl_2
Answer: A
Diff: 1 Page Ref: Sec. 2.8

171) The charge on the __________ ion is -3.
A) sulfate
B) acetate
C) permanganate
D) oxide
E) nitride
Answer: E
Diff: 2 Page Ref: Sec. 2.8

172) Which one of the following polyatomic ions has the same charge as the hydroxide ion?
A) ammonium
B) carbonate
C) nitrate
D) sulfate
E) phosphate
Answer: C
Diff: 1 Page Ref: Sec. 2.8

173) Which element forms an ion with the same charge as the ammonium ion?
A) potassium
B) chlorine
C) calcium
D) oxygen
E) nitrogen
Answer: A
Diff: 1 Page Ref: Sec. 2.8

174) When a fluorine atom forms the fluoride ion, it has the same charge as the __________ ion.
A) sulfide
B) ammonium
C) nitrate
D) phosphate
E) sulfite
Answer: C
Diff: 1 Page Ref: Sec. 2.8

175) The formula for the compound formed between aluminum ions and phosphate ions is __________.
A) $Al_3(PO_4)_3$
B) $AlPO_4$
C) $Al(PO_4)_3$
D) $Al_2(PO_4)_3$
E) AlP
Answer: B
Diff: 1 Page Ref: Sec. 2.8

176) Which metal does not form cations of differing charges?
A) Na
B) Cu
C) Co
D) Fe
E) Sn
Answer: A
Diff: 1 Page Ref: Sec. 2.8

177) Which metal forms cations of differing charges?
A) K
B) Cs
C) Ba
D) Al
E) Sn
Answer: E
Diff: 1 Page Ref: Sec. 2.8

178) The correct name for $Ni(CN)_2$ is __________.
A) nickel (I) cyanide
B) nickel cyanate
C) nickel carbonate
D) nickel (II) cyanide
E) nickel (I) nitride
Answer: D
Diff: 1 Page Ref: Sec. 2.8

179) Which metal does not require to have its charge specified in the names of ionic compounds it forms?
A) Mn
B) Fe
C) Cu
D) Ca
E) Pb
Answer: D
Diff: 1 Page Ref: Sec. 2.8

Short Answer

1) What group in the periodic table would the fictitious element $:\overset{\cdot\cdot}{\underset{\cdot\cdot}{X}}:$ be found?

Answer: VIIA
Diff: 2 Page Ref: Sec. 2.5

2) Carbon can exist in different forms called __________.
Answer: allotropes
Diff: 3 Page Ref: Sec. 2.5

3) Which element in Group IA is the most metallic?
Answer: francium
Diff: 2 Page Ref: Sec. 2.5

4) Which element in the halogen family would require the greatest ionization energy?
Answer: fluorine
Diff: 1 Page Ref: Sec. 2.5

5) The formula for potassium sulfide is __________.
Answer: K_2S
Diff: 1 Page Ref: Sec. 2,8

6) What is the name of an alcohol derived from hexane__________?
Answer: hexanol
Diff: 2 Page Ref: Sec. 2.9

True/False

1) The most metallic halogen is astatine.
Answer: TRUE
Diff: 3 Page Ref: Sec. 2.5

2) the possible oxication numbers for gold are 1+ and 2+.
Answer: FALSE
Diff: 1 Page Ref: Sec. 2.7

3) The formula for chromium (II) iodide is CrI_2.
Answer: TRUE
Diff: 1 Page Ref: Sec. 2.8

4) H_2SeO_4 is called selenic acid.
Answer: TRUE
Diff: 2 Page Ref: Sec. 2.8

5) The correct name for Na_3N is sodium azide.
Answer: FALSE
Diff: 2 Page Ref: Sec. 2.8

Algorithmic Questions

1) An atom of ^{17}O contains __________ protons.
A) 8
B) 25
C) 9
D) 11
E) 17
Answer: A
Diff: 1 Page Ref: Sec. 2.3

2) An atom of ^{15}N contains __________ neutrons.
A) 7
B) 22
C) 8
D) 10
E) 15
Answer: C
Diff: 2 Page Ref: Sec. 2.3

3) An atom of ^{131}I contains __________ electrons.
A) 131
B) 184
C) 78
D) 124
E) 53
Answer: E
Diff: 1 Page Ref: Sec. 2.3

4) The mass number of an atom of ^{118}Xe is __________.
A) 54
B) 172
C) 64
D) 118
E) 110
Answer: D
Diff: 2 Page Ref: Sec. 2.5

5) The atomic number of an atom of ^{80}Br is __________.
A) 115
B) 35
C) 45
D) 73
E) 80
Answer: B
Diff: 1 Page Ref: Sec. 2.5

6) An ion has 8 protons, 9 neutrons, and 10 electrons. The symbol for the ion is __________.
A) $^{17}O^{2-}$
B) $^{17}O^{2+}$
C) $^{19}F^{+}$
D) $^{19}F^{-}$
E) $^{17}Ne^{2+}$
Answer: A
Diff: 1 Page Ref: Sec. 2.5

7) How many electrons does the Al^{3+} ion possess?
A) 16
B) 10
C) 6
D) 0
E) 13
Answer: B
Diff: 1 Page Ref: Sec. 2.7

8) How many protons does the Br^{-} ion possess?
A) 34
B) 36
C) 6
D) 8
E) 35
Answer: E
Diff: 1 Page Ref: Sec. 2.7

9) Predict the charge of the most stable ion of fluorine.
A) +2
B) +1
C) +3
D) -1
E) -2
Answer: D
Diff: 1 Page Ref: Sec. 2.7

10) Predict the charge of the most stable ion of potassium.
A) +3
B) -1
C) +2
D) -2
E) +1
Answer: E
Diff: 1 Page Ref: Sec. 2.7

11) 420 ppm is the same as __________ Angstroms.
A) 4200
B) 42
C) 420
D) 4.2
E) 0.42
Answer: D
Diff: 2 Page Ref: Sec. 2.3

Chemistry, 11e (Brown)
Chapter 3, Stoichiometry: Calculations with ... Equations

Multiple-Choice Bimodal

1) When the following equation is balanced, the coefficients are __________.

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

A) 1, 1, 1, 1
B) 4, 7, 4, 6
C) 2, 3, 2, 3
D) 1, 3, 1, 2
E) 4, 3, 4, 3
Answer: B
Diff: 1   Page Ref: Sec. 3.1

2) When the following equation is balanced, the coefficients are __________.

$$Al(NO_3)_3 + Na_2S \rightarrow Al_2S_3 + NaNO_3$$

A) 2, 3, 1, 6
B) 2, 1, 3, 2
C) 1, 1, 1, 1
D) 4, 6, 3, 2
E) 2, 3, 2, 3
Answer: A
Diff: 1   Page Ref: Sec. 3.1

3) When the following equation is balanced, the coefficient of H_2 is __________.

$$K\ (s) + H_2O\ (l) \rightarrow KOH\ (aq) + H_2\ (g)$$

A) 1
B) 2
C) 3
D) 4
E) 5
Answer: A
Diff: 1   Page Ref: Sec. 3.1

4) When the following equation is balanced, the coefficient of Al is __________.

$$Al\ (s) + H_2O\ (l) \rightarrow Al(OH)_3\ (s) + H_2\ (g)$$

A) 1
B) 2
C) 3
D) 5
E) 4
Answer: B
Diff: 1   Page Ref: Sec. 3.1

5) When the following equation is balanced, the coefficient of H_2O is __________.

$$Ca\ (s) + H_2O\ (l) \rightarrow Ca(OH)_2\ (aq) + H_2\ (g)$$

A) 1
B) 2
C) 3
D) 5
E) 4
Answer: B
Diff: 1 Page Ref: Sec. 3.1

6) When the following equation is balanced, the coefficient of Al_2O_3 is __________.

$$Al_2O_3\ (s) + C\ (s) + Cl_2\ (g) \rightarrow AlCl_3\ (s) + CO\ (g)$$

A) 1
B) 2
C) 3
D) 4
E) 5
Answer: A
Diff: 1 Page Ref: Sec. 3.1

7) When the following equation is balanced, the coefficient of H_2S is __________.

$$FeCl_3\ (aq) + H_2S\ (g) \rightarrow Fe_2S_3\ (s) + HCl\ (aq)$$

A) 1
B) 2
C) 3
D) 5
E) 4
Answer: C
Diff: 1 Page Ref: Sec. 3.1

8) When the following equation is balanced, the coefficient of HCl is __________.

$$CaCO_3\ (s) + HCl\ (aq) \rightarrow CaCl_2\ (aq) + CO_2\ (g) + H_2O\ (l)$$

A) 1
B) 2
C) 3
D) 4
E) 0
Answer: B
Diff: 1 Page Ref: Sec. 3.1

9) When the following equation is balanced, the coefficient of HNO_3 is __________.

$$HNO_3\ (aq) + CaCO_3\ (s) \rightarrow Ca(NO_3)_2\ (aq) + CO_2\ (g) + H_2O\ (l)$$

A) 1
B) 2
C) 3
D) 5
E) 4
Answer: B
Diff: 1 Page Ref: Sec. 3.1

10) When the following equation is balanced, the coefficient of H_3PO_4 is __________.

$$H_3PO_4\ (aq) + NaOH\ (aq) \rightarrow Na_3PO_4\ (aq) + H_2O\ (l)$$

A) 1
B) 2
C) 3
D) 4
E) 0
Answer: A
Diff: 1 Page Ref: Sec. 3.1

11) When the following equation is balanced, the coefficient of $C_3H_8O_3$ is __________.

$$C_3H_8O_3\ (g) + O_2\ (g) \rightarrow CO_2\ (g) + H_2O\ (g)$$

A) 1
B) 2
C) 3
D) 7
E) 5
Answer: B
Diff: 1 Page Ref: Sec. 3.1

12) When the following equation is balanced, the coefficient of O_2 is __________.

$$C_2H_4O\ (g) + O_2\ (g) \rightarrow CO_2\ (g) + H_2O\ (g)$$

A) 2
B) 3
C) 4
D) 5
E) 1
Answer: D
Diff: 1 Page Ref: Sec. 3.1

13) When the following equation is balanced, the coefficient of H_2 is __________.

$$CO\ (g) + H_2\ (g) \rightarrow H_2O\ (g) + CH_4\ (g)$$

A) 1
B) 2
C) 3
D) 4
E) 0
Answer: C
Diff: 1 Page Ref: Sec. 3.1

14) When the following equation is balanced, the coefficient of H_2SO_4 is __________.

$$H_2SO_4\ (aq) + NaOH\ (aq) \rightarrow Na_2SO_4\ (aq) + H_2O\ (l)$$

A) 1
B) 2
C) 3
D) 4
E) 0.5
Answer: A
Diff: 1 Page Ref: Sec. 3.1

15) When the following equation is balanced, the coefficient of water is __________.

$$K\ (s) + H_2O\ (l) \rightarrow KOH\ (aq) + H_2\ (g)$$

A) 1
B) 2
C) 3
D) 4
E) 5
Answer: B
Diff: 1 Page Ref: Sec. 3.1

16) When the following equation is balanced, the coefficient of hydrogen is __________.

$$K\ (s) + H_2O\ (l) \rightarrow KOH\ (aq) + H_2\ (g)$$

A) 1
B) 2
C) 3
D) 4
E) 5
Answer: A
Diff: 1 Page Ref: Sec. 3.1

17) When the following equation is balanced, the coefficient of oxygen is __________.

$$PbS\ (s) + O_2\ (g) \rightarrow PbO\ (s) + SO_2\ (g)$$

A) 1
B) 3
C) 2
D) 4
E) 5
Answer: B
Diff: 1 Page Ref: Sec. 3.1

18) When the following equation is balanced, the coefficient of sulfur dioxide is __________.

$$PbS\ (s) + O_2\ (g) \rightarrow PbO\ (s) + SO_2\ (g)$$

A) 5
B) 1
C) 3
D) 2
E) 4
Answer: D
Diff: 1 Page Ref: Sec. 3.1

19) When the following equation is balanced, the coefficient of dinitrogen pentoxide is __________.

$$N_2O_5\ (g) + H_2O\ (l) \rightarrow HNO_3\ (aq)$$

A) 1
B) 2
C) 3
D) 4
E) 5
Answer: A
Diff: 1 Page Ref: Sec. 3.1

20) When the following equation is balanced, the coefficient of water is __________.

$$N_2O_5\ (g) + H_2O\ (l) \rightarrow HNO_3\ (aq)$$

A) 5
B) 2
C) 3
D) 4
E) 1
Answer: E
Diff: 1 Page Ref: Sec. 3.1

21) When the following equation is balanced, the coefficient of nitric acid is __________.

$$N_2O_5\ (g) + H_2O\ (l) \rightarrow HNO_3\ (aq)$$

A) 5
B) 2
C) 3
D) 4
E) 1
Answer: B
Diff: 1 Page Ref: Sec. 3.1

22) Write the balanced equation for the reaction that occurs when methanol, CH_3CH (l) is burned in air. What is the coefficient of methanol in the balanced equation?
A) 1
B) 2
C) 3
D) 4
E) 3/2
Answer: B
Diff: 2 Page Ref: Sec. 3.2

23) Write the balanced equation for the reaction that occurs when methanol, CH_3CH (l) is burned in air. What is the coefficient of oxygen in the balanced equation?
A) 1
B) 2
C) 3
D) 4
E) 3/2
Answer: C
Diff: 2 Page Ref: Sec. 3.2

24) What is the coefficient of O_2 when the following equation is completed and balanced?

$$C_4H_8O_2 + O_2 \rightarrow \underline{\qquad\qquad}$$

A) 2
B) 3
C) 5
D) 6
E) 1
Answer: C
Diff: 3 Page Ref: Sec. 3.2

25) Predict the product in the combination reaction below.

$Al\ (s) + N_2\ (g) \rightarrow$ ________

A) AlN
B) Al_3N
C) AlN_2
D) Al_3N_2
E) AlN_3
Answer: A
Diff: 3 Page Ref: Sec. 3.2

26) The balanced equation for the decomposition of sodium azide is __________.
A) $2NaN_3\ (s) \rightarrow 2Na\ (s) + 3N_2\ (g)$
B) $2NaN_3\ (s) \rightarrow Na_2\ (s) + 3N_2\ (g)$
C) $NaN_3\ (s) \rightarrow Na\ (s) + N_2\ (g)$
D) $NaN_3\ (s) \rightarrow Na\ (s) + N_2\ (g) + N\ (g)$
E) $2NaN_3\ (s) \rightarrow 2Na\ (s) + 2N_2\ (g)$
Answer: A
Diff: 4 Page Ref: Sec. 3.2

27) There are __________ mol of carbon atoms in 4 mol of dimethylsulfoxide (C_2H_6SO).
A) 2
B) 6
C) 8
D) 4
E) 3
Answer: C
Diff: 1 Page Ref: Sec. 3.4

28) There are __________ sulfur atoms in 25 molecules of $C_4H_4S_2$.
A) 1.5×10^{25}
B) 4.8×10^{25}
C) 3.0×10^{25}
D) 50
E) 6.02×10^{23}
Answer: D
Diff: 2 Page Ref: Sec. 3.4

29) There are __________ hydrogen atoms in 25 molecules of $C_4H_4S_2$.
A) 25
B) 3.8×10^{24}
C) 6.0×10^{25}
D) 100
E) 1.5×10^{25}
Answer: D
Diff: 2 Page Ref: Sec. 3.4

30) A sample of C_3H_8O that contains 200 molecules contains __________ carbon atoms.
A) 600
B) 200
C) 3.61×10^{26}
D) 1.20×10^{26}
E) 4.01×10^{25}
Answer: A
Diff: 2 Page Ref: Sec. 3.4

31) How many grams of hydrogen are in 46 g of CH_4O?
A) 5.8
B) 1.5
C) 2.8
D) 0.36
E) 184
Answer: A
Diff: 3 Page Ref: Sec. 3.4

32) How many grams of oxygen are in 65 g of $C_2H_2O_2$?
A) 18
B) 29
C) 9.0
D) 36
E) 130
Answer: D
Diff: 3 Page Ref: Sec. 3.4

33) How many moles of carbon dioxide are there in 52.06 g of carbon dioxide?
A) 0.8452
B) 1.183
C) 6.022×10^{23}
D) 8.648×10^{23}
E) 3.134×10^{25}
Answer: B
Diff: 2 Page Ref: Sec. 3.4

34) There are __________ molecules of methane in 0.123 mol of methane (CH_4).
A) 5
B) 2.46×10^{-2}
C) 2.04×10^{-25}
D) 7.40×10^{22}
E) 0.615
Answer: D
Diff: 2 Page Ref: Sec. 3.4

35) A 2.25-g sample of magnesium nitrate, $Mg(NO_3)_2$, contains __________ mol of this compound.
A) 38.4
B) 65.8
C) 148.3
D) 0.0261
E) 0.0152
Answer: E
Diff: 2 Page Ref: Sec. 3.4

36) A 22.5-g sample of ammonium carbonate contains __________ mol of ammonium ions.
A) 0.468
B) 0.288
C) 0.234
D) 2.14
E) 3.47
Answer: A
Diff: 2 Page Ref: Sec. 3.4

37) What is the empirical formula of a compound that contains 27.0% S, 13.4% O, and 59.6% Cl by mass?
A) SOCl
B) $SOCl_2$
C) S_2OCl
D) SO_2Cl
E) $ClSO_4$
Answer: B
Diff: 3 Page Ref: Sec. 3.5

38) What is the empirical formula of a compound that contains 29% Na, 41% S, and 30% O by mass?
A) $Na_2S_2O_3$
B) $NaSO_2$
C) NaSO
D) $NaSO_3$
E) $Na_2S_2O_6$
Answer: A
Diff: 3 Page Ref: Sec. 3.5

39) What is the empirical formula of a compound that contains 49.4% K, 20.3% S, and 30.3% O by mass?
A) KSO_2
B) KSO_3
C) K_2SO_4
D) K_2SO_3
E) KSO_4
Answer: D
Diff: 3 Page Ref: Sec. 3.5

40) A compound contains 40.0% C, 6.71% H, and 53.29% O by mass. The molecular weight of the compound is 60.05 amu. The molecular formula of this compound is __________.

A) $C_2H_4O_2$

B) CH_2O

C) $C_2H_3O_4$

D) $C_2H_2O_4$

E) CHO_2

Answer: A

Diff: 3 Page Ref: Sec. 3.5

41) A compound that is composed of carbon, hydrogen, and oxygen contains 70.6% C, 5.9% H, and 23.5% O by mass. The molecular weight of the compound is 136 amu. What is the molecular formula?

A) $C_8H_8O_2$

B) C_8H_4O

C) C_4H_4O

D) $C_9H_{12}O$

E) $C_5H_6O_2$

Answer: A

Diff: 3 Page Ref: Sec. 3.5

42) A compound that is composed of only carbon and hydrogen contains 85.7% C and 14.3% H by mass. What is the empirical formula of the compound?

A) CH_2

B) C_2H_4

C) CH_4

D) C_4H_8

E) $C_{86}H_{14}$

Answer: A

Diff: 3 Page Ref: Sec. 3.5

43) A compound that is composed of only carbon and hydrogen contains 80.0% C and 20.0% H by mass. What is the empirical formula of the compound?

A) $C_{20}H_{60}$

B) C_7H_{20}

C) CH_3

D) C_2H_6

E) CH_4

Answer: C

Diff: 3 Page Ref: Sec. 3.5

44) A compound contains 38.7% K, 13.9% N, and 47.4% O by mass. What is the empirical formula of the compound?
A) KNO_3
B) $K_2N_2O_3$
C) KNO_2
D) K_2NO_3
E) K_4NO_5
Answer: A
Diff: 3 Page Ref: Sec. 3.5

45) A compound is composed of only C, H, and O. The combustion of a 0.519-g sample of the compound yields 1.24 g of CO_2 and 0.255 g of H_2O . What is the empirical formula of the compound?
A) C_6H_6O
B) C_3H_3O
C) CH_3O
D) $C_2H_6O_5$
E) $C_2H_6O_2$
Answer: B
Diff: 4 Page Ref: Sec. 3.5

46) Combustion of a 1.031-g sample of a compound containing only carbon, hydrogen, and oxygen produced 2.265 g of CO_2 and 1.236 g of H_2O . What is the empirical formula of the compound?
A) C_3H_8O
B) C_3H_5O
C) $C_6H_{16}O_2$
D) $C_3H_9O_3$
E) $C_3H_6O_3$
Answer: A
Diff: 4 Page Ref: Sec. 3.5

47) Combustion of a 0.9835-g sample of a compound containing only carbon, hydrogen, and oxygen produced 1.900 g of CO_2 and 1.070 g of H_2O . What is the empirical formula of the compound?
A) C_2H_5O
B) $C_4H_{10}O_2$
C) $C_4H_{11}O_2$
D) $C_4H_{10}O$
E) $C_2H_5O_2$
Answer: C
Diff: 4 Page Ref: Sec. 3.5

48) Magnesium and nitrogen react in a combination reaction to produce magnesium nitride:

$$3\ Mg + N_2 \rightarrow Mg_3N_2$$

In a particular experiment, a 9.27-g sample of N_2 reacts completely. The mass of Mg consumed is __________ g.
A) 8.04
B) 24.1
C) 16.1
D) 0.92
E) 13.9
Answer: B
Diff: 3 Page Ref: Sec. 3.6

49) The combustion of ammonia in the presence of excess oxygen yields NO_2 and H_2O :

$$4\ NH_3\ (g) + 7\ O_2\ (g) \rightarrow 4\ NO_2\ (g) + 6\ H_2O\ (g)$$

The combustion of 28.8 g of ammonia consumes __________ g of oxygen.
A) 94.9
B) 54.1
C) 108
D) 15.3
E) 28.8
Answer: A
Diff: 3 Page Ref: Sec. 3.6

50) The combustion of ammonia in the presence of excess oxygen yields NO_2 and H_2O :

$$4\ NH_3\ (g) + 7\ O_2\ (g) \rightarrow 4\ NO_2\ (g) + 6\ H_2O\ (g)$$

The combustion of 43.9 g of ammonia produces __________ g of NO_2 .
A) 2.58
B) 178
C) 119
D) 0.954
E) 43.9
Answer: C
Diff: 3 Page Ref: Sec. 3.6

51) The combustion of propane (C_3H_8) produces CO_2 and H_2O :

$$C_3H_8\ (g) + 5O_2\ (g) \rightarrow 3CO_2\ (g) + 4H_2O\ (g)$$

The reaction of 2.5 mol of O_2 will produce __________ mol of H_2O .
A) 4.0
B) 3.0
C) 2.5
D) 2.0
E) 1.0
Answer: D
Diff: 2 Page Ref: Sec. 3.6

52) The combustion of propane (C_3H_8) in the presence of excess oxygen yields CO_2 and H_2O:

$$C_3H_8\ (g) + 5O_2\ (g) \rightarrow 3CO_2\ (g) + 4H_2O\ (g)$$

When 2.5 mol of O_2 are consumed in their reaction, __________ mol of CO_2 are produced.
A) 1.5
B) 3.0
C) 5.0
D) 6.0
E) 2.5
Answer: A
Diff: 2 Page Ref: Sec. 3.6

53) Calcium carbide (CaC_2) reacts with water to produce acetylene (C_2H_2):

$$CaC_2\ (s) + 2H_2O\ (g) \rightarrow Ca(OH)_2\ (s) + C_2H_2\ (g)$$

Production of 13g of C_2H_2 requires consumption of __________ g of H_2O.
A) 4.5
B) 9.0
C) 18
D) 4.8×10^2
E) 4.8×10^{-2}
Answer: C
Diff: 3 Page Ref: Sec. 3.6

54) Under appropriate conditions, nitrogen and hydrogen undergo a combination reaction to yield ammonia:

$$N_2\ (g) + 3H_2\ (g) \rightarrow 2NH_3\ (g)$$

A 7.1-g sample of N_2 requires __________ g of H_2 for complete reaction.
A) 0.51
B) 0.76
C) 1.2
D) 1.5
E) 17.2
Answer: D
Diff: 3 Page Ref: Sec. 3.6

55) Lead (II) carbonate decomposes to give lead (II) oxide and carbon dioxide:

$$PbCO_3\ (s) \rightarrow PbO\ (s) + CO_2\ (g)$$

How many grams of lead (II) oxide will be produced by the decomposition of 2.50 g of lead (II) carbonate?
A) 0.41
B) 2.50
C) 0.00936
D) 2.09
E) 2.61
Answer: D
Diff: 3 Page Ref: Sec. 3.6

56) GeF_3H is formed from GeH_4 and GeF_4 in the combination reaction:

$$GeH_4 + 3GeF_4 \rightarrow 4GeF_3H$$

If the reaction yield is 92.6%, how many moles of GeF_4 are needed to produce 8.00 mol of GeF_3H ?
A) 3.24
B) 5.56
C) 6.48
D) 2.78
E) 2.16
Answer: C
Diff: 4 Page Ref: Sec. 3.7

57) What mass in grams of hydrogen is produced by the reaction of 4.73 g of magnesium with 1.83 g of water?

$$Mg\ (s) + 2H_2O\ (l) \rightarrow Mg(OH)_2\ (s) + H_2\ (g)$$

A) 0.102
B) 0.0162
C) 0.0485
D) 0.219
E) 0.204
Answer: A
Diff: 4 Page Ref: Sec. 3.7

58) Silver nitrate and aluminum chloride react with each other by exchanging anions:

$$3AgNO_3\ (aq) + AlCl_3\ (aq) \rightarrow Al(NO_3)_3\ (aq) + 3AgCl\ (s)$$

What mass in grams of AgCl is produced when 4.22 g of $AgNO_3$ react with 7.73 g of $AlCl_3$?
A) 17.6
B) 4.22
C) 24.9
D) 3.56
E) 11.9
Answer: D
Diff: 4 Page Ref: Sec. 3.7

59) How many moles of magnesium oxide are produced by the reaction of 3.82 g of magnesium nitride with 7.73 g of water?

$$Mg_3N_2 + 3H_2O \rightarrow 2NH_3 + 3MgO$$

A) 0.113
B) 0.0378
C) 0.429
D) 0.0756
E) 4.57
Answer: A
Diff: 4 Page Ref: Sec. 3.7

60) A 3.82-g sample of magnesium nitride is reacted with 7.73 g of water.

$$Mg_3N_2 + 3H_2O \rightarrow 2NH_3 + 3MgO$$

The yield of MgO is 3.60 g. What is the percent yield in the reaction?
A) 94.5
B) 78.8
C) 46.6
D) 49.4
E) 99.9
Answer: B
Diff: 4 Page Ref: Sec. 3.7

61) Pentacarbonyliron ($Fe(CO)_5$) reacts with phosphorous trifluoride (PF_3) and hydrogen, releasing carbon monoxide:

$$Fe(CO)_5 + PF_3 + H_2 \rightarrow Fe(CO)_2(PF_3)_2(H)_2 + CO \text{ (not balanced)}$$

The reaction of 5.0 mol of $Fe(CO)_5$, 8.0 mol of PF_3 and 6.0 mol of H_2 will release __________ mol of CO.
A) 15
B) 5.0
C) 24
D) 6.0
E) 12
Answer: E
Diff: 3 Page Ref: Sec. 3.7

62) What is the maximum mass in grams of NH_3 that can be produced by the reaction of 1.0 g of N_2 with 3.0 g of H_2 via the equation below?

$$N_2\ (g) + H_2\ (g) \rightarrow NH_3\ (g) \text{ (not balanced)}$$

A) 2.0
B) 1.2
C) 0.61
D) 17
E) 4.0
Answer: B
Diff: 3 Page Ref: Sec. 3.7

63) What is the maximum amount in grams of SO_3 that can be produced by the reaction of 1.0 g of S with 1.0 g of O_2 via the equation below?

$$S\ (s) + O_2\ (g) \rightarrow SO_3\ (g) \text{ (not balanced)}$$

A) 0.27
B) 1.7
C) 2.5
D) 3.8
E) 2.0
Answer: B
Diff: 3 Page Ref: Sec. 3.7

64) Solid aluminum and gaseous oxygen react in a combination reaction to produce aluminum oxide:

$$4Al\ (s) + 3O_2\ (g) \rightarrow 2Al_2O_3\ (s)$$

The maximum amount of Al_2O_3 that can be produced from 2.5 g of Al and 2.5 g of O_2 is __________ g.
A) 9.4
B) 7.4
C) 4.7
D) 5.3
E) 5.0
Answer: C
Diff: 3 Page Ref: Sec. 3.7

65) Sulfur and fluorine react in a combination reaction to produce sulfur hexafluoride:

$$S(s) + 3F_2\ (g) \rightarrow SF_6\ (g)$$

The maximum amount of SF_6 that can be produced from the reaction of 3.5 g of sulfur with 4.5 g of fluorine is __________ g.
A) 12
B) 3.2
C) 5.8
D) 16
E) 8.0
Answer: C
Diff: 3 Page Ref: Sec. 3.7

66) Solid aluminum and gaseous oxygen react in a combination reaction to produce aluminum oxide:

$$4Al\ (s) + 3O_2\ (g) \rightarrow 2Al_2O_3\ (s)$$

In a particular experiment, the reaction of 2.5 g of Al with 2.5 g of O_2 produced 3.5 g of Al_2O_3. The % yield of the reaction is __________.
A) 74
B) 37
C) 47
D) 66
E) 26
Answer: A
Diff: 4 Page Ref: Sec. 3.7

67) Sulfur and oxygen react in a combination reaction to produce sulfur trioxide, an environmental pollutant:

$$2S\ (s) + 3O_2\ (g) \rightarrow 2SO_3\ (g)$$

In a particular experiment, the reaction of 1.0 g S with 1.0 g O_2 produced 0.80 g of SO_3. The % yield in this experiment is __________.
A) 30
B) 29
C) 21
D) 88
E) 48
Answer: E
Diff: 4 Page Ref: Sec. 3.7

68) Sulfur and fluorine react in a combination reaction to produce sulfur hexafluoride:

$$S\ (s) + 3F_2\ (g) \rightarrow SF_6\ (g)$$

In a particular experiment, the percent yield is 79.0%. This means that a 7.90-g sample of fluorine yields __________ g of SF_6 in the presence of excess sulfur.
A) 30.3
B) 10.1
C) 7.99
D) 24.0
E) 0.110
Answer: C
Diff: 4 Page Ref: Sec. 3.7

Multiple-Choice

69) When a hydrocarbon burns in air, what component of air reacts?
A) oxygen
B) nitrogen
C) carbon dioxide
D) water
E) argon
Answer: A
Diff: 2 Page Ref: Sec. 3.2

70) Of the reactions below, which one is not a combination reaction?
A) $C + O_2 \rightarrow CO_2$
B) $2Mg + O_2 \rightarrow 2MgO$
C) $2N_2 + 3H_2 \rightarrow 2NH_3$
D) $CaO + H_2O \rightarrow Ca(OH)_2$
E) $2CH_4 + 4O_2 \rightarrow 2CO_2 + 4H_2O$
Answer: E
Diff: 3 Page Ref: Sec. 3.2

71) Of the reactions below, which one is a decomposition reaction?
A) $NH_4Cl \rightarrow NH_3 + HCl$
B) $2Mg + O_2 \rightarrow 2MgO$
C) $2N_2 + 3H_2 \rightarrow 2NH_3$
D) $2CH_4 + 4O_2 \rightarrow 2CO_2 + 4H_2O$
E) $Cd(NO_3)_2 + Na_2S \rightarrow CdS + 2NaNO_3$
Answer: A
Diff: 3 Page Ref: Sec. 3.2

72) Which one of the following substances is the product of this combination reaction?

$$Al\ (s) + I_2\ (s) \rightarrow \underline{\hspace{3em}}$$

A) AlI_2
B) AlI
C) AlI_3
D) Al_2I_3
E) Al_3I_2
Answer: C
Diff: 2 Page Ref: Sec. 3.2

73) Which one of the following is <u>not</u> true concerning automotive air bags?
A) They are inflated as a result of a decomposition reaction
B) They are loaded with sodium azide initially
C) The gas used for inflating them is oxygen
D) The two products of the decomposition reaction are sodium and nitrogen
E) A gas is produced when the air bag activates.
Answer: C
Diff: 2 Page Ref: Sec. 3.2

74) The reaction used to inflate automobile airbags __________.
A) produces sodium gas
B) is a combustion reaction
C) is a combination reaction
D) violates the law of conservation of mass
E) is a decomposition reaction
Answer: E
Diff: 2 Page Ref: Sec. 3.2

75) Which of the following are combination reactions?
1) $CH_4\ (g) + O_2\ (g) \rightarrow CO_2\ (g) + H_2O\ (l)$
2) $CaO\ (s) + CO_2\ (g) \rightarrow CaCO_3\ (s)$
3) $Mg\ (s) + O_2\ (g) \rightarrow MgO\ (s)$
4) $PbCO_3\ (s) \rightarrow PbO\ (s) + CO_2\ (g)$

A) 1, 2, and 3
B) 2 and 3
C) 1, 2, 3, and 4
D) 4 only
E) 2, 3, and 4
Answer: B
Diff: 3 Page Ref: Sec. 3.2

76) Which of the following are combustion reactions?

1) CH_4 (g) + O_2 (g) $\rightarrow$ CO_2 (g) + H_2O (l)

2) CaO (s) + CO_2 (g) $\rightarrow$ $CaCO_3$ (s)

3) $PbCO_3$ (s) $\rightarrow$ PbO (s) + CO_2 (g)

4) CH_3OH (l) + O_2 (g) $\rightarrow$ CO_2 (g) + H_2O (l)

A) 1 and 4
B) 1, 2, 3, and 4
C) 1, 3, and 4
D) 2, 3, and 4
E) 3 and 4
Answer: A
Diff: 2 Page Ref: Sec. 3.2

77) Which of the following are decomposition reactions?

1) CH_4 (g) + O_2 (g) $\rightarrow$ CO_2 (g) + H_2O (l)

2) CaO (s) + CO_2 (g) $\rightarrow$ $CaCO_3$ (s)

3) Mg (s) + O_2 (g) $\rightarrow$ MgO (s)

4) $PbCO_3$ (s) $\rightarrow$ PbO (s) + CO_2 (g)

A) 1, 2, and 3
B) 4 only
C) 1, 2, 3, and 4
D) 2 and 3
E) 2, 3, and 4
Answer: B
Diff: 3 Page Ref: Sec. 3.2

78) The formula of nitrobenzene is $C_6H_5NO_2$. The molecular weight of this compound is __________ amu.

A) 107.11
B) 43.03
C) 109.10
D) 123.11
E) 3.06
Answer: D
Diff: 2 Page Ref: Sec. 3.3

79) The formula weight of potassium dichromate ($K_2Cr_2O_7$) is __________ amu.

A) 107.09
B) 255.08
C) 242.18
D) 294.18
E) 333.08
Answer: D
Diff: 2 Page Ref: Sec. 3.3

80) The formula weight of potassium phosphate (K_3PO_4) is __________ amu.

A) 173.17
B) 251.37
C) 212.27
D) 196.27
E) 86.07
Answer: C
Diff: 2 Page Ref: Sec. 3.3

81) The formula weight of aluminum sulfate $(Al_2(SO_4)_3)$ is __________ amu.

A) 342.14
B) 123.04
C) 59.04
D) 150.14
E) 273.06
Answer: A
Diff: 2 Page Ref: Sec. 3.3

82) The formula weight of silver chromate (Ag_2CrO_4) is __________ amu.

A) 159.87
B) 223.87
C) 331.73
D) 339.86
E) 175.87
Answer: C
Diff: 2 Page Ref: Sec. 3.3

83) The formula weight of ammonium sulfate $((NH_4)_2SO_4)$ is __________ amu.

A) 100
B) 118
C) 116
D) 132
E) 264
Answer: D
Diff: 2 Page Ref: Sec. 3.3

84) The molecular weight of the acetic acid (CH_3CO_2H) is __________ amu.

A) 60
B) 48
C) 44
D) 32
Answer: A
Diff: 1 Page Ref: Sec. 3.3

85) The molecular weight of the ethanol (C_2H_5OH) is __________ amu.

A) 34
B) 41
C) 30
D) 46
E) 92
Answer: D
Diff: 1 Page Ref: Sec. 3.3

86) What is the mass % of carbon in dimethylsulfoxide (C_2H_6SO) ?

A) 60.0
B) 20.6
C) 30.7
D) 7.74
E) 79.8
Answer: C
Diff: 3 Page Ref: Sec. 3.3

87) The mass % of H in methane (CH_4) is __________.

A) 25.13
B) 4.032
C) 74.87
D) 92.26
E) 7.743
Answer: A
Diff: 2 Page Ref: Sec. 3.3

88) The mass % of Al in aluminum sulfate ($Al_2(SO_4)_3$) is __________.

A) 7.886
B) 15.77
C) 21.93
D) 45.70
E) 35.94
Answer: B
Diff: 3 Page Ref: Sec. 3.3

89) The formula weight of a substance is __________.
A) identical to the molar mass
B) the same as the percent by mass weight
C) determined by combustion analysis
D) the sum of the atomic weights of each atom in its chemical formula
E) the weight of a sample of the substance
Answer: D
Diff: 1 Page Ref: Sec. 3.3

90) The formula weight of calcium nitrate ($Ca(NO_3)_2$) is __________ amu.

A) 102.1
B) 164.0
C) 204.2
D) 150.1
E) 116.1
Answer: B
Diff: 2 Page Ref: Sec. 3.3

91) The formula weight of magnesium fluoride (MgF_2) is __________ amu.

A) 86.6
B) 43.3
C) 62.3
D) 67.6
E) 92.9
Answer: C
Diff: 2 Page Ref: Sec. 3.3

92) The mass % of C in methane (CH_4) is __________.

A) 25.13
B) 133.6
C) 74.87
D) 92.26
E) 7.743
Answer: C
Diff: 2 Page Ref: Sec. 2.4

93) The mass % of F in the binary compound KrF_2 is __________.
A) 18.48
B) 45.38
C) 68.80
D) 81.52
E) 31.20
Answer: E
Diff: 2 Page Ref: Sec. 2.4

94) Calculate the percentage by mass of nitrogen in $PtCl_2(NH_3)_2$.
A) 4.67
B) 9.34
C) 9.90
D) 4.95
E) 12.67
Answer: B
Diff: 2 Page Ref: Sec. 2.4

95) Calculate the percentage by mass of chlorine in $PtCl_2(NH_3)_2$.
A) 23.63
B) 11.82
C) 25.05
D) 12.53
E) 18.09
Answer: A
Diff: 3 Page Ref: Sec. 2.4

96) Calculate the percentage by mass of hydrogen in $PtCl_2(NH_3)_2$.
A) 1.558
B) 1.008
C) 0.672
D) 0.034
E) 2.016
Answer: E
Diff: 3 Page Ref: Sec. 2.4

97) One mole of __________ contains the largest number of atoms.
A) S_8
B) $C_{10}H_8$
C) $Al_2(SO_4)_3$
D) Na_3PO_4
E) Cl_2
Answer: B
Diff: 3 Page Ref: Sec. 3.4

98) One million argon atoms is __________ mol of argon atoms.
A) 3
B) 1.7×10^{-18}
C) 6.0×10^{23}
D) 1.0×10^{-6}
E) $1.0 \times 10^{+6}$
Answer: B
Diff: 2 Page Ref: Sec. 3.4

99) There are __________ atoms of oxygen are in 300 molecules of CH_3CO_2H .
A) 300
B) 600
C) 3.01×10^{24}
D) 3.61×10^{26}
E) 1.80×10^{26}
Answer: B
Diff: 2 Page Ref: Sec. 3.4

100) How many molecules of CH_4 are in 48.2 g of this compound?
A) 5.00×10^{24}
B) 3.00
C) 2.90×10^{25}
D) 1.81×10^{24}
E) 4.00
Answer: D
Diff: 3 Page Ref: Sec. 3.4

101) A sample of CH_2F_2 with a mass of 19 g contains __________ atoms of F.
A) 2.2×10^{23}
B) 38
C) 3.3×10^{24}
D) 4.4×10^{23}
E) 9.5
Answer: D
Diff: 3 Page Ref: Sec. 3.4

102) A sample of CH_4O with a mass of 32.0 g contains __________ molecules of CH_4O .
A) 5.32×10^{-23}
B) 1.00
C) 1.88×10^{22}
D) 6.02×10^{23}
E) 32.0
Answer: D
Diff: 2 Page Ref: Sec. 3.4

103) How many atoms of nitrogen are in 10 g of NH_4NO_3?
A) 3.5
B) 1.5×10^{23}
C) 3.0×10^{23}
D) 1.8
E) 2
Answer: B
Diff: 3 Page Ref: Sec. 3.4

104) Gaseous argon has a density of 1.40 g/L at standard conditions. How many argon atoms are in 1.00 L of argon gas at standard conditions?
A) 4.7×10^{22}
B) 3.4×10^{25}
C) 2.1×10^{22}
D) 1.5×10^{25}
E) 6.02×10^{23}
Answer: C
Diff: 4 Page Ref: Sec. 3.4

105) What is the mass in grams of 9.76×10^{12} atoms of naturally occurring sodium?
A) 22.99
B) 1.62×10^{-11}
C) 3.73×10^{-10}
D) 7.05×10^{-13}
E) 2.24×10^{14}
Answer: C
Diff: 3 Page Ref: Sec. 3.4

106) How many moles of pyridine (C_5H_5N) are contained in 3.13 g of pyridine?
A) 0.0396
B) 25.3
C) 0.319
D) 0.00404
E) 4.04×10^{3}
Answer: A
Diff: 3 Page Ref: Sec. 3.4

107) How many oxygen atoms are contained in 2.74 g of $Al_2(SO_4)_3$?
A) 12
B) 6.02×10^{23}
C) 7.22×10^{24}
D) 5.79×10^{22}
E) 8.01×10^{-3}
Answer: D
Diff: 3 Page Ref: Sec. 3.4

108) The total number of atoms in 0.111 mol of $Fe(CO)_3(PH_3)_2$ is __________.
A) 15
B) 1.07×10^{24}
C) 4.46×10^{21}
D) 1.67
E) 2.76×10^{-24}
Answer: B
Diff: 3 Page Ref: Sec. 3.4

109) How many sulfur dioxide molecules are there in 1.80 mol of sulfur dioxide?
A) 1.08×10^{23}
B) 6.02×10^{24}
C) 1.80×10^{24}
D) 1.08×10^{24}
E) 6.02×10^{23}
Answer: D
Diff: 2 Page Ref: Sec. 3.4

110) How many sulfur dioxide molecules are there in 0.180 mol of sulfur dioxide?
A) 1.80×10^{23}
B) 6.02×10^{24}
C) 6.02×10^{23}
D) 1.08×10^{24}
E) 1.08×10^{23}
Answer: E
Diff: 2 Page Ref: Sec. 3.4

111) How many carbon atoms are there in 52.06 g of carbon dioxide?
A) 5.206×10^{24}
B) 3.134×10^{25}
C) 7.122×10^{23}
D) 8.648×10^{-23}
E) 1.424×10^{24}
Answer: C
Diff: 3 Page Ref: Sec. 3.4

112) How many oxygen atoms are there in 52.06 g of carbon dioxide?
A) 1.424×10^{24}
B) 6.022×10^{23}
C) 1.204×10^{24}
D) 5.088×10^{23}
E) 1.018×10^{24}
Answer: A
Diff: 3 Page Ref: Sec. 3.4

113) How many moles of sodium carbonate contain 1.773×10^{17} carbon atoms?
A) 5.890×10^{-7}
B) 2.945×10^{-7}
C) 1.473×10^{-7}
D) 8.836×10^{-7}
E) 9.817×10^{-8}
Answer: B
Diff: 2 Page Ref: Sec. 3.4

114) How many grams of sodium carbonate contain 1.773×10^{17} carbon atoms?
A) 3.121×10^{-5}
B) 1.011×10^{-5}
C) 1.517×10^{-5}
D) 9.100×10^{-5}
E) 6.066×10^{-5}
Answer: A
Diff: 2 Page Ref: Sec. 3.4

115) The compound responsible for the characteristic smell of garlic is allicin, $C_6H_{10}OS_2$ The mass of 1.00 mol of allicin is __________ g.
A) 34
B) 162
C) 86
D) 61
E) 19
Answer: B
Diff: 1 Page Ref: Sec. 3.4

116) The molecular formula of aspartame, the generic name of NutraSweet®, is $C_{14}H_{18}N_2O_5$ The molar mass of aspartame is __________ g.
A) 24
B) 156
C) 294
D) 43
E) 39
Answer: C
Diff: 1 Page Ref: Sec. 3.4

117) A nitrogen oxide is 63.65% by mass nitrogen. The molecular formula could be __________.
A) NO
B) NO_2
C) N_2O
D) N_2O_4
E) either NO_2 or N_2O_4
Answer: C
Diff: 3 Page Ref: Sec. 3.5

118) A sulfur oxide is 50.0% by mass sulfur. This molecular formula could be __________.
A) SO
B) SO_2
C) S_2O
D) S_2O_4
E) either SO_2 or S_2O_4
Answer: E
Diff: 3 Page Ref: Sec. 3.5

119) Which hydrocarbon pair below have identical mass percentage of C?
A) C_3H_4 and C_3H_6
B) C_2H_4 and C_3H_4
C) C_2H_4 and C_4H_2
D) C_2H_4 and C_3H_6
E) none of the above
Answer: D
Diff: 3 Page Ref: Sec. 3.5

Short Answer

1) Complete and balance the following reaction, given that elemental rubidium reacts with elemental sulfur to form Rb_2S (s).

Na (s) + S (s) $\rightarrow$ __________

Answer: $\rightarrow$ Na_2S (s)
Diff: 3 Page Ref: Sec. 3.2

2) A compound was found to contain 90.6% lead (Pb) and 9.4% oxygen. The empirical formula for this compound is __________.
Answer: Pb_3O_4
Diff: 3 Page Ref: Sec. 3.5

3) The combustion of propane (C_3H_8) in the presence of excess oxygen yields CO_2 and H_2O:

$$C_3H_8\ (g) + 5O_2\ (g) \rightarrow 3CO_2\ (g) + 4H_2O\ (g)$$

When 7.3 g of C_3H_8 burns in the presence of excess O_2, __________ g of CO_2 is produced.
Answer: 22
Diff: 3 Page Ref: Sec. 3.6

4) Under appropriate conditions, nitrogen and hydrogen undergo a combination reaction to yield ammonia:

$$N_2\ (g) + 3H_2\ (g) \rightarrow 2NH_3\ (g)$$

A 9.3-g sample of hydrogen requires __________ g of N_2 for a complete reaction.
Answer: 43
Diff: 3 Page Ref: Sec. 3.6

5) Water can be formed from the stoichiometric reaction of hydrogen with oxygen:

$$2H_2\ (g) + O_2\ (g) \rightarrow 2H_2O\ (g)$$

A complete reaction of 5.0 g of O_2 with excess hydrogen produces __________ g of H_2O.
Answer: 5.6
Diff: 3 Page Ref: Sec. 3.6

6) The combustion of carbon disulfide in the presence of excess oxygen yields carbon dioxide and sulfur dioxide:

$$CS_2\ (g) + 3O_2\ (g) \rightarrow CO_2\ (g) + 2SO_2\ (g)$$

The combustion of 15 g of CS_2 in the presence of excess oxygen yields __________ g of SO_2.
Answer: 25
Diff: 3 Page Ref: Sec. 3.6

True/False

1) The mass of a single atom of an element (in amu) is numerically EQUAL to the mass in grams of 1 mole of that element.
Answer: TRUE
Diff: 2 Page Ref: Sec. 3,4

2) The molecular weight is ALWAYS a whole-number multiple of the empirical formula weight.
Answer: TRUE
Diff: 1 Page Ref: Sec. 3.5

3) Carbon dioxide called a greenhouse gas because bacterial degradation of fertilizers in a greenhouse environment produce large quantities of carbon dioxide.
Answer: FALSE
Diff: 2 Page Ref: Sec. 3.6

4) A great deal of the carbon dioxide produced by the combustion of fossil fuels is absorbed into the oceans.
Answer: TRUE
Diff: 2 Page Ref: Sec. 3.6

5) The quantity of product that is calculated to form when all of the limiting reagent reacts is called the actual yield.
Answer: FALSE
Diff: 1 Page Ref: Sec. 3.7

Algorithmic Questions

1) The molecular weight of urea ($(NH_2)_2CO$), a compound used as a nitrogen fertilizer, is __________ amu.
A) 44.0
B) 43.0
C) 60.1
D) 8.0
E) 32.0
Answer: C
Diff: 1 Page Ref: Sec. 3.3

2) Determine the mass percent (to the hundredth's place) of H in sodium bicarbonate ($NaHCO_3$).
Answer: 1.20
Diff: 2 Page Ref: Sec 3.3

3) What is the empirical formula of a compound that is 64.8% C, 13.6% H, and 21.6% O by mass?
A) C_4HO_1
B) C_5HO_2
C) $C_8H_{20}O_2$
D) $C_5H_{14}O_1$
E) $C_4H_{10}O_1$
Answer: E
Diff: 4 Page Ref: Sec. 3.5

4) A certain alcohol contains only three elements, carbon, hydrogen, and oxygen. Combustion of a 50.00 gram sample of the alcohol produced 95.50 grams of CO_2 and 58.70 grams of H_2O. What is the empirical formula of the alcohol?
Answer: C_2H_6O
Diff: 4 Page Ref: Sec. 3.5

5) Lithium and nitrogen react in a combination reaction to produce lithium nitride:

$$6Li\ (s) + N_2\ (g) \rightarrow 2Li_3N\ (s)$$

How many moles of N_2 are needed to react with 0.500 mol of lithium?
A) 3.00
B) 0.500
C) 0.167
D) 1.50
E) 0.0833
Answer: E
Diff: 2 Page Ref: Sec. 3.6

6) Lithium and nitrogen react in a combination reaction to produce lithium nitride:

$$6Li\ (s) + N_2\ (g) \rightarrow 2Li_3N\ (s)$$

How many moles of lithium nitride are produced when 0.450 mol of lithium react in this fashion?
A) 0.150
B) 0.900
C) 0.0750
D) 1.35
E) 0.225
Answer: A
Diff: 2 Page Ref: Sec. 3.6

7) Lithium and nitrogen react in a combination reaction to produce lithium nitride:

$$6Li\ (s) + N_2\ (g) \rightarrow 2Li_3N\ (s)$$

How many moles of lithium are needed to produce 0.60 mol of Li_3N when the reaction is carried out in the presence of excess nitrogen?
A) 0.30
B) 1.8
C) 0.20
D) 0.40
E) 3.6
Answer: B
Diff: 2 Page Ref: Sec. 3.6

8) Automotive air bags inflate when sodium azide decomposes explosively to its constituent elements:

$$2NaN_3\ (s) \rightarrow 2Na\ (s) + 3N_2\ (g)$$

How many moles of N_2 are produced by the decomposition of 2.88 mol of sodium azide?
A) 1.92
B) 8.64
C) 4.32
D) 0.960
E) 1.44
Answer: C
Diff: 2 Page Ref: Sec. 3.6

9) Automotive air bags inflate when sodium azide decomposes explosively to its constituent elements:

$$2NaN_3\ (s) \rightarrow 2Na\ (s) + 3N_2\ (g)$$

How many grams of sodium azide are required to produce 18.0 g of nitrogen?
A) 0.964
B) 0.428
C) 41.8
D) 27.9
E) 62.7
Answer: D
Diff: 3 Page Ref: Sec. 3.6

10) Magnesium burns in air with a dazzling brilliance to produce magnesium oxide:

$$2Mg\ (s) + O_2\ (g) \rightarrow 2MgO\ (s)$$

How many moles of O_2 are consumed when 0.770 mol of magnesium burns?
A) 0.0317
B) 2.60
C) 0.770
D) 1.54
E) 0.385
Answer: E
Diff: 2 Page Ref: Sec. 3.6

11) Lithium and nitrogen react in a combination reaction to produce lithium nitride:

$$6Li\ (s) + N_2\ (g) \rightarrow 2Li_3N\ (s)$$

In a particular experiment, 3.50-g samples of each reagent are reacted. The theoretical yield of lithium nitride is __________ g.
A) 3.52
B) 2.93
C) 17.6
D) 5.85
E) 8.7
Answer: D
Diff: 3 Page Ref: Sec. 3.7

12) Magnesium burns in air with a dazzling brilliance to produce magnesium oxide:

$$2Mg\ (s) + O_2\ (g) \rightarrow 2MgO\ (s)$$

When 4.00 g of magnesium burns, the theoretical yield of magnesium oxide is __________ g.
A) 4.00
B) 6.63
C) 0.165
D) 3.32
E) 13.3
Answer: B
Diff: 3 Page Ref: Sec. 3.7

13) Calcium oxide reacts with water in a combination reaction to produce calcium hydroxide:

$$CaO\ (s) + H_2O\ (l) \rightarrow Ca(OH)_2\ (s)$$

A 1.50-g sample of CaO is reacted with 1.45 g of H_2O. How many grams of water remains after completion of reaction?
A) 0.00
B) 0.00297
C) 0.966
D) 1.04
E) 0.0536
Answer: C
Diff: 4 Page Ref: Sec. 3.7

14) If 294 grams of FeS_2 is allowed to react with 176 grams of O_2 according to the following equation, how many grams of Fe_2O_3 are produced?

$$FeS_2 + O_2 \rightarrow Fe_2O_3 + SO_2$$

Answer: 160
Diff: 4 Page Ref: Sec. 3.7

15) Calcium oxide reacts with water in a combination reaction to produce calcium hydroxide:

$$CaO\ (s) + H_2O\ (l) \rightarrow Ca(OH)_2\ (s)$$

In a particular experiment, a 5.00-g sample of CaO is reacted with excess water and 6.11 g of $Ca(OH)_2$ is recovered. What is the percent yield in this experiment?
A) 122
B) 1.22
C) 7.19
D) 92.4
E) 81.9
Answer: D
Diff: 4 Page Ref: Sec. 3.7

Chemistry, 11e (Brown)
Chapter 4, Aqueous Reactions and Solution Stoichiometry

Multiple-Choice and Bimodal

1) The total concentration of ions in a 0.250 M solution of HCl is __________.
A) essentially zero.
B) 0.125 M
C) 0.250 M
D) 0.500 M
E) 0.750 M
Answer: D
Diff: 1 Page Ref: Sec. 4.1

2) A strong electrolyte is one that __________ completely in solution.
A) reacts
B) decomposes
C) disappears
D) ionizes
Answer: D
Diff: 2 Page Ref: Sec. 4.1

3) A weak electrolyte exists predominantly as __________ in solution.
A) atoms
B) ions
C) molecules
D) electrons
E) an isotope
Answer: C
Diff: 2 Page Ref: Sec. 4.1

4) Which of the following are strong electrolytes?
HCl
$HC_2H_3O_2$
NH_3
KCl

A) HCl, KCl
B) HCl, NH_3, KCl
C) HCl, $HC_2H_3O_2$, NH_3, KCl
D) HCl, $HC_2H_3O_2$, KCl
E) $HC_2H_3O_2$, KCl
Answer: A
Diff: 2 Page Ref: Sec. 4.1

5) Which of the following are weak electrolytes?

1) HCl
2) $HC_2H_3O_2$
3) NH_3
4) KCl

A) HCl, KCl
B) HCl, $HC_2H_3O_2$, NH_3, KCl
C) $HC_2H_3O_2$, KCl
D) $HC_2H_3O_2$, NH_3
E) HCl, $HC_2H_3O_2$, KCl
Answer: D
Diff: 2 Page Ref: Sec. 4.1

6) What are the spectator ions in the reaction between KOH (aq) and HNO_3 (aq)?
A) K^+ and H^+
B) H^+ and OH^-
C) K^+ and NO_3^-
D) H^+ and NO_3^-
E) OH^- only
Answer: C
Diff: 2 Page Ref: Sec. 4.2

7) The net ionic equation for the reaction between aqueous solutions of HF and KOH is __________.
A) $HF + KOH \rightarrow H_2O + K^+ + F^-$
B) $HF + OH^- \rightarrow H_2O + F^-$
C) $HF + K^+ + OH^- \rightarrow H_2O + KF$
D) $H^+ + OH^- \rightarrow H_2O$
E) $H^+ + F^- + K^+ + OH^- \rightarrow H_2O + K^+ + F^-$
Answer: B
Diff: 2 Page Ref: Sec. 4.2

8) Combining aqueous solutions of BaI_2 and Na_2SO_4 affords a precipitate of $BaSO_4$. Which ion(s) is/are spectator ions in the reaction?
A) Ba^{2+} only
B) Na^+ only
C) Ba^{2+} and SO_4^{2-}
D) Na^+ and I^-
E) SO_4^{2-} and I^-
Answer: D
Diff: 2 Page Ref: Sec. 4.2

9) Which ion(s) is/are spectator ions in the formation of a precipitate of AgCl via combining aqueous solutions of $CoCl_2$ and $AgNO_3$?

A) Co^{2+} and NO_3-

B) NO_3- and Cl^-

C) Co^{2+} and Ag^+

D) Cl^-

E) NO_3-

Answer: A

Diff: 2 Page Ref: Sec. 4.2

10) The balanced net ionic equation for precipitation of $CaCO_3$ when aqueous solutions of Na_2CO_3 and $CaCl_2$ are mixed is __________.

A) $2Na^+ (aq) + CO_3^{2-} (aq) \rightarrow Na_2CO_3 (aq)$

B) $2Na^+ (aq) + 2Cl^- (aq) \rightarrow 2NaCl (aq)$

C) $Na^+ (aq) + Cl^- (aq) \rightarrow NaCl (aq)$

D) $Ca^{2+} (aq) + CO_3^{2-} (aq) \rightarrow CaCO_3 (s)$

E) $Na_2CO_3 (aq) + CaCl_2 (aq) \rightarrow 2NaCl (aq) + CaCO_3 (s)$

Answer: D

Diff: 3 Page Ref: Sec. 4.2

11) When aqueous solutions of $AgNO_3$ and KI are mixed, AgI precipitates. The balanced net ionic equation is __________.

A) $Ag^+ (aq) + I^- (aq) \rightarrow AgI (s)$

B) $Ag^+ (aq) + NO_3^- (aq) \rightarrow AgNO_3 (s)$

C) $Ag^+ (aq) + NO_3^- (aq) \rightarrow AgNO_3 (aq)$

D) $AgNO_3 (aq) + KI (aq) \rightarrow AgI (s) + KNO_3 (aq)$

E) $AgNO_3 (aq) + KI (aq) \rightarrow AgI (s) + KNO_3 (s)$

Answer: A

Diff: 3 Page Ref: Sec. 4.2

12) When H_2SO_4 is neutralized by NaOH in aqueous solution, the net ionic equation is __________.

A) $SO_4^{2-} (aq) + 2Na^+ (aq) \rightarrow Na_2SO_4 (aq)$

B) $SO_4^{2-} (aq) + 2Na^+ (aq) \rightarrow Na_2SO_4 (s)$

C) $H^+ (aq) + OH^- (aq) \rightarrow H_2O (l)$

D) $H_2SO_4 (aq) + 2OH^- (aq) \rightarrow H_2O (l) + SO_4^{2-} (aq)$

E) $2H^+ (aq) + 2NaOH (aq) \rightarrow 2H_2O (l) + 2Na^+ (aq)$

Answer: C

Diff: 2 Page Ref: Sec. 4.2

13) The spectator ions in the reaction between aqueous perchloric acid and aqueous barium hydroxide are __________.

A) OH^{-} and ClO_4-

B) H^{+}, OH^{-}, ClO_4- , and Ba^{2+}

C) H^{+} and OH^{-}

D) H^{+} and Ba^{2+}

E) ClO_4- and Ba^{2+}

Answer: E

Diff: 3 Page Ref: Sec. 4.2

14) The spectator ions in the reaction between aqueous hydrofluoric acid and aqueous barium hydroxide are __________.

A) OH^{-}, F^{-}, and Ba^{2+}

B) F^{-} and Ba^{2+}

C) OH^{-} and F^{-}

D) Ba^{2+} only

E) H+, OH^{-}, F^{-}, and Ba^{2+}

Answer: D

Diff: 2 Page Ref: Sec. 4.2

15) The spectator ions in the reaction between aqueous hydrochloric acid and aqueous ammonia are __________.

A) H^{+} and NH_3

B) H^{+}, Cl^{-}, NH_3, and NH_4^{+}

C) Cl^{-} and NH_4^{+}

D) H^{+}, Cl^{-}, and NH_4^{+}

E) Cl^{-} only

Answer: E

Diff: 3 Page Ref: Sec. 4.2

16) Which of the following are strong acids?

HI
HNO_3
HF
HBr

A) HF, HBr

B) HI, HNO_3, HF, HBr

C) HI, HF, HBr

D) HNO_3, HF, HBr

E) HI, HNO_3, HBr

Answer: E

Diff: 3 Page Ref: Sec. 4.3

17) Which hydroxides are strong bases?

$Sr(OH)_2$
KOH
NaOH
$Ba(OH)_2$

A) KOH, $Ba(OH)_2$
B) KOH, NaOH
C) KOH, NaOH, $Ba(OH)_2$
D) $Sr(OH)_2$, KOH, NaOH, $Ba(OH)_2$
E) None of these is a strong base.
Answer: D
Diff: 2 Page Ref: Sec. 4.3

18) A neutralization reaction between an acid and a metal hydroxide produces __________.
A) water and a salt
B) hydrogen gas
C) oxygen gas
D) sodium hydroxide
E) ammonia
Answer: A
Diff: 2 Page Ref: Sec. 4.3

19) Of the metals below, only __________ will not dissolve in an aqueous solution containing nickel ions.

aluminum
chromium
barium
tin
potassium

A) aluminum
B) chromium
C) barium
D) tin
E) potassium
Answer: D
Diff: 4 Page Ref: Sec. 4.4

20) Which of these metals is the least easily oxidized?

Na
Au
Fe
Ca
Ag

A) Na
B) Au
C) Fe
D) Ca
E) Ag
Answer: B
Diff: 3 Page Ref: Sec. 4.4

21) Of the following elements, __________ is the only one that cannot be found in nature in its elemental form.

Cu
Hg
Au
Ag
Na

A) Cu
B) Hg
C) Au
D) Ag
E) Na
Answer: E
Diff: 2 Page Ref: Sec. 4.4

22) Of the following elements, __________ is the <u>most</u> easily oxidized.

oxygen
fluorine
nitrogen
aluminum
gold

A) oxygen
B) fluorine
C) nitrogen
D) aluminum
E) gold
Answer: D
Diff: 3 Page Ref: Sec. 4.4

23) Based on the equations below, which metal is the most active?

$Pb(NO_3)_2\ (aq) + Ni\ (s) \rightarrow Ni(NO_2)_2\ (aq) + Pb\ (s)$
$Pb(NO_3)_2\ (aq) + Ag\ (s) \rightarrow$ No reaction
$Cu(NO_3)_2\ (aq) + Ag\ (s) \rightarrow$ No reaction

A) Ni
B) Ag
C) Cu
D) Pb
E) N
Answer: A
Diff: 3 Page Ref: Sec. 4.4

24) Consider the following reactions:

$AgNO_3$ (aq) + Zn (s) $\rightarrow$ Ag (s) + $Zn(NO_3)_2$
$Co(NO_3)_2$ (aq) + Zn (s) $\rightarrow$ No reaction
$AgNO_3$ (aq) + Co (s) $\rightarrow$ $Co(NO_3)_2$ (aq) + Ag (s)

Which is the correct order of increasing activity for these metals?
A) Ag < Zn < Co
B) Co < Ag < Zn
C) Co < Zn < Ag
D) Ag < Co < Zn
E) Zn < Co < Ag
Answer: D
Diff: 3 Page Ref: Sec. 4.4

25) When gold dissolves in aqua regia, what is reduced

H^+
NO_3^-
Cl^-
H_2O
Au

A) H^+
B) NO_3^-
C) Cl^-
D) H_2O
E) Au
Answer: B
Diff: 4 Page Ref: Sec. 4.5

26) What is the concentration (M) of KCl in a solution made by mixing 25.0 mL of 0.100 M KCl with 50.0 mL of 0.100 M KCl?
A) 0.100
B) 0.0500
C) 0.0333
D) 0.0250
E) 125
Answer: A
Diff: 3 Page Ref: Sec. 4.5

27) What is the concentration (M) of CH_3OH in a solution prepared by dissolving 11.7 g of CH_3OH in sufficient water to give exactly 230 mL of solution?
A) 11.9
B) 1.59×10^{-3}
C) 0.0841
D) 1.59
E) 11.9×10^{-3}
Answer: D
Diff: 3 Page Ref: Sec. 4.5

28) How many grams of H_3PO_4 are in 175 mL of a 3.5 M solution of H_3PO_4?
A) 0.61
B) 60
C) 20
D) 4.9
E) 612
Answer: B
Diff: 3 Page Ref: Sec. 4.5

29) What is the concentration (M) of a NaCl solution prepared by dissolving 9.3 g of NaCl in sufficient water to give 350 mL of solution?
A) 18
B) 0.16
C) 0.45
D) 27
E) 2.7×10^{-2}
Answer: C
Diff: 3 Page Ref: Sec. 4.5

30) How many grams of NaOH (MW = 40.0) are there in 500.0 mL of a 0.175 M NaOH solution?
A) 2.19×10^{-3}
B) 114
C) 14.0
D) 3.50
E) 3.50×10^{3}
Answer: D
Diff: 4 Page Ref: Sec. 4.5

31) How many grams of CH_3OH must be added to water to prepare 150 mL of a solution that is 2.0 M CH_3OH?
A) 9.6×10^{3}
B) 4.3×10^{2}
C) 2.4
D) 9.6
E) 4.3
Answer: D
Diff: 4 Page Ref: Sec. 4.5

32) There are __________ mol of bromide ions in 0.500 L of a 0.300 M solution of $AlBr_3$.
A) 0.150
B) 0.0500
C) 0.450
D) 0.167
E) 0.500
Answer: C
Diff: 3 Page Ref: Sec. 4.5

33) How many moles of Co^{2+} are present in 0.200 L of a 0.400 M solution of CoI_2 ?
A) 2.00
B) 0.500
C) 0.160
D) 0.0800
E) 0.0400
Answer: D
Diff: 3 Page Ref: Sec. 4.5

34) How many moles of K^+ are present in 343 mL of a 1.27 M solution of K_3PO_4 ?
A) 0.436
B) 1.31
C) 0.145
D) 3.70
E) 11.1
Answer: B
Diff: 3 Page Ref: Sec. 4.5

35) What are the respective concentrations (M) of Na^+ and SO_4^{2-} afforded by dissolving 0.500 mol Na_2SO_4 in water and diluting to 1.33 L?
A) 0.665 and 0.665
B) 0.665 and 1.33
C) 1.33 and 0.665
D) 0.376 and 0.752
E) 0.752 and 0.376
Answer: E
Diff: 4 Page Ref: Sec. 4.5

36) Calculate the concentration (M) of sodium ions in a solution made by diluting 50.0 mL of a 0.874 M solution of sodium sulfide to a total volume of 250.0 mL.
A) 0.175
B) 4.37
C) 0.525
D) 0.350
E) 0.874
Answer: D
Diff: 4 Page Ref: Sec. 4.5

37) An aqueous ethanol solution (400 mL) was diluted to 4.00 L, giving a concentration of 0.0400 M. The concentration of the original solution was __________ M.
A) 0.400
B) 0.200
C) 2.00
D) 1.60
E) 4.00
Answer: A
Diff: 4 Page Ref: Sec. 4.5

38) The concentration (M) of an aqueous methanol produced when 0.200 L of a 2.00 M solution was diluted to 0.800 L is __________.
A) 0.800
B) 0.200
C) 0.500
D) 0.400
E) 8.00
Answer: C
Diff: 4 Page Ref: Sec. 4.5

39) The molarity (M) of an aqueous solution containing 22.5 g of sucrose $(C_{12}H_{22}O_{11})$ in 35.5 mL of solution is __________.
A) 0.0657
B) 1.85×10^{-3}
C) 1.85
D) 3.52
E) 0.104
Answer: C
Diff: 3 Page Ref: Sec. 4.5

40) The molarity (M) of an aqueous solution containing 52.5 g of sucrose $(C_{12}H_{22}O_{11})$ in 35.5 mL of solution is __________.
A) 5.46
B) 1.48
C) 0.104
D) 4.32
E) 1.85
Answer: D
Diff: 3 Page Ref: Sec. 4.5

41) The molarity (M) of an aqueous solution containing 22.5 g of glucose $(C_6H_{12}O_6)$ in 35.5 mL of solution is __________.
A) 3.52
B) 0.634
C) 0.197
D) 0.125
E) 1.85
Answer: A
Diff: 3 Page Ref: Sec. 4.5

42) The molarity of an aqueous solution containing 75.3 g of glucose $(C_6H_{12}O_6)$ in 35.5 mL of solution is __________.
A) 1.85
B) 2.12
C) 0.197
D) 3.52
E) 11.8
Answer: E
Diff: 3 Page Ref: Sec. 4.5

43) How many grams of sodium chloride are there in 55.0 mL of a 1.90 M aqueous solution of sodium chloride?
A) 0.105
B) 6.11
C) 3.21
D) 6.11×10^3
E) 12.2
Answer: B
Diff: 3 Page Ref: Sec. 4.5

44) How many grams of sodium chloride are there in 550 mL of a 1.90 M aqueous solution of sodium chloride?
A) 61.1
B) 1.05
C) 30.5
D) 6.11×10^4
E) 122
Answer: A
Diff: 3 Page Ref: Sec. 4.5

45) The molarity of a solution prepared by diluting 43.72 mL of 1.005 M aqueous $K_2Cr_2O_7$ to 500 mL is __________.
A) 0.0879
B) 87.9
C) 0.0218
D) 0.0115
E) 0.870
Answer: A
Diff: 2 Page Ref: Sec. 4.5

46) The molarity of a solution prepared by diluting 43.72 mL of 5.005 M aqueous $K_2Cr_2O_7$ to 500 mL is __________.
A) 57.2
B) 0.0044
C) 0.438
D) 0.0879
E) 0.870
Answer: C
Diff: 2 Page Ref: Sec. 4.5

47) The concentration of chloride ions in a 0.193 M solution of potassium chloride is __________.
A) 0.0643 M
B) 0.386 M
C) 0.0965 M
D) 0.579 M
E) 0.193 M
Answer: E
Diff: 3 Page Ref: Sec. 4.5

48) The concentration of iodide ions in a 0.193 M solution of barium iodide is __________.
A) 0.193 M
B) 0.386 M
C) 0.0965 M
D) 0.579 M
E) 0.0643 M
Answer: B
Diff: 3 Page Ref: Sec. 4.5

49) The concentration of species in 500 mL of a 2.104 M solution of sodium sulfate is __________ M sodium ion and __________ M sulfate ion.
A) 2.104, 1.052
B) 2.104, 2.104
C) 2.104, 4.208
D) 1.052, 1.052
E) 4.208, 2.104
Answer: E
Diff: 4 Page Ref: Sec. 4.5

50) When 0.500 mol of $HC_2H_3O_2$ is combined with enough water to make a 300 mL solution, the concentration of $HC_2H_3O_2$ is __________ M.
A) 3.33
B) 1.67
C) 0.835
D) 0.00167
E) 0.150
Answer: B
Diff: 3 Page Ref: Sec. 4.5

51) In a titration of 35.00 mL of 0.737 M H_2SO_4, __________ mL of a 0.827 M KOH solution is required for neutralization.
A) 35.0
B) 1.12
C) 25.8
D) 62.4
E) 39.3
Answer: D
Diff: 3 Page Ref: Sec. 4.6

52) Oxalic acid is a diprotic acid. Calculate the percent of oxalic acid $(H_2C_2O_4)$ in a solid given that a 0.7984 g sample of that solid required 37.98 mL of 0.2283 M NaOH for neutralization.
A) 48.89
B) 97.78
C) 28.59
D) 1.086
E) 22.83
Answer: A
Diff: 5 Page Ref: Sec. 4.6

53) A 17.5 mL sample of an acetic acid (CH_3CO_2H) solution required 29.6 mL of 0.250 M NaOH for neutralization. The concentration of acetic acid was __________ M.
A) 0.15
B) 0.42
C) 130
D) 6.8
E) 0.21
Answer: B
Diff: 4 Page Ref: Sec. 4.6

54) A 25.5 mL aliquot of HCl (aq) of unknown concentration was titrated with 0.113 M NaOH (aq). It took 51.2 mL of the base to reach the endpoint of the titration. The concentration (M) of the acid was __________.
A) 1.02
B) 0.114
C) 0.454
D) 0.113
E) 0.227
Answer: E
Diff: 5 Page Ref: Sec. 4.6

55) A 31.5 mL aliquot of HNO_3 (aq) of unknown concentration was titrated with 0.0134 M NaOH (aq). It took 23.9 mL of the base to reach the endpoint of the titration. The concentration (M) of the acid was __________.
A) 0.0102
B) 0.0051
C) 0.0204
D) 0.227
E) 1.02
Answer: A
Diff: 5 Page Ref: Sec. 4.6

56) A 31.5 mL aliquot of H_2SO_4 (aq) of unknown concentration was titrated with 0.0134 M NaOH (aq). It took 23.9 mL of the base to reach the endpoint of the titration. The concentration (M) of the acid was __________.
A) 0.0102
B) 0.0051
C) 0.0204
D) 0.102
E) 0.227
Answer: B
Diff: 5 Page Ref: Sec. 4.6

Multiple-Choice

57) Of the species below, only __________ is NOT an electrolyte.
A) HCl
B) Rb_2SO_4
C) Ar
D) KOH
E) NaCl
Answer: C
Diff: 1 Page Ref: Sec. 4.1

58) The balanced molecular equation for complete neutralization of H_2SO_4 by KOH in aqueous solution is __________.

A) $2H^+ (aq) + 2OH^- (aq) \rightarrow 2H_2O (l)$

B) $2H^+ (aq) + 2KOH (aq) \rightarrow 2H_2O (l) + 2K^+ (aq)$

C) $H_2SO_4 (aq) + 2OH^- (aq) \rightarrow 2H_2O (l) + SO_4^{2-} (aq)$

D) $H_2SO_4 (aq) + 2KOH (aq) \rightarrow 2H_2O (l) + K_2SO_4 (s)$

E) $H_2SO_4 (aq) + 2KOH (aq) \rightarrow 2H_2O (l) + K_2SO_4 (aq)$

Answer: E
Diff: 1 Page Ref: Sec. 4.2

59) Aqueous potassium chloride will react with which one of the following in an exchange (metathesis) reaction?
A) calcium nitrate
B) sodium bromide
C) lead nitrate
D) barium nitrate
E) sodium chloride
Answer: C
Diff: 2 Page Ref: Sec. 4.2

60) Aqueous solutions of a compound did not form precipitates with Cl^-, Br^-, I^-, SO_4^{2-}, CO_3^{2-}, PO_4^{3-}, OH^-, or S^{2-}. This highly water-soluble compound produced the foul-smelling gas H_2S when the solution was acidified. This compound is __________.

A) $Pb(NO_3)_2$

B) $(NH_4)_2S$

C) KBr

D) Li_2CO_3

E) $AgNO_3$

Answer: B
Diff: 3 Page Ref: Sec. 4.2

61) The net ionic equation for formation of an aqueous solution of NiI_2 accompanied by evolution of CO_2 gas via mixing solid $NiCO_3$ and aqueous hydriodic acid is __________.

A) $2NiCO_3 (s) + HI (aq) \rightarrow 2H_2O (l) + CO_2 (g) + 2Ni^{2+} (aq)$

B) $NiCO_3 (s) + I^- (aq) \rightarrow 2H_2O (l) + CO_2 (g) + Ni^{2+} (aq) + HI (Aq)$

C) $NiCO_3 (s) + 2H^+ (aq) \rightarrow H_2O (l) + CO_2 (g) + Ni^{2+} (aq)$

D) $NiCO_3 (s) + 2HI (aq) \rightarrow 2H_2O (l) + CO_2 (g) + NiI_2 (aq)$

E) $NiCO_3 (s) + 2HI (aq) \rightarrow H_2O (l) + CO_2 (g) + Ni^{2+} (aq) + 2I^- (aq)$

Answer: C
Diff: 4 Page Ref: Sec. 4.2

62) The net ionic equation for formation of an aqueous solution of $Al(NO_3)_3$ via mixing solid $Al(OH)_3$ and aqueous nitric acid is __________.
A) $Al(OH)_3$ (s) + $3HNO_3$ (aq) $\rightarrow$ $3H_2O$ (l) + $Al(NO_3)_3$ (aq)
B) $Al(OH)_3$ (s) + $3NO_3$ - (aq) $\rightarrow$ $3OH^-$ (aq) + $Al(NO_3)_3$ (aq)
C) $Al(OH)_3$ (s) + $3NO_3$ - (aq) $\rightarrow$ $3OH^-$ (aq) + $Al(NO_3)_3$ (s)
D) $Al(OH)_3$ (s) + $3H^+$ (aq) $\rightarrow$ $3H_2O$ (l) + Al^{3+} (aq)
E) $Al(OH)_3$ (s) + $3HNO_3$ (aq) $\rightarrow$ $3H_2O$ (l) + Al^{3+} (aq) + NO_3 - (aq)
Answer: D
Diff: 4 Page Ref: Sec. 4.2

63) Which of the following is soluble in water at 25°C?
A) $Fe_3(PO_4)_2$
B) $Fe(OH)_2$
C) $Fe(NO_3)_2$
D) $FeCO_3$
E) FeS
Answer: C
Diff: 2 Page Ref: Sec. 4.2

64) When aqueous solutions of __________ are mixed, a precipitate forms.
A) $NiBr_2$ and $AgNO_3$
B) NaI and KBr
C) K_2SO_4 and $CrCl_3$
D) KOH and $Ba(NO_3)_2$
E) Li_2CO_3 and CsI
Answer: A
Diff: 2 Page Ref: Sec. 4.2

65) Which one of the following compounds is insoluble in water?
A) Na_2CO_3
B) K_2SO_4
C) $Fe(NO_3)_3$
D) ZnS
E) $AgNO_3$
Answer: D
Diff: 1 Page Ref: Sec. 4.2

66) Which combination will produce a precipitate?
A) $NaC_2H_3O_2$ (aq) and HCl (aq)
B) NaOH (aq) and HCl (aq)
C) $AgNO_3$ (aq) and $Ca(C_2H_3O_2)_2$ (aq)
D) KOH (aq) and $Mg(NO_3)_2$ (aq)
E) NaOH (aq) and HCl (aq)
Answer: D
Diff: 3 Page Ref: Sec. 4.2

67) Which combination will produce a precipitate?
A) NH_4OH (aq) and HCl (aq)
B) $AgNO_3$ (aq) and $Ca(C_2H_3O_2)_2$ (aq)
C) NaOH (aq) and HCl (aq)
D) NaCl (aq) and $HC_2H_3O_2$ (aq)
E) NaOH (aq) and $Fe(NO_3)_3$ (aq)
Answer: E
Diff: 3 Page Ref: Sec. 4.2

68) With which of the following will ammonium ion form an insoluble salt?
A) chloride
B) sulfate
C) carbonate
D) sulfate and carbonate
E) none of the above
Answer: E
Diff: 1 Page Ref: Sec. 4.2

69) The net ionic equation for the reaction between aqueous sulfuric acid and aqueous sodium hydroxide is __________.
A) H^+ (aq) + HSO_4- (aq) + $2OH^-$ (aq) $\rightarrow$ $2H_2O$ (l) + SO_4^{2-} (aq)
B) H^+ (aq) + HSO_4- (aq) + $2Na^+$ (aq) $2OH^-$(aq) $\rightarrow$ $2H_2O$ (l) + $2Na^+$ (aq) + SO_4^{2-} (aq)
C) SO_4^{2-} (aq) + $2Na^+$ (aq) $\rightarrow$ $2Na^+$ (aq) + SO_4^{2-} (aq)
D) $2H^+$ (aq) + $2OH^-$ (aq) $\rightarrow$ $2H_2O$ (l)
E) $2H^+$ (aq) + SO_4^{2-} (aq) + 2Na+ (aq) + $2OH^-$ (aq) $\rightarrow$ $2H_2O$ (l) + $2Na^+$ (aq) + SO_4^{2-} (aq)
Answer: D
Diff: 3 Page Ref: Sec. 4.2

70) The reaction between strontium hydroxide and chloric acid produces __________.
A) a molecular compound and a weak electrolyte
B) two weak electrolytes
C) two strong electrolytes
D) a molecular compound and a strong electrolyte
E) two molecular compounds
Answer: D
Diff: 3 Page Ref: Sec. 4.3

71) Which one of the following is a diprotic acid?
A) nitric acid
B) chloric acid
C) phosphoric acid
D) hydrofluroric acid
E) sulfuric acid
Answer: E
Diff: 2 Page Ref: Sec. 4.3

72) Which one of the following solutions will have the greatest concentration of hydroxide ions?
A) 0.100 M rubidium hydroxide
B) 0.100 M magnesium hydroxide
C) 0.100 M ammonia
D) 0.100 M beryllium hydroxide
E) 0.100 M hydrochloric acid
Answer: A
Diff: 3 Page Ref: Sec. 4.3

73) Which one of the following is a weak acid?
A) HNO_3
B) HCl
C) HI
D) HF
E) $HClO_4$
Answer: D
Diff: 1 Page Ref: Sec. 4.3

74) A compound was found to be soluble in water. It was also found that addition of acid to an aqueous solution of this compound resulted in the formation of carbon dioxide. Which one of the following cations would form a precipitate when added to an aqueous solution of this compound?
A) NH_4^+
B) K+
C) Cr_3^+
D) Rb^+
E) Na^+
Answer: C
Diff: 4 Page Ref: Sec. 4.3

75) Which hydroxides are weak bases?
1) $Sr(OH)_2$
2) KOH
3) NaOH
4) $Ba(OH)_2$
A) 2, 4
B) 1, 2, 3, 4
C) 2, 3
D) 2, 3, 4
E) None of these is a weak base.
Answer: E
Diff: 2 Page Ref: Sec. 4.3

76) The balanced reaction between aqueous potassium hydroxide and aqueous acetic acid is __________.
A) $KOH\ (aq) + HC_2H_3O_2\ (aq) \rightarrow OH^-\ (l) + HC_2H_3O_2^+\ (aq) + K\ (s)$
B) $KOH\ (aq) + HC_2H_3O_2\ (aq) \rightarrow H_2O\ (l) + KC_2H_3O_2\ (aq)$
C) $KOH\ (aq) + HC_2H_3O_2\ (aq) \rightarrow H_2C_2H_3O_3\ (aq) + K\ (s)$
D) $KOH\ (aq) + HC_2H_3O_2\ (aq) \rightarrow KC_2H_3O_3\ (aq) + H_2\ (g)$
E) $KOH\ (aq) + HC_2H_3O_2\ (aq) \rightarrow H_2KC_2H_3O\ (aq) + O_2\ (g)$
Answer: B
Diff: 2 Page Ref: Sec. 4.3

77) The balanced reaction between aqueous nitric acid and aqueous strontium hydroxide is __________.

A) HNO_3 (aq) + $Sr(OH)_2$ (aq) $\rightarrow$ $Sr(NO_3)_2$ (aq) + H_2 (g)

B) HNO_3 (aq) + $Sr(OH)_2$ (aq) $\rightarrow$ H_2O (l) + $Sr(NO_3)_2$ (aq)

C) HNO_3 (aq) + Sr(OH) (aq) $\rightarrow$ H_2O (l) + $SrNO_3$ (aq)

D) $2HNO_3$ (aq) + $Sr(OH)_2$ (aq) $\rightarrow$ $2H_2O$ (l) + $Sr(NO_3)_2$ (aq)

E) $2HNO_3$ (aq) + $Sr(OH)_2$ (aq) $\rightarrow$ $Sr(NO_3)_2$ (aq) + $2H_2$ (g)

Answer: D
Diff: 2 Page Ref: Sec. 4.3

78) In which reaction does the oxidation number of oxygen increase?

A) $Ba(NO_3)_2$ (aq) + K_2SO_4 (aq) $\rightarrow$ $BaSO_4$ (s) + 2 KNO_3 (aq)

B) HCl (aq) + NaOH (aq) → NaCl (aq) + H_2O (*l*)

C) MgO (s) + H_2O (*l*) $\rightarrow$ $Mg(OH)_2$ (s)

D) 2 SO_2 (g) + O_2 (g) $\rightarrow$ 2 SO_3 (g)

E) 2 H_2O (*l*) $\rightarrow$ 2 H_2 (g) + O_2 (g)

Answer: E
Diff: 3 Page Ref: Sec. 4.4

79) In which reaction does the oxidation number of hydrogen change?

A) HCl (aq) + NaOH (aq) → NaCl (aq) + H_2O (*l*)

B) 2 Na (s) + 2 H_2O (*l*) $\rightarrow$ 2 NaOH (aq) + H_2 (g)

C) CaO (s) + H_2O (*l*) $\rightarrow$ $Ca(OH)_2$ (s)

D) 2 $HClO_4$ (aq) + $CaCO_3$ (s) $\rightarrow$ $Ca(ClO_4)_2$ (aq) + H_2O (*l*) + CO_2 (g)

E) SO_2(g) + H_2O (*l*) $\rightarrow$ H_2SO_3 (aq)

Answer: B
Diff: 3 Page Ref: Sec. 4.4

80) In which species does sulfur have the highest oxidation number?

A) S_8 (elemental form of sulfur)

B) H_2S

C) SO_2

D) H_2SO_3

E) K_2SO_4

Answer: E
Diff: 4 Page Ref: Sec. 4.4

81) Which compound has the atom with the highest oxidation number?

A) CaS

B) Na_3N

C) $MgSO_3$

D) $Al(NO_2)_3$

E) NH_4Cl

Answer: C
Diff: 4 Page Ref: Sec. 4.4

82) Of the choices below, which would be the best for the lining of a tank intended for use in storage of hydrochloric acid?
A) copper
B) zinc
C) nickel
D) iron
E) tin
Answer: A
Diff: 5 Page Ref: Sec. 4.4

83) One method for removal of metal ions from a solution is to convert the metal to its elemental form so it can be filtered out as a solid. Which metal can be used to remove aluminum ions from solution?
A) zinc
B) cobalt
C) lead
D) copper
E) none of these
Answer: E
Diff: 3 Page Ref: Sec. 4.4

84) Of the reactions below, only __________ is not spontaneous.
A) $Mg (s) + 2HCl (aq) \rightarrow MgCl_2 (aq) + H_2 (g)$
B) $2Ag (s) + 2HNO_3 (aq) \rightarrow 2AgNO_3 (aq) + H_2 (g)$
C) $2Ni (s) + H_2SO_4 (aq) \rightarrow Ni_2SO_4 (aq) + H_2 (g)$
D) $2Al (s) + 6HBr (aq) \rightarrow 2AlBr_3 (aq) + 3H_2 (g)$
E) $Zn (s) + 2HI (aq) \rightarrow ZnI_2 (aq) + H_2 (g)$
Answer: B
Diff: 4 Page Ref: Sec. 4.4

85) Based on the activity series, which one of the reactions below will occur?
A) $Zn (s) + MnI_2 (aq) \rightarrow ZnI_2 (aq) + Mn (s)$
B) $SnCl_2 (aq) + Cu (s) \rightarrow Sn (s) + CuCl_2 (aq)$
C) $2AgNO_3 (aq) + Pb (s) \rightarrow 2Ag (s) + Pb(NO_3)_2 (aq)$
D) $3Hg (l) + 2Cr(NO_3)_3 (aq) \rightarrow 3Hg(NO_3)_2 + 2Cr (s)$
E) $3FeBr_2 (aq) + 2Au (s) \rightarrow 3Fe (s) + 2AuBr_3 (aq)$
Answer: C
Diff: 3 Page Ref: Sec. 4.4

86) The net ionic equation for the dissolution of zinc metal in aqueous hydrobromic acid is __________.
A) $Zn (s) + 2Br^- (aq) \rightarrow ZnBr_2 (aq)$
B) $Zn (s) + 2HBr (aq) \rightarrow ZnBr_2 (aq) + 2H^+ (aq)$
C) $Zn (s) + 2HBr (aq) \rightarrow ZnBr_2 (s) + 2H^+ (aq)$
D) $Zn (s) + 2H^+ (aq) \rightarrow Zn^{2+} (aq) + H_2 (g)$
E) $2Zn (s) + H^+ (aq) \rightarrow 2Zn^{2+} (aq) + H_2 (g)$
Answer: D
Diff: 2 Page Ref: Sec. 4.4

87) Sodium does not occur in nature as Na (s) because __________.
A) it is easily reduced to Na^-
B) it is easily oxidized to Na^+
C) it reacts with water with great difficulty
D) it is easily replaced by silver in its ores
E) it undergoes a disproportionation reaction to Na^- and Na^+
Answer: B
Diff: 2   Page Ref: Sec. 4.4

88) Zinc is more active than cobalt and iron but less active than aluminum. Cobalt is more active than nickel but less active than iron. Which of the following correctly lists the elements in order of increasing activity?
A) Co < Ni < Fe < Zn < Al
B) Ni < Fe < Co < Zn < Al
C) Ni < Co < Fe < Zn < Al
D) Fe < Ni < Co < Al < Zn
E) Zn < Al < Co < Ni < Fe
Answer: C
Diff: 2   Page Ref: Sec. 4.4

89) Oxidation is the __________ and reduction is the __________.
A) gain of oxygen, loss of electrons
B) loss of oxygen, gain of electrons
C) loss of electrons, gain of electrons
D) gain of oxygen, loss of mass
E) gain of electrons, loss of electrons
Answer: C
Diff: 2   Page Ref: Sec. 4.4

90) Oxidation and __________ mean essentially the same thing.
A) activity
B) reduction
C) metathesis
D) decomposition
E) corrosion
Answer: E
Diff: 2   Page Ref: Sec. 4.4

91) Oxidation cannot occur without __________.
A) acid
B) oxygen
C) water
D) air
E) reduction
Answer: E
Diff: 1   Page Ref: Sec. 4.4

92) Which of the following is an oxidation-reduction reaction?
A) $Cu\ (s) + 2AgNO_3\ (aq) \rightarrow 2Ag\ (s) + Cu(NO_3)_2\ (aq)$
B) $HCl\ (aq) + NaOH\ (aq) \rightarrow H_2O\ (l) + NaCl\ (aq)$
C) $AgNO_3\ (aq) + HCl\ (aq) \rightarrow AgCl\ (s) + HNO_3\ (aq)$
D) $Ba(C_2H_3O_2)_2\ (aq) + Na_2SO_4\ (aq) \rightarrow BaSO_4\ (s) + 2NaC_2H_3O_2\ (aq)$
E) $H_2CO_3\ (aq) + Ca(NO_3)_2\ (aq) \rightarrow 2HNO_3\ (aq) + CaCO_3\ (s)$
Answer: A
Diff: 2 Page Ref: Sec. 4.4

93) Which of the following reactions will not occur as written?
A) $Zn\ (s) + Pb(NO_3)_2\ (aq) \rightarrow Pb\ (s) + Zn(NO_3)_2\ (aq)$
B) $Mg\ (s) + Ca(OH)_2\ (aq) \rightarrow Ca\ (s) + Mg(OH)_2\ (aq)$
C) $Sn\ (s) + 2AgNO_3\ (aq) \rightarrow 2Ag\ (s) + Sn(NO_3)_2\ (aq)$
D) $Co\ (s) + 2AgCl\ (aq) \rightarrow 2Ag\ (s) + CoCl_2\ (aq)$
E) $Co\ (s) + 2HI\ (aq) \rightarrow H_2\ (g) + CoI_2\ (aq)$
Answer: B
Diff: 3 Page Ref: Sec. 4.4

94) Which one of the following is a correct expression for molarity?
A) mol solute/L solvent
B) mol solute/mL solvent
C) mmol solute/mL solution
D) mol solute/kg solvent
E) μmol solute/L solution
Answer: C
Diff: 3 Page Ref: Sec. 4.5

95) Which one of the following is <u>not</u> true concerning 2.00 L of 0.100 M solution of $Ca_3(PO_4)_2$?
A) This solution contains 0.200 mol of $Ca_3(PO_4)_2$.
B) This solution contains 0.800 mol of oxygen atoms.
C) 1.00 L of this solution is required to furnish 0.300 mol of Ca^{2+} ions.
D) There are 6.02×10^{22} phosphorus atoms in 500.0 mL of this solution.
E) This solution contains 6.67×10^{-2} mol of Ca^{2+}.
Answer: B
Diff: 2 Page Ref: Sec. 4.5

96) A 0.200 M K_2SO_4 solution is produced by __________.
A) dilution of 250.0 mL of 1.00 M K_2SO_4 to 1.00 L
B) dissolving 43.6 g of K_2SO_4 in water and diluting to a total volume of 250.0 mL
C) diluting 20.0 mL of 5.00 M K_2SO_4 solution to 500.0 mL
D) dissolving 20.2 g of K_2SO_4 in water and diluting to 250.0 mL, then diluting 25.0 mL of this solution to a total volume of 500.0 mL
E) dilution of 1.00 mL of 250 M K_2SO_3 to 1.00 L
Answer: C
Diff: 3 Page Ref: Sec. 4.5

97) Which solution has the same number of moles of solute A as 50.00 mL of 0.100*M* solution of NaOH?
A) 20.00 mL of 0.200*M* solution of A
B) 25.00 mL of 0.175*M* solution of A
C) 30.00 mL of 0.145*M* solution of A
D) 50.00 mL of 0.125*M* solution of A
E) 100.00 mL of 0.0500*M* solution of A
Answer: E
Diff: 4 Page Ref: Sec. 4.5

98) What are the respective concentrations (M) of Fe^{3+} and I^- afforded by dissolving 0.200 mol FeI_3 in water and diluting to 725 mL?
A) 0.276 and 0.828
B) 0.828 and 0.276
C) 0.276 and 0.276
D) 0.145 and 0.435
E) 0.145 and 0.0483
Answer: A
Diff: 4 Page Ref: Sec. 4.5

99) A tenfold dilution of a sample solution can be obtained by taking __________.
A) 1 part sample and 9 parts solvent
B) 1 part sample and 10 parts solvent
C) 9 parts sample and 1 part solvent
D) 10 parts sample and 1 part solvent
E) 99 parts sample and 1 part solvent
Answer: A
Diff: 2 Page Ref: Sec. 4.5

100) Mixing 10.00 mL of an aqueous solution with 10.00 mL of water represents a __________.
A) crystallization
B) neutralization
C) twofold dilution
D) tenfold dilution
E) titration
Answer: C
Diff: 2 Page Ref: Sec. 4.5

101) You are given two clear solutions of the same unknown monoprotic acid, but with different concentrations. Which statement is true?
A) There is no chemical method designed to tell the two solutions apart.
B) It would take more base solution (per milliliter of the unknown solution) to neutralize the more concentrated solution.
C) A smaller volume of the less concentrated solution contains the same number of moles of the acid compared to the more concentrated solution.
D) If the same volume of each sample was taken, then more base solution would be required to neutralize the one with lower concentration.
E) The product of concentration and volume of the less concentrated solution equals the product of concentration and volume of the more concentrated solution.
Answer: B
Diff: 2 Page Ref: Sec. 4.5

102) A 0.100 M solution of __________ will contain the highest concentration of potassium ions.
A) potassium phosphate
B) potassium hydrogen carbonate
C) potassium hypochlorite
D) potassium iodide
E) potassium oxide
Answer: A
Diff: 3 Page Ref: Sec. 4.5

103) Which solution contains the largest number of moles of chloride ions?
A) 10.0 mL of 0.500M $BaCl_2$
B) 4.00 mL of 1.000M NaCl
C) 7.50 mL of 0.500M $FeCl_3$
D) 25.00 mL of 0.400M KCl
E) 30.00 mL of 0.100M $CaCl_2$
Answer: C
Diff: 3 Page Ref: Sec. 4.5

104) What volume (mL) of a concentrated solution of sodium hydroxide (6.00 M) must be diluted to 200. mL to make a 1.50 M solution of sodium hydroxide?
A) 0.05
B) 50.0
C) 45
D) 800
E) 0.800
Answer: B
Diff: 2 Page Ref: Sec. 4.5

105) What volume (mL) of a concentrated solution of sodium hydroxide (6.00 M) must be diluted to 200 mL to make a 0.88 M solution of sodium hydroxide?
A) 2.64
B) 176
C) 26.4
D) 29.3
E) 50.0
Answer: D
Diff: 2 Page Ref: Sec. 4.5

106) What mass (g) of potassium chloride is contained in 430 mL of a potassium chloride solution that has a chloride ion concentration of 0.193 M?
A) 0.0643
B) 0.0830
C) 12.37
D) 0.386
E) 6.19
Answer: E
Diff: 4 Page Ref: Sec. 4.5

107) What mass (g) of barium iodide is contained in 250 mL of a barium iodide solution that has an iodide ion concentration of 0.193 M?
A) 9.44
B) 18.9
C) 0.024
D) 0.048
E) 37.7
Answer: A
Diff: 3 Page Ref: Sec. 4.5

108) What mass (g) of AgBr is formed when 35.5 mL of 0.184 M $AgNO_3$ is treated with an excess of aqueous hydrobromic acid?
A) 1.44
B) 1.23
C) 53.6
D) 34.5
E) 188
Answer: B
Diff: 4 Page Ref: Sec. 4.6

109) What mass (g) of CaF_2 is formed when 47.8 mL of 0.334 M NaF is treated with an excess of aqueous calcium nitrate?
A) 1.25
B) 0.472
C) 2.49
D) 0.943
E) 0.623
Answer: E
Diff: 4 Page Ref: Sec. 4.6

110) What volume (mL) of 0.135 M NaOH is required to neutralize 13.7 mL of 0.129 M HCl?
A) 13.1
B) 0.24
C) 14.3
D) 0.076
E) 6.55
Answer: A
Diff: 3 Page Ref: Sec. 4.6

111) What volume (L) of 0.250 M HNO_3 is required to neutralize a solution prepared by dissolving 17.5 g of NaOH in 350 mL of water?
A) 50.0
B) 0.44
C) 1.75
D) 0.070
E) 1.75×10^{-3}
Answer: C
Diff: 4 Page Ref: Sec. 4.6

112) An aliquot (28.7 mL) of a KOH solution required 31.3 mL of 0.118 M HCl for neutralization. What mass (g) of KOH was in the original sample?
A) 1.6
B) 7.2
C) 0.17
D) 0.21
E) 0.42
Answer: D
Diff: 4 Page Ref: Sec. 4.6

113) The point in a titration at which the indicator changes is called the __________.
A) equivalence point
B) indicator point
C) standard point
D) endpoint
E) volumetric point
Answer: D
Diff: 1 Page Ref: Sec. 4.6

114) Which of the following would require the largest volume of 0.100 M sodium hydroxide solution for neutralization?
A) 10.0 mL of 0.0500 M phosphoric acid
B) 20.0 mL of 0.0500 M nitric acid
C) 5.0 mL of 0.0100 M sulfuric acid
D) 15.0 mL of 0.0500 M hydrobromic acid
E) 10.0 mL of 0.0500 M perchloric acid
Answer: A
Diff: 4 Page Ref: Sec. 4.6

115) Which one of the following substances is produced during the reaction of an acid with a metal hydroxide?
A) H_2
B) H_2O
C) CO_2
D) NaOH
E) O_2
Answer: B
Diff: 2 Page Ref: Sec. 4.6

116) A 36.3 mL aliquot of 0.0529 M H_2SO_4 (aq) is to be titrated with 0.0411 M NaOH (aq). What volume (mL) of base will it take to reach the equivalence point?
A) 93.6
B) 46.8
C) 187
D) 1.92
E) 3.84
Answer: A
Diff: 5 Page Ref: Sec. 4.6

117) A 13.8 mL aliquot of 0.176 M H_3PO_4 (aq) is to be titrated with 0.110 M NaOH (aq). What volume (mL) of base will it take to reach the equivalence point?
A) 7.29
B) 22.1
C) 199
D) 66.2
E) 20.9
Answer: D
Diff: 5   Page Ref: Sec. 4.6

118) What volume (mL) of 7.48×10^{-2} M perchloric acid can be neutralized with 115 mL of 0.244 M sodium hydroxide?
A) 125
B) 8.60
C) 188
D) 750
E) 375
Answer: E
Diff: 4   Page Ref: Sec. 4.6

119) What volume (mL) of 7.48×10^{-2} M phosphoric acid can be neutralized with 115 mL of 0.244 M sodium hydroxide?
A) 125
B) 375
C) 750
D) 188
E) 75.0
Answer: A
Diff: 4   Page Ref: Sec. 4.6

120) __________ is an oxidation reaction.
A) Ice melting in a soft drink
B) Table salt dissolving in water for cooking vegetables
C) Rusting of iron
D) The reaction of sodium chloride with lead nitrate to form lead chloride and sodium nitrate
E) Neutralization of HCl by NaOH
Answer: C
Diff: 2   Page Ref: Sec. 4.6

Short answer

1) The solvent in an aqueous solution is __________.
Answer: water
Diff: 1   Page Ref: Sec. 4.1

2) What is aqua regia?
Answer: a 3:1 mixture of concentrated hydrochloric and nitric acids
Diff: 3   Page Ref: Sec. 4.4

3) When gold dissolves in aqua regia, into what form is the gold converted?
Answer: $AuCl_4^-$ (aq)
Diff: 3   Page Ref: Sec. 4.5

4) Calculate the concentration (M) of arsenic acid (H_3AsO_4) in a solution if 25.00 mL of that solution required 35.21 mL of 0.1894 M KOH for neutralization.
Answer: 0.08892
Diff: 4 Page Ref: Sec. 4.6

5) How many moles of $BaCl_2$ are formed in the neutralization of 393 mL of 0.171 M $Ba(OH)_2$ with aqueous HCl?
Answer: 0.0672
Diff: 4 Page Ref: Sec. 4.6

True/False

1) $Ca(OH)_2$ is a strong base.
Answer: TRUE
Diff: 1 Page Ref: Sec. 4.3

2) The compound $HClO_4$ is a weak acid.
Answer: FALSE
Diff: 2 Page Ref: Sec. 4.3

3) HNO_2 is a strong acid.
Answer: FALSE
Diff: 1 Page Ref: Sec. 4.3

4) The compound NH_4Cl is a weak acid.
Answer: TRUE
Diff: 2 Page Ref: Sec. 4.3

5) Ammonia is a strong base.
Answer: FALSE
Diff: 1 Page Ref: Sec. 4.3

Algorithmic Questions

1) What is the concentration (M) of sodium ions in 4.57 L of a .398 M Na_3P solution?
Answer: 1.19
Diff: 3 Page Ref: Sec. 4.5

2) What is the concentration (M) of CH_3OH in a solution prepared by dissolving 16.8 g of CH_3OH in sufficient water to give exactly 230 mL of solution?
Answer: 2.28
Diff: 3 Page Ref: Sec. 4.5

3) How many grams of H_3PO_4 are in 265 mL of a 1.50 M solution of H_3PO_4?
Answer: 39.0
Diff: 3 Page Ref: Sec. 4.5

4) What is the concentration (M) of a NaCl solution prepared by dissolving 7.2 g of NaCl in sufficient water to give 425 mL of solution?
Answer: 0.29
Diff: 3 Page Ref: Sec. 4.5

5) How many grams of NaOH (MW = 40.0) are there in 250.0 mL of a 0.275 M NaOH solution?
Answer: 2.75
Diff: 4 Page Ref: Sec. 4.5

6) How many grams of CH_3OH must be added to water to prepare 150mL of a solution that is 2.0 M CH_3OH ?
Answer: 9.6
Diff: 4 Page Ref: Sec. 4.5

7) There are __________ mol of bromide ions in 0.900 L of a 0.500M solution of $AlBr_3$.
Answer: 1.35
Diff: 3 Page Ref: Sec. 4.5

8) How many moles of Co^{2+} are present in 0.150 L of a 0.200 M solution of CoI_2 ?
Answer: 0.0300
Diff: 3 Page Ref: Sec. 4.5

9) Calculate the concentration (M) of sodium ions in a solution made by diluting 40.0 mL of a 0.474 M solution of sodium sulfide to a total volume of 300 mL.
Answer: 0.126
Diff: 4 Page Ref: Sec. 4.5

10) How many milliliters of a stock solution of 11.1 M HNO_3 would be needed to prepare 0.500 L of 0.500 M HNO_3 ?
A) 0.0444
B) 22.5
C) 2.78
D) 44.4
E) 0.0225
Answer: B
Diff: 3 Page Ref: Sec. 4.5

11) A stock solution of HNO_3 is prepared and found to contain 13.5 M of HNO_3 . If 25.0 mL of the stock solution is diluted to a final volume of 0.500 L, the concentration of the diluted solution is __________ M.
A) 0.270
B) 1.48
C) 0.675
D) 675
E) 270
Answer: C
Diff: 3 Page Ref: Sec. 4.5

12) Pure acetic acid $(HC_2H_3O_2)$ is a liquid and is known as glacial acetic acid. Calculate the molarity of a solution prepared by dissolving 10.00 mL of glacial acetic acid at 25°C in sufficient water to give 500.0 mL of solution. The density of glacial acetic acid at 25°C is 1.049 g/mL.
A) 1.26×10^3
B) 21.0
C) 0.0210
D) 0.350
E) 3.50×10^{-4}
Answer: D
Diff: 4 Page Ref: Sec. 4.5

13) A solution is prepared by mixing 50.0 mL of 0.100 M HCl and 10.0 mL of 0.200 M NaCl. What is the molarity of chloride ion in this solution?
A) 0.183
B) 8.57
C) 3.50
D) 0.0500
E) 0.117
Answer: E
Diff: 3 Page Ref: Sec. 4.5

14) A solution is prepared by adding 1.60 g of solid NaCl to 50.0 mL of 0.100 M $CaCl_2$. What is the molarity of chloride ion in the final solution? Assume that the volume of the final solution is 50.0 mL.
A) 0.747
B) 0.647
C) 0.132
D) 0.232
E) 0.547
Answer: A
Diff: 4 Page Ref: Sec. 4.5

15) Calculate the number of grams of solute in 500.0 mL of 0.189 M KOH.
A) 148
B) 1.68
C) 5.30×10^3
D) 5.30
E) 1.68×10^{-3}
Answer: D
Diff: 2 Page Ref: Sec. 4.5

16) What is the molarity of a NaOH solution if 28.2 mL of a 0.355 M H_2SO_4 solution is required to neutralize a 25.0-mL sample of the NaOH solution?
A) 0.801
B) 0.315
C) 0.629
D) 125
E) 0.400
Answer: A
Diff: 4 Page Ref: Sec. 4.6

17) Lead ions can be precipitated from aqueous solutions by the addition of aqueous iodide:

$$Pb^{2+}\ (aq) + 2I^-\ (aq) \rightarrow PbI_2\ (s)$$

Lead iodide is virtually insoluble in water so that the reaction appears to go to completion. How many milliliters of 3.550 M HI(aq) must be added to a solution containing 0.700 mol of $Pb(NO_3)_2$ (aq) to completely precipitate the lead?
A) 2.54×10^{-3}
B) 394
C) 197
D) 0.197
E) 0.394
Answer: B
Diff: 4 Page Ref: Sec. 4.6

18) Silver ions can be precipitated from aqueous solutions by the addition of aqueous chloride:

$$Ag^{+}(aq) + Cl^{-}(aq) \rightarrow AgCl(s)$$

Silver chloride is virtually insoluble in water so that the reaction appears to go to completion. How many grams of solid NaCl must be added to 25.0 mL of 0.366 M $AgNO_3$ solution to completely precipitate the silver?

A) 9.15×10^{-3}
B) 1.57×10^{-4}
C) 0.535
D) 0.157
E) 6.39×10^{3}
Answer: C
Diff: 4   Page Ref: Sec. 4.6

19) How many milliliters of 0.132 M $HClO_4$ solution are needed to neutralize 50.00 mL of 0.0789 M NaOH?

A) 0.521
B) 0.0120
C) 83.7
D) 0.0335
E) 29.9
Answer: E
Diff: 3   Page Ref: Sec. 4.6

Chemistry, 11e (Brown)
Chapter 5, Thermochemistry

Multiple-Choice and Bimodal

1) Calculate the kinetic energy in J of an electron moving at 6.00×10^{6} m/s. The mass of an electron is 9.11×10^{-28} g.
A) 4.98×10^{-48}
B) 3.28×10^{-14}
C) 1.64×10^{-14}
D) 2.49×10^{-48}
E) 6.56×10^{-14}
Answer: C
Diff: 2 Page Ref: Sec. 5.1

2) Calculate the kinetic energy in joules of an automobile weighing 2135 lb and traveling at 55 mph.
(1 mile = 1.6093 km, 1 lb = 453.59 g)
A) 1.2×10^{4}
B) 2.9×10^{5}
C) 5.9×10^{5}
D) 3.2×10^{6}
E) 3.2×10^{-6}
Answer: B
Diff: 2 Page Ref: Sec. 5.1

3) The kinetic energy of a 7.3 kg steel ball traveling at 18.0 m/s __________ J.
A) 1.2×10^{3}
B) 66
C) 2.4×10^{3}
D) 1.3×10^{2}
E) 7.3
Answer: A
Diff: 3 Page Ref: Sec. 5.1

4) Calculate the kinetic energy in joules of a 150 lb jogger (68.1 kg) traveling at 12.0 mile/hr (5.36 m/s).
A) 1.96×10^{3}
B) 365
C) 978
D) 183
E) 68.1
Answer: C
Diff: 3 Page Ref: Sec. 5.1

5) Calculate the kinetic energy in joules of an 80.0 g bullet traveling at 300.0 m/s.
A) 3.60×10^{6}
B) 1.20×10^{4}
C) 3.60×10^{3}
D) 12.0
E) 80.0
Answer: C
Diff: 3 Page Ref: Sec. 5.1

6) The kinetic energy of a 23.2-g object moving at a speed of 81.9 m/s is __________ J.
A) 145
B) 0.95
C) 77.8
D) 77,800
E) 1900
Answer: C
Diff: 3 Page Ref: Sec. 5.1

7) The kinetic energy of a 23.2-g object moving at a speed of 81.9 km/hr is __________ J.
A) 1900
B) 77.8
C) 145
D) 1.43×10^{-3}
E) 6.00
Answer: E
Diff: 3 Page Ref: Sec. 5.1

8) The kinetic energy of a 23.2-g object moving at a speed of 81.9 km/hr is __________ kcal.
A) 1.43×10^{-3}
B) 6.00
C) 1900
D) 454
E) 0.0251
Answer: A
Diff: 3 Page Ref: Sec. 5.1

9) A 100-watt electric incandescent light bulb consumes __________ J of energy in 24 hours.
A) 2.40×10^{3}
B) 8.64×10^{3}
C) 4.17
D) 2.10×10^{3}
E) 8.64×10^{6}
Answer: E
Diff: 3 Page Ref: Sec. 5.1

10) The ΔE of a system that releases 12.4 J of heat and does 4.2 J of work on the surroundings is __________ J.
A) 16.6
B) 12.4
C) 4.2
D) -16.6
E) -8.2
Answer: D
Diff: 2 Page Ref: Sec. 5.2

11) The value of ΔE for a system that performs 213 kJ of work on its surroundings and loses 79 kJ of heat is __________ kJ.
A) +292
B) -292
C) +134
D) -134
E) -213
Answer: B
Diff: 2 Page Ref: Sec. 5.2

12) Calculate the value of ΔE in joules for a system that loses 50 J of heat and has 150 J of work performed on it by the surroundings.
A) 50
B) 100
C) -100
D) -200
E) +200
Answer: B
Diff: 2   Page Ref: Sec. 5.2

13) The change in the internal energy of a system that absorbs 2,500 J of heat and that does 7,655 J of work on the surroundings is __________ J.
A) 10,155
B) 5,155
C) -5,155
D) -10,155
E) 1.91×10^7
Answer: C
Diff: 3   Page Ref: Sec. 5.2

14) The change in the internal energy of a system that releases 2,500 J of heat and that does 7,655 J of work on the surroundings is __________ J.
A) -10,155
B) -5,155
C) -1.91×10^7
D) 10,155
E) 5,155
Answer: A
Diff: 4   Page Ref: Sec. 5.2

15) The value of $\Delta H°$ for the reaction below is -72 kJ. __________ kJ of heat are released when 1.0 mol of HBr is formed in this reaction.

$$H_2\ (g) + Br_2\ (g) \rightarrow 2HBr\ (g)$$

A) 144
B) 72
C) 0.44
D) 36
E) -72
Answer: D
Diff: 3   Page Ref: Sec. 5.4

16) The value of ΔH° for the reaction below is -126 kJ. _________kJ are released when 2.00 mol of NaOH is formed in the reaction?

$$2Na_2O_2\ (s) + 2H_2O\ (l) \rightarrow 4NaOH\ (s) + O_2\ (g)$$

A) 252
B) 63
C) 3.9
D) 7.8
E) -126
Answer: B
Diff: 3 Page Ref: Sec. 5.4

17) The value of ΔH° for the reaction below is -126 kJ. The amount of heat that is released by the reaction of 25.0 g of Na_2O_2 with water is __________ kJ.

$$2Na_2O_2\ (s) + 2H_2O\ (l) \rightarrow 4NaOH\ (s) + O_2\ (g)$$

A) 20.2
B) 40.4
C) 67.5
D) 80.8
E) -126
Answer: A
Diff: 3 Page Ref: Sec. 5.4

18) The value of ΔH° for the reaction below is -790 kJ. The enthalpy change accompanying the reaction of 0.95 g of S is __________ kJ.

$$2S\ (s) + 3O_2\ (g) \rightarrow 2SO_3\ (g)$$

A) 23
B) -23
C) -12
D) 12
E) -790
Answer: C
Diff: 3 Page Ref: Sec. 5.4

19) The value of ΔH° for the reaction below is -6535 kJ. __________ kJ of heat are released in the combustion of 16.0 g of C_6H_6 (l)?

$$2C_6H_6\ (l) + 15O_2\ (g) \rightarrow 12CO_2\ (g) + 6H_2O\ (l)$$

A) 1.34×10^3
B) 5.23×10^4
C) 673
D) 2.68×10^3
E) -6535
Answer: C
Diff: 3 Page Ref: Sec. 5.4

20) The value of $\Delta H°$ for the reaction below is -482 kJ. Calculate the heat (kJ) released to the surroundings when 12.0 g of CO (g) reacts completely.

$$2CO\ (g) + O_2\ (g) \rightarrow 2CO_2\ (g)$$

A) 2.89×10^3
B) 207
C) 103
D) 65.7
E) -482
Answer: C
Diff: 3 Page Ref: Sec. 5.4

21) The value of $\Delta H°$ for the reaction below is -336 kJ. Calculate the heat (kJ) released to the surroundings when 23.0 g of HCl is formed.

$$CH_4\ (g) + 3Cl_2\ (g) \rightarrow CHCl_3\ (l) + 3HCl\ (g)$$

A) 177
B) 2.57×10^3
C) 70.7
D) 211
E) -336
Answer: C
Diff: 2 Page Ref: Sec. 5.4

22) The value of $\Delta H°$ for the reaction below is -186 kJ. Calculate the heat (kJ) released from the reaction of 25 g of Cl_2.

$$H_2\ (g) + Cl_2\ (g) \rightarrow 2HCl\ (g)$$

A) 66
B) 5.3×10^2
C) 33
D) 47
E) -186
Answer: A
Diff: 2 Page Ref: Sec. 5.4

23) The enthalpy change for the following reaction is -483.6 kJ:

$$2H_2\ (g) + O_2\ (g) \rightarrow 2H_2O\ (g)$$

Therefore, the enthalpy change for the following reaction is __________ kJ:

$$4H_2\ (g) + 2O_2\ (g) \rightarrow 4H_2O\ (g)$$

A) -483.6
B) -967.2
C) 2.34×10^5
D) 483.6
E) 967.2
Answer: B
Diff: 2   Page Ref: Sec. 5.4

24) The value of $\Delta H°$ for the reaction below is +128.1 kJ:

$$CH_3OH\ (l) \rightarrow CO\ (g) + 2H_2\ (g)$$

How many kJ of heat are consumed when 15.5 g of CH_3OH (l) decomposes as shown in the equation?
A) 0.48
B) 62.0
C) 1.3×10^2
D) 32
E) 8.3
Answer: B
Diff: 2   Page Ref: Sec. 5.4

25) The value of $\Delta H°$ for the reaction below is +128.1 kJ:

$$CH_3OH\ (l) \rightarrow CO\ (g) + 2H_2\ (g)$$

How many kJ of heat are consumed when 5.10 g of H_2 (g) is formed as shown in the equation?
A) 162
B) 62.0
C) 128
D) 653
E) 326
Answer: A
Diff: 2   Page Ref: Sec. 5.4

26) The value of $\Delta H°$ for the reaction below is +128.1 kJ:

$$CH_3OH\ (l) \rightarrow CO\ (g) + 2H_2\ (g)$$

How many kJ of heat are consumed when 5.10 g of CO (g) is formed as shown in the equation?
A) 0.182
B) 162
C) 8.31
D) 23.3
E) 62.0
Answer: D
Diff: 2 Page Ref: Sec. 5.4

27) The value of $\Delta H°$ for the reaction below is +128.1 kJ:

$$CH_3OH\ (l) \rightarrow CO\ (g) + 2H_2\ (g)$$

How many kJ of heat are consumed when 5.75 g of CO (g) reacts completely with hydrogen to form CH_3OH (l) ?
A) 23.3
B) 62.0
C) 26.3
D) 162
E) 8.3
Answer: C
Diff: 2 Page Ref: Sec. 5.4

28) The value of $\Delta H°$ for the reaction below is -1107 kJ:

$$2Ba\ (s) + O_2\ (g) \rightarrow 2BaO\ (s)$$

How many kJ of heat are released when 5.75 g of Ba (s) reacts completely with oxygen to form BaO (s) ?
A) 96.3
B) 26.3
C) 46.4
D) 23.2
E) 193
Answer: D
Diff: 2 Page Ref: Sec. 5.4

29) The value of $\Delta H°$ for the reaction below is -1107 kJ:

$$2Ba\ (s) + O_2\ (g) \rightarrow 2BaO\ (s)$$

How many kJ of heat are released when 5.75 g of BaO (s) is produced?
A) 56.9
B) 23.2
C) 20.8
D) 193
E) 96.3
Answer: C
Diff: 2 Page Ref: Sec. 5.4

30) The value of $\Delta H°$ for the reaction below is -1107 kJ:

$$2Ba\ (s) + O_2\ (g) \rightarrow 2BaO\ (s)$$

How many kJ of heat are released when 15.75 g of Ba (s) reacts completely with oxygen to form BaO (s)?
A) 20.8
B) 63.5
C) 114
D) 70.3
E) 35.1
Answer: B
Diff: 2 Page Ref: Sec. 5.4

31) The molar heat capacity of a compound with the formula C_2H_6SO is 88.0 J/mol-K. The specific heat of this substance is __________ J/g-K.
A) 88.0
B) 1.13
C) 4.89
D) 6.88×10^3
E) -88.0
Answer: B
Diff: 3 Page Ref: Sec. 5.5

32) A sample of aluminum metal absorbs 9.86 J of heat, upon which the temperature of the sample increases from 23.2°C to 30.5°C. Since the specific heat capacity of aluminum is 0.90 J/g-K, the mass of the sample is __________ g.
A) 72
B) 1.5
C) 65
D) 8.1
E) 6.6
Answer: B
Diff: 3 Page Ref: Sec. 5.5

33) The specific heat capacity of lead is 0.13 J/g-K. How much heat (in J) is required to raise the temperature of 15 g of lead from 22°C to 37°C?
A) 2.0
B) -0.13
C) 5.8×10^{-4}
D) 29
E) 0.13
Answer: D
Diff: 3 Page Ref: Sec. 5.5

34) The temperature of a 15-g sample of lead metal increases from 22°C to 37°C upon the addition of 29.0 J of heat. The specific heat capacity of the lead is __________ J/g-K.
A) 7.8
B) 1.9
C) 29
D) 0.13
E) -29
Answer: D
Diff: 3 Page Ref: Sec. 5.5

35) The specific heat of bromine liquid is 0.226 J/g · K. The molar heat capacity (in J/mol-K) of bromine liquid is __________.
A) 707
B) 36.1
C) 18.1
D) 9.05
E) 0.226
Answer: B
Diff: 3 Page Ref: Sec. 5.5

36) The specific heat of liquid bromine is 0.226 J/g-K. How much heat (J) is required to raise the temperature of 10.0 mL of bromine from 25.00°C to 27.30°C? The density of liquid bromine: 3.12 g/mL.
A) 5.20
B) 16.2
C) 300
D) 32.4
E) 10.4
Answer: B
Diff: 4 Page Ref: Sec. 5.5

37) The ΔH for the solution process when solid sodium hydroxide dissolves in water is 44.4 kJ/mol. When a 13.9-g sample of NaOH dissolves in 250.0 g of water in a coffee-cup calorimeter, the temperature increases from 23.0°C to ________°C. Assume that the solution has the same specific heat as liquid water, i.e., 4.18 J/g-K.
A) 35.2°C
B) 24.0°C
C) 37.8°C
D) 37.0°C
E) 40.2°C
Answer: D
Diff: 4 Page Ref: Sec. 5.5

38) ΔH for the reaction

$$IF_5\ (g) \rightarrow IF_3\ (g) + F_2\ (g)$$

is __________ kJ, give the data below.

$$IF\ (g) + F_2\ (g) \rightarrow IF_3\ (g) \quad \Delta H = -390\ kJ$$

$$IF\ (g) + 2F_2\ (g) \rightarrow IF_5\ (g) \quad \Delta H = -745\ kJ$$

A) +355
B) -1135
C) +1135
D) +35
E) -35
Answer: A
Diff: 3 Page Ref: Sec. 5.6

39) Given the following reactions

$$Fe_2O_3\ (s) + 3CO\ (s) \rightarrow 2Fe\ (s) + 3CO_2\ (g) \quad \Delta H = -28.0\ kJ$$

$$3Fe\ (s) + 4CO_2\ (s) \rightarrow 4CO\ (g) + Fe_3O_4\ (s) \quad \Delta H = +12.5\ kJ$$

the enthalpy of the reaction of Fe_2O_3 with CO

$$3Fe_2O_3\ (s) + CO\ (g) \rightarrow CO_2\ (g) + 2Fe_3O_4\ (s)$$

is __________ kJ.
A) -59.0
B) 40.5
C) -15.5
D) -109
E) +109
Answer: A
Diff: 3 Page Ref: Sec. 5.6

40) Given the following reactions

$$N_2\ (g) + 2O_2\ (g) \rightarrow 2NO_2\ (g) \quad \Delta H = 66.4\ kJ$$

$$2NO\ (g) + O_2\ (g) \rightarrow 2NO_2\ (g) \quad \Delta H = -114.2\ kJ$$

the enthalpy of the reaction of the nitrogen to produce nitric oxide

$$N_2\ (g) + O_2\ (g) \rightarrow 2NO\ (g)$$

is __________ kJ.
A) 180.6
B) -47.8
C) 47.8
D) 90.3
E) -180.6
Answer: A
Diff: 3 Page Ref: Sec. 5.6

41) Given the following reactions

(1) $2NO \rightarrow N_2 + O_2$ $\Delta H = -180$ kJ
(2) $2NO + O_2 \rightarrow 2NO_2$ $\Delta H = -112$ kJ

the enthalpy of the reaction of nitrogen with oxygen to produce nitrogen dioxide

$$N_2 + 2O_2 \rightarrow 2NO_2$$

is __________ kJ.
A) 68
B) -68
C) -292
D) 292
E) -146
Answer: A
Diff: 3 Page Ref: Sec. 5.6

42) Calculate ΔH° (in kJ) for reaction 3.

$2S\ (s) + 3O_2\ (g) \rightarrow 2SO_3\ (g)$ $\Delta H = -790$ kJ
$S\ (s) + O_2\ (g) \rightarrow SO_2\ (g)$ $\Delta H = -297$ kJ

the enthalpy of the reaction in which sulfur dioxide is oxidized to sulfur trioxide

$$2SO_2\ (g) + O_2\ (g) \rightarrow 2SO_3\ (g)$$

is __________ kJ.
A) 196
B) -196
C) 1087
D) -1384
E) -543
Answer: B
Diff: 3 Page Ref: Sec. 5.6

43) Given the following reactions

$CaCO_3\ (s) \rightarrow CaO\ (s) + CO_2\ (g)$ $\Delta H = 178.1$ kJ
$C\ (s, \text{graphite}) + O_2\ (g) \rightarrow CO_2\ (g)$ $\Delta H = -393.5$ kJ

the enthalpy of the reaction

$$CaCO_3\ (s) \rightarrow CaO\ (s) + C\ (s, \text{graphite}) + O_2\ (g)$$

is __________ kJ.
A) 215.4
B) 571.6
C) -215.4
D) -571.6
E) 7.01×10^4
Answer: B
Diff: 3 Page Ref: Sec. 5.6

44) Given the following reactions

H_2O (l) $\rightarrow$ H_2O (g) $\Delta H = 44.01$ kJ

$2H_2$ (g) + O_2 (g) $\rightarrow$ $2H_2O$ (g) $\Delta H = -483.64$ kJ

the enthalpy for the decomposition of liquid water into gaseous hydrogen and oxygen

$2H_2O$ (l) $\rightarrow$ $2H_2$ (g) + O_2 (g)

is __________ kJ.
A) -395.62
B) -527.65
C) 439.63
D) 571.66
E) 527.65
Answer: D
Diff: 3 Page Ref: Sec. 5.6

45) Given the following reactions

N_2 (g) + O_2 (g) $\rightarrow$ 2NO (g) $\Delta H = +180.7$ kJ
2NO (g) + O_2 (g) $\rightarrow$ $2NO_2$ (g) $\Delta H = -113.1$ kJ

the enthalpy for the decomposition of nitrogen dioxide into molecular nitrogen and oxygen

$2NO_2$ (g) + N_2 (g) + $2O_2$ (g)

is __________ kJ.
A) 67.6
B) -67.6
C) 293.8
D) -293.8
E) 45.5
Answer: B
Diff: 3 Page Ref: Sec. 5.6

46) Given the following reactions

$$N_2\ (g) + O_2\ (g) \rightarrow 2NO\ (g) \qquad \Delta H = +180.7\ kJ$$
$$2NO\ (g) + O_2\ (g) \rightarrow 2NO_2\ (g) \qquad \Delta H = -113.1\ kJ$$

the enthalpy of reaction for

$$4NO\ (g) + 2NO_2\ (g) + N_2\ (g)$$

is __________ kJ.
A) 67.6
B) 45.5
C) -293.8
D) -45.5
E) 293.8
Answer: C
Diff: 3 Page Ref: Sec. 5.6

47) Given the following reactions

$$N_2\ (g) + O_2\ (g) \rightarrow 2NO\ (g) \qquad \Delta H = +180.7\ kJ$$
$$2N_2O\ (g) + O_2\ (g) \rightarrow 2N_2\ (g) \qquad \Delta H = -163.2\ kJ$$

the enthalpy of reaction for

$$2N_2O\ (g) \rightarrow 2NO\ (g) + N_2\ (g)$$

is __________ kJ.
A) 145.7
B) 343.9
C) -343.9
D) 17.5
E) -145.7
Answer: D
Diff: 3 Page Ref: Sec. 5.6

48) The value of $\Delta H°$ for the reaction below is -186 kJ.

$$H_2\ (g) + Cl_2\ (g) \rightarrow 2HCl\ (g)$$

The value of ΔH_f^o for HCl (g) is __________ kJ/mol.
A) -3.72×10^2
B) -1.27×10^2
C) -93.0
D) -186
E) +186
Answer: C
Diff: 2 Page Ref: Sec. 5.7

49) The value of $\Delta H°$ for the following reaction is -3351 kJ:

$$2Al\,(s) + 3O_2\,(g) \rightarrow 2Al_2O_3\,(s)$$

The value of ΔH_f^o for Al_2O_3 (s) is __________ kJ.
A) -3351
B) -1676
C) -32.86
D) -16.43
E) +3351
Answer: B
Diff: 2 Page Ref: Sec. 5.7

50) Given the data in the table below, $\Delta H°_{rxn}$ for the reaction

$$Ca(OH)_2 + 2H_3AsO_4 \rightarrow Ca(H_2AsO_4)_2 + 2H_2O$$

is __________ kJ.

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

A) -744.9
B) -4519
C) -4219
D) -130.4
E) -76.4
Answer: D
Diff: 3 Page Ref: Sec. 5.7

51) Given the data in the table below, ΔH°_{rxn} for the reaction

$$4NH_3\ (g) + 5O_2\ (g) \rightarrow 4NO\ (g) + 6H_2O\ (l)$$

is __________ kJ.

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

A) -1172
B) -150
C) -1540
D) -1892
E) The ΔH_f^o of O_2 (g) is needed for the calculation.
Answer: A
Diff: 3 Page Ref: Sec. 5.7

52) Given the data in the table below, ΔH°_{rxn} for the reaction

$$C_2H_5OH\ (l) + O_2\ (g) \rightarrow CH_3CO_2H\ (l) + H_2O\ (l)$$

is __________ kJ.

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

A) -79.0
B) -1048.0
C) -476.4
D) -492.6
E) The value of ΔH_f° of O_2 (g) is required for the calculation.
Answer: D
Diff: 3 Page Ref: Sec. 5.7

53) Given the data in the table below, ΔH°_{rxn} for the reaction

$$3NO_2\ (g) + H_2O\ (l) \rightarrow 2HNO_3\ (aq) + NO\ (g)$$

is __________ kJ.

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

A) 64
B) 140
C) -140
D) -508
E) -64
Answer: C
Diff: 3 Page Ref: Sec. 5.7

54) Given the data in the table below, ΔH°_{rxn} for the reaction

$$IF_5\ (g) + F_2\ (g) \rightarrow IF_7\ (g)$$

is __________ kJ.

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

A) 1801
B) -1801
C) 121
D) -121
E) -101
Answer: E
Diff: 3 Page Ref: Sec. 5.7

55) Given the data in the table below, ΔH° for the reaction

$$2CO\ (g) + O_2\ (g) \rightarrow 2CO_2\ (g)$$

is __________ kJ.

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

A) -566.4
B) -283.3
C) 283.3
D) -677.0
E) The $\Delta H°_f$ of O_2 (g) is needed for the calculation.
Answer: A
Diff: 3 Page Ref: Sec. 5.7

56) The value of ΔH° for the following reaction is 177.8 kJ. The value of $\Delta H°_f$ for CaO(s) is __________ kJ/mol.

$$CaCO_3\ (s) \rightarrow CaO\ (s) + CO_2\ (g)$$

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

A) -1600
B) -813.4
C) -635.5
D) 813.4
E) 177.8
Answer: C
Diff: 3 Page Ref: Sec. 5.7

57) Given the data in the table below, ΔH°_{rxn} for the reaction

$$2Ag_2S\ (s) + O_2\ (g) \rightarrow 2Ag_2O\ (s) + 2S\ (s)$$

is __________ kJ.

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

A) -1.6
B) +1.6
C) -3.2
D) +3.2
E) THe ΔH°_f of S (s) and of O_2 (g) are needed for the calculation.
Answer: D
Diff: 3 Page Ref: Sec. 5.7

58) Given the data in the table below, ΔH°_{rxn} for the reaction

$$Ag_2O\ (s) + H_2S\ (g) \rightarrow Ag_2S\ (s) + H_2O\ (l)$$

is __________ kJ.

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

A) -267
B) -370
C) -202
D) -308
E) More data are needed to complete the calculation.
Answer: A
Diff: 3 Page Ref: Sec. 5.7

59) Given the data in the table below, $\Delta H°_{rxn}$ for the reaction

$$2SO_2\ (g) + O_2\ (g) \rightarrow 2SO_3\ (g)$$

is __________ kJ.

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

A) -99
B) 99
C) -198
D) 198
E) The $\Delta H°_f$ of O_2 (g) is needed for the calculation.
Answer: C
Diff: 3 Page Ref: Sec. 5.7

60) Given the data in the table below, $\Delta H°_{rxn}$ for the reaction

$$SO_3\ (g) + H_2O\ (l) \rightarrow H_2SO_4\ (l)$$

is __________ kJ.

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

A) -132
B) 1496
C) 704
D) -704
E) -2.16×10^3
Answer: A
Diff: 3 Page Ref: Sec. 5.7

61) Given the data in the table below, $\Delta H°_{rxn}$ for the reaction

$$3\ Cl_2\ (g) + PH_3\ (g) \rightarrow PCl_3\ (g) + 3\ HCl\ (g)$$

is __________ kJ.

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

A) -385.77
B) -570.37
C) 570.37
D) 385.77
E) The $\Delta H°_f$ of Cl_2 (g) is needed for the calculation.
Answer: B
Diff: 3 Page Ref: Sec. 5.7

62) Given the data in the table below, $\Delta H°_{rxn}$ for the reaction

$$PCl_3\ (g) + 3\ HCl\ (g) \rightarrow 3\ Cl_2\ (g) + PH_3\ (g)$$

is __________ kJ.

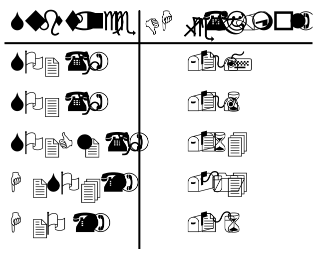
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

A) -570.37
B) -385.77
C) 570.37
D) 385.77
E) The $\Delta H°_f$ of Cl_2 (g) is needed for the calculation.
Answer: C
Diff: 3 Page Ref: Sec. 5.7

63) Given the data in the table below and $\Delta H°_{rxn}$ for the reaction

$$SO_2Cl_2\,(g) + 2H_2O\,(l) \rightarrow H_2SO_4\,(l) + 2HCl\,(g) \qquad \Delta H° = -62\text{kJ}$$

ΔH_f^o of HCl (g) is __________ kJ/mol.



A) -184
B) 60
C) -92
D) 30
E) Insufficient data are given.
Answer: C
Diff: 4 Page Ref: Sec. 5.8

64) A 5-ounce cup of raspberry yogurt contains 6.0 g of protein, 2.0 g of fat, and 26.9 g of carbohydrate. The fuel values for protein, fat, and carbohydrate are 17, 38, and 17 kJ/g, respectively. The fuel value of this cup of yogurt is __________ kJ.
A) 640
B) 830
C) 600
D) 720
E) 72
Answer: A
Diff: 3 Page Ref: Sec. 5.8

65) A 25.5-g piece of cheddar cheese contains 37% fat, 28% protein, and 4% carbohydrate. The respective fuel values for protein, fat, and carbohydrate are 17, 38, and 17 kJ/g, respectively. The fuel value for this piece of cheese is __________ kJ.
A) 500
B) 330
C) 790
D) 99
E) 260
Answer: A
Diff: 3 Page Ref: Sec. 5.8

66) The average fuel value of sugars is 17 kJ/g. A 2.0 L pitcher of sweetened Kool-Aid contains 400 g of sugar. What is the fuel value (in kJ) of a 500 mL serving of Kool-Aid? (Assume that the sugar is the only fuel source.)
A) 4.2×10^4
B) 1.7×10^3
C) 1.7×10^6
D) 1.7×10^2
E) 17
Answer: B
Diff: 4 Page Ref: Sec. 5.8

Multiple-Choice

67) At what velocity (m/s) must a 20.0 g object be moving in order to possess a kinetic energy of 1.00 J?
A) 1.00
B) 100×10^2
C) 10.0
D) 1.00×10^3
E) 50.0
Answer: C
Diff: 2 Page Ref: Sec. 5.1

68) Objects can possess energy as __________.

(a) endothermic energy
(b) potential energy
(c) kinetic energy

A) a only
B) b only
C) c only
D) a and c
E) b and c
Answer: E
Diff: 1 Page Ref: Sec. 5.1

69) The internal energy of a system is always increased by __________.
A) adding heat to the system
B) having the system do work on the surroundings
C) withdrawing heat from the system
D) adding heat to the system and having the system do work on the surroundings
E) a volume compression
Answer: A
Diff: 2 Page Ref: Sec. 5.2

70) Which one of the following conditions would always result in an increase in the internal energy of a system?
A) The system loses heat and does work on the surroundings.
B) The system gains heat and does work on the surroundings.
C) The system loses heat and has work done on it by the surroundings.
D) The system gains heat and has work done on it by the surroundings.
E) None of the above is correct.
Answer: D
Diff: 2 Page Ref: Sec. 5.2

71) When a system __________, ΔE is <u>always</u> negative.
A) absorbs heat and does work
B) gives off heat and does work
C) absorbs heat and has work done on it
D) gives off heat and has work done on it
E) none of the above is <u>always</u> negative.
Answer: B
Diff: 2 Page Ref: Sec. 5.2

72) Which one of the following is an exothermic process?
A) ice melting
B) water evaporating
C) boiling soup
D) condensation of water vapor
E) Ammonium thiocyanate and barium hydroxide are mixed at 25°C: the temperature drops.
Answer: D
Diff: 2 Page Ref: Sec. 5.2

73) Of the following, which one is a state function?
A) H
B) q
C) w
D) heat
E) none of the above
Answer: A
Diff: 2 Page Ref: Sec. 5.2

74) Which of the following is a statement of the first law of thermodynamics?
A) $E_k = \frac{1}{2}mv^2$
B) A negative ΔH corresponds to an exothermic process.
C) $\Delta E = E_{final} - E_{initial}$
D) Energy lost by the system must be gained by the surroundings.
E) 1 cal = 4.184 J (exactly)
Answer: D
Diff: 3 Page Ref: Sec. 5.2

75) A __________ ΔH corresponds to an __________ process.
A) negative, endothermic
B) negative, exothermic
C) positive, exothermic
D) zero, exothermic
E) zero, endothermic
Answer: B
Diff: 1 Page Ref: Sec. 5.3

76) The internal energy can be increased by __________.

(a) transferring heat from the surroundings to the system
(b) transferring heat from the system to the surroundings
(c) doing work on the system

A) a only
B) b only
C) c only
D) a and c
E) b and c
Answer: D
Diff: 2 Page Ref: Sec. 5.2

77) ΔH for an endothermic process is __________ while ΔH for an exothermic process is __________.
A) zero, positive
B) zero, negative
C) positive, zero
D) negative, positive
E) positive, negative
Answer: E
Diff: 1 Page Ref: Sec. 5.3

78) For a given process at constant pressure, ΔH is negative. This means that the process is __________.
A) endothermic
B) equithermic
C) exothermic
D) a state function
E) energy
Answer: C
Diff: 1 Page Ref: Sec. 5.3

79) Which one of the following statements is true?
A) Enthalpy is an intensive property.
B) The enthalphy change for a reaction is independent of the state of the reactants and products.
C) Enthalpy is a state function.
D) H is the value of q measured under conditions of constant volume.
E) The enthalpy change of a reaction is the reciprocal of the ΔH of the reverse reaction.
Answer: C
Diff: 3 Page Ref: Sec. 5.4

80) A chemical reaction that absorbs heat from the surroundings is said to be __________ and has a __________ ΔH at constant pressure.
A) endothermic, positive
B) endothermic, negative
C) exothermic, negative
D) exothermic, positive
E) exothermic, neutral
Answer: A
Diff: 2 Page Ref: Sec. 5.4

81) The reaction

$$4Al\ (s) + 3O_2\ (g) \rightarrow 2Al_2O_3\ (s) \qquad \Delta H^\circ = -3351\ kJ$$

is __________, and therefore heat is __________ by the reaction.
A) endothermic, released
B) endothermic, absorbed
C) exothermic, released
D) exothermic, absorbed
E) thermoneutral, neither released nor absorbed
Answer: C
Diff: 1 Page Ref: Sec. 5.4

82) Under what condition(s) is the enthalpy change of a process equal to the amount of heat transferred into or out of the system?

(a) temperature is constant
(b) pressure is constant
(c) volume is constant

A) a only
B) b only
C) c only
D) a and b
E) b and c
Answer: B
Diff: 3 Page Ref: Sec. 5.4

83) The units of of heat capacity are __________.
A) K/J or °C/J
B) J/K or J/°C
C) J/g-K or J/g-°C
D) J/mol
E) g-K/J or g-°C/J
Answer: B
Diff: 2 Page Ref: Sec. 5.5

84) The units of of specific heat are __________.
A) K/J or °C/J
B) J/K or J/°C
C) J/g-K or J/g-°C
D) J/mol
E) g-K/J or g-°C/J
Answer: C
Diff: 2 Page Ref: Sec. 5.5

85) The British thermal unit (Btu) is commonly used in engineering applications. A Btu is defined as the amount of heat required to raise the temperature of 1 lb of water by 1°F. There are __________ joules in one Btu.
1 lb = 453.59 g; °C = (5/9)(°F - 32°); specific heat of H_2O (l) = 4.18 J/g-K.
A) 3415
B) 60.29
C) 1054
D) 5.120×10^{-3}
E) Additional information is needed to complete the calculation.
Answer: C
Diff: 3 Page Ref: Sec. 5.5

86) Which of the following is a statement of Hess's law?
A) If a reaction is carried out in a series of steps, the ΔH for the reaction will equal the sum of the enthalpy changes for the individual steps.
B) If a reaction is carried out in a series of steps, the ΔH for the reaction will equal the product of the enthalpy changes for the individual steps.
C) The ΔH for a process in the forward direction is equal in magnitude and opposite in sign to the ΔH for the process in the reverse direction.
D) The ΔH for a process in the forward direction is equal to the ΔH for the process in the reverse direction.
E) The ΔH of a reaction depends on the physical states of the reactants and products.
Answer: A
Diff: 2 Page Ref: Sec. 5.6

87) For which one of the following reactions is $\Delta H°_{rxn}$ equal to the heat of formation of the product?
A) N_2 (g) + $3H_2$ (g) $\rightarrow$ $2NH_3$ (g)
B) (1/2)N_2 (g) + O_2 (g) $\rightarrow$ NO_2 (g)
C) 6C (s) + 6H (g) $\rightarrow$ C_6H_6 (l)
D) P (g) + 4H (g) + Br (g) $\rightarrow$ PH_4Br (l)
E) 12C (g) + $11H_2$ (g) + 11O (g) $\rightarrow$ $C_6H_{22}O_{11}$ (g)
Answer: B
Diff: 3 Page Ref: Sec. 5.7

88) Of the following, ΔH_f^o is not zero for __________.
A) O_2 (g)
B) C (graphite)
C) N_2 (g)
D) F_2 (s)
E) Cl_2 (g)
Answer: D
Diff: 2 Page Ref: Sec. 5.7

89) In the reaction below, ΔH_f^o is zero for __________.

$$Ni\ (s) + 2CO\ (g) + 2PF_3\ (g) \rightarrow Ni(CO)_2(PF_3)_2\ (l)$$

A) Ni (s)
B) CO (g)
C) PF_3 (g)
D) $Ni(CO)_2(PF_3)_2$ (l)
E) both CO (g) and PF_3 (g)
Answer: A
Diff: 1 Page Ref: Sec. 5.7

90) For the species in the reaction below, ΔH_f^o is zero for __________.

$$2Co\ (s) + H_2\ (g) + 8PF_3\ (g) \rightarrow 2HCo(PF_3)_4\ (l)$$

A) Co (s)
B) H_2 (g)
C) PF_3 (g)
D) $HCo(PF_3)_4$ (l)
E) both Co(s) and H_2 (g)
Answer: E
Diff: 1 Page Ref: Sec. 5.7

91) For which one of the following equations is $\Delta H°_{rxn}$ equal to ΔH_f^o for the product?
A) $Xe (g) + 2F_2 (g) \rightarrow XeF_4 (g)$
B) $CH_4 (g) + 2Cl_2 (g) \rightarrow CH_2Cl_2 (l) + 2HCl (g)$
C) $N_2 (g) + O_3 (g) \rightarrow N_2O_3 (g)$
D) $2CO (g) + O_2 (g) \rightarrow 2CO_2 (g)$
E) $C (diamond) + O_2 (g) \rightarrow CO_2 (g)$
Answer: A
Diff: 3 Page Ref: Sec. 5.7

92) For which one of the following reactions is the value of $\Delta H°_{rxn}$ equal to ΔH_f^o for the product?
A) $2Ca (s) + O_2 (g) \rightarrow 2CaO (s)$
B) $C_2H_2 (g) + H_2 (g) \rightarrow C_2H_4 (g)$
C) $2C (graphite) + O_2 (g) \rightarrow 2CO (g)$
D) $3Mg (s) + N_2 (g) \rightarrow Mg_2N_2 (s)$
E) $C (diamond) + O_2 (g) \rightarrow CO_2 (g)$
Answer: D
Diff: 3 Page Ref: Sec. 5.7

93) For which one of the following reactions is the value of $\Delta H°_{rxn}$ equal to $\Delta H°_f$ for the product?
A) $2 C (s, graphite) + 2 H_2 (g) \rightarrow C_2H_4 (g)$
B) $N_2 (g) + O_2 (g) \rightarrow 2NO (g)$
C) $2 H_2 (g) + O_2 (g) \rightarrow 2 H_2O (l)$
D) $2 H_2 (g) + O_2 (g) \rightarrow 2 H_2O (g)$
E) $H_2O (l) + 1/2 O_2 (g) \rightarrow H_2O_2 (l)$
Answer: A
Diff: 2 Page Ref: Sec. 5.7

94) For which one of the following reactions is the value of $\Delta H°_{rxn}$ equal to $\Delta H°_f$ for the product?
A) $H_2O (l) + 1/2 O_2 (g) \rightarrow H_2O_2 (l)$
B) $N_2 (g) + O_2 (g) \rightarrow 2NO (g)$
C) $2 H_2 (g) + O_2 (g) \rightarrow 2 H_2O (l)$
D) $2 H_2 (g) + O_2 (g) \rightarrow 2 H_2O (g)$
E) none of the above
Answer: E
Diff: 2 Page Ref: Sec. 5.7

95) For which one of the following reactions is the value of $\Delta H°_{rxn}$ equal to $\Delta H°_f$ for the product?
A) $H_2 (g) + 1/2 O_2 (g) \rightarrow H_2O (l)$
B) $H_2 (g) + O_2 (g) \rightarrow H_2O_2 (l)$
C) $2 C (s, graphite) + 2 H_2 (g) \rightarrow C_2H_4 (g)$
D) $1/2 N_2 (g) + O_2 (g) \rightarrow NO_2 (g)$
E) all of the above
Answer: E
Diff: 2 Page Ref: Sec. 5.7

96) With reference to enthalpy changes, the term standard conditions means __________.

(a) P = 1 atm
(b) some common temperature, usually 298 K
(c) V = 1 L

A) a only
B) b only
C) c only
D) a and c
E) a and b
Answer: E
Diff: 1 Page Ref: Sec. 5.7

97) The energy released by combustion of 1 g of a substance is called the __________ of the substance.
A) specific heat
B) fuel value
C) nutritional calorie content
D) heat capacity
E) enthalpy
Answer: B
Diff: 2 Page Ref: Sec. 5.8

98) Fuel values of hydrocarbons increase as the H/C atomic ratio increases. Which of the following compounds has the highest fuel value?
A) C_2H_6
B) C_2H_4
C) C_2H_2
D) CH_4
E) C_6H_6
Answer: D
Diff: 1 Page Ref: Sec. 5.8

99) Of the substances below, the highest fuel value is obtained from __________.
A) charcoal
B) bituminous coal
C) natural gas
D) hydrogen
E) wood
Answer: D
Diff: 2 Page Ref: Sec. 5.8

100) Which one of the choices below is not considered a fossil fuel?
A) anthracite coal
B) crude oil
C) natural gas
D) hydrogen
E) petroleum
Answer: D
Diff: 2 Page Ref: Sec. 5.8

101) The most abundant fossil fuel is __________.
A) natural gas
B) petroleum
C) coal
D) uranium
E) hydrogen
Answer: C
Diff: 1 Page Ref: Sec. 5.8

Short Answer

1) Given the equation

$$H_2O\ (l) \rightarrow H_2O\ (g) \qquad \Delta H_{rxn} = 40.7\ kJ\ at\ 100^oC$$

Calculate the mass of liquid water (in grams) at 100^{o}C that can converted to vapor by absorbing 2.400 kJ of heat.
Answer: 1.06 grams
Diff: 3 Page Ref: Sec. 5.5

2) Given the equation

$$H_2O\ (l) \rightarrow H_2O\ (g) \qquad \Delta H_{rxn} = 40.7\ kJ\ at\ 100^oC$$

Calculate the heat required to convert 3.00 grams of liquid water at 100^{o}C to vapor.
Answer: 6.78 kJ
Diff: 3 Page Ref: Sec. 5.5

3) When 0.800 grams of NaOH is dissolved in 100.0 grams of water, the temperature of the solution increases from 25.00 ^{o}C to 27.06 ^{o}C. The amount of heat absorbed by the water is __________ J. (The specific heat of water is 4.18 J/g - ^{o}C.)
Answer: 861
Diff: 3 Page Ref: Sec. 5.5

4) Given the equation:

$$CH_4\ (g) + 2\ O_2\ (g) \rightarrow CO_2\ (g) + H_2O\ (l) \qquad \Delta H = -890\ kJ$$

The heat liberated when 34.78 grams of methane (CH_4) are burned in an excess amount of oxygen is __________ kJ.
Answer: 1930
Diff: 3 Page Ref: Sec. 5.5

5) Syngas is produced by treating __________ with superheated steam.
Answer: coal
Diff: 2 Page Ref: Sec. 5.8

True/False

1) Work equals force times distance.
Answer: TRUE
Diff: 1 Page Ref: Sec. 5.1

2) One joule equals 1 kg $\bullet$ m^2/s^2 .
Answer: TRUE
Diff: 2 Page Ref: Sec. 5.1

3) Units of energy include newtons, joules, and calories.
Answer: FALSE
Diff: 1 Page Ref: Sec. 5.1

4) The primary component of natural gas is propane.
Answer: FALSE
Diff: 1 Page Ref: Sec. 5.8

5) Renewable energy sources are essentially inexhaustible.
Answer: TRUE
Diff: 1 Page Ref: Sec. 5.8

Algorithmic Questions

1) The combustion of titanium with oxygen produces titanium dioxide:

$$Ti\ (s) + O_2\ (g) \rightarrow TiO_2\ (s)$$

When 0.721 g of titanium is combusted in a bomb calorimeter, the temperature of the calorimeter increases from 25.00°C to 53.80°C. In a separate experiment, the heat capacity of the calorimeter is measured to be 9.84 kJ/K. The heat of reaction for the combustion of a mole of Ti in this calorimeter is __________ kJ/mol.
A) 2.67
B) 4.98
C) -311
D) -0.154
E) -1.49×10^4
Answer: E
Diff: 4 Page Ref: Sec. 5.4

2) In the presence of excess oxygen, methane gas burns in a constant-pressure system to yield carbon dioxide and water:

$$CH_4\ (g) + 2O_2\ (g) \rightarrow CO_2\ (g) + 2H_2O\ (l) \qquad \Delta H = -890 kJ$$

Calculate the value of q (kJ) in this exothermic reaction when 1.70 g of methane is combusted at constant pressure.
A) -94.6
B) 0.0306
C) -0.0106
D) 32.7
E) -9.46×10^4
Answer: A
Diff: 3 Page Ref: Sec. 5.4

3) Hydrogen peroxide decomposes to water and oxygen at constant pressure by the following reaction:

$$2H_2O_2\ (l) \rightarrow 2H_2O\ (l) + O_2\ (g) \qquad \Delta H = -196\ kJ$$

Calculate the value of q (kJ) in this exothermic reaction when 4.00 g of hydrogen peroxide decomposes at constant pressure?
A) -23.1
B) -11.5
C) - 0.0217
D) 1.44
E) -2.31×10^4
Answer: B
Diff: 3 Page Ref: Sec. 5.4

4) The specific heat capacity of liquid water is 4.18 J/g-K. How many joules of heat are needed to raise the temperature of 5.00 g of water from 25.1°C to 65.3°C?
A) 48.1
B) 840
C) 1.89×10^3
D) 2.08×10^{-2}
E) 54.4
Answer: B
Diff: 4 Page Ref: Sec. 5.5

5) The specific heat capacity of methane gas is 2.20 J/g-K. How many joules of heat are needed to raise the temperature of 5.00 g of methane from 36.0°C to 75.0°C?
A) 88.6
B) 429
C) 1221
D) 0.0113
E) 22.9
Answer: B
Diff: 4 Page Ref: Sec. 5.5

6) The specific heat capacity of liquid mercury is 0.14 J/g-K. How many joules of heat are needed to raise the temperature of 5.00 g of mercury from 15.0°C to 36.5°C?
A) 7.7×10^2
B) 15
C) 36
D) 0.0013
E) 1.7
Answer: B
Diff: 4 Page Ref: Sec. 5.5

7) The specific heat capacity of solid copper metal is 0.385 J/g-K. How many joules of heat are needed to raise the temperature of a 1.55-kg block of copper from 33.0°C to 77.5°C?
A) 1.79×10^5
B) 26.6
C) 2.66×10^4
D) 5.58×10^{-6}
E) 0.00558
Answer: C
Diff: 4 Page Ref: Sec. 5.5

8) A 5.00-g sample of liquid water at 25.0 C is heated by the addition of 84.0 J of energy. The final temperature of the water is __________ °C. The specific heat capacity of liquid water is 4.18 J/g-K.
A) 95.2
B) 25.2
C) -21.0
D) 29.0
E) 4.02
Answer: D
Diff: 3 Page Ref: Sec. 5.5

9) A 50.0-g sample of liquid water at 25.0 C is mixed with 29.0 g of water at 45.0°C. The final temperature of the water is ________°C. The specific heat capacity of liquid water is 4.18 J/g-K.
A) 102
B) 27.6
C) 35.0
D) 142
E) 32.3
Answer: E
Diff: 3 Page Ref: Sec. 5.5

10) A 6.50-g sample of copper metal at 25.0°C is heated by the addition of 84.0 J of energy. The final temperature of the copper is ________°C. The specific heat capacity of liquid water is 0.38 J/g-K.
A) 29.9
B) 25.0
C) 9.0
D) 59.0
E) 34.0
Answer: D
Diff: 3 Page Ref: Sec. 5.5

11) What is the enthalpy change (in kJ) of a chemical reaction that raises the temperature of 250.0 ml of solution having a density of 1.25 g/ml by 7.80 ºC? (The specific heat of the solution is 3.74 joules/gram-K.)
A) -7.43
B) -12.51
C) 8.20
D) -9.12
E) 6.51
Answer: D
Diff: 4 Page Ref: Sec. 5.5

Chemistry, 11e (Brown)
Chapter 6, Electronic Structure of Atoms

Multiple-Choice and Bimodal

1) Electromagnetic radiation travels through vacuum at a speed of __________ m/s.
A) 186,000
B) 125
C) 3.00×10^{8}
D) 10,000
E) It depends on wavelength.
Answer: C
Diff: 1 Page Ref: Sec. 6.1

2) The wavelength of light that has a frequency of $1.20 \times 10^{13} s^{-1}$ is __________ m.
A) 25.0
B) 2.50×10^{-5}
C) 0.0400
D) 12.0
E) 2.5
Answer: B
Diff: 1 Page Ref: Sec. 6.1

3) Ham radio operators often broadcast on the 6-meter band. The frequency of this electromagnetic radiation is __________ MHz.
A) 500
B) 200
C) 50
D) 20
E) 2.0
Answer: C
Diff: 1 Page Ref: Sec. 6.1

4) What is the frequency (s^{-1}) of electromagnetic radiation that has a wavelength of 0.53 m __________?
A) 5.7×10^{8}
B) 1.8×10^{-9}
C) 1.6×10^{8}
D) 1.3×10^{-33}
E) 1.3×10^{33}
Answer: A
Diff: 1 Page Ref: Sec. 6.1

5) The energy of a photon of light is __________ proportional to its frequency and __________ proportional to its wavelength.
A) directly, directly
B) inversely, inversely
C) inversely, directly
D) directly, inversely
E) indirectly, not
Answer: D
Diff: 1 Page Ref: Sec. 6.1

6) Of the following, __________ radiation has the shortest wavelength.
A) X-ray
B) radio
C) microwave
D) ultraviolet
E) infrared
Answer: A
Diff: 1 Page Ref: Sec. 6.1

7) What is the frequency of light (s^{-1}) that has a wavelength of 1.23×10^{-6} cm __________?
A) 3.69
B) 2.44×10^{16}
C) 4.10×10^{-17}
D) 9.62×10^{12}
E) 1.04×10^{-13}
Answer: B
Diff: 1 Page Ref: Sec. 6.1

8) What is the frequency of light (s^{-1}) that has a wavelength of 3.12×10^{-3} cm __________?
A) 3.69
B) 2.44×10^{16}
C) 9.62×10^{12}
D) 4.10×10^{-17}
E) 1.04×10^{-13}
Answer: C
Diff: 1 Page Ref: Sec. 6.1

9) What is the wavelength of light (nm) that has a frequency of $3.22 \times 10^{14} s^{-1}$ __________?
A) 932
B) 649
C) 9.66×10^{22}
D) 9.32×10^{-7}
E) 1.07×10^{6}
Answer: A
Diff: 1 Page Ref: Sec. 6.1

10) What is the wavelength of light (nm) that has a frequency $4.62 \times 10^{14} s^{-1}$ __________?
A) 932
B) 649
C) 1.39×10^{23}
D) 1.54×10^{-3}
E) 1.07×10^{6}
Answer: B
Diff: 1 Page Ref: Sec. 6.1

11) The wavelength of a photon that has an energy of 5.25×10^{-19} J is __________ m.
A) 3.79×10^{-7}
B) 2.64×10^{6}
C) 2.38×10^{23}
D) 4.21×10^{-24}
E) 3.79×10^{7}
Answer: A
Diff: 2 Page Ref: Sec. 6.2

12) The energy of a photon that has a wavelength of 9.0 m is __________ J.
A) 2.2×10^{-26}
B) 4.5×10^{25}
C) 6.0×10^{-23}
D) 2.7×10^{9}
E) 4.5×10^{-25}
Answer: A
Diff: 2 Page Ref: Sec. 6.2

13) The frequency of a photon that has an energy of 3.7×10^{-18} J is __________ s^{-1}.
A) 5.6×10^{15}
B) 1.8×10^{-16}
C) 2.5×10^{-15}
D) 5.4×10^{-8}
E) 2.5×10^{15}
Answer: A
Diff: 2 Page Ref: Sec. 6.2

14) The energy of a photon that has a wavelength of 12.3 nm is __________ J.
A) 1.51×10^{-17}
B) 4.42×10^{-23}
C) 1.99×10^{-25}
D) 2.72×10^{-50}
E) 1.62×10^{-17}
Answer: E
Diff: 2 Page Ref: Sec. 6.2

15) The energy of a photon that has a wavelength of 13.2 nm is __________ J.
A) 9.55×10^{-25}
B) 1.62×10^{-17}
C) 1.99×10^{-25}
D) 4.42×10^{-23}
E) 1.51×10^{-17}
Answer: E
Diff: 2 Page Ref: Sec. 6.2

16) The energy of a photon that has a frequency of $8.21 \times 10^{-15} s^{-1}$ is __________ J.

A) 8.08×10^{-50}

B) 1.99×10^{-25}

C) 5.44×10^{-18}

D) 1.24×10^{49}

E) 1.26×10^{-19}

Answer: C

Diff: 2 Page Ref: Sec. 6.2

17) The energy of a photon that has a frequency of $18.21 \times 10^{-15} s^{-1}$ is __________ J.

A) 5.44×10^{-18}

B) 1.99×10^{-25}

C) 3.49×10^{-48}

D) 1.21×10^{-17}

E) 5.44×10^{-18}

Answer: D

Diff: 2 Page Ref: Sec. 6.2

18) What is the frequency (s^{-1}) of a photon that has an energy of $4.38 \times 10^{-18} J$?

A) 436

B) 6.61×10^{15}

C) 1.45×10^{-16}

D) 2.30×10^{7}

E) 1.31×10^{-9}

Answer: B

Diff: 2 Page Ref: Sec. 6.2

19) What is the wavelength (angstroms) of a photon that has an energy of $4.38 \times 10^{-18} J$ __________ ?

A) 454

B) 2.30×10^{7}

C) 6.89×10^{15}

D) 1.45×10^{-16}

E) 1.31×10^{-9}

Answer: A

Diff: 2 Page Ref: Sec. 6.2

20) A mole of red photons of wavelength 725 nm has __________ kJ of energy.

A) 2.74×10^{-19}

B) 4.56×10^{-46}

C) 6.05×10^{-3}

D) 165

E) 227

Answer: D

Diff: 2 Page Ref: Sec. 6.2

21) A mole of yellow photons of wavelength 527 nm has __________ kJ of energy.
A) 165
B) 227
C) 4.56×10^{-46}
D) 6.05×10^{-3}
E) 2.74×10^{-19}
Answer: B
Diff: 2 Page Ref: Sec. 6.2

22) It takes 254 kJ/mol to eject electrons from a certain metal surface. What is the longest wavelength of light (nm) that can be used to eject electrons from the surface of this metal via the photoelectric effect __________ ?
A) 472
B) 233
C) 165
D) 725
E) 552
Answer: A
Diff: 2 Page Ref: Sec. 6.2

23) Of the following, __________ radiation has the longest wavelength and __________ radiation has the greatest energy.

gamma ultraviolet visible

A) ultraviolet, gamma
B) visible, ultraviolet
C) gamma, gamma
D) visible, gamma
E) gamma, visible
Answer: D
Diff: 1 Page Ref: Sec. 6.2

24) What color of visible light has the longest wavelength __________ ?
A) blue
B) violet
C) red
D) yellow
E) green
Answer: C
Diff: 1 Page Ref: Sec. 6.2

25) Of the following, __________ radiation has the shortest wavelength and __________ radiation has the greatest energy.

gamma ultraviolet visible

A) gamma, visible
B) visible, gamma
C) visible, ultraviolet
D) ultraviolet, gamma
E) gamma, gamma
Answer: E
Diff: 1 Page Ref: Sec. 6.2

26) What color of visible light has the highest energy?
A) violet
B) blue
C) red
D) green
E) yellow
Answer: A
Diff: 1 Page Ref: Sec. 6.2

27) Which one of the following is considered to be ionizing radiation __________?
A) visible light
B) radio waves
C) X-rays
D) microwaves
E) infrared radiation
Answer: C
Diff: 1 Page Ref: Sec. 6.2

28) Of the following transitions in the Bohr hydrogen atom, the __________ transition results in the emission of the highest-energy photon.
A) $n = 1 \rightarrow n = 6$
B) $n = 6 \rightarrow n = 1$
C) $n = 6 \rightarrow n = 3$
D) $n = 3 \rightarrow n = 6$
E) $n = 1 \rightarrow n = 4$
Answer: B
Diff: 1 Page Ref: Sec. 6.3

29) Using Bohr's equation for the energy levels of the electron in the hydrogen atom, determine the energy (J) of an electron in the n = 4 level. __________ .
A) -1.36×10^{-19}
B) -5.45×10^{-19}
C) -7.34×10^{18}
D) -1.84×10^{-29}
E) $+1.84 \times 10^{-29}$
Answer: A
Diff: 1 Page Ref: Sec. 6.3

30) An electron in a Bohr hydrogen atom has an energy of -1.362×10^{-19} J. The value of n for this electron is __________.
A) 1
B) 2
C) 3
D) 4
E) 5
Answer: D
Diff: 1 Page Ref: Sec. 6.3

31) The energy (J) required for an electronic transition in a Bohr hydrogen atom from n = 2 to n = 3 is __________ J.
A) 4.0×10^{-19}
B) 3.0×10^{-19}
C) -3.0×10^{-19}
D) -7.9×10^{-19}
E) 4.6×10^{14}
Answer: B
Diff: 1 Page Ref: Sec. 6.3

32) Calculate the energy (J) change associated with an electron transition from n = 2 to n = 5 in a Bohr hydrogen atom __________.
A) 6.5×10^{-19}
B) 5.5×10^{-19}
C) 8.7×10^{-20}
D) 4.6×10^{-19}
E) 5.8×10^{-53}
Answer: D
Diff: 1 Page Ref: Sec. 6.3

33) The frequency of electromagnetic radiation required to promote an electron from n = 2 to n = 4 in a Bohr hydrogen atom is __________ Hz.
A) 4.1×10^{-19}
B) 6.2×10^{14}
C) 5.4×10^{-19}
D) 8.2×10^{14}
E) 4.1×10^{19}
Answer: B
Diff: 1 Page Ref: Sec. 6.3

34) A spectrum containing only specific wavelengths is called a __________ spectrum.
A) line
B) continuous
C) visible
D) Rydberg
E) invariant
Answer: A
Diff: 1 Page Ref: Sec. 6.3

35) When the electron in a hydrogen atom moves from n = 6 to n = 2, light with a wavelength of __________ nm is emitted.
A) 93.8
B) 434
C) 487
D) 657
E) 411
Answer: E
Diff: 1 Page Ref: Sec. 6.3

36) When the electron in a hydrogen atom moves from n = 6 to n = 1, light with a wavelength of __________ nm is emitted.
A) 487
B) 411
C) 434
D) 93.8
E) 657
Answer: D
Diff: 1 Page Ref: Sec. 6.3

37) When the electron in a hydrogen atom moves from n = 8 to n = 2 light with a wavelength of __________ nm is emitted.
A) 657
B) 93.8
C) 411
D) 487
E) 389
Answer: E
Diff: 1 Page Ref: Sec. 6.3

38) The n = 2 to n = 6 transition in the Bohr hydrogen atom corresponds to the __________ of a photon with a wavelength of __________ nm.
A) emission, 411
B) absorption, 411
C) absorption, 657
D) emission, 93.8
E) emission, 389
Answer: B
Diff: 2 Page Ref: Sec. 6.3

39) The n = 5 to n = 3 transition in the Bohr hydrogen atom corresponds to the __________ of a photon with a wavelength of __________ nm.
A) absorption, 657
B) absorption, 1280
C) emission, 657
D) emission, 1280
E) emission, 389
Answer: D
Diff: 1 Page Ref: Sec. 6.3

40) The n = 8 to n = 4 transition in the Bohr hydrogen atom occurs in the __________ region of the electromagnetic spectrum.
A) infrared
B) visible
C) ultraviolet
D) microwave
E) X-ray
Answer: A
Diff: 1 Page Ref: Sec. 6.3

41) The n = 8 to n = 2 transition in the Bohr hydrogen atom occurs in the __________ region of the electromagnetic spectrum.
A) radio
B) X-ray
C) infrared
D) microwave
E) ultraviolet
Answer: E
Diff: 1 Page Ref: Sec. 6.4

42) The deBroglie wavelength of a particle is given by __________.
A) *h + mv*
B) *hmv*
C) *h/mv*
D) *mv/c*
E) *mv*
Answer: C
Diff: 1 Page Ref: Sec. 6.4

43) What is the de Broglie wavelength (m) of a 2.0 kg object moving at a speed of 50 m/s __________?
A) 6.6×10^{-36}
B) 1.5×10^{35}
C) 5.3×10^{-33}
D) 2.6×10^{-35}
E) 3.8×10^{34}
Answer: A
Diff: 1 Page Ref: Sec. 6.4

44) What is the de Broglie wavelength (m) of a 25 g object moving at a speed of 5.0 m/s?
A) 1.9×10^{32}
B) 5.3×10^{-33}
C) 6.6×10^{-36}
D) 3.32×10^{-36}
E) 3.02×10^{45}
Answer: B
Diff: 1 Page Ref: Sec. 6.4

45) At what speed (m/s) must a 10 mg object be moving to have a de Broglie wavelength of 3.3×10^{-41} m __________?
A) 4.1
B) 1.9×10^{-11}
C) 2.0×10^{12}
D) 3.3×10^{-42}
E) 1.9×10^{13}
Answer: C
Diff: 1 Page Ref: Sec. 6.4

46) At what speed (m/s) must a 3.0 mg object be moving in order to have a de Broglie wavelength of 5.4×10^{-29} m?
A) 1.6×10^{-28}
B) 3.9×10^{-4}
C) 2.0×10^{12}
D) 4.1
E) 6.3
Answer: D
Diff: 1 Page Ref: Sec. 6.4

47) The de Broglie wavelength of an electron is 8.7×10^{-11} m. The mass of an electron is 9.1×10^{-31} kg. The velocity of this electron is __________ m/s.
A) 8.4×10^{3}
B) 1.2×10^{-7}
C) 6.9×10^{-5}
D) 8.4×10^{6}
E) 8.4×10^{-3}
Answer: D
Diff: 1 Page Ref: Sec. 6.4,

48) The de Broglie wavelength of a bullet (7.5g) traveling at 700 m/s is __________ m.
A) 7.7×10^{33}
B) 1.3×10^{-34}
C) 6.2×10^{-29}
D) 1.3×10^{-27}
E) 1.3×10^{-23}
Answer: B
Diff: 1 Page Ref: Sec. 6.4,

49) The de Broglie wavelength of a car (1.0×10^{3} kg) traveling at 75 km/hr is __________ m.
A) 3.2×10^{-38}
B) 8.8×10^{-39}
C) 3.2×10^{-35}
D) 1.4×10^{-35}
E) 1.4×10^{35}
Answer: A
Diff: 1 Page Ref: Sec. 6.4,

50) The wavelength of an electron whose velocity is 1.7×10^{4} m/s and whose mass is 9.1×10^{-28} g is __________ m.
A) 4.3×10^{-11}
B) 12
C) 4.3×10^{-8}
D) 2.3×10^{7}
E) 2.3×10^{-7}
Answer: C
Diff: 1 Page Ref: Sec. 6.4,

51) The __________ quantum number defines the shape of an orbital.
A) spin
B) magnetic
C) principal
D) azimuthal
E) psi
Answer: D
Diff: 1 Page Ref: Sec. 6.5

52) There are __________ orbitals in the third shell.
A) 25
B) 4
C) 9
D) 16
E) 1
Answer: C
Diff: 1 Page Ref: Sec. 6.5

53) The __________ subshell contains only one orbital.
A) 5d
B) 6f
C) 4s
D) 3d
E) 1p
Answer: C
Diff: 1 Page Ref: Sec. 6.5

54) There are __________ orbitals in the second shell.
A) 1
B) 2
C) 4
D) 8
E) 9
Answer: C
Diff: 1 Page Ref: Sec. 6.5

55) The azimuthal quantum number is 3 in __________ orbitals.
A) s
B) p
C) d
D) f
E) a
Answer: D
Diff: 2 Page Ref: Sec. 6.5

56) The $n = 1$ shell contains __________ p orbitals. All the other shells contain __________ p orbitals.
A) 3, 6
B) 0, 3
C) 6, 2
D) 3, 3
E) 0, 6
Answer: B
Diff: 1 Page Ref: Sec. 6.5

57) The lowest energy shell that contains f orbitals is the shell with n = __________.
A) 3
B) 2
C) 4
D) 1
E) 5
Answer: C
Diff: 1 Page Ref: Sec. 6.5

58) The principal quantum number of the first d subshell is __________.
A) 1
B) 2
C) 3
D) 4
E) 0
Answer: C
Diff: 1 Page Ref: Sec. 6.5

59) The total number of orbitals in a shell is given by __________.
A) I^2
B) n^2
C) 2n
D) 2n + 1
E) 2l + 1
Answer: B
Diff: 1 Page Ref: Sec. 6.5

60) In a hydrogen atom, an electron in a __________ orbital can absorb a photon, but cannot emit a photon.
A) 3s
B) 2s
C) 3p
D) 1s
E) 3f
Answer: D
Diff: 1 Page Ref: Sec. 6.5

61) __________-orbitals are spherically symmetrical.
A) s
B) p
C) d
D) f
E) g
Answer: A
Diff: 1 Page Ref: Sec. 6.6

62) How many p-orbitals are occupied in a Ne atom __________?
A) 0
B) 1
C) 6
D) 3
E) 2
Answer: D
Diff: 1 Page Ref: Sec. 6.7

63) How many p-orbitals are occupied in a Ne atom __________?
A) 5
B) 6
C) 1
D) 3
E) 2
Answer: E
Diff: 1 Page Ref: Sec. 6.7

64) Each p-subshell can accommodate a maximum of __________ electrons.
A) 6
B) 2
C) 10
D) 3
E) 5
Answer: A
Diff: 1 Page Ref: Sec. 6.7

65) An electron in a(n) __________ subshell experiences the greatest effective nuclear charge in a many-electron atom.
A) 3f
B) 3p
C) 3d
D) 3s
E) 4s
Answer: D
Diff: 1 Page Ref: Sec. 6.7

66) A tin atom has 50 electrons. Electrons in the __________ subshell experience the lowest effective nuclear charge.
A) 1s
B) 3p
C) 3d
D) 5s
E) 5p
Answer: E
Diff: 2 Page Ref: Sec. 6.8

67) A __________ orbital is degenerate with a $5d_{z^2}$ in a many-electron atom.
A) $5p_z$
B) $4d_{z^2}$
C) 5s
D) $5d_{zy}$
E) $4d_{zz}$
Answer: D
Diff: 2 Page Ref: Sec. 6.8

68) How many quantum numbers are necessary to designate a particular electron in an atom __________?
A) 3
B) 4
C) 2
D) 1
E) 5
Answer: B
Diff: 1 Page Ref: Sec. 6.7

69) In which orbital does an electron in a phosphorus atom experience the greatest shielding __________?
A) 2p
B) 3s
C) 3p
D) 2s
E) 1s
Answer: C
Diff: 2 Page Ref: Sec. 6.8

70) The 3p subshell in the ground state of atomic xenon contains __________ electrons.
A) 2
B) 6
C) 8
D) 10
E) 36
Answer: B
Diff: 1 Page Ref: Sec. 6.8

71) The second shell in the ground state of atomic argon contains __________ electrons.
A) 2
B) 6
C) 8
D) 18
E) 36
Answer: C
Diff: 1 Page Ref: Sec. 6.8

72) The 4d subshell in the ground state of atomic xenon contains __________ electrons.
A) 2
B) 6
C) 8
D) 10
E) 36
Answer: D
Diff: 1 Page Ref: Sec. 6.8

73) $[Ar]4s^2 3d^{10} 4p^3$ is the electron configuration of a(n) __________ atom.
A) As
B) V
C) P
D) Sb
E) Sn
Answer: A
Diff: 3 Page Ref: Sec. 6.8

74) The electron configuration of a ground-state Ag atom is __________.

A) $[Ar]4s^2 4d^9$

B) $[Kr]5s^1 4d^{10}$

C) $[Kr]5s^2 3d^9$

D) $[Ar]4s^1 4d^{10}$

E) $[Kr]5s^2 4d^{10}$

Answer: B

Diff: 2 Page Ref: Sec. 6.8

75) The ground state electron configuration for Zn is __________.

A) $[Kr]4s^2 3d^{10}$

B) $[Ar]4s^2 3d^{10}$

C) $[Ar]4s^1 3d^{10}$

D) $[Ar]3s^2 3d^{10}$

E) $[Kr]3s^2 3d^{10}$

Answer: B

Diff: 1 Page Ref: Sec. 6.8

76) There are __________ unpaired electrons in a ground state phosphorus atom.

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

Answer: D

Diff: 1 Page Ref: Sec. 6.8

77) There are __________ unpaired electrons in a ground state fluorine atom.

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

Answer: B

Diff: 1 Page Ref: Sec. 6.8

78) In a ground-state manganese atoms, the __________ subshell is partially filled.

A) 3s
B) 4s
C) 4p
D) 3d
E) 4d

Answer: D

Diff: 1 Page Ref: Sec. 6.8

79) The principal quantum number for the outermost electrons in a Br atom in the ground state is __________.
A) 2
B) 3
C) 4
D) 5
E) 1
Answer: C
Diff: 2 Page Ref: Sec. 6.8

80) The azimuthal quantum number for the outermost electrons in a nitrogen atom in the ground state is __________.
A) 0
B) 1
C) 2
D) 3
E) -1
Answer: B
Diff: 3 Page Ref: Sec. 6.8

81) Which is the correct ground-state electron configuration for silver __________ ?
A) $[Kr]5s^2 4d^9$
B) $[Kr]5s^1 4d^{10}$
C) $[Kr]5s^2 4d^{10}$
D) $[Xe]5s^2 4d^9$
E) $[Xe]5s^1 4d^{10}$
Answer: B
Diff: 1 Page Ref: Sec. 6.8

82) What is the correct ground-state electron configuration for molybdenum __________?
A) $[Kr]5s^1 4d^{10}$
B) $[Kr]5s^2 4d^4$
C) $[Kr]5s^1 4d^5$
D) $[Kr]5s^2 4d^5$
E) $[Kr]5s^2 4d^9$
Answer: C
Diff: 1 Page Ref: Sec. 6.9

83) All of the __________ have a valence shell electron configuration ns^1.
A) noble gases
B) halogens
C) chalcogens
D) alkali metals
E) alkaline earth metals
Answer: D
Diff: 1 Page Ref: Sec. 6.9

84) The elements in the __________ period of the periodic table have a core-electron configuration that is the same as the electron configuration of neon.
A) first
B) second
C) third
D) fourth
E) fifth
Answer: C
Diff: 1 Page Ref: Sec. 6.9

85) The largest principal quantum number in the ground state electron configuration of iodine is __________.
A) 1
B) 4
C) 5
D) 6
E) 7
Answer: C
Diff: 1 Page Ref: Sec. 6.9

86) The largest principal quantum number in the ground state electron configuration of barium is __________.
A) 1
B) 2
C) 4
D) 5
E) 6
Answer: E
Diff: 1 Page Ref: Sec. 6.9

87) The largest principal quantum number in the ground state electron configuration of cobalt is __________.
A) 2
B) 3
C) 4
D) 7
E) 9
Answer: C
Diff: 1 Page Ref: Sec. 6.9

88) Elements in group __________ have a np^6 electron configuration in the outer shell.
A) 4A
B) 6A
C) 7A
D) 8A
E) 5A
Answer: D
Diff: 1 Page Ref: Sec. 6.9

89) Which group in the periodic table contains elements with the valence electron configuration of ns^2np^1 __________?
A) 1A
B) 2A
C) 3A
D) 4A
E) 8A
Answer: C
Diff: 1 Page Ref: Sec. 6.9

Multiple-Choice

90) Which one of the following is correct?
A) $\nu + \lambda = c$
B) $\nu \div \lambda = c$
C) $\nu = c\lambda$
D) $\lambda = c\,\nu$
E) $\nu\lambda = c$
Answer: E
Diff: 1 Page Ref: Sec. 6.1

91) The photoelectric effect is __________.
A) the total reflection of light by metals giving them their typical luster
B) the production of current by silicon solar cells when exposed to sunlight
C) the ejection of electrons by a metal when struck with light of sufficient energy
D) the darkening of photographic film when exposed to an electric field
E) a relativistic effect
Answer: C
Diff: 1 Page Ref: Sec. 6.2

92) Low-frequency electromagnetic fields with potential biological effects have frequencies of __________ Hz.
A) 10^{-3}-10^{-5}
B) 10^{-5}-10^{-9}
C) 100-10,000
D) 400-700
E) 1-1000
Answer: E
Diff: 1 Page Ref: Sec. 6.2

93) In the Bohr model of the atom, __________.
A) electrons travel in circular paths called orbitals
B) electrons can have any energy
C) electron energies are quantized
D) electron paths are controlled by probability
E) both A and C
Answer: C
Diff: 1 Page Ref: Sec. 6.3

94) According to the Heisenberg Uncertainty Principle, it is impossible to know precisely both the position and the __________ of an electron.
A) mass
B) color
C) momentum
D) shape
E) velocity
Answer: C
Diff: 1 Page Ref: Sec. 6.4

95) The de Broglie wavelength of a __________ will have the shortest wavelength when traveling at 30 cm/s.
A) marble
B) car
C) planet
D) uranium atom
E) hydrogen atom
Answer: C
Diff: 1 Page Ref: Sec. 6.4,

96) The uncertainty principle states that __________.
A) matter and energy are really the same thing
B) it is impossible to know anything with certainty
C) it is impossible to know the exact position and momentum of an electron
D) there can only be one uncertain digit in a reported number
E) it is impossible to know how many electrons there are in an atom
Answer: C
Diff: 1 Page Ref: Sec. 6.5

97) All of the orbitals in a given electron shell have the same value of the __________ quantum number.
A) principal
B) azimuthal
C) magnetic
D) spin
E) psi
Answer: A
Diff: 1 Page Ref: Sec. 6.5

98) All of the orbitals in a given subshell have the same value of the __________ quantum number.
A) principal
B) azimuthal
C) magnetic
D) A and B
E) B and C
Answer: D
Diff: 1 Page Ref: Sec. 6.5

99) Which one of the following is not a valid value for the magnetic quantum number of an electron in a 5d subshell?
A) 2
B) 3
C) 0
D) 1
E) -1
Answer: B
Diff: 1 Page Ref: Sec. 6.5

100) Which of the subshells below do not exist due to the constraints upon the azimuthal quantum number?
A) 2d
B) 2s
C) 2p
D) all of the above
E) none of the above
Answer: A
Diff: 1 Page Ref: Sec. 6.5

101) Which of the subshells below do not exist due to the constraints upon the azimuthal quantum number?
A) 4f
B) 4d
C) 4p
D) 4s
E) none of the above
Answer: E
Diff: 1 Page Ref: Sec. 6.5

102) An electron cannot have the quantum numbers n = __________, l = __________, m_l = __________.
A) 2, 0, 0
B) 2, 1, -1
C) 3, 1, -1
D) 1, 1, 1
E) 3, 2, 1
Answer: D
Diff: 2 Page Ref: Sec. 6.5

103) An electron cannot have the quantum numbers n = __________, l = __________, m_l = __________.
A) 6, 1, 0
B) 3, 2, 3
C) 3, 2, -2
D) 1, 0, 0
E) 3, 2, 1
Answer: B
Diff: 2 Page Ref: Sec. 6.5

104) Which one of the following is an incorrect subshell notation?
A) 4f
B) 2d
C) 3s
D) 2p
E) 3d
Answer: B
Diff: 1 Page Ref: Sec. 6.5

105) Which one of the following is an incorrect orbital notation?
A) 2s
B) $3p_y$
C) 3f
D) $4d_{xy}$
E) 4s
Answer: C
Diff: 1 Page Ref: Sec. 6.5

106) Which quantum number determines the energy of an electron in a hydrogen atom?
A) n
B) E
C) m_l
D) l
E) n and l
Answer: A
Diff: 2 Page Ref: Sec. 6.5

107) Which one of the quantum numbers does not result from the solution of the Schroedinger equation?
A) principal
B) azimuthal
C) magnetic
D) spin
E) angular momentum
Answer: D
Diff: 1 Page Ref: Sec. 6.5, 6.7

108) Which quantum numbers must be the same for the orbitals that they designate to be degenerate in a one-electron system (such as hydrogen)?
A) n, l, and m_l
B) n and l only
C) l and m_l
D) m_l only
E) n only
Answer: E
Diff: 1 Page Ref: Sec. 6.6

109) In a p_x orbital, the subscript x denotes the __________ of the electron.
A) energy
B) spin of the electrons
C) probability of the shell
D) size of the orbital
E) axis along which the orbital is aligned
Answer: E
Diff: 1 Page Ref: Sec. 6.6

110) The __________ orbital is degenerate with $5p_y$ in a many-electron atom.
A) 5s
B) $5p_x$
C) $4p_y$
D) $5d_{xy}$
E) $5d^2$
Answer: B
Diff: 1 Page Ref: Sec. 6.6

111) Which set of three quantum numbers (n, l, m_l) corresponds to a 3d orbital?
A) 3, 2, 2
B) 3, 3, 2
C) 3, 2, 3
D) 2, 1, 0
E) 2, 3, 3
Answer: A
Diff: 1 Page Ref: Sec. 6.6

112) At maximum, an f-subshell can hold __________ electrons, a d-subshell can hold __________ electrons, and a p-subshell can hold __________ electrons.
A) 14, 10, 6
B) 2, 8, 18
C) 14, 8, 2
D) 2, 12, 21
E) 2, 6, 10
Answer: A
Diff: 2 Page Ref: Sec. 6.7

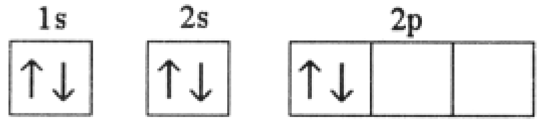
113) Which one of the following represents an acceptable set of quantum numbers for an electron in an atom? (arranged as n, l, m_l, and m_s)
A) 2, 2, -1, -1/2
B) 1, 0, 0, 1/2
C) 3, 3, 3, 1/2
D) 5, 4,- 5, 1/2
E) 3, 3, 3, -1/2
Answer: B
Diff: 1 Page Ref: Sec. 6.7

114) Which one of the following represents an acceptable possible set of quantum numbers
(in the order n, l, m_l, m_s) for an electron in an atom?
A) 2, 1, -1, 1/2
B) 2, 1, 0, 0
C) 2, 2, 0, 1/2
D) 2, 0, 1, -1/2
E) 2, 0, 2, +1/2
Answer: A
Diff: 1 Page Ref: Sec. 6.7

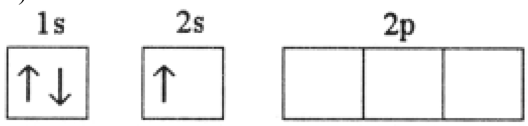
115) Which one of the following represents an impossible set of quantum numbers for an electron in an atom? (arranged as n, l, m_l, and m_s)
A) 2, 1, -1, -1/2
B) 1, 0, 0, 1/2
C) 3, 3, 3, 1/2
D) 5, 4, - 3, 1/2
E) 5, 4, -3, -1/2
Answer: C
Diff: 1 Page Ref: Sec. 6.7

116) Which electron configuration represents a violation of the Pauli exclusion principle?

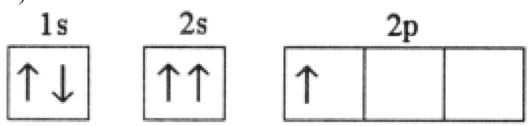
A)



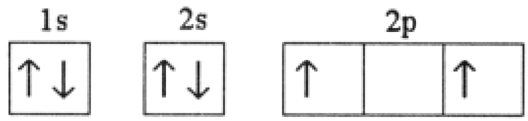
B)



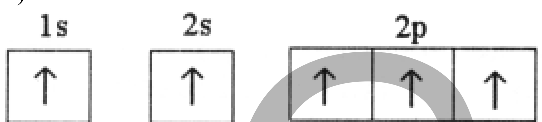
C)



D)



E)

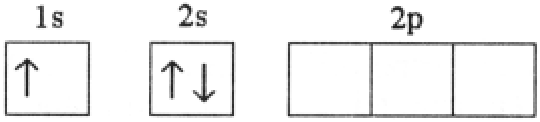


Answer: C

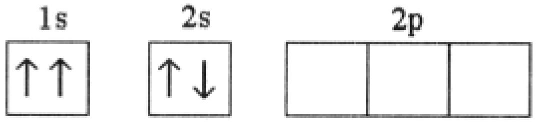
Diff: 1 Page Ref: Sec. 6.8

117) Which electron configuration represents a violation of the Pauli exclusion principle?

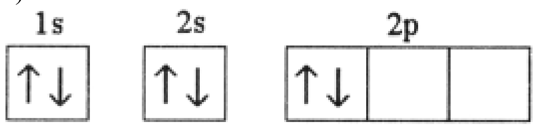
A)



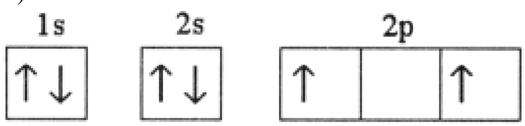
B)



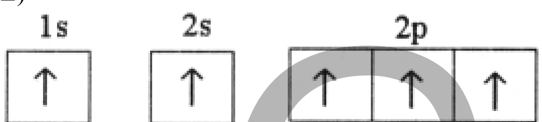
C)



D)



E)

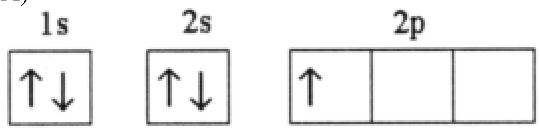


Answer: B

Diff: 1 Page Ref: Sec. 6.8

118) Which electron configuration represents a violation of the Pauli exclusion principle?

A)



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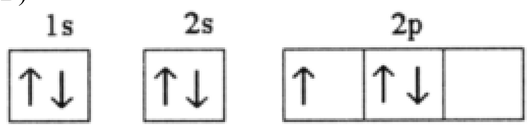

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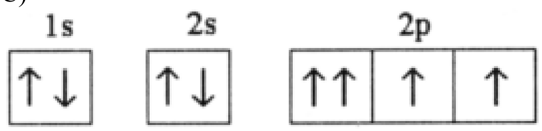

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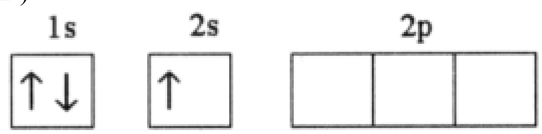
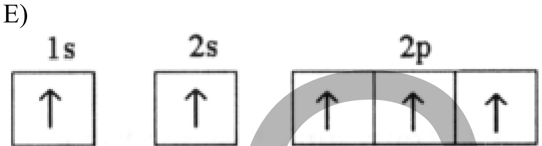


E)



Answer: C

Diff: 1 Page Ref: Sec. 6.7

119) Which one of the following orbitals can hold two electrons?

A) $2p_x$

B) 3s

C) $4d_{xy}$

D) all of the above

E) none of the above

Answer: D

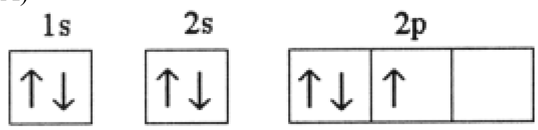
Diff: 1 Page Ref: Sec. 6.7

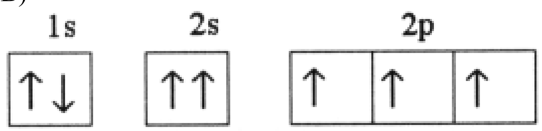
120) In which orbital does an electron in a phosphorus atom experience the greatest effective nuclear charge?
A) 1s
B) 2s
C) 2p
D) 3s
E) 3p
Answer: A
Diff: 2   Page Ref: Sec. 6.8

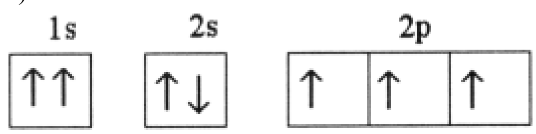
121) Which of the following is a valid set of four quantum numbers? (n, l, m_l, m_s)
A) 2, 1, 0, +1/2
B) 2, 2, 1, -1/2
C) 1, 0, 1, +1/2
D) 2, 1, +2, +1/2
E) 1, 1, 0, -1/2
Answer: A
Diff: 2   Page Ref: Sec. 6.7

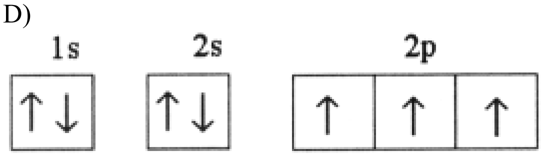
122) Which of the following is not a valid set of four quantum numbers? (n, l, m_l, m_s)
A) 2, 0, 0, +1/2
B) 2, 1, 0, -1/2
C) 3, 1, -1, -1/2
D) 1, 0, 0, +1/2
E) 1, 1, 0, +1/2
Answer: E
Diff: 2   Page Ref: Sec. 6.7

123) Which quantum numbers must be the same for the orbitals that they designate to be degenerate in a many-electron system?
A) n, l, and m_l
B) n only
C) n, l, m_l, and m_s
D) m_s only
E) n and l only
Answer: E
Diff: 2   Page Ref: Sec. 6.7

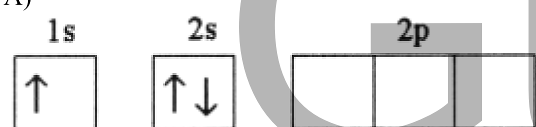
124) Which one of the following is the correct electron configuration for a ground-state nitrogen atom?
A)


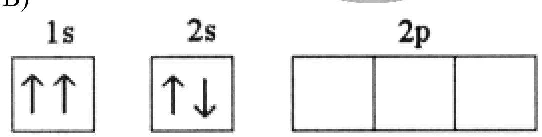
B)


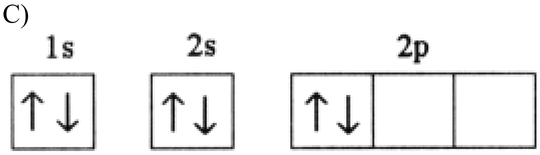
C)


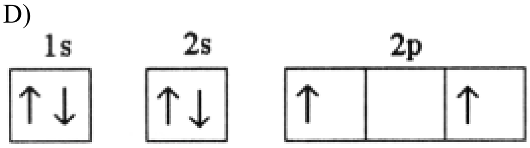
D)


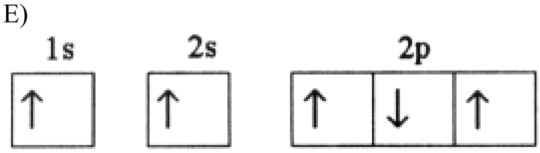
E) None of the above is correct.
Answer: D
Diff: 1 Page Ref: Sec. 6.8

125) Which electron configuration denotes an atom in its ground state?
A)


B)


C)


D)


E)


Answer: D
Diff: 1 Page Ref: Sec. 6.8

126) The ground state electron configuration of Fe is __________.

A) $1s^2 2s^2 3s^2 3p^6 3d^6$

B) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$

C) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

D) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4d^6$

E) $1s^2 2s^2 3s^2 3p^{10}$

Answer: B
Diff: 1 Page Ref: Sec. 6.8

127) The ground state electron configuration of Ga is __________.

A) $1s^2 2s^2 3s^2 3p^6 3d^{10} 4s^2 4p^1$

B) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 4d^{10} 4p^1$

C) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^1$

D) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4d^1$

E) $[Ar]4s^2 3d^{11}$

Answer: C
Diff: 1 Page Ref: Sec. 6.8

128) The ground-state electron configuration of the element __________ is $[Kr]5s^1 4d^5$.

A) Nb
B) Mo
C) Cr
D) Mn
E) Tc

Answer: B
Diff: 1 Page Ref: Sec. 6.8

129) The ground-state electron configuration of __________ is $[Ar]4s^1 3d^5$.

A) V
B) Mn
C) Fe
D) Cr
E) K

Answer: D
Diff: 1 Page Ref: Sec. 6.8

130) Which one of the following configurations depicts an excited oxygen atom?

A) $1s^2 2s^2 2p^2$

B) $1s^2 2s^2 2p^2 3s^2$

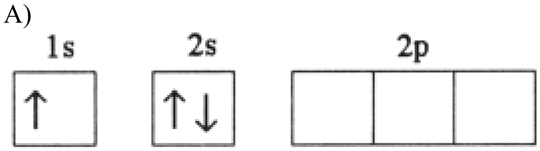
C) $1s^2 2s^2 2p^1$

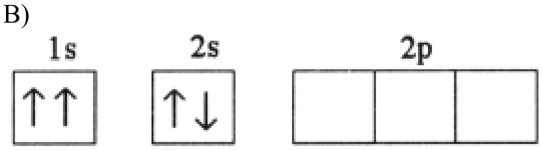
D) $1s^2 2s^2 2p^4$

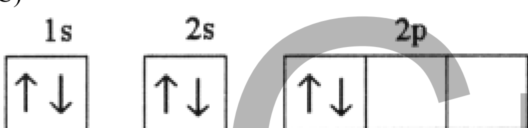
E) $[He]2s^2 2p^4$

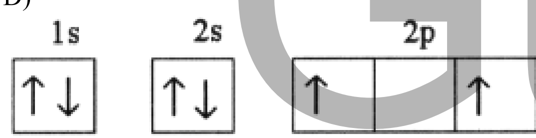
Answer: B
Diff: 2 Page Ref: Sec. 6.8

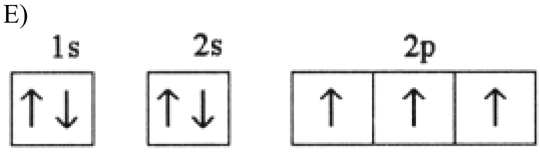
131) Which one of the following configurations depicts an excited carbon atom?
A) $1s^2 2s^2 2p^1 3s^1$
B) $1s^2 2s^2 2p^3$
C) $1s^2 2s^2 2p^1$
D) $1s^2 2s^2 3s^1$
E) $1s^2 2s^2 2p^2$
Answer: A
Diff: 1 Page Ref: Sec. 6.8

132) Which electron configuration represents a violation of Hund's rule for an atom in its ground state?
A)


B)


C)


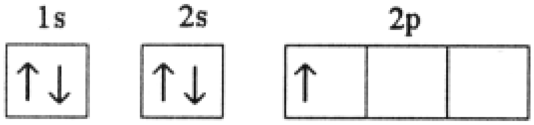
D)


E)


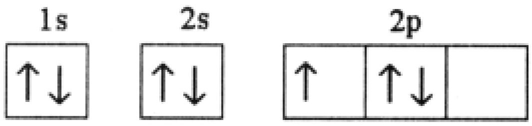
Answer: C
Diff: 1 Page Ref: Sec. 6.8

133) Which electron configuration represents a violation of Hund's rule for an atom in its ground state?

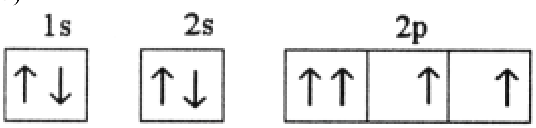
A)



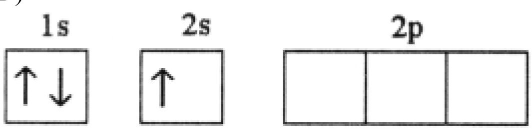
B)



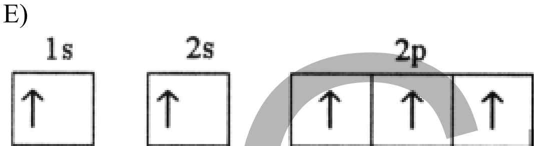
C)



D)

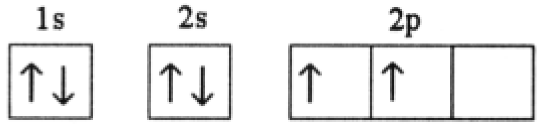


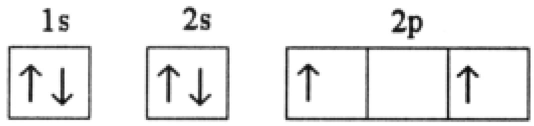
E)

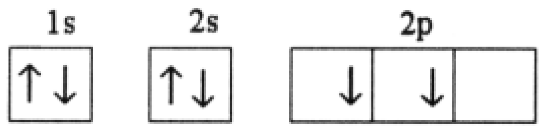


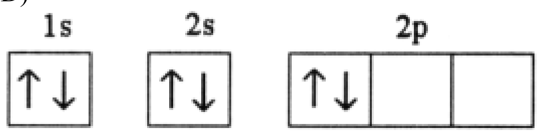
Answer: B

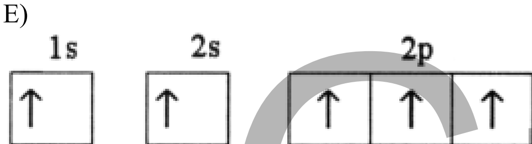
Diff: 1 Page Ref: Sec. 6.8

134) Which electron configuration represents a violation of Hund's rule for an atom in its ground state?
A)


B)


C)


D)


E)


Answer: D
Diff: 1 Page Ref: Sec. 6.8

135) Which of the following elements has a ground-state electron configuration different from the predicted one?
A) Cu
B) Ca
C) Xe
D) Cl
E) Ti
Answer: A
Diff: 2 Page Ref: Sec. 6.8

136) Which two elements have the same ground-state electron configuration?
A) Pd and Pt
B) Cu and Ag
C) Fe and Cu
D) Cl and Ar
E) No two elements have the same ground-state electron configuration.
Answer: E
Diff: 1 Page Ref: Sec. 6.8

137) How many different principal quantum numbers can be found in the ground state electron configuration of nickel?
A) 2
B) 3
C) 4
D) 5
E) 6
Answer: C
Diff: 1 Page Ref: Sec. 6.9

138) The valence shell of the element X contains 2 electrons in a 5s subshell. Below that shell, element X has a partially filled 4d subshell. What type of element is X?
A) main group element
B) chalcogen
C) halogen
D) transition metal
E) alkali metal
Answer: D
Diff: 1 Page Ref: Sec. 6.9

Short Answer

1) What wavelengths correspond to the visible region of the electromagnetic spectrum?
Answer: About 400 to 700 nm.
Diff: 1 Page Ref: Sec. 6.1

2) All of the subshells in a given shell have the same energy in the hydrogen atom. In a many-electron atom, the subshells in a given shell do not have the same energy. Why?
Answer: Hydrogen atoms have only one electron. Therefore, in a hydrogen atom, the energy of orbitals depends only on *n*. In many-electron atoms, electron-electron repulsion causes the energies of subshells in a given shell to differ.
Diff: 1 Page Ref: Sec. 6.7

3) "The largest principal quantum number in the ground state electron configuration of francium is __________ ?
Answer: 7
Diff: 1 Page Ref: Sec 6.8

4) The ground state electron configuration of copper is __________.
Answer: $[Ar]3d^{10}4s^1$
Diff: 1 Page Ref: Sec. 6.8

5) The ground state electron configuration of scandium is __________.
Answer: $[Ar]4s^2 3d^1$
Diff: 1 Page Ref: Sec 6.8

6) The electron configuration of the valence electrons of an atom in its ground state is ns^2np^3 .` This atom is a group __________ element.
Answer: 5A
Diff: 1 Page Ref: Sec6.8

7) Elements in group __________ have a np^5 electron configuration in the outer shell.
Answer: 7A
Diff: 1 Page Ref: Sec 6.8

8) The shape of an orbital is defined by the azimuthal quantum number which is represented as letter __________
Answer: l
Diff: 1 Page Ref: Sec 6.5

True/False

1) The wavelength of radio waves can be longer than a football field.
Answer: TRUE
Diff: 1 Page Ref: Sec 6.1

2) Black body radiation is the emission of light from metal surfaces.
Answer: FALSE
Diff: 1 Page Ref: Sec 6.2

3) If a hydrogen atom electron jumps from the n=6 orbit to the n=2 orbit, energy is released.
Answer: TRUE
Diff: 1 Page Ref: Sec 6.3

4) The square of Schrodinger's wave equation is called an orbital.
Answer: TRUE
Diff: 1 Page Ref: Sec 6.4

5) The electron density of the 2s orbital is asymmetric.
Answer: FALSE
Diff: 1 Page Ref: Sec 6.5

Algorithmic Questions

1) Electromagnetic radiation with a wavelength of 525 nm appears as green light to the human eye. The frequency of this light is __________ s^{-1}.

A) 5.71×10^{14}

B) 5.71×10^{5}

C) 1.58×10^{2}

D) 1.58×10^{11}

E) 1.75×10^{-15}

Answer: A

Diff: 1 Page Ref: Sec. 6.1

2) An FM radio station broadcasts electromagnetic radiation at a frequency of 100.6 MHz. The wavelength of this radiation is __________ m.

A) 2.982×10^{6}

B) 2.982

C) 3.018×10^{16}

D) 3.018×10^{10}

E) 0.3353

Answer: B

Diff: 1 Page Ref: Sec. 6.1

3) Electromagnetic radiation with a wavelength of 640 nm appears as orange light to the human eye. The energy of one photon of this light is __________ J.

A) 1.272×10^{-31}

B) 3.106×10^{-28}

C) 3.106×10^{-19}

D) 1.272×10^{-22}

E) 3.220×10^{18}

Answer: C

Diff: 1 Page Ref: Sec. 6.2

4) Electromagnetic radiation with a wavelength of 531 nm appears as green light to the human eye. The energy of one photon of this light is 3.74×10^{-19} J. Thus, a laser that emits 1.3×10^{-2} J of energy in a pulse of light at this wavelength produces __________ photons in each pulse.

A) 2.9×10^{-17}

B) 9.2×10^{-24}

C) 1.8×10^{19}

D) 3.5×10^{16}

E) 6.5×10^{13}

Answer: D

Diff: 1 Page Ref: Sec. 6.2

5) The wavelength of an electron with a velocity of 6.00×10^6 m/s is __________ m. The mass of the electron is 9.11×10^{-28} g .

A) 8.25×10^9

B) 8.25×10^{12}

C) 1.21×10^{-16}

D) 1.21×10^{-13}

E) 1.21×10^{-10}

Answer: E

Diff: 2 Page Ref: Sec. 6.4

6) The element that corresponds to the electron configuration $1s^2 2s^2 2p^6$ is __________.

A) sodium

B) magnesium

C) lithium

D) beryllium

E) neon

Answer: E

Diff: 1 Page Ref: Sec. 6.8

7) The complete electron configuration of argon, element 18, is __________.

A) $1s^2 2s^2 2p^6 3s^2 3p^6$

B) $1s^2 2s^2 2p^{10} 3s^2 3p^2$

C) $1s^4 2s^4 2p^6 3s^4$

D) $1s^4 2s^4 2p^{10}$

E) $1s^6 2s^6 2p^2 3s^4$

Answer: A

Diff: 2 Page Ref: Sec. 6.8

8) The complete electron configuration of gallium, element 31, is __________.

A) $1s^2 2s^2 2p^{10} 3s^2 3p^{10} 4s^2 3d^3$

B) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^1$

C) $1s^4 2s^4 2p^6 3s^4 3p^6 4s^4 3d^3$

D) $1s^4 2s^4 2p^{10} 3s^4 3p^9$

E) $1s^4 2s^4 2p^8 3s^4 3p^8 4s^3$

Answer: B

Diff: 2 Page Ref: Sec. 6.8

9) The condensed electron configuration of silicon, element 14, is __________.

A) $[He]2s^4 2p^6$

B) $[Ne]2p^{10}$

C) $[Ne]3s^2 3p^2$

D) $[He]2s^4$

E) $[He]2s^6 2p^2$

Answer: C

Diff: 2 Page Ref: Sec. 6.8

10) The condensed electron configuration of krypton, element 36, is __________.

A) [Kr]$4s^2 3d^8$

B) [Ar]$4s^4$

C) [Kr]$4s^4 3d^8$

D) [Ar]$3d^{10} 4s^2 4p^6$

E) [Ar]$4s^4 3d^4$

Answer: D

Diff: 2 Page Ref: Sec. 6.8

Chemistry, 11e (Brown)
Chapter 7, Periodic Properties of the Elements

Multiple-Choice and Bimodal

1) __________ is credited with developing the concept of atomic numbers.
A) Dmitri Mendeleev
B) Lothar Meyer
C) Henry Moseley
D) Ernest Rutherford
E) Michael Faraday
Answer: C
Diff: 1 Page Ref: Sec. 7.1

2) Elements in the modern version of the periodic table are arranged in order of increasing __________.
A) oxidation number
B) atomic mass
C) average atomic mass
D) atomic number
E) number of isotopes
Answer: D
Diff: 1 Page Ref: Sec. 7.1

3) The first ionization energies of the elements __________ as you go from left to right across a period of the periodic table, and __________ as you go from the bottom to the top of a group in the table.
A) increase, increase
B) increase, decrease
C) decrease, increase
D) decrease, decrease
E) are completely unpredictable
Answer: A
Diff: 1 Page Ref: Sec. 7.3

4) The __________ have the most negative electron affinities.
A) alkaline earth metals
B) alkali metals
C) halogens
D) transition metals
E) chalcogens
Answer: C
Diff: 1 Page Ref: Sec. 7.4

5) In general, as you go across a period in the periodic table from left to right:

(1) the atomic radius __________;
(2) the electron affinity becomes __________ negative; and
(3) the first ionization energy __________.

A) decreases, decreasingly, increases
B) increases, increasingly, decreases
C) increases, increasingly, increases
D) decreases, increasingly, increases
E) decreases, increasingly, decreases
Answer: D
Diff: 2 Page Ref: Sec. 7.4

6) Element M reacts with chlorine to form a compound with the formula MCl_2. Element M is more reactive than magnesium and has a smaller radius than barium. This element is __________.
A) Sr
B) K
C) Na
D) Ra
E) Be
Answer: A
Diff: 2 Page Ref: Sec. 7.5

7) The oxide of which element below can react with hydrochloric acid?
A) sulfur
B) selenium
C) nitrogen
D) sodium
E) carbon
Answer: D
Diff: 1 Page Ref: Sec. 7.5

8) Metals can be __________ at room temperature.
A) liquid only
B) solid only
C) solid or liquid
D) solid, liquid, or gas
E) liquid or gas
Answer: C
Diff: 1 Page Ref: Sec. 7.5

9) Most of the elements on the periodic table are __________.
A) gases
B) nonmetals
C) metalloids
D) liquids
E) metals
Answer: E
Diff: 1 Page Ref: Sec. 7.6

10) Na reacts with element X to form an ionic compound with the formula Na_3X. Ca will react with X to form __________.
A) CaX_2
B) CaX
C) Ca_2X_3
D) Ca_3X_2
E) Ca_3X
Answer: D
Diff: 1 Page Ref: Sec. 7.6

11) What is the coefficient of M when the following equation is completed and balanced if M is an alkali metal?

$$M (s) + H_2O (l) \rightarrow \_\_\_\_\_\_\_\_$$

A) 1
B) 2
C) 3
D) 4
E) 0
Answer: B
Diff: 1 Page Ref: Sec. 7.6

12) The substance, __________ is always produced when an active metal reacts with water.
A) NaOH
B) H_2O
C) CO_2
D) H_2
E) O_2
Answer: D
Diff: 1 Page Ref: Sec. 7.6

13) The reaction of potassium metal with elemental hydrogen produces __________.
A) KH
B) KH_2
C) K_2H
D) None of the above; potassium will not react directly with hydrogen.
E) KOH
Answer: A
Diff: 1 Page Ref: Sec. 7.7

14) Which alkaline earth metal will not react with liquid water or with steam __________?
A) Be
B) Mg
C) Ca
D) Ba
E) They all react with liquid water and with steam.
Answer: A
Diff: 2 Page Ref: Sec. 7.6

15) What is the coefficient of H_2O when the following equation is completed and balanced?

$$Ba (s) + H_2O (l) \rightarrow \_\_\_\_\_\_\_\_$$

A) 1
B) 2
C) 3
D) 5
E) Ba(s) does not react with H_2O (l).
Answer: B
Diff: 1 Page Ref: Sec. 7.7

16) The element(s) __________ could be used to produce a red or crimson color in fireworks.
A) Mg or Ba
B) Sr
C) Ca, Sr, or Li
D) Ba
E) Na or K
Answer: B
Diff: 1 Page Ref: Sec. 7.7

17) Oxides of the active metals combine with water to form __________.
A) metal hydroxides
B) metal hydrides
C) hydrogen gas
D) oxygen gas
E) water and a salt
Answer: A
Diff: 1 Page Ref: Sec. 7.6

18) Oxides of the active metals combine with acid to form __________.
A) hydrogen gas
B) metal hydrides
C) water and a salt
D) oxygen gas
E) metal hydroxides
Answer: C
Diff: 1 Page Ref: Sec. 7.6

19) Oxides of most nonmetals combine with water to form __________.
A) an acid
B) a base
C) water and a salt
D) water
E) hydrogen gas
Answer: A
Diff: 1 Page Ref: Sec. 7.6

20) Oxides of most nonmetals combine with base to form __________.
A) hydrogen gas
B) an acid
C) a base
D) water
E) water and a salt
Answer: E
Diff: 1 Page Ref: Sec. 7.6

21) An alkaline earth metal forms a compound with oxygen with the formula __________.
(The symbol M represents any one of the alkaline earth metals.)
A) MO
B) M_2O
C) MO_2
D) M_2O_2
E) MO_3
Answer: A
Diff: 1 Page Ref: Sec. 7.6

22) An alkali metal forms a compound with chlorine with the formula __________.
(The symbol M represents any one of the alkali metals.)
A) M_2Cl_2
B) M_2Cl
C) MCl_2
D) MCl
E) MCl_3
Answer: D
Diff: 1 Page Ref: Sec. 7.6

23) Element X reacts with chlorine to form a compound with the formula XCl_2. The oxide of element X is basic.
Element X is __________.
A) Rb
B) Ca
C) Al
D) P
E) H
Answer: B
Diff: 1 Page Ref: Sec. 7.7

24) The reaction of a metal with a nonmetal produces a(n) __________.
A) base
B) salt
C) acid
D) oxide
E) hydroxide
Answer: B
Diff: 1 Page Ref: Sec. 7.7

25) Which nonmetal exists as a diatomic solid?
A) bromine
B) antimony
C) phosphorus
D) iodine
E) boron
Answer: D
Diff: 3 Page Ref: Sec. 7.7

26) The most common and stable allotrope of sulfur is __________.
A) S
B) S_2
C) S_4
D) S_8
E) Sulfur does not form allotropes.
Answer: D
Diff: 1 Page Ref: Sec. 7.7

27) Which group 6A element is a metal?
A) tellurium and polonium
B) sulfur
C) selenium
D) tellurium
E) polonium
Answer: E
Diff: 2   Page Ref: Sec. 7.7

28) The most common sulfur ion has a charge of __________.
A) -2
B) -1
C) +4
D) +6
E) Sulfur does not form ions.
Answer: A
Diff: 1   Page Ref: Sec. 7.7

29) The element phosphorus exists in two forms in nature called white phosphorus and red phosphorus. These two forms are examples of __________.
A) isotopes
B) allotropes
C) oxidation
D) metalloids
E) noble gases
Answer: B
Diff: 1   Page Ref: Sec. 7.7

30) Which periodic table group contains only nonmetals __________?
A) 8A
B) 2A
C) 6A
D) 7A
E) 5A
Answer: A
Diff: 1   Page Ref: Sec. 7.7

31) Of the hydrogen halides, only __________ is a weak acid.
A) HCl (aq)
B) HBr (aq)
C) HF (aq)
D) HI (aq)
E) They are all weak acids.
Answer: C
Diff: 2   Page Ref: Sec. 7.7

32) The first noble gas to be incorporated into a compound was __________.
A) Ar
B) Kr
C) He
D) Ne
E) Xe
Answer: E
Diff: 1   Page Ref: Sec. 7.8

33) All the elements in group 8A are gases at room temperature. Of all the groups in the periodic table, only group __________ contains examples of elements that are gas, liquid, and solid at room temperature.
A) 2A
B) 1A
C) 7A
D) 5A
E) 6A
Answer: C
Diff: 1 Page Ref: Sec. 7.7

34) Of the halogens, which are gases at room temperature and atmospheric pressure?
A) fluorine, bromine, and iodine
B) fluorine, chlorine, and bromine
C) fluorine, chlorine, bromine, and iodine
D) fluorine, chlorine, and iodine
E) fluorine and chlorine
Answer: E
Diff: 2 Page Ref: Sec. 7.8

35) The only noble gas that does not have the ns^2np^6 valence electron configuration is __________.
A) radon
B) neon
C) helium
D) krypton
E) All noble gases have the ns^2np^6 valence electron configuration.
Answer: C
Diff: 1 Page Ref: Sec. 7.7

36) $2\ F_2\ (g) + 2\ H_2O\ (l) \rightarrow$ __________.
A) $2\ HF\ (aq) + 2\ HFO\ (aq)$
B) $2\ F^-\ (aq) + 2\ H^+\ (aq) + H_2O_2\ (aq)$
C) $4\ HF\ (aq) + O_2\ (g)$
D) $2\ HF_2\ (aq) + 2\ OH^-\ (aq)$
E) $4\ HF\ (aq) + 2\ O^{2-}\ (aq)$
Answer: C
Diff: 1 Page Ref: Sec. 7.7

37) $Cl_2\ (g) + H_2O\ (l) \rightarrow$ ________
A) $HCl\ (aq) + HOCl\ (aq)$
B) $2\ Cl^-\ (aq) + H_2O\ (l)$
C) $2\ HCl\ (aq) + O_2\ (g)$
D) $2\ HCl\ (aq) + O_2^-\ (g)$
E) $Cl_2\ (aq) + H_2O\ (l)$
Answer: A
Diff: 2 Page Ref: Sec. 7.7

Multilpe-Choice

38) In which set of elements would all members be expected to have very similar chemical properties?
A) O, S, Se
B) N, O, F
C) Na, Mg, K
D) S, Se, Si
E) Ne, Na, Mg
Answer: A
Diff: 1 Page Ref: Sec. 7.1

39) Which element would be expected to have chemical and physical properties closest to those of fluorine?
A) S
B) Fe
C) Ne
D) O
E) Cl
Answer: E
Diff: 1 Page Ref: Sec. 7.1

40) Electrons in the 1s subshell are much closer to the nucleus in Ar than in He due to the larger __________ in Ar.
A) nuclear charge
B) paramagnetism
C) diamagnetism
D) Hund's rule
E) azimuthal quantum number
Answer: A
Diff: 1 Page Ref: Sec. 7.2

41) Atomic radius generally increases as we move __________.
A) down a group and from right to left across a period
B) up a group and from left to right across a period
C) down a group and from left to right across a period
D) up a group and from right to left across a period
E) down a group; the period position has no effect
Answer: A
Diff: 1 Page Ref: Sec. 7.2

42) Of the following, which gives the correct order for atomic radius for Mg, Na, P, Si and Ar?
A) Mg > Na > P > Si > Ar
B) Ar > Si > P > Na > Mg
C) Si > P > Ar > Na > Mg
D) Na > Mg > Si > P > Ar
E) Ar > P > Si > Mg > Na
Answer: D
Diff: 1 Page Ref: Sec. 7.2

43) Screening by the valence electrons in atoms is __________.
A) less efficient than that by core electrons
B) more efficient than that by core electrons
C) essentially identical to that by core electrons
D) responsible for a general increase in atomic radius going across a period
E) both more efficient than that by core electrons and responsible for a general increase in atomic radius going across a period
Answer: A
Diff: 1 Page Ref: Sec. 7.2

44) The atomic radius of main-group elements generally increases down a group because __________.
A) effective nuclear charge increases down a group
B) effective nuclear charge decreases down a group
C) effective nuclear charge zigzags down a group
D) the principal quantum number of the valence orbitals increases
E) both effective nuclear charge increases down a group and the principal quantum number of the valence orbitals increases
Answer: D
Diff: 2 Page Ref: Sec. 7.2

45) Screening by core electrons in atoms is __________.
A) less efficient than that by valence electrons
B) more efficient than that by valence electrons
C) essentially identical to that by valence electrons
D) responsible for a general decrease in atomic radius going down a group
E) both essentially identical to that by valence electrons and responsible for a general decrease in atomic radius going down a group
Answer: B
Diff: 1 Page Ref: Sec. 7.2

46) Which one of the following atoms has the largest radius?
A) O
B) F
C) S
D) Cl
E) Ne
Answer: C
Diff: 1 Page Ref: Sec. 7.2

47) Which one of the following atoms has the largest radius?
A) Sr
B) Ca
C) K
D) Rb
E) Y
Answer: D
Diff: 1 Page Ref: Sec. 7.2

48) Which one of the following has the smallest radius?
A) Na
B) Cl
C) Fe
D) P
E) Br
Answer: B
Diff: 1 Page Ref: Sec. 7.2

49) Which one of the following atoms has the largest radius?
A) I
B) Co
C) Ba
D) Sr
E) Ca
Answer: C
Diff: 1 Page Ref: Sec. 7.2

50) Which one of the following elements has the largest atomic radius?
A) Se
B) As
C) S
D) Sb
E) Te
Answer: D
Diff: 1   Page Ref: Sec. 7.2

51) Which one of the following elements has the largest atomic radius?
A) O
B) F
C) Al
D) P
E) B
Answer: C
Diff: 1   Page Ref: Sec. 7.2

52) In which of the following atoms is the 2s orbital closest to the nucleus?
A) S
B) Cl
C) P
D) Si
E) The 2s orbitals are the same distance from the nucleus in all of these atoms.
Answer: B
Diff: 1   Page Ref: Sec. 7.2

53) In which of the following atoms is the 3s orbital closest to the nucleus?
A) Br
B) Cl
C) At
D) I
E) The 3s orbitals are the same distance from the nucleus in all of these atoms.
Answer: C
Diff: 2   Page Ref: Sec. 7.2

54) Which of the following correctly lists the five atoms in order of increasing size (smallest to largest)?
A) O < F < S < Mg < Ba
B) F < O < S < Mg < Ba
C) F < O < S < Ba < Mg
D) O < F < S < Ba < Mg
E) F < S < O < Mg < Ba
Answer: B
Diff: 1   Page Ref: Sec. 7.2

55) Which of the following correctly lists the five atoms in order of increasing size (smallest to largest)?
A) F < K < Ge < Br < Rb
B) F < Ge < Br < K < Rb
C) F < K < Br < Ge < Rb
D) F < Br < Ge < K < Rb
E) F < Br < Ge < Rb < K
Answer: D
Diff: 1   Page Ref: Sec. 7.2

56) Of the choices below, which gives the order for first ionization energies?
A) Cl > S > Al > Ar > Si
B) Ar > Cl > S > Si > Al
C) Al > Si > S > Cl > Ar
D) Cl > S > Al > Si > Ar
E) S > Si > Cl > Al > Ar
Answer: B
Diff: 1 Page Ref: Sec. 7.4

57) Of the following atoms, which has the largest first ionization energy?
A) Br
B) O
C) C
D) P
E) I
Answer: B
Diff: 1 Page Ref: Sec. 7.4

58) Of the following elements, which has the largest first ionization energy?
A) Na
B) Al
C) Se
D) Cl
E) Br
Answer: D
Diff: 1 Page Ref: Sec. 7.4

59) Of the following elements, which has the largest first ionization energy?
A) K
B) Rb
C) Sr
D) Ca
E) Ba
Answer: D
Diff: 1 Page Ref: Sec. 7.3

60) Of the following elements, which has the largest first ionization energy?
A) Se
B) As
C) S
D) Sb
E) Ge
Answer: C
Diff: 1 Page Ref: Sec. 7.4

61) Of the following elements, which has the largest first ionization energy?
A) B
B) N
C) P
D) Si
E) C
Answer: B
Diff: 1 Page Ref: Sec. 7.4

62) Of the elements below, __________ has the largest first ionization energy.
A) Li
B) K
C) Na
D) H
E) Rb
Answer: D
Diff: 1 Page Ref: Sec. 7.4

63) __________ have the lowest first ionization energies of the groups listed.
A) Alkali metals
B) Transition elements
C) Halogens
D) Alkaline earth metals
E) Noble gases
Answer: A
Diff: 1 Page Ref: Sec. 7.4

64) Which of the following has the largest second ionization energy?
A) Si
B) Mg
C) Al
D) Na
E) P
Answer: D
Diff: 2 Page Ref: Sec. 7.3

65) Which of the following has the largest second ionization energy?
A) Ca
B) K
C) Ga
D) Ge
E) Se
Answer: B
Diff: 1 Page Ref: Sec. 7.4

66) Which equation correctly represents the first ionization of aluminum?
A) $Al^- (g) \rightarrow Al (g) + e^-$
B) $Al (g) \rightarrow Al^- (g) + e^-$
C) $Al (g) + e^- \rightarrow Al^- (g)$
D) $Al (g) \rightarrow Al^+ (g) + e^-$
E) $Al^+ (g) + e^- \rightarrow Al (g)$
Answer: D
Diff: 1 Page Ref: Sec. 7.4

67) Which of the following correctly represents the second ionization of aluminum?

A) Al^{+} (g) + e^{-} $\rightarrow$ Al (g)

B) Al (g) $\rightarrow$ Al^{+} (g) + e^{-}

C) Al- (g) + e^{-} $\rightarrow$ Al^{2-} (g)

D) Al^{+} (g) + e^{-} $\rightarrow$ Al^{2+} (g)

E) Al^{+} (g) $\rightarrow$ Al^{2+} (g) + e^{-}

Answer: E
Diff: 1 Page Ref: Sec. 7.4

68) Which equation correctly represents the first ionization of phosphorus?

A) P (g) + e^{-} $\rightarrow$ P^{-} (g)

B) P (g) $\rightarrow$ P^{-} (g) + e^{-}

C) P (g) $\rightarrow$ P^{+} (g) + e^{-}

D) P^{-} (g) $\rightarrow$ P (g) + e^{-}

E) P^{+} (g) + e^{-} $\rightarrow$ P (g)

Answer: C
Diff: 1 Page Ref: Sec. 7.4

69) Which of the following correctly represents the second ionization of phosphorus?

A) P^{+} (g) + e^{-} $\rightarrow$ P^{2+} (g)

B) P (g) $\rightarrow$ P^{+} (g) + e^{-}

C) P^{-} (g) + e^{-} $\rightarrow$ P^{2-} (g)

D) P^{+} (g) $\rightarrow$ P^{2+} (g) + e^{-}

E) P^{+} (g) + e^{-} $\rightarrow$ P (g)

Answer: D
Diff: 1 Page Ref: Sec. 7.4

70) Which equation correctly represents the first ionization of calcium?

A) Ca (g) $\rightarrow$ Ca^{+} (g) + e^{-}

B) Ca (g) $\rightarrow$ Ca^{-} (g) + e^{-}

C) Ca (g) + e^{-} $\rightarrow$ Ca^{-} (g)

D) Ca^{-} (g) $\rightarrow$ Ca (g) + e^{-}

E) Ca^{+} (g) + e^{-} $\rightarrow$ Ca (g)

Answer: A
Diff: 1 Page Ref: Sec. 7.4

71) Which of the following correctly represents the second ionization of calcium?

A) Ca (g) $\rightarrow$ Ca^{+} (g) + e^{-}

B) Ca^{+} (g) $\rightarrow$ Ca^{2+} (g) + e^{-}

C) Ca- (g) + e^{-} $\rightarrow$ Ca^{2-} (g)

D) Ca^{+} (g) + e^{-} $\rightarrow$ Ca^{2+} (g)

E) Ca^{+} (g) + e^{-} $\rightarrow$ Ca (g)

Answer: B
Diff: 1 Page Ref: Sec. 7.4

72) Which ion below has the largest radius?

A) Cl^-

B) K^+

C) Br^-

D) F^-

E) Na^+

Answer: C

Diff: 1 Page Ref: Sec. 7.4

73) The ion with the smallest diameter is __________.

A) Br^-

B) Cl^-

C) I^-

D) F^-

E) O^{2-}

Answer: D

Diff: 1 Page Ref: Sec. 7.4

74) Of the following species, __________ has the largest radius.

A) Rb^+

B) Sr^{2+}

C) Br^-

D) Kr

E) Ar

Answer: C

Diff: 1 Page Ref: Sec. 7.3

75) Of the compounds below, __________ has the smallest ionic separation.

A) KF

B) K_2S

C) RbCl

D) $SrBr_2$

E) RbF

Answer: A

Diff: 1 Page Ref: Sec. 7.3

76) Which of the following is an isoelectronic series?

A) B^{5-}, Si^{4-}, As^{3-}, Te^{2-}

B) F^-, Cl^-, Br^-, I^-

C) S, Cl, Ar, K

D) Si^{2-}, P^{2-}, S^{2-}, Cl^{2-}

E) O^{2-}, P^-, Ne, Na^+

Answer: E

Diff: 1 Page Ref: Sec. 7.3

77) Which isoelectronic series is correctly arranged in order of increasing radius?
A) $K^{+} < Ca2^{+} < Ar < Cl^{-}$
B) $Cl^{-} < Ar < K^{+} < Ca^{2+}$
C) $Ca^{2+} < Ar < K^{+} < Cl^{-}$
D) $Ca^{2+} < K^{+} < Ar < Cl^{-}$
E) $Ca^{2+} < K^{+} < Cl^{-} < Ar$
Answer: D
Diff: 1 Page Ref: Sec. 7.3

78) __________ is isoelectronic with argon and __________ is isoelectronic with neon.
A) Cl^{-}, F^{-}
B) Cl^{-}, Cl^{+}
C) F^{+}, F^{-}
D) Ne^{-}, Kr^{+}
E) Ne^{-}, Ar^{+}
Answer: A
Diff: 1 Page Ref: Sec. 7.3

79) Of the following elements, __________ has the most negative electron affinity.
A) Na
B) Li
C) Be
D) N
E) F
Answer: E
Diff: 1 Page Ref: Sec. 7.4

80) Of the following elements, __________ has the most negative electron affinity.
A) S
B) Cl
C) Se
D) Br
E) I
Answer: B
Diff: 1 Page Ref: Sec. 7.4

81) Of the following elements, __________ has the most negative electron affinity.
A) P
B) Al
C) Si
D) Cl
E) B
Answer: D
Diff: 1 Page Ref: Sec. 7.4

82) Of the following elements, __________ has the most negative electron affinity.
A) O
B) K
C) B
D) Na
E) S
Answer: E
Diff: 1 Page Ref: Sec. 7.4

83) Chlorine is much more apt to exist as an anion than is sodium. This is because __________.
A) chlorine is bigger than sodium
B) chlorine has a greater ionization energy than sodium does
C) chlorine has a greater electron affinity than sodium does
D) chlorine is a gas and sodium is a solid
E) chlorine is more metallic than sodium
Answer: C
Diff: 1 Page Ref: Sec. 7.4

84) Sodium is much more apt to exist as a cation than is chlorine. This is because __________.
A) chlorine is a gas and sodium is a solid
B) chlorine has a greater electron affinity than sodium does
C) chlorine is bigger than sodium
D) chlorine has a greater ionization energy than sodium does
E) chlorine is more metallic than sodium
Answer: D
Diff: 1 Page Ref: Sec. 7.4

85) Which equation correctly represents the electron affinity of calcium?
A) $Ca (g) + e^- \rightarrow Ca^- (g)$
B) $Ca (g) \rightarrow Ca^+ (g) + e^-$
C) $Ca (g) \rightarrow Ca^- (g) + e^-$
D) $Ca^- (g) \rightarrow Ca (g) + e^-$
E) $Ca^+ (g) + e^- \rightarrow Ca (g)$
Answer: A
Diff: 1 Page Ref: Sec. 7.4

86) Which of the following correctly represents the electron affinity of bromine?
A) $Br (g) \rightarrow Br^+ (g) + e^-$
B) $Br (g) + e^- \rightarrow Br^- (g)$
C) $Br_2 (g) + e^- \rightarrow Br^- (g)$
D) $Br_2 (g) + 2e^- \rightarrow 2Br^- (g)$
E) $Br^+ (g) + e^- \rightarrow Br (g)$
Answer: B
Diff: 1 Page Ref: Sec. 7.4

Consider the following electron configurations to answer the questions that follow:

(i) $1s^2 2s^2 2p^6 3s^1$

(ii) $1s^2 2s^2 2p^6 3s^2$

(iii) $1s^2 2s^2 2p^6 3s^2 3p^1$

(iv) $1s^2 2s^2 2p^6 3s^2 3p^4$

(v) $1s^2 2s^2 2p^6 3s^2 3p^5$

87) The electron configuration belonging to the atom with the highest second ionization energy is __________.
A) (i)
B) (ii)
C) (iii)
D) (iv)
E) (v)
Answer: A
Diff: 1 Page Ref: Sec. 7.4

88) The electron configuration that belongs to the atom with the lowest second ionization energy is __________.
A) (i)
B) (ii)
C) (iii)
D) (iv)
E) (v)
Answer: B
Diff: 1 Page Ref: Sec. 7.4

89) The electron configuration of the atom with the most negative electron affinity is __________.
A) (i)
B) (ii)
C) (iii)
D) (iv)
E) (v)
Answer: E
Diff: 1 Page Ref: Sec. 7.5

90) The electron configuration of the atom that is expected to have a positive electron affinity is __________.
A) (i)
B) (ii)
C) (iii)
D) (iv)
E) (v)
Answer: B
Diff: 1 Page Ref: Sec. 7.5

91) Of the elements below, __________ is the most metallic.
A) sodium
B) barium
C) magnesium
D) calcium
E) cesium
Answer: E
Diff: 1 Page Ref: Sec. 7.5

92) Which one of the following is a metalloid?
A) Ge
B) S
C) Br
D) Pb
E) C
Answer: A
Diff: 1 Page Ref: Sec. 7.5

93) Of the elements below, __________ is the most metallic.
A) Na
B) Mg
C) Al
D) K
E) Ar
Answer: D
Diff: 1 Page Ref: Sec. 7.5

94) The list that correctly indicates the order of metallic character is __________.
A) B > N > C
B) F > Cl > S
C) Si > P > S
D) P > S > Se
E) Na > K > Rb
Answer: C
Diff: 1 Page Ref: Sec. 7.5

95) Of the elements below, __________ has the highest melting point.
A) Ca
B) K
C) Fe
D) Na
E) Ba
Answer: C
Diff: 1 Page Ref: Sec. 7.5

96) Of the following metals, __________ exhibits multiple oxidation states.
A) Al
B) Cs
C) V
D) Ca
E) Na
Answer: C
Diff: 1 Page Ref: Sec. 7.6

97) Which of these oxides is most basic?
A) K_2O
B) Al_2O_3
C) CO_2
D) MgO
E) Na_2O
Answer: A
Diff: 1 Page Ref: Sec. 7.6

98) Of the following oxides, __________ is the most acidic.
A) CaO
B) CO_2
C) Al_2O_3
D) Li_2O
E) Na_2O
Answer: B
Diff: 1 Page Ref: Sec. 7.6

99) Which one of the following compounds would produce an acidic solution when dissolved in water?
A) Na_2O
B) CaO
C) MgO
D) CO_2
E) SrO
Answer: D
Diff: 1 Page Ref: Sec. 7.5

100) Nonmetals can be __________ at room temperature.
A) solid, liquid, or gas
B) solid or liquid
C) solid only
D) liquid only
E) liquid or gas
Answer: A
Diff: 1 Page Ref: Sec. 7.5

101) Which of the following is not a characteristic of metals?
A) acidic oxides
B) low ionization energies
C) malleability
D) ductility
E) These are all characteristics of metals.
Answer: A
Diff: 1 Page Ref: Sec. 7.6

102) When two elements combine to form a compound, the greater the difference in metallic character between the two elements, the greater the likelihood that the compound will be __________.
A) a gas at room temperature
B) a solid at room temperature
C) metallic
D) nonmetallic
E) a liquid at room temperature
Answer: B
Diff: 1 Page Ref: Sec. 7.6

103) Between which two elements is the difference in metallic character the greatest?
A) Rb and O
B) O and I
C) Rb and I
D) Li and O
E) Li and Rb
Answer: A
Diff: 1 Page Ref: Sec. 7.6

104) Which of the following traits characterizes the alkali metals?
A) very high melting point
B) existence as diatomic molecules
C) formation of dianions
D) the lowest first ionization energies in a period
E) the smallest atomic radius in a period
Answer: D
Diff: 1 Page Ref: Sec. 7.6

105) This element is more reactive than lithium and magnesium but less reactive than potassium. This element is __________.
A) Na
B) Rb
C) Ca
D) Be
E) Fr
Answer: A
Diff: 1 Page Ref: Sec. 7.6

106) Which one of the following is not true about the alkali metals?
A) They are low density solids at room temperature.
B) They all readily form ions with a +1 charge.
C) They all have 2 electrons in their valence shells.
D) They are very reactive elements.
E) They have the lowest first ionization energies of the elements.
Answer: C
Diff: 1 Page Ref: Sec. 7.6

107) Consider the following properties of an element:

(i) It is solid at room temperature.
(ii) It easily forms an oxide when exposed to air.
(iii) When it reacts with water, hydrogen gas evolves.
(iv) It must be stored submerged in oil.

Which element fits the above description the best?
A) sulfur
B) copper
C) mercury
D) sodium
E) magnesium
Answer: D
Diff: 1 Page Ref: Sec. 7.7

108) Alkaline earth metals __________.
A) have the smallest atomic radius in a given period
B) form monoanions
C) form basic oxides
D) exist as triatomic molecules
E) form halides with the formula MX
Answer: C
Diff: 1 Page Ref: Sec. 7.7

109) Which of the following generalizations cannot be made with regard to reactions of alkali metals? (The symbol M represents any one of the alkali metals.)
A) $M (s) + O_2 (g) \rightarrow MO_2 (s)$
B) $2M (s) + 2H_2O (l) \rightarrow 2MOH (aq) + H_2 (g)$
C) $2M (s) + H_2 (g) \rightarrow 2MH (s)$
D) $2M (s) + Cl_2 (g) \rightarrow 2MCl (s)$
E) $2M (s) + S (s) \rightarrow M_2S (s)$
Answer: A
Diff: 1 Page Ref: Sec. 7.7

110) Alkali metals tend to be more reactive than alkaline earth metals because __________.
A) alkali metals have lower densities
B) alkali metals have lower melting points
C) alkali metals have greater electron affinities
D) alkali metals have lower ionization energies
E) alkali metals are not more reactive than alkaline earth metals
Answer: D
Diff: 1 Page Ref: Sec. 7.7

111) Which one of the following beverages originally contained lithium salts?
A) Coca-Cola®
B) Pepsi-Cola®
C) Gatorade®
D) Koolaid®
E) Seven-Up®
Answer: E
Diff: 1 Page Ref: Sec. 7.7

112) Consider the general valence electron configuration of ns^2np^5 and the following statements:

(i) Elements with this electron configuration are expected to form -1 anions.
(ii) Elements with this electron configuration are expected to have large positive electron affinities.
(iii) Elements with this electron configuration are nonmetals.
(iv) Elements with this electron configuration form acidic oxides.

Which statements are true?
A) (i) and (ii)
B) (i), (ii), and (iii)
C) (ii) and (iii)
D) (i), (iii,) and (iv)
E) All statements are true.
Answer: D
Diff: 2 Page Ref: Sec. 7.6, 7.7

113) All of the following are ionic compounds except __________.
A) K_2O
B) Na_2SO_4
C) SiO_2
D) Li_3N
E) NaCl
Answer: C
Diff: 1 Page Ref: Sec. 7.7

114) Which one of the following compounds produces a basic solution when dissolved in water?
A) SO_2
B) Na_2O
C) CO_2
D) OF_2
E) O_2
Answer: B
Diff: 1 Page Ref: Sec. 7.7

115) Element M reacts with oxygen to form an oxide with the formula MO. When MO is dissolved in water, the resulting solution is basic. Element M could be __________.
A) Na
B) Ba
C) S
D) N
E) C
Answer: B
Diff: 1 Page Ref: Sec. 7.7

116) Which element is solid at room temperature?
A) Cl_2
B) F_2
C) Br_2
D) I_2
E) H_2
Answer: D
Diff: 1 Page Ref: Sec. 7.7

117) __________ is a unique element and does not truly belong to any family.
A) Nitrogen
B) Radium
C) Hydrogen
D) Uranium
E) Helium
Answer: C
Diff: 1 Page Ref: Sec. 7.7

118) Of the following statements, __________ is not true for oxygen.
A) The most stable allotrope of oxygen is O_2.
B) The chemical formula of ozone is O_3.
C) Dry air is about 79% oxygen.
D) Oxygen forms peroxide and superoxide anions.
E) Oxygen is a colorless gas at room temperature.
Answer: C
Diff: 1 Page Ref: Sec. 7.7

119) Which one of the following elements has an allotrope that is produced in the upper atmosphere by lightning?
A) N
B) O
C) S
D) Cl
E) He
Answer: B
Diff: 1 Page Ref: Sec. 7.7

120) In nature, sulfur is most commonly found in __________.
A) pure elemental sulfur
B) sulfur oxides
C) metal sulfides
D) sulfuric acid
E) H_2S
Answer: C
Diff: 1 Page Ref: Sec. 7.7

121) All of the halogens __________.
A) exist under ambient conditions as diatomic gases
B) tend to form positive ions of several different charges
C) tend to form negative ions of several different charges
D) exhibit metallic character
E) form salts with alkali metals with the formula MX
Answer: E
Diff: 1 Page Ref: Sec. 7.7

122) This element reacts with hydrogen to produce a gas with the formula HX. When dissolved in water, HX forms an acidic solution. X is __________,
A) Na
B) H
C) C
D) Br
E) O
Answer: D
Diff: 1 Page Ref: Sec. 7.7

123) In nature, the noble gases exist as
A) monatomic gaseous atoms
B) the gaseous fluorides
C) solids in rocks and in minerals
D) alkali metal salts
E) the sulfides
Answer: A
Diff: 1 Page Ref: Sec. 7.8

124) Hydrogen is unique among the elements because __________.

1. It is not really a member of any particular group.
2. Its electron is not at all shielded from its nucleus.
3. It is the lightest element.
4. It is the only element to exist at room temperature as a diatomic gas.
5. It exhibits some chemical properties similar to those of groups 1A and 7A.

A) 1, 2, 3, 5
B) 1, 2, 3, 4, 5
C) 1, 4, 5
D) 3, 4
E) 2, 3, 4, 5
Answer: A
Diff: 1 Page Ref: Sec. 7.8

125) Hydrogen is unique among the elements because __________.

1. It has only one valence electron.
2. It is the only element that can emit an atomic spectrum.
3. Its electron is not at all shielded from its nucleus.
4. It is the lightest element.
5. It is the only element to exist at room temperature as a diatomic gas.

A) 1, 2, 3, 4, 5
B) 1, 3, 4
C) 1, 2, 3, 4
D) 2, 3, 4
E) 3, 4
Answer: E
Diff: 2 Page Ref: Sec. 7.8

126) The noble gases were, until relatively recently, thought to be entirely unreactive. Experiments in the early 1960s showed that Xe could, in fact, form compounds with fluorine. The formation of compounds consisting of Xe is made possible by __________.
A) the availability of xenon atoms
B) xenon's noble gas electron configuration
C) the stability of xenon atoms
D) xenon's relatively low ionization energy
E) xenon's relatively low electron affinity
Answer: D
Diff: 1 Page Ref: Sec. 7.7

127) Of the following elements, which have been shown to form compounds?

helium neon argon krypton xenon

A) xenon and argon
B) xenon only
C) xenon, krypton, and argon
D) xenon and krypton
E) None of the above can form compounds.
Answer: C
Diff: 2 Page Ref: Sec. 7.7

128) Xenon has been shown to form compounds only when it is combined with __________.
A) something with a tremendous ability to remove electrons from other substances
B) another noble gas
C) something with a tremendous ability to donate electrons to other substances
D) an alkali metal
E) an alkaline earth metal
Answer: A
Diff: 1 Page Ref: Sec. 7.8

Short Answer

1) Write the balanced reaction between zinc oxide and sulfuric acid.
Answer: $ZnO + H_2SO_4 \rightarrow ZnSO_4 + H_2O$
Diff: 1 Page Ref: Sec. 7.5

2) In their compounds, the charges on the alkali metals and the alkaline earth metals are __________ and __________, respectively.
Answer: +1, +2
Diff: 1 Page Ref: Sec. 7.6

3) Which alkali metals can react with oxygen to form either the peroxide or the superoxide?
Answer: K, Rb, and Cs
Diff: 1 Page Ref: Sec. 7.7

4) Write the balanced equation for the reaction of elemental fluorine with liquid water.
Answer: $2H_2O\ (l) + 2F_2\ (g) \rightarrow 4HF\ (aq) + O_2\ (g)$
Diff: 1 Page Ref: Sec. 7.7

5) Write the balanced equation for the reaction of elemental chlorine with liquid water.
Answer: $Cl_2\ (g) + H_2O\ (l) \rightarrow HCl\ (aq) + HOCl\ (aq)$
Diff: 1 Page Ref: Sec. 7.7

6) Of the alkaline earth metals, which two elements are the least reactive?
Answer: Be and Mg
Diff: 3 Page Ref: Sec. 7.7

7) List seven nonmetals that exist as diatomic molecules in their elemental forms.
Answer: hydrogen, oxygen, nitrogen, fluorine, chlorine, bromine, iodine
Diff: 2 Page Ref: Sec. 7.7

8) What are the elements called that are located between the metals and non-metalsa?
Answer: Metalloids
Diff: 1 Page Ref: Sec 7.6

9) Which metal is a liquid at room temperature?
Answer: Mercury (Hg)
Diff: 1 Page Ref: Sec 7.6

10) Complete the following: $P_4O_6 + 6H_2O$
Answer: $4H_3PO_4$
Diff: 1 Page Ref: Sec 7.6

11) $[Xe]6s^2$ is the electron configuration for __________?
Answer: barium
Diff: 2 Page Ref: Sec 7.6

12) All of the group VIA elements are solids except __________?
Answer: oxygen
Diff: 2 Page Ref: Sec 7.8

13) As successive electrons are removed from an element, the ionization energy __________.
Answer: increases
Diff: 2 Page Ref: Sec 7.4

14) Which noble gas has the highest first ionization energy?
Answer: helium
Diff: 2 Page Ref: Sec 7.4

15) When electrons are removed from a lithium atom they are removed first from which orbital __________?
Answer: $2s^1$
Diff: 2 Page Ref: Sec 7.4

16) An added electron to the element bromine goes into which orbital __________?
Answer: 4p
Diff: 2 Page Ref: Sec 7.5

True/False

1) Electron affinity measures how easy an atom gains an electron.
Answer: TRUE
Diff: 2 Page Ref: Sec 7.5

2) The effective nuclear charge acting on an electron is larger than the actual nuclear charge.
Answer: FALSE
Diff: 1 Page Ref: Sec 7.2

3) The atomic radius of iodine is one-half the distance separating the iodine nuclei.
Answer: TRUE
Diff: 1 Page Ref: Sec 7.3

4) A group of ions all containing the same number of electrons constitute an isoelectronic series.
Answer: TRUE
Diff: 1 Page Ref: Sec 7.3

5) Cadmium preferentially binds to carbonic anhydrase, displacing zinc.
Answer: TRUE
Diff: 1 Page Ref: Sec 7.3

Chemistry, 11e (Brown)
Chapter 8, Basic Concepts of Chemical Bonding

Multiple-Choice and Bimodal

1) There are __________ paired and __________ unpaired electrons in the Lewis symbol for a phosphorus atom.
A) 4, 2
B) 2, 4
C) 2, 3
D) 4, 3
E) 0, 3
Answer: C
Diff: 1 Page Ref: Sec. 8.1

2) In the Lewis symbol for a fluorine atom, there are __________ paired and __________ unpaired electrons.
A) 4, 2
B) 4,1
C) 2, 5
D) 6, 1
E) 0, 5
Answer: D
Diff: 1 Page Ref: Sec. 8.1

3) Based on the octet rule, magnesium most likely forms a __________ ion.
A) Mg^{2+}
B) Mg^{2-}
C) Mg^{6-}
D) Mg^{6+}
E) Mg^{-}
Answer: A
Diff: 1 Page Ref: Sec. 8.1

4) Based on the octet rule, phosphorus most likely forms a __________ ion.
A) P^{3+}
B) P^{3-}
C) P^{5+}
D) P^{5-}
E) P^{+}
Answer: B
Diff: 1 Page Ref: Sec. 8.1

5) Based on the octet rule, iodine most likely forms an __________ ion.
A) I^{2+}
B) I^{4+}
C) I^{4-}
D) I^{+}
E) I^{-}
Answer: E
Diff: 1 Page Ref: Sec. 8.1

6) There are __________ unpaired electrons in the Lewis symbol for an oxygen atom.
A) 0
B) 1
C) 2
D) 4
E) 3
Answer: C
Diff: 1 Page Ref: Sec. 8.1

7) How many unpaired electrons are there in the Lewis structures of a N^{3-} ion?
A) 0
B) 1
C) 2
D) 3
E) This cannot be predicted.
Answer: A
Diff: 1 Page Ref: Sec. 8.1

8) How many unpaired electrons are there in an O^{2-} ion?
A) 0
B) 1
C) 2
D) 3
E) This cannot be predicted.
Answer: A
Diff: 1 Page Ref: Sec. 8.1

9) The electron configuration of the phosph?ide ion (P^{3-}) is __________.
A) $[Ne]3s^2$
B) $[Ne]3s^2 3p^1$
C) $[Ne]3s^2 3p^3$
D) $[Ne]3p^2$
E) $[Ne]3s^2 3p^6$
Answer: E
Diff: 1 Page Ref: Sec. 8.1

10) The halogens, alkali metals, and alkaline earth metals have __________ valence electrons, respectively.
A) 7, 4, and 6
B) 1, 5, and 7
C) 8, 2, and 3
D) 7, 1, and 2
E) 2, 7, and 4
Answer: D
Diff: 2 Page Ref: Sec. 8.1

11) The only noble gas without eight valence electrons is __________.
A) Ar
B) Ne
C) He
D) Kr
E) All noble gases have eight valence electrons.
Answer: C
Diff: 1 Page Ref: Sec. 8.1

12) Which of the following would have to lose two electrons in order to achieve a noble gas electron configuration __________?

O Sr Na Se Br

A) O, Se
B) Sr
C) Na
D) Br
E) Sr, O, Se
Answer: B
Diff: 1 Page Ref: Sec. 8.1

13) Which of the following would have to gain two electrons in order to achieve a noble gas electron configuration __________?

O Sr Na Se Br

A) Br
B) Sr
C) Na
D) O, Se
E) Sr, O, Se
Answer: D
Diff: 1 Page Ref: Sec. 8.1

14) For a given arrangement of ions, the lattice energy increases as ionic radius __________ and as ionic charge __________.
A) decreases, increases
B) increases, decreases
C) increases, increases
D) decreases, decreases
E) This cannot be predicted.
Answer: A
Diff: 1 Page Ref: Sec. 8.2

15) The electron configuration of the S^{2-} ion is __________.
A) $[Ar]3s^2 3p^6$
B) $[Ar]3s^2 3p^2$
C) $[Ne]3s^2 3p^2$
D) $[Ne]3s^2 3p^6$
E) $[Kr]3s^2 2p^{-6}$
Answer: D
Diff: 1 Page Ref: Sec. 8.2

16) The principal quantum number of the electrons that are lost when tungsten forms a caton is __________.
A) 6
B) 5
C) 4
D) 3
E) 2
Answer: A
Diff: 1 Page Ref: Sec. 8.2

17) Which one of the following species has the electron configuration $[Ar]3d^4$?
A) Mn^{2+}
B) Cr^{2+}
C) V^{3+}
D) Fe^{3+}
E) K^{+}
Answer: B
Diff: 1 Page Ref: Sec. 8.2

18) What is the electron configuration for the Co^{2+} ion?
A) $[Ar]4s^1 3d^6$
B) $[Ar]4s^0 3d^7$
C) $[Ar]4s^0 3d^5$
D) $[Ar]4s^2 3d^9$
E) $[Ne]3s^2 3p^{10}$
Answer: B
Diff: 1 Page Ref: Sec. 8.2

19) What is the electron configuration for the Fe^{2+} ion?
A) $[Ar]4s^0 3d^6$
B) $[Ar]4s^2 3d^4$
C) $[Ar]4s^0 3d^8$
D) $[Ar]4s^2 3d^8$
E) $[Ar]4s^6 3d^2$
Answer: A
Diff: 1 Page Ref: Sec. 8.2

20) The formula of palladium(IV) sulfide is __________.
A) Pd_2S_4
B) PdS_4
C) Pd_4S
D) PdS_2
E) Pd_2S_2
Answer: D
Diff: 1 Page Ref: Sec. 8.2

21) Elements from opposite sides of the periodic table tend to form __________.
A) covalent compounds
B) ionic compounds
C) compounds that are gaseous at room temperature
D) homonuclear diatomic compounds
E) covalent compounds that are gaseous at room temperature
Answer: B
Diff: 1 Page Ref: Sec. 8.2

22) Determining lattice energy from Born-Haber cycle data requires the use of __________.
A) the octet rule
B) Coulomb's law
C) Periodic law
D) Hess's law
E) Avogadro's number
Answer: D
Diff: 2 Page Ref: Sec. 8.2

23) How many single covalent bonds must a silicon atom form to have a complete octet in its valence shell?
A) 3
B) 4
C) 1
D) 2
E) 0
Answer: B
Diff: 1 Page Ref: Sec. 8.3

24) A __________ covalent bond between the same two atoms is the longest.
A) single
B) double
C) triple
D) They are all the same length.
E) strong
Answer: A
Diff: 1 Page Ref: Sec. 8.3

25) How many hydrogen atoms must bond to silicon to give it an octet of valence electrons?
A) 1
B) 2
C) 3
D) 4
E) 5
Answer: D
Diff: 1 Page Ref: Sec. 8.3

26) A double bond consists of __________ pairs of electrons shared between two atoms.
A) 1
B) 2
C) 3
D) 4
E) 6
Answer: B
Diff: 2 Page Ref: Sec. 8.3

27) What is the maximum number of double bonds that a hydrogen atom can form?
A) 0
B) 1
C) 2
D) 3
E) 4
Answer: A
Diff: 1 Page Ref: Sec. 8.3

28) What is the maximum number of double bonds that a carbon atom can form?
A) 4
B) 1
C) 0
D) 2
E) 3
Answer: D
Diff: 1 Page Ref: Sec. 8.3

29) In the molecule below, which atom has the largest partial negative charge __________?

```
      Cl
      |
F – C – Br
      |
      I
```


A) Cl
B) F
C) Br
D) I
E) C
Answer: B
Diff: 1 Page Ref: Sec. 8.4

30) The ability of an atom in a molecule to attract electrons is best quantified by the __________.
A) paramagnetism
B) diamagnetism
C) electronegativity
D) electron change-to-mass ratio
E) first ionization potential
Answer: C
Diff: 1 Page Ref: Sec. 8.4

31) Given the electronegativities below, which covalent single bond is most polar?

Element:	H	C	N	O
Electronegativity:	2.1	2.5	3.0	3.5

A) C–H
B) N–H
C) O–H
D) O–C
E) O–N
Answer: C
Diff: 1 Page Ref: Sec. 8.4

32) Electronegativity __________ from left to right within a period and __________ from top to bottom within a group.
A) decreases, increases
B) increases, increases
C) increases, decreases
D) stays the same, increases
E) increases, stays the same
Answer: C
Diff: 1 Page Ref: Sec. 8.4

33) A nonpolar bond will form between two __________ atoms of __________ electronegativity.
A) different, opposite
B) identical, different
C) different, different
D) similar, different
E) identical, equal
Answer: E
Diff: 1 Page Ref: Sec. 8.4

34) The ion ICl_4^- has __________ valence electrons.
A) 34
B) 35
C) 36
D) 28
E) 8
Answer: C
Diff: 1 Page Ref: Sec. 8.5

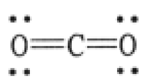
35) The ion NO^- has __________ valence electrons.
A) 15
B) 14
C) 16
D) 10
E) 12
Answer: E
Diff: 1 Page Ref: Sec. 8.5

36) The Lewis structure of AsH_3 shows __________ nonbonding electron pair(s) on As.
A) 0
B) 1
C) 2
D) 3
E) This cannot be determined from the data given.
Answer: B
Diff: 1 Page Ref: Sec. 8.5

37) The Lewis structure of PF_3 shows that the central phosphorus atom has __________ nonbonding and __________ bonding electron pairs.
A) 2, 2
B) 1, 3
C) 3, 1
D) 1, 2
E) 3, 3
Answer: B
Diff: 1 Page Ref: Sec. 8.5

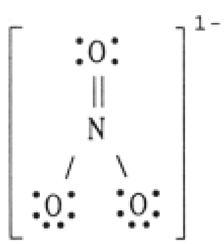
38) The Lewis structure of HCN (H bonded to C) shows that __________ has __________ nonbonding electron pairs.
A) C, 1
B) N, 1
C) H, 1
D) N, 2
E) C, 2
Answer: B
Diff: 2 Page Ref: Sec. 8.5

39) The formal charge on carbon in the molecule below is __________.



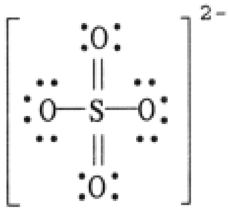
A) 0
B) +1
C) +2
D) +3
E) -1
Answer: A
Diff: 1 Page Ref: Sec. 8.5

40) The formal charge on nitrogen in NO_3- is __________.



A) -1
B) 0
C) +1
D) +2
E) -2
Answer: C
Diff: 2 Page Ref: Sec. 8.5

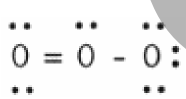
41) The formal charge on sulfur in SO_4^{2-} is __________, where the Lewis structure of the ion is:



A) -2
B) 0
C) +2
D) +4
E) -4
Answer: B
Diff: 2 Page Ref: Sec. 8.5

42) In the Lewis structure of ClF, the formal charge on Cl is __________ and the formal charge on F is __________.
A) -1, -1
B) 0, 0
C) 0, -1
D) +1, -1
E) -1, +1
Answer: B
Diff: 1 Page Ref: Sec. 8.5

43) In the resonance form of ozone shown below, the formal charge on the central oxygen atom is __________.



A) 0
B) +1
C) -1
D) +2
E) -2
Answer: B
Diff: 1 Page Ref: Sec. 8.6

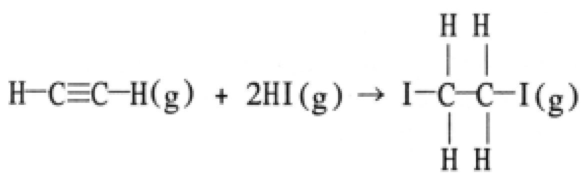
44) How many equivalent resonance forms can be drawn for CO_3^{2-} - (carbon is the central atom)?
A) 1
B) 2
C) 3
D) 4
E) 0
Answer: C
Diff: 1 Page Ref: Sec. 8.6

45) How many equivalent resonance forms can be drawn for SO_2 without expanding octet on the sulfur atom (sulfur is the central atom)?
A) 0
B) 2
C) 3
D) 4
E) 1
Answer: B
Diff: 1 Page Ref: Sec. 8.6

46) How many equivalent resonance structures can be drawn for the molecule of SO_3 without having to violate the octet rule on the sulfur atom?
A) 5
B) 2
C) 1
D) 4
E) 3
Answer: E
Diff: 1 Page Ref: Sec. 8.6

47) How many different types of resonance structures can be drawn for the ion SO_3^{2-} where all atoms satisfy the octet rule?
A) 1
B) 2
C) 3
D) 4
E) 5
Answer: A
Diff: 2 Page Ref: Sec. 8.6

48) Using the table of average bond energies below, the ΔH for the reaction is __________ kJ.



Bond:	C≡C	C–C	H–I	C–I	C–H
D (kJ/mol):	839	348	299	240	413

A) +160
B) -160
C) -217
D) -63
E) +63
Answer: C
Diff: 1 Page Ref: Sec. 8.8

49) Using the table of average bond energies below, the ΔH for the reaction is __________ kJ.

$$H\text{-}C \equiv C\text{-}H\ (g) + H\text{-}I\ (g) \rightarrow H_2C{=}CHI\ (g)$$

Bond:	C≡C	C=C	H–I	C–I	C–H
D (kJ/mol):	839	614	299	240	413

A) +506
B) -931
C) -506
D) -129
E) +129
Answer: D
Diff: 1   Page Ref: Sec. 8.8

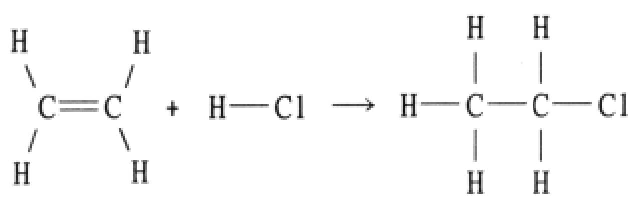
50) Using the table of average bond energies below, the ΔH for the reaction is __________ kJ.

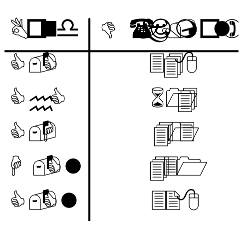
$$C \equiv O\ (g) + 2H_2\ (g) \rightarrow H_3C\text{-}O\text{-}H\ (g)$$

Bond:	C–O	C=O	C≡O	C–H	H–H	O–H
D (kJ/mol):	358	799	1072	413	436	463

A) +276
B) -276
C) +735
D) -735
E) -116
Answer: E
Diff: 1   Page Ref: Sec. 8.8

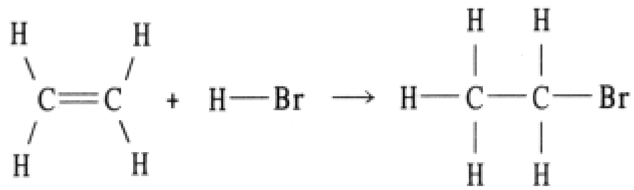
51) Using the table of bond dissociation energies, the ΔH for the following gas-phase reaction is __________ kJ.

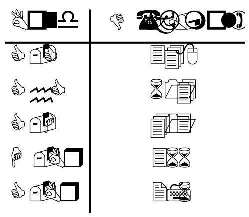




A) -44
B) 38
C) 304
D) 2134
E) -38
Answer: A
Diff: 1   Page Ref: Sec. 8.8

52) Using the table of bond dissociation energies, the ΔH for the following gas-phase reaction is __________ kJ.

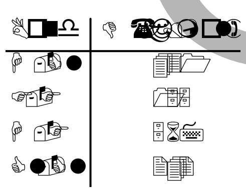




A) 291
B) 2017
C) -57
D) -356
E) -291
Answer: C
Diff: 1 Page Ref: Sec. 8.8

53) Using the table of bond dissociation energies, the ΔH for the following reaction is __________ kJ.

$$2HCl\,(g) + F_2\,(g) \rightarrow 2HF\,(g) + Cl_2\,(g)$$



A) -359
B) -223
C) 359
D) 223
E) 208
Answer: A
Diff: 1 Page Ref: Sec. 8.8

Multiple-Choice

54) Which ion below has a noble gas electron configuration?
A) Li^{2+}
B) Be^{2+}
C) B^{2+}
D) C^{2+}
E) N^{2-}
Answer: B
Diff: 1   Page Ref: Sec. 8.1

55) Of the ions below, only __________ has a noble gas electron configuration.
A) S^{3-}
B) O^{2+}
C) I^{+}
D) K^{-}
E) Cl^{-}
Answer: E
Diff: 1   Page Ref: Sec. 8.1

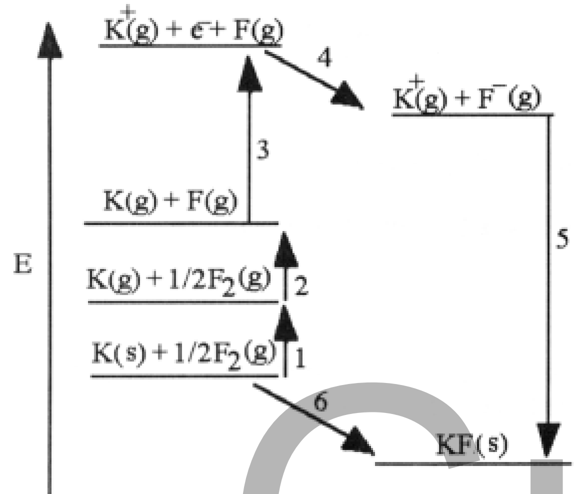
56) Which of the following has eight valence electrons?
A) Ti^{4+}
B) Kr
C) Cl^{-}
D) Na^{+}
E) all of the above
Answer: E
Diff: 3   Page Ref: Sec. 8.1

57) Which of the following does not have eight valence electrons?
A) Ca^{+}
B) Rb^{+}
C) Xe
D) Br^{-}
E) All of the above have eight valence electrons.
Answer: A
Diff: 3   Page Ref: Sec. 8.1

58) The chloride of which of the following metals should have the greatest lattice energy?
A) potassium
B) rubidium
C) sodium
D) lithium
E) cesium
Answer: D
Diff: 2   Page Ref: Sec. 8.2

59) Lattice energy is __________.
A) the energy required to convert a mole of ionic solid into its constituent ions in the gas phase
B) the energy given off when gaseous ions combine to form one mole of an ionic solid
C) the energy required to produce one mole of an ionic compound from its constituent elements in their standard states
D) the sum of ionization energies of the components in an ionic solid
E) the sum of electron affinities of the components in an ionic solid
Answer: A
Diff: 1   Page Ref: Sec. 8.2

The diagram below is the Born-huber cycle for the formation of crystalline potassium fluoride.



60) Which energy change corresponds to the electron affinity of fluorine?
A) 2
B) 5
C) 4
D) 1
E) 6
Answer: C
Diff: 1   Page Ref: Sec. 8.2

61) Which energy change corresponds to the first ionization energy of potassium?
A) 2
B) 5
C) 4
D) 3
E) 6
Answer: D
Diff: 1   Page Ref: Sec. 8.2

62) Using the Born-Haber cycle, the ΔH_f° of KBr is equal to __________.

A) $\Delta H_f^\circ[K\ (g)] + \Delta H_f^\circ[Br\ (g)] + I_1(K) + E(Br) + \Delta H_{lattice}$

B) $\Delta H_f^\circ[K\ (g)] - \Delta H_f^\circ[Br\ (g)] - I_1(K) - E(Br) - \Delta H_{lattice}$

C) $\Delta H_f^\circ[K\ (g)] - \Delta H_f^\circ[Br\ (g)] + I_1(K) - E(Br) + \Delta H_{lattice}$

D) $\Delta H_f^\circ[K\ (g)] + \Delta H_f^\circ[Br\ (g)] - I_1 - E(Br) + \Delta H_{lattice}$

E) $\Delta H_f^\circ[K\ (g)] + \Delta H_f^\circ[Br\ (g)] + I_1(K) + E(Br) - \Delta H_{lattice}$

Answer: E
Diff: 2 Page Ref: Sec. 8.2

63) The type of compound that is most likely to contain a covalent bond is __________.
A) one that is composed of a metal from the far left of the periodic table and a nonmetal from the far right of the periodic table
B) a solid metal
C) one that is composed of only nonmetals
D) held together by the electrostatic forces between oppositely charged ions
E) There is no general rule to predict covalency in bonds.
Answer: C
Diff: 1 Page Ref: Sec. 8.3

64) In which of the molecules below is the carbon-carbon distance the shortest?

A) $H_2C{=}CH_2$

B) $H\text{-}C \equiv C\text{-}H$

C) $H_3C\text{-}CH_3$

D) $H_2C{=}C{=}CH_2$

E) $H_3C\text{-}CH_2\text{-}CH_3$

Answer: B
Diff: 1 Page Ref: Sec. 8.3

65) Of the atoms below, __________ is the most electronegative.
A) Br
B) O
C) Cl
D) N
E) F
Answer: E
Diff: 1 Page Ref: Sec. 8.4

66) Of the atoms below, __________ is the most electronegative.
A) Si
B) Cl
C) Rb
D) Ca
E) S
Answer: B
Diff: 1 Page Ref: Sec. 8.4

67) Of the atoms below, __________ is the least electronegative.
A) Rb
B) F
C) Si
D) Cl
E) Ca
Answer: A
Diff: 1 Page Ref: Sec. 8.4

68) Which of the elements below has the largest electronegativity?
A) Si
B) Mg
C) P
D) S
E) Na
Answer: D
Diff: 1 Page Ref: Sec. 8.4

69) Of the molecules below, the bond in __________ is the most polar.
A) HBr
B) HI
C) HCl
D) HF
E) H_2
Answer: D
Diff: 1 Page Ref: Sec. 8.4

70) Of the bonds below, __________ is the least polar.
A) Na, S
B) P, S
C) C, F
D) Si, Cl
E) Na, Cl
Answer: B
Diff: 1 Page Ref: Sec. 8.4

71) Which of the following has the bonds correctly arranged in order of increasing polarity?
A) Be–F, Mg–F, N–F, O–F
B) O–F, N–F, Be–F, Mg–F
C) O–F, Be–F, Mg–F, N–F
D) N–F, Be–F, Mg–F, O–F
E) Mg–F, Be–F, N–F, O–F
Answer: B
Diff: 1 Page Ref: Sec. 8.4

72) Which two bonds are most similar in polarity?
A) O–F and Cl–F
B) B–F and Cl–F
C) Al–Cl and I–Br
D) I–Br and Si–Cl
E) Cl–Cl and Be–Cl
Answer: A
Diff: 2 Page Ref: Sec. 8.4

73) The bond length in an HI molecule is 1.61 Å and the measured dipole moment is 0.44 D. What is the magnitude (in units of *e*) of the negative charge on I in HI?

(1 debye = 3.34×10^{-34} coulomb-meters; ; e=1.6×10^{-19} coulombs)

A) 1.6×10^{-19}
B) 0.057
C) 9.1
D) 1
E) 0.22
Answer: B
Diff: 3 Page Ref: Sec. 8.4

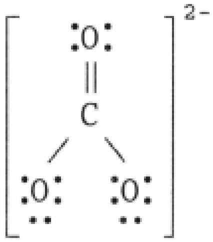
74) Which of the following names is/are correct for the compound TiO_2?
A) titanium dioxide and titanium (IV) oxide
B) titanium (IV) dioxide
C) titanium oxide
D) titanium oxide and titanium (IV) dioxide
E) titanium (II) oxide
Answer: A
Diff: 1 Page Ref: Sec. 8.4

75) Which of the following names is/are correct for the compound $SnCl_4$?
A) tin (II) chloride and tin (IV) chloride
B) tin tetrachloride and tin (IV) chloride
C) tin (IV) tetrachloride
D) tin chloride
E) tin chloride and tin (II) tetrachloride
Answer: B
Diff: 1 Page Ref: Sec. 8.4

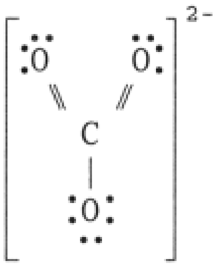
76) The Lewis structure of N_2H_2 shows __________.
A) a nitrogen-nitrogen triple bond
B) a nitrogen-nitrogen single bond
C) each nitrogen has one nonbinding electron pair
D) each nitrogen has two nonbinding electron pairs
E) each hydrogen has one nonbonding electron pair
Answer: C
Diff: 2 Page Ref: Sec. 8.5

77) The Lewis structure of the CO_3^{2-} ion is __________.

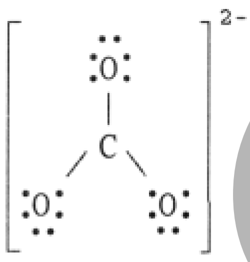
A)



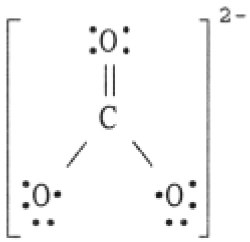
B)



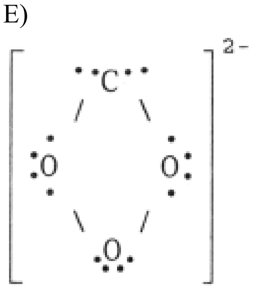
C)



D)



E)



Answer: A

Diff: 2 Page Ref: Sec. 8.5

78) In the nitrite ion (NO_2-) , __________.
A) both bonds are single bonds
B) both bonds are double bonds
C) one bond is a double bond and the other is a single bond
D) both bonds are the same
E) there are 20 valence electrons
Answer: D
Diff: 2 Page Ref: Sec. 8.6

79) Resonance structures differ by __________.
A) number and placement of electrons
B) number of electrons only
C) placement of atoms only
D) number of atoms only
E) placement of electrons only
Answer: E
Diff: 1 Page Ref: Sec. 8.6

80) To convert from one resonance structure to another, __________.
A) only atoms can be moved
B) electrons and atoms can both be moved
C) only electrons can be moved
D) neither electrons nor atoms can be moved
E) electrons must be added
Answer: C
Diff: 1 Page Ref: Sec. 8.6

81) For resonance forms of a molecule or ion, __________.
A) one always corresponds to the observed structure
B) all the resonance structures are observed in various proportions
C) the observed structure is an average of the resonance forms
D) the same atoms need not be bonded to each other in all resonance forms
E) there cannot be more than two resonance structures for a given species
Answer: C
Diff: 1 Page Ref: Sec. 8.6

For the questions that follow, consider the BEST Lewis structures of the following ox_yanions:

(i) NO_2- (ii) NO_3- (iii) SO_3^{2-} (iv) SO_4^{2-} (v) Br_3-

82) There can be four equivalent best resonance structures of __________.
A) (i)
B) (ii)
C) (iii)
D) (iv)
E) (v)
Answer: D
Diff: 2 Page Ref: Sec. 8.5-8.7

83) In which of the ions do all X-O bonds (X indicates the central atom) have the same length?
A) none
B) all
C) (i) and (ii)
D) (iii) and (v)
E) (iii), (iv), and (v)
Answer: B
Diff: 1 Page Ref: Sec. 8.6, 8.7

84) Of the following, __________ cannot accommodate more than an octet of electrons.
A) P
B) As
C) O
D) S
E) I
Answer: C
Diff: 1 Page Ref: Sec. 8.7

85) A valid Lewis structure of __________ cannot be drawn without violating the octet rule.
A) NF_3
B) IF_3
C) PF_3
D) SbF_3
E) SO_4^{2-}
Answer: B
Diff: 2 Page Ref: Sec. 8.7

86) A valid Lewis structure of __________ cannot be drawn without violating the octet rule.
A) PO_4^{3-}
B) SiF_4
C) CF_4
D) SeF_4
E) NF_3
Answer: D
Diff: 3 Page Ref: Sec. 8.7

87) The central atom in __________ does not violate the octet rule.
A) SF_4
B) KrF_2
C) CF_4
D) XeF_4
E) lCl_4 -
Answer: C
Diff: 2 Page Ref: Sec. 8.7

88) The central atom in __________ violates the octet rule.
A) NH_3
B) SeF_2
C) BF_3
D) AsF_3
E) CF_4
Answer: C
Diff: 2 Page Ref: Sec. 8.7

89) A valid Lewis structure of __________ cannot be drawn without violating the octet rule.
A) ClF_3
B) PCl_3
C) SO_3
D) CCl_4
E) CO_2
Answer: A
Diff: 1 Page Ref: Sec. 8.7

90) A valid Lewis structure of __________ cannot be drawn without violating the octet rule.
A) NI_3
B) SO_2
C) ICl_5
D) SiF_4
E) CO_2
Answer: C
Diff: 1 Page Ref: Sec. 8.7

91) A valid Lewis structure of __________ cannot be drawn without violating the octet rule.
A) NF_3
B) BeH_2
C) SO_2
D) CF_4
E) SO_3^{2-}
Answer: B
Diff: 1 Page Ref: Sec. 8.7

92) Why don't we draw double bonds between the Be atom and the Cl atoms in $BeCl_2$?
A) That would give positive formal charges to the chlorine atoms and a negative formal charge to the beryllium atom.
B) There aren't enough electrons.
C) That would result in more than eight electrons around beryllium.
D) That would result in more than eight electrons around each chlorine atom.
E) That would result in the formal charges not adding up to zero.
Answer: A
Diff: 2 Page Ref: Sec. 8.7

93) Which atom can accommodate an octet of electrons, but doesn't necessarily have to accommodate an octet?
A) N
B) C
C) H
D) O
E) B
Answer: E
Diff: 1   Page Ref: Sec. 8.7

94) Bond enthalpy is __________.
A) always positive
B) always negative
C) sometimes positive, sometimes negative
D) always zero
E) unpredictable
Answer: A
Diff: 1   Page Ref: Sec. 8.8

95) Given that the average bond energies for C–H and C–Br bonds are 413 and 276 kJ/mol, respectively, the heat of atomization of bromoform ($CHBr_3$) is __________ kJ/mol.
A) 1241
B) 689
C) -689
D) 1378
E) -1378
Answer: A
Diff: 1   Page Ref: Sec. 8.8

96) Of the bonds C–N, C=N, and C≡N, the C–N bond is __________.
A) strongest/shortest
B) strongest/longest
C) weakest/shortest
D) weakest/longest
E) intermediate in both strength and length
Answer: D
Diff: 1   Page Ref: Sec. 8.8

97) As the number of covalent bonds between two atoms increases, the distance between the atoms __________ and the strength of the bond between them __________.
A) increases, increases
B) decreases, decreases
C) increases, decreases
D) decreases, increases
E) is unpredictable
Answer: D
Diff: 1   Page Ref: Sec. 8.8

98) Of the possible bonds between carbon atoms (single, double, and triple), __________.
A) a triple bond is longer than a single bond
B) a double bond is stronger than a triple bond
C) a single bond is stronger than a triple bond
D) a double bond is longer than a triple bond
E) a single bond is stronger than a double bond
Answer: D
Diff: 1   Page Ref: Sec. 8.8

99) Most explosives are compounds that decompose rapidly to produce __________ products and a great deal of __________.
A) gaseous, gases
B) liquid, heat
C) soluble, heat
D) solid, gas
E) gaseous, heat
Answer: E
Diff: 1 Page Ref: Sec. 8.8

100) Dynamite consists of nitroglycerine mixed with __________.
A) potassium nitrate
B) damp KOH
C) TNT
D) diatomaceous earth or cellulose
E) solid carbon
Answer: D
Diff: 1 Page Ref: Sec. 8.8

101) Dynamite __________.
A) was invented by Alfred Nobel
B) is made of nitroglycerine and an absorbent such as diatomaceous earth
C) is a much safer explosive than pure nitroglycerine
D) is an explosive
E) all of the above
Answer: E
Diff: 1 Page Ref: Sec. 8.8

Short Answer

1) The electron configuration that corresponds to the Lewis symbol, $:\ddot{\underset{..}{Cl}}\cdot$ is __________.

Answer: [Ne] $3s^2 3p^5$

Diff: 2 Page Ref: Sec 8.1

2) Write the balanced chemical equation for the reaction for which ΔH°_{rxn} is the lattice energy for potassium bromide.

Answer: $KBr\ (s) \rightarrow K^+\ (g) + Br^-\ (g)$

Diff: 1 Page Ref: Sec. 8.2

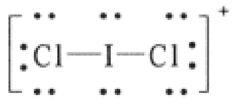
3) Give the electron configuration of Cu^{2+}.

Answer: $[Ar]3d^9$

Diff: 2 Page Ref: Sec. 8.2

4) Which halogen, bromine or iodine, will form the more polar bond with phophorus?
Answer: bromine
Diff: 1 Page Ref: Sec 8.4

5) Draw the Lewis structure of ICl_2^+.
Answer:



Diff: 1 Page Ref: Sec. 8.5

6) Alternative but equivalent Lewis structures are called __________.
Answer: resonance structures
Diff: 1 Page Ref: Sec 8.6

7) In a reaction, if the bonds in the reactants are stronger than the bonds in the product, the reaction is __________.
Answer: endothermic
Diff: 1 Page Ref: Sec 8.7

8) The strength of a covalent bond is measured by its __________.
Answer: bond enthalpy
Diff: 1 Page Ref: Sec 8.8

9) Calculate the bond energy of C–F given that the heat of atomization of CHFClBr is 1502 kJ/mol, and that the bond energies of C–H, C–Br, and C–Cl are 413, 276, and 328 kJ/mol, respectively.
Answer: $\Delta H_{atomization} = [D(C\text{-}H) + D(C\text{-}F) + D(C\text{-}Cl) + D(C\text{-}Br)]$

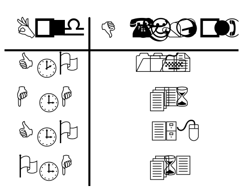
$D(C\text{-}F) = \Delta H_{atomization} - [D(C\text{-}H) + D(C\text{-}Cl) + D(C\text{-}Br)]$
$= [1502 - (413 + 276 + 328)]$ kJ/mol
$= 485$ kJ/mol

Diff: 1 Page Ref: Sec. 8.8

10) The reaction below is used to produce methanol:

$$CO\ (g) + 2\ H_2\ (g) \rightarrow CH_3OH\ (l) \qquad \Delta H_{rxn} + -128 kJ$$

(a) Calculate the C–H bond energy given the following data:



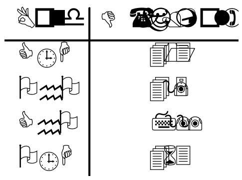
(b) The tabulated value of the (C–H) bond energy is 413 kJ/mol. Explain why there is a difference between the number you have calculated in (a) and the tabulated value.
Answer: (a)

$\Delta H^\circ_{rxn} = D(C{\equiv}O) + 2\ D(H\text{-}H) - [3\ D(C\text{-}H) + D(C\text{-}O) + D(O\text{-}H)]$

$3\ D(C\text{-}H) = -\Delta H^\circ_{rxn} + D(C{\equiv}O) + 2\ D(H\text{-}H) - D(C\text{-}O) - D(O\text{-}H)$

$D(C\text{-}H) = (128 + 1072 + 2(436) - 358 - 463)/3 = 417$
$D(C\text{-}H) = 417$ kJ/mol
(b) Tabulated values, like those in Table 8.4, are averaged from many bond energies measured for C–H bonds in many different molecules.
Diff: 1 Page Ref: Sec. 8.8

11) From the information given below, calculate the heat of combustion of methane (CH_4)(in kJ/mol) Start by writing the balanced equation.



Answer: $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

$\Delta H_{combustion} = (4 \text{ mol C-H})(D_{C\text{-}H}) + (2 \text{ mol O=O})(D_{O=O})$

$\quad - [(2 \text{ mol C=O})(D_{C=O}) - (4 \text{ mol O-H})(D_{O\text{-}H})]$

$[(4 \times 413 + 2 \times 495) - (2 \times 799 + 4 \times 463)]$ kJ

$\Delta H_{combustion} = -808$ kJ

Diff: 1 Page Ref: Sec. 8.8

True/False

1) Atoms surrounded by eight valence electrons tend to lose electrons.
Answer: FALSE
Diff: 1 Page Ref: Sec 8.1

2) The greater the lattice energy, the greater the charges on the participatory ions and the smaller their radii.
Answer: TRUE
Diff: 1 Page Ref: Sec 8.2

3) When a metal gains an electron, the process is endothermic.
Answer: FALSE
Diff: 1 Page Ref: Sec 8.2

4) Electron affinity is a measure of how strongly an atom can attract additional electrons.
Answer: TRUE
Diff: 1 Page Ref: Sec 8.3

5) As electronegativity difference increases, bond length will decrease.
Answer: TRUE
Diff: 1 Page Ref: Sec 8.4

6) In some molecules and polyatomic ions, the sum of the valence electrons is odd and as a result the octet rule fails.
Answer: TRUE
Diff: 1 Page Ref: Sec 8.7

7) Bond enthalpy can be positive or negative.
Answer: FALSE
Diff: 1 Page Ref: Sec 8.8

Chemistry, 11e (Brown)
Chapter 9, Molecular Geometry and Bonding Theories

Multiple-Choice and Bimodal

1) For a molecule with the formula AB_2 the molecular shape is __________.
A) linear or bent
B) linear or trigonal planar
C) linear or T-shaped
D) T-shaped
E) trigonal planar
Answer: A
Diff: 1 Page Ref: Sec. 9.1

2) According to VSEPR theory, if there are five electron domains in the valence shell of an atom, they will be arranged in a(n) __________ geometry.
A) octahedral
B) linear
C) tetrahedral
D) trigonal planar
E) trigonal bipyramidal
Answer: E
Diff: 1 Page Ref: Sec. 9.2

3) According to VSEPR theory, if there are four electron domains in the valence shell of an atom, they will be arranged in a(n) __________ geometry.
A) octahedral
B) linear
C) tetrahedral
D) trigonal planar
E) trigonal bipyramidal
Answer: C
Diff: 1 Page Ref: Sec. 9.2

4) The electron-domain geometry and molecular geometry of iodine trichloride are __________ and __________, respectively.
A) trigonal bipyramidal, trigonal planar
B) tetrahedral, trigonal pyramidal
C) trigonal bipyramidal, T-shaped
D) octahedral, trigonal planar
E) T-shaped, trigonal planar
Answer: C
Diff: 1 Page Ref: Sec. 9.2

5) The molecular geometry of __________ is square planar.
A) CCl_4
B) XeF_4
C) PH_3
D) XeF_2
E) ICl_3
Answer: B
Diff: 2 Page Ref: Sec. 9.2

6) The molecular geometry of the H_3O^+ ion is __________.
A) linear
B) tetrahedral
C) bent
D) trigonal pyramidal
E) octahedral
Answer: D
Diff: 2 Page Ref: Sec. 9.3

7) The molecular geometry of the CS_2 molecule is __________.
A) linear
B) bent
C) tetrahedral
D) trigonal planar
E) T-shaped
Answer: A
Diff: 1 Page Ref: Sec. 9.2

8) The molecular geometry of the SiH_2Cl_2 molecule is __________.
A) trigonal planar
B) tetrahedral
C) trigonal pyramidal
D) octahedral
E) T-shaped
Answer: B
Diff: 1 Page Ref: Sec. 9.2

9) The molecular geometry of the $PHCl_2$ molecule is __________.
A) bent
B) trigonal planar
C) trigonal pyramidal
D) tetrahedral
E) T-shaped
Answer: C
Diff: 2 Page Ref: Sec. 9.2

10) The molecular geometry of the $CHCl_3$ molecule is __________.
A) bent
B) trigonal planar
C) trigonal pyramidal
D) tetrahedral
E) T-shaped
Answer: D
Diff: 1 Page Ref: Sec. 9.2

11) The molecular geometry of the SF_2 molecule is __________.
A) linear
B) bent
C) trigonal planar
D) tetrahedral
E) octahedral
Answer: B
Diff: 2 Page Ref: Sec. 9.2

12) The molecular geometry of the PF_2^+ ion is __________.

A) octahedral
B) tetrahedral
C) trigonal pyramidal
D) trigonal planar
E) trigonal bipyramidal
Answer: B
Diff: 1 Page Ref: Sec. 9.2

13) The F–B–F bond angle in the BF_2^- ion is approximately __________.

A) 90°
B) 109.5°
C) 120°
D) 180°
E) 60°
Answer: C
Diff: 1 Page Ref: Sec. 9.2

14) The Cl–Si–Cl bond angle in the $SiCl_2F_2$ molecule is approximately __________.

A) 90°
B) 109.5°
C) 120°
D) 180°
E) 60°
Answer: B
Diff: 1 Page Ref: Sec. 9.2

15) The F–B–F bond angle in the BF_3 molecule is __________.

A) 90°
B) 109.5°
C) 120°
D) 180°
E) 60°
Answer: C
Diff: 2 Page Ref: Sec. 9.2

16) The O–S–O bond angle in SO_2 is slightly less than __________.

A) 90°
B) 109.5°
C) 120°
D) 180°
E) 60°
Answer: C
Diff: 1 Page Ref: Sec. 9.2

17) The F–N–F bond angle in the NF_3 molecule is slightly less than __________.

A) 90°
B) 109.5°
C) 120°
D) 180°
E) 60°
Answer: B
Diff: 1 Page Ref: Sec. 9.2

18) According to valence bond theory, which orbitals on bromine atoms overlap in the formation of the bond in Br_2 ?
A) 3s
B) 3p
C) 4s
D) 4p
E) 3d
Answer: D
Diff: 1 Page Ref: Sec. 9.4

19) The electron-domain geometry of a sulfur-centered compound is trigonal bipyramidal. The hybridization of the central nitrogen atom is __________.
A) sp
B) sp^2
C) sp^3
D) sp^3d
E) sp^3d^2
Answer: D
Diff: 1 Page Ref: Sec. 9.5

20) The hybridization of orbitals on the central atom in a molecule is sp. The electron-domain geometry around this central atom is __________.
A) octahedral
B) linear
C) trigonal planar
D) trigonal bipyramidal
E) tetrahedral
Answer: B
Diff: 1 Page Ref: Sec. 9.5

21) The hybridization of orbitals on the central atom in a molecule is sp2. The electron-domain geometry about this central atom is __________.
A) octahedral
B) linear
C) trigonal planar
D) trigonal bipyramidal
E) tetrahedral
Answer: C
Diff: 1 Page Ref: Sec. 9.5

22) The hybridization of the carbon atom in carbon dioxide is __________.
A) sp
B) sp^2
C) sp^3
D) sp^3d
E) sp^3d^2
Answer: A
Diff: 1 Page Ref: Sec. 9.5

23) The hybridization of the central atom in the XeF_4 molecule is __________.
A) sp
B) sp^2
C) sp^3
D) sp^3d
E) sp^3d^2
Answer: E
Diff: 2 Page Ref: Sec. 9.5

24) The electron-domain geometry of the AsF_6^- ion is octahedral. The hybrid orbitals used by the As atom for bonding are __________ orbitals.
A) sp^2d^2
B) sp^3
C) sp^3d
D) sp^3d^2
E) sp^2
Answer: D
Diff: 2 Page Ref: Sec. 9.5

25) In order to produce sp^3 hybrid orbitals, __________ s atomic orbital(s) and __________ p atomic orbital(s) must be mixed.
A) one, two
B) one, three
C) one, one
D) two, two
E) two, three
Answer: B
Diff: 1 Page Ref: Sec. 9.5

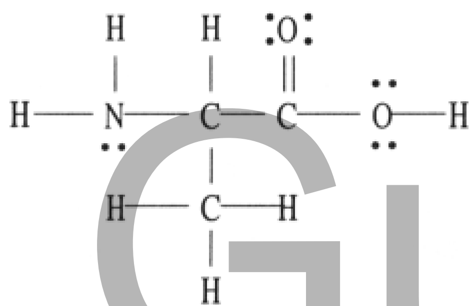
26) The angles between sp^2 orbitals are __________.
A) 45°
B) 180°
C) 90°
D) 109.5°
E) 120°
Answer: E
Diff: 1 Page Ref: Sec. 9.5

27) There are __________ σ and __________ π bonds in the H–C≡C–H molecule.
A) 3 and 2
B) 3 and 4
C) 4 and 3
D) 2 and 3
E) 5 and 0
Answer: A
Diff: 1 Page Ref: Sec. 9.6

28) There are __________ σ and __________ π bonds in the $H_2C{=}C{=}CH_2$ molecule.
A) 4, 2
B) 6, 4
C) 2, 2
D) 2, 6
E) 6, 2
Answer: E
Diff: 1 Page Ref: Sec. 9.6

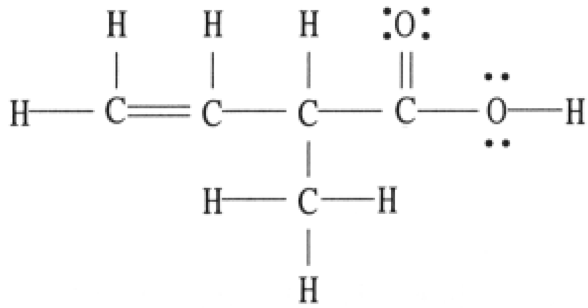
29) The total number of π bonds in the H–C≡C–C≡C–C≡N molecule is __________.
A) 3
B) 4
C) 6
D) 9
E) 12
Answer: C
Diff: 1 Page Ref: Sec. 9.6

30) There is/are __________ σ bond(s) in the molecule below.



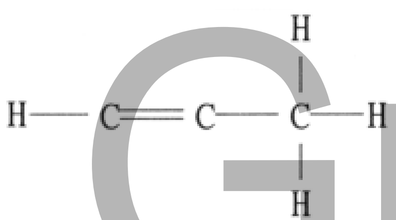
A) 1
B) 2
C) 12
D) 13
E) 18
Answer: C
Diff: 1 Page Ref: Sec. 9.6

31) There is/are __________ π bond(s) in the molecule below.



A) 0
B) 1
C) 2
D) 4
E) 16
Answer: C
Diff: 1 Page Ref: Sec. 9.6

32) There is/are __________ π bond(s) in the molecule below.



A) 7
B) 6
C) 2
D) 1
E) 0
Answer: D
Diff: 1 Page Ref: Sec. 9.6

33) The Lewis structure of carbon monoxide is given below. The hybridizations of the carbon and oxygen atoms in carbon monoxide are __________ and __________, respectively.

: C ≡ O :

A) sp, sp^3
B) sp^2, sp^3
C) sp^3, sp^2
D) sp, sp
E) sp^2, sp^2
Answer: D
Diff: 2 Page Ref: Sec. 9.6

Multiple-Choice

34) The basis of the VSEPR model of molecular bonding is __________.
A) regions of electron density on an atom will organize themselves so as to maximize *s-character*
B) regions of electron density in the valence shell of an atom will arrange themselves so as to maximize overlap
C) atomic orbitals of the bonding atoms must overlap for a bond to form
D) electron domains in the valence shell of an atom will arrange themselves so as to minimize repulsions
E) hybrid orbitals will form as necessary to, as closely as possible, achieve spherical symmetry
Answer: D
Diff: 1 Page Ref: Sec. 9.2

35) According to VSEPR theory, if there are three electron domains in the valence shell of an atom, they will be arranged in a(n) __________ geometry.
A) octahedral
B) linear
C) tetrahedral
D) trigonal planar
E) trigonal bipyramidal
Answer: D
Diff: 2 Page Ref: Sec. 9.2

36) In counting the electron domains around the central atom in VSEPR theory, a __________ is not included.
A) nonbonding pair of electrons
B) single covalent bond
C) core level electron pair
D) double covalent bond
E) triple covalent bond
Answer: C
Diff: 1 Page Ref: Sec. 9.2

37) The electron-domain geometry of __________ is tetrahedral.
A) CBr_4
B) PH_3
C) CCl_2BR_2
D) XeF_4
E) all of the above except XeF_4
Answer: E
Diff: 2 Page Ref: Sec. 9.2

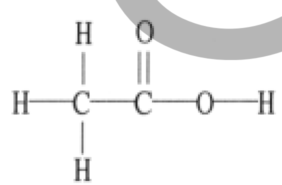
38) The O–C–O bond angle in the CO_3^{2-} ion is approximately __________.
A) 90°
B) 109.5°
C) 120°
D) 180°
E) 60°
Answer: C
Diff: 2 Page Ref: Sec. 9.2

39) The Cl–C–Cl bond angle in the CCl_2O molecule (C is the central atom) is slightly __________.
A) greater than 90°
B) less than 109.5°
C) less than 120°
D) greater than 120°
E) greater than 109.5°
Answer: C
Diff: 1 Page Ref: Sec. 9.2

40) Of the following species, __________ will have bond angles of 120°.
A) PH_3
B) ClF_3
C) NCl_3
D) BCl_3
E) All of these will have bond angles of 120°.
Answer: D
Diff: 1 Page Ref: Sec. 9.2

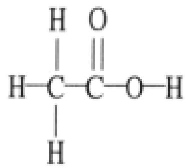
41) The molecular geometry of the BrO_3^- ion is __________.
A) trigonal pyramidal
B) trigonal planar
C) bent
D) tetrahedral
E) T-shaped
Answer: A
Diff: 2 Page Ref: Sec. 9.2

42) The molecular geometry of the left-most carbon atom in the molecule below is __________.



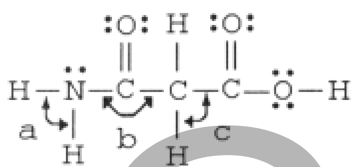
A) trigonal planar
B) trigonal bipyramidal
C) tetrahedral
D) octahedral
E) T-shaped
Answer: C
Diff: 1 Page Ref: Sec. 9.2

43) The molecular geometry of the right-most carbon in the molecule below is __________.



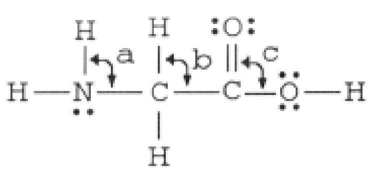
A) trigonal planar
B) trigonal bipyramidal
C) tetrahedral
D) octahedral
E) T-shaped
Answer: A
Diff: 1 Page Ref: Sec. 9.2

44) The bond angles marked a, b, and c in the molecule below are about __________, __________, and __________, respectively.



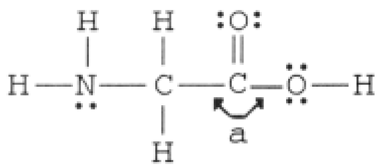
A) 90°, 90°, 90°
B) 120°, 120°, 90°
C) 120°, 120°, 109.5°
D) 109.5°, 120°, 109.5°
E) 109.5°, 90°, 120°
Answer: D
Diff: 2 Page Ref: Sec. 9.2

45) The bond angles marked a, b, and c in the molecule below are about __________, __________, and __________, respectively.



A) 109.5°, 109.5°, 109.5°
B) 120°, 109.5°, 120°
C) 109.5°, 109.5°, 120°
D) 90°, 180°, 90°
E) 109.5°, 109.5°, 90°
Answer: C
Diff: 2 Page Ref: Sec. 9.2

46) The bond angle marked a in the following molecule is about __________.



A) 90°
B) 109.5°
C) 120°
D) 180°
E) 60°
Answer: C
Diff: 1 Page Ref: Sec. 9.2

47) The central iodine atom in the ICl_4^- ion has __________ nonbonded electron pairs and __________ bonded electron pairs in its valence shell.
A) 2, 2
B) 3, 4
C) 1, 3
D) 3, 2
E) 2, 4
Answer: E
Diff: 1 Page Ref: Sec. 9.2

48) The central iodine atom in IF_5 has __________ unbonded electron pairs and __________ bonded electron pairs in its valence shell.
A) 1, 5
B) 0, 5
C) 5, 1
D) 4, 1
E) 1, 4
Answer: A
Diff: 1 Page Ref: Sec. 9.2

49) The central Xe atom in the XeF_4 molecule has __________ unbonded electron pairs and __________ bonded electron pairs in its valence shell.
A) 1, 4
B) 2, 4
C) 4, 0
D) 4, 1
E) 4, 2
Answer: B
Diff: 1 Page Ref: Sec. 9.2

50) An electron domain consists of __________.

a) a nonbonding pair of electrons
b) a single bond
c) a multiple bond

A) a only
B) b only
C) c only
D) a, b, and c
E) b and c
Answer: D
Diff: 1 Page Ref: Sec. 9.2

51) According to VSEPR theory, if there are three electron domains on a central atom, they will be arranged such that the angles between the domains are __________.
A) 90°
B) 180°
C) 109.5°
D) 360°
E) 120°
Answer: E
Diff: 1 Page Ref: Sec. 9.2

52) According to VSEPR theory, if there are four electron domains on a central atom, they will be arranged such that the angles between the domains are __________.
A) 120°
B) 109.5°
C) 180°
D) 360°
E) 90°
Answer: B
Diff: 1 Page Ref: Sec. 9.2

53) According to VSEPR theory, if there are two electron domains on a central atom, they will be arranged such that the angles between the domains are __________.
A) 360°
B) 120°
C) 109.5°
D) 180°
E) 90°
Answer: D
Diff: 1 Page Ref: Sec. 9.2

54) The electron-domain geometry and the molecular geometry of a molecule of the general formula AB_n are __________.
A) never the same
B) always the same
C) sometimes the same
D) not related
E) mirror images of one another
Answer: C
Diff: 1 Page Ref: Sec. 9.2

55) The electron-domain geometry and the molecular geometry of a molecule of the general formula AB_n will always be the same if __________.
A) there are no lone pairs on the central atom
B) there is more than one central atom
C) n is greater than four
D) n is less than four
E) the octet rule is obeyed
Answer: A
Diff: 1 Page Ref: Sec. 9.2

56) For molecules of the general formula AB_n , n can be greater than four __________.
A) for any element A
B) only when A is an element from the third period or below the third period
C) only when A is boron or beryllium
D) only when A is carbon
E) only when A is Xe
Answer: B
Diff: 1 Page Ref: Sec. 9.2

Consider the following species when answering the following questions:

(i) PCl_3 (ii) CCl_4 (iii) $TeCl_4$ (iv) XeF_4 (v) SF_6

57) For which of the molecules is the molecular geometry (shape) the same as the VSEPR electron domain arrangement (electron domain geometry)?
A) (i) and (ii)
B) (i) and (iii)
C) (ii) and (v)
D) (iv) and (v)
E) (v) only
Answer: C
Diff: 2 Page Ref: Sec. 9.2

58) Of the molecules below, only __________ is polar.
A) SbF_5
B) AsH_3
C) I_2
D) SF_6
E) CH_4
Answer: B
Diff: 2 Page Ref: Sec. 9.3

59) Of the molecules below, only __________ is nonpolar.
A) CO_2
B) H_2O
C) NH_3
D) HCl
E) $TeCl_2$
Answer: A
Diff: 1 Page Ref: Sec. 9.3

60) Of the molecules below, only __________ is polar.
A) CCl_4
B) CH_4
C) SeF_4
D) $SiCl_4$
E) BF_4
Answer: C
Diff: 1 Page Ref: Sec. 9.3

61) Of the molecules below, only __________ is nonpolar.
A) BF_3
B) NF_3
C) IF_3
D) PBr_3
E) $BrCl_3$
Answer: A
Diff: 1 Page Ref: Sec. 9.3

62) Three monosulfur fluorides are observed: SF_2 , SF_4 , and SF_6 . Of these, __________ is/are polar.
A) SF_2 only
B) SF_2 and SF_4 only
C) SF_4 only
D) SF_6 only
E) SF_2 , SF_4 , and SF_6
Answer: B
Diff: 2 Page Ref: Sec. 9.3

63) The molecular geometry of the $BeCl_2$ molecule is __________, and this molecule is __________.
A) linear, nonpolar
B) linear, polar
C) bent, nonpolar
D) bent, polar
E) trigonal planar, polar
Answer: A
Diff: 1 Page Ref: Sec. 9.3

64) The molecular geometry of the PF_3 molecule is __________, and this molecule is __________.
A) trigonal planar, polar
B) trigonal planar, nonpolar
C) trigonal pyramidal, polar
D) trigonal pyramidal, nonpolar
E) tetrahedral, unipolar
Answer: C
Diff: 2 Page Ref: Sec. 9.3

65) Of the following molecules, only __________ is polar.
A) $BeCl_2$
B) BF_3
C) CBr_4
D) SiH_2Cl_2
E) Cl_2
Answer: D
Diff: 1 Page Ref: Sec. 9.3

66) Of the following molecules, only __________ is polar.
A) CCl_4
B) BCl_3
C) NCl_3
D) $BeCl_2$
E) Cl_2
Answer: C
Diff: 1 Page Ref: Sec. 9.3

67) For molecules with only one central atom, how many lone pairs on the central atom guarantees molecular polarity?
A) 1
B) 2
C) 1 or 2
D) 3
E) 1 or 3
Answer: A
Diff: 1 Page Ref: Sec. 9.3

68) The molecular geometry of the CHF_3 molecule is __________, and the molecule is __________.
A) trigonal pyramidal, polar
B) tetrahedral, nonpolar
C) seesaw, nonpolar
D) tetrahedral, polar
E) seesaw, polar
Answer: D
Diff: 1 Page Ref: Sec. 9.3

69) The molecular geometry of the BCl_3 molecule is __________, and this molecule is __________.
A) trigonal pyramidal, polar
B) trigonal pyramidal, nonpolar
C) trigonal planar, polar
D) trigonal planar, nonpolar
E) trigonal bipyramidal, polar
Answer: D
Diff: 1 Page Ref: Sec. 9.3

70) According to valence bond theory, which orbitals overlap in the formation of the bond in HBr?
A) 1s on H and 4p on Br
B) 1s on H and 4s on Br
C) 1s on H and 3p on Br
D) 2s on H and 4p on Br
E) 2s on H and 3p on Br
Answer: A
Diff: 1 Page Ref: Sec. 9.4

71) The combination of two atomic orbitals results in the formation of __________ molecular orbitals.
A) 1
B) 2
C) 3
D) 4
E) 0
Answer: B
Diff: 1 Page Ref: Sec. 9.5

72) The electron-domain geometry of a carbon-centered compound is tetrahedral. The hybridization of the central carbon atom is __________.
A) sp
B) sp^2
C) sp^3
D) sp^3d
E) sp^3d^2
Answer: C
Diff: 2 Page Ref: Sec. 9.5

73) Of the following, only __________ has sp^2 hybridization of the central atom.
A) PH_3
B) CO_3^{2-}
C) ICl_3
D) I_3^-
E) PF_5
Answer: B
Diff: 1 Page Ref: Sec. 9.5

74) Of the following, the central atom is sp^3d^2 hybridized only in __________.
A) PCl_5
B) XeF_4
C) PH_3
D) Br_3^-
E) BeF_2
Answer: B
Diff: 1 Page Ref: Sec. 9.5

75) The sp^3d^2 atomic hybrid orbital set accommodates __________ electron domains.
A) 2
B) 3
C) 4
D) 5
E) 6
Answer: E
Diff: 1 Page Ref: Sec. 9.5

76) The sp^2 atomic hybrid orbital set accommodates __________ electron domains.
A) 2
B) 3
C) 4
D) 5
E) 6
Answer: B
Diff: 1 Page Ref: Sec. 9.5

77) The hybridizations of nitrogen in NF_3 and NH_3 are __________ and __________, respectively.
A) sp^2, sp^2
B) sp, sp^3
C) sp^3, sp
D) sp^3, sp^3
E) sp^2, sp^3
Answer: D
Diff: 1 Page Ref: Sec. 9.5

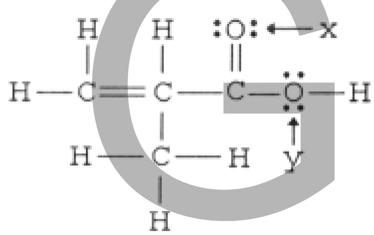
78) The hybridizations of iodine in IF_3 and IF_5 are __________ and __________, respectively.
A) sp^3, sp^3d
B) sp^3d, sp^3d^2
C) sp^3d, sp^3
D) sp^3d^2, sp^3d
E) sp^3d^2, sp^3d^2
Answer: B
Diff: 1 Page Ref: Sec. 9.5

79) The hybridizations of bromine in BrF_5 and of arsenic in AsF_5 are __________ and __________, respectively.
A) sp^3, sp^3d
B) sp^3d, sp^3d^2
C) sp^3d, sp^3
D) sp^3d^2, sp^3d
E) sp^3d^2, sp^3d^2
Answer: D
Diff: 1 Page Ref: Sec. 9.5

80) The hybrid orbitals used for bonding by the sulfur atom in the SF_4 molecule are __________ orbitals.
A) sp
B) sp^2
C) sp^3
D) sp^3d
E) sp^3d^2
Answer: D
Diff: 1 Page Ref: Sec. 9.5

81) The hybrid orbitals used for bonding by Xe in the unstable XeF_2 molecule are __________ orbitals.
A) sp^2
B) sp^3
C) sp^3d
D) sp^3d^2
E) sp
Answer: C
Diff: 2 Page Ref: Sec. 9.5

82) The hybridization of the oxygen atom labeled y in the structure below is __________.
The C–O–H bond angle is __________.



A) sp, 180°
B) sp^2, 109.5°
C) sp^3, 109.5°
D) sp^3d^2, 90°
E) sp, 90°
Answer: C
Diff: 2 Page Ref: Sec. 9.5

83) The electron-domain geometry of the AsF_5 molecule is trigonal bipyramidal. The hybrid orbitals used by the As atom for bonding are __________ orbitals.
A) sp^2d^2
B) sp^3
C) sp^3d^2
D) sp^3d
E) sp^2
Answer: D
Diff: 1 Page Ref: Sec. 9.5

84) __________ hybrid orbitals are used for bonding by Xe in the XeF_4 molecule.

A) sp^2

B) sp^3

C) sp^3d

D) sp^3d^2

E) sp

Answer: D

Diff: 1 Page Ref: Sec. 9.5

Consider the following species when answering the following questions:

(i) PCl_3 (ii) CCl_4 (iii) $TeCl_4$ (iv) XeF_4 (v) SF_6

85) In which of the molecules does the central atom utilize d orbitals to form hybrid orbitals?

A) (i) and (ii)

B) (iii) only

C) (i) and (v)

D) (iii), (iv), and (v)

E) (v) only

Answer: D

Diff: 2 Page Ref: Sec. 9.5

86) Which of the molecules has a see-saw shape?

A) (i)

B) (ii)

C) (iii)

D) (iv)

E) (v)

Answer: C

Diff: 3 Page Ref: Sec. 9.3, 9.5

87) In which of the molecules is the central atom sp^3d^2 hybridized?

A) (i) and (ii)

B) (iii) only

C) (iii) and (iv)

D) (iv) and (v)

E) (v) only

Answer: D

Diff: 1 Page Ref: Sec. 9.5

88) There are __________ unhybridized p atomic orbitals in an sp-hybridized carbon atom.

A) 0

B) 1

C) 2

D) 3

E) 4

Answer: C

Diff: 1 Page Ref: Sec. 9.5

89) When three atomic orbitals are mixed to form hybrid orbitals, how many hybrid orbitals are formed?
A) one
B) six
C) three
D) four
E) five
Answer: C
Diff: 1 Page Ref: Sec. 9.5

90) The blending of one s atomic orbital and two p atomic orbitals produces __________.
A) three sp hybrid orbitals
B) two sp^2 hybrid orbitals
C) three sp^3 hybrid orbitals
D) two sp^3 hybrid orbitals
E) three sp^2 hybrid orbitals
Answer: E
Diff: 1 Page Ref: Sec. 9.5

91) A triatomic molecule cannot be linear if the hybridization of the central atoms is __________.
A) sp
B) sp^2
C) sp^3
D) sp^2 or sp^3
E) sp^2d or sp^3d^2
Answer: D
Diff: 1 Page Ref: Sec. 9.5

92) A typical double bond __________.
A) is stronger and shorter than a single bond
B) consists of one σ bond and one π bond
C) imparts rigidity to a molecule
D) consists of two shared electron pairs
E) All of the above answers are correct.
Answer: E
Diff: 1 Page Ref: Sec. 9.6

93) A typical triple bond __________.
A) consists of one σ bond and two π bonds
B) consists of three shared electrons
C) consists of two σ bonds and one π bond
D) consists of six shared electron pairs
E) is longer than a single bond
Answer: A
Diff: 1 Page Ref: Sec. 9.6

94) In a polyatomic molecule, "localized" bonding electrons are associated with __________.
A) one particular atom
B) two particular atoms
C) all of the atoms in the molecule
D) all of the π bonds in the molecule
E) two or more σ bonds in the molecule
Answer: B
Diff: 1 Page Ref: Sec. 9.6

95) Which of the following molecules or ions will exhibit delocalized bonding?

SO_2 SO_3 SO_3^{2-}

A) SO_2, SO_3, and SO_3^{2-}
B) SO_3^{2-} only
C) SO_2 and SO_3
D) SO_3 and SO_3^{2-}
E) None of the above will exhibit delocalized bonding.
Answer: C
Diff: 1 Page Ref: Sec. 9.6

96) Which of the following molecules or ions will exhibit delocalized bonding?

NO_2- NO_4+ N_3-

A) NO_4+ and N_3-
B) NO_2- only
C) NO_2-, NO_4+, and N_3-
D) N_3- only
E) NO_2- and N_3-
Answer: B
Diff: 1 Page Ref: Sec. 9.6

97) In order to exhibit delocalized π bonding, a molecule must have __________.
A) at least two π bonds
B) at least two resonance structures
C) at least three σ bonds
D) at least four atoms
E) trigonal planar electron domain geometry
Answer: B
Diff: 1 Page Ref: Sec. 9.6

98) In a typical multiple bond, the σ bond results from overlap of __________ orbitals and the π bond(s) result from overlap of __________ orbitals.
A) hybrid, atomic
B) hybrid, hybrid
C) atomic, hybrid
D) hybrid, hybrid or atomic
E) hybrid or atomic, hybrid or atomic
Answer: A
Diff: 1 Page Ref: Sec. 9.6

99) The carbon-carbon σ bond in ethylene, CH_2CH_2, results from the overlap of __________.

A) sp hybrid orbitals
B) sp^3 hybrid orbitals
C) sp^2 hybrid orbitals
D) s atomic orbitals
E) p atomic orbitals
Answer: C
Diff: 1 Page Ref: Sec. 9.6

100) The π bond in ethylene, CH_2CH_2, results from the overlap of __________.

A) sp^3 hybrid orbitals
B) s atomic orbitals
C) sp hybrid orbitals
D) sp^2 hybrid orbitals
E) p atomic orbitals
Answer: E
Diff: 1 Page Ref: Sec. 9.6

101) In order for rotation to occur about a double bond, __________.

A) the σ bond must be broken
B) the π bond must be broken
C) the bonding must be delocalized
D) the bonding must be localized
E) the σ and π bonds must both be broken
Answer: B
Diff: 1 Page Ref: Sec. 9.6

102) A typical triple bond consists of __________.

A) three sigma bonds
B) three pi bonds
C) one sigma and two pi bonds
D) two sigma and one pi bond
E) three ionic bonds
Answer: C
Diff: 1 Page Ref: Sec. 9.6

103) The N–N bond in HNNH consists of __________.

A) one σ bond and one π bond
B) one σ bond and two π bonds
C) two σ bonds and one π bond
D) two σ bonds and two π bonds
E) one σ bond and no π bonds
Answer: A
Diff: 1 Page Ref: Sec. 9.6

104) The hybridization of the terminal carbons in the $H_2C{=}C{=}CH_2$ molecule is __________.

A) sp

B) sp^2

C) sp^3

D) sp^3d

E) sp^3d^2

Answer: B

Diff: 2 Page Ref: Sec. 9.6

105) The hybridization of nitrogen in the H–C≡N: molecule is __________.

A) sp

B) s^2p

C) s^3p

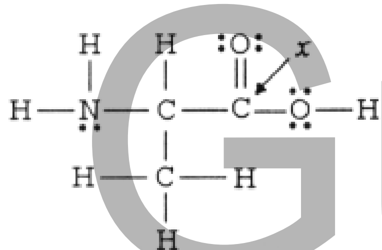
D) sp^2

E) sp^3

Answer: A

Diff: 1 Page Ref: Sec. 9.6

106) The hybridization of the carbon atom labeled x in the molecule below is __________.



A) sp

B) sp^2

C) sp^3

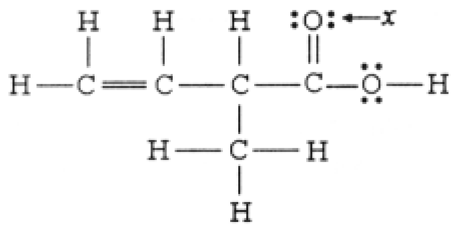
D) sp^3d

E) sp^3d^2

Answer: B

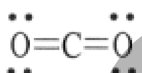
Diff: 1 Page Ref: Sec. 9.6

107) The hybridization of the oxygen atom labeled x in the structure below is __________.



A) sp
B) sp^2
C) sp^3
D) sp^3d
E) sp^3d^2
Answer: B
Diff: 1 Page Ref: Sec. 9.6

108) The Lewis structure of carbon dioxide is given below. The hybridization of the carbon atom in carbon dioxide is __________.



A) sp^3
B) sp^2
C) sp
D) sp^2d
E) sp^2d^2
Answer: C
Diff: 2 Page Ref: Sec. 9.6

109) Electrons in __________ bonds remain localized between two atoms. Electrons in __________ bonds can become delocalized between more than two atoms.
A) pi, sigma
B) sigma, pi
C) pi, pi
D) sigma, sigma
E) ionic, sigma
Answer: B
Diff: 2 Page Ref: Sec. 9.6

110) Valence bond theory does not address the issue of __________.
A) excited states of molecules
B) molecular shape
C) covalent bonding
D) hybridization
E) multiple bonds
Answer: A
Diff: 2 Page Ref: Sec. 9.5

111) Structural changes around a double bond in the __________ portion of the rhodopsin molecule trigger the chemical reactions that result in vision.
A) protein
B) opsin
C) retinal
D) cones
E) rods
Answer: C
Diff: 3 Page Ref: Sec. 9.6

112) The bond order of any molecule containing equal numbers of bonding and antibonding electrons is __________.
A) 0
B) 1
C) 2
D) 3
E) 1/2
Answer: A
Diff: 3 Page Ref: Sec. 9.7

113) In molecular orbital theory, the σ_{1s} orbital is __________ and the σ_{1s}^{*} orbital is __________ in the H_2 molecule.
A) filled, filled
B) filled, empty
C) filled, half-filled
D) half-filled, filled
E) empty, filled
Answer: B
Diff: 4 Page Ref: Sec. 9.7

114) Based on molecular orbital theory, the only molecule in the list below that has unpaired electrons is __________.
A) C_2
B) N_2
C) F_2
D) O_2
E) Li_2
Answer: D
Diff: 3 Page Ref: Sec. 9.8

115) Based on molecular orbital theory, there are __________ unpaired electrons in the OF^{+} ion.
A) 0
B) 3
C) 1
D) 2
E) 1/2
Answer: D
Diff: 3 Page Ref: Sec. 9.8

116) Based on molecular orbital theory, the bond orders of the H–H bonds in H_2, H_2+, and H_2- are __________, respectively
A) 1, 0, and 0
B) 1, 1/2, and 0

C) 1, 0, and 1/2
D) 1, 1/2, and 1/2
E) 1, 2, and 0
Answer: D
Diff: 4 Page Ref: Sec. 9.7

117) Based on molecular orbital theory, the bond order of the H–H bond in the H_2+ ion is __________.
A) 0
B) 1/2
C) 1
D) 3/2
E) 2
Answer: B
Diff: 4 Page Ref: Sec. 9.7

118) Based on molecular orbital theory, the bond order of the N–N bond in the N_2 molecule is __________.
A) 0
B) 1
C) 2
D) 3
E) 5
Answer: D
Diff: 4 Page Ref: Sec. 9.8

119) Based on molecular orbital theory, the bond order of the N–N bond in the N_2^{2+} ion is __________.
A) 0
B) 3
C) 1
D) 2
E) 1/2
Answer: D
Diff: 4 Page Ref: Sec. 9.8

120) Based on molecular orbital theory, the bond order of the Be–Be bond in the Be_2 molecule is __________.
A) 0
B) 1
C) 2
D) 3
E) 4
Answer: A
Diff: 4 Page Ref: Sec. 9.8

121) Based on molecular orbital theory, the bond order of the C–C bond in the C_2 molecule is __________.
A) 0
B) 1
C) 2
D) 3
E) 4
Answer: C
Diff: 4 Page Ref: Sec. 9.8

122) An antibonding π orbital contains a maximum of __________ electrons.
A) 1
B) 2
C) 4
D) 6
E) 8
Answer: B
Diff: 3 Page Ref: Sec. 9.7

123) According to MO theory, overlap of two s atomic orbitals produces __________.
A) one bonding molecular orbital and one hybrid orbital
B) two bonding molecular orbitals
C) two bonding molecular orbitals and two antibonding molecular orbitals
D) two bonding molecular orbitals and one antibonding molecular orbital
E) one bonding molecular orbital and one antibonding molecular orbital
Answer: E
Diff: 3 Page Ref: Sec. 9.7

124) A molecular orbital can accommodate a maximum of __________ electron(s).
A) one
B) two
C) four
D) six
E) twelve
Answer: B
Diff: 3 Page Ref: Sec. 9.7

125) Molecular Orbital theory correctly predicts paramagnetism of oxygen gas, O_2. This is because __________.
A) the bond order in O_2 can be shown to be equal to 2.
B) there are more electrons in the bonding orbitals than in the antibonding orbitals.
C) the energy of the π_{2p}MOs is higher than that of the σ_{2p}MO
D) there are two unpaired electrons in the MO electron configuration of O_2
E) the O–O bond distance is relatively short
Answer: D
Diff: 4 Page Ref: Sec. 9.7, 9.8

126) Molecular Orbital theory correctly predicts diamagnetism of fluorine gas, F_2. This is because __________.
A) the bond order in F_2 can be shown to be equal to 1.
B) there are more electrons in the bonding orbitals than in the antibonding orbitals.
C) all electrons in the MO electron configuration of F_2 are paired.
D) the energy of the π_{2p}MOs is higher than that of the σ_{2p}MO
E) the F–F bond enthalpy is very low
Answer: C
Diff: 4 Page Ref: Sec. 9.7, 9.8

127) Of the following, only __________ appears to gain mass in a magnetic field.
A) C_2
B) N_2
C) F_2
D) O_2
E) Li_2
Answer: D
Diff: 4 Page Ref: Sec. 9.8

128) Of the following, __________ appear(s) to gain mass in a magnetic field.

B_2 N2 O2

A) O_2 only
B) N_2 only
C) B_2 and N_2
D) N_2 and O_2
E) B_2 and O_2
Answer: E
Diff: 4 Page Ref: Sec. 9.8

129) According to MO theory, overlap of two p atomic orbitals produces __________.
A) two bonding molecular orbitals
B) one bonding molecular orbital and one antibonding molecular orbital
C) two bonding molecular orbitals and two antibonding molecular orbitals
D) two bonding molecular orbitals and one antibonding molecular orbital
E) three bonding molecular orbitals and three antibonding molecular orbitals
Answer: B
Diff: 3 Page Ref: Sec. 9.8

130) According to MO theory, overlap of two p atomic orbitals produces __________.
A) one π MO and one σ^* MO
B) one π MO and one σ MO
C) one π MO and one π^* MO <u>or</u> one σ MO and one σ^* MO
D) one π^+ MO and one σ^* MO
E) two π MOs, two π^+ MOs, one σ MO, and one σ^* MO
Answer: C
Diff: 3 Page Ref: Sec. 9.8

131) An antibonding MO __________ the corresponding bonding MO.
A) is always lower in energy than
B) can accommodate more electrons than
C) can accommodate fewer electrons than
D) is always higher in energy than
E) is always degenerate with
Answer: D
Diff: 3 Page Ref: Sec. 9.8

132) The more effectively two atomic orbitals overlap, __________.
A) the more bonding MOs will be produced by the combination
B) the higher will be the energy of the resulting bonding MO and the lower will be the energy of the resulting antibonding MO
C) the higher will be the energies of both bonding and antibonding MOs that result
D) the fewer antibonding MOs will be produced by the combination
E) the lower will be the energy of the resulting bonding MO and the higher will be the energy of the resulting antibonding MO
Answer: E
Diff: 4 Page Ref: Sec. 9.8

133) The bond order of a homonuclear diatomic molecule can be decreased by __________.
A) removing electrons from a bonding MO or adding electrons to an antibonding MO
B) adding electrons to a bonding MO or removing electrons from an antibonding MO
C) adding electrons to any MO
D) removing electrons from any MO
E) The bond order of a homonuclear diatomic molecule cannot be decreased by any means.
Answer: A
Diff: 4 Page Ref: Sec. 9.8

134) The order of MO energies in B_2, C_2, and N_2 $(\sigma_{2p} > \pi_{2p})$, is different from the order in O_2, F_2, and Ne_2 $(\sigma_{2p} < \pi_{2p})$ This is due to __________.
A) less effective overlap of p orbitals in O_2, F2, and Ne2
B) the more metallic character of boron, carbon and nitrogen as compared to oxygen, fluorine, and neon
C) greater 2s-2p interaction in O_2, F_2, and Ne_2
D) greater 2s-2p interaction in B_2, C_2, and N_2
E) less effective overlap of p orbitals in B_2, C_2, and N_2
Answer: D
Diff: 5 Page Ref: Sec. 9.8

Short Answer

1) The 1s hydrogen orbital overlaps with the __________ iodine orbital in HI.
Answer: 5p
Diff: 2 Page Ref: Sec 9.5

2) A covalent bond in which overlap regions lie above and below an internuclear axis is called a(n) __________.
Answer: π bond
Diff: 2 Page Ref: Sec 9.6

3) The sensation of vision results from a nerve impulse that is triggered by the separation of retinal from __________.
Answer: opsin
Diff: 2 Page Ref: Sec 9.6

4) In molecular orbital theory the stability of a covalent body is related to its __________.
Answer: bond order
Diff: 2 Page Ref: Sec 9.7

5) Each molecular orbital can accommodate, at most, two electrons with their spins paired. This is called the __________.
Answer: Pauli principle
Diff: 4 Page Ref: Sec 9.8

6) The more unpaired electrons in a species, the stronger is the force of magnetic attraction. This is called __________.
Answer: paramagnetism
Diff: 1 Page Ref: Sec 9.8

True/False

1) Possible shapes of AB_3 molecules are linear, trigonal planar, and T-shaped.
Answer: FALSE
Diff: 2 Page Ref: Sec 9.1

2) Boron trifluoride has three bonding domains and its electron domain geometry is trigonal planar.
Answer: TRUE
Diff: 2 Page Ref: Sec 9.2

3) Electron domains for single bonds exert greater force on adjacent domains than the electron domains for multiple bonds.
Answer: FALSE
Diff: 1 Page Ref: Sec 9.2

4) The quantitative amount of charge separation in a diatomic molecule contributes t o the dipole moment of that molecule.
Answer: TRUE
Diff: 1 Page Ref: Sec 9.3

5) Hybridization is the process of mixing atomic orbitals as atoms approach each other to form a bond.
Answer: TRUE
Diff: 1 Page Ref: Sec 9.5

6) Electrons in core orbitals contribute to atom bonding.
Answer: FALSE
Diff: 1 Page Ref: Sec 9.6

Algorithmic Questions

1) Using the VSEPR model, the electron-domain geometry of the central atom in BF_3 is __________.
A) linear
B) trigonal planar
C) tetrahedral
D) trigonal bipyramidal
E) octahedral
Answer: B
Diff: 1 Page Ref: Sec. 9.2

2) Using the VSEPR model, the electron-domain geometry of the central atom in SF_2 is __________.
A) linear
B) trigonal planar
C) tetrahedral
D) trigonal bipyramidal
E) octahedral
Answer: C
Diff: 1 Page Ref: Sec. 9.2

3) Using the VSEPR model, the electron-domain geometry of the central atom in ClF_3 is __________.
A) linear
B) trigonal planar
C) tetrahedral
D) trigonal bipyramidal
E) octahedral
Answer: D
Diff: 1 Page Ref: Sec. 9.2

4) Using the VSEPR model, the electron-domain geometry of the central atom in BrF_4^- is __________.
A) linear
B) trigonal planar
C) tetrahedral
D) trigonal bipyramidal
E) octahedral
Answer: E
Diff: 1 Page Ref: Sec. 9.2

5) Using the VSEPR model, the molecular geometry of the central atom in XeF_2 is __________.
A) linear
B) trigonal planar
C) tetrahedral
D) bent
E) trigonal pyramidal
Answer: A
Diff: 1 Page Ref: Sec. 9.2

6) Using the VSEPR model, the molecular geometry of the central atom in BCl_3 is __________.
A) linear
B) trigonal planar
C) tetrahedral
D) bent
E) trigonal pyramidal
Answer: B
Diff: 1 Page Ref: Sec. 9.2

7) Using the VSEPR model, the molecular geometry of the central atom in CF_4 is __________.
A) linear
B) trigonal planar
C) tetrahedral
D) bent
E) trigonal pyramidal
Answer: C
Diff: 1 Page Ref: Sec. 9.2

8) Using the VSEPR model, the molecular geometry of the central atom in SO_2 is __________.
A) linear
B) trigonal planar
C) tetrahedral
D) bent
E) trigonal pyramidal
Answer: D
Diff: 1 Page Ref: Sec. 9.2

9) Using the VSEPR model, the molecular geometry of the central atom in NCl_3 is __________.
A) linear
B) trigonal planar
C) tetrahedral
D) bent
E) trigonal pyramidal
Answer: E
Diff: 1 Page Ref: Sec. 9.2

10) Using the VSEPR model, the molecular geometry of the central atom in PF_5 is __________.
A) tetrahedral
B) square planar
C) trigonal bipyramidal
D) seesaw
E) square pyramidal
Answer: C
Diff: 1 Page Ref: Sec. 9.2

11) The hybrid orbital set used by the central atom in NO_3^- is __________.
A) sp
B) sp^2
C) sp^3
D) sp^3d
E) sp^3d^2
Answer: B
Diff: 1 Page Ref: Sec. 9.5

12) The hybrid orbital set used by the central atom in BF_4^- is __________.
A) sp
B) sp^2
C) sp^3
D) sp^3d
E) sp^3d^2
Answer: C
Diff: 1 Page Ref: Sec. 9.5

13) The hybrid orbital set used by the central atom in KrF_2 is __________.
A) sp
B) sp^2
C) sp^3
D) sp^3d
E) sp^3d^2
Answer: D
Diff: 1 Page Ref: Sec. 9.5

Chemistry, 11e (Brown)
Chapter 10, Gases

Multiple-Choice and Bimodal

1) A gas at a pressure of 10.0 Pa exerts a force of __________ N on an area of $5.5\ m^2$.
A) 55
B) 0.55
C) 5.5
D) 1.8
E) 18
Answer: A
Diff: 2   Page Ref: Sec. 10.2

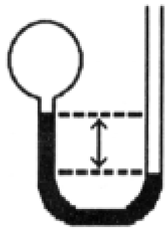
2) A gas at a pressure of 325 torr exerts a force of __________ N on an area of $5.5\ m^2$.
A) 1.8×10^3
B) 59
C) 2.4×10^5
D) 0.018
E) 2.4
Answer: C
Diff: 2   Page Ref: Sec. 10.2

3) A pressure of 1.00 atm is the same as a pressure of __________ of mmHg.
A) 193
B) 101
C) 760.0
D) 29.92
E) 33.0
Answer: C
Diff: 2   Page Ref: Sec. 10.2

4) The National Weather Service routinely supplies atmospheric pressure data to help pilots set their altimeters. The units the NWS uses for atmospheric pressure are inches of mercury. A barometric pressure of 30.51 inches of mercury corresponds to __________ kPa.
A) 77.50
B) 775
C) 1.020
D) 103.3
E) 16.01
Answer: D
Diff: 2   Page Ref: Sec. 10.2

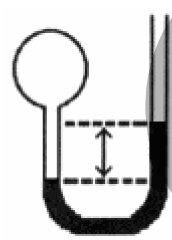
5) A closed-end manometer was attached to a vessel containing argon. The difference in the mercury levels in the two arms of the manometer was 12.2 cm. Atmospheric pressure was 783 mmHg. The pressure of the argon in the container was __________ mmHg.
A) 122
B) 661
C) 771
D) 795
E) 882
Answer: A
Diff: 2   Page Ref: Sec. 10.2

6) A gas vessel is attached to an open-end manometer containing a nonvolatile liquid of density 0.791 g/mL as shown below.



The difference in heights of the liquid in the two sides of the manometer is 43.4 cm when the atmospheric pressure is 755 mmHg. Given that the density of mercury is 13.6 g/mL, the pressure of the enclosed gas is __________ atm.
A) 1.03
B) 0.960
C) 0.993
D) 0.990
E) 0.987
Answer: B
Diff: 3   Page Ref: Sec. 10.2

7) A gas vessel is attached to an open-end manometer filled with a nonvolatile liquid of density 0.993 g/mL as shown below.



The difference in heights of the liquid in the two sides of the manometer is 32.3 cm when the atmospheric pressure is 765 mmHg. Given that the density of mercury is 13.6 g/mL, the pressure of the enclosed gas is __________ atm.
A) 1.04
B) 1.01
C) 0.976
D) 0.993
E) 1.08
Answer: A
Diff: 3   Page Ref: Sec. 10.2

8) In a Torricelli barometer, a pressure of one atmosphere supports a 760 mm column of mercury. If the original tube containing the mercury is replaced with a tube having twice the diameter of the original, the height of the mercury column at one atmosphere pressure is __________ mm.
A) 380
B) 760
C) 1.52×10^3
D) 4.78×10^3
E) 121
Answer: B
Diff: 3   Page Ref: Sec. 10.2

9) A sample of gas (24.2 g) initially at 4.00 atm was compressed from 8.00 L to 2.00 L at constant temperature. After the compression, the gas pressure was __________ atm.
A) 4.00
B) 2.00
C) 1.00
D) 8.00
E) 16.0
Answer: E
Diff: 2   Page Ref: Sec. 10.3

10) A sample of a gas (5.0 mol) at 1.0 atm is expanded at constant temperature from 10 L to 15 L. The final pressure is __________ atm.
A) 1.5
B) 7.5
C) 0.67
D) 3.3
E) 15
Answer: C
Diff: 2   Page Ref: Sec. 10.3

11) A balloon originally had a volume of 4.39 L at 44 °C and a pressure of 729 torr. The balloon must be cooled to __________°C to reduce its volume to 3.78 L (at constant pressure).
A) 38
B) 0
C) 72.9
D) 273
E) 546
Answer: B
Diff: 2   Page Ref: Sec. 10.3

12) If 3.21 mol of a gas occupies 56.2 L at 44 °C and 793 torr, 5.29 mol of this gas occupies __________ L under these conditions.
A) 14.7
B) 61.7
C) 30.9
D) 92.6
E) 478
Answer: D
Diff: 2   Page Ref: Sec. 10.3

13) A gas originally at 27 °C and 1.00 atm pressure in a 3.9 L flask is cooled at constant pressure until the temperature is 11 °C. The new volume of the gas is __________ L.
A) 0.27
B) 3.7
C) 3.9
D) 4.1
E) 0.24
Answer: B
Diff: 2   Page Ref: Sec. 10.3

14) If 50.75 g of a gas occupies 10.0 L at STP, 129.3 g of the gas will occupy __________ L at STP.
A) 3.92
B) 50.8
C) 12.9
D) 25.5
E) 5.08
Answer: D
Diff: 2 Page Ref: Sec. 10.3

15) A sample of He gas (2.35 mol) occupies 57.9 L at 300.0 K and 1.00 atm. The volume of this sample is __________ L at 423 K and 1.00 atm.
A) 0.709
B) 41.1
C) 81.6
D) 1.41
E) 57.9
Answer: C
Diff: 2 Page Ref: Sec. 10.3

16) A sample of H_2 gas (12.28 g) occupies 100.0 L at 400.0 K and 2.00 atm. A sample weighing 9.49 g occupies __________ L at 353 K and 2.00 atm.
A) 109
B) 68.2
C) 54.7
D) 147
E) 77.3
Answer: B
Diff: 2 Page Ref: Sec. 10.3

17) A sample of an ideal gas (3.00 L) in a closed container at 25.0 °C and 76.0 torr is heated to 300 °C. The pressure of the gas at this temperature is __________ torr.
A) 912
B) 146
C) 76.5
D) 39.5
E) 2.53×10^{-2}
Answer: B
Diff: 3 Page Ref: Sec. 10.3

18) A sample of a gas (1.50 mol) is contained in a 15.0 L cylinder. The temperature is increased from 100 °C to 150 °C. The ratio of final pressure to initial pressure $[\frac{P_2}{P_1}]$ is __________.
A) 1.50
B) 0.667
C) 0.882
D) 1.13
E) 1.00
Answer: D
Diff: 3 Page Ref: Sec. 10.3

19) A sample of a gas originally at 25 °C and 1.00 atm pressure in a 2.5 L container is allowed to expand until the pressure is 0.85 atm and the temperature is 15 °C. The final volume of the gas is __________ L.
A) 3.0
B) 2.8
C) 2.6
D) 2.1
E) 0.38
Answer: B
Diff: 3 Page Ref: Sec. 10.3

20) The reaction of 50 mL of Cl_2 gas with 50 mL of CH_4 gas via the equation:

$$Cl_2\ (g) + CH_4\ (g) \rightarrow HCl\ (g) + CH_3Cl\ (g)$$

will produce a total of __________ mL of products if pressure and temperature are kept constant.
A) 100
B) 50
C) 200
D) 150
E) 250
Answer: A
Diff: 3 Page Ref: Sec. 10.3

21) The reaction of 50 mL of N_2 gas with 150 mL of H_2 gas to form ammonia via the equation:

$$N_2\ (g) + 3H_2\ (g) \rightarrow 2NH_3\ (g)$$

will produce __________ mL of ammonia if pressure and temperature are kept constant.
A) 250
B) 50
C) 200
D) 150
E) 100
Answer: E
Diff: 3 Page Ref: Sec. 10.3

22) The reaction of 50 mL of Cl_2 gas with 50 mL of CH_4 gas via the equation:

$$Cl_2\ (g) + C_2H_4\ (g) \rightarrow C_2H_4Cl_2\ (g)$$

will produce a total of __________ mL of products if pressure and temperature are kept constant.
A) 100
B) 50
C) 25
D) 125
E) 150
Answer: B
Diff: 4 Page Ref: Sec. 10.3

23) The amount of gas that occupies 60.82 L at 31 °C and 367 mmHg is __________ mol.
A) 1.18
B) 0.850
C) 894
D) 11.6
E) 0.120
Answer: A
Diff: 2 Page Ref: Sec. 10.4

24) The pressure of a sample of CH_4 gas (6.022 g) in a 30.0 L vessel at 402 K is __________ atm.
A) 2.42
B) 6.62
C) 0.414
D) 12.4
E) 22.4
Answer: C
Diff: 3 Page Ref: Sec. 10.4

25) At a temperature of __________ °C, 0.444 mol of CO gas occupies 11.8 L at 889 torr.
A) 379
B) 73
C) 14
D) 32
E) 106
Answer: E
Diff: 3 Page Ref: Sec. 10.4

26) The volume of 0.25 mol of a gas at 72.7 kPa and 15 °C is __________ m^3.
A) 8.1×10^{-5}
B) 1.2×10^{-4}
C) 4.3×10^{-4}
D) 8.2×10^{-3}
E) 2.2×10^{-1}
Answer: D
Diff: 3 Page Ref: Sec. 10.4

27) The pressure exerted by 1.3 mol of gas in a 13 L flask at 22 °C is __________ kPa.
A) 560
B) 250
C) 18
D) 2.4
E) 1.0
Answer: B
Diff: 3 Page Ref: Sec. 10.4

28) A 0.325 L flask filled with gas at 0.914 atm and 19 °C contains __________ mol of gas.
A) 1.24×10^{-2}
B) 1.48×10^{-2}
C) 9.42
D) 12.4
E) 80.7
Answer: A
Diff: 2 Page Ref: Sec. 10.4

29) A gas in a 325 mL container has a pressure of 695 torr at 19 °C. There are __________ mol of gas in the flask.
A) 1.24×10^{-2}
B) 1.48×10^{-2}
C) 9.42
D) 12.4
E) 80.6
Answer: A
Diff: 2 Page Ref: Sec. 10.4

30) A sample of gas (1.9 mol) is in a flask at 21 °C and 697 mmHg. The flask is opened and more gas is added to the flask. The new pressure is 795 mmHg and the temperature is now 26 °C. There are now __________ mol of gas in the flask.
A) 1.6
B) 2.1
C) 2.9
D) 3.5
E) 0.28
Answer: B
Diff: 3   Page Ref: Sec. 10.4

31) A sample of gas (1.3 mol) occupies __________ L at 22 °C and 2.5 atm.
A) 0.079
B) 0.94
C) 13
D) 31
E) 3.2×10^{-2}
Answer: C
Diff: 2   Page Ref: Sec. 10.4

32) The volume of 0.65 mol of an ideal gas at 365 torr and 97 °C is __________ L.
A) 0.054
B) 9.5
C) 11
D) 41
E) 2.4×10^{-2}
Answer: D
Diff: 2   Page Ref: Sec. 10.4

33) The volume occupied by 1.5 mol of gas at 35 °C and 2.0 atm pressure is __________ L.
A) 38
B) 19
C) 2.2
D) 0.053
E) 0.026
Answer: B
Diff: 2   Page Ref: Sec. 10.4

34) The mass of nitrogen dioxide contained in a 4.32 L vessel at 48 °C and 141600 Pa is __________ g.
A) 5.35×10^{4}
B) 53.5
C) 10.5
D) 70.5
E) 9.46×10^{-2}
Answer: C
Diff: 3   Page Ref: Sec. 10.4

35) The density of ammonia gas in a 4.32 L container at 837 torr and 45.0 °C is __________ g/L.
A) 3.86
B) 0.717
C) 0.432
D) 0.194
E) 4.22×10^{-2}
Answer: B
Diff: 3 Page Ref: Sec. 10.5

36) The density of N_2O at 1.53 atm and 45.2 °C is __________ g/L.
A) 18.2
B) 1.76
C) 0.388
D) 9.99
E) 2.58
Answer: E
Diff: 4 Page Ref: Sec. 10.5

37) The molecular weight of a gas is __________ g/mol if 3.5 g of the gas occupies 2.1 L at STP.
A) 41
B) 5.5×10^{3}
C) 37
D) 4.6×10^{2}
E) 2.7×10^{-2}
Answer: C
Diff: 3 Page Ref: Sec. 10.5

38) The molecular weight of a gas that has a density of 6.70 g/L at STP is __________ g/mol.
A) 496
B) 150
C) 73.0
D) 3.35
E) 0.298
Answer: B
Diff: 4 Page Ref: Sec. 10.5

39) The molecular weight of a gas that has a density of 7.10 g/L at 25.0 °C and 1.00 atm pressure is __________ g/mol.
A) 174
B) 14.6
C) 28.0
D) 5.75×10^{-3}
E) 6.85×10^{-2}
Answer: A
Diff: 4 Page Ref: Sec. 10.5

40) The molecular weight of a gas that has a density of 5.75 g/L at STP is __________ g/mol.
A) 3.90
B) 129
C) 141
D) 578
E) 1.73×10^{-3}
Answer: B
Diff: 4   Page Ref: Sec. 10.5

41) The density of chlorine (Cl_2) gas at 25 °C and 60. kPa is __________ g/L.
A) 20
B) 4.9
C) 1.7
D) 0.86
E) 0.58
Answer: C
Diff: 4   Page Ref: Sec. 10.5

42) The volume of hydrogen gas at 38.0 °C and 763 torr that can be produced by the reaction of 4.33 g of zinc with excess sulfuric acid is __________ L.
A) 1.69
B) 2.71×10^{-4}
C) 3.69×10^{4}
D) 2.84
E) 0.592
Answer: A
Diff: 5   Page Ref: Sec. 10.5

43) The volume of HCl gas required to react with excess magnesium metal to produce 6.82 L of hydrogen gas at 2.19 atm and 35.0 °C is __________ L.
A) 6.82
B) 2.19
C) 13.6
D) 4.38
E) 3.41
Answer: C
Diff: 4   Page Ref: Sec. 10.5

44) The volume of fluorine gas required to react with 2.67 g of calcium bromide to form calcium fluoride and bromine at 41.0 °C and 4.31 atm is __________ mL.
A) 10.4
B) 210
C) 420
D) 79.9
E) 104
Answer: D
Diff: 4   Page Ref: Sec. 10.5

45) What volume (mL) of sulfur dioxide can be produced by the complete reaction of 3.82 g of calcium sulfite with excess HCl (aq), when the final SO_2 pressure is 827 torr at 44.0 °C?

A) 761
B) 1.39×10^{-4}
C) 1.00×10^{-3}
D) 0.106
E) 578
Answer: A
Diff: 4 Page Ref: Sec. 10.5

46) Automobile air bags use the decomposition of sodium azide as their source of gas for rapid inflation:

$$2NaN_3\ (s) \rightarrow 2Na\ (s) + 3N_2\ (g).$$

What mass (g) of NaN_3 is required to provide 40.0 L of N_2 at 25.0 °C and 763 torr?

A) 1.64
B) 1.09
C) 160
D) 71.1
E) 107
Answer: D
Diff: 4 Page Ref: Sec. 10.5

47) The Mond process produces pure nickel metal via the thermal decomposition of nickel tetracarbonyl:

$$Ni(CO)_4\ (l) \rightarrow Ni\ (s) + 4CO\ (g).$$

What volume (L) of CO is formed from the complete decomposition of 444 g of $Ni(CO)_4$ at 752 torr and 22.0 °C?

A) 0.356
B) 63.7
C) 255
D) 20.2
E) 11.0
Answer: C
Diff: 4 Page Ref: Sec. 10.5

48) What volume (L) of NH_3 gas at STP is produced by the complete reaction of 7.5 g of H_2O according to the following reaction?

$$Mg_3N_2\ (s) + 6H_2O\ (l) \rightarrow 3Mg(OH)_2\ (aq) + 2NH_3\ (g)$$

A) 3.1
B) 9.3
C) 19
D) 28
E) 0.32
Answer: A
Diff: 4 Page Ref: Sec. 10.5

49) Ammonium nitrite undergoes thermal decomposition to produce only gases:

$$NH_4NO_2\ (s) \rightarrow N_2\ (g) + 2H_2O\ (g)$$

What volume (L) of gas is produced by the decomposition of 35.0 g of NH_4NO_2 (s) at 525 ° C and 1.5 atm?
A) 47
B) 160
C) 15
D) 72
E) 24
Answer: D
Diff: 4 Page Ref: Sec. 10.5

50) The thermal decomposition of potassium chlorate can be used to produce oxygen in the laboratory.

$$2KClO_3\ (s) \rightarrow 2KCl\ (s) + 3O_2\ (g)$$

What volume (L) of O_2 gas at 25 °C and 1.00 atm pressure is produced by the decomposition of 7.5 g of $2KClO_3$ (s) ?
A) 4.5
B) 7.5
C) 2.2
D) 3.7
E) 11
Answer: C
Diff: 4 Page Ref: Sec. 10.5

51) Since air is a mixture, it does not have a "molar mass." However, for calculation purposes, it is possible to speak of its "effective molar mass." (An effective molar mass is a weighted average of the molar masses of a mixture's components.) If air at STP has a density of 1.285 g/L, its effective molar mass is __________ g/mol.
A) 26.9
B) 31.4
C) 30.0
D) 34.4
E) 28.8
Answer: E
Diff: 5 Page Ref: Sec. 10.5

52) A vessel contained N_2 , Ar, He, and Ne. The total pressure in the vessel was 987 torr. The partial pressures of nitrogen, argon, and helium were 44.0, 486, and 218 torr, respectively. The partial pressure of neon in the vessel was __________ torr.
A) 42.4
B) 521
C) 19.4
D) 239
E) 760
Answer: D
Diff: 3 Page Ref: Sec. 10.6

53) The pressure in a 12.2 L vessel that contains 2.34 g of carbon dioxide, 1.73 g of sulfur dioxide, and 3.33 g of argon, all at 42 °C is __________ mmHg.
A) 263
B) 134
C) 395
D) 116
E) 0.347
Answer: A
Diff: 3   Page Ref: Sec. 10.6

54) A sample of He gas (3.0 L) at 5.6 atm and 25 °C was combined with 4.5 L of Ne gas at 3.6 atm and 25 °C at constant temperature in a 9.0 L flask. The total pressure in the flask was __________ atm. Assume the initial pressure in the flask was 0.00 atm.
A) 2.6
B) 9.2
C) 1.0
D) 3.7
E) 24
Answer: D
Diff: 3   Page Ref: Sec. 10.6

55) A sample of H_2 gas (2.0 L) at 3.5 atm was combined with 1.5 L of N_2 gas at 2.6 atm pressure at a constant temperature of 25 °C into a 7.0 L flask. The total pressure in the flask is __________ atm. Assume the initial pressure in the flask was 0.00 atm.
A) 0.56
B) 2.8
C) 1.0
D) 1.6
E) 24
Answer: D
Diff: 3   Page Ref: Sec. 10.6

56) In a gas mixture of He, Ne, and Ar with a total pressure of 8.40 atm, the mole fraction of Ar is __________ if the partial pressures of He and Ne are 1.50 and 2.00 atm, respectively.
A) 0.179
B) 0.238
C) 0.357
D) 0.583
E) 0.417
Answer: D
Diff: 4   Page Ref: Sec. 10.6

57) A gas mixture of Ne and Ar has a total pressure of 4.00 atm and contains 16.0 mol of gas. If the partial pressure of Ne is 2.75 atm, how many moles of Ar are in the mixture?
A) 11.0
B) 5.00
C) 6.75
D) 9.25
E) 12.0
Answer: B
Diff: 4   Page Ref: Sec. 10.6

58) A mixture of He and Ne at a total pressure of 0.95 atm is found to contain 0.32 mol of He and 0.56 mol of Ne. The partial pressure of Ne is __________ atm.
A) 1.7
B) 1.5
C) 0.60
D) 0.35
E) 1.0
Answer: C
Diff: 3 Page Ref: Sec. 10.6

59) A flask contains a mixture of He and Ne at a total pressure of 2.6 atm. There are 2.0 mol of He and 5.0 mol of Ne in the flask. The partial pressure of He is __________ atm.
A) 9.1
B) 6.5
C) 1.04
D) 0.74
E) 1.86
Answer: D
Diff: 3 Page Ref: Sec. 10.6

60) Sodium hydride reacts with excess water to produce aqueous sodium hydroxide and hydrogen gas:

$$NaH (s) + H_2O (l) \rightarrow NaOH (aq) + H_2 (g)$$

A sample of NaH weighing __________ g will produce 982 mL of gas at 28.0 °C and 765 torr, when the hydrogen is collected over water. The vapor pressure of water at this temperature is 28 torr.
A) 2.93
B) 0.960
C) 0.925
D) 0.0388
E) 925
Answer: C
Diff: 4 Page Ref: Sec. 10.6

61) SO_2 (5.00 g) and CO_2 (5.00 g) were placed in a 750.0 mL container at 50.0 °C. The total pressure in the container was __________ atm.
A) 0.192
B) 4.02
C) 2.76
D) 6.78
E) 1.60
Answer: D
Diff: 3 Page Ref: Sec. 10.6

62) SO_2 (5.00 g) and CO_2 (5.00 g) are placed in a 750.0 mL container at 50.0 °C. The partial pressure of SO_2 in the container was __________ atm.
A) 2.76
B) 4.02
C) 6.78
D) 0.192
E) 1.60
Answer: A
Diff: 3 Page Ref: Sec. 10.6

63) SO_2 (5.00 g) and CO_2 (5.00 g) were placed in a 750.0 mL container at 50.0 °C. The partial pressure of CO_2 in the container was __________ atm.
A) 6.78
B) 2.76
C) 1.60
D) 0.192
E) 4.02
Answer: E
Diff: 3 Page Ref: Sec. 10.6

64) CO (5.00 g) and CO_2 (5.00 g) were placed in a 750.0 mL container at 50.0 °C. The total pressure in the container was __________ atm.
A) 10.3
B) 4.02
C) 6.31
D) 0.292
E) 1.60
Answer: A
Diff: 3 Page Ref: Sec. 10.6

65) CO (5.00 g) and CO_2 (5.00 g) were placed in a 750.0 mL container at 50.0 °C. The partial pressure of CO in the container was __________ atm.
A) 6.31
B) 4.02
C) 10.3
D) 0.292
E) 1.60
Answer: A
Diff: 3 Page Ref: Sec. 10.6

66) CO (5.00 g) and CO_2 (5.00 g) were placed in a 750.0 mL container at 50.0 °C. The partial pressure of CO_2 in the container was __________ atm.
A) 4.01
B) 10.3
C) 1.60
D) 0.292
E) 6.31
Answer: A
Diff: 3 Page Ref: Sec. 10.6

67) The root-mean-square speed of CO at 113 °C is __________ m/s.
A) 317
B) 58.3
C) 586
D) 993
E) 31.5
Answer: C
Diff: 3 Page Ref: Sec. 10.8

68) A sample of N_2 gas (2.0 mmol) effused through a pinhole in 5.5 s. It will take __________ s for the same amount of CH_4 to effuse under the same conditions.
A) 7.3
B) 5.5
C) 3.1
D) 4.2
E) 9.6
Answer: D
Diff: 4   Page Ref: Sec. 10.8

69) A sample of O_2 gas (2.0 mmol) effused through a pinhole in 5.0 s. It will take __________ s for the same amount of CO_2 to effuse under the same conditions.
A) 4.3
B) 0.23
C) 3.6
D) 5.9
E) 6.9
Answer: D
Diff: 4   Page Ref: Sec. 10.8

70) A sample of He gas (2.0 mmol) effused through a pinhole in 53 s. The same amount of an unknown gas, under the same conditions, effused through the pinhole in 248 s. The molecular mass of the unknown gas is __________ g/mol.
A) 0.19
B) 5.5
C) 88
D) 19
E) 350
Answer: C
Diff: 4   Page Ref: Sec. 10.8

71) Using the van der Waals equation, the pressure in a 22.4 L vessel containing 1.00 mol of neon gas at 100 °C is __________ atm. (a = 0.211 L^2-atm/mol^2, b = 0.0171 L/mol)
A) 0.730
B) 1.00
C) 1.21
D) 1.37
E) 0.367
Answer: D
Diff: 5   Page Ref: Sec. 10.9

72) Using the van der Waals equation, the pressure in a 22.4 L vessel containing 1.50 mol of chlorine gas at 0.00 °C is __________ atm. (a = 6.49L^2-atm/mol^2, b = 0.0562 L/mol)
A) 0.993
B) 1.50
C) 0.676
D) 1.91
E) 1.48
Answer: E
Diff: 5   Page Ref: Sec. 10.9

Multiple-Choice

73) Of the following, ___________ is a greenhouse gas.
A) O_2
B) CH_4
C) Cl_2
D) C_2H_4
E) Xe
Answer: B
Diff: 1 Page Ref: Sec. 10.1

74) Which of the following statements about gases is false?
A) Gases are highly compressible.
B) Distances between molecules of gas are very large compared to bond distances within molecules.
C) Non-reacting gas mixtures are homogeneous.
D) Gases expand spontaneously to fill the container they are placed in.
E) All gases are colorless and odorless at room temperature.
Answer: E
Diff: 1 Page Ref: Sec. 10.1

75) Of the following, ___________ has a slight odor of bitter almonds and is toxic.
A) NH_3
B) N_2O
C) CO
D) CH_4
E) HCN
Answer: E
Diff: 2 Page Ref: Sec. 10.1

76) Of the following, ___________ has the odor of rotting eggs.
A) NH_3
B) H_2S
C) CO
D) NO_2
E) HCN
Answer: B
Diff: 2 Page Ref: Sec. 10.1

77) One significant difference between gases and liquids is that ___________.
A) a gas is made up of molecules
B) a gas assumes the volume of its container
C) a gas may consist of both elements and compounds
D) gases are always mixtures
E) All of the above answers are correct.
Answer: B
Diff: 1 Page Ref: Sec. 10.1

78) Molecular compounds of low molecular weight tend to be gases at room temperature. Which of the following is most likely not a gas at room temperature?
A) Cl_2
B) HCl
C) LiCl
D) H_2
E) CH_4
Answer: C
Diff: 1 Page Ref: Sec. 10.1

79) Gaseous mixtures __________.
A) can only contain molecules
B) are all heterogeneous
C) can only contain isolated atoms
D) are all homogeneous
E) must contain both isolated atoms and molecules
Answer: D
Diff: 1 Page Ref: Sec. 10.1

80) Which of the following equations shows an incorrect relationship between pressures given in terms of different units?
A) 1.20 atm = 122 kPa
B) 152 mmHg = 2.03×10^4 Pa
C) 0.760 atm = 578 mmHg
D) 1.0 torr = 2.00 mmHg
E) 1.00 atm = 760 torr
Answer: D
Diff: 2 Page Ref: Sec. 10.2

81) The pressure exerted by a column of liquid is equal to the product of the height of the column times the gravitational constant times the density of the liquid, P = *ghd*. How high a column of water (d = 1.0g/mL) would be supported by a pressure that supports a 713 mm column of mercury (d = 13.6g/mL)?
A) 14 mm
B) 52 mm
C) 713 mm
D) 1.2×10^4 mm
E) 9.7×10^3 mm
Answer: E
Diff: 3 Page Ref: Sec. 10.2

82) The pressure exerted by a column of liquid is equal to the product of the height of the column times the gravitational constant times the density of the liquid, P = *ghd*. How high a column of methanol (d = 0.79 g/mL) would be supported by a pressure that supports a 713 mm column of mercury (d = 13.6 g/mL)?
A) 713 mm
B) 41 mm
C) 1.2×10^4 mm
D) 9.7×10^3 mm
E) 17 mm
Answer: C
Diff: 3 Page Ref: Sec. 10.2

83) If one was told that their blood pressure was 130/80, their systolic pressure was __________.
A) 130 Pa
B) 130 mmHg
C) 80 Pa
D) 80 mmHg
E) 80 psi
Answer: B
Diff: 1   Page Ref: Sec. 10.2

84) The first person to investigate the relationship between the pressure of a gas and its volume was __________.
A) Amadeo Avogadro
B) Lord Kelvin
C) Jacques Charles
D) Robert Boyle
E) Joseph Louis Gay-Lussac
Answer: D
Diff: 1   Page Ref: Sec. 10.3

85) Which statement about atmospheric pressure is false?
A) As air becomes thinner, its density decreases.
B) Air actually has weight.
C) With an increase in altitude, atmospheric pressure increases as well.
D) The warmer the air, the lower the atmospheric pressure.
E) Atmospheric pressure prevents water in lakes, rivers, and oceans from boiling away.
Answer: C
Diff: 1   Page Ref: Sec. 10.2, 10.3

86) In ideal gas equation calculations, expressing pressure in Pascals (Pa), necessitates the use of the gas constant, R, equal to __________.
A) 0.08206 atm L $mol^{-1}K^{-1}$
B) 8.314 J $mol^{-1}K^{-1}$
C) 62.36 L torr $mol^{-1}K^{-1}$
D) 1.987 cal $mol^{-1}K^{-1}$
E) none of the above
Answer: B
Diff: 2   Page Ref: Sec. 10.2, 10.3

87) Of the following, __________ is a correct statement of Boyle's law.
A) PV = constant
B) $\frac{P}{V}$ = constant
C) $\frac{V}{P}$ = constant
D) $\frac{V}{T}$ = constant
E) $\frac{n}{P}$ = constant
Answer: A
Diff: 2   Page Ref: Sec. 10.3

88) "Isothermal" means __________.
A) at constant pressure
B) at constant temperature
C) at variable temperature and pressure conditions
D) at ideal temperature and pressure conditions
E) that $\Delta H_{rxn} = 0$
Answer: B
Diff: 1 Page Ref: Sec. 10.3

89) Of the following, __________ is a valid statement of Charles' law.
A) $\frac{P}{T}$ = constant
B) $\frac{V}{T}$ = constant
C) PV = constant
D) V = constant × n
E) V = constant × P
Answer: B
Diff: 2 Page Ref: Sec. 10.3

90) Which one of the following is a valid statement of Avogadro's law?
A) $\frac{P}{T}$ = constant
B) $\frac{V}{T}$ = constant
C) PV = constant
D) V = constant × n
E) V = constant × P
Answer: D
Diff: 2 Page Ref: Sec. 10.3

91) The volume of an ideal gas is zero at __________.
A) 0 °C
B) -45 °F
C) -273 K
D) -363 K
E) -273 °C
Answer: E
Diff: 1 Page Ref: Sec. 10.3

92) Of the following, only __________ is impossible for an ideal gas.

A) $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

B) $V_1T_1 = V_2T_2$

C) $\frac{V_1}{V_2} = \frac{T_1}{T_2}$

D) $V_2 = \frac{T_2}{T_1}V_1$

E) $\frac{V_1}{V_2} = \frac{T_1}{T_2} = 0$

Answer: B
Diff: 2 Page Ref: Sec. 10.3

93) The molar volume of a gas at STP is __________ L.
A) 0.08206
B) 62.36
C) 1.00
D) 22.4
E) 14.7
Answer: D
Diff: 1 Page Ref: Sec. 10.4

94) Which statement about ideal behavior of gases is false?
A) At low densities all gases have similar properties.
B) Volume of 2.00 moles of oxygen gas, O_2, is assumed to be the same as that of 2.00 moles of carbon dioxide gas, CO_2, as long as the temperature and pressure conditions are the same.
C) Gas ideality assumes that there are no interactions between gas particles.
D) All particles in the ideal gas behave independently of each other.
E) Low pressures and high temperatures typically cause deviations from the ideal gas behavior.
Answer: E
Diff: 3 Page Ref: Sec. 10.4

95) Standard temperature and pressure (STP), in the context of gases, refers to __________.
A) 298 K and 1 atm
B) 273 K and 1 atm
C) 298 K and 1 torr
D) 273 K and 1 pascal
E) 273 K and 1 torr
Answer: B
Diff: 1 Page Ref: Sec. 10.4

96) The volume of a sample of gas (2.49 g) was 752 mL at 1.98 atm and 62 °C. The gas is __________.
A) SO_2
B) SO_3
C) NH_3
D) NO_2
E) Ne
Answer: D
Diff: 4 Page Ref: Sec. 10.5

97) The density of __________ is 0.900 g/L at STP.
A) CH_4
B) Ne
C) CO
D) N_2
E) NO
Answer: B
Diff: 4 Page Ref: Sec. 10.5

98) Of the following gases, __________ has density of 2.104 g/L at 303 K and 1.31 atm.
A) He
B) Ne
C) Ar
D) Kr
E) Xe
Answer: C
Diff: 4 Page Ref: Sec. 10.5

99) A 255 mL round-bottom flask is weighed and found to have a mass of 114.85 g. A few milliliters of an easily vaporized liquid are added to the flask and the flask is immersed in a boiling water bath. All of the liquid vaporizes at the boiling temperature of water, filling the flask with vapor. When all of the liquid has vaporized, the flask is removed from the bath, cooled, dried, and reweighed. The new mass of the flask and the condensed vapor is 115.23 g. Which of the following compounds could the liquid be? (Assume the ambient pressure is 1 atm.)
A) C_4H_{10}
B) C_3H_7OH
C) C_2H_6
D) C_2H_5OH
E) C_4H_9OH
Answer: D
Diff: 5 Page Ref: Sec. 10.5

100) A sample of an unknown volatile liquid was injected into a Dumas flask (m_{flask} = 27.0928 g, V_{flask} = 01040 L) and heated until no visible traces of the liquid could be found. The flask and its contents were then rapidly cooled and reweighed ($m_{flask + vapor}$ = 27.4593 g) The atmospheric pressure and temperature during the experiment were 0.976 atm and 18.0 °C, respectively. The unknown volatile liquid was __________.
A) C_6H_{12}
B) C_6H_{14}
C) C_7H_{14}
D) C_7H_{16}
E) C_6H_6
Answer: B
Diff: 5 Page Ref: Sec. 10.5

101) The density of air at STP is 1.285 g/L. Which of the following cannot be used to fill a balloon that will float in air at STP?
A) CH_4
B) NO
C) Ne
D) NH_3
E) HF
Answer: B
Diff: 4   Page Ref: Sec. 10.5

102) Removal of __________ from the natural gas both purifies the natural gas and serves as an alternative method of production of an industrially important chemical element.
A) CO_2
B) H_2S
C) NH_3
D) As_2O_3
E) He
Answer: B
Diff: 2   Page Ref: Sec. 10.6

103) The average kinetic energy of the particles of a gas is directly proportional to __________.
A) the rms speed
B) the square of the rms speed
C) the square root of the rms speed
D) the square of the particle mass
E) the particle mass
Answer: B
Diff: 2   Page Ref: Sec. 10.7

104) The kinetic-molecular theory predicts that pressure rises as the temperature of a gas increases because __________.
A) the average kinetic energy of the gas molecules decreases
B) the gas molecules collide more frequently with the wall
C) the gas molecules collide less frequently with the wall
D) the gas molecules collide more energetically with the wall
E) both the gas molecules collide more frequently with the wall and the gas molecules collide more energetically with the wall
Answer: E
Diff: 2   Page Ref: Sec. 10.7

105) According to kinetic-molecular theory, in which of the following gases will the root-mean-square speed of the molecules be the highest at 200 °C?
A) HCl
B) Cl_2
C) H_2O
D) SF_6
E) None. The molecules of all gases have the same root-mean-square speed at any given temperature.
Answer: C
Diff: 3   Page Ref: Sec. 10.7

106) According to kinetic-molecular theory, if the temperature of a gas is raised from 100 °C to 200 °C, the average kinetic energy of the gas will __________.
A) double
B) increase by a factor of 1.27
C) increase by a factor of 100
D) decrease by half
E) decrease by a factor of 100
Answer: B
Diff: 3 Page Ref: Sec. 10.7

107) Which of the following is not part of the kinetic-molecular theory?
A) Atoms are neither created nor destroyed by ordinary chemical reactions.
B) Attractive and repulsive forces between gas molecules are negligible.
C) Gases consist of molecules in continuous, random motion.
D) Collisions between gas molecules do not result in the loss of energy.
E) The volume occupied by all of the gas molecules in a container is negligible compared to the volume of the container.
Answer: A
Diff: 2 Page Ref: Sec. 10.7

108) Of the following gases, __________ will have the greatest rate of effusion at a given temperature.
A) NH_3
B) CH_4
C) Ar
D) HBr
E) HCl
Answer: B
Diff: 2 Page Ref: Sec. 10.8

109) A tank containing both HF and HBr gases developed a leak. The ratio of the rate of effusion of HF to the rate of effusion of HBr is __________.
A) 4.04
B) 0.247
C) 2.01
D) 0.497
E) 16.3
Answer: C
Diff: 3 Page Ref: Sec. 10.8

110) At 333 K, which of the pairs of gases below would have the most nearly identical rates of effusion?
A) N_2O and NO_2
B) CO and N_2
C) N_2 and O_2
D) CO and CO_2
E) NO_2 and N_2O_4
Answer: B
Diff: 3 Page Ref: Sec. 10.8

111) At STP, the ratio of the root-mean-square speed of CO_2 to that of SO_2 is __________.
A) 2.001
B) 2.119
C) 1.000
D) 1.207
E) 1.456
Answer: D
Diff: 3 Page Ref: Sec. 10.8

112) Arrange the following gases in order of increasing average molecular speed at 25 °C.

He, O_2, CO_2, N_2

A) He < N_2 < O_2 < CO_2
B) He < O_2 < N_2 < CO_2
C) CO_2 < O_2 < N_2 < He
D) CO_2 < N_2 < O_2 < He
E) CO_2 < He < N_2 < O_2
Answer: C
Diff: 3 Page Ref: Sec. 10.8

113) Arrange the following gases in order of increasing average molecular speed at 25 °C.

Cl_2, O_2, F_2, N_2

A) Cl_2 < F_2 < O_2 < N_2
B) Cl_2 < O_2 < F_2 < N_2
C) N_2 < F_2 < Cl_2 < O_2
D) Cl_2 < F_2 < N_2 < O_2
E) F_2 < O_2 < N_2 < Cl_2
Answer: A
Diff: 3 Page Ref: Sec. 10.8

114) Which one of the following gases would have the <u>highest</u> average molecular speed at 25 °C?
A) O_2
B) N_2
C) CO_2
D) CH_4
E) SF_6
Answer: D
Diff: 2 Page Ref: Sec. 10.8

115) A sample of oxygen gas (O_2) was found to effuse at a rate equal to three times that of an unknown gas. The molecular weight of the unknown gas is __________ g/mol.
A) 288
B) 96
C) 55
D) 4
E) 10.7
Answer: A
Diff: 3 Page Ref: Sec. 10.8

116) A sample of oxygen gas was found to effuse at a rate equal to two times that of an unknown gas. The molecular weight of the unknown gas is __________ g/mol.
A) 64
B) 128
C) 8
D) 16
E) 8.0
Answer: B
Diff: 3 Page Ref: Sec. 10.8

117) A mixture of two gases was allowed to effuse from a container. One of the gases escaped from the container 1.43 times as fast as the other one. The two gases could have been __________.
A) CO and SF_6
B) O_2 and Cl_2
C) CO and CO_2
D) Cl_2 and SF_6
E) O_2 and SF_6
Answer: D
Diff: 3 Page Ref: Sec. 10.8

118) A mixture of carbon dioxide and an unknown gas was allowed to effuse from a container. The carbon dioxide took 1.25 times as long to escape as the unknown gas. Which one could be the unknown gas?
A) Cl_2
B) CO
C) HCl
D) H_2
E) SO_2
Answer: B
Diff: 3 Page Ref: Sec. 10.8

119) How much faster does ${}^{235}UF_6$ effuse than ${}^{238}UF_6$?
A) 1.013 times as fast
B) 1.009 times as fast
C) 1.004 times as fast
D) 1.006 times as fast
E) 1.018 times as fast
Answer: C
Diff: 4 Page Ref: Sec. 10.8

120) An ideal gas differs from a real gas in that the molecules of an ideal gas __________.
A) have no attraction for one another
B) have appreciable molecular volumes
C) have a molecular weight of zero
D) have no kinetic energy
E) have an average molecular mass
Answer: A
Diff: 2   Page Ref: Sec. 10.9

121) A real gas will behave most like an ideal gas under conditions of __________.
A) high temperature and high pressure
B) high temperature and low pressure
C) low temperature and high pressure
D) low temperature and low pressure
E) STP
Answer: B
Diff: 2   Page Ref: Sec. 10.9

122) Which one of the following gases would deviate the <u>least</u> from ideal gas behavior?
A) Ne
B) CH_3Cl
C) Kr
D) CO_2
E) F_2
Answer: A
Diff: 2   Page Ref: Sec. 10.9

123) Which noble gas is expected to show the largest deviations from the ideal gas behavior?
A) helium
B) neon
C) argon
D) krypton
E) xenon
Answer: E
Diff: 2   Page Ref: Sec. 10.9

124) The van der Waals equation for real gases recognizes that __________.
A) gas particles have non-zero volumes and interact with each other
B) molar volumes of gases of different types are different
C) the non-zero volumes of gas particles effectively decrease the amount of "empty space" between them
D) the molecular attractions between particles of gas decreases the pressure exerted by the gas
E) all of the above statements are true
Answer: E
Diff: 3   Page Ref: Sec. 10.9

125) When gases are treated as real, via use of the van der Waals equation, the actual volume occupied by gas molecules __________ the pressure exerted and the attractive forces between gas molecules __________ the pressure exerted, as compared to an ideal gas.
A) decreases, increases
B) increases, increases
C) increases, decreases
D) does not affect, decreases
E) does not affect, increases
Answer: C
Diff: 3   Page Ref: Sec. 10.9

Short Answer

1) The temperature and pressure specified by STP are __________ °C and __________ atm.
Answer: 0, 1
Diff: 1 Page Ref: Sec. 10.4

2) What is the partial pressure (in mm Hg) of neon in a 4.00 L vessel that contains 0.838 mol of methane, 0.184 mol of ethane, and 0.755 mol of neon at a total pressure of 928 mmHg?
Answer: 394
Diff: 4 Page Ref: Sec. 10.6

3) The rms speed of methane molecules at 45.0 °C is __________ m/sec.
Answer: 704
Diff: 4 Page Ref: Sec. 10.8

4) How many molecules are there in 4.00 L of oxygen gas at 500 °C and 50.0 torr?
Answer: 2.50×10^{21}
Diff: 3 Page Ref: Sec. 10.4

5) What is the density (in g/L) of oxygen gas at 77 °C and 700 torr?
Answer: 1.03
Diff: 4 Page Ref: Sec. 10.5

True/False

1) The main component of air is oxygen.
Answer: FALSE
Diff: 1 Page Ref: Sec. 10.1

2) A gas is considered "ideal" if one mole of it in a one-liter container exerts a pressure of exactly 1 atm at room temperature.
Answer: FALSE
Diff: 2 Page Ref: Sec. 10.4

3) Kinetic-molecular theory assumes that attractive and repulsive forces between gas particles are stronger than those between gas particles and container walls.
Answer: FALSE
Diff: 2 Page Ref: Sec. 10.7

4) According to the kinetic-molecular theory, molecules of different gases at the same temperature always have the same average kinetic energy.
Answer: TRUE
Diff: 2 Page Ref: Sec. 10.7

5) Two deviations of real gases from ideal gases which are treated in the van der Waals equation are finite molecular volume and non-zero molecular attractions.
Answer: TRUE
Diff: 2 Page Ref: Sec. 10.9

Algorithmic Questions

1) A fixed amount of gas at 25.0 °C occupies a volume of 10.0 L when the pressure is 667 torr. Use Boyle's law to calculate the pressure (torr) when the volume is reduced to 7.88 L at a constant temperature of 25.0 °C.
A) 846
B) 0.118
C) 5.26×10^4
D) 526
E) 1.11
Answer: A
Diff: 4   Page Ref: Sec. 10.3

2) A fixed amount of gas at 25.0 °C occupies a volume of 10.0 L when the pressure is 629 torr. Use Charles's law to calculate the volume (L) the gas will occupy when the temperature is increased to 121 °C while maintaining the pressure at 629 torr.
A) 10.9
B) 13.2
C) 2.07
D) 7.56
E) 48.4
Answer: B
Diff: 4   Page Ref: Sec. 10.3

3) The density of nitric oxide (NO) gas at 1.21 atm and 54.1 °C is __________ g/L.
A) 0.0451
B) 0.740
C) 1.35
D) 0.273
E) 8.2
Answer: C
Diff: 3   Page Ref: Sec. 10.5

4) The density of krypton gas at 1.21 atm and 50.0 °C is __________ g/L.
A) 0.0456
B) 0.262
C) 0.295
D) 3.82
E) 7.65
Answer: D
Diff: 3   Page Ref: Sec. 10.5

5) The density of chlorine gas at 1.21 atm and 34.9 °C is __________ g/L.
A) 0.0479
B) 0.295
C) 0.423
D) 1.70
E) 3.39
Answer: E
Diff: 3   Page Ref: Sec. 10.5

6) A 1.44-g sample of an unknown pure gas occupies a volume of 0.335 L at a pressure of 1.00 atm and a temperature of 100.0 °C. The unknown gas is __________.
A) argon
B) helium
C) krypton
D) neon
E) xenon
Answer: E
Diff: 4 Page Ref: Sec. 10.5

7) Calcium hydride (CaH_2) reacts with water to form hydrogen gas:

$$CaH_2\ (s) + 2H_2O\ (l) \rightarrow Ca(OH)_2\ (aq) + 2H_2\ (g)$$

How many grams of CaH_2 are needed to generate 48.0 L of H_2 gas at a pressure of 0.888 atm and a temperature of 32 °C?
A) 50.7
B) 0.851
C) 143
D) 35.8
E) 71.7
Answer: D
Diff: 4 Page Ref: Sec. 10.5

8) The total pressure exerted by a mixture of 1.50 g of H_2 and 5.00 g of N_2 in a 5.00-L vessel at 298 K is __________ atm.
A) 1.06
B) 9.08
C) 4.54
D) 32.4
E) 5.27
Answer: C
Diff: 4 Page Ref: Sec. 10.6

9) Zinc reacts with aqueous sulfuric acid to form hydrogen gas:

$$Zn\ (s) + H_2SO_4\ (aq) \rightarrow ZnSO_4\ (aq) + H_2\ (g)$$

In an experiment, 225 mL of wet H_2 is collected over water at 27 °C and a barometric pressure of 748 torr. How many grams of Zn have been consumed? The vapor pressure of water at 27 °C is 26.74 torr.
A) 4.79×10^6
B) 0.567
C) 567
D) 431
E) 4.31×10^5
Answer: B
Diff: 4 Page Ref: Sec. 10.6

10) Zinc reacts with aqueous sulfuric acid to form hydrogen gas:

$$Zn\ (s) + H_2SO_4\ (aq) \rightarrow ZnSO_4\ (aq) + H_2\ (g)$$

In an experiment, 201 mL of wet H_2 is collected over water at 27 °C and a barometric pressure of 733 torr. The vapor pressure of water at 27 °C is 26.74 torr. The partial pressure of hydrogen in this experiment is __________ atm.
A) 0.929
B) 706
C) 0.964
D) 760
E) 1.00
Answer: A
Diff: 4   Page Ref: Sec. 10.6

11) Given the equation

$$C_2H_6\ (g) + O_2\ (g) \rightarrow CO_2\ (g) + H_2O\ (g)$$

Determine the number of liters of CO_2 formed at STP. when 240.0 grams of C_2H_6 is burned in excess oxygen gas.
Answer: 358
Diff: 4   Page Ref: Sec 10.5

12) Given the equation

$$C_2H_6\ (g) + O_2\ (g) \rightarrow CO_2\ (g) + H_2O\ (g)$$

Determine the number of liters of O_2 consumed at STP when 270.0 grams of C_2H_6 is burned.
Answer: 706
Diff: 4   Page Ref: Sec. 10.5

Chemistry, 11e (Brown)
Chapter 11, Intermolecular Forces, Liquids, and Solids

Multiple-Choice and Bimodal

1) Based on molecular mass and dipole moment of the five compounds in the table below, which should have the highest boiling point?

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

A) $CH_3CH_2CH_3$

B) CH_3OCH_3

C) CH_3Cl

D) CH_3CHO

E) CH_3CN

Answer: E
Diff: 3 Page Ref: Sec. 11.2

2) Of the following substances, only __________ has London dispersion forces as its only intermolecular force.

CH_3OH
NH_3
H_2S
CH_4
HCl

A) CH_3OH

B) NH_3

C) H_2S

D) CH_4

E) HCl

Answer: D
Diff: 2 Page Ref: Sec. 11.2

3) Of the following substances, only __________ has London dispersion forces as the only intermolecular force.

CH_3OH
NH_3
H_2S
Kr
HCl

A) CH_3OH
B) NH_3
C) H_2S
D) Kr
E) HCl
Answer: D
Diff: 2 Page Ref: Sec. 11.2

4) Which one of the following should have the lowest boiling point?

PH_3
H_2S
HCl
SiH_4
H_2O

A) PH_3
B) H_2S
C) HCl
D) SiH_4
E) H_2O
Answer: D
Diff: 3 Page Ref: Sec. 11.2

5) Of the following substances, __________ has the highest boiling point.

H_2O
CO_2
CH_4
Kr
NH_3
A) H_2O
B) CO_2
C) CH_4
D) Kr
E) NH_3
Answer: A
Diff: 3 Page Ref: Sec. 11.2

6) Of the following, __________ has the highest boiling point.

N_2
Br_2
H_2
Cl_2
O_2

A) N_2
B) Br_2
C) H_2
D) Cl_2
E) O_2
Answer: B
Diff: 3 Page Ref: Sec. 11.2

7) In which of the following molecules is hydrogen bonding likely to be the most significant component of the total intermolecular forces?

CH_4
$C_5H_{11}OH$
$C_6H_{13}NH_2$
CH_3OH
CO_2

A) CH_4
B) $C_5H_{11}OH$
C) $C_6H_{13}NH_2$
D) CH_3OH
E) CO_2
Answer: D
Diff: 3 Page Ref: Sec. 11.2

8) Which of the following has dispersion forces as its only intermolecular force?

CH_4
HCl
$C_6H_{13}NH_2$
NaCl
CH_3Cl

A) CH_4
B) HCl
C) $C_6H_{13}NH_2$
D) NaCl
E) CH_3Cl
Answer: A
Diff: 2 Page Ref: Sec. 11.2

9) The substance with the largest heat of vaporization is __________.

I_2
Br_2
Cl_2
F_2
O_2

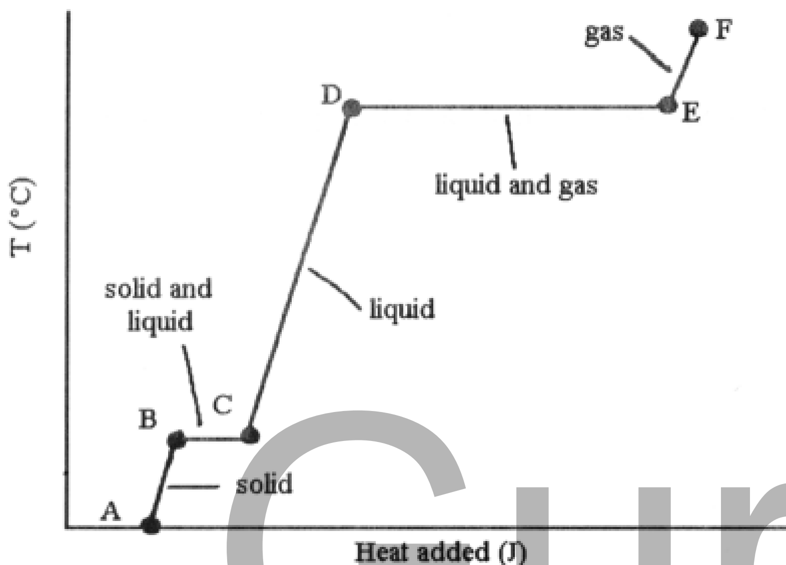
A) I_2
B) Br_2
C) Cl_2
D) F_2
E) O_2
Answer: A
Diff: 3 Page Ref: Sec. 11.4

10) Of the following, __________ is an exothermic process.

melting
subliming
freezing
boiling

A) melting
B) subliming
C) freezing
D) boiling
E) All of the above are exothermic.
Answer: C
Diff: 2 Page Ref: Sec. 11.4

11) The heat of fusion of water is 6.01 kJ/mol. The heat capacity of liquid water is 75.3 J/mol · K. The conversion of 50.0 g of ice at 0.00°C to liquid water at 22.0°C requires __________ kJ of heat.
A) 3.8×10^2
B) 21.3
C) 17.2
D) 0.469
E) Insufficient data are given.
Answer: B
Diff: 3 Page Ref: Sec. 11.4



12) The heating curve shown was generated by measuring the heat flow and temperature for a solid as it was heated. The slope of the __________ segment corresponds to the heat capacity of the liquid of the substance.
A) AB
B) BC
C) CD
D) DE
E) EF
Answer: C
Diff: 3 Page Ref: Sec. 11.4

13) The heating curve shown was generated by measuring the heat flow and temperature for a solid as it was heated. The slope of the __________ segment corresponds to the heat capacity of the solid.
A) AB
B) BC
C) CD
D) DE
E) EF
Answer: A
Diff: 3 Page Ref: Sec. 11.4

14) The heating curve shown was generated by measuring the heat flow and temperature of a solid as it was heated. The heat flow into the sample in the segment __________ will yield the value of the ΔH_{vap} of this substance.

A) AB
B) BC
C) CD
D) DE
E) EF
Answer: D
Diff: 3 Page Ref: Sec. 11.4

15) Of the following, __________ should have the highest critical temperature.

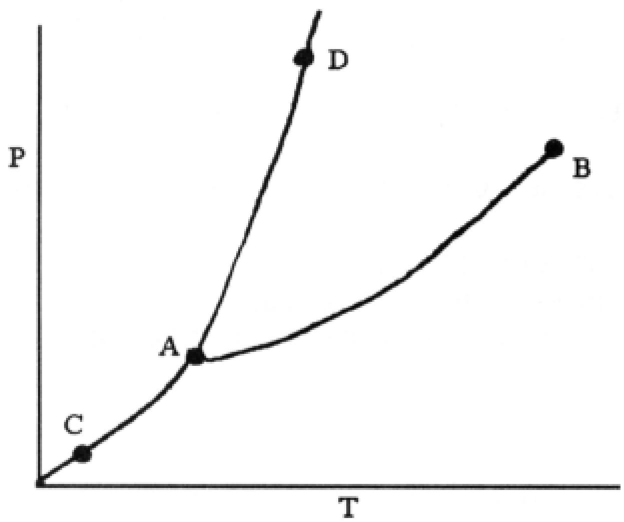
CBr_4
CCl_4
CF_4
CH_4
H_2

A) CBr_4
B) CCl_4
C) CF_4
D) CH_4
E) H_2
Answer: A
Diff: 3 Page Ref: Sec. 11.4

16) Of the following, __________ is the most volatile.

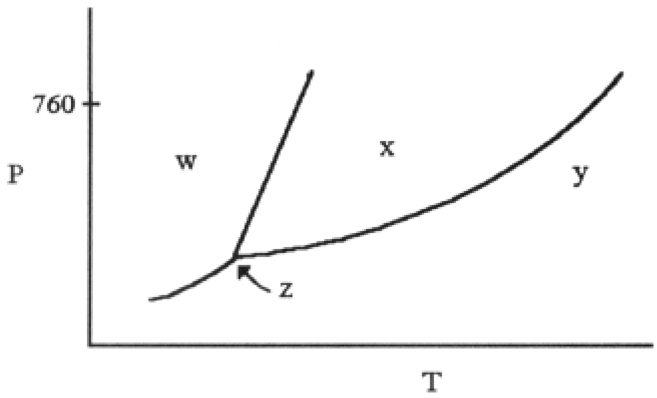
CBr_4
CCl_4
CF_4
CH_4
C_6H_{14}

A) CBr_4
B) CCl_4
C) CF_4
D) CH_4
E) C_6H_{14}
Answer: D
Diff: 3 Page Ref: Sec. 11.5

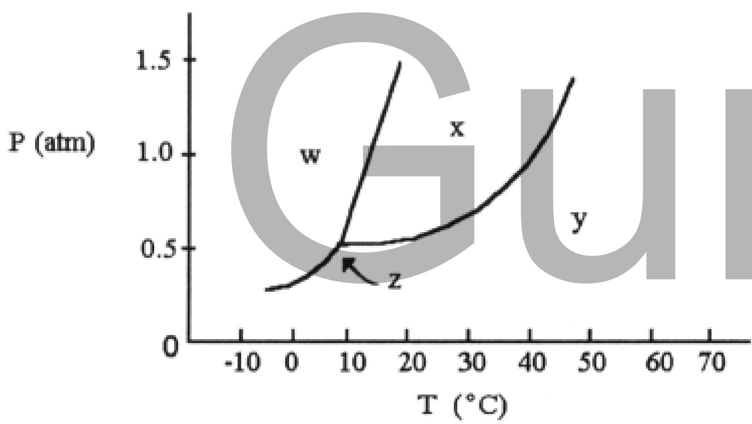


17) On the phase diagram below, segment __________ corresponds to the conditions of temperature and pressure under which the solid and the gas of the substance are in equilibrium.
A) AB
B) AC
C) AD
D) CD
E) BC
Answer: B
Diff: 2 Page Ref: Sec. 11.6

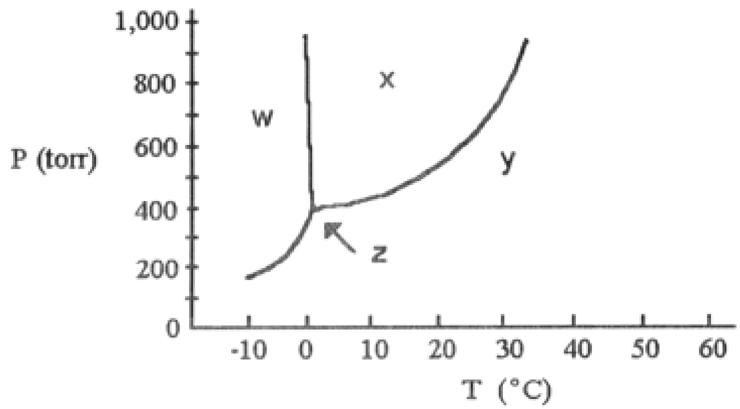
18) On the phase diagram shown, the coordinates of point __________ correspond to the critical temperature and pressure.
A) A
B) B
C) C
D) D
E) E
Answer: B
Diff: 2 Page Ref: Sec. 11.6



19) The phase diagram of a substance is given above. The region that corresponds to the solid phase is __________.
A) w
B) x
C) y
D) z
E) x and y
Answer: A
Diff: 2 Page Ref: Sec. 11.6



20) The normal boiling point of the substance with the phase diagram shown above is __________ °C.
A) 10
B) 20
C) 30
D) 40
E) 50
Answer: D
Diff: 2 Page Ref: Sec. 11.6



21) The phase diagram of a substance is shown above. The area labeled __________ indicates the gas phase for the substance.
A) w
B) x
C) y
D) z
E) y and z
Answer: C
Diff: 2 Page Ref: Sec. 11.6

22) According to the phase diagram shown above, the normal boiling point of this substance is __________ °C.
A) -3
B) 10
C) 29
D) 38
E) 0
Answer: C
Diff: 2 Page Ref: Sec. 11.6

23) Which one of the following cannot form a solid with a lattice based on the sodium chloride structure?

NaBr
LiF
RbI
CuO
$CuCl_2$

A) NaBr
B) LiF
C) RbI
D) CuO
E) $CuCl_2$
Answer: E
Diff: 3 Page Ref: Sec. 11.7

24) Gallium crystallizes in a primitive cubic unit cell. The length of the unit cell edge is 3.70 Ă The radius of a Ga atom is __________ Å.
A) 7.40
B) 3.70
C) 1.85
D) 0.930
E) Insufficient data is given.
Answer: C
Diff: 4 Page Ref: Sec. 11.7

25) Potassium metal crystallizes in a body-centered cubic structure with a unit cell edge length of 5.31 Ă . The radius of a potassium atom is __________ Å.
A) 1.33
B) 1.88
C) 2.30
D) 2.66
E) 5.31
Answer: C
Diff: 4 Page Ref: Sec. 11.7

26) Which of the following is not a type of solid?

ionic
molecular
supercritical
metallic
covalent-network

A) ionic
B) molecular
C) supercritical
D) metallic
E) covalent-network
Answer: C
Diff: 3 Page Ref: Sec. 11.8

27) __________ solids consist of atoms or molecules held together by dipole-dipole forces, London disperson forces, and/or hydrogen bonds.
A) Ionic
B) Molecular
C) Metallic
D) Covalent-network
E) Metallic and covalent-network
Answer: B
Diff: 2 Page Ref: Sec. 11.8

Multiple-Choice

28) Crystalline solids __________.
A) have their particles arranged randomly
B) have highly ordered structures
C) are usually very soft
D) exist only at high temperatures
E) exist only at very low temperatures
Answer: B
Diff: 1 Page Ref: Sec. 11.1

29) In liquids, the attractive intermolecular forces are __________.
A) very weak compared with kinetic energies of the molecules
B) strong enough to hold molecules relatively close together
C) strong enough to keep the molecules confined to vibrating about their fixed lattice points
D) not strong enough to keep molecules from moving past each other
E) strong enough to hold molecules relatively close together but not strong enough to keep molecules from moving past each other
Answer: E
Diff: 2 Page Ref: Sec. 11.1

30) As a solid element melts, the atoms become __________ and they have __________ attraction for one another.
A) more separated, more
B) more separated, less
C) closer together, more
D) closer together, less
E) larger, greater
Answer: B
Diff: 2 Page Ref: Sec. 11.1

31) A gas is __________ and assumes __________ of its container whereas a liquid is __________ and assumes __________ of its container.
A) compressible, the volume and shape, not compressible, the shape of a portion
B) compressible, the shape, not compressible, the volume and shape
C) compressible, the volume and shape, compressible, the volume
D) condensed, the volume and shape, condensed, the volume and shape
E) condensed, the shape, compressible, the volume and shape
Answer: A
Diff: 1 Page Ref: Sec. 11.1

32) Together, liquids and solids constitute __________ phases of matter.
A) the compressible
B) the fluid
C) the condensed
D) all of the
E) the disordered
Answer: C
Diff: 1 Page Ref: Sec. 11.1

33) Which statement is true about liquids but not true about solids?
A) They flow and are highly ordered.
B) They are highly ordered and not compressible.
C) They flow and are compressible.
D) They assume both the volume and the shape of their containers.
E) They flow and are not compressible.
Answer: E
Diff: 2 Page Ref: Sec. 11.1

34) The strongest interparticle attractions exist between particles of a __________ and the weakest interparticle attractions exist between particles of a __________.
A) solid, liquid
B) solid, gas
C) liquid, gas
D) liquid, solid
E) gas, solid
Answer: B
Diff: 1 Page Ref: Sec. 11.1

35) Which one of the following exhibits dipole-dipole attraction between molecules?
A) XeF_4
B) AsH_3
C) CO_2
D) BCl_3
E) Cl_2
Answer: B
Diff: 3 Page Ref: Sec. 11.2

36) When NaCl dissolves in water, aqueous Na^+ and Cl^- ions result. The force of attraction that exists between Na^+ and H_2O is called a(n) __________ interaction.
A) dipole-dipole
B) ion-ion
C) hydrogen bonding
D) ion-dipole
E) London dispersion force
Answer: D
Diff: 2 Page Ref: Sec. 11.2

37) __________ are particularly polarizable.
A) Small nonpolar molecules
B) Small polar molecules
C) Large nonpolar molecules
D) Large polar molecules
E) Large molecules, regardless of their polarity,
Answer: E
Diff: 2 Page Ref: Sec. 11.2

38) The ease with which the charge distribution in a molecule can be distorted by an external electrical field is called the __________.
A) electronegativity
B) hydrogen bonding
C) polarizability
D) volatility
E) viscosity
Answer: C
Diff: 1 Page Ref: Sec. 11.2

39) Which one of the following derivatives of ethane has the highest boiling point?
A) C_2Br_6
B) C_2F_6
C) C_2I_6
D) C_2Cl_6
E) C_2H_6
Answer: C
Diff: 2 Page Ref: Sec. 11.2

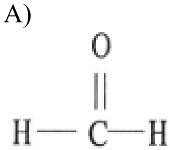
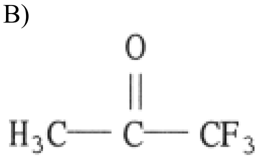
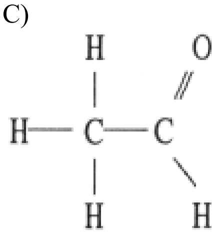
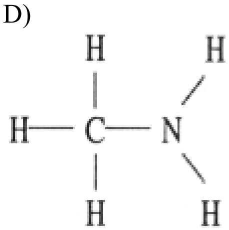
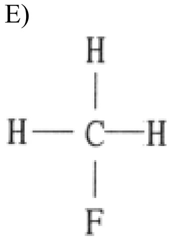
40) What is the predominant intermolecular force in CBr_4?
A) London-dispersion forces
B) ion-dipole attraction
C) ionic bonding
D) dipole-dipole attraction
E) hydrogen-bonding
Answer: A
Diff: 2 Page Ref: Sec. 11.2

41) The intermolecular force(s) responsible for the fact that CH_4 has the lowest boiling point in the set CH_4, SiH_4, GeH_4, SnH_4 is/are __________.
A) hydrogen bonding
B) dipole-dipole interactions
C) London dispersion forces
D) mainly hydrogen bonding but also dipole-dipole interactions
E) mainly London-dispersion forces but also dipole-dipole interactions
Answer: C
Diff: 2 Page Ref: Sec. 11.2

42) Elemental iodine (I_2) is a solid at room temperature. What is the major attractive force that exists among different I_2 molecules in the solid?
A) London dispersion forces
B) dipole-dipole rejections
C) ionic-dipole interactions
D) covalent-ionic interactions
E) dipole-dipole attractions
Answer: A
Diff: 2 Page Ref: Sec. 11.2

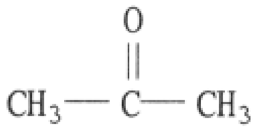
43) Hydrogen bonding is a special case of __________.
A) London-dispersion forces
B) ion-dipole attraction
C) dipole-dipole attractions
D) none of the above
E) ion-ion interactions
Answer: C
Diff: 1 Page Ref: Sec. 11.2

44) Which one of the following substances will have hydrogen bonding as one of its intermolecular forces?

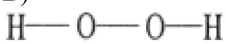
A)

B)

C)

D)

E)

Answer: D
Diff: 2 Page Ref: Sec. 11.2

45) Which one of the following substances will <u>not</u> have hydrogen bonding as one of its intermolecular forces?

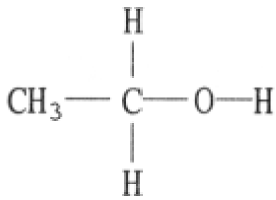
A)



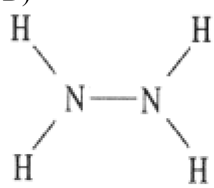
B)



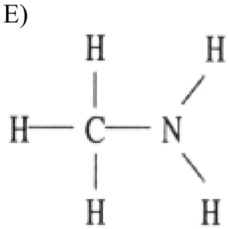
C)



D)



E)



Answer: A
Diff: 2 Page Ref: Sec. 11.2

46) What intermolecular force is responsible for the fact that ice is less dense than liquid water?
A) London dispersion forces
B) dipole-dipole forces
C) ion-dipole forces
D) hydrogen bonding
E) ionic bonding
Answer: D
Diff: 1 Page Ref: Sec. 11.2

47) The predominant intermolecular force in $(CH_3)_2NH$ is __________.
A) London dispersion forces
B) ion-dipole forces
C) ionic bonding
D) dipole-dipole forces
E) hydrogen bonding
Answer: E
Diff: 2 Page Ref: Sec. 11.2

48) $C_{12}H_{26}$ molecules are held together by __________.
A) ion-ion interactions
B) hydrogen bonding
C) ion-dipole interactions
D) dipole-dipole interactions
E) dispersion forces
Answer: E
Diff: 2 Page Ref: Sec. 11.2

49) Which of the following molecules has hydrogen bonding as its only intermolecular force?
A) HF
B) H_2O
C) $C_6H_{13}NH_2$
D) $C_5H_{11}OH$
E) None, all of the above exhibit dispersion forces.
Answer: E
Diff: 2 Page Ref: Sec. 11.2

50) __________ is the energy required to expand the surface area of a liquid by a unit amount of area.
A) Viscosity
B) Surface tension
C) Volatility
D) Meniscus
E) Capillary action
Answer: B
Diff: 2 Page Ref: Sec. 11.3

51) Which statements about viscosity are true?
(i) Viscosity increases as temperature decreases.
(ii) Viscosity increases as molecular weight increases.
(iii) Viscosity increases as intermolecular forces increase.
A) (i) only
B) (ii) and (iii)
C) (i) and (iii)
D) none
E) all
Answer: E
Diff: 3 Page Ref: Sec. 11.3

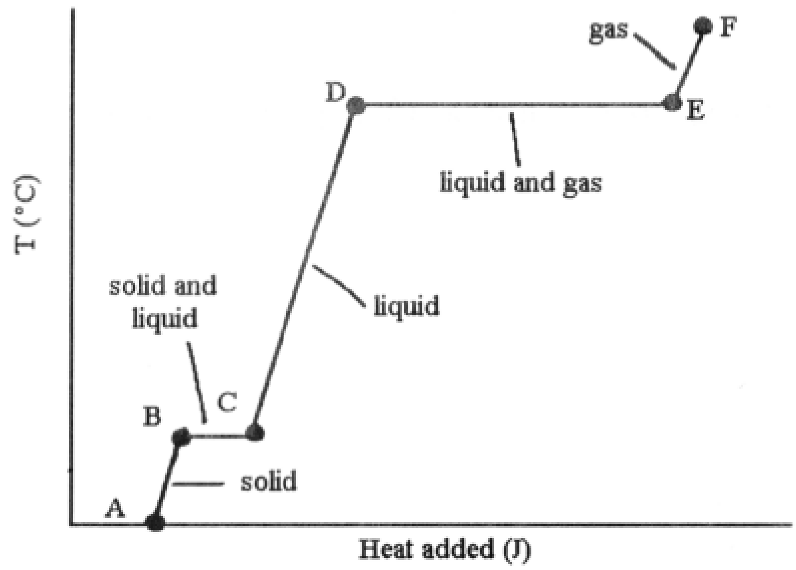
52) The shape of a liquid's meniscus is determined by __________.
A) the viscosity of the liquid
B) the type of material the container is made of
C) the relative magnitudes of cohesive forces in the liquid and adhesive forces between the liquid and its container
D) the amount of hydrogen bonding in the liquid
E) the volume of the liquid
Answer: C
Diff: 2 Page Ref: Sec. 11.3

53) Viscosity is __________.
A) the "skin" on a liquid surface caused by intermolecular attraction
B) the resistance to flow
C) the same as density
D) inversely proportional to molar mass
E) unaffected by temperature
Answer: B
Diff: 2 Page Ref: Sec. 11.3

54) How high a liquid will rise up a narrow tube as a result of capillary action depends on __________.
A) the magnitudes of cohesive forces in the liquid and adhesive forces between the liquid and the tube, and gravity
B) gravity alone
C) only the magnitude of adhesive forces between the liquid and the tube
D) the viscosity of the liquid
E) only the magnitude of cohesive forces in the liquid
Answer: A
Diff: 2 Page Ref: Sec. 11.3

55) The property responsible for the "beading up" of water is __________.
A) density
B) viscosity
C) vapor pressure
D) surface tension
E) hydrogen bonding
Answer: D
Diff: 2 Page Ref: Sec. 11.3

56) Heat of sublimation can be approximated by adding together __________ and __________.
A) heat of fusion, heat of condensation
B) heat of fusion, heat of vaporization
C) heat of freezing (solidification), heat of condensation
D) heat of freezing (solidification), heat of vaporization
E) heat of deposition, heat of vaporization
Answer: B
Diff: 2 Page Ref: Sec. 11.4



57) The phase changes B → C and D → E are not associated with temperature increases because the heat energy is used up to __________.
A) increase distances between molecules
B) break intramolecular bonds
C) rearrange atoms within molecules
D) increase the velocity of molecules
E) increase the density of the sample
Answer: A
Diff: 3 Page Ref: Sec. 11.4

58) Which of the following is not an existing or a potential application of the supercritical carbon dioxide?
A) extraction of caffeine from coffee beans
B) isolation of the flavor components of herbs and spices
C) extraction of essential flavor elements from hops for use in brewing
D) use as a solvent in dry cleaning
E) use as a coolant in refrigeration
Answer: E
Diff: 2 Page Ref: Sec. 11.4

59) Large intermolecular forces in a substance are manifested by __________.
A) low vapor pressure
B) high boiling point
C) high heats of fusion and vaporization
D) high critical temperatures and pressures
E) all of the above
Answer: E
Diff: 2 Page Ref: Sec. 11.4

60) A substance that expands to fill its container yet has a density approaching that of a liquid, and that can behave as a solvent is called a(n) __________.
A) plasma
B) gas
C) liquid
D) amorphous solid
E) supercritical fluid and gas
Answer: E
Diff: 2 Page Ref: Sec. 11.4

61) The critical temperature and pressure of CS_2 are 279°C and 78 atm, respectively. At temperatures above 279°C, CS_2 can only occur as a __________.
A) solid
B) liquid
C) liquid and gas
D) gas
E) supercritical fluid
Answer: E
Diff: 2 Page Ref: Sec. 11.4

62) A volatile liquid is one that __________.
A) is highly flammable
B) is highly viscous
C) is highly hydrogen-bonded
D) is highly cohesive
E) readily evaporates
Answer: E
Diff: 1 Page Ref: Sec. 11.5

63) In general, the vapor pressure of a substance increases as __________ increases.
A) surface tension
B) molecular weight
C) hydrogen bonding
D) viscosity
E) temperature
Answer: E
Diff: 1 Page Ref: Sec. 11.5

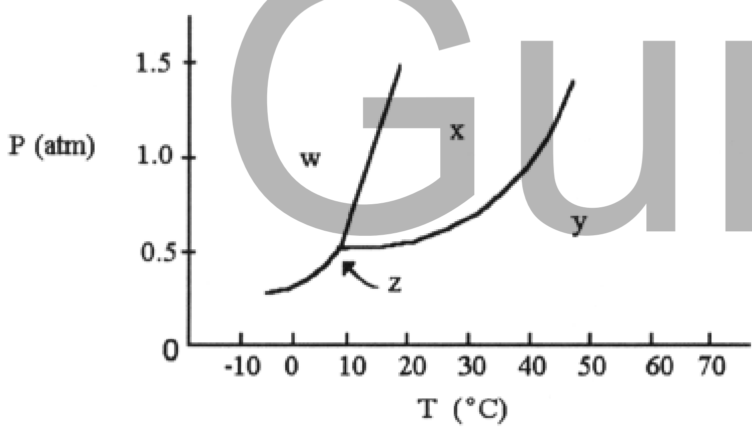
64) The vapor pressure of any substance at its normal boiling point is
A) 1 Pa
B) 1 torr
C) 1 atm
D) equal to atmospheric pressure
E) equal to the vapor pressure of water
Answer: C
Diff: 1 Page Ref: Sec. 11.5

65) Volatility and vapor pressure are __________.
A) inversely proportional to one another
B) directly proportional to one another
C) not related
D) the same thing
E) both independent of temperature
Answer: B
Diff: 2 Page Ref: Sec. 11.5

66) Some things take longer to cook at high altitudes than at low altitudes because __________.
A) water boils at a lower temperature at high altitude than at low altitude
B) water boils at a higher temperature at high altitude than at low altitude
C) heat isn't conducted as well in low density air
D) natural gas flames don't burn as hot at high altitudes
E) there is a higher moisture content in the air at high altitude
Answer: A
Diff: 2 Page Ref: Sec. 11.5

67) The vapor pressure of a liquid __________.
A) increases linearly with increasing temperature
B) increases nonlinearly with increasing temperature
C) decreases linearly with increasing temperature
D) decreases nonlinearly with increasing temperature
E) is totally unrelated to its molecular structure
Answer: B
Diff: 2 Page Ref: Sec. 11.5

68) The slope of a plot of the natural log of the vapor pressure of a substance versus 1/T is __________.
A) ΔH_{vap}
B) $-\Delta H_{vap}$
C) $\dfrac{1}{\Delta H_{vap}}$
D) $-\dfrac{\Delta H_{vap}}{R}$
E) $\dfrac{-1}{\Delta H_{vap}}$
Answer: D
Diff: 4 Page Ref: Sec. 11.5



69) The phase diagram of a substance is given above. This substance is a __________ at 25°C and 1.0 atm.
A) solid
B) liquid
C) gas
D) supercritical fluid
E) crystal
Answer: B
Diff: 2 Page Ref: Sec. 11.6

70) On a phase diagram, the critical pressure is __________.
A) the pressure required to melt a solid
B) the pressure below which a substance is a solid at all temperatures
C) the pressure above which a substance is a liquid at all temperatures
D) the pressure at which a liquid changes to a gas
E) the pressure required to liquefy a gas at its critical temperature
Answer: E
Diff: 2 Page Ref: Sec. 11.6

71) On a phase diagram, the critical temperature is __________.
A) the temperature below which a gas cannot be liquefied
B) the temperature above which a gas cannot be liquefied
C) the temperature at which all three states are in equilibrium
D) the temperature required to melt a solid
E) the temperature required to cause sublimation of a solid
Answer: B
Diff: 2 Page Ref: Sec. 11.6

72) On a phase diagram, the melting point is the same as __________.
A) the triple point
B) the critical point
C) the freezing point
D) the boiling point
E) the vapor-pressure curve
Answer: C
Diff: 1 Page Ref: Sec. 11.6

73) When the phase diagram for a substance has a solid-liquid phase boundary line that has a negative slope (leans to the left), the substance __________.
A) can go from solid to liquid, within a small temperature range, via the application of pressure
B) sublimes rather than melts under ordinary conditions
C) cannot go from solid to liquid by application of pressure at any temperature
D) cannot be liquefied above its triple point
E) melts rather than sublimes under ordinary conditions
Answer: A
Diff: 2 Page Ref: Sec. 11.6

74) Crystalline solids differ from amorphous solids in that crystalline solids have __________.
A) appreciable intermolecular attractive forces
B) a long-range repeating pattern of atoms, molecules, or ions
C) atoms, molecules, or ions that are close together
D) much larger atoms, molecules, or ions
E) no orderly structure
Answer: B
Diff: 2 Page Ref: Sec. 11.7

75) The unit cell with all sides the same length and all angles equal to 90° that has lattice points only at the corners is called __________.
A) monoclinic
B) body-centered cubic
C) primitive cubic
D) face-centered cubic
E) spherical cubic
Answer: C
Diff: 3 Page Ref: Sec. 11.7

76) What fraction of the volume of each corner atom is actually within the volume of a face-centered cubic unit cell?
A) 1
B) $\frac{1}{2}$
C) $\frac{1}{4}$
D) $\frac{1}{8}$
E) $\frac{1}{16}$
Answer: D
Diff: 3 Page Ref: Sec. 11.7

77) CsCl crystallizes in a unit cell that contains the Cs^+ ion at the center of a cube that has a Cl^- at each corner. Each unit cell contains __________ Cs^+ ions and __________ Cl^-, ions, respectively.
A) 1 and 8
B) 2 and 1
C) 1 and 1
D) 2 and 2
E) 2 and 4
Answer: C
Diff: 3 Page Ref: Sec. 11.7

78) The predominant intermolecular force in $CaBr_2$ is __________.
A) London-dispersion forces
B) ion-dipole forces
C) ionic bonding
D) dipole-dipole forces
E) hydrogen bonding
Answer: C
Diff: 2 Page Ref: Sec. 11.7

79) CsCl crystallizes in a unit cell that contains a Cs^+ ion at the center of a cube and a Cl^- ion at each corner. The unit cell of CsCl is __________.
A) close packed
B) body-centered cubic
C) face-centered cubic
D) amorphous
E) primitive cubic
Answer: E
Diff: 3 Page Ref: Sec. 11.7

80) NaCl crystallizes in a face-centered cubic cell. What is the total number of ions (Na^+ ions and Cl^- ions) that lie within a unit cell of NaCl?
A) 2
B) 4
C) 8
D) 6
E) 5
Answer: C
Diff: 3 Page Ref: Sec. 11.7

81) What portion of the volume of each atom or ion on the face of a unit cell is actually within the unit cell?
A) 1/2
B) 1/4
C) 3/4
D) all of it
E) none of it
Answer: A
Diff: 3 Page Ref: Sec. 11.7

82) The scattering of light waves upon passing through a narrow slit is called __________.
A) diffusion
B) grating
C) diffraction
D) adhesion
E) incidence
Answer: C
Diff: 1 Page Ref: Sec. 11.7

83) Consider the following statements about crystalline solids:

(i) Molecules or atoms in molecular solids are held together via intermolecular forces.
(ii) Metallic solids have atoms in the points of the crystal lattice.
(iii) Ionic solids have formula units in the point of the crystal lattice.
(iv) Atoms in covalent-network solids are connected via a network of covalent bonds.

Which of the statements is false?
A) (i)
B) (ii)
C) (iii)
D) (iv)
E) none
Answer: C
Diff: 3 Page Ref: Sec. 11.8

84) A solid has a very high melting point, great hardness, and poor electrical conduction. This is a(n) __________ solid.
A) ionic
B) molecular
C) metallic
D) covalent network
E) metallic and covalent network
Answer: D
Diff: 3 Page Ref: Sec. 11.8

85) An ionic solid, NaCl (s), dissolves in water because of the __________.
A) relatively low lattice energy due to small charges of Na^+ and Cl^- ions
B) simple face-centered cubic unit cell type it forms
C) 1:1 ratio of ions in the unit cell
D) strong coulombic interactions between oppositely charged ions
E) relatively low melting point
Answer: A
Diff: 3 Page Ref: Sec. 11.8

86) Metallic solids do not exhibit__________.
A) excellent thermal conductivity
B) excellent electrical conductivity
C) variable hardness
D) extreme brittleness
E) variable melting point
Answer: D
Diff: 2 Page Ref: Sec. 11.8

Short Answer

1) In general, intramolecular forces determine the __________ properties of a substance and intermolecular forces determine its __________ properties.
Answer: chemical, physical
Diff: 2 Page Ref: Sec 11.1

2) London Dispersion Forces tend to __________ in strength with increasing molecular weight.
Answer: increase
Diff: 1 Page Ref: Sec. 11.2

3) The direct conversion of a solid to a gas is called __________.
Answer: sublimation
Diff: 1 Page Ref: Sec. 11.4

4) How many atoms are contained in a face-centered cubic unit cell?
Answer: 4
Diff: 3 Page Ref: Sec. 11.7

5) Chromium crystallizes in a body-centered cubic unit cell. There are __________ chromium atoms per unit cell.
Answer: 2
Diff: 2 Page Ref: Sec. 11.7

True/False

1) The principal source of the difference in the normal boiling points of ICl (97°C; molecular mass 162 amu) and Br_2 (59°C; molecular mass 160 amu) is both dipole-dipole interactions and London dispersion forces.
Answer: FALSE
Diff: 2 Page Ref: Sec. 11.2

2) The boiling points of normal hydrocarbons are higher than those of branched hydrocarbons of similar molecular weight because the London-dispersion forces between normal hydrocarbons are greater than those between branched hydrocarbons.
Answer: TRUE
Diff: 2 Page Ref: Sec. 11.2

3) Heats of vaporization are greater than heats of fusion.
Answer: TRUE
Diff: 1 Page Ref: Sec. 11.4

4) Under ordinary conditions, a substance will sublime rather than melt if its triple point occurs at a pressure above atmospheric pressure.
Answer: TRUE
Diff: 2 Page Ref: Sec. 11.6

5) The type of solid that is characterized by low melting point, softness, and low electrical conduction is a covalent-network solid.
Answer: FALSE
Diff: 2 Page Ref: Sec. 11.8

Algorithmic Questions

1) The enthalpy change for converting 1.00 mol of ice at -50.0°C to water at 70.0°C is ________kJ The specific heats of ice, water, and steam are 2.09 J/g-K, 4.18 J/g-K, and 1.84 J/g-K, respectively.
For H_2O, ΔH_{fus} = 6.01 kJ/mol, and ΔH_{vap} = 40.67 kJ/mol

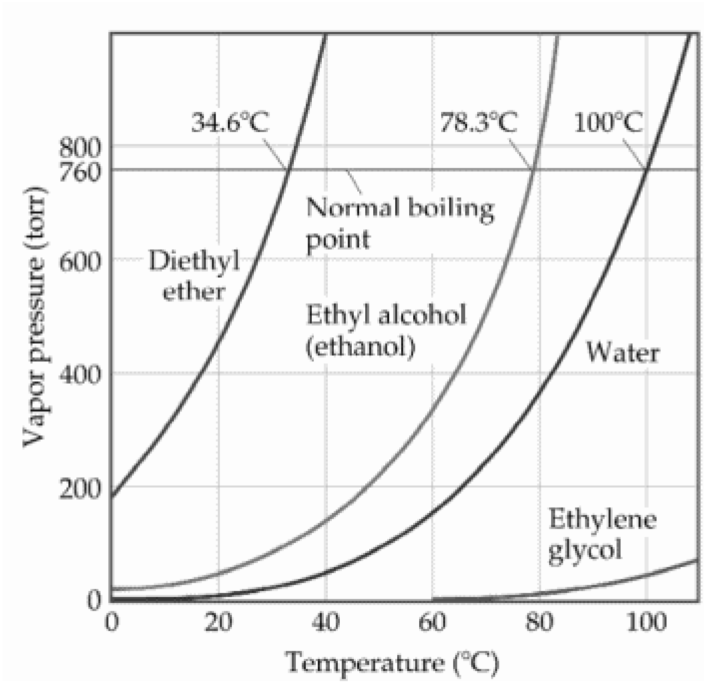
A) 12.28
B) 6.41
C) 13.16
D) 7154
E) 9.40
Answer: C
Diff: 3 Page Ref: Sec. 11.4

2) The enthalpy change for converting 10.0 g of ice at -25.0°C to water at 80.0°C is __________ kJ. The specific heats of ice, water, and steam are 2.09 J/g-K, 4.18 J/g-K, and 1.84 J/g-K, respectively.
For H_2O, ΔH_{fus} = 6.01 kJ/mol, and ΔH_{vap} = 40.67 kJ/mol .

A) 12.28
B) 6.16
C) 3870
D) 7.21
E) 9.88
Answer: D
Diff: 3 Page Ref: Sec. 11.4

3) The fluorocarbon $C_2Cl_3F_3$ has a normal boiling point of 47.6°C. The specific heats of $C_2Cl_3F_3$ (l) and $C_2Cl_3F_3$ (g) are 0.91 J/g-K and 0.67 J/g-K, respectively. The heat of vaporization of the compound is 27.49 kJ/mol. The heat required to convert 50.0 g of the compound from the liquid at 5.0°C to the gas at 80.0°C is __________ kJ.
A) 8.19
B) 1454
C) 30.51
D) 3031
E) 10.36
Answer: E
Diff: 4 Page Ref: Sec. 11.4

4) Ethanol (C_2H_5OH) melts at -114°C. The enthalpy of fusion is 5.02 kJ/mol. The specific heats of solid and liquid ethanol are 0.97 J/g-K and 2.3 J/g-K, respectively. How much heat (kJ) is needed to convert 25.0 g of solid ethanol at -135°C to liquid ethanol at -50°C?
A) 207.3
B) -12.7
C) 6.91
D) 4192
E) 9.21
Answer: C
Diff: 4 Page Ref: Sec. 11.4



5) Based on the figure above, the boiling point of diethyl ether under an external pressure of 1.32 atm is ________°C.
A) 10
B) 20
C) 30
D) 40
E) 0
Answer: D
Diff: 3 Page Ref: Sec. 11.5

6) Based on the figure above, the boiling point of ethyl alcohol under an external pressure of 0.0724 atm is ________°C.
A) 80
B) 60
C) 70
D) 40
E) 20
Answer: E
Diff: 3 Page Ref: Sec. 11.5

7) Based on the figure above, the boiling point of water under an external pressure of 0.316 atm atm is ________°C.
A) 70
B) 40
C) 60
D) 80
E) 90
Answer: A
Diff: 3 Page Ref: Sec. 11.5

Chemistry, 11e (Brown)
Chapter 12, Modern Materials

Multiple-Choice and Bimodal

1) MRI stands for __________.
A) Meissner Resonance Inductance
B) Magnetic Resonance Imaging
C) Material Research Instrument
D) Material Resistive Impedance
E) Me Really Imaginative
Answer: B
Diff: 2 Page Ref: Sec. 12.1

2) Of the following, only __________ is not a polymer.

cellulose
nylon
starch
protein
stainless steel

A) cellulose
B) nylon
C) starch
D) protein
E) stainless steel
Answer: E
Diff: 2 Page Ref: Sec. 12.2

3) Which one of the following is an addition polymer with the same structure as polyethylene except that one hydrogen on every other carbon is replaced by a benzene ring?

polyvinyl chloride
polypropylene
polystyrene
polyurethane
nylon 6,6

A) polyvinyl chloride
B) polypropylene
C) polystyrene
D) polyurethane
E) nylon 6, 6
Answer: C
Diff: 2 Page Ref: Sec. 12.2

4) A sample of natural rubber (200.0 g) is vulcanized, with the complete consumption of 4.8 g of sulfur. Natural rubber is a polymer of isoprene (C_5H_8). Four sulfur atoms are used in each crosslink connection. What percent of the isoprene units will be crosslinked?
A) 7.6
B) 5.1
C) 2.5
D) 9.4
E) 1.3
Answer: E
Diff: 3 Page Ref: Sec. 12.2

5) Which of the following is not a natural polymer?

silk
starch
protein
cellulose
nylon

A) silk
B) starch
C) protein
D) cellulose
E) nylon
Answer: E
Diff: 1 Page Ref: Sec. 12.2

6) A category ___________ plastic container will generally be the most easily recycled.
A) 1
B) 2
C) 3
D) 4
E) 22
Answer: A
Diff: 1 Page Ref: Sec. 12.2

7) There are ___________ different amino acids present in most proteins.
A) 1
B) 2
C) 16
D) 20
E) 99
Answer: D
Diff: 2 Page Ref: Sec. 12.3

8) Which of the following is not a biopolymer?

protein
polysaccharide
polyurethane
RNA
DNA

A) protein
B) polysaccharide
C) polyurethane
D) RNA
E) DNA
Answer: C
Diff: 2 Page Ref: Sec. 12.3

9) A __________ liquid crystal has the least order and is the most liquid-like.
A) nematic
B) smectic
C) cholesteric
D) smectic B
E) smectic C
Answer: A
Diff: 1 Page Ref: Sec. 12.5

10) Which type of liquid crystal is colored and changes color with temperature?
A) nematic
B) smectic A
C) cholesteric
D) smectic B
E) smectic C
Answer: C
Diff: 1 Page Ref: Sec. 12.5

Multiple-Choice

11) Superconductivity means that __________.
A) electrons move faster
B) electrons move through a shorter path
C) super expensive materials were used
D) electrons move without resistance
E) diamagnetic atoms become elongated
Answer: D
Diff: 2 Page Ref: Sec. 12.1

12) The material first shown to exhibit what we now call superconductivity was __________.
A) a thin film
B) a ceramic
C) a polymer
D) a metal
E) a composite
Answer: D
Diff: 2 Page Ref: Sec. 12.1

13) Of the following chemical forms, __________ are not commonly found in ceramics.
A) silicates
B) oxides
C) nitrates
D) carbides
E) aluminates
Answer: C
Diff: 2 Page Ref: Sec. 12.1

14) A material is sintered by __________.
A) placing in the middle
B) finely dividing the solid
C) sieving to achieve uniform particle size
D) heating the finely divided solid to a high temperature under pressure
E) heating with sulfur
Answer: D
Diff: 2 Page Ref: Sec. 12.1

15) In initial steps of the sol-gel process, a reactive metal is treated with an alcohol to form a metal alkoxide. The metal alkoxide is then combined with water to form the metal hydroxide. The metal hydroxide is not formed directly by reaction of the metal with water because __________.
A) finer particles are obtained in the two-step process
B) the metal hydroxide formed in the two-step process is more soluble and is more easily utilized
C) the alcohol stabilizes the metal hydroxide making it less susceptible to attack by the base added later
D) the two-step process prevents oxidation of the metal to an unstable oxidation state
E) the direct reaction of a reactive metal with water will give a complex mixture of metal oxides and hydroxide
Answer: E
Diff: 3 Page Ref: Sec. 12.1

16) Advantages to replacement of metal parts used in high-temperature applications with ceramics include:
1. Ceramics are easily manufactured free of defects.
2. Ceramics are less dense than metals.
3. Ceramics are less brittle than metals.
4. Ceramics are more resistant to corrosion than metals.

A) 2, 4
B) 1, 2, 3, 4
C) 2, 3, 4
D) 1, 3, 4
E) 1, 2, 4
Answer: A
Diff: 3 Page Ref: Sec. 12.1

17) The empirical formula of an addition polymer __________.
A) is the same as that of the monomer from which it is formed except that 2 H and 1 O have been added
B) is the same as that of the monomer from which it is formed except that 2 H and 1 O have been subtracted
C) is the same as that of the monomer from which it is formed
D) is the same as that of the monomer from which it is formed except that 2 H and 1 C have been added
E) is the same as that of the monomer from which it is formed except that 2 H and 1 C have been subtracted
Answer: C
Diff: 2 Page Ref: Sec. 12.2

18) An elastomer will fail to regain its original dimensions following a distortion beyond its __________.
A) glass transition
B) phase boundary
C) London force
D) crystallinity
E) elastic limit
Answer: E
Diff: 2 Page Ref: Sec. 12.2

19) As a polymer becomes more crystalline, __________.
A) its melting point decreases
B) its density decreases
C) its stiffness decreases
D) its yield stress decreases
E) none of the above are correct
Answer: E
Diff: 2 Page Ref: Sec. 12.2

20) The monomer that is polymerized to make natural rubber is __________.
A) melamine
B) formaldehyde
C) ethylene
D) isoprene
E) adipic acid
Answer: D
Diff: 1 Page Ref: Sec. 12.2

21) Natural rubber is too soft and chemically reactive for practical applications. Vulcanization of natural rubber entails __________.
A) conversion of an addition polymer to a condensation polymer
B) conversion of a condensation polymer to an addition polymer
C) increasing the average molecular weight of a condensation polymer
D) decreasing the average molecular weight of an addition polymer
E) crosslinking reactive polymer chains with sulfur atoms
Answer: E
Diff: 2 Page Ref: Sec. 12.2

22) The formation of a condensation polymer generally involves __________.
A) the addition of a plasticizer
B) the mixing of sulfur with an addition polymer
C) the elimination of a small molecule
D) the vaporization of a plasticizer
E) the formation of significant crosslinking
Answer: C
Diff: 2 Page Ref: Sec. 12.2

23) Biocompatibility means that material is __________.
A) made by biological methods
B) made from biological material
C) biodegradable
D) integratable into living organisms
E) none of the above
Answer: D
Diff: 2 Page Ref: Sec. 12.3

24) A biomaterial intended for use as a long-term replacement of a bone must __________.
A) be chemically inert
B) have sufficient rigidity
C) not degrade over time
D) not cause an immune response
E) possess all of these qualities
Answer: E
Diff: 1 Page Ref: Sec. 12.3

25) A biomaterial intended for use as a long-term replacement of a blood vessel __________.
A) must be rigid and have rough surfaces
B) must be rigid and chemically inert
C) must be rigid and must not degrade over time
D) must be flexible and have an open porous structure
E) should be designed such that it encourages coagulation of blood
Answer: D
Diff: 1 Page Ref: Sec. 12.3

26) Materials that eventually break down in the body __________.
A) are always toxic
B) cannot be used as biomaterials
C) can be used to construct long-term replacements for heart valves
D) can be used to construct "scaffoldings" on which natural cells grow
E) can be used to construct bone-replacements
Answer: D
Diff: 2 Page Ref: Sec. 12.3

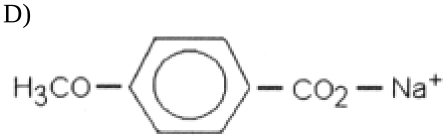
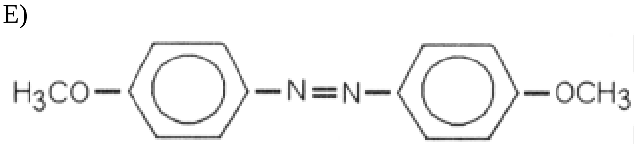
27) In the context of biopolymers, the opposite of the polymerization process is __________.
A) sublimation
B) condensation
C) addition
D) cross-linking
E) hydrolysis
Answer: E
Diff: 2 Page Ref: Sec. 12.3

28) In what year was the first systematic work involving liquid crystals reported?
A) 1888
B) 1943
C) 1776
D) 1978
E) 1954
Answer: A
Diff: 1 Page Ref: Sec. 12.5

29) Which of the following is most likely to exhibit liquid-crystalline behavior?
A) $CH_3CH_2\text{-}C(CH_3)_2\text{-}CH_2CH_3$

B) $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$

C) $CH_3CH_2CH_2CH_2CH_2\text{-}Na^+$

D)

E)


Answer: E
Diff: 2 Page Ref: Sec. 12.5

30) In the smectic A liquid-crystalline phase, __________.
A) the molecules are aligned along their long axes, with no ordering with respect to the ends of the molecules
B) the molecules are arranged in sheets, with their long axes parallel and their ends aligned as well
C) the molecules are aligned with their long axes tilted with respect to a line perpendicular to the plane in which the molecules are stacked
D) disk-shaped molecules are aligned through a stacking of the disks in layers
E) the molecules are oriented in a totally random fashion
Answer: B
Diff: 2   Page Ref: Sec. 12.5

31) Cholesteric liquid crystals are colored because __________.
A) each molecule is a chromophore
B) of the slight twist between layers
C) of the large spacing between layers
D) of the large number of conjugated bonds
E) All of the molecules contain multiple benzene rings.
Answer: B
Diff: 1   Page Ref: Sec. 12.5

32) Molecules with only single bonds do not generally exhibit liquid-crystalline properties because __________.
A) molecules without multiple bonds lack the rigidity necessary for alignment
B) molecules without multiple bonds are too small to exhibit liquid-crystalline properties
C) molecules with only single bonds are gases
D) molecules with only single bonds are too big to exhibit liquid-crystalline properties
E) molecules without multiple bonds lack the flexibility necessary for alignment
Answer: A
Diff: 1   Page Ref: Sec. 12.5

33) For a given substance that exhibits liquid-crystalline properties, the transition from solid to liquid-crystal state occurs __________.
A) over a range of temperatures between the melting point of the solid and the boiling point of the liquid
B) at the melting point of the solid
C) over a range of temperatures that includes the melting point of the solid
D) at a well defined temperature above the melting point of the solid
E) at a well defined temperature below the melting point of the solid
Answer: B
Diff: 1   Page Ref: Sec. 12.5

34) For a given substance that exhibits liquid-crystalline properties, the liquid-crystalline state exists __________.
A) at one particular temperature below the melting point of the solid
B) in a range of temperatures below the melting point of the solid
C) at one particular temperature above the melting point of the solid
D) in a range of temperatures above the melting point of the solid
E) in a range of temperatures from below the melting point to above the melting point
Answer: D
Diff: 2   Page Ref: Sec. 12.5

35) Cholesteric liquid crystals have not been used for monitoring of __________.
A) hot spots in microelectronic circuits
B) skin temperature
C) temperature of light
D) temperature of cookware
E) all of the above
Answer: D
Diff: 1   Page Ref: Sec. 12.5

Short Answer

1) __________ are materials characterized by an energy gap between a filled valence band and an empty conduction band.
Answer: Semiconductors
Diff: 2 Page Ref: Sec. 12.1

2) The process of adding controlled amounts of impurity atoms to a material is known as __________.
Answer: doping
Diff: 1 Page Ref: Sec. 12.1

3) Write the chemical formulas for both polyethylene and the monomer from which it is formed.

Answer: Polyethylene is $-\left[\begin{array}{c} \mathrm{H}\ \ \mathrm{H} \\ |\quad | \\ \text{-C-C-} \\ |\quad | \\ \mathrm{H}\ \ \mathrm{H} \end{array}\right]-$ and ethylene is $H_2C{=}CH_2$.

Diff: 2 Page Ref: Sec. 12.2

4) Nylon is formed by the reaction of a __________ with a __________.
Answer: diamine, diacid
Diff: 1 Page Ref: Sec. 12.2

5) Short, high purity __________ fibers reinforced with aluminum borosilicate fibers are used to manufacture the space shuttle tiles.
Answer: silica
Diff: 2 Page Ref: Sec. 12.2

6) __________ are solid-state materials that can be made either semiconducting or metallic without any doping.
Answer: Carbon nanotubes
Diff: 2 Page Ref: Sec. 12.6

True/False

1) Molecules containing only single bonds do not exhibit liquid-crystal behavior because free rotation can occur around single bonds making these molecules flexible.
Answer: TRUE
Diff: 2 Page Ref: Sec. 12.1

2) Superconductors exhibit the Meissner effect.
Answer: TRUE
Diff: 2 Page Ref: Sec. 12.1

3) Polyethylene is formed by a condensation reaction.
Answer: FALSE
Diff: 2 Page Ref: Sec. 12.2

4) Vulcanization involves heating rubber with sulfur dioxide to produce a thermosetting polymer.
Answer: FALSE
Diff: 2 Page Ref: Sec. 12.2

5) A plasticizer makes a polymer more pliable by reducing the interactions between polymer chains.
Answer: TRUE

Diff: 1 Page Ref: Sec. 12.2

6) Silicon technology is based on the fact that silicon oxide is a chemically stable conductor.
Answer: FALSE
Diff: 1 Page Ref: Sec 12.4

Chemistry, 11e (Brown)
Chapter 13, Properties of Solutions

Multiple-Choice and Bimodal

1) The process of solute particles being surrounded by solvent particles is known as __________.
A) salutation
B) agglomeration
C) solvation
D) agglutination
E) dehydration
Answer: C
Diff: 1 Page Ref: Sec. 13.1

2) Pairs of liquids that will mix in all proportions are called __________ liquids.
A) miscible
B) unsaturated
C) polar liquids
D) saturated
E) supersaturated
Answer: A
Diff: 1 Page Ref: Sec. 13.3

3) The solubility of oxygen gas in water at 25 °C and 1.0 atm pressure of oxygen is 0.041 g/L The solubility of oxygen in water at 3.0 atm and 25 °C is __________ g/L.
A) 0.041
B) 0.014
C) 0.31
D) 0.12
E) 3.0
Answer: D
Diff: 3 Page Ref: Sec. 13.3

4) The solubility of nitrogen gas in water at 25 °C and a nitrogen pressure of 1.0 atm is 6.9×10^{-4}M The solubility of nitrogen in water at a nitrogen pressure of 0.80 atm is __________ M.
A) 5.5×10^{-4}
B) 8.6×10^{-4}
C) 1.2×10^{3}
D) 3.7×10^{-3}
E) 0.80
Answer: A
Diff: 3 Page Ref: Sec. 13.3

5) The solubility of Ar in water at 25 °C is 1.6×10^{-3} M when the pressure of the Ar above the solution is 1.0 atm. The solubility of Ar at a pressure of 2.5 atm is __________ M.
A) 1.6×10^{3}
B) 6.4×10^{-4}
C) 4.0×10^{-3}
D) 7.5×10^{-2}
E) 1.6×10^{-3}
Answer: C
Diff: 3 Page Ref: Sec. 13.3

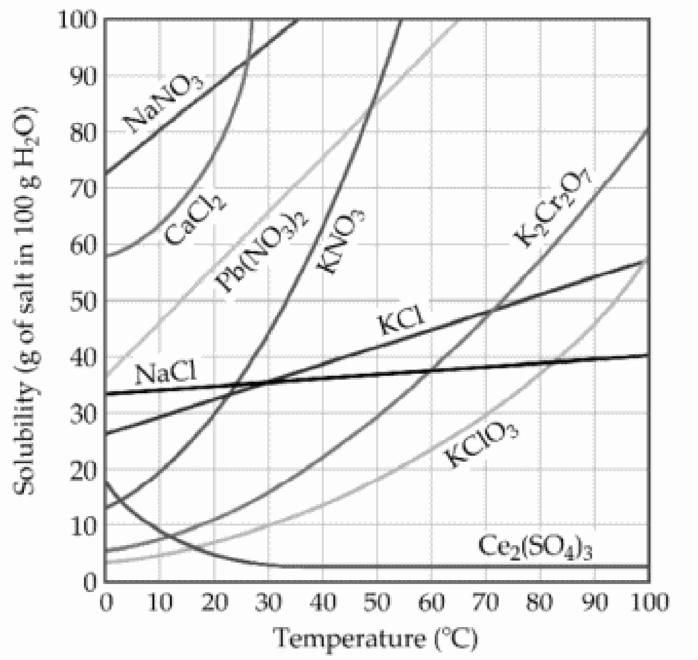
6) On a clear day at sea level, with a temperature of 25 °C, the partial pressure of N_2 in air is 0.78 atm and the concentration of nitrogen in water is 5.3×10^{-4}M . When the partial pressure of N_2 is __________ atm, the concentration in water is 1.1×10^{-3}M .

A) 0.63 atm
B) 0.78 atm
C) 1.0 atm
D) 2.1 atm
E) 1.6 atm
Answer: E
Diff: 4 Page Ref: Sec. 13.3

7) Which one of the following vitamins is water soluble?

A
B
K
D
E

A) A
B) B
C) K
D) D
E) E
Answer: B
Diff: 3 Page Ref: Sec. 13.3



8) A sample of potassium nitrate (49.0 g) is dissolved in 101 g of water at 100 °C, with precautions taken to avoid evaporation of any water. The solution is cooled to 30.0 °C and no precipitate is observed. This solution is __________.
A) hydrated
B) placated
C) saturated
D) unsaturated
E) supersaturated
Answer: E
Diff: 2 Page Ref: Sec. 13.3

9) A sample of potassium chlorate (15.0 g) is dissolved in 201 g of water at 70 °C with precautions taken to avoid evaporation of any water. The solution is cooled to 30.0 °C and no precipitate is observed. This solution is __________.
A) hydrated
B) miscible
C) saturated
D) unsaturated
E) supersaturated
Answer: D
Diff: 2 Page Ref: Sec. 13.3

10) A sample of potassium nitrate (49.0 g) is dissolved in 101 g of water at 100 °C with precautions taken to avoid evaporation of any water. The solution is cooled to 30.0 °C and a small amount of precipitate is observed. This solution is __________.
A) hydrated
B) placated
C) saturated
D) unsaturated
E) supersaturated
Answer: C
Diff: 2 Page Ref: Sec. 13.3

11) The solubility of $MnSO_4$ monohydrate in water at 20 °C is 70.0 g per 100.0 mL of water. A solution at 20 °C that is 4.22 *M* in $MnSO_4$ monohydrate is best described as a(n) __________ solution. The formula weight of $MnSO_4$ monohydrate is 168.97 g/mol.
A) hydrated
B) solvated
C) saturated
D) unsaturated
E) supersaturated
Answer: E
Diff: 3 Page Ref: Sec. 13.3

12) A solution is prepared by dissolving 23.7 g of $CaCl_2$ in 375 g of water. The density of the resulting solution is 1.05 g/mL. The concentration of $CaCl_2$ is __________% by mass.
A) 5.94
B) 6.32
C) 0.0632
D) 0.0594
E) 6.24
Answer: A
Diff: 3 Page Ref: Sec. 13.4

13) The concentration of urea in a solution prepared by dissolving 16 g of urea in 39 g of H_2O is __________% by mass. The molar mass of urea is 60.0 g/mol.
A) 29
B) 41
C) 0.29
D) 0.41
E) 0.48
Answer: A
Diff: 3 Page Ref: Sec. 13.4

14) The concentration of nitrate ion in a solution that contains 0.900 M aluminum nitrate is __________ M.
A) 0.900
B) 0.450
C) 0.300
D) 2.70
E) 1.80
Answer: D
Diff: 3 Page Ref: Sec. 13.4

15) The concentration of KBr in a solution prepared by dissolving 2.21 g of KBr in 897 g of water is __________ molal.
A) 2.46
B) 0.0167
C) 0.0207
D) 2.07×10^{-5}
E) 0.0186
Answer: C
Diff: 3 Page Ref: Sec. 13.4

16) The concentration of lead nitrate $(Pb(NO_3)_2)$ in a 0.726 M solution is __________ molal. The density of the solution is 1.202 g/mL.
A) 0.476
B) 1.928
C) 0.755
D) 0.819
E) 0.650
Answer: C
Diff: 4 Page Ref: Sec. 13.4

17) The concentration of a benzene solution prepared by mixing 12.0 g C_6H_6 with 38.0 g CCl_4 is __________ molal.
A) 4.04
B) 0.240
C) 0.622
D) 0.316
E) 0.508
Answer: A
Diff: 4 Page Ref: Sec. 13.4

18) A solution is prepared by dissolving 15.0 g of NH_3 in 250 g of water. The density of the resulting solution is 0.974 g/mL. The mole fraction of NH_3 in the solution is __________.
A) 0.0640
B) 0.0597
C) 0.940
D) 0.922
E) 16.8
Answer: B
Diff: 4 Page Ref: Sec. 13.4

19) A solution is prepared by dissolving 15.0 g of NH_3 in 250 g of water. The density of the resulting solution is 0.974 g/mL. The molarity of NH_3 in the solution is __________.
A) 0.00353
B) 0.882
C) 60.0
D) 3.24
E) 3.53
Answer: D
Diff: 4 Page Ref: Sec. 13.4

20) A solution is prepared by dissolving 23.7 g of $CaCl_2$ in 375 g of water. The density of the resulting solution is 1.05 g/mL. The concentration of Cl^- in this solution is __________ M.
A) 0.214
B) 0.562
C) 1.12
D) 1.20
E) 6.64×10^{-2}
Answer: C
Diff: 4 Page Ref: Sec. 13.4

21) A solution is prepared by dissolving 23.7 g of $CaCl_2$ in 375 g of water. The density of the resulting solution is 1.05 g/mL. The concentration of $CaCl_2$ in this solution is __________ molal.
A) 0.214

B) 0.569
C) 5.70
D) 63.2
E) 1.76
Answer: B
Diff: 4 Page Ref: Sec. 13.4

22) The concentration of HCl in a solution that is prepared by dissolving 5.5 g of HCl in 200 g of C_2H_6O is __________ molal.
A) 27.5
B) 7.5×10^{-4}
C) 3.3×10^{-2}
D) 0.75
E) 1.3
Answer: D
Diff: 3 Page Ref: Sec. 13.4

23) The concentration (M) of HCl in a solution prepared by dissolving 5.5 g of HCl in 200 g of C_2H_6O is __________ M. The density of the solution is 0.79 g/mL.
A) 21
B) 0.93
C) 0.58
D) 6.0×10^{-4}
E) 1.72
Answer: C
Diff: 3 Page Ref: Sec. 13.4

24) The mole fraction of He in a gaseous solution prepared from 4.0 g of He, 6.5 g of Ar, and 10.0 g of Ne is __________.
A) 0.61
B) 1.5
C) 0.20
D) 0.11
E) 0.86
Answer: A
Diff: 3 Page Ref: Sec. 13.4

25) The mole fraction of urea (MW = 60.0 g/mol) in a solution prepared by dissolving 16 g of urea in 39 g of H_2O is __________.
A) 0.58
B) 0.37
C) 0.13
D) 0.11
E) 9.1
Answer: D
Diff: 3 Page Ref: Sec. 13.4

26) The concentration of urea (MW = 60.0 g/mol) in a solution prepared by dissolving 16 g of urea in 39 g of H_2O is __________ molal.
A) 96
B) 6.9
C) 0.68
D) 6.3
E) 0.11
Answer: B
Diff: 3 Page Ref: Sec. 13.4

27) The molarity of urea in a solution prepared by dissolving 16 g of urea (MW = 60.0 g/mol) in 39 g of H_2O is __________ M. The density of the solution is 1.3 g/mL.
A) 0.11
B) 3.7
C) 6.8
D) 6.3
E) 0.16
Answer: D
Diff: 3 Page Ref: Sec. 13.4

28) What is the molarity of sodium chloride in solution that is 13.0% by mass sodium chloride and that has a density of 1.10 g/mL?
A) 143
B) 2.45
C) 2.56
D) 2.23
E) 1.43×10^{-2}
Answer: B
Diff: 4 Page Ref: Sec. 13.4

29) The concentration of sodium chloride in an aqueous solution that is 2.23 M and that has a density of 1.01 g/mL is __________% by mass.
A) 2.21
B) 7.83
C) 45.3
D) 12.9
E) 10.1
Answer: D
Diff: 4 Page Ref: Sec. 13.4

30) The vapor pressure of pure ethanol at 60 °C is 0.459 atm. Raoult's Law predicts that a solution prepared by dissolving 10.0 mmol naphthalene (nonvolatile) in 90.0 mmol ethanol will have a vapor pressure of __________ atm.
A) 0.498
B) 0.413
C) 0.790
D) 0.367
E) 0.0918
Answer: B
Diff: 3 Page Ref: Sec. 13.5

31) The vapor pressure of pure water at 25 °C is 23.8 torr. What is the vapor pressure (torr) of water above a solution prepared by dissolving 18.0 g of glucose (a nonelectrolyte, MW = 180.0 g/mol) in 95.0 g of water?
A) 24.3
B) 23.4
C) 0.451
D) 0.443
E) 23.8
Answer: B
Diff: 4 Page Ref: Sec. 13.5

32) The vapor pressure of pure water at 25 °C is 23.8 torr. Determine the vapor pressure (torr) of water at 25 °C above a solution prepared by dissolving 35 g of urea (a nonvolatile, non-electrolyte, MW = 60.0 g/mol) in75 g of water.
A) 2.9
B) 3.3
C) 21
D) 27
E) 0.88
Answer: C
Diff: 4 Page Ref: Sec. 13.5

33) The freezing point of ethanol (C_2H_5OH) is -114.6 °C. The molal freezing point depression constant for ethanol is 2.00 °C/m. What is the freezing point (°C) of a solution prepared by dissolving 50.0 g of glycerin ($C_3H_8O_3$ a nonelectrolyte) in 200 g of ethanol?
A) -115
B) -5.42
C) -132.3
D) -120.0
E) -114.6
Answer: D
Diff: 4 Page Ref: Sec. 13.5

34) What is the freezing point (°C) of a solution prepared by dissolving 11.3 g of $Ca(NO_3)_2$ (formula weight = 164 g/mol) in 115 g of water? The molal freezing point depression constant for water is 1.86 °C/m.
A) -3.34
B) -1.11
C) 3.34
D) 1.11
E) 0.00
Answer: A
Diff: 4 Page Ref: Sec. 13.5

35) A solution containing 10.0 g of an unknown liquid and 90.0 g water has a freezing point of -3.33 °C. Given K_f = 1.86°C/m for water, the molar mass of the unknown liquid is ________ g/mol.
A) 69.0
B) 333
C) 619
D) 161
E) 62.1
Answer: E
Diff: 4 Page Ref: Sec. 13.5

36) A solution is prepared by dissolving 0.60 g of nicotine (a nonelectrolyte) in water to make 12 mL of solution. The osmotic pressure of the solution is 7.55 atm at 25 °C. The molecular weight of nicotine is ________ g/mol.
A) 28
B) 43
C) 50
D) 160
E) 0.60
Answer: D
Diff: 4 Page Ref: Sec. 13.5

37) A solution is prepared by dissolving 6.00 g of an unknown nonelectrolyte in enough water to make 1.00 L of solution. The osmotic pressure of this solution is 0.750 atm at 25.0 °C. What is the molecular weight (g/mol) of the unknown solute?
A) 16.4
B) 195
C) 110
D) 30.6
E) 5.12×10^{-3}
Answer: B
Diff: 4 Page Ref: Sec. 13.5

38) Calculate the freezing point (0°C) of a 0.05500 m aqueous solution of glucose. The molal freezing-point-depression constant of water is 1.86 °C/m.
A) 0.0286
B) 0.1023
C) -0.05627
D) -0.1023
E) -0.2046
Answer: D
Diff: 4 Page Ref: Sec. 13.5

39) Calculate the freezing point (0°C) of a 0.05500 m aqueous solution of $NaNO_3$. The molal freezing-point-depression constant of water is 1.86 °C/m.
A) 0.0286
B) -0.1023
C) 0.1023
D) -0.05627
E) -0.2046
Answer: E
Diff: 4 Page Ref: Sec. 13.5

40) An aqueous solution of a soluble compound (a nonelectrolyte) is prepared by dissolving 33.2 g of the compound in sufficient water to form 250 mL of solution. The solution has an osmotic pressure of 1.2 atm at 25.0 °C What is the molar mass (g/mL) of the compound?
A) 1.0×10^3
B) 2.7×10^3
C) 2.3×10^2
D) 6.8×10^2
E) 28
Answer: B
Diff: 4 Page Ref: Sec. 13.5

41) A 0.15 m aqueous solution of a weak acid has a freezing point of -0.31 °C. What is the percent ionization of this weak acid at this concentration? The molal freezing-point-depression constant of water is 1.86 °C/m.
A) 17
B) 11
C) 89
D) 31
E) 35
Answer: B
Diff: 4 Page Ref: Sec. 13.5

42) Determine the fraction of ionization of HX if a solution prepared by dissolving 0.020 mol of HX in 115 g of water freezes at -0.47 °C. The molal freezing-point-depression constant of water is 1.86 °C/m.
A) 0.044
B) 0.30
C) 0.45
D) 1.45
E) 0.348
Answer: C
Diff: 3 Page Ref: Sec. 13.5

43) Determine the freezing point (°C) of a 0.015 molal aqueous solution of $MgSO_4$. Assume i = 2.0 for $MgSO_4$. The molal freezing-point-depression constant of water is 1.86 °C/m.
A) -0.056
B) -0.028
C) -0.17
D) -0.084
E) 0.000
Answer: A
Diff: 3 Page Ref: Sec. 13.5

44) A solution is prepared by dissolving 2.60 g of a strong electrolyte (formula weight = 101 g/mol) in enough water to make 1.00 L of solution. The osmotic pressure of the solution is 1.25 atm at 25.0 °C. What is the van't Hoff factor (i) for the unknown solute?
A) 0
B) 0.99
C) 1.98
D) 2.98
E) 0.630
Answer: C
Diff: 4 Page Ref: Sec. 13.5

45) George is making spaghetti for dinner. He places 4.01 kg of water in a pan and brings it to a boil. Before adding the pasta, he adds 58 g of table salt to the water and again brings it to a boil. The temperature of the salty, boiling water is __________°C.

It is a nice day at sea level so that pressure is 1.00 atm. Assume negligible evaporation of water. K_b for water is 0.52°C/*m*.
A) 99.87
B) 100.26
C) 100.13
D) 99.74
E) 100.00
Answer: B
Diff: 3 Page Ref: Sec. 13.5

Multiple-Choice

46) The dissolution of water in octane (C_8H_{18}) is prevented by __________.
A) London dispersion forces between octane molecules
B) hydrogen bonding between water molecules
C) dipole-dipole attraction between octane molecules
D) ion-dipole attraction between water and octane molecules
E) repulsion between like-charged water and octane molecules
Answer: B
Diff: 2 Page Ref: Sec. 13.1

47) When argon is placed in a container of neon, the argon spontaneously disperses throughout the neon because __________.
A) of the large attractive forces between argon and neon atoms
B) of hydrogen bonding
C) a decrease in energy occurs when the two mix
D) the dispersion of argon atoms produces an increase in disorder
E) of solvent-solute interactions
Answer: D
Diff: 2 Page Ref: Sec. 13.1

48) Hydration is a specific example of the phenomenon known generally as __________.
A) salutation
B) disordering
C) solvation
D) condensation
E) dilution
Answer: C
Diff: 1 Page Ref: Sec. 13.1

49) The dissolution of gases in water is virtually always exothermic because __________.
A) one of the two endothermic steps (separation of solute particles) in the solution-formation process is unnecessary
B) the exothermic step in the solution-formation process is unnecessary
C) gases react exothermically with water
D) neither of the two endothermic steps in the solution-formation process is necessary
E) all three steps in the solution-formation process are exothermic
Answer: A
Diff: 2 Page Ref: Sec. 13.1

50) Formation of solutions where the process is endothermic can be spontaneous provided that __________.
A) they are accompanied by another process that is exothermic
B) they are accompanied by an increase in order
C) they are accompanied by an increase in disorder
D) the solvent is a gas and the solute is a solid
E) the solvent is water and the solute is a gas
Answer: C
Diff: 2 Page Ref: Sec. 13.1

51) The phrase "like dissolves like" refers to the fact that __________.
A) gases can only dissolve other gases
B) polar solvents dissolve polar solutes and nonpolar solvents dissolve nonpolar solutes
C) solvents can only dissolve solutes of similar molar mass
D) condensed phases can only dissolve other condensed phases
E) polar solvents dissolve nonpolar solutes and vice versa
Answer: B
Diff: 1 Page Ref: Sec. 13.1

52) Ammonium nitrate (NH_4NO_3) dissolves readily in water even though the dissolution is endothermic by 26.4 kJ/mol. The solution process is spontaneous because __________.
A) the vapor pressure of the water decreases upon addition of the solute
B) osmotic properties predict this behavior
C) of the decrease in enthalpy upon addition of the solute
D) of the increase in enthalpy upon dissolution of this strong electrolyte
E) of the increase in disorder upon dissolution of this strong electrolyte
Answer: E
Diff: 2 Page Ref: Sec. 13.1

53) When solutions of strong electrolytes in water are formed, the ions are surrounded by water molecules. These interactions are **best** described as a case of __________.
A) hydration
B) supersaturation
C) crystallization
D) dehydration
E) solvation
Answer: A
Diff: 2 Page Ref: Sec. 13.1

54) When two <u>nonpolar</u> organic liquids are mixed, a solution forms and the enthalpy of solution is quite small. Label the two organic liquids as *A* (solvent) and *B* (solute). The formation of solution is favored by __________.
A) hydration of the solute, *B*
B) the equal enthalpy of the solvent and solute
C) the highly negative enthalpy of the solution process
D) solvation of the solvent, *A*
E) an increase in disorder, since A–A, B–B, and A–B interactions are similar
Answer: E
Diff: 2 Page Ref: Sec. 13.1

55) A saturated solution __________.
A) contains as much solvent as it can hold
B) contains no double bonds
C) contains dissolved solute in equilibrium with undissolved solid
D) will rapidly precipitate if a seed crystal is added
E) cannot be attained
Answer: C
Diff: 1 Page Ref: Sec. 13.2

56) In a saturated solution of a salt in water, __________.
A) the rate of crystallization > the rate of dissolution
B) the rate of dissolution > the rate of crystallization
C) seed crystal addition may cause massive crystallization
D) the rate of crystallization = the rate of dissolution
E) addition of more water causes massive crystallization
Answer: D
Diff: 1 Page Ref: Sec. 13.2

57) An unsaturated solution is one that __________.
A) has no double bonds
B) contains the maximum concentration of solute possible, and is in equilibrium with undissolved solute
C) has a concentration lower than the solubility
D) contains more dissolved solute than the solubility allows
E) contains no solute
Answer: C
Diff: 1 Page Ref: Sec. 13.2

58) A solution with a concentration higher than the solubility is __________.
A) is not possible
B) is unsaturated
C) is supercritical
D) is saturated
E) is supersaturated
Answer: E
Diff: 1 Page Ref: Sec. 13.2

59) A supersaturated solution __________.
A) is one with more than one solute
B) is one that has been heated
C) is one with a higher concentration than the solubility
D) must be in contact with undissolved solid
E) exists only in theory and cannot actually be prepared
Answer: C
Diff: 1 Page Ref: Sec. 13.2

60) The principal reason for the extremely low solubility of NaCl in benzene (C_6H_6) is the __________.
A) strong solvent-solvent interactions
B) hydrogen bonding in C_6H_6
C) strength of the covalent bond in NaCl
D) weak solvation of Na^+ and Cl^- by C_6H_6
E) increased disorder due to mixing of solute and solvent
Answer: D
Diff: 2 Page Ref: Sec. 13.3

61) Which one of the following substances would be the most soluble in CCl_4 ?
A) CH_3CH_2OH
B) H_2O
C) NH_3
D) $C_{10}H_{22}$
E) NaCl
Answer: D
Diff: 3 Page Ref: Sec. 13.3

62) Which of the following substances is more likely to dissolve in water?
A) $HOCH_2CH_2OH$
B) $CHCl_3$
C) O
‖
$CH_3(CH_2)_9CH$
D) $CH_3(CH_2)_8CH_2OH$
E) CCl_4
Answer: A
Diff: 3 Page Ref: Sec. 13.3

63) Which of the following substances is more likely to dissolve in CH_3OH?
A) CCl_4
B) Kr
C) N_2
D) CH_3CH_2OH
E) H_2
Answer: D
Diff: 3 Page Ref: Sec. 13.3

64) Which one of the following substances is more likely to dissolve in CCl_4?
A) CBr_4
B) HBr
C) HCl
D) CH_3CH_2OH
E) NaCl
Answer: A
Diff: 3 Page Ref: Sec. 13.3

65) Which one of the following substances is more likely to dissolve in benzene (C_6H_6)?
A) CH_3CH_2OH
B) NH_3
C) NaCl
D) CCl_4
E) HBr
Answer: D
Diff: 3 Page Ref: Sec. 13.3

66) Which one of the following is most soluble in water?
A) CH_3OH
B) $CH_3CH_2CH_2OH$
C) CH_3CH_2OH
D) $CH_3CH_2CH_2CH_2OH$
E) $CH_3CH_2CH_2CH_2CH_2OH$
Answer: A
Diff: 3 Page Ref: Sec. 13.3

67) Which one of the following is most soluble in hexane (C_6H_{14}) ?
A) CH_3OH
B) $CH_3CH_2CH_2OH$
C) CH_3CH_2OH
D) $CH_3CH_2CH_2CH_2OH$
E) $CH_3CH_2CH_2CH_2CH_2OH$
Answer: E
Diff: 3 Page Ref: Sec. 13.3

68) The largest value of the Henry's Law constant for the liquid solvent H_2O will be obtained with __________ gas as the solute and a temperature of __________°C.
A) C_2H_4 , 45
B) Ar, 11
C) HCl, 49
D) CO_2 , 32
E) N_2 , 15
Answer: C
Diff: 3 Page Ref: Sec. 13.3

69) Pressure has an appreciable effect on the solubility of __________ in liquids.
A) gases
B) solids
C) liquids
D) salts
E) solids and liquids
Answer: A
Diff: 2 Page Ref: Sec. 13.3

70) Which of the following choices has the compounds correctly arranged in order of increasing solubility in water? (least soluble to most soluble)
A) $CCl_4 < CHCl_3 < NaNO_3$
B) $CH_3OH < CH_4 < LiF$
C) $CH_4 < NaNO_3 < CHCl_3$
D) $LiF < NaNO_3 < CHCl_3$
E) $CH_3OH < Cl_4 < CHCl_3$
Answer: A
Diff: 3 Page Ref: Sec. 13.3

71) The Procter & Gamble Company product called olestra™ is formed by combining a sugar molecule with __________.
A) alcohols
B) vitamin A
C) fatty acids
D) protein
E) cholesterol
Answer: C
Diff: 2 Page Ref: Sec. 13.3

72) Which component of air is the primary problem in a condition known as "the bends?"
A) O_2
B) CO_2
C) He
D) N_2
E) CO
Answer: D
Diff: 2 Page Ref: Sec. 13.3

73) If the partial pressure of oxygen in the air a diver breathes is too great, __________.
A) respiratory tissue is damaged by oxidation
B) hyperventilation results
C) the urge to breathe is increased and excessive CO_2 is removed from the body
D) the urge to breathe is reduced and not enough CO_2 is removed from the body
E) No problems result from this situation.
Answer: D
Diff: 2 Page Ref: Sec. 13.3

74) A solution contains 28% phosphoric acid by mass. This means that __________.
A) 1 mL of this solution contains 28 g of phosphoric acid
B) 1 L of this solution has a mass of 28 g
C) 100 g of this solution contains 28 g of phosphoric acid
D) 1 L of this solution contains 28 mL of phosphoric acid
E) the density of this solution is 2.8 g/mL
Answer: C
Diff: 2 Page Ref: Sec. 13.4

75) The concentration of chloride ion in a solution that contains 35.0 ppm chloride is __________% by mass.
A) 3.50×10^{-3}
B) 3.50×10^{2}
C) 3.50×10^{-2}
D) 3.50×10^{-6}
E) 3.50×10^{1}
Answer: A
Diff: 3 Page Ref: Sec. 13.4

76) A solution is prepared by dissolving calcium chloride in water and diluting to 500.0 mL. If this solution contains 44 ppm chloride ions, the concentration of calcium ions is __________ ppm.
A) 44
B) 88
C) 22
D) 11
E) 500
Answer: C
Diff: 2 Page Ref: Sec. 13.4

77) Molality is defined as the __________.
A) moles solute/moles solvent
B) moles solute/Liters solution
C) moles solute/kg solution
D) moles solute/kg solvent
E) none (dimensionless)
Answer: D
Diff: 1 Page Ref: Sec. 13.4

78) Which one of the following concentration units varies with temperature?
A) molarity
B) mass percent
C) mole fraction
D) molality
E) all of the above
Answer: A
Diff: 3 Page Ref: Sec. 13.4

79) Of the concentration units below, only __________ is temperature dependent.
A) mass %
B) ppm
C) ppb
D) molarity
E) molality
Answer: D
Diff: 2 Page Ref: Sec. 13.4

80) A solution contains 11% by mass of sodium chloride. This means that __________.
A) there are 11 g of sodium chloride in in 1.0 mL of this solution
B) 100 g of the solution contains 11 g of sodium chloride
C) 100 mL of the solution contains 11 g of sodium chloride
D) the density of the solution is 11 g/mL
E) the molality of the solution is 11
Answer: B
Diff: 2 Page Ref: Sec. 13.4

81) A solution contains 15 ppm of benzene. The density of the solution is 1.00 g/mL. This means that __________.
A) there are 15 mg of benzene in 1.0 L of this solution
B) 100 g of the solution contains 15 g of benzene
C) 100 g of the solution contains 15 mg of benzene
D) the solution is 15% by mass of benzene
E) the molarity of the solution is 15
Answer: A
Diff: 2 Page Ref: Sec. 13.4

82) A solution contains 15 ppm of benzene. The density of the solution is 1.00 g/mL. This means that __________.
A) there are 15 mg of benzene in 1.0 g of this solution
B) 100 g of the solution contains 15 g of benzene
C) 1.0 g of the solution contains 15×10^{-6} g of benzene
D) 1.0 L of the solution contains 15 g of benzene
E) the solution is 15% by mass of benzene
Answer: C
Diff: 2 Page Ref: Sec. 13.4

83) A 0.100 m solution of which one of the following solutes will have the lowest vapor pressure?
A) $KClO_4$
B) $Ca(ClO_4)_2$
C) $Al(ClO_4)_3$
D) sucrose
E) NaCl
Answer: C
Diff: 3 Page Ref: Sec. 13.5

84) The magnitudes of K_f and of K_b depend on the identity of the __________.
A) solute
B) solvent
C) solution
D) solvent and on temperature
E) solute and solvent
Answer: B
Diff: 2 Page Ref: Sec. 13.5

85) As the concentration of a solute in a solution increases, the freezing point of the solution __________ and the vapor pressure of the solution __________.
A) increases, increases
B) increases, decreases
C) decreases, increases
D) decreases, decreases
E) decreases, is unaffected
Answer: D
Diff: 2 Page Ref: Sec. 13.5

86) Which of the following liquids will have the lowest freezing point?
A) pure H_2O
B) aqueous glucose (0.60 m)
C) aqueous sucrose (0.60 m)
D) aqueous FeI_3 (0.24 m)
E) aqueous KF (0.50 m)
Answer: E
Diff: 2 Page Ref: Sec. 13.5

87) Which of the following liquids will have the lowest freezing point?
A) pure H_2O
B) aqueous glucose (0.050 m)
C) aqueous CoI_2 (0.030 m)
D) aqueous FeI_3 (0.030 m)
E) aqueous NaI (0.030 m)
Answer: D
Diff: 2 Page Ref: Sec. 13.5

88) A 1.35 m aqueous solution of compound X had a boiling point of 101.4°C. Which one of the following could be compound X? The boiling point elevation constant for water is 0.52°C/m.
A) CH_3CH_2OH
B) $C_6H_{12}O_6$
C) Na_3PO_4
D) KCl
E) $CaCl_2$
Answer: D
Diff: 3 Page Ref: Sec. 13.5

89) Which produces the greatest number of ions when one mole dissolves in water?
A) NaCl
B) NH_4NO_3
C) NH_4Cl
D) Na_2SO_4
E) sucrose
Answer: D
Diff: 2 Page Ref: Sec. 13.5

90) Of the following, a 0.1 M aqueous solution of __________ will have the lowest freezing point.
A) NaCl
B) $Al(NO_3)_3$
C) K_2CrO_4
D) Na_2SO_4
E) sucrose
Answer: B
Diff: 3 Page Ref: Sec. 13.5

91) Which of the following aqueous solutions will have the highest boiling point?
A) 0.10 m Na_2SO_4
B) 0.20 m glucose
C) 0.25 m sucrose
D) 0.10 m NaCl
E) 0.10 m $SrSO_4$
Answer: A
Diff: 3 Page Ref: Sec. 13.5

92) The most likely van't Hoff factor for an 0.01 m CaI_2 solution is __________.
A) 1.00
B) 3.00
C) 1.27
D) 2.69
E) 3.29
Answer: D
Diff: 3 Page Ref: Sec. 13.5

93) Which one of the following solutes has a limiting van't Hoff factor (i) of 3 when dissolved in water?
A) KNO_3
B) CH_3OH
C) CCl_4
D) Na_2SO_4
E) sucrose
Answer: D
Diff: 3 Page Ref: Sec. 13.5

94) The ideal value of i (van't Hoff factor) for $(NH_4)_3PO_4$.
A) 1
B) 2
C) 3
D) 4
E) 5
Answer: D
Diff: 3 Page Ref: Sec. 13.5

95) Colligative properties of solutions include all of the following except __________.
A) depression of vapor pressure upon addition of a solute to a solvent
B) elevation of the boiling point of a solution upon addition of a solute to a solvent
C) depression of the freezing point of a solution upon addition of a solute to a solvent
D) an increase in the osmotic pressure of a solution upon the addition of more solute
E) the increase of reaction rates with increase in temperature
Answer: E
Diff: 3 Page Ref: Sec. 13.5

96) The process of a substance sticking to the surface of another is called
A) absorption
B) diffusion
C) effusion
D) adsorption
E) coagulation
Answer: D
Diff: 2 Page Ref: Sec. 13.6

97) Which of the following is not a colloid?
A) air
B) fog
C) smoke
D) whipped cream
E) homogenized milk
Answer: A
Diff: 2 Page Ref: Sec. 13.6

98) Which of the following cannot be a colloid?
A) an emulsion
B) an aerosol
C) a homogenous mixture
D) a foam
E) All of the above are colloids.
Answer: C
Diff: 2 Page Ref: Sec. 13.6

99) Hydrophobic colloids __________.
A) are those that contain water
B) can be stabilized by adsorption of ions
C) are those that do not contain water
D) can be stabilized by coagulation
E) will separate into two phases if they are stabilized
Answer: B
Diff: 2 Page Ref: Sec. 13.6

Short Answer

1) Water (H_2O) and the alcohol methanol (CH_3OH) are infinitely soluble in each other. The primary intermolecular force responsible for this is __________.
Answer: hydrogen bonding
Diff: 2 Page Ref: Sec. 13.3

2) The phenomenon used to differentiate colloids and true solutions is called the __________ effect.
Answer: Tyndall
Diff: 2 Page Ref: Sec. 13.6

3) What is the osmotic pressure (in atm) of a 0.040 M solution of a non-electrolyte at 30.0 ^{o}C?
Answer: 1.0
Diff: 3 Page Ref: Sec. 13.5

4) Physical properties of a solution that depend on the quantity of the solute particles present, but not the kind or identity of the particles, are termed __________ properties.
Answer: colligative
Diff: 2 Page Ref: Sec. 13.5

5) A solution contains 150.8 grams of NaCl in 678.3 grams of water. Calculate the vapor pressure lowering (in torr) of the solution at 25.0 ^{o}C. (Note: the vapor pressure of pure water at 25.0 ^{o}C is 23.76 torr.)
Answer: 2.85
Diff: 2 Page Ref: Sec. 13.5

6) A solution contains 150.8 grams of NaCl in 678.3 grams of water. Calculate the vapor pressure of water (in torr) over the solution at 25.0 ^{o}C. (Note: the vapor pressure of pure water at 25.0 ^{o}C is 23.76 torr.)
Answer: 20.91
Diff: 3 Page Ref: Sec. 13.5

True/False

1) A solution with a solute concentration greater than the solubility is called a supercritical solution.
Answer: FALSE
Diff: 2 Page Ref: Sec. 13.3

2) Adding solute to a solution decreases the vapor pressure of the solution.
Answer: TRUE
Diff: 2 Page Ref: Sec. 13.5

3) After swimming in the ocean for several hours, swimmers noticed that their fingers appeared to be very wrinkled. This is an indication that seawater is supertonic relative to the fluid in cells.
Answer: FALSE
Diff: 2 Page Ref: Sec. 13.5

4) The value of the boiling-point-elevation constant (K_b) depends on the identity of the solvent.
Answer: TRUE
Diff: 2 Page Ref: Sec. 13.5

5) Emulsifying agents typically have a hydrophobic end and a hydrophilic end.
Answer: TRUE
Diff: 2 Page Ref: Sec. 13.6

Algorithmic Questions

1) The Henry's law constant for helium gas in water at 30 °C is 3.70×10^{-4} M/atm. When the partial pressure of helium above a sample of water is 0.650 atm, the concentration of helium in the water is __________ M.
A) 5.69×10^{-4}
B) 1.76×10^{3}
C) 1.30
D) 2.41×10^{-4}
E) 3.70×10^{-4}
Answer: D
Diff: 2 Page Ref: Sec. 13.3

2) A solution is prepared by adding 1.43 mol of KCl to 889 g of water. The concentration of KCl is __________ molal.
A) 1.61×10^{-3}
B) 622
C) 0.622
D) 1.27×10^{3}
E) 1.61
Answer: E
Diff: 3 Page Ref: Sec. 13.4

3) The concentration of KCl in a solution prepared by adding 0.0660 mol of KCl to 1.00 mol of water is __________ % by mass.
A) 5.19
B) 0.0130
C) 0.0519
D) 0.733
E) 7.33×10^{-4}
Answer: A
Diff: 3 Page Ref: Sec. 13.4

4) A solution is prepared by dissolving 16.2 g of benzene (C_6H_6) in 282 g of carbon tetrachloride (CCl_4) The concentration of benzene in this solution is __________ molal. The molar masses of C_6H_6 and CCl_4 are 78.1 g/mol and 154 g/mol, respectively.
A) 7.36×10^{-4}
B) 0.736
C) 0.102
D) 0.0543
E) 5.43
Answer: B
Diff: 3 Page Ref: Sec. 13.4

5) At 20°C, an aqueous solution that is 24.00% by mass in ammonium chloride has a density of 1.0674 g/mL. What is the molarity of ammonium chloride in the solution? The formula weight of NH_4Cl is 53.50 g/mol.

A) 5.90
B) 0.479
C) 4.79
D) 0.0445
E) 22.5
Answer: C
Diff: 4 Page Ref: Sec. 13.4

6) At 20°C, a 2.32 M aqueous solution of ammonium chloride has a density of 1.0344 g/mL. What is the molality of ammonium chloride in the solution? The formula weight of NH_4Cl is 53.50 g/mol.

A) 2.55
B) 0.0449
C) 2.32
D) 0.446
E) 12.00
Answer: A
Diff: 4 Page Ref: Sec. 13.4

7) At 20°C, a 3.54 M aqueous solution of ammonium chloride has a density of 1.0512 g/mL. What is the mass % of ammonium chloride in the solution? The formula weight of NH_4Cl is 53.50 g/mol.

A) 4.10
B) 6.95
C) 3.36
D) 0.297
E) 18.00
Answer: E
Diff: 4 Page Ref: Sec. 13.4

8) A solution is prepared by dissolving 7.00 g of glycerin $(C_3H_8O_3)$ in 201 g of ethanol (C_2H_5OH). The freezing point of the solution is _______°C. The freezing point of pure ethanol is -114.6 °C at 1 atm. The molal-freezing-point-depression constant (K_f) for ethanol is 1.99 °C/*m*. The molar masses of glycerin and of ethanol are 92.1 g/mol and 46.1 g/mol, respectively.

A) -121.3
B) 0.752
C) -107.9
D) -113.8
E) -115.4
Answer: E
Diff: 4 Page Ref: Sec. 13.5

9) Calculate the freezing point of a solution containing 40.0 grams of KCl and 4400.0 grams of water. The molal-freezing-point-depression constant (K_f) for water is 1.86 °C/*m*.

A) -0.45 ^{o}C
B) +0.45 ^{o}C
C) -0.23 ^{o}C
D) +0.23 ^{o}C
E) 1.23 ^{o}C
Answer: A
Diff: 4 Page Ref: Sec. 13.5

10) The osmotic pressure of a solution formed by dissolving 25.0 mg of aspirin $(C_9H_8O_4)$ in 0.250 L of water at 25 °C is __________ atm.
A) 13.6
B) 1.14×10^{-3}
C) 0.0136
D) 2.45
E) 1.38
Answer: C
Diff: 4   Page Ref: Sec. 13.5

11) A solution is prepared by adding 30.00 g of lactose (milk sugar) to 110.0 g of water at 55 °C. The partial pressure of water above the solution is __________ torr. The vapor pressure of pure water at 55 °C is 118 torr. The MW of lactose is 342.3 g/mol.
A) 1.670
B) 94.1
C) 169.4
D) 116.3
E) 92.7
Answer: D
Diff: 4   Page Ref: Sec. 13.5

Chemistry, 11e (Brown)
Chapter 14: Chemical Kinetics

Multiple-Choice and Bimodal

1) Consider the following reaction:

$$3A \rightarrow 2B$$

The average rate of appearance of B is given by $\Delta[B]/\Delta t$. Comparing the rate of appearance of B and the rate of disappearance of A, we get $\Delta[B]/\Delta t$ = _____ $\times$ $(-\Delta[A]/\Delta t)$.
A) -2/3
B) +2/3
C) -3/2
D) +1
E) +3/2
Answer: B
Diff: 1 Page Ref: Sec. 14.2

2) Nitrogen dioxide decomposes to nitric oxide and oxygen via the reaction:

$$2N_2 \rightarrow 2NO + O_2$$

In a particular experiment at 300°C, $[NO_2]$ drops from 0.0100 to 0.00650 M in 100 s The rate of appearance of O_2 for this period is __________ M/s.
A) 1.8×10^{-5}
B) 3.5×10^{-5}
C) 7.0×10^{-5}
D) 3.5×10^{-3}
E) 7.0×10^{-3}
Answer: A
Diff: 1 Page Ref: Sec. 14.2

3) Which substance in the reaction below either appears or disappears the fastest?

$$4NH_3 + 7O_2 \rightarrow 4NO_2 + 6H_2O$$

A) NH_3
B) O_2
C) NO_2
D) H_2O
E) The rates of appearance/disappearance are the same for all of these.
Answer: B
Diff: 1 Page Ref: Sec. 14.2

4) Consider the following reaction:

$$A \rightarrow 2C$$

The average rate of appearance of C is given by $\Delta[C]/\Delta t$. Comparing the rate of appearance of C and the rate of disappearance of A, we get $\Delta[C]/\Delta t$ = _____ × $(\Delta[A]/\Delta t)$

A) +2
B) -1
C) +1
D) +1/2
E) -1/2
Answer: A
Diff: 1 Page Ref: Sec. 14.2

A flask is charged with 0.124 mol of A *and allowed to react to form* B *according to the reaction* A(g) →B(g). *The following data are obtained for* [A] *as the reaction proceeds:*

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

5) The average rate of disappearance of A between 10 s and 20 s is __________ mol/s.
A) 2.2×10^{-3}
B) 1.1×10^{-3}
C) 4.4×10^{-3}
D) 454
E) 9.90×10^{-3}
Answer: A
Diff: 1 Page Ref: Sec. 14.2

6) The average rate of disappearance of A between 20 s and 40 s is __________ mol/s.
A) 8.5×10^{-4}
B) 1.7×10^{-3}
C) 590
D) 7.1×10^{-3}
E) 1.4×10^{-3}
Answer: B
Diff: 1 Page Ref: Sec. 14.2

7) The average rate of appearance of B between 20 s and 30 s is __________ mol/s.
A) $+1.5 \times 10^{-3}$
B) $+5.0 \times 10^{-4}$
C) -1.5×10^{-3}
D) $+7.3 \times 10^{-3}$
E) -7.3×10^{-3}
Answer: A
Diff: 1 Page Ref: Sec. 14.2

8) The average rate disappearance of A between 20 s and 30 s is __________ mol/s.
A) 5.0×10^{-4}
B) 1.6×10^{-2}
C) 1.5×10^{-3}
D) 670
E) 0.15
Answer: C
Diff: 1 Page Ref: Sec. 14.2

A flask is charged with 0.124 mol of A *and allowed to react to form* B *according to the reaction* A(g) →B(g). *The following data are obtained for* [A] *as the reaction proceeds:*

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

9) How many moles of B are present at 10 s?
A) 0.011
B) 0.220
C) 0.110
D) 0.014
E) 1.4×10^{-3}
Answer: D
Diff: 1 Page Ref: Sec. 14.2

10) How many moles of B are present at 30 s?
A) 2.4×10^{-3}
B) 0.15
C) 0.073
D) 1.7×10^{-3}
E) 0.051
Answer: E
Diff: 1 Page Ref: Sec. 14.2

The peroxydisulfate ion $(S_2O_8^{2-})$ *reacts with the iodide ion in aqueous solution via the reaction:*

$$(S_2O_8^{2-})\ (aq) + 3I^- \rightarrow 2SO_4\ (aq) + I3^-\ (aq)$$

An aqueous solution containing 0.050 M *of* $S_2O_8^{2-}$ *ion and* 0.072 M *of* I^- *is prepared, and the progress of the reaction followed by measuring* $[I^-]$. *The data obtained is given in the table below.*

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

11) The average rate of disappearance of I^- between 400 s and 800 s is __________ M/s.
A) 2.8×10^{-5}
B) 1.4×10^{-5}
C) 5.8×10^{-5}
D) 3.6×10^{4}
E) 2.6×10^{-4}
Answer: A
Diff: 1 Page Ref: Sec. 14.2

12) The average rate of disappearance of I in the initial 400 s is __________ M/s.
A) 6.00
B) 3.8×10^{-5}
C) 1.4×10^{-4}
D) 2.7×10^{4}
E) 3.2×10^{-4}
Answer: B
Diff: 1 Page Ref: Sec. 14.2

13) The average rate of disappearance of I between 1200 s and 1600 s is __________ M/s.
A) 1.8×10^{-5}
B) 1.2×10^{-5}
C) 2.0×10^{-5}
D) 5.0×10^{4}
E) 1.6×10^{-4}
Answer: C
Diff: 1 Page Ref: Sec. 14.2

14) The concentration of $S_2O_8^{2-}$ remaining at 400 s is __________ M.
A) +0.015
B) +0.035
C) -0.007
D) +0.045
E) +0.057
Answer: D
Diff: 1 Page Ref: Sec. 14.2

15) The concentration of $S_2O_8^{2-}$ remaining at 800 s is __________ M.
A) 0.046
B) 0.076
C) 4.00×10^{-3}
D) 0.015
E) 0.041
Answer: E
Diff: 1 Page Ref: Sec. 14.2

16) The concentration of $S_2O_8^{2-}$ remaining at 1600 s is __________ M.
A) 0.036
B) 0.014
C) 0.043
D) 0.064
E) 0.029
Answer: A
Diff: 1 Page Ref: Sec. 14.2

17) At elevated temperatures, dinitrogen pentoxide decomposes to nitrogen dioxide and oxygen:

$$2N_2O_5(g) \rightarrow 4NO_2\ (g) + O_2\ (g)$$

When the rate of formation of NO_2 is 5.5×10^{-4} M/s, the rate of decomposition of N_2O_5 is __________ M/s.
A) 2.2×10^{-3}
B) 1.4×10^{-4}
C) 10.1×10^{-4}
D) 2.8×10^{-4}
E) 5.5×10^{-4}
Answer: D
Diff: 1 Page Ref: Sec. 14.2

18) At elevated temperatures, methylisonitrile (CH_3NC) isomerizes to acetonitrile (CH_3CN):

$$CH_3NC\ (g) \rightarrow CH_3CN\ (g)$$

At the start of an experiment, there are 0.200 mol of reactant and 0 mol of product in the reaction vessel. After 25 min, 0.108 mol of reactant (CH_3NC) remain. There are __________ mol of product (CH_3CN) in the reaction vessel.
A) 0.022
B) 0.540
C) 0.200
D) 0.308
E) 0.092
Answer: E
Diff: 1 Page Ref: Sec. 14.2

19) At elevated temperatures, methylisonitrile (CH_3NC) isomerizes to acetonitrile (CH_3CN):

$$CH_3NC\ (g) \rightarrow CH_3CN\ (g)$$

At the start of the experiment, there are 0.200 mol of reactant (CH_3NC) and 0 mol of product (CH_3CN) in the reaction vessel. After 25 min of reaction, 0.108 mol of reactant (CH_3NC) remain. The average rate of decomposition of methyl isonitrile, CH_3NC, in this 25 min period is __________ mol/min.
A) 3.7×10^{-3}
B) 0.092
C) 2.3
D) 4.3×10^{-3}
E) 0.54
Answer: A
Diff: 1 Page Ref: Sec. 14.2

20) A reaction was found to be second order in carbon monoxide concentration. The rate of the reaction __________ if the [CO] is doubled, with everything else kept the same.
A) doubles
B) remains unchanged
C) triples
D) increases by a factor of 4
E) is reduced by a factor of 2.
Answer: D
Diff: 1 Page Ref: Sec. 14.3

21) If the rate law for the reaction

$$2A + 3B \rightarrow \text{products}$$

is first order in A and second order in B, then the rate law is

A) k[A][B]

B) $k[A]^2[B]^3$

C) $k[A][B]^2$

D) $k[A]^2[B]$

E) $k[A]^2[B]^2$

Answer: C

Diff: 1   Page Ref: Sec. 14.3

22) The overall order of a reaction is 2. The units of the rate constant for the reaction are __________.

A) M/s

B) $M^{-1}s^{-1}$

C) 1/s

D) 1/M

E) s/M^2

Answer: B

Diff: 1   Page Ref: Sec. 14.3

23) The kinetics of the reaction below were studied and it was determined that the reaction rate increased by a factor of 9 when the concentration of B was tripled. The reaction is __________ order in B.

$$A + B \rightarrow P$$

A) zero

B) first

C) second

D) third

E) one-half

Answer: C

Diff: 1   Page Ref: Sec. 14.3

24) The kinetics of the reaction below were studied and it was determined that the reaction rate did not change when the concentration of B was tripled. The reaction is __________ order in B.

$$A + B \rightarrow P$$

A) zero

B) first

C) second

D) third

E) one-half

Answer: A

Diff: 1   Page Ref: Sec. 14.3

25) A reaction was found to be third order in A. Increasing the concentration of A by a factor of 3 will cause the reaction rate to __________.
A) remain constant
B) increase by a factor of 27
C) increase by a factor of 9
D) triple
E) decrease by a factor of the cube root of 3
Answer: B
Diff: 1   Page Ref: Sec. 14.3

26) A reaction was found to be zero order in A. Increasing the concentration of A by a factor of 3 will cause the reaction rate to __________.
A) remain constant
B) increase by a factor of 27
C) increase by a factor of 9
D) triple
E) decrease by a factor of the cube root of 3
Answer: A
Diff: 1   Page Ref: Sec. 14.3

The data in the table below were obtained for the reaction:

$A + B \rightarrow P$

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

27) The order of the reaction in A is __________.
A) 1
B) 2
C) 3
D) 4
E) 0
Answer: B
Diff: 1   Page Ref: Sec. 14.3

28) The order of the reaction in B is __________.
A) 1
B) 2
C) 3
D) 4
E) 0
Answer: E
Diff: 1   Page Ref: Sec. 14.3

29) The overall order of the reaction is __________.
A) 1
B) 2
C) 3
D) 4
E) 0
Answer: B
Diff: 1 Page Ref: Sec. 14.3

30) For a first-order reaction, a plot of __________ versus __________ is linear.

A) In $[A]_t$, $\frac{1}{t}$

B) ln $[A]_{t,\ t}$

C) $\frac{1}{[A]_t}$, t

D) $[A]_{t,\ t}$

E) t, $\frac{1}{[A]_t}$

Answer: B
Diff: 1 Page Ref: Sec. 14.3

31) The following reaction occurs in aqueous solution:

$$NH_4^+ \text{ (aq)} + NO_2^- \rightarrow N_2 \text{ (g)} + 2H_2O \text{ (l)}$$

The data below is obtained at 25°C.

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

The order of the reaction in NH_4^+ is __________.
A) -2
B) -1
C) +2
D) +1
E) 0
Answer: D
Diff: 1 Page Ref: Sec. 14.3

32) The rate constant for a particular second-order reaction is 0.47 $M^{-1}s^{-1}$. If the initial concentration of reactant is 0.25 mol/L, it takes __________ s for the concentration to decrease to 0.13 mol/L.
A) 7.9
B) 1.4
C) 3.7
D) 1.7
E) 0.13
Answer: A
Diff: 2 Page Ref: Sec. 14.4

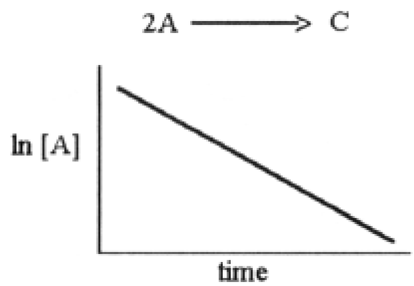
33) A first-order reaction has a rate constant of $0.33\ min^{-1}$. It takes __________ min for the reactant concentration to decrease from 0.13 M to 0.088 M.
A) 1.2
B) 1.4
C) 0.51
D) 0.13
E) 0.85
Answer: A
Diff: 1 Page Ref: Sec. 14.4

34) The initial concentration of reactant in a first-order reaction is 0.27 M. The rate constant for the reaction is $0.75\ s^{-1}$ What is the concentration (mol/L) of reactant after 1.5 s?
A) 3.8
B) 1.7
C) 8.8×10^{-2}
D) 2.0×10^{-2}
E) 0.135
Answer: C
Diff: 1 Page Ref: Sec. 14.4

35) The rate constant for a second-order reaction is $0.13\ M^{-1}s^{-1}$. If the initial concentration of reactant is 0.26 mol/L, it takes __________ s for the concentration to decrease to 0.13 mol/L.
A) 0.017
B) 0.50
C) 1.0
D) 30
E) 4.4×10^{-3}
Answer: D
Diff: 1 Page Ref: Sec. 14.4

36) The half-life of a first-order reaction is 13 min. If the initial concentration of reactant is 0.085 M, it takes ________min for it to decrease to 0.055 M.
A) 8.2
B) 11
C) 3.6
D) 0.048
E) 8.4
Answer: A
Diff: 1 Page Ref: Sec. 14.4

37) The graph shown below depicts the relationship between concentration and time for the following chemical reaction.



The slope of this line is equal to __________.
A) k
B) -1/k
C) $\ln[A]_o$
D) -k
E) 1/k
Answer: D
Diff: 1 Page Ref: Sec. 14.4

38) The reaction below is first order in $[H_2O_2]$:

$$2H_2O_2(l) \rightarrow 2H_2O\ (l) + O_2\ (g)$$

A solution originally at 0.600 M H_2O_2 is found to be 0.075 M after 54 min. The half-life for this reaction is __________ min.
A) 6.8
B) 18
C) 14
D) 28
E) 54
Answer: B
Diff: 4 Page Ref: Sec. 14.4

39) A second-order reaction has a half-life of 18 s when the initial concentration of reactant is 0.71 M. The rate constant for this reaction is __________ $M^{-1}s^{-1}$.
A) 7.8×10^{-2}
B) 3.8×10^{-2}
C) 2.0×10^{-2}
D) 1.3
E) 18
Answer: A
Diff: 2 Page Ref: Sec. 14.4

Multiple-Choice

40) A burning splint will burn more vigorously in pure oxygen than in air because
A) oxygen is a reactant in combustion and concentration of oxygen is higher in pure oxygen than is in air.
B) oxygen is a catalyst for combustion.
C) oxygen is a product of combustion.
D) nitrogen is a product of combustion and the system reaches equilibrium at a lower temperature.
E) nitrogen is a reactant in combustion and its low concentration in pure oxygen catalyzes the combustion.
Answer: A
Diff: 1 Page Ref: Sec. 14.1

41) Of the following, all are valid units for a reaction rate except __________.
A) mol/L
B) M/s
C) mol/hr
D) g/s
E) mol/L-hr
Answer: A
Diff: 1 Page Ref: Sec. 14.2

42) Nitrogen dioxide decomposes to nitric oxide and oxygen via the reaction:

$$2NO_2 \rightarrow 2NO + O_2$$

In a particular experiment at 300°C, $[NO_2]$ drops from 0.0100 to 0.00650 M in 100 s. The rate of disappearance of NO_2 for this period is __________ M/s.
A) 0.35
B) 3.5×10^{-3}
C) 3.5×10^{-5}
D) 7.0×10^{-3}
E) 1.8×10^{-3}
Answer: C
Diff: 1 Page Ref: Sec. 14.2

43) Which one of the following is not a valid expression for the rate of the reaction below?

$$4NH_3 + 7O_2 \rightarrow 4NO_2 + 6H_2O$$

A) $-\frac{1}{7}\ \frac{\Delta[O_2]}{\Delta t}$
B) $\frac{1}{4}\ \frac{\Delta[NO_2]}{\Delta t}$
C) $\frac{1}{6}\ \frac{\Delta[H_2O]}{\Delta t}$
D) $-\frac{1}{4}\ \frac{\Delta[NH_3]}{\Delta t}$
E) All of the above are valid expressions of the reaction rate.
Answer: E
Diff: 1 Page Ref: Sec. 14.2

44) Of the units below, __________ are appropriate for a first-order reaction rate constant.
A) M s^{-1}
B) s^{-1}
C) mol/L
D) $M^{-1}s^{-1}$
E) L mol^{-1} s^{-1}
Answer: B
Diff: 1 Page Ref: Sec. 14.2

45) The rate law of a reaction is rate = k[D][X]. The units of the rate constant are __________.
A) mol $L^{-1}s^{-1}$
B) L $mol^{-1}s^{-1}$
C) mol^2 $L^{-2}s^{-1}$
D) mol $L^{-1}s_{-2}$
E) L^2 $mol^{-2}s^{-1}$
Answer: B
Diff: 2 Page Ref: Sec. 14.3

The data in the table below were obtained for the reaction:

A + B → P

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

46) The magnitude of the rate constant is __________.
A) 38.0
B) 0.278
C) 13.2
D) 42.0
E) 2.21
Answer: A
Diff: 3 Page Ref: Sec. 14.3

The data in the table below were obtained for the reaction:

2 ClO_2 (aq) + 2 OH- (aq) → ClO_3- (aq) + ClO_2- (aq) + H_2O (1)

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

47) What is the order of the reaction with respect to ClO_2?
A) 1
B) 0
C) 2
D) 3
E) 4
Answer: C
Diff: 1 Page Ref: Sec. 14.3

48) What is the order of the reaction with respect to OH^-?
A) 0
B) 1
C) 2
D) 3
E) 4
Answer: B
Diff: 1 Page Ref: Sec. 14.3

49) What is the overall order of the reaction?
A) 4
B) 0
C) 1
D) 2
E) 3
Answer: E
Diff: 1 Page Ref: Sec. 14.3

50) What is the magnitude of the rate constant for the reaction?
A) 1.15×10^4
B) 4.6
C) 230
D) 115
E) 713
Answer: C
Diff: 1 Page Ref: Sec. 14.3

51) The rate law for a reaction is

$$\text{rate} = k\,[A][B]^2$$

Which one of the following statements is false?
A) The reaction is first order in A.
B) The reaction is second order in B.
C) The reaction is second order overall.
D) *k* is the reaction rate constant
E) If [B] is doubled, the reaction rate will increase by a factor of 4.
Answer: C
Diff: 1 Page Ref: Sec. 14.3

52) The half-life of a first-order reaction __________.
A) is the time necessary for the reactant concentration to drop to half its original value
B) is constant
C) can be calculated from the reaction rate constant
D) does not depend on the initial reactant concentration
E) All of the above are correct.
Answer: E
Diff: 1 Page Ref: Sec. 14.3

53) The reaction

$$2NO_2 \rightarrow 2NO + O_2$$

follows second-order kinetics. At 300°C, $[NO_2]$ drops from 0.0100- to 0.00650-M in 100 s. The rate constant for the reaction is __________ $M^{-1}s^{-1}$.
A) 0.096
B) 0.65
C) 0.81
D) 1.2
E) 0.54
Answer: E
Diff: 2 Page Ref: Sec. 14.4

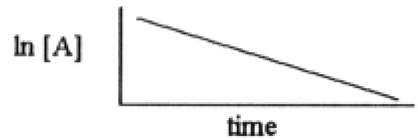
54) The reaction

$$CH_3\text{-}N \equiv C \rightarrow CH_3\text{-}C \equiv N$$

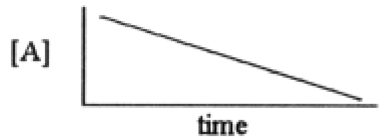
is a first-order reaction. At 230.3°C, k = $6.29 \times 10^{-4} s^{-1}$ If $[CH_3\text{-}N \equiv C]$ is 1.00×10^{-3} initially, $[CH_3\text{-}N \equiv C]$ is __________ after $1.000 \times 10^3 s$.
A) 5.33×10^{-4}
B) 2.34×10^{-4}
C) 1.88×10^{-3}
D) 4.27×10^{-3}
E) 1.00×10^{-6}
Answer: A
Diff: 2 Page Ref: Sec. 14.4

55) Which one of the following graphs shows the correct relationship between concentration and time for a reaction that is second order in [A]?

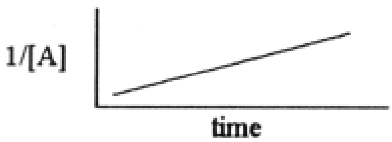
A)



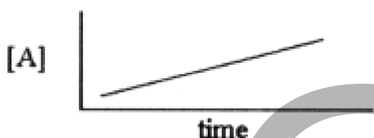
B)



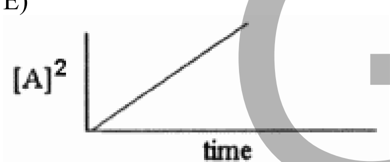
C)



D)



E)



Answer: C
Diff: 2   Page Ref: Sec. 14.4

56) The following reaction is second order in [A] and the rate constant is 0.039 $M^{-1}s^{-1}$:

$A \rightarrow B$

The concentration of A was 0.30 M at 23s. The initial concentration of A was __________ M.

A) 2.4
B) 0.27
C) 0.41
D) 3.7
E) 1.2×10^{-2}

Answer: C
Diff: 1   Page Ref: Sec. 14.4

The reaction A → B *is first order in* [A]. *Consider the following data.*

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

57) The rate constant for this reaction is __________ s^{-1}.
A) 0.013
B) 0.030
C) 0.14
D) 3.0
E) 3.1×10^{-3}
Answer: C
Diff: 1   Page Ref: Sec. 14.4

58) The half-life of this reaction is __________ s.
A) 0.97
B) 7.1
C) 4.9
D) 3.0
E) 0.14
Answer: C
Diff: 2   Page Ref: Sec. 14.4

The reaction A → B *is first order in* [A]. *Consider the following data.*

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

59) The rate constant for this reaction is __________ s^{-1}.
A) 6.9×10^{-2}
B) 3.0×10^{-2}
C) 14
D) 0.46
E) 4.0×10^{2}
Answer: A
Diff: 2   Page Ref: Sec. 14.4

60) The concentration of A is __________ M after 40.0 s.
A) 1.2×10^{-2}
B) 1.2
C) 0.17
D) 3.5×10^{-4}
E) 0.025
Answer: A
Diff: 2   Page Ref: Sec. 14.4

61) The rate constant of a first-order process that has a half-life of 225 s is __________ s^{-1} .
A) 0.693
B) 3.08×10^{-3}
C) 1.25
D) 12.5
E) 4.44×10^{-3}
Answer: B
Diff: 2 Page Ref: Sec. 14.4

62) The reaction A (aq) → B (aq) is first order in [A]. A solution is prepared with [A] = 1.22 M. The following data are obtained as the reaction proceeds:

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

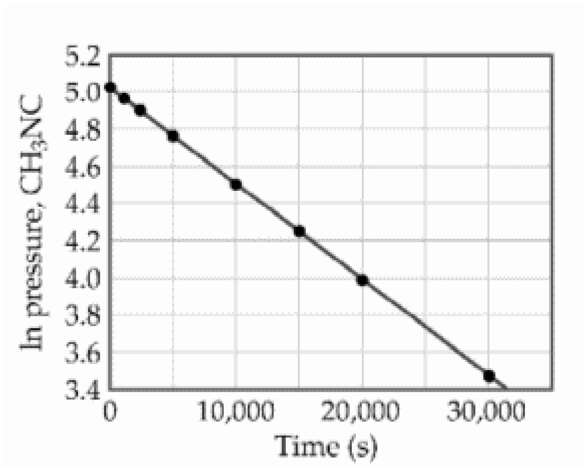
The rate constant for this reaction is __________ s^{-1} .
A) 0.23
B) 1.0
C) 0.17
D) 0.12
E) -0.12
Answer: D
Diff: 2 Page Ref: Sec. 14.4

63) One difference between first- and second-order reactions is that __________.
A) the half-life of a first-order reaction does not depend on $[A]_0$; the half-life of a second-order reaction does depend on $[A]_0$
B) the rate of a first-order reaction does not depend on reactant concentrations; the rate of a second-order reaction does depend on reactant concentrations
C) the rate of a first-order reaction depends on reactant concentrations; the rate of a second-order reaction does not depend on reactant concentrations
D) a first-order reaction can be catalyzed; a second-order reaction cannot be catalyzed
E) the half-life of a first-order reaction depends on $[A]_0$; the half-life of a second-order reaction does not depend on $[A]_0$
Answer: A
Diff: 1 Page Ref: Sec. 14.4

64) At elevated temperatures, methylisonitrile (CH_3NC) isomerizes to acetonitrile (CH_3CN):

CH_3NC (g) → $CH_{3}3CN$ (g)

The reaction is first order in methylisonitrile. The attached graph shows data for the reaction obtained at 198.9°C.



The rate constant for the reaction is __________ s^{-1}.
A) -1.9×10^4
B) $+1.9 \times 10^4$
C) -5.2×10^{-5}
D) $+5.2 \times 10^{-5}$
E) +6.2
Answer: B
Diff: 2 Page Ref: Sec. 14.4

65) At elevated temperatures, nitrogen dioxide decomposes to nitrogen oxide and oxygen:

$$NO_2\ (g) \rightarrow NO\ (g) + \frac{1}{2}O_2\ (g)$$

The reaction is second order in NO_2 with a rate constant of 0.543 M^{-1} s^{-1} at 300°C If the initial [NO_2] is 0.260 M it will take __________ s for the concentration to drop to 0.100 M.
A) 3.34
B) 8.8×10^{-2}
C) -0.611
D) 0.299
E) 11.3
Answer: E
Diff: 2 Page Ref: Sec. 14.4

66) The decomposition of N_2O_5 in solution in carbon tetrachloride proceeds via the reaction

$2N_2O_5$ (soln) → $4NO_2$ (soln) + O_2 (soln)

The reaction is first order and has a rate constant of 4.82×10^{-3} s^{-1} at 64°C. The rate law for the reaction is rate = __________.
A) $k[N_2O_5]^2$

B) $k\frac{[NO_2]^4[O_2]}{[N_2O_5]^2}$

C) $k[N_2O_5]$

D $k\frac{[N_2O_5]^2}{[NO_2]^4[O_2]}$

E) $2k[N_2O_5]$

Answer: C

Diff: 2   Page Ref: Sec. 14.4

67) As the temperature of a reaction is increased, the rate of the reaction increases because the __________.

A) reactant molecules collide less frequently

B) reactant molecules collide with greater energy per collision

C) activation energy is lowered

D) reactant molecules collide less frequently and with greater energy per collision

E) reactant molecules collide more frequently with less energy per collision

Answer: B

Diff: 1   Page Ref: Sec. 14.5

68) The rate of a reaction depends on __________.

A) collision frequency

B) collision energy

C) collision orientation

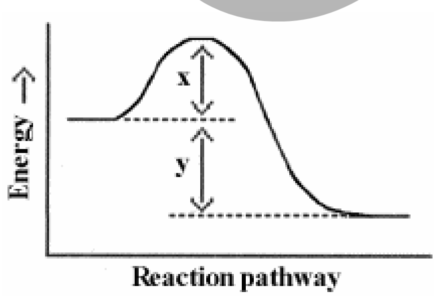
D) all of the above

E) none of the above

Answer: D

Diff: 1   Page Ref: Sec. 14.5

69) Which energy difference in the energy profile below corresponds to the activation energy for the forward reaction?



A) x

B) y

C) x + y

D) x - y

E) y - x

Answer: A

Diff: 1   Page Ref: Sec. 14.5

70) In the energy profile of a reaction, the species that exists at the maximum on the curve is called the __________.
A) product
B) activated complex
C) activation energy
D) enthalpy of reaction
E) atomic state
Answer: B
Diff: 1 Page Ref: Sec. 14.5

71) In the Arrhenius equation,

$$k = Ae^{-Ea/RT}$$

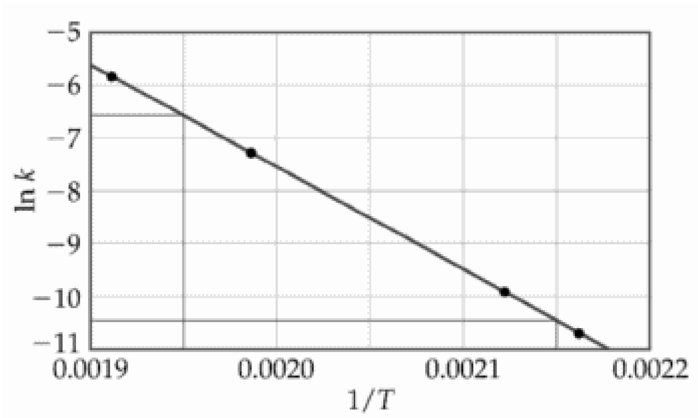
__________ is the frequency factor.
A) k
B) A
C) e
D) E_a
E) R
Answer: B
Diff: 3 Page Ref: Sec. 14.5

72) In general, as temperature goes up, reaction rate __________.
A) goes up if the reaction is exothermic
B) goes up if the reaction is endothermic
C) goes up regardless of whether the reaction is exothermic or endothermic
D) stays the same regardless of whether the reaction is exothermic or endothermic
E) stays the same if the reaction is first order
Answer: C
Diff: 1 Page Ref: Sec. 14.5

73) At elevated temperatures, methylisonitrile (CH_3NC) isomerizes to acetonitrile (CH_3CN):

$CH_3NC\ (g) \rightarrow CH_3CN\ (g)$

The dependence of the rate constant on temperature is studied and the graph below is prepared from the results.



The energy of activation of this reaction is __________ kJ/mol.
A) 160
B) 1.6×10^5
C) 4.4×10^{-7}
D) 4.4×10^{-4}
E) 1.9×10^4
Answer: A
Diff: 2 Page Ref: Sec. 14.5

74) The mechanism for formation of the product X is:

$A + B \rightarrow C + D$	(slow)
$B + D \rightarrow X$	(fast)

The intermediate reactant in the reaction is __________.
A) A
B) B
C) C
D) D
E) X
Answer: D
Diff: 1 Page Ref: Sec. 14.6

75) The overall reactions and rate laws for several reactions are given below. Of these, only __________ could represent an elementary step.

A) $2A \rightarrow P$	rate = $k[A]$
B) $A + B \rightarrow P$	rate = $k[A][B]$
C) $A + 2B \rightarrow P$	rate = $k[A]^2$
D) $A + B + C \rightarrow P$	rate = $k[A][C]$
E) $A + 2B \rightarrow P$	rate = $k[A][B]$

Answer: B
Diff: 1 Page Ref: Sec. 14.6

76) For the elementary reaction

$$NO_3 + CO \rightarrow NO_2 + CO_2$$

the molecularity of the reaction is __________, and the rate law is rate = __________.

A) 2, $k[NO_3][CO]$

B) 4, $k[NO_3][CO][NO_2][CO_2]$

C) 2, $k[NO_2][CO_2]$

D) 2, $k[NO_3][CO]/[NO_2][CO_2]$

E) 4, $k[NO_2][CO_2]/[NO_3][CO]$

Answer: A

Diff: 2 Page Ref: Sec. 14.6

77) The first step of a mechanism involving the reactant I_2 is shown below, where the equilibrium is established.

$$I_2\,(aq) \rightleftharpoons 2I\,(aq) \qquad (1, -1)$$

The expression relating [I] to $[I_2]$ is [I] = __________.

A) $k_1[I_2]$

B) $k_1[I_2]^{1/2}$

C) $(k_1/k^{-1})^{1/2}[I_2]^{1/2}$

D) $(k_1/k^{-1})^2[I_2]^2$

E) $(k_1/k^{-1})^2[I_2]^{1/2}$

Answer: C

Diff: 2 Page Ref: Sec. 14.6

78) A possible mechanism for the overall reaction

$$Br_2\,(g) + 2NO\,(g) \rightarrow 2NOBr\,(g)$$

is

$$NO\,(g) + Br_2\,(g) \underset{k_{-1}}{\overset{k1}{\rightleftharpoons}} NO\,Br_2\,(g) \qquad \text{(fast)}$$

$$NO\,Br_2\,(g) + NO\,(g) \xrightarrow{\&} 2NOBr \qquad \text{(slow)}$$

The rate law for formation of NOBr based on this mechanism is rate = ________.

A) $k_1[NO]^{1/2}$

B) $k_1[Br_2]^{1/2}$

C) $(k_2k_1/k^{-1})[NO]^2[Br_2]$

D) $(k_1/k^{-1})^2[NO]^2$

E) $(k_2k_1/k^{-1})[NO][Br_2]^2$

Answer: C

Diff: 3 Page Ref: Sec. 14.6

79) Of the following, __________ will lower the activation energy for a reaction.
A) increasing the concentrations of reactants
B) raising the temperature of the reaction
C) adding a catalyst for the reaction
D) removing products as the reaction proceeds
E) increasing the pressure
Answer: C
Diff: 1 Page Ref: Sec. 14.7

80) The rate law of the overall reaction

$$A + B \rightarrow C$$

is rate $= k[A]^2$. Which of the following will not increase the rate of the reaction?
A) increasing the concentration of reactant A
B) increasing the concentration of reactant B
C) increasing the temperature of the reaction
D) adding a catalyst for the reaction
E) All of these will increase the rate.
Answer: B
Diff: 1 Page Ref: Sec. 14.7

81) A catalyst can increase the rate of a reaction __________.
A) by changing the value of the frequency factor (A)
B) by lowering the overall activation energy (E_a) of the reaction
C) by lowering the activation energy of the reverse reaction
D) by providing an alternative pathway with a lower activation energy
E) All of these are ways that a catalyst might act to increase the rate of reaction.
Answer: D
Diff: 1 Page Ref: Sec. 14.7

82) The primary source of the specificity of enzymes is __________.
A) their polarity, which matches that of their specific substrate
B) their delocalized electron cloud
C) their bonded transition metal, which is specific to the target substrate
D) their locations within the cell
E) their shape, which relates to the lock-and-key model
Answer: E
Diff: 1 Page Ref: Sec. 14.7

83) __________ are used in automotive catalytic converters.
A) Heterogeneous catalysts
B) Homogeneous catalysts
C) Enzymes
D) Noble gases
E) Nonmetal oxides
Answer: A
Diff: 1 Page Ref: Sec. 14.7

84) The enzyme nitrogenase converts __________ into __________.
A) ammonia, urea
B) CO and unburned hydrocarbons, H_2O and CO_2
C) nitrogen, ammonia
D) nitrogen oxides, N_2 and O_2
E) nitroglycerine, nitric acid, and glycerine
Answer: C
Diff: 1 Page Ref: Sec. 14.7

85) The active site of nitrogenase is a cofactor that contains two transition metals. These transition metals are __________.
A) Cr and Mg
B) Mn and V
C) Os and Ir
D) Fe and Zn
E) Fe and Mo
Answer: E
Diff: 1 Page Ref: Sec. 14.7

86) Nitrogen fixation is a difficult process because __________.
A) there is so little nitrogen in the atmosphere
B) nitrogen exists in the atmosphere primarily as its oxides which are very unreactive
C) nitrogen is very unreactive, largely due to its triple bond
D) of the extreme toxicity of nitrogen
E) of the high polarity of nitrogen molecules preventing them from dissolving in biological fluids, such as those inside cells
Answer: C
Diff: 1 Page Ref: Sec. 14.7

Short Answer

1) The relationship of absorbed light to the concentration of the substance absorbing the light is governed by __________.
Answer: Beer's Law
Diff: 1 Page Ref: Sec 14.2

2) For the reaction aA + Bb → cC + dD the rate law is __________.
Answer: $k[A]^m[B]^n$
Diff: 1 Page Ref: Sec 14.3

3) If a rate law is second order (reactant) , doubling the reactant __________ the reaction rate.
Answer: quadruples
Diff: 1 Page Ref: Sec 14.3

4) The earth's ozone layer is located in the __________.
Answer: stratosphere
Diff: 1 Page Ref: Sec 14.4

5) Reaction rates are affected by reactant concentrations and temperature. This is accounted for by the __________.
Answer: collision model
Diff: 1 Page Ref: Sec 14.5

6) The minimum energy to initiate a chemical reaction is the __________.
Answer: activation energy
Diff: 1   Page Ref: Sec 14.5

7) Reaction rate data obey an equation devised by __________.
Answer: Arrhenius
Diff: 1   Page Ref: Sec 14.5

8) The number of molecules that participate as reactants defines the __________ of the reaction.
Answer: molecularity
Diff: 1   Page Ref: Sec 14.6

True/False

1) Rates of reaction can be positive or negative.
Answer: FALSE
Diff: 1   Page Ref: Sec 14.2

2) The instantaneous rate of a reaction can be determined from the graph of molarity versus time at any point on the graph.
Answer: FALSE
Diff: 1   Page Ref: Sec 14.2

3) The overall reaction order is the sum of the orders of each reactant in the rate law.
Answer: TRUE
Diff: 1   Page Ref: Sec 14.3

4) Units of the rate constant of a reaction are independent of the overall reaction order.
Answer: FALSE
Diff: 1   Page Ref: Sec 14.3

5) The concentration of reactants or products at any time during the reaction can be calculated from the integrated rate law.
Answer: TRUE
Diff: 1   Page Ref: Sec 14.3

6) The rate of a second order reaction can depend on the concentrations of more than one reactant.
Answer: TRUE
Diff: 1   Page Ref: Sec 14.4

7) The half life for a first order rate law depends on the starting concentration.
Answer: FALSE
Diff: 1   Page Ref: Sec 14.4

8) The rate limiting step in a reaction is the slowest step in the reaction sequence.
Answer: TRUE
Diff: 1   Page Ref: Sec 14.6

9) Heterogeneous catalysts have different phases from reactants.
Answer: TRUE
Diff: 1   Page Ref: Sec 14.7

Algorithmic Questions

1) The rate of disappearance of HBr in the gas phase reaction

$$2HBr\ (g) \rightarrow H_2\ (g) + Br_2\ (g)$$

is 0.301 $M\ s^{-1}$ at 150°C. The rate of appearance of Br_2 is __________ $M\ s^{-1}$.

A) 1.66
B) 0.151
C) 0.0906
D) 0.602
E) 0.549
Answer: B
Diff: 2 Page Ref: Sec. 14.2

2) The rate of disappearance of HBr in the gas phase reaction

$$2HBr\ (g) \rightarrow H_2\ (g) + Br_2\ (g)$$

is 0.190 $M\ s^{-1}$ at 150°C. The rate of reaction is __________ $M\ s^{-1}$.

A) 2.63
B) 0.095
C) 0.0361
D) 0.380
E) 0.086
Answer: B
Diff: 2 Page Ref: Sec. 14.2

3) The combustion of ethylene proceeds by the reaction

$$C_2H_4\ (g) + 3O_2\ (g) \rightarrow 2CO_2\ (g) + 2H_2O\ (g)$$

When the rate of disappearance of O_2 is 0.28 $M\ s^{-1}$, the rate of appearance of CO_2 is __________ $M\ s^{-1}$.

A) 0.19
B) 0.093
C) 0.84
D) 0.42
E) 0.56
Answer: A
Diff: 2 Page Ref: Sec. 14.2

4) The isomerization of methylisonitrile to acetonitrile

$$CH_3NC\ (g) \rightarrow CH_3CN\ (g)$$

is first order in CH_3NC. The rate constant for the reaction is $9.45 \times 10^{-5}\ s^{-1}$ at 478 K. The half-life of the reaction when the initial $[CH_3NC]$ is 0.030 M is __________ s.

A) 1.06×10^4
B) 5.29×10^3
C) $3.53E \times 10^5$
D) 7.33×10^3
E) 1.36×10^{-4}
Answer: D
Diff: 3 Page Ref: Sec. 14.4

5) The elementary reaction

$$2NO_2\ (g) \rightarrow 2NO\ (g) + O_2\ (g)$$

is second order in NO_2 and the rate constant at 501 K is $7.93 \times 10^{-3}\ M^{-1}s^{-1}$. The reaction half-life at this temperature when $[NO_2]_0 = 0.450$ M is __________ s.

A) 3.6×10^{-3}
B) 0.011
C) 126
D) 87
E) 280
Answer: E
Diff: 2 Page Ref: Sec. 14.4

6) The isomerization of methylisonitrile to acetonitrile

$$CH_3NC\ (g) \rightarrow CH_3CN\ (g)$$

is first order in CH_3NC. The half life of the reaction is 1.60×10^5 s at 444 K. The rate constant when the initial $[CH_3NC]$ is 0.030 M is __________ s^{-1}.

A) 2.31×10^5
B) 2.08×10^{-4}
C) 4.33×10^{-6}
D) 4.80×10^3
E) 7.10×10^7
Answer: C
Diff: 2 Page Ref: Sec. 14.4

7) The combustion of ethylene proceeds by the reaction

$$C_2H_4\ (g) + 3O_2\ (g) \rightarrow 2CO_2\ (g) + 2H_2O\ (g)$$

When the rate of disappearance of O_2 is 0.23 M s^{-1}, the rate of disappearance of C_2H_4 is __________ M s^{-1}.
A) 0.15
B) 0.077
C) 0.69
D) 0.35
E) 0.46
Answer: B
Diff: 2   Page Ref: Sec. 14.2

8) The decomposition of N_2O_5 in solution in carbon tetrachloride proceeds via the reaction

$$2N_2O_5\ (soln) \rightarrow 4NO_2\ (soln) + O_2\ (soln)$$

The reaction is first order and has a rate constant of $4.82 \times 10^{-3} s^{-1}$ at 64°C. If the reaction is initiated with 0.058 mol in a 1.00-L vessel, how many moles remain after 151 s?
A) 0.055
B) 0.060
C) 0.028
D) 12
E) 2.0×10^3
Answer: C
Diff: 2   Page Ref: Sec. 14.4

9) SO_2Cl_2 decomposes in the gas phase by the reaction

$$SO_2Cl_2\ (g) \rightarrow SO_2\ (g) + Cl_2\ (g)$$

The reaction is first order in SO_2Cl_2 and the rate constant is $3.0 \times 10^{-6} s^{-1}$ at 600 K. A vessel is charged with 3.3 atm of SO_2Cl_2 at 600 K. The partial pressure of SO_2 at $3.0 \times 10^5 s$ is __________ atm.
A) 2.1
B) 2.0
C) 1.3
D) 3.0
E) 3.7
Answer: B
Diff: 2   Page Ref: Sec. 14.4

10) SO_2Cl_2 decomposes in the gas phase by the reaction

$$SO_2Cl_2\ (g) \rightarrow SO_2\ (g) + Cl_2\ (g)$$

The reaction is first order in SO_2Cl_2 and the rate constant is $3.0 \times 10^{-6} s^{-1}$ at 600 K. A vessel is charged with 2.4 atm of SO_2Cl_2 at 600 K. The partial pressure of SO_2Cl_2 at $3.0 \times 10^5 s$ is __________ atm.
A) 0.76
B) 2.2
C) 0.98
D) 0.29
E) 1.4×10^5
Answer: C
Diff: 2   Page Ref: Sec. 14.4

11) A particular first-order reaction has a rate constant of $1.35 \times 10^2 s^{-1}$ at 25°C. What is the magnitude of k at 95°C if E_a = 55.5 kJ/mol?
A) 9.60×10^3
B) 2.85×10^4
C) 576
D) 4.33×10^{87}
E) 1.36×10^2
Answer: A
Diff: 4   Page Ref: Sec. 14.5

12) A particular first-order reaction has a rate constant of $1.35 \times 10^2 s^{-1}$ at 25°C. What is the magnitude of k at 75°C if E_a = 85.6 kJ/mol?
A) 3.47×10^4
B) 1.93×10^4
C) 670
D) 3.85×10^6
E) 1.36×10^2
Answer: B
Diff: 4   Page Ref: Sec. 14.5

Chemistry, 11e (Brown)
Chapter 15: Chemical Equilibrium

Multiple-Choice and Bimodal

1) The value of K_{eq} for the equilibrium

$$H_2\,(g) + I_2\,(g) \rightleftharpoons 2\,HI\,(g)$$

is 794 at 25 °C. What is the value of K_{eq} for the equilibrium below?

$$1/2\,H_2\,(g) + 1/2\,I_2\,(g) \rightleftharpoons HI\,(g)$$

A) 397
B) 0.035
C) 28
D) 1588
E) 0.0013
Answer: C
Diff: 3 Page Ref: Sec. 15.3

2) The value of K_{eq} for the equilibrium

$$H_2\,(g) + I_2\,(g) \rightleftharpoons 2\,HI\,(g)$$

is 794 at 25 °C. At this temperature, what is the value of K_{eq} for the equilibrium below?

$$HI\,(g) \rightleftharpoons 1/2\,H_2\,(g) + 1/2\,I_2\,(g)$$

A) 1588
B) 28
C) 397
D) 0.035
E) 0.0013
Answer: D
Diff: 3 Page Ref: Sec. 15.3

3) The value of K_{eq} for the equilibrium

$$H_2\,(g) + I_2\,(g) \rightleftharpoons 2\,HI\,(g)$$

is 54.0 at 427 °C. What is the value of K_{eq} for the equilibrium below?

$$HI\,(g) \rightleftharpoons 1/2\,H_2\,(g) + 1/2\,I_2\,(g)$$

A) 27
B) 7.35
C) 0.136
D) 2.92×10^{3}
E) 3.43×10^{-4}
Answer: C
Diff: 3 Page Ref: Sec. 15.3

4) Consider the following chemical reaction:

$$H_2\,(g) + I_2\,(g) \rightleftharpoons 2HI\,(g)$$

At equilibrium in a particular experiment, the concentrations of H_2, I_2, and HI were 0.15 M, 0.033 M, and 0.55 M respectively. The value of K_{eq} for this reaction is __________.

A) 23
B) 111
C) 9.0×10^{-3}
D) 6.1
E) 61
Answer: E
Diff: 3 Page Ref: Sec. 15.5

5) A reaction vessel is charged with hydrogen iodide, which partially decomposes to molecular hydrogen and iodine:

$$2HI\,(g) \rightleftharpoons H_2(g) + I_2(g)$$

When the system comes to equilibrium at 425 °C, P_{HI} = 0.708 atm, and $PH_2 = PI_2 = 0.0960$ atm. The value of K_p at this temperature is __________.

A) 6.80×10^{-2}
B) 1.30×10^{-2}
C) K_p cannot be calculated for this gas reaction when the volume of the reaction vessel is not given.
D) 54.3
E) 1.84×10^{-2}
Answer: E
Diff: 3 Page Ref: Sec. 15.5

6) Acetic acid is a weak acid that dissociates into the acetate ion and a proton in aqueous solution:

$$HC_2H_3O_2\,(aq) \rightleftharpoons C_2H_3O_2^-\,(aq) + H^+\,(aq)$$

At equilibrium at 25 °C a 0.100 M solution of acetic acid has the following concentrations: $[HC_2H_3O_2] = 0.0990$ M, $[C_2H_3O_2^-] = 1.33 \times 10^{-3}$ M and $[H^+] = 1.33 \times 10^{-3}$ M. The equilibrium constant, K_{eq}, for the ionization of acetic acid at 25 °C is __________.

A) 5.71×10^{4}
B) 0.100
C) 1.75×10^{-7}
D) 1.79×10^{-5}
E) 5.71×10^{6}
Answer: D
Diff: 3 Page Ref: Sec. 15.5

7) At elevated temperatures, molecular hydrogen and molecular bromine react to partially form hydrogen bromide:

$$H_2\,(g) + Br_2\,(g) \rightleftharpoons 2HBr\,(g)$$

A mixture of 0.682 mol of H_2 and 0.440 mol of Br_2 is combined in a reaction vessel with a volume of 2.00 L. At equilibrium at 700 K, there are 0.566 mol of H_2 present. At equilibrium, there are __________ mol of Br_2 present in the reaction vessel.
A) 0.000
B) 0.440
C) 0.566
D) 0.232
E) 0.324
Answer: E
Diff: 4 Page Ref: Sec. 15.5

8) Dinitrogentetraoxide partially decomposes according to the following equilibrium:

$$N_2O_4\,(g) \rightleftharpoons 2NO_2\,(g)$$

A 1.00-L flask is charged with 0.400 mol of N_2O_4. At equilibrium at 373 K, 0.0055 mol of N_2O_4 remains. K_{eq} for this reaction is __________.
A) 2.2×10^{-4}
B) 13
C) 0.22
D) 0.022
E) 0.87
Answer: E
Diff: 3 Page Ref: Sec. 15.5

9) At 200 °C, the equilibrium constant (K_p) for the reaction below is 2.40×10^3.

$$2NO\,(g) \rightleftharpoons N_2\,(g) + O_2\,(g)$$

A closed vessel is charged with 36.1 atm of NO. At equilibrium, the partial pressure of O_2 is __________ atm.
A) 294
B) 35.7
C) 18.1
D) 6.00
E) 1.50×10^{-2}
Answer: C
Diff: 3 Page Ref: Sec. 15.5

10) At 22 °C, K_p = 0.070 for the equilibrium:

$$NH_4HS\ (s) \rightleftharpoons NH_3\ (g) + H_2S\ (g)$$

A sample of solid NH_4HS is placed in a closed vessel and allowed to equilibrate. Calculate the equilibrium partial pressure (atm) of ammonia, assuming that some solid NH_4HS remains.
A) 0.26
B) 0.070
C) 0.52
D) 4.9×10^{-3}
E) 3.8
Answer: A
Diff: 4 Page Ref: Sec. 15.5

11) In the coal-gasification process, carbon monoxide is converted to carbon dioxide via the following reaction:

$$CO\ (g) + H_2O\ (g) \rightleftharpoons CO_2\ (g) + H_2\ (g)$$

In an experiment, 0.35 mol of CO and 0.40 mol of H_2O were placed in a 1.00-L reaction vessel. At equilibrium, there were 0.19 mol of CO remaining. K_{eq} at the temperature of the experiment is __________.
A) 5.47
B) 0.75
C) 1.78
D) 0.56
E) 1.0
Answer: D
Diff: 4 Page Ref: Sec. 15.5

12) A sealed 1.0 L flask is charged with 0.500 mol of I_2 and 0.500 mol of Br_2. An equilibrium reaction ensues:

$$I_2\ (g) + Br_2\ (g) \rightleftharpoons 2IBr\ (g)$$

When the container contents achieve equilibrium, the flask contains 0.84 mol of IBr. The value of K_{eq} is __________.
A) 11
B) 4.0
C) 110
D) 6.1
E) 2.8
Answer: C
Diff: 3 Page Ref: Sec. 15.5

13) The equilibrium constant (K_p) for the interconversion of PCl_5 and PCl_3 is 0.0121:

$$PCl_5\ (g) \rightleftharpoons PCl_3\ (g) + Cl_2\ (g)$$

A vessel is charged with PCl_5, giving an initial pressure of 0.123 atm. At equilibrium, the partial pressure of PCl_3 is __________ atm.
A) 0.078
B) 0.045
C) 0.090
D) 0.033
E) 0.123
Answer: D
Diff: 4 Page Ref: Sec. 15.5

14) K_p = 0.0198 at 721 K for the reaction

$$2HI\ (g) \rightleftharpoons H_2\ (g) + I_2\ (g)$$

In a particular experiment, the partial pressures of H_2 and I_2 at equilibrium are 0.710 and 0.888 atm, respectively. The partial pressure of HI is __________ atm.
A) 7.87
B) 1.98
C) 5.64
D) 0.125
E) 0.389
Answer: C
Diff: 4 Page Ref: Sec. 15.5

Multiple-Choice

15) At equilibrium, __________.
A) all chemical reactions have ceased
B) the rates of the forward and reverse reactions are equal
C) the rate constants of the forward and reverse reactions are equal
D) the value of the equilibrium constant is 1
E) the limiting reagent has been consumed
Answer: B
Diff: 1 Page Ref: Sec. 15.1

16) What role did Karl Bosch play in development of the Haber-Bosch process?
A) He discovered the reaction conditions necessary for formation of ammonia.
B) He originally isolated ammonia from camel dung and found a method for purifying it.
C) Haber was working in his lab with his instructor at the time he worked out the process.
D) He developed the equipment necessary for industrial production of ammonia.
E) He was the German industrialist who financed the research done by Haber.
Answer: D
Diff: 1 Page Ref: Sec. 15.2

17) In what year was Fritz Haber awarded the Nobel Prize in chemistry for his development of a process for synthesizing ammonia directly from nitrogen and hydrogen?
A) 1954
B) 1933
C) 1918
D) 1900
E) 1912
Answer: C
Diff: 1 Page Ref: Sec. 15.2

18) Which one of the following is true concerning the Haber process?
A) It is a process used for shifting equilibrium positions to the right for more economical chemical synthesis of a variety of substances.
B) It is a process used for the synthesis of ammonia.
C) It is another way of stating LeChatelier's principle.
D) It is an industrial synthesis of sodium chloride that was discovered by Karl Haber.
E) It is a process for the synthesis of elemental chlorine.
Answer: B
Diff: 2 Page Ref: Sec. 15.2

19) Which one of the following will change the value of an equilibrium constant?
A) changing temperature
B) adding other substances that do not react with any of the species involved in the equilibrium
C) varying the initial concentrations of reactants
D) varying the initial concentrations of products
E) changing the volume of the reaction vessel
Answer: A
Diff: 2 Page Ref: Sec. 15.2

20) The equilibrium-constant expression depends on the __________ of the reaction.
A) stoichiometry
B) mechanism
C) stoichiometry and mechanism
D) the quantities of reactants and products initially present
E) temperature
Answer: A
Diff: 2 Page Ref: Sec. 15.2

21) The relationship between the rate constants for the forward and reverse reactions and the equilibrium constant for the process is K_{eq} = __________.
A) $k_f k_r$
B) $k_f - k_r$
C) $k_f + k_r$
D) k_f / k_r
E) k_r / k_f
Answer: D
Diff: 3 Page Ref: Sec. 15.3

22) The equilibrium constant for the gas phase reaction

$$N_2 (g) + 3H_2 (g) \rightleftharpoons 2NH_3 (g)$$

is $K_{eq} = 4.34 \times 10^{-3}$ at 300 °C. At equilibrium, __________.

A) products predominate
B) reactants predominate
C) roughly equal amounts of products and reactants are present
D) only products are present
E) only reactants are present
Answer: B
Diff: 1 Page Ref: Sec. 15.3

23) The equilibrium constant for the gas phase reaction

$$2NH_3 (g) \rightleftharpoons N_2 (g) + 3H_2 (g)$$

is $K_{eq} = 230$ at 300 °C. At equilibrium, __________.

A) products predominate
B) reactants predominate
C) roughly equal amounts of products and reactants are present
D) only products are present
E) only reactants are present
Answer: A
Diff: 1 Page Ref: Sec. 15.3

24) The equilibrium constant for reaction 1 is K. The equilibrium constant for reaction 2 is __________.

(1) $SO_2 (g) + (1/2) O_2 (g) \rightleftharpoons SO_3 (g)$
(2) $2SO_3 (g) \rightleftharpoons 2SO_2 (g) + O_2 (g)$

A) K^2
B) 2K
C) 1/2K
D) $1/K^2$
E) $-K^2$
Answer: D
Diff: 4 Page Ref: Sec. 15.3

25) The value of K_{eq} for the following reaction is 0.25:

$$SO_2\,(g) + NO_2\,(g) \rightleftharpoons SO_3\,(g) + NO\,(g)$$

The value of K_{eq} at the same temperature for the reaction below is __________.

$$2SO_2\,(g) + 2NO_2\,(g) \rightleftharpoons 2SO_3\,(g) + 2NO\,(g)$$

A) 0.50
B) 0.062
C) 0.12
D) 0.25
E) 16
Answer: B
Diff: 2 Page Ref: Sec. 15.3

26) Which of the following expressions is the correct equilibrium-constant expression for the equilibrium between dinitrogen tetroxide and nitrogen dioxide?

$$N_2O_4\,(g) \rightleftharpoons 2NO_2\,(g)$$

A) $-\dfrac{[NO_2]}{[N_2O_4]}$
B) $\dfrac{[NO_2]^2}{[N_2O_4]}$
C) $\dfrac{[NO_2]}{[N_2O_4]^2}$
D) $[NO_2][N_2O_4]$
E) $[NO_2]^2[N_2O_4]$
Answer: B
Diff: 2 Page Ref: Sec. 15.3

27) The equilibrium expression for K_p for the reaction below is __________.

$$2O_3\ (g) \rightleftharpoons 3O_2\ (g)$$

A) $\frac{3Po_2}{2Po_3}$

B) $\frac{2Po_3}{3Po_2}$

C) $\frac{3Po_3}{2Po_2}$

D) $\frac{{Po_3}^2}{{Po_2}^2}$

E) $\frac{{Po_2}^3}{{Po_3}^2}$

Answer: E
Diff: 3 Page Ref: Sec. 15.3

28) The K_{eq} for the equilibrium below is 7.52×10^{-2} at 480 °C.

$$2Cl_2\ (g) + 2H2O\ (g) \rightleftharpoons 4HCl\ (g) + O_2\ (g)$$

What is the value of K_{eq} at this temperature for the following reaction?

$$Cl_2\ (g) + H_2O\ (g) \rightleftharpoons 2HCl\ (g) + \frac{1}{2}O_2\ (g)$$

A) 0.0752
B) 5.66×10^{-3}
C) 0.274
D) 0.0376
E) 0.150
Answer: C
Diff: 2 Page Ref: Sec. 15.3

29) The K_{eq} for the equilibrium below is 7.52×10^{-2} at 480 °C.

$$2Cl_2\,(g) + 2H_2O\,(g) \rightleftharpoons 4HCl\,(g) + O_2\,(g)$$

What is the value of K_{eq} at this temperature for the following reaction?

$$4HCl\,(g) + O_2\,(g) \rightleftharpoons 2Cl_2\,(g) + 2H_2O\,(g)$$

A) 0.0752
B) -0.0752
C) 13.3
D) 5.66×10^{-3}
E) 0.150
Answer: C
Diff: 2 Page Ref: Sec. 15.3

30) The K_{eq} for the equilibrium below is 7.52×10^{-2} at 480 °C.

$$2Cl_2\,(g) + 2H_2O\,(g) \rightleftharpoons 4HCl\,(g) + O_2\,(g)$$

What is the value of K_{eq} at this temperature for the following reaction?

$$2HCl\,(g) + \frac{1}{2}O_2\,(g) \rightleftharpoons Cl_2\,(g) + H_2O\,(g)$$

A) 13.3
B) 3.65
C) -0.0376
D) 5.66×10^{-3}
E) 0.274
Answer: B
Diff: 2 Page Ref: Sec. 15.3

31) The K_{eq} for the equilibrium below is 0.112 at 700 °C.

$$SO_2\,(g) + \frac{1}{2}O_2\,(g) \rightleftharpoons SO_3\,(g)$$

What is the value of K_{eq} at this temperature for the following reaction?

$$2SO_2\,(g) + O_2\,(g) \rightleftharpoons 2SO_3\,(g)$$

A) 0.224
B) 0.335
C) 0.0125
D) 0.0560
E) 0.112
Answer: C
Diff: 2 Page Ref: Sec. 15.3

32) The K_{eq} for the equilibrium below is 0.112 at 700 °C.

$$SO_2\,(g) + \frac{1}{2}O_2\,(g) \rightleftharpoons SO_3\,(g)$$

What is the value of K_{eq} at this temperature for the following reaction?

$$SO_3\,(g) \rightleftharpoons SO_2\,(g) + \frac{1}{2}O_2\,(g)$$

A) 0.224
B) 0.0125
C) 0.112
D) 8.93
E) -0.112
Answer: D
Diff: 2 Page Ref: Sec. 15.3

33) The K_{eq} for the equilibrium below is 0.112 at 700 °C.

$$SO_2\,(g) + \frac{1}{2}O_2\,(g) \rightleftharpoons SO_3\,(g)$$

What is the value of K_{eq} at this temperature for the following reaction?

$$2SO_3\,(g) \rightleftharpoons 2SO_2\,(g) + O2\,(g)$$

A) 79.7
B) 2.99
C) 17.86
D) 4.46
E) 8.93
Answer: A
Diff: 2 Page Ref: Sec. 15.3

34) At 1000 K, the equilibrium constant for the reaction

$$2NO\,(g) + Br_2\,(g) \rightleftharpoons 2NOBr\,(g)$$

is K_p = 0.013. Calculate K_p for the reverse reaction,

$$2NOBr\,(g) \rightleftharpoons 2NO\,(g) + Br_2\,(g).$$

A) 0.013
B) 1.6×10^{-4}
C) 77
D) 0.99
E) 1.1
Answer: C
Diff: 2 Page Ref: Sec. 15.3

35) Consider the following equilibrium.

$$2\ SO_2\ (g) + O_2\ (g) \rightleftharpoons 2\ SO_3\ (g)$$

The equilibrium cannot be established when __________ is/are placed in a 1.0-L container.
A) 0.25 mol SO_2 (g) and 0.25 mol O_2 (g)
B) 0.75 mol SO_2 (g)
C) 0.25 mol of SO_2 (g) and 0.25 mol of SO_3 (g)
D) 0.50 mol O_2 (g) and 0.50 mol SO_3 (g)
E) 1.0 mol SO_3 (g)
Answer: B
Diff: 3 Page Ref: Sec. 15.3

36) The expression for K_p for the reaction below is __________.

$$4CuO\ (s) + CH_4\ (g) \rightleftharpoons CO_2\ (g) + 4Cu\ (s) + 2\ H_2O\ (g)$$

A) $\dfrac{P_{CH_4}}{P_{CO_2} P_{H_2}{}^2}$
B) $\dfrac{[Cu] P_{CO_2} P_{H_2O}{}^2}{[CuO]^4 P_{CH_4}}$
C) $\dfrac{P_{CO_2} P_{H_2O}{}^2}{P_{CH_4}}$
D) $\dfrac{P_{CO_2} P_{H_2O}{}^2}{P_{CuO}}$
E) $\dfrac{P_{CH_4}}{P_{H_2O}{}^2 P_{CO_2}}$
Answer: C
Diff: 2 Page Ref: Sec. 15.3

37) The equilibrium-constant expression for the reaction

$$Ti\ (s) + 2Cl_2\ (g) \rightleftharpoons TiCl_4\ (l)$$

is given by

A) $\dfrac{[TiCl_4(l)]}{[Ti(s)][Cl_2(g)]}$

B) $\dfrac{[Ti\ (s)][Cl_2(g)]^2}{[TiCl4(l)]}$

C) $\dfrac{[TiCl_4(l)]}{[Cl_2(g)]^2}$

D) $[Cl_2\ (g)]^{-2}$

E) $\dfrac{[TiCl_4(l)]}{[Ti(s)][Cl_2(g)]^2}$

Answer: D
Diff: 2 Page Ref: Sec. 15.3

38) At 400 K, the equilibrium constant for the reaction

$$Br_2\ (g) + Cl_2\ (g) \rightleftharpoons 2BrCl\ (g)$$

is $K_p = 7.0$. A closed vessel at 400 K is charged with 1.00 atm of Br_2 (g), 1.00 atm of Cl_2 (g), and 2.00 atm of BrCl (g). Use Q to determine which of the statements below is true.
A) The equilibrium partial pressures of Br_2, Cl_2, and BrCl will be the same as the initial values.
B) The equilibrium partial pressure of Br_2 will be greater than 1.00 atm.
C) At equilibrium, the total pressure in the vessel will be less than the initial total pressure.
D) The equilibrium partial pressure of BrCl (g) will be greater than 2.00 atm.
E) The reaction will go to completion since there are equal amounts of Br_2 and Cl_2.
Answer: D
Diff: 3 Page Ref: Sec. 15.6

39) How does the reaction quotient of a reaction (Q) differ from the equilibrium constant (K_{eq}) of the same reaction?
A) Q does not change with temperature.
B) K_{eq} does not change with temperature, whereas Q is temperature dependent.
C) K does not depend on the concentrations or partial pressures of reaction components.
D) Q does not depend on the concentrations or partial pressures of reaction components.
E) Q is the same as K_{eq} when a reaction is at equilibrium.
Answer: E
Diff: 3 Page Ref: Sec. 15.6

40) How is the reaction quotient used to determine whether a system is at equilibrium?
A) The reaction quotient must be satisfied for equilibrium to be achieved.
B) At equilibrium, the reaction quotient is undefined.
C) The reaction is at equilibrium when $Q < K_{eq}$.
D) The reaction is at equilibrium when $Q > K_{eq}$.
E) The reaction is at equilibrium when $Q = K_{eq}$.
Answer: E
Diff: 3 Page Ref: Sec. 15.6

41) Nitrosyl bromide decomposes according to the following equation.

$$2NOBr\ (g) \rightleftharpoons 2NO\ (g) + Br_2\ (g)$$

A sample of NOBr (0.64 mol) was placed in a 1.00-L flask containing no NO or Br_2. At equilibrium the flask contained 0.46 mol of NOBr. How many moles of NO and Br_2, respectively, are in the flask at equilibrium?

A) 0.18, 0.18
B) 0.46, 0.23
C) 0.18, 0.090
D) 0.18, 0.360
E) 0.46, 0.46
Answer: C
Diff: 4 Page Ref: Sec. 15.6

42) Of the following equilibria, only __________ will shift to the left in response to a decrease in volume.
A) $H_2\ (g) + Cl_2\ (g) \rightleftharpoons 2\ HCl\ (g)$
B) $2\ SO_3\ (g) \rightleftharpoons 2\ SO_2\ (g) + O_2\ (g)$
C) $N_2\ (g) + 3\ H_2\ (g) \rightleftharpoons 2\ NH_3\ (g)$
D) $4\ Fe\ (s) + 3\ O_2\ (g) \rightleftharpoons 2\ Fe_2O_3\ (s)$
E) $2HI\ (g) \rightleftharpoons H_2\ (g) + I_2\ (g)$
Answer: B
Diff: 3 Page Ref: Sec. 15.6

43) The reaction below is exothermic:

$$2SO_2\ (g) + O_2\ (g) \rightleftharpoons 2SO_3\ (g)$$

Le Chätelier's Principle predicts that __________ will result in an increase in the number of moles of SO_3 (g) in the reaction container.
A) increasing the pressure
B) decreasing the pressure
C) increasing the temperature
D) removing some oxygen
E) increasing the volume of the container
Answer: A
Diff: 3 Page Ref: Sec. 15.7

44) For the endothermic reaction

$$CaCO_3\ (s) \rightleftharpoons CaO\ (s) + CO_2\ (g)$$

Le Chätelier's principle predicts that __________ will result in an increase in the number of moles of CO_2.
A) increasing the temperature
B) decreasing the temperature
C) increasing the pressure
D) removing some of the $CaCO_3$ (s)
E) adding more $CaCO_3$ (s)
Answer: A
Diff: 3 Page Ref: Sec. 15.7

45) In which of the following reactions would increasing pressure at constant temperature not change the concentrations of reactants and products, based on Le Chätelier's principle?
A) N_2 (g) + 3 H_2 (g) $\rightleftharpoons$ 2NH_3 (g)
B) N_2O_4 (g) $\rightleftharpoons$ 2NO_2 (g)
C) N_2 (g) + 2O_2 (g) $\rightleftharpoons$ 2NO_2 (g)
D) 2N_2 (g) + O_2 (g) $\rightleftharpoons$ 2 N_2O (g)
E) N_2 (g) + O_2 (g) $\rightleftharpoons$ 2NO (g)
Answer: E
Diff: 4 Page Ref: Sec. 15.7

46) Consider the following reaction at equilibrium:

$$2NH_3 (g) \rightleftharpoons N_2 (g) + 3H_2 (g) \qquad \Delta H° = +92.4 \text{ kJ}$$

Le Chätelier's principle predicts that adding N_2 (g) to the system at equilibrium will result in __________.
A) a decrease in the concentration of NH_3 (g)
B) a decrease in the concentration of H_2 (g)
C) an increase in the value of the equilibrium constant
D) a lower partial pressure of N_2
E) removal of all of the H_2 (g)
Answer: B
Diff: 3 Page Ref: Sec. 15.7

47) Consider the following reaction at equilibrium:

$$2NH_3 (g) \rightleftharpoons N_2 (g) + 3H_2 (g)$$

Le Chätelier's principle predicts that the moles of H_2 in the reaction container will increase with __________
A) some removal of NH_3 from the reaction vessel (V and T constant)
B) a decrease in the total pressure (T constant)
C) addition of some N_2 to the reaction vessel (V and T constant)
D) a decrease in the total volume of the reaction vessel (T constant)
E) an increase in total pressure by the addition of helium gas (V and T constant)
Answer: B
Diff: 3 Page Ref: Sec. 15.7

48) Consider the following reaction at equilibrium:

$$2CO_2 (g) \rightleftharpoons 2CO (g) + O_2 (g) \qquad \Delta H° = -514 \text{ kJ}$$

Le Chätelier's principle predicts that adding O_2 (g) to the reaction container will __________.
A) increase the partial pressure of CO (g) at equilibrium
B) decrease the partial pressure of CO_2 (g) at equilibrium
C) increase the value of the equilibrium constant
D) increase the partial pressure of CO_2 (g) at equilibrium
E) decrease the value of the equilibrium constant
Answer: D
Diff: 3 Page Ref: Sec. 15.7

49) Consider the following reaction at equilibrium:

$$2CO_2\,(g) \rightleftharpoons 2CO\,(g) + O_2\,(g) \qquad \Delta H° = -514\ kJ$$

Le Chätelier's principle predicts that an increase in temperature will __________.
A) increase the partial pressure of O_2 (g)
B) decrease the partial pressure of CO_2 (g)
C) decrease the value of the equilibrium constant
D) increase the value of the equilibrium constant
E) increase the partial pressure of CO
Answer: C
Diff: 3 Page Ref: Sec. 15.7

50) Consider the following reaction at equilibrium.

$$2CO_2\,(g) \rightleftharpoons 2CO\,(g) + O_2\,(g) \qquad \Delta H° = -514\ kJ$$

Le Chätelier's principle predicts that the equilibrium partial pressure of CO (g) can be maximized by carrying out the reaction __________.
A) at high temperature and high pressure
B) at high temperature and low pressure
C) at low temperature and low pressure
D) at low temperature and high pressure
E) in the presence of solid carbon
Answer: C
Diff: 3 Page Ref: Sec. 15.7

51) Consider the following reaction at equilibrium:

$$2SO_2\,(g) + O_2\,(g) \rightleftharpoons 2SO_3\,(g) \qquad \Delta H° = -99\ kJ$$

Le Chätelier's principle predicts that an increase in temperature will result in __________.
A) a decrease in the partial pressure of SO_3
B) a decrease in the partial pressure of SO_2
C) an increase in K_{eq}
D) no changes in equilibrium partial pressures
E) the partial pressure of O_2 will decrease
Answer: A
Diff: 3 Page Ref: Sec. 15.7

52) The effect of a catalyst on an equilibrium is to __________.
A) increase the rate of the forward reaction only
B) increase the equilibrium constant so that products are favored
C) slow the reverse reaction only
D) increase the rate at which equilibrium is achieved without changing the composition of the equilibrium mixture
E) shift the equilibrium to the right
Answer: D
Diff: 3 Page Ref: Sec. 15.7

Short Answer

1) The equilibrium-constant expression for a reaction written in one direction is the __________ of the one for the reaction written for the reverse direction.
Answer: reciprocal
Diff: 1 Page Ref: Sec. 15.3

2) Pure __________ and pure __________ are excluded from equilibrium-constant expressions.
Answer: solids, liquids
Diff: 1 Page Ref: Sec. 15.4

3) Exactly 3.5 moles if N_2O_4 is placed in an empty 2.0-L container and allowed to reach equilibrium described by the equation

$$N_2O_4\,(g) \rightleftharpoons 2NO_2\,(g)$$

If at equilibrium the N_2O_4 is 25% dissociated, what is the value of the equilibrium constant for the reaction?
Answer: 0.58
Diff: 4 Page Ref: Sec. 15.5

4) The number obtained by substituting starting reactant and product concentrations into an equilibrium-constant expression is known as the __________.
Answer: reaction quotient
Diff: 2 Page Ref: Sec. 15.6

5) If the value for the equilibrium constant is much greater than 1, then the equilibrium mixture contains mostly __________.
Answer: products
Diff: 2 Page Ref: Sec. 15.3

True/False

1) The relationship between the concentrations of reactants and products of a system at equilibrium is given by the law of mass action.
Answer: TRUE
Diff: 2 Page Ref: Sec. 15.2

2) The effect of a catalyst on a chemical reaction is to react with product, effectively removing it and shifting the equilibrium to the right.
Answer: FALSE
Diff: 2 Page Ref: Sec. 15.7

3) At constant temperature, reducing the volume of a gaseous equilibrium mixture causes the reaction to shift in the direction that increases the number of moles of gas in the system.
Answer: FALSE
Diff: 2 Page Ref: Sec. 15.7

4) In an exothermic equilibrium reaction, increasing the reaction temperature favors the formation of reactants.
Answer: TRUE
Diff: 3 Page Ref: Sec. 15.7

5) Le Chatelier's principle states that if a system at equilibrium is disturbed, the equilibrium will shift to minimize the disturbance.
Answer: TRUE
Diff: 2 Page Ref: Sec. 15.7

Algorithmic Questions

1) Phosphorous trichloride and phosphorous pentachloride equilibrate in the presence of molecular chlorine according to the reaction:

$$PCl_3\ (g) + Cl_2\ (g) \rightarrow PCl_5\ (g)$$

An equilibrium mixture at 450 K contains
P_{PCl_3} = 0.202 atm,
P_{Cl_2} = 0.256 atm, and
P_{PCl_5} = 3.45 atm. What is the value of K_p at this temperature?
A) 66.8
B) 1.50×10^{-2}
C) 1.78×10^{-1}
D) 2.99
E) 7.54
Answer: A
Diff: 4 Page Ref: Sec. 15.5

2) Dinitrogentetraoxide partially decomposes according to the following equilibrium:

$$N_2O_4\ (g) \rightarrow 2NO_2\ (g)$$

A 1.000-L flask is charged with 3.00×10^{-2} mol of N_2O_4. At equilibrium, 2.36×10^{-2} mol of N_2O_4 remains. K_{eq} for this reaction is __________.
A) 0.723
B) 0.391
C) 0.212
D) 6.93×10^{-3}
E) 1.92×10^{-4}
Answer: D
Diff: 4 Page Ref: Sec. 15.5

3) The K_p for the reaction below is 1.49×10^{8} at 100 °C:

$$CO\ (g) + Cl_2\ (g) \rightarrow COCl_2\ (g)$$

In an equilibrium mixture of the three gases, $P_{CO} = P_{Cl_2} = 8.60 \times 10^{-4}$ atm. The partial pressure of the product, phosgene $(COCl_2)$, is __________ atm.
A) 1.10×10^{2}
B) 2.01×10^{14}
C) 4.96×10^{-15}
D) 1.28×10^{5}
E) 1.72×10^{11}
Answer: A
Diff: 4 Page Ref: Sec. 15.5

4) At 900 K, the equilibrium constant (K_p) for the following reaction is 0.345.

$$2SO_2 + O_2\ (g) \rightarrow 2SO_3\ (g)$$

At equilibrium, the partial pressure of SO_2 is 35.0 atm and that of O_2 is 15.9 atm. The partial pressure of SO_3 is __________ atm.
A) 82.0
B) 4.21×10^{-3}
C) 192
D) 6.20×10^{-4}
E) 40.2
Answer: A
Diff: 3 Page Ref: Sec. 15.5

5) The equilibrium constant (K_p) for the reaction below is 7.00×10^{-2} at 22 °C:

$$NH_4HS\ (s) \rightarrow NH_3\ (g) + H_2S\ (g)$$

A sample of NH_4HS is placed in an evacuated container and allowed to come to equilibrium. The partial pressure of NH_3 is then increased by the addition of 0.590 atm of NH_3. The partial pressure of H_2S at equilibrium is now __________ atm.
A) 0.691
B) 0.101
C) 0.855
D) 0.265
E) 0.119
Answer: B
Diff: 4 Page Ref: Sec. 15.5

Chemistry, 11e (Brown)
Chapter 16: Acid-Base Equilibria

Multiple-Choice and Bimodal

1) What is the conjugate acid of NH_3?
A) NH_3
B) NH_2^+
C) NH_3^+
D) NH_4^+
E) NH_4OH
Answer: D
Diff: 2 Page Ref: Sec. 16.2

2) The conjugate base of HSO_4^- is
A) OH^-
B) H_2SO_4
C) SO_4^{2-}
D) HSO_4^+
E) $H_3SO_4^+$
Answer: C
Diff: 2 Page Ref: Sec. 16.2

3) The conjugate acid of HSO_4^- is
A) SO_4^{2-}
B) H_2SO_4
C) HSO_4^+
D) H^+
E) HSO_3^+
Answer: B
Diff: 2 Page Ref: Sec. 16.2

4) What is the conjugate base of OH^-?
A) O_2
B) O^-
C) H_2O
D) O^{2-}
E) H_2O^+
Answer: D
Diff: 2 Page Ref: Sec. 16.2

5) What is the pH of an aqueous solution at 25.0 °C in which $[H^+]$ is 0.00250 M?
A) 3.40
B) 2.60
C) -2.60
D) -3.40
E) 2.25
Answer: B
Diff: 2 Page Ref: Sec. 16.4

6) What is the pH of an aqueous solution at 25.0 °C in which $[OH^-]$ is 0.00250 M?
A) +2.60
B) -2.60
C) +11.4
D) -11.4
E) -2.25
Answer: C
Diff: 2 Page Ref: Sec. 16.4

7) What is the pH of an aqueous solution at 25.0 °C that contains 3.98×10^{-9} M hydronium ion?
A) 8.40
B) 5.60
C) 9.00
D) 3.98
E) 7.00
Answer: A
Diff: 2 Page Ref: Sec. 16.4

8) What is the pH of an aqueous solution at 25.0 °C that contains 3.98×10^{-9} M hydroxide ion?
A) 8.40
B) 5.60
C) 9.00
D) 3.98
E) 7.00
Answer: B
Diff: 2 Page Ref: Sec. 16.4

9) What is the concentration (in M) of hydronium ions in a solution at 25.0 °C with pH = 4.282?
A) 4.28
B) 9.71
C) 1.92×10^{-10}
D) 5.22×10^{-5}
E) 1.66×10^{4}
Answer: D
Diff: 2 Page Ref: Sec. 16.4

10) What is the concentration (in M) of hydroxide ions in a solution at 25.0 °C with pH = 4.282?
A) 4.28
B) 9.72
C) 1.92×10^{-10}
D) 5.22×10^{-5}
E) 1.66×10^{4}
Answer: C
Diff: 2 Page Ref: Sec. 16.4

11) Calculate the pOH of a solution at 25.0 °C that contains 1.94×10^{-10} M hydronium ions.
A) 1.94
B) 4.29
C) 7.00
D) 14.0
E) 9.71
Answer: B
Diff: 2 Page Ref: Sec. 16.4

12) Calculate the concentration (in M) of hydronium ions in a solution at 25.0 °C with a pOH of 4.223.

A) 5.98×10^{-5}

B) 1.67×10^{-10}

C) 1.67×10^{4}

D) 5.99×10^{-19}

E) 1.00×10^{-7}

Answer: B

Diff: 2 Page Ref: Sec. 16.4

13) What is the pH of a 0.0150 M aqueous solution of barium hydroxide?

A) 12.5

B) 12.2

C) 1.82

D) 10.4

E) 1.52

Answer: A

Diff: 3 Page Ref: Sec. 16.5

14) What is the pOH of a 0.0150 M solution of barium hydroxide?

A) 12.2

B) 12.5

C) 1.52

D) 1.82

E) 10.4

Answer: C

Diff: 2 Page Ref: Sec. 16.5

15) An aqueous solution contains 0.100 M NaOH at 25.0 °C. The pH of the solution is __________.

A) 0.100

B) 1.00

C) 13.0

D) 7.00

E) -1.00

Answer: C

Diff: 3 Page Ref: Sec. 16.5

16) HZ is a weak acid. An aqueous solution of HZ is prepared by dissolving 0.020 mol of HZ in sufficient water to yield 1.0 L of solution. The pH of the solution was 4.93 at 25.0 °C. The K_a of HZ is __________.

A) 1.2×10^{-5}

B) 6.9×10^{-9}

C) 1.4×10^{-10}

D) 9.9×10^{-2}

E) 2.8×10^{-12}

Answer: B

Diff: 4 Page Ref: Sec. 16.6

17) The pH of a 0.55 M aqueous solution of hypobromous acid, HBrO, at 25.0 °C is 4.48. What is the value of K_a for HBrO?
A) 2.0×10^{-9}
B) 1.1×10^{-9}
C) 6.0×10^{-5}
D) 3.3×10^{-5}
E) 3.0×10^{4}
Answer: A
Diff: 4 Page Ref: Sec. 16.6

18) A 0.15 M aqueous solution of the weak acid HA at 25.0 °C has a pH of 5.35. The value of K_a for HA is __________.
A) 3.0×10^{-5}
B) 1.8×10^{-5}
C) 7.1×10^{-9}
D) 1.4×10^{-10}
E) 3.3×10^{4}
Answer: D
Diff: 4 Page Ref: Sec. 16.6

19) The K_a of hypochlorous acid (HClO) is 3.00×10^{-8} at 25.0 °C. Calculate the pH of a 0.0385 M hypochlorous acid solution.
A) 1.41
B) 8.94
C) 4.47
D) 7.52
E) -1.41
Answer: C
Diff: 4 Page Ref: Sec. 16.6

20) The K_a of hypochlorous acid (HClO) is 3.00×10^{-8} What is the pH at 25.0 °C of an aqueous solution that is 0.0200 M in HClO?
A) +2.45
B) -2.45
C) -9.22
D) +9.22
E) +4.61
Answer: E
Diff: 4 Page Ref: Sec. 16.6

21) The K_a of hydrofluoric acid (HF) at 25.0 °C is 6.8×10^{-4} . What is the pH of a 0.35 M aqueous solution of HF?
A) 3.2
B) 1.8
C) 3.6
D) 0.46
E) 12
Answer: B
Diff: 3 Page Ref: Sec. 16.6

22) The K_a of hydrazoic acid (HN_3) is 1.9×10^{-5} at 25.0 °C. What is the pH of a 0.35 M aqueous solution of HN_3?
A) 11
B) 2.4
C) 5.2
D) 2.6
E) -2.4
Answer: D
Diff: 4 Page Ref: Sec. 16.6

23) The acid-dissociation constants of sulfurous acid (H_2SO_3) are $K_{a1} = 1.7 \times 10^{-2}$ and $K_{a2} = 6.4 \times 10^{-8}$ at 25.0 °C. Calculate the pH of a 0.163 M aqueous solution of sulfurous acid.
A) 4.5
B) 1.4
C) 1.8
D) 7.2
E) 1.3
Answer: B
Diff: 5 Page Ref: Sec. 16.6

24) The acid-dissociation constants of phosphoric acid (H_3PO_4) are $K_{a1} = 7.5 \times 10^{-3}$, $K_{a2} = 6.2 \times 10^{-8}$, and $K_{a3} = 4.2 \times 10^{-13}$ at 25.0 °C. What is the pH of a 2.5 M aqueous solution of phosphoric acid?
A) 1.8
B) 0.40
C) 2.5
D) 0.87
E) 0.13
Answer: D
Diff: 5 Page Ref: Sec. 16.6

25) The acid-dissociation constants of phosphoric acid (H_3PO_4) are $K_{a1} = 7.5 \times 10^{-3}$, $K_{a2} = 6.2 \times 10^{-8}$, and $K_{a3} = 4.2 \times 10^{-13}$ at 25.0°C What is the molar concentration of phosphate ion in a 2.5 M aqueous solution of phosphoric acid?
A) 2.0×10^{-19}
B) 9.1×10^{-5}
C) 0.13
D) 2.5×10^{-5}
E) 8.2×10^{-9}
Answer: A
Diff: 5 Page Ref: Sec. 16.6

26) The acid-dissociation constant for chlorous acid, $HClO_2$, at 25.0 °C is 1.0×10^{-2}. Calculate the concentration of H^+ if the initial concentration of acid is 0.10 M.
A) 1.0×10^{-3}
B) 2.7×10^{-2}
C) 3.2×10^{-2}
D) 3.7×10^{-2}
E) 1.0×10^{-2}
Answer: B
Diff: 4 Page Ref: Sec. 16.6

27) The pH of a 0.10 M solution of a weak base is 9.82. What is the K_b for this base?

A) 2.1×10^{-4}

B) 4.3×10^{-8}

C) 8.8×10^{-8}

D) 6.6×10^{-4}

E) 2.0×10^{-5}

Answer: B

Diff: 4 Page Ref: Sec. 16.7

28) Calculate the pH of a 0.500 M aqueous solution of NH_3. The K_b of NH_3 is 1.77×10^{-5}.

A) 8.95

B) 11.5

C) 2.52

D) 5.05

E) 3.01

Answer: B

Diff: 3 Page Ref: Sec. 16.7

29) Determine the pH of a 0.35 M aqueous solution of CH_3NH_2 (methylamine). The K_b of methylamine is 4.4×10^{-4}.

A) 10

B) 3.8

C) 12

D) 1.9

E) 13

Answer: C

Diff: 3 Page Ref: Sec. 16.7

30) An aqueous solution contains 0.050 M of methylamine. The concentration of hydroxide ion in this solution is ________M. K_b for methylamine is 4.4×10^{-4}.

A) 0.050

B) 2.2×10^{-5}

C) -4.9×10^{-3}

D) 4.5×10^{-3}

E) 4.7×10^{-3}

Answer: D

Diff: 4 Page Ref: Sec. 16.7

31) The acid-dissociation constant, K_a, for gallic acid is 4.57×10^{-3}. What is the base-dissociation constant, K_b, for the gallate ion?

A) 4.57×10^{-3}

B) 2.19×10^{-12}

C) 5.43×10^{-5}

D) 7.81×10^{-6}

E) 2.19×10^{2}

Answer: B

Diff: 3 Page Ref: Sec. 16.8

32) The base-dissociation constant, K_b, for pyridine, C_5H_5N, is 1.4×10^{-9}. The acid-dissociation constant, K_a, for the pyridinium ion, $C_5H_5NH^+$ is __________.

A) 1.0×10^{-7}
B) 1.4×10^{-23}
C) 7.1×10^{-4}
D) 1.4×10^{-5}
E) 7.1×10^{-6}
Answer: E
Diff: 3 Page Ref: Sec. 16.8

33) The K_a for HCN is 4.9×10^{-10}. What is the value of K_b for CN^-?

A) 2.0×10^{-5}
B) 4.0×10^{-6}
C) 4.9×10^{4}
D) 4.9×10^{-24}
E) 2.0×10^{9}
Answer: A
Diff: 3 Page Ref: Sec. 16.8

34) K_a for HF is 7.0×10^{-4}. K_b for the fluoride ion is __________.

A) 2.0×10^{-8}
B) 1.4×10^{-11}
C) 7.0×10^{-18}
D) 7.0×10^{-4}
E) 1.4×10^{3}
Answer: B
Diff: 3 Page Ref: Sec. 16.8

35) Calculate the pOH of a 0.0827 M aqueous sodium cyanide solution at 25.0 °C. K_b for CN^- is 4.9×10^{-10}.

A) 9.3
B) 10
C) 5.2
D) 1.1
E) 8.8
Answer: C
Diff: 3 Page Ref: Sec. 16.9

36) Determine the pH of a 0.15 M aqueous solution of KF. For hydrofluoric acid, $K_a = 7.0 \times 10^{-4}$.

A) 12
B) 5.8
C) 8.2
D) 2.3
E) 6.6
Answer: C
Diff: 3 Page Ref: Sec. 16.9

37) Calculate the pH of 0.726 M anilinium hydrochloride ($C_6H_5NH_3Cl$) solution in water, given that K_b for aniline is 3.83×10^{-4}.
A) 1.77
B) 12.2
C) 5.36
D) 8.64
E) 12.4
Answer: C
Diff: 4 Page Ref: Sec. 16.9

38) K_b for NH_3 is 1.8×10^{-5}. What is the pH of a 0.35 M aqueous solution of NH_4Cl at 25.0 °C?
A) 9.7
B) 4.3
C) 9.1
D) 4.9
E) 11
Answer: D
Diff: 4 Page Ref: Sec. 16.9

39) The K_a for formic acid (HCO_2H) is 1.8×10^{-4}. What is the pH of a 0.35 M aqueous solution of sodium formate ($NaHCO_2$)?
A) 11
B) 5.4
C) 3.3
D) 8.6
E) 4.2
Answer: D
Diff: 4 Page Ref: Sec. 16.9

40) K_a for HCN is 4.9×10^{-10}. What is the pH of a 0.068 M aqueous solution of sodium cyanide?
A) 0.74
B) 2.9
C) 11
D) 13
E) 7.0
Answer: C
Diff: 4 Page Ref: Sec. 16.9

41) K_a for HX is 7.5×10^{-12}. What is the pH of a 0.15 M aqueous solution of NaX?
A) 7.9
B) 1.9
C) 6.0
D) 8.0
E) 12
Answer: E
Diff: 4 Page Ref: Sec. 16.9

42) The pH of a 0.15 M aqueous solution of NaZ (the sodium salt of HZ) is 10.7. What is the K_a for HZ?

A) 1.6×10^{-6}

B) 6.0×10^{-9}

C) 8.9×10^{-4}

D) 1.3×10^{-12}

E) 3.3×10^{-8}

Answer: B

Diff: 4 Page Ref: Sec. 16.9

Multiple-Choice

43) According to the Arrhenius concept, an acid is a substance that __________.

A) is capable of donating one or more H^+

B) causes an increase in the concentration of H^+ in aqueous solutions

C) can accept a pair of electrons to form a coordinate covalent bond

D) reacts with the solvent to form the cation formed by autoionization of that solvent

E) tastes bitter

Answer: B

Diff: 1 Page Ref: Sec. 16.1

44) A Br≅ nsted-Lowry base is defined as a substance that __________.

A) increases $[H^+]$ when placed in H_2O

B) decreases $[H^+]$ when placed in H_2O

C) increases $[OH^-]$ when placed in H_2O

D) acts as a proton acceptor

E) acts as a proton donor

Answer: D

Diff: 1 Page Ref: Sec. 16.2

45) A Brønsted-Lowry acid is defined as a substance that __________.

A) increases $[H^+]$ when placed in H_2O

B) decreases $[H^+]$ when placed in H_2O

C) increases $[OH^-]$ when placed in H_2O

D) acts as a proton acceptor

E) acts as a proton donor

Answer: E

Diff: 1 Page Ref: Sec. 16.2

46) A substance that is capable of acting as both an acid and as a base is __________.

A) autosomal

B) conjugated

C) amphoteric

D) saturated

E) miscible

Answer: C

Diff: 1 Page Ref: Sec. 16.2

47) The molar concentration of hydronium ion in pure water at 25°C is __________.
A) 0.00
B) 1.0×10^{-7}
C) 1.0×10^{-14}
D) 1.00
E) 7.00
Answer: B
Diff: 1   Page Ref: Sec. 16.3

48) The molar concentration of hydroxide ion in pure water at 25°C is __________.
A) 1.00
B) 0.00
C) 1.0×10^{-14}
D) 1.0×10^{-7}
E) 7.00
Answer: D
Diff: 1   Page Ref: Sec. 16.3

49) The magnitude of K_w indicates that __________.
A) water autoionizes very slowly
B) water autoionizes very quickly
C) water autoionizes only to a very small extent
D) the autoionization of water is exothermic
Answer: C
Diff: 2   Page Ref: Sec. 16.3

50) The concentration of water in pure water is approximately __________ M.
A) 18
B) 100
C) 55
D) 0.100
E) 83
Answer: C
Diff: 2   Page Ref: Sec. 16.3

51) In basic solution, __________.
A) $[H_3O^+] = [OH^-]$
B) $[H_3O^+] > [OH^-]$
C) $[H_3O^+] < [OH^-]$
D) $[H_3O^+] = 0$ M
E) $[OH^-] > 7.00$
Answer: C
Diff: 2   Page Ref: Sec. 16.3

52) Which solution below has the highest concentration of hydroxide ions?
A) pH = 3.21
B) pH = 12.6
C) pH = 7.93
D) pH = 9.82
E) pH = 7.00
Answer: B
Diff: 1 Page Ref: Sec. 16.4

53) Which one of the following statements regarding K_W is false?
A) pK_W is 14.00 at 25°C
B) The value of K_W is always 1.0×10^{-14}.
C) K_W changes with temperature.
D) The value of K_W shows that water is a weak acid.
E) K_W is known as the ion product of water.
Answer: B
Diff: 2 Page Ref: Sec. 16.4

54) The hydride ion, H^-, is a stronger base than the hydroxide ion, OH^-. The product(s) of the reaction of hydride ion with water is/ are __________.
A) H_3O^+ (aq)
B) OH^- (aq) + H_2 (g)
C) OH^- (aq) + $2H^+$ (aq)
D) no reaction occurs
E) H_2O_2 (aq)
Answer: B
Diff: 3 Page Ref: Sec. 16.5

55) An aqueous solution contains 0.10 M NaOH. The solution is __________.
A) very dilute
B) highly colored
C) basic
D) neutral
E) acidic
Answer: C
Diff: 1 Page Ref: Sec. 16.5

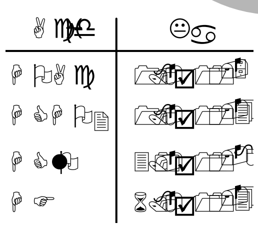
56) Nitric acid is a strong acid. This means that __________.
A) aqueous solutions of HNO_3 contain equal concentrations of H^+ (aq) and OH^- (aq)
B) HNO_3 does not dissociate at all when it is dissolved in water
C) HNO_3 dissociates completely to H^+ (aq) and NO_3^- (aq) when it dissolves in water
D) HNO_3 produces a gaseous product when it is neutralized
E) HNO_3 cannot be neutralized by a weak base
Answer: C
Diff: 2 Page Ref: Sec. 16.5

57) Of the following acids, __________ is not a strong acid.
A) HNO_2
B) H_2SO_4
C) HNO_3
D) $HClO_4$
E) HCl
Answer: A
Diff: 2 Page Ref: Sec. 16.6

58) Of the following, __________ is a weak acid.
A) HF
B) HCl
C) HBr
D) HNO_3
E) $HClO_4$
Answer: A
Diff: 2 Page Ref: Sec. 16.6

59) Which one of the following is the weakest acid?
A) HF (K_a = 6.8 × 10^{-4})
B) HClO (K_a = 3.0 × 10^{-8})
C) HNO_2 (K_a = 4.5 × 10^{-4})
D) HCN (K_a = 4.9 × 10^{-10})
E) Acetic acid (K_a = 1.8 × 10^{-5})
Answer: D
Diff: 2 Page Ref: Sec. 16.6

60) Of the acids in the table below, __________ is the strongest acid.



A) HOAc
B) $HCHO_2$
C) HClO
D) HF
E) HOAc and $HCHO_2$
Answer: D
Diff: 3 Page Ref: Sec. 16.6

61) The K_a of hypochlorous acid (HClO) is 3.0×10^{-8} at 25.0°C. What is the % ionization of hypochlorous acid in a 0.015-M aqueous solution of HClO at 25.0°C?

A) 4.5×10^{-8}
B) 14
C) 2.1×10^{-5}
D) 0.14
E) 1.4×10^{-3}
Answer: D
Diff: 4 Page Ref: Sec. 16.6

62) Which one of the following is a Brønsted-Lowry acid?

A) $(CH_3)_3NH^+$
B) CH_3COOH
C) HF
D) HNO_2
E) all of the above
Answer: E
Diff: 2 Page Ref: Sec. 16.6

63) In which of the following aqueous solutions does the weak acid exhibit the highest percentage ionization?

A) 0.01 M $HC_2H_3O_2$ ($K_a = 1.8 \times 10^{-5}$)
B) 0.01 M HNO_2 ($K_a = 4.5 \times 10^{-4}$)
C) 0.01 M HF ($K_a = 6.8 \times 10^{-4}$)
D) 0.01 M HClO ($K_a = 3.0 \times 10^{-8}$)
E) These will all exhibit the same percentage ionization.
Answer: C
Diff: 4 Page Ref: Sec. 16.6

64) Classify the following compounds as weak acids (W) or strong acids (S):

nitrous acid hydrochloric acid hydrofluoric acid

A) W W W
B) S S S
C) S W W
D) W S S
E) W S W
Answer: E
Diff: 3 Page Ref: Sec. 16.6

65) Classify the following compounds as weak acids (W) or strong acids (S):

hypochlorous acid perchloric acid chloric acid

A) W S S
B) S S S
C) S W W
D) W W W
E) W S W
Answer: A
Diff: 3 Page Ref: Sec. 16.6

66) Ammonia is a __________.
A) weak acid
B) strong base
C) weak base
D) strong acid
E) salt
Answer: C
Diff: 2 Page Ref: Sec. 16.7

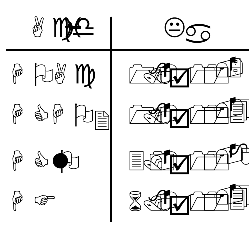
67) HA is a weak acid. Which equilibrium corresponds to the equilibrium constant K_b for A^- ?
A) HA (aq) + H_2O (l) $\rightleftharpoons$ H_2A^+ (aq) + OH^- (aq)
B) A^- (aq) + H_3O^+ (Aq) $\rightleftharpoons$ HA (aq) + H_2O (l)
C) HA (aq) + OH^- (aq) $\rightleftharpoons$ H_2O (l) + H^+ (aq)
D) A^- (aq) + H_2O (l) $\rightleftharpoons$ HA (aq) + OH^- (aq)
E) A^- (aq) + OH^- (aq) $\rightleftharpoons$ HOA^{2-} (aq)
Answer: D
Diff: 3 Page Ref: Sec. 16.7

68) Classify the following compounds as weak bases (W) or strong bases (S):

ammonia flouride ion sodium hydroxide

A) W W S
B) S S S
C) S W W
D) W S S
E) W S W
Answer: A
Diff: 2 Page Ref: Sec. 16.7

69) Using the data in the table, which of the conjugate bases below is the strongest base?



A) OAc^-
B) CHO_2^-
C) ClO^-
D) F^-
E) OAc^- and CHO_2^-
Answer: C
Diff: 2 Page Ref: Sec. 16.8

70) Which of the following ions will act as a weak base in water?

A) OH^-

B) Cl^-

C) NO_3^-

D) ClO^-

E) None of the above will act as a weak base in water.

Answer: D

Diff: 3 Page Ref: Sec. 16.9

71) Which of the following aqueous solutions has the highest $[OH^-]$?

A) a solution with a pH of 3.0

B) a 1×10^{-4} M solution of HNO_3

C) a solution with a pOH of 12.0

D) pure water

E) a 1×10^{-3} M solution of NH_4Cl

Answer: D

Diff: 3 Page Ref: Sec. 16.9

72) A 0.0035-M aqueous solution of a particular compound has pH = 2.46. The compound is __________.

A) a weak base

B) a weak acid

C) a strong acid

D) a strong base

E) a salt

Answer: C

Diff: 3 Page Ref: Sec. 16.9

73) Of the following substances, an aqueous solution of __________ will form basic solutions.

NH_4Cl $Cu(NO_3)_2$ K_2CO_3 NaF

A) NH_4Cl, $Cu(NO_3)_2$

B) K_2CO_3, NH_4Cl

C) NaF only

D) NaF, K_2CO_3

E) NH_4Cl only

Answer: D

Diff: 3 Page Ref: Sec. 16.9

74) A 0.1 M aqueous solution of __________ will have a pH of 7.0 at 25.0 °C.

NaOCl KCl NH_4Cl $Ca(OAc)_2$

A) NaOCl

B) KCl

C) NH_4Cl

D) $Ca(OAc)_2$

E) KCl and NH_4Cl

Answer: B

Diff: 4 Page Ref: Sec. 16.9

75) Of the compounds below, a 0.1 M aqueous solution of __________ will have the highest pH.
A) KCN, K_a of HCN = 4.0×10^{-10}
B) NH_4NO_3, K_b of NH_3 = 1.8×10^{-5}
C) NaOAc, K_a of HOAc = 1.8×10^{-5}
D) NaClO, K_a of HClO = 3.2×10^{-8}
E) NaHS, K_b of HS^- = 1.8×10^{-7}
Answer: A
Diff: 5 Page Ref: Sec. 16.9

76) A 0.1 M solution of __________ has a pH of 7.0.
A) Na_2S
B) KF
C) $NaNO_3$
D) NH_4Cl
E) NaF
Answer: C
Diff: 4 Page Ref: Sec. 16.9

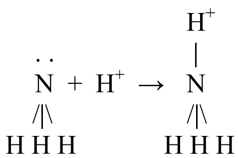
77) An aqueous solution of __________ will produce a basic solution.
A) NH_4ClO_4
B) KBr
C) NaCl
D) $NaHSO_4$
E) Na_2SO_3
Answer: E
Diff: 3 Page Ref: Sec. 16.9

78) Of the following, which is the strongest acid?
A) HIO
B) HIO_4
C) HIO_2
D) HIO_3
E) The acid strength of all of the above is the same.
Answer: B
Diff: 3 Page Ref: Sec. 16.10

79) Which of the following acids will be the strongest?
A) H_2SO_4
B) HSO_4^-
C) H_2SO_3
D) H_2SeO_4
E) HSO_3^-
Answer: A
Diff: 3 Page Ref: Sec. 16.10

80) Of the following, which is the strongest acid?
A) HClO
B) $HClO_3$
C) $HClO_2$
D) $HClO_4$
E) HIO
Answer: D
Diff: 3 Page Ref: Sec. 16.10

81) In the gas phase reaction below, NH_3 is acting as a(n) __________ base but <u>not</u> as a(n) __________ base.



A) Arrhenius, Brønsted-Lowry
B) Brønsted-Lowry, Lewis
C) Lewis, Arrhenius
D) Lewis, Brønsted-Lowry
E) Arrhenius, Lewis
Answer: C
Diff: 3 Page Ref: Sec. 16.11

Short Answer

1) A solution of acetic acid is 2.0% dissociated at 25.0 ^{o}C. What was the original concentration (in M) of the acetic acid solution? The K_a at 25.0 ^{o}C for acetic acid is 1.8×10^{-5}.
Answer: 0.045
Diff: 5 Page Ref: Sec. 16.6

2) A solution of formic acid is 3.0% dissociated at 25.0 ^{o}C. What is the original concentration (in M) of the formic acid solution? The K_a at 25.0 ^{o}C for formic acid is 1.8×10^{-4}.
Answer: 0.20
Diff: 5 Page Ref: Sec. 16.6

3) A solution of ammonia is 2.0% dissociated at 25.0 ^{o}C. What was the original concentration (in M) of the ammonia solution? The K_b at 25.0 ^{o}C for ammonia is 1.8×10^{-5}.
Answer: 0.045
Diff: 5 Page Ref: Sec. 16.7

4) What is the pH of a sodium acetate solution prepared by adding 0.820 grams of sodium acetate to 100.0 ml of water at 25.0 ^{o}C? The K_a at 25.0 ^{o}C for acetic acid is 1.8×10^{-5}.
Answer: 8.87
Diff: 5 Page Ref: Sec. 16.9

5) What is the pH of a sodium formate solution prepared by adding 0.680 grams of sodium formate to 100.0 ml of water at 25.0 ^{o}C? The K_a at 25.0 ^{o}C for formic acid is 1.8×10^{-4}.
Answer: 8.37
Diff: 5 Page Ref: Sec. 16.9

True/False

1) An acid containing the COOH group is called a carbo-oxy acid.
Answer: FALSE
Diff: 2 Page Ref: Sec. 16.10

2) In the reaction

$$BF_3 + F^- \rightarrow BF_4^-$$

BF_3 acts as a Brønsted-Lowry acid.
Answer: FALSE
Diff: 3 Page Ref: Sec. 16.11

3) The simplest amino acid is glycine.
Answer: TRUE
Diff: 1 Page Ref: Sec. 16.11

4) When the proton in the COOH group in an amino acid is transferred to the NH_2 group of that same amino acid molecule, a zwitterion is formed.
Answer: TRUE
Diff: 2 Page Ref: Sec. 16.11

5) A Lewis acid is an electron-pair acceptor, and a Lewis base is an electron-pair donor.
Answer: TRUE
Diff: 2 Page Ref: Sec. 16.11

Algorithmic Questions

1) An aqueous solution at 25.0 °C contains $[H^+]$ = 0.0990 M. What is the pH of the solution?
A) 1.00
B) -1.00
C) 13.0
D) 0.0990
E) 1.00×10^{-13}
Answer: A
Diff: 3 Page Ref: Sec. 16.4

2) The pH of an aqueous solution at 25.0 °C is 10.66. What is the molarity of H^+ in this solution?
A) 2.2×10^{-11}
B) 4.6×10^{-4}
C) 3.3
D) 1.1×10^{-13}
E) 4.6×10^{10}
Answer: A
Diff: 3 Page Ref: Sec. 16.4

3) Calculate the molarity of hydroxide ion in an aqueous solution that has a pOH of 5.33.
A) 4.7×10^{-6}
B) 8.67
C) 2.1×10^{-9}
D) 5.3×10^{-14}
E) 8.7×10^{-14}
Answer: A
Diff: 3 Page Ref: Sec. 16.4

4) A 7.0×10^{-3} M aqueous solution of $Ca(OH)_2$ at 25.0 °C has a pH of __________.
A) 12.15
B) 1.85
C) 1.4×10^{-2}
D) 7.1×10^{-13}
E) 11.85
Answer: A
Diff: 3 Page Ref: Sec. 16.5

5) The acid-dissociation constant at 25.0 °C for hypochlorous acid (HClO) is 3.0×10^{-8}. At equilibrium, the molarity of H_3O^+ in a 0.010 M solution of HClO is __________.
A) 1.7×10^{-5}
B) 0.010
C) 5.8×10^{-10}
D) 4.76
E) 2.00
Answer: A
Diff: 4 Page Ref: Sec. 16.6

6) The base-dissociation constant of ethylamine $(C_2H_5NH_2)$ is 6.4×10^{-4} at 25.0 °C. The of $[H^+]$ in a 1.6×10^{-2}M solution of ethylamine is __________ M.
A) 3.5×10^{-12}
B) 2.9×10^{-3}
C) 3.1×10^{-12}
D) 3.2×10^{-3}
E) 11.46
Answer: A
Diff: 4 Page Ref: Sec. 16.7

7) The acid-dissociation constant of hydrocyanic acid (HCN) at 25.0 °C is 4.9×10^{-10}. What is the pH of an aqueous solution of 0.080 M sodium cyanide (NaCN)?
A) 11.11
B) 2.89
C) 1.3×10^{-3}
D) 7.8×10^{-12}
E) 3.9×10^{-11}
Answer: A
Diff: 4 Page Ref: Sec. 16.9

Chemistry, 11e (Brown)
Chapter 17: Additional Aspects of Aqueous Equilibria

Multiple-Choice and Bimodal

1) The pH of a solution that contains 0.818 M acetic acid $(K_a = 1.76 \times 10^{-5})$ and 0.172 M sodium acetate is __________.
A) 4.08
B) 5.43
C) 8.57
D) 8.37
E) 9.92
Answer: A
Diff: 3 Page Ref: Sec. 17.1

2) Consider a solution containing 0.100 M fluoride ions and 0.126 M hydrogen fluoride. The concentration of fluoride ions after the addition of 5.00 mL of 0.0100 M HCl to 25.0 mL of this solution is __________ M.
A) 0.0850
B) 0.00167
C) 0.0980
D) 0.0817
E) 0.00253
Answer: D
Diff: 4 Page Ref: Sec. 17.2

3) Consider a solution containing 0.100 M fluoride ions and 0.126 M hydrogen fluoride. The concentration of hydrogen fluoride after addition of 5.00 mL of 0.0100 M HCl to 25.0 mL of this solution is __________ M.
A) 0.107
B) 0.100
C) 0.126
D) 0.00976
E) 0.00193
Answer: A
Diff: 4 Page Ref: Sec. 17.2

4) The K_a of acetic acid is 1.76×10^{-5}. The pH of a buffer prepared by combining 50.0 mL of 1.00 M potassium acetate and 50.0 mL of 1.00 M acetic acid is __________.
A) 1.70
B) 0.85
C) 3.40
D) 4.77
E) 2.38
Answer: D
Diff: 4 Page Ref: Sec. 17.2

5) The K_b of ammonia is 1.77×10^{-5}. The pH of a buffer prepared by combining 50.0 mL of 1.00 M ammonia and 50.0 mL of 1.00 M ammonium nitrate is __________.
A) 4.63
B) 9.25
C) 4.74
D) 9.37
E) 7.00
Answer: B
Diff: 4 Page Ref: Sec. 17.2

6) Calculate the pH of a solution prepared by dissolving 0.370 mol of formic acid (HCO_2H) and 0.230 mol of sodium formate ($NaCO_2H$) in water sufficient to yield 1.00 L of solution. The K_a of formic acid is 1.77×10^{-4} .
A) 2.09
B) 10.46
C) 3.54
D) 2.30
E) 3.95
Answer: C
Diff: 4   Page Ref: Sec. 17.2

7) Calculate the pH of a solution prepared by dissolving 0.750 mol of NH_3 and 0.250 mol of NH_4Cl in water sufficient to yield 1.00 L of solution. The K_b of ammonia is 1.77×10^{-4} .
A) 5.22
B) 4.27
C) 9.73
D) 8.78
E) 0.89
Answer: C
Diff: 4   Page Ref: Sec. 17.2

8) Calculate the pH of a solution prepared by dissolving 0.250 mol of benzoic acid ($C_7H_5O_2H$) and 0.150 mol of sodium benzoate ($NaC_7H_5O_2$) ($NaC_7H_5O_2H$) in water sufficient to yield 1.00 L of solution. The K_a of benzoic acid is 6.50×10^{-5} .
A) 4.41
B) 2.39
C) 3.97
D) 10.0
E) 4.19
Answer: C
Diff: 4   Page Ref: Sec. 17.2

9) Calculate the pH of a solution prepared by dissolving 0.150 mol of benzoic acid (HBz) and 0.300 mol of sodium benzoate in water sufficient to yield 1.00 L of solution. The K_a of benzoic acid is 6.50×10^{-5} .
A) 2.51
B) 3.89
C) 4.49
D) 10.1
E) 4.19
Answer: C
Diff: 4   Page Ref: Sec. 17.2

10) The pH of a solution prepared by dissolving 0.350 mol of solid methylamine hydrochloride (CH_3NH_3Cl) in 1.00 L of 1.10 M methylamine (CH_3NH_2) is __________. The K_b for methylamine is 4.40×10^{-4} .
A) 1.66
B) 2.86
C) 10.2
D) 11.1
E) 10.6
Answer: D
Diff: 4   Page Ref: Sec. 17.2

11) A 25.0 mL sample of 0.723 M $HClO_4$ is titrated with a 0.273 M KOH solution. What is the $[H^+]$ (molarity) before any base is added?
A) 0.439
B) 1.00×10^{-7}
C) 0.723
D) 2.81×10^{-13}
E) 0.273
Answer: C
Diff: 2 Page Ref: Sec. 17.3

12) A 25.0 mL sample of 0.723 M $HClO_4$ is titrated with a 0.273 M KOH solution. The H_3O^+ concentration after the addition of 10.0 mL of KOH is __________ M.
A) 0.440
B) 1.00×10^{-7}
C) 0.723
D) 2.81×10^{-13}
E) 0.273
Answer: A
Diff: 3 Page Ref: Sec. 17.3

13) A 25.0 mL sample of 0.723 M $HClO_4$ is titrated with a 0.273 M KOH solution. The H_3O^+ concentration after the addition of 66.2 mL of KOH is __________ M.
A) 0.439
B) 1.00×10^{-7}
C) 0.723
D) 2.81×10^{-13}
E) 0.273
Answer: B
Diff: 3 Page Ref: Sec. 17.3

14) A 25.0 mL sample of 0.723 M $HClO_4$ is titrated with a 0.27 M KOH solution. The H_3O^+ concentration after the addition of 80.0 mL of KOH is __________ M.
A) 0.44
B) 1.0×10^{-7}
C) 0.72
D) 2.8×10^{-13}
E) 3.6×10^{-2}
Answer: E
Diff: 3 Page Ref: Sec. 17.3

15) The pH of a solution prepared by mixing 50.0 mL of 0.125 M KOH and 50.0 mL of 0.125 M HCl is __________.
A) 6.29
B) 7.00
C) 8.11
D) 5.78
E) 0.00
Answer: B
Diff: 3 Page Ref: Sec. 17.3

16) A 25.0 mL sample of an acetic acid solution is titrated with a 0.175 M NaOH solution. The equivalence point is reached when 37.5 mL of the base is added. The concentration of acetic acid is __________ M.
A) 0.119
B) 1.83×10^{-4}
C) 0.263
D) 0.365
E) 0.175
Answer: C
Diff: 4   Page Ref: Sec. 17.3

17) A 25.0 mL sample of an HCl solution is titrated with a 0.139 M NaOH solution. The equivalence point is reached with 15.4 mL of base. The concentration of HCl is __________ M.
A) 11.7
B) 0.00214
C) 0.0856
D) 0.267
E) 0.139
Answer: C
Diff: 4   Page Ref: Sec. 17.3

18) A 50.0 mL sample of an aqueous H_2SO_4 solution is titrated with a 0.375 M NaOH solution. The equivalence point is reached with 62.5 mL of the base. The concentration of H_2SO_4 is __________ M.
A) 0.234
B) 0.469
C) 0.150
D) 0.300
E) 0.938
Answer: A
Diff: 4   Page Ref: Sec. 17.3

19) The concentration of iodide ions in a saturated solution of lead (II) iodide is __________ M. The solubility product constant of PbI_2 is 1.4×10^{-8}.
A) 3.8×10^{-4}
B) 3.0×10^{-3}
C) 1.5×10^{-3}
D) 3.5×10^{-9}
E) 1.4×10^{-8}
Answer: B
Diff: 3   Page Ref: Sec. 17.4

20) The solubility of lead (II) chloride ($PbCl_2$) is 1.6×10^{-2} M. What is the K_{sp} of $PbCl_2$
A) 5.0×10^{-4}
B) 4.1×10^{-6}
C) 3.1×10^{-7}
D) 1.6×10^{-5}
E) 1.6×10^{-2}
Answer: D
Diff: 3   Page Ref: Sec. 17.4

21) The solubility of manganese (II) hydroxide ($Mn(OH)_2$) is 2.2×10^{-5} M. What is the Ksp of $Mn(OH)_2$?
A) 1.1×10^{-14}
B) 4.3×10^{-14}
C) 2.1×10^{-14}
D) 4.8×10^{-10}
E) 2.2×10^{-5}
Answer: B
Diff: 3 Page Ref: Sec. 17.4

22) Determine the K_{sp} for magnesium hydroxide ($Mg(OH)_2$) where the solubility of $Mg(OH)_2$ is 1.4×10^{-4} M.
A) 2.7×10^{-12}
B) 1.1×10^{-11}
C) 2.0×10^{-8}
D) 3.9×10^{-8}
E) 1.4×10^{-4}
Answer: B
Diff: 3 Page Ref: Sec. 17.4

23) Calculate the maximum concentration (in M) of silver ions (Ag^+) in a solution that contains 0.025 M of CO_3^{2-}. The K_{sp} of Ag_2CO_3 is 8.1×10^{-12}.
A) 1.8×10^{-5}
B) 1.4×10^{-6}
C) 2.8×10^{-6}
D) 3.2×10^{-10}
E) 8.1×10^{-12}
Answer: A
Diff: 4 Page Ref: Sec. 17.5

24) What is the solubility (in M) of $PbCl_2$ in a 0.15 M solution of HCl? The K_{sp} of $PbCl_2$ is 1.6×10^{-5}.
A) 2.0×10^{-3}
B) 1.1×10^{-4}
C) 1.8×10^{-4}
D) 7.1×10^{-4}
E) 1.6×10^{-5}
Answer: D
Diff: 4 Page Ref: Sec. 17.5

25) The K_{sp} for $Zn(OH)_2$ is 5.0×10^{-17}. Determine the molar solubility of $Zn(OH)_2$ in a buffer solution with a pH of 11.5.
A) 5.0×10^{6}
B) 1.2×10^{-12}
C) 1.6×10^{-14}
D) 5.0×10^{-12}
E) 5.0×10^{-17}
Answer: D
Diff: 4 Page Ref: Sec. 17.5

Multiple-Choice

26) Which one of the following pairs cannot be mixed together to form a buffer solution?
A) NH_3, NH_4Cl
B) $NaC_2H_3O_2$, HCl ($C_2H_3O_2$- = acetate)
C) RbOH, HBr
D) KOH, HF
E) H_3PO_4, KH_2PO_4
Answer: C
Diff: 2 Page Ref: Sec. 17.2

27) A solution containing which one of the following pairs of substances will be a buffer solution?
A) NaI, HI
B) KBr, HBr
C) RbCl, HCl
D) CsF, HF
E) none of the above
Answer: D
Diff: 2 Page Ref: Sec. 17.2

28) What change will be caused by addition of a small amount of HCl to a solution containing fluoride ions and hydrogen fluoride?
A) The concentration of hydronium ions will increase significantly.
B) The concentration of fluoride ions will increase as will the concentration of hydronium ions.
C) The concentration of hydrogen fluoride will decrease and the concentration of fluoride ions will increase.
D) The concentration of fluoride ion will decrease and the concentration of hydrogen fluoride will increase.
E) The fluoride ions will precipitate out of solution as its acid salt.
Answer: D
Diff: 3 Page Ref: Sec. 17.2

29) The Henderson-Hasselbalch equation is __________.
A) $[H^+] = K_a + \frac{[base]}{[acid]}$
B) $pH = pK_a - \log\frac{[base]}{[acid]}$
C) $pH = pK_a + \log\frac{[base]}{[acid]}$
D) $pH = pK_a + \log\frac{[acid]}{[base]}$
E) $pH = \log\frac{[acid]}{[base]}$
Answer: C
Diff: 1 Page Ref: Sec. 17.2

30) Of the following solutions, which has the greatest buffering capacity?
A) 0.821 M HF and 0.217 M NaF
B) 0.821 M HF and 0.909 M NaF
C) 0.100 M HF and 0.217 M NaF
D) 0.121 M HF and 0.667 M NaF
E) They are all buffer solutions and would all have the same capacity.
Answer: B
Diff: 3 Page Ref: Sec. 17.2

31) The addition of hydrofluoric acid and __________ to water produces a buffer solution.
A) HCl
B) $NaNO_3$
C) NaF
D) NaCl
E) NaBr
Answer: C
Diff: 1 Page Ref: Sec. 17.2

32) Which of the following could be added to a solution of sodium acetate to produce a buffer?

acetic acid hydrochloric acid potassium acetate sodium chloride

A) acetic acid only
B) acetic acid or hydrochloric acid
C) hydrochloric acid only
D) potassium acetate only
E) sodium chloride or potassium acetate
Answer: B
Diff: 2 Page Ref: Sec. 17.2

33) Which of the following could be added to a solution of potassium fluoride to prepare a buffer?
A) sodium hydroxide
B) potassium acetate
C) hydrochloric acid
D) sodium fluoride
E) ammonia
Answer: C
Diff: 2 Page Ref: Sec. 17.2

34) Which of the following could be added to a solution of acetic acid to prepare a buffer?
A) sodium hydroxide
B) hydrochloric acid
C) nitric acid
D) more acetic acid
E) None of the above can be added to an acetic acid solution to prepare a buffer.
Answer: A
Diff: 2 Page Ref: Sec. 17.2

35) Which of the following could be added to a solution of acetic acid to prepare a buffer?

sodium acetate sodium hydroxide nitric acid hydrofluoric acid

A) sodium acetate only
B) sodium acetate or sodium hydroxide
C) nitric acid only
D) hydrofluoric acid or nitric acid
E) sodium hydroxide only
Answer: B
Diff: 2 Page Ref: Sec. 17.2

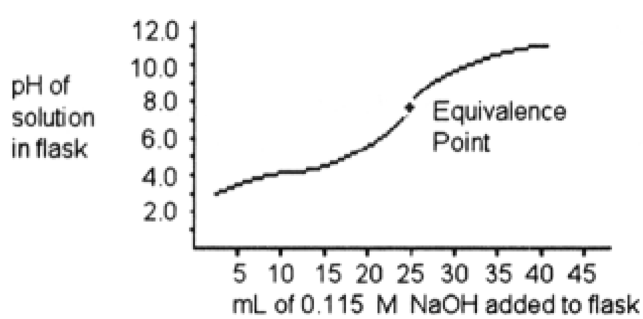
36) The primary buffer system that controls the pH of the blood is the __________ buffer system.
A) carbon dioxide, carbonate
B) carbonate, bicarbonate
C) carbonic acid, carbon dioxide
D) carbonate, carbonic acid
E) carbonic acid, bicarbonate
Answer: E
Diff: 2 Page Ref: Sec. 17.2

37) What are the principal organs that regulate the pH of the carbonic acid-bicarbonate buffer system in the blood?
A) kidneys, liver
B) lungs, kidneys
C) spleen, liver
D) lungs, skin
E) brain stem, heart
Answer: B
Diff: 3 Page Ref: Sec. 17.2

38) Human blood is __________.
A) neutral
B) very basic
C) slightly acidic
D) very acidic
E) slightly basic
Answer: E
Diff: 2 Page Ref: Sec. 17.2

39) Which one of the following will cause hemoglobin to release oxygen?
A) increase in pH
B) decrease in pH
C) decrease in temperature
D) decrease in CO_2 concentration
E) increase in O_2 concentration
Answer: B
Diff: 3 Page Ref: Sec. 17.2

40) The pH of a solution prepared by mixing 45 mL of 0.183 M KOH and 65 mL of 0.145 M HCl is __________.
A) 1.31
B) 2.92
C) 0.74
D) 1.97
E) 70.145
Answer: D
Diff: 4 Page Ref: Sec. 17.3

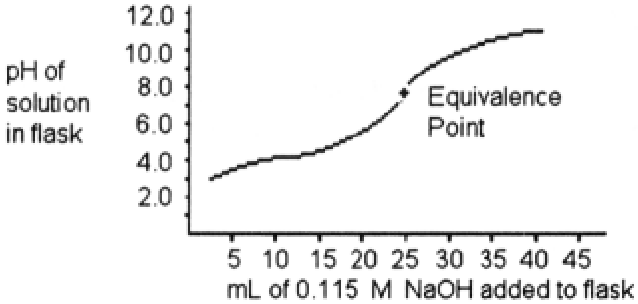


41) A 25.0 mL sample of a solution of an unknown compound is titrated with a 0.115 M NaOH solution. The titration curve above was obtained. The unknown compound is __________.
A) a strong acid
B) a strong base
C) a weak acid
D) a weak base
E) neither an acid nor a base
Answer: C
Diff: 3 Page Ref: Sec. 17.3

42) A 25.0 mL sample of a solution of a monoprotic acid is titrated with a 0.115 M NaOH solution. The titration curve above was obtained. The concentration of the monoprotic acid is about __________ mol/L.
A) 25.0
B) 0.0600
C) 0.240
D) 0.120
E) 0.100
Answer: D
Diff: 3 Page Ref: Sec. 17.3

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

43) A solution of HF is titrated with a 0.150 M NaOH solution. Based on the table above, the best indicator for this reaction is __________. The K_a of hydrofluoric acid is 6.8×10^{-4}.
A) methyl orange
B) methyl red
C) bromocresol purple
D) thymol blue
E) phenolpthalein
Answer: B
Diff: 4 Page Ref: Sec. 17.3



44) A 25.0 mL sample of a solution of a monoprotic acid is titrated with a 0.115 M NaOH solution. The titration curve above was obtained. Which of the following indicators would be best for this titration?
A) methyl red
B) bromthymol blue
C) thymol blue
D) phenolpthalein
E) bromocresol purple
Answer: B
Diff: 4 Page Ref: Sec. 17.3

Consider the following table of K_{sp} values.

45) Which compound listed below has the greatest molar solubility in water?
A) $CdCO_3$
B) $Cd(OH)_2$
C) AgI
D) CaF_2
E) $ZnCO_3$
Answer: D
Diff: 3 Page Ref: Sec. 17.4

46) Which compound listed below has the smallest molar solubility in water?
A) $ZnCO_3$
B) $Cd(OH)_2$
C) $CdCO_3$
D) AgI
E) CaF_2
Answer: D
Diff: 3 Page Ref: Sec. 17.4

47) The molar solubility of __________ is not affected by the pH of the solution.
A) Na_3PO_4
B) NaF
C) KNO_3
D) $AlCl_3$
E) MnS
Answer: C
Diff: 2 Page Ref: Sec. 17.5

48) In which of the following aqueous solutions would you expect AgCl to have the lowest solubility?
A) pure water
B) 0.020 M $BaCl_2$
C) 0.015 NaCl
D) 0.020 $AgNO_3$
E) 0.020 KCl
Answer: B
Diff: 2 Page Ref: Sec. 17.5

49) In which of the following aqueous solutions would you expect AgCl to have the highest solubility?
A) pure water
B) 0.020 M $BaCl_2$
C) 0.015 NaCl
D) 0.020 $AgNO_3$
E) 0.020 KCl
Answer: A
Diff: 2 Page Ref: Sec. 17.5

50) In which of the following aqueous solutions would you expect AgBr to have the lowest solubility?
A) pure water
B) 0.20 M NaBr
C) 0.10 M $AgNO_3$
D) 0.15 M KBr
E) 0.10 M LiBr
Answer: B
Diff: 2 Page Ref: Sec. 17.5

51) In which of the following aqueous solutions would you expect AgBr to have the highest solubility?
A) 0.10 M LiBr
B) 0.10 M $AgNO_3$
C) 0.20 M NaBr
D) 0.15 M KBr
E) pure water
Answer: E
Diff: 2 Page Ref: Sec. 17.5

52) In which of the following aqueous solutions would you expect $PbCl_2$ to have the lowest solubility?
A) 0.020 M KCl
B) 0.020 M $BaCl_2$
C) 0.015 M $PbNO_3$
D) pure water
E) 0.015 M NaCl
Answer: B
Diff: 2 Page Ref: Sec. 17.5

53) In which one of the following solutions is silver chloride the most soluble?
A) 0.181 M HCl
B) 0.0176 M NH_3
C) 0.744 M $LiNO_3$
D) pure water
E) 0.181 M NaCl
Answer: B
Diff: 3 Page Ref: Sec. 17.5

54) Which one of the following is <u>not</u> amphoteric?
A) $Al(OH)_3$
B) $Ca(OH)_2$
C) $Cr(OH)_3$
D) $Zn(OH)_2$
E) $Sn(OH)_2$
Answer: B
Diff: 2 Page Ref: Sec. 17.5

55) For which salt should the aqueous solubility be most sensitive to pH?
A) $Ca(NO3)_2$
B) CaF_2
C) $CaCl_2$
D) $CaBr_2$
E) CaI_2
Answer: B
Diff: 3 Page Ref: Sec. 17.5

56) In which aqueous system is PbI_2 least soluble?
A) H_2O
B) 0.5 M HI
C) 0.2 M HI
D) 1.0 M HNO_3
E) 0.8 M KI
Answer: E
Diff: 2 Page Ref: Sec. 17.5

57) Which below best describe(s) the behavior of an amphoteric hydroxide in water?
A) With conc. aq. NaOH, its suspension dissolves.
B) With conc. aq. HCl, its suspension dissolves.
C) With conc. aq. NaOH, its clear solution forms a precipitate.
D) With conc. aq. HCl, its clear solution forms a precipitate.
E) With <u>both</u> conc. aq. NaOH <u>and</u> conc. aq. HCl, its suspension dissolves.
Answer: E
Diff: 3 Page Ref: Sec. 17.5

58) Of the substances below, __________ will <u>decrease</u> the solubility of $Pb(OH)_2$ in a saturated solution.
A) $NaNO_3$
B) H_2O_2
C) HNO_3
D) $Pb(NO_3)_2$
E) NaCl
Answer: D
Diff: 3 Page Ref: Sec. 17.5

59) Why does fluoride treatment render teeth more resistant to decay?
A) Fluoride kills the bacteria in the mouth that make the acids that decay teeth.
B) Fluoride stimulates production of tooth enamel to replace that lost to decay.
C) Fluoride reduces saliva production, keeping teeth drier and thus reducing decay.
D) Fluoride converts hydroxyapatite to fluoroapatite that is less reactive with acids.
E) Fluoride dissolves plaque, reducing its decaying contact with teeth.
Answer: D
Diff: 2   Page Ref: Sec. 17.5

60) The common-ion effect refers to the observation __________.
A) that some ions, such as Na^+ (aq), frequently appear in solutions but do not participate in solubility equilibria
B) common ions, such as Na^+ (aq), don't affect equilibrium constants
C) that the selective precipitation of a metal ion, such as Ag^+, is promoted by the addition of an appropriate counterion (X^-) that produces a compound (AgX) with a very low solubility
D) ions such as K^+ and Na^+ are common ions, so that their values in equilibrium constant expressions are always 1.00
E) that common ions precipitate all counter-ions
Answer: C
Diff: 3   Page Ref: Sec. 17.6

Short Answer

1) Calculate the pH of a buffer that contains 0.270 M hydrofluoric acid (HF) and 0.180 M cesium fluoride (CsF). The Ka of hydrofluoric acid is 6.80×10^{-4}.
Answer: 2.99
Diff: 3   Page Ref: Sec. 17.2

2) Calculate the pH of a buffer solution that contains 0.820 grams of sodium acetate and 0.01 moles of acetic acid in 100 ml of water. The Ka of acetic acid is 1.77×10^{-5}.
Answer: 4.75
Diff: 3   Page Ref: Sec. 17.2

3) Suppose you have just added 100.0 ml of a solution containing 0.5000 moles of acetic acid per liter to 400.0 ml of 0.5000 M NaOH. What is the final pH? The Ka of acetic acid is 1.770×10^{-5}.
Answer: 13.48
Diff: 4   Page Ref: Sec 17.3

4) Suppose you have just added 200.0 ml of a solution containing 0.5000 moles of acetic acid per liter to 100.0 ml of 0.5000 M NaOH. What is the final pH? The Ka of acetic acid is 1.770×10^{-5}.
Answer: 4.75
Diff: 4   Page Ref: Sec. 17.3

5) 200.0 ml of a solution containing 0.5000 moles of acetic acid per liter is added to 200.0 ml of 0.5000 M NaOH. What is the final pH? The Ka of acetic acid is 1.770×10^{-5}.
Answer: 9.075
Diff: 5   Page Ref: Sec 17.3

True/False

1) The extent of ionization of a weak electrolyte is increased by adding to the solution a strong electrolyte that has an ion in common with the weak electrolyte.
Answer: FALSE
Diff: 2   Page Ref: Sec. 17.1

2) For any buffer system, the buffer capacity depends on the amount of acid and base from which the buffer is made.
Answer: TRUE
Diff: 2   Page Ref: Sec. 17.2

3) The solubility product of a compound is numerically equal to the product of the concentration of the ions involved in the equilibrium, each multiplied by its coefficient in the equilibrium reaction.
Answer: FALSE
Diff: 2   Page Ref: Sec. 17.4

4) The solubility of a slightly soluble salt is decreased by the presence of a second solule that provides a common ion to the system.
Answer: TRUE
Diff: 2   Page Ref: Sec. 17.5

5) The solubility of slightly soluble salts containing basic anions is proportional to the pH of the solution.
Answer: FALSE
Diff: 2   Page Ref: Sec. 17.5

Algorithmic Questions

1) Calculate the pH of a solution that is 0.295 M in sodium formate ($NaHCO_2$) and 0.205 M in formic acid (HCO_2H). The K_a of formic acid is 1.77×10^{-4}.
A) 3.903
B) 3.587
C) 13.84
D) 10.10
E) 4.963
Answer: A
Diff: 3   Page Ref: Sec. 17.1

2) Calculate the percent ionization of formic acid (HCO_2H) in a solution that is 0.311 M in formic acid and 0.189 M in sodium formate ($NaHCO_2$). The K_a of formic acid is 1.77×10^{-4}.
A) 37.8
B) 0.0952
C) 11.3
D) 1.06×10^{-3}
E) 3.529
Answer: B
Diff: 4   Page Ref: Sec. 17.1

3) Calculate the percent ionization of formic acid (HCO_2H) in a solution that is 0.219 M in formic acid. The K_a of formic acid is 1.77×10^{-4}.
A) 3.94×10^{-5}
B) 0.0180
C) 2.87
D) 0.280
E) 12.2
Answer: C
Diff: 4   Page Ref: Sec. 17.1

4) Calculate the pH of a solution that is 0.210 M in nitrous acid (HNO_2) and 0.290 M in potassium nitrite (KNO_2). The acid dissociation constant of nitrous acid is 4.50×10^{-4}.
A) 3.490
B) 3.210
C) 13.86
D) 10.51
E) 4.562
Answer: A
Diff: 4   Page Ref: Sec. 17.1

5) Calculate the percent ionization of nitrous acid in a solution that is 0.222 M in nitrous acid (HNO_2) and 0.278 M in potassium nitrite (KNO_2). The acid dissociation constant of nitrous acid is 4.50×10^{-4}.
A) 55.6
B) 0.161
C) 15.5
D) 2.78×10^{-3}
E) 3.448
Answer: B
Diff: 4   Page Ref: Sec. 17.1

6) Calculate the percent ionization of nitrous acid in a solution that is 0.249 M in nitrous acid. The acid dissociation constant of nitrous acid is 4.50×10^{-4}.
A) 1.12×10^{-4}
B) 0.0450
C) 4.25
D) 0.342
E) 5.53
Answer: C
Diff: 4   Page Ref: Sec. 17.1

7) What is the pH of a buffer solution that is 0.211 M in lactic acid and 0.111 M in sodium lactate? The K_a of lactic acid is 1.37×10^{-4}.
A) 14.28
B) 10.43
C) 5.48
D) 3.57
E) 4.13
Answer: D
Diff: 4   Page Ref: Sec. 17.2

8) What is the pH of a buffer solution that is 0.255 M in hypochlorous acid (HClO) and 0.333 M in sodium hypochlorite? The K_a of hypochlorous acid is 3.81×10^{-8}.
A) 13.88
B) 6.46
C) 8.49
D) 7.30
E) 7.54
Answer: E
Diff: 4   Page Ref: Sec. 17.2

9) A solution is prepared by dissolving 0.23 mol of chloroacetic acid and 0.27 mol of sodium chloroacetate in water sufficient to yield 1.00 L of solution. The addition of 0.05 mol of HCl to this buffer solution causes the pH to drop slightly. The pH does not decrease drastically because the HCl reacts with the __________ present in the buffer solution. The K_a of chloroacetic acid is 1.36×10^{-3}.
A) H_2O
B) H_3O^+
C) chloroacetate ion
D) chloroacetic acid
E) This is a buffer solution: the pH does not change upon addition of acid or base.
Answer: C
Diff: 4 Page Ref: Sec. 17.2

10) A solution is prepared by dissolving 0.23 mol of hydrazoic acid and 0.27 mol of sodium azide in water sufficient to yield 1.00 L of solution.The addition of 0.05 mol of NaOH to this buffer solution causes the pH to increase slightly. The pH does not increase drastically because the NaOH reacts with the __________ present in the buffer solution. The K_a of hydrazoic acid is 1.9×10^{-5}.
A) H_2O
B) H_3O^+
C) azide
D) hydrazoic acid
E) This is a buffer solution: the pH does not change upon addition of acid or base.
Answer: D
Diff: 4 Page Ref: Sec. 17.2

11) How many milliliters of 0.0850 M NaOH are required to titrate 25.0 mL of 0.0720 M HBr to the equivalence point?
A) 21.2
B) 0.245
C) 3.92
D) 0.153
E) 29.5
Answer: A
Diff: 3 Page Ref: Sec. 17.3

12) A 25.0 mL sample of 0.150 M nitrous acid is titrated with a 0.150 M NaOH solution. What is the pH at the equivalence point? The K_a of nitrous acid is 4.50×10^{-4}.
A) 10.35
B) 10.65
C) 3.35
D) 7.00
E) 8.11
Answer: E
Diff: 4 Page Ref: Sec. 17.3

13) A 25.0-mL sample of 0.150 M butanoic acid is titrated with a 0.150 M NaOH solution. What is the pH before any base is added? The K_a of butanoic acid is 1.5×10^{-5}.
A) 2.83
B) 1.5×10^{-3}
C) 4.82
D) 4.00
E) 1.0×10^{4}
Answer: A
Diff: 4 Page Ref: Sec. 17.3

14) A 25.0 mL sample of 0.150 M hypochlorous acid is titrated with a 0.150 M NaOH solution. What is the pH after 26.0 mL of base is added? The K_a of hypochlorous acid is 3.0×10^{-8}.
A) 2.54
B) 11.47
C) 7.00
D) 7.51
E) 7.54
Answer: B
Diff: 4 Page Ref: Sec. 17.3

15) How many milliliters of 0.120 M NaOH are required to titrate 50.0 mL of 0.0998 M butanoic acid to the equivalence point? The K_a of butanoic acid is 1.5×10^{-5}.
A) 4.90
B) 50.0
C) 41.6
D) 60.1
E) 4.65
Answer: C
Diff: 5 Page Ref: Sec. 17.3

16) A 25.0-mL sample of 0.150 M hydrazoic acid is titrated with a 0.150 M NaOH solution. What is the pH after 13.3 mL of base is added? The K_a of hydrazoic acid is 1.9×10^{-5}.
A) 4.45
B) 1.34
C) 3.03
D) 4.78
E) 4.66
Answer: D
Diff: 5 Page Ref: Sec. 17.3

17) What is the molar solubility of magnesium carbonate ($MgCO_3$) in water? The solubility-product constant for $MgCO_3$ is 3.5×10^{-8} at 25°C.
A) 1.8×10^{-8}
B) 7.0×10^{-8}
C) 7.46
D) 2.6×10^{-4}
E) 1.9×10^{-4}
Answer: E
Diff: 4 Page Ref: Sec. 17.4

18) What is the molar solubility of barium fluoride (BaF_2) in water? The solubility-product constant for BaF_2 is 1.7×10^{-6} at 25°C.
A) 6.5×10^{-4}
B) 1.2×10^{-2}
C) 1.8×10^{-3}
D) 7.5×10^{-3}
E) 5.7×10^{-7}
Answer: D
Diff: 4 Page Ref: Sec. 17.4

19) A solution of NaF is added dropwise to a solution that is 0.0144 M in Ba^{2+}. When the concentration of F^- exceeds __________ M, BaF_2 will precipitate. Neglect volume changes. For BaF_2, $K_{sp} = 1.7 \times 10^{-6}$.

A) 5.9×10^{-5}

B) 1.1×10^{-2}

C) 2.4×10^{-8}

D) 2.7×10^{-3}

E) 1.2×10^{-4}

Answer: B

Diff: 5 Page Ref: Sec. 17.6

Chemistry, 11e (Brown)
Chapter 18: Chemistry of the Environment

U Multiple-Choice and Bimodal

1) The liquid portion of the Earth is called the __________.
A) stratosphere
B) lithosphere
C) atmosphere
D) hydrosphere
E) mesosphere
Answer: D
Diff: 1 Page Ref: Sec. 18.1

2) The layer of the atmosphere that contains our weather is called the __________.`
A) mesosphere
B) heterosphere
C) stratosphere
D) thermosphere
E) troposphere
Answer: E
Diff: 1 Page Ref: Sec. 18.1

3) Of the noble gases, __________ is present in highest concentration in dry air at sea level.
A) Ne
B) He
C) Xe
D) Kr
E) Ar
Answer: E
Diff: 1 Page Ref: Sec. 18.1

4) The dividing line between the troposphere and stratosphere is known as the __________.
A) mesosphere
B) tropopause
C) thermosphere
D) stratopause
E) mesopause
Answer: B
Diff: 1 Page Ref: Sec. 18.1

5) The pressure of the atmosphere __________.
A) increases with altitude
B) follows the same trend as temperature
C) decreases with altitude
D) follows the reverse trend as temperature
E) stays the same
Answer: C
Diff: 1 Page Ref: Sec. 18.1

6)

Components of Air	Mole Fraction
Nitrogen	0.781
Oxygen	0.209
Argon	0.010

What is the partial pressure or oxygen (in torr) in the atmosphere when the atmospheric pressure is 760 torr?
A) 159
B) 430
C) 601
D) 720
E) 760
Answer: A
Diff: 1   Page Ref: Sec. 18.1

7) What is/are the product(s) of photodissociation of molecular oxygen?
A) molecular nitrogen
B) excited oxygen molecules
C) ozone
D) ozone and atomic oxygen
E) atomic oxygen
Answer: E
Diff: 1   Page Ref: Sec. 18.2

8) The amount of atomic O relative to O_2 __________.
A) is highest in the troposphere
B) is highest in the stratosphere
C) increases with altitude in the thermosphere
D) decreases with altitude in the thermosphere
E) is essentially independent of altitude in the thermosphere
Answer: C
Diff: 1   Page Ref: Sec. 18.3

9) The C–Cl and C–F bond dissociation energies in CF_3Cl are 339 kJ/mol and 482 kJ/mol, respectively. The maximum wavelengths of electromagnetic radiation required to rupture these bonds are __________ and __________, respectively.
A) 45.0 nm, 307 nm
B) 742 nm, 654 nm
C) 482 nm, 248 nm
D) 353 nm, 248 nm
E) 979 nm, 953 nm
Answer: D
Diff: 2   Page Ref: Sec. 18.3

10) In the equation below, M is most likely __________.

$$O + O_2 + M \rightarrow O_3 + M^*$$

A) Cl_2
B) N_2
C) Ne
D) CO_2
E) H_2O
Answer: B
Diff: 1   Page Ref: Sec. 18.3

11) Ozone is a(n) __________ of oxygen.
A) isomer
B) allotrope
C) isotope
D) resonance structure
E) atomic form
Answer: B
Diff: 1 Page Ref: Sec. 18.3

12) CFC stands for __________.
A) chlorinated freon compound
B) chlorofluorocarbon
C) carbonated fluorine compound
D) caustic fluorine carbohydrate
E) carbofluoro compound
Answer: B
Diff: 1 Page Ref: Sec. 18.3

13) Natural, unpolluted rainwater is typically acidic. What is the source of this natural acidity __________?
A) CO_2
B) SO_2
C) NO_2
D) HCl
E) chlorofluorocarbons
Answer: A
Diff: 1 Page Ref: Sec. 18.4

14) What compound in limestone and marble is attacked by acid rain __________?
A) hydroxyapatite
B) calcium carbonate
C) gypsum
D) graphite
E) potassium hydroxide
Answer: B
Diff: 1 Page Ref: Sec. 18.4

15) CO_2 from hydrocarbon combustion creates a major environmental problem that is described as __________.
A) the greenhouse effect
B) photochemical smog
C) acid rain
D) stratospheric ozone depletion
E) all of the above
Answer: A
Diff: 1 Page Ref: Sec. 18.4

16) Radiation in the infrared portion of the spectrum is absorbed by __________ found in the atmosphere.
A) N_2
B) O_2
C) CO_2
D) Ar
E) He
Answer: C
Diff: 1 Page Ref: Sec. 18.4

17) Compounds found in fossil fuels that contain __________ are primarily responsible for acid rain.
A) sulfur
B) carbon
C) hydrogen
D) phosphorus
E) neon
Answer: A
Diff: 1 Page Ref: Sec. 18.4

18) Acid rain typically has a pH of about __________.
A) 7
B) 5
C) 4
D) 2
E) 1
Answer: C
Diff: 1 Page Ref: Sec. 18.4

19) Sulfur dioxide is not released into the atmosphere in any significant amount by __________.
A) burning of coal
B) bacterial action
C) internal combustion engines
D) volcanic eruption
E) Sulfur dioxide is produced in significant amount by all of these processes.
Answer: C
Diff: 1 Page Ref: Sec. 18.4

20) Ozone is a necessary, protective component of the __________, but is considered a pollutant in the __________.
A) troposphere, upper atmosphere
B) troposphere, air
C) photochemical smog, air we breathe
D) upper atmosphere, troposphere
E) air we breathe
Answer: D
Diff: 1 Page Ref: Sec. 18.4

21) The brown color of photochemical smog over a city is mainly due to __________.
A) NO_2
B) N_2O_4
C) CO
D) SO_2
E) CO_2
Answer: A
Diff: 1 Page Ref: Sec. 18.4

22) The concentration of which greenhouse gas has increased steadily over the last few decades __________?
A) H_2O
B) CO
C) CO_2
D) H_2O_2
E) O_2
Answer: C
Diff: 1 Page Ref: Sec. 18.4

23) What is the percentage of freshwater on planet Earth __________?
A) 97%
B) 2.1%
C) 2.8%
D) 0.6%
E) 100%
Answer: D
Diff: 2   Page Ref: Sec. 18.5

24) In the world's oceans, the average salinity is about __________g/kg.
A) 0.03
B) 0.1
C) 35
D) 17
E) 3.5
Answer: C
Diff: 1   Page Ref: Sec. 18.5

25) The sterilizing action of chlorine in water is due to what substance __________?
A) Cl^-
B) Cl_2
C) HCl
D) HClO
E) H^+
Answer: D
Diff: 1   Page Ref: Sec. 18.6

26) The "scale" caused by hard water is __________.
A) calcium ions
B) calcium carbonate
C) chloride ions
D) magnesium oxalate
E) magnesium ions
Answer: B
Diff: 1   Page Ref: Sec. 18.6

Multiple-Choice

27) In the troposphere, temperature __________ with increasing altitude, while in the stratosphere, temperature __________ with increasing altitude.
A) increases, increases
B) decreases, decreases
C) increases, decreases
D) decreases, increases
E) decreases, remains constant
Answer: D
Diff: 1   Page Ref: Sec. 18.1

28) Which of the following is arranged correctly in order of increasing distance from Earth's surface?
A) mesosphere < troposphere < stratosphere < thermosphere
B) troposphere < mesosphere < stratosphere < thermosphere
C) troposphere < mesosphere < thermosphere < stratosphere
D) troposphere < stratosphere < mesosphere < thermosphere
E) mesosphere < troposphere < thermosphere < stratosphere
Answer: D
Diff: 1   Page Ref: Sec. 18.1

29) As one gains altitude in the atmosphere, based on the ionization energies shown below, which sequence of mole fractions is the correct one?

Process	Ionization Energy (kJ/mol)
$N_2 + h\nu \rightarrow N_2^+ + e^-$	1495
$O_2 + h\nu \rightarrow O_2^+ + e^-$	1205
$O + h\nu \rightarrow O^+ + e^-$	1313
$NO + h\nu \rightarrow NO+ + e^-$	890

A) $N_2 > N > NO > O_2$
B) $N_2 > O > O_2 > NO$
C) $N_2 > O_2 > O > NO$
D) $NO > O_2 > O > N_2$
E) All will be equal.
Answer: B
Diff: 1 Page Ref: Sec. 18.2

30) Why does the upper atmosphere contain only very little dissociated nitrogen?
A) most of the nitrogen is in the troposphere and not in the upper atmosphere
B) the dissociated nitrogen very rapidly diffuses out of the atmosphere and into space
C) nitrogen atoms are extremely reactive and so react with other substances immediately upon their formation
D) the bond energy of nitrogen is very high and it does not absorb radiation very efficiently
E) There is no N_2 in the upper atmosphere.
Answer: D
Diff: 1 Page Ref: Sec. 18.2

31) Of the compounds below, the one that requires the shortest wavelength for photoionization is __________.
A) O
B) O_2
C) NO
D) N_2
E) They all require the same wavelength.
Answer: D
Diff: 1 Page Ref: Sec. 18.2

32) Photoionization processes (e.g., $N_2 + h\nu \rightarrow N_2^+ + e^-$) remove UV of <150 nm. Which photoreaction is the principal absorber of UV in the 150-200 nm range in the upper atmosphere?
A) $N_2 + h\nu \rightarrow 2N$
B) $O_2 + h\nu \rightarrow 2O$
C) $O_3 + h\nu \rightarrow O_2 + O$
D) $N_2 + O_2 + h\nu \rightarrow 2NO$
E) $NO + O_2 + h\nu \rightarrow NO_3$
Answer: B
Diff: 2 Page Ref: Sec. 18.3

33) Why does ozone not form in high concentrations in the atmosphere above 50 km?
A) Insufficient oxygen is available.
B) Insufficient molecules exist for removal of excess energy from ozone upon its formation.
C) Light of the required wavelength is not available at those altitudes.
D) Atomic oxygen concentration is too low at high altitudes.
E) The pressure is too high.
Answer: B
Diff: 1 Page Ref: Sec. 18.3

34) Why are chlorofluorocarbons so damaging to the ozone layer when they are such stable molecules?
A) They contain a double bond that ozone readily attacks, resulting in the destruction of the ozone.
B) They are very light molecules that rapidly diffuse into the upper atmosphere and block the radiation that causes formation of ozone.
C) They are greenhouse gases that raise the temperature above the dissociation temperature of ozone.
D) The radiation in the stratosphere dissociates them producing chlorine atoms that catalytically destroy ozone.
E) CFCs do not damage the ozone.
Answer: D
Diff: 1 Page Ref: Sec. 18.3

35) Cl atoms formed via photolysis of C-Cl bonds of chlorofluorocarbons in the stratosphere are particularly effective in destroying ozone at these altitudes because __________.
A) Cl atoms absorb UV, which generate O atoms to react with O_2 to produce ozone
B) Cl atoms catalytically convert O_3 to O_2
C) Cl atoms stoichiometrically convert O_3 to O_2
D) Cl atoms react with H atoms, which catalyze conversion of O_2 to O_3
E) Cl atoms react with N atoms, which catalyze conversion of O_2 to O_3
Answer: B
Diff: 1 Page Ref: Sec. 18.3

36) Select the substance that is thought to be partially responsible for depleting the concentration of ozone in the stratosphere.
A) $CFCl_3$
B) CO_2
C) O_2
D) N_2
E) He
Answer: A
Diff: 1 Page Ref: Sec. 18.3

37) Of the reactions involved in the photodecomposition of ozone (shown below), which are photochemical?
1. $O_2 (g) + h\nu \rightarrow O (g) + O (g)$
2. $O (g) + O_2 (g) + M (g) \rightarrow O_3 (g) + M^* (g)$
3. $O_3 (g) + h\nu \rightarrow O_2 (g) + O (g)$
4. $O (g) + O (g) + M (g) \rightarrow O_2 (g) + M^* (g)$

A) 2 and 4
B) 1, 2, and 4
C) 1 and 3
D) 1 only
E) all of them
Answer: C
Diff: 1 Page Ref: Sec. 18.3

38) Of the reactions involved in the photodecomposition of ozone (shown below), which are exothermic?
1. $O_2 (g) + h\nu \rightarrow O (g) + O (g)$
2. $O (g) + O_2 (g) + M (g) \rightarrow O3 (g) + M^* (g)$
3. $O_3 (g) + h\nu \rightarrow O_2 (g) + O (g)$
4. $O (g) + O (g) + M (g) \rightarrow O_2 (g) + M^* (g)$

A) 2 and 4
B) 1 and 3
C) 1, 2, and 4
D) 2 only
E) all of them
Answer: A
Diff: 1 Page Ref: Sec. 18.3

39) In the reactions involved in the photodecomposition of ozone (shown below), what does M symbolize?

1. O_2 (g) + hν → O (g) + O (g)
2. O (g) + O_2 (g) + M (g) → O_3 (g) + M* (g)
3. O_3 (g) + hν → O_2 (g) + O (g)
4. O (g) + O (g) + M (g) → O_2 (g) + M* (g)

A) mesosphere
B) metal
C) molybdenum
D) methane
E) molecule
Answer: E
Diff: 1 Page Ref: Sec. 18.3

40) In the past, CFCs were not used in __________.
A) spray cans
B) plastic manufacturing
C) air conditioners
D) refrigerators
E) dry cleaning
Answer: E
Diff: 1 Page Ref: Sec. 18.3

41) Which one of the following is a source of carbon dioxide in the troposphere?
A) natural gas seepage
B) electrical discharges
C) fossil-fuel combustion
D) volcanic gases
E) forest fires
Answer: C
Diff: 1 Page Ref: Sec. 18.4

42) The source(s) of sulfur dioxide in the atmosphere is/are _________.
A) volcanic gases
B) forest fires
C) bacterial action
D) fossil-fuel combustion
E) all of the above
Answer: E
Diff: 1 Page Ref: Sec. 18.4

43) Of the following, only __________ does not result in the formation of acid rain.
A) carbon dioxide
B) nitrogen dioxide
C) sulfur dioxide
D) nitrogen monoxide
E) methane
Answer: E
Diff: 1 Page Ref: Sec. 18.4

44) Organic matter is a source for all of the following atmospheric gases, except __________.
A) SO_2
B) CO_2
C) CH_4
D) NO
E) CO
Answer: A
Diff: 1 Page Ref: Sec. 18.4

45) How does lime reduce sulfur dioxide emissions from the burning of coal?
A) It reacts with the sulfur dioxide to form calcium sulfite solid that can be precipitated.
B) It reduces the sulfur dioxide to elemental sulfur that is harmless to the environment.
C) It oxidizes the sulfur dioxide to tetrathionate that is highly water soluble so it can be scrubbed from the emission gases.
D) It catalyzes the conversion of sulfur dioxide to sulfur trioxide which is much less volatile and can be removed by condensation.
E) It converts SO_2 to solid, elemental sulfur.
Answer: A
Diff: 1 Page Ref: Sec. 18.4

46) Why is carbon monoxide toxic?
A) It causes renal failure.
B) It binds to hemoglobin, thus blocking the transport of oxygen.
C) It blocks acetylcholine receptor sites causing paralysis and rapid death.
D) It induces leukemia.
E) It binds to oxygen and causes suffocation.
Answer: B
Diff: 1 Page Ref: Sec. 18.4

47) Carbon dioxide contributes to atmospheric warming by __________.
A) absorbing incoming radiation from the sun and converting it to heat
B) absorbing radiation emitted from the surface of the earth preventing its loss to space
C) undergoing exothermic reactions extensively in the atmosphere
D) increasing the index of refraction of the atmosphere so that infrared radiation from the sun is refracted to the surface of the earth where it is converted to heat
E) reducing the concentration of CO in the atmosphere.
Answer: B
Diff: 1 Page Ref: Sec. 18.4

48) Which one of the following substances found in the atmosphere will absorb radiation in the infrared portion of the spectrum?
A) N_2
B) O_2
C) Kr
D) H_2O
E) He
Answer: D
Diff: 1 Page Ref: Sec. 18.4

49) Which gaseous sulfur compound combines with water to form the principal acidic constituent of acid rain?
A) H_2SO_4
B) SO_2
C) SO
D) SO_3
E) H_2S
Answer: D
Diff: 1   Page Ref: Sec. 18.4

50) The reaction that forms most of the acid in acid rain is __________.
A) SO_2 (g) + H_2O (l) → H_2SO_4 (aq)
B) SO_2 (g) + H_2O (l) → H_2SO_3 (aq)
C) H_2S (g) + 2 O_2 (g) → H_2SO_4 (l)
D) Cl_2 (g) + H_2O (l) → HCl (aq) + HClO (aq)
E) SO_3 (g) + H_2O (l) → H_2SO_4 (aq)
Answer: E
Diff: 1   Page Ref: Sec. 18.4

51) Incomplete combustion of carbon-containing materials occurs when __________.
A) there is insufficient oxygen to convert all of the carbon to carbon dioxide
B) there are sulfur impurities in the carbon-containing material
C) the carbon-containing material is a gas
D) the combustion flame is too hot
E) there is an excess of oxygen
Answer: A
Diff: 1   Page Ref: Sec. 18.4

52) What is meant by the salinity of seawater?
A) percent by mass of salt in seawater
B) mass in grams of dry salts present in 1 kg of seawater
C) molality of NaCl in seawater
D) osmotic pressure of seawater
E) molarity of NaCl in seawater
Answer: B
Diff: 1   Page Ref: Sec. 18.5

53) The concentration of Br^- in a sample of seawater is 8.3×10^{-4} M. If a liter of seawater has a mass of 1.0 kg, the concentration of Br^- - is __________ ppm.
A) 0.066
B) 66
C) 0.83
D) 8.3
E) 8.3×10^{-6}
Answer: B
Diff: 2   Page Ref: Sec. 18.5

54) A single individual typically uses the greatest quantity of water for __________.
A) flushing toilets
B) cooking
C) cleaning (bathing, laundering, and house cleaning)
D) watering lawns
E) drinking water
Answer: C
Diff: 1   Page Ref: Sec. 18.6

55) The primary detrimental effect of the presence of large amounts of biodegradable organic materials in water is __________.
A) it causes death of bottom dwelling organisms because it agglutinates and settles to the bottom, poisoning bottom dwelling organisms
B) it causes oxygen depletion in the water
C) it rises to the surface and absorbs wavelengths needed by aquatic plants
D) it decomposes endothermically causing the temperature of the water to decrease below the limits within which most aquatic organisms can live
E) it causes the water to become murky
Answer: B
Diff: 1 Page Ref: Sec. 18.6

56) What is the final stage in municipal water treatment?
A) filtration through sand and gravel
B) aeration
C) settling
D) treatment with ozone or chlorine
E) removal of added fluoride
Answer: D
Diff: 1 Page Ref: Sec. 18.6

57) Which of the following is not a stage in water treatment?
A) coarse filtration
B) aeration
C) chlorination
D) distillation
E) settling
Answer: D
Diff: 1 Page Ref: Sec. 18.6

58) In the presence of oxygen, the nitrogen present in biodegradable material ends up mainly as __________.
A) NH_3
B) NH_4^+
C) NO
D) NO_2
E) NO_3^-
Answer: E
Diff: 1 Page Ref: Sec. 18.6

59) Chemical treatment of municipal water supplies commonly entails use of CaO, $Al_2(SO_4)_3$, and Cl_2. The purpose of adding CaO is to __________.
A) remove all HCO_3- as solid $CaCO_3$
B) remove all SO_4^{2-} as solid $CaSO_4$
C) remove all Cl^- as solid $CaCl_2$
D) selectively kill anaerobic (but not aerobic) bacteria
E) make the water slightly basic so that addition of $Al_2(SO_4)_3$ will afford a gelatinous precipitate of $Al(OH)_3$
Answer: E
Diff: 1 Page Ref: Sec. 18.6

60) Biodegradable material degraded by aerobic processes ends up as __________.
A) SO_4^{2-}
B) NH_3
C) H_2S
D) CH_4
E) PH_3
Answer: A
Diff: 1 Page Ref: Sec. 18.6

61) Which one of the following could be produced by anaerobic bacteria decomposing biodegradable waste?
A) nitrate
B) sulfate
C) carbon dioxide
D) hydrogen sulfide
E) water
Answer: D
Diff: 1 Page Ref: Sec. 18.6

62) Eutrophication of a lake is the process of __________.
A) rapid increase in the amount of dead and decaying plant matter in the lake as a result of excessive plant growth
B) rapid decline in the lake's pH due to acid rain
C) dissolved oxygen being depleted by an overpopulation of fish
D) stocking the lake with fish
E) restoration of the lake's dissolved oxygen supply by aerobic bacteria
Answer: A
Diff: 1 Page Ref: Sec. 18.6

63) The lime-soda process is used for large-scale water-softening operations. CaO is added to __________.
A) oxidize Fe^{2+} to insoluble Fe_2O_3
B) cause precipitation of magnesium as $Mg(OH)_2$
C) remove most Al^{3+} as solid $Al(OH)_3$
D) cause precipitation of iron and magnesium as Fe_2MgO_4
E) reduce the pH to 3-4
Answer: B
Diff: 1 Page Ref: Sec. 18.6

64) Water containing high concentrations of __________ cations is called hard water.
A) Ca^{2+}
B) Mg^{2+}
C) Na+
D) K+
E) Ca^{2+} or Mg^{2+}
Answer: E
Diff: 1 Page Ref: Sec. 18.6

65) THMs are __________.
A) non-toxic
B) natural
C) used in green chemistry
D) carcinogens
E) atmospheric pollutants
Answer: D
Diff: 1 Page Ref: Sec. 18.7

Short Answer

1) The fourth most abundant component of dry air is __________.
Answer: carbon dioxide; CO_2
Diff: 1 Page Ref: Sec 18.1

2) A chemical bond rupture from the absorption of a photon is called __________.
Answer: disassociation
Diff: 1 Page Ref: Sec 18.2

3) The concept that radiowave propagation was affected by the atmosphere of the earth was discovered by __________.
Answer: Marconi
Diff: 1 Page Ref: Sec 18.2

4) Show how a molecule of $C_2F_2Cl_2$ can destroy two molecules of ozone, O_3.
Answer: $C_2F_2Cl_2\ (g) + h\nu \rightarrow C_2F_2Cl\ (g) + Cl\ (g)$
$Cl\ (g) + O_3\ (g) \rightarrow ClO\ (g) + O_2\ (g)$
$ClO\ (g) + h\nu \rightarrow Cl\ (g) + O\ (g)$
$Cl\ (g) + O_3\ (g) \rightarrow ClO\ (g) + O_2\ (g)$

$C_2F_2Cl_2\ (g) + 2\ O_3\ (g) \rightarrow C_2F_2Cl\ (g) + ClO\ (g) + 2\ O_2\ (g) + O\ (g)$
Diff: 3 Page Ref: Sec. 18.3

5) In the equation below, what is the meaning of the asterisk?

$$O + O_2 \rightarrow O_3^*$$

Answer: The asterisk indicates that the ozone formed contains excess energy.
Diff: 1 Page Ref: Sec. 18.3

6) Approximately 90% of the earth's ozone is in the __________.
Answer: stratosphere
Diff: 1 Page Ref: Sec 18.3

7) Clean rainwater is acidic mainly due to the presence of __________.
Answer: carbon dioxide; CO_2
Diff: 1 Page Ref: Sec 18.4

8) The approximate pH of acid rain is __________.
Answer: 4.0
Diff: 1 Page Ref: Sec 18.4

9) The contribution of sulfur to acid rain is via the production of __________.
Answer: sulfuric acid; H_2SO_4
Diff: 1 Page Ref: Sec 18.4

10) The three most concentrated ions in seawater are __________.
Answer: chloride ions, sodium ions, and sulfate ions
Diff: 1 Page Ref: Sec. 18.5

11) The average pH of the oceans is __________ and is maintained by the buffering capacity of __________.
Answer: 8.0 - 8.3; H_2CO_3
Diff: 1 Page Ref: Sec 18.5

12) The world's largest desalinization plant is in __________ and uses the process of __________ to produce drinking water.
Answer: Saudi Arabia; reverse osmosis
Diff: 2   Page Ref: Sec 18.5

13) The average adult in the U.S. needs __________ liters of water per day.
Answer: 2
Diff: 1   Page Ref: Sec 18.5

14) To reduce lead toxicity, the metal, __________, is used in the electrodeposition of automobiles to prevent corrosion.
Answer: yttrium
Diff: 2   Page Ref: Sec 18.7

True/False

1) Volume fraction and mole fraction are the same.
Answer: TRUE
Diff: 1   Page Ref: Sec 18.1

2) The bond energy of oxygen is higher than that of nitrogen.
Answer: FALSE
Diff: 1   Page Ref: Sec 18.1

3) The partial pressure of a component in a gas mixture is the product of its mole fraction and the total mixture pressure.
Answer: TRUE
Diff: 1   Page Ref: Sec 18.1

4) Nitrogen oxides catalytically destroy ozone.
Answer: TRUE
Diff: 1   Page Ref: Sec 18.3

5) Ozone depletion from chlorofluorocarbons is chiefly due to the production of free chlorine.
Answer: TRUE
Diff: 1   Page Ref: Sec 18.3

6) Nitric oxide arises from internal combustion engines.
Answer: TRUE
Diff: 1   Page Ref: Sec 18.3

7) Sulfur compounds in the atmosphere are equally derived from natural sources and from human activity.
Answer: FALSE
Diff: 1   Page Ref: 18.4

8) The greenhouse effect of methane far exceeds the effect of carbon dioxide.
Answer: TRUE
Diff: 1   Page Ref: Sec 18.4

9) Most fresh water in the U.S. is used for agriculture.
Answer: TRUE
Diff: 1   Page Ref: Sec 18.5

10) Municipal water treatment consists of five steps beginning with chlorination.
Answer: TRUE
Diff: 1   Page Ref: Sec 18.6

Essay

1) Polar stratospheric clouds aid in the destruction of stratospheric ozone in two ways. What are these ways?
Answer: They remove NO_2, thus stopping removal of ClO and the crystalline surface in the clouds catalyze the recombination of HCl and $ClONO_2$ to form Cl_2.
Diff: 2 Page Ref: Sec. 18.4

2) Why is ozone depletion in the Arctic generally much less severe than that in the Antarctic?
Answer: The Arctic generally does not get cold enough for polar stratospheric clouds to form.
Diff: 1 Page Ref: Sec. 18.4

3) Describe the process of reverse osmosis that is used to desalinate seawater.
Answer: Water is fed, at high pressure, through tubes of semipermeable material. The water passes through the tubing material and the ions do not.
Diff: 1 Page Ref: Sec. 18.5

4) How can the presence of biodegradable waste in a lake result in the death of fish in the lake?
Answer: Bacteria utilize oxygen to degrade the waste and deplete the oxygen in the lake water.
Diff: 1 Page Ref: Sec. 18.6

5) List two of the three major sources of nitrogen and phosphorus in water.
Answer: domestic sewage, runoff from agricultural land, runoff from livestock areas
Diff: 1 Page Ref: Sec. 18.6

6) Ozone is more efficient at killing bacteria in water yet chlorine is used more commonly for that purpose in municipal water treatment. Why?
Answer: Ozone must be generated on site, whereas chlorine can be shipped in tanks as a liquified gas
Diff: 1 Page Ref: Sec. 18.6

Algorithmic Questions

1) The concentration of water vapor in a sample of air that has a partial pressure of water of 0.91 torr and a total pressure of air of 735 torr is __________ ppm.
A) 1.2×10^3
B) 1.2
C) 0.12
D) 8.1×10^{-4}
E) 0.81
Answer: A
Diff: 3 Page Ref: Sec. 18.1

2) A sample of air from a home is found to contain 6.2 ppm of carbon monoxide. This means that if the total pressure is 695 torr, then the partial pressure of CO is __________ torr.
A) 4.3×10^3
B) 4.3×10^{-3}
C) 4.3
D) 8.9×10^3
E) 1.1×10^8
Answer: B
Diff: 3 Page Ref: Sec. 18.1

3) The concentration of ozone in Los Angeles is 0.67 ppm on a summer day. This means that if the total pressure is 735 torr, then the partial pressure of O_3 is __________ torr.
A) 4.9×10^2
B) 4.9×10^{-4}
C) 0.49
D) 9.1×10^2
E) 1.1×10^9
Answer: C
Diff: 3 Page Ref: Sec. 18.1

4) The concentration of ozone in a sample of air that has a partial pressure of O_3 of 0.33 torr and a total pressure of air of 735 torr is __________ ppm.
A) 4.5×10^2
B) 0.45
C) 0.045
D) 2.2×10^{-3}
E) 2.2
Answer: A
Diff: 3 Page Ref: Sec. 18.1

5) The mole fraction of carbon dioxide in dry air near sea level is 0.000375, where the molar mass of carbon dioxide is 44.010. The partial pressure of carbon dioxide when the total atmospheric pressure (dry air) is 97.5 kPa is __________ kPa.
A) 2.63×10^5
B) 5.97×10^3
C) 0.0370
D) 1.63
E) 8.40×10^{-4}
Answer: C
Diff: 5 Page Ref: Sec. 18.1

6) The concentration of carbon monoxide in a sample of air is 9.2 ppm. There are __________ molecules of CO in 1.00 L of this air at 755 torr and 23°C.
A) 3.8×10^{-7}
B) 2.2×10^{21}
C) 2.9×10^{18}
D) 1.7×10^{20}
E) 2.3×10^{17}
Answer: E
Diff: 5 Page Ref: Sec. 18.1

7) The mole fraction of neon in dry air near sea level is 1.818×10^{-5} where the molar mass of neon is 20.183. The concentration of neon in the atmosphere is __________ ppm.
A) 5.50×10^{10}
B) 0.001818
C) 1.818×10^4
D) 18.18
E) 1.818×10^{-11}
Answer: D
Diff: 5 Page Ref: Sec. 18.1

8) The mole fraction of oxygen in dry air near sea level is 0.20948. The concentration of oxygen is __________ molecules per liter, assuming an atmospheric pressure of 739 torr and a temperature of 29.5°C.
A) 6.23
B) 0.00819
C) 4.93×10^{21}
D) 3.75×10^{24}
E) 5.07×10^{22}
Answer: C
Diff: 5 Page Ref: Sec. 18.1

9) The dissociation energy of the C–Cl bond in CF_3Cl is 339 kJ/mol. The maximum wavelength of light that has enough energy per photon to dissociate the C–Cl bond is __________ nm.
A) 1130
B) 3.53×10^{-4}
C) 3.53×10^{-7}
D) 3.53×10^{5}
E) 353
Answer: E
Diff: 6 Page Ref: Sec. 18.2

10) The ionization energy of O_2 is 1205 kJ/mol:

$$O_2 + hv \rightarrow O_2^+ + e^-$$

The maximum wavelength of light capable of causing the ionization of O_2 is __________ nm.
A) 4017
B) 9.94×10^{-5}
C) 9.94×10^{-8}
D) 99.4
E) 9.94×10^{4}
Answer: D
Diff: 6 Page Ref: Sec. 18.2

Chemistry, 11e (Brown)
Chapter 19: Chemical Thermodynamics

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.
Use the table below to answer the questions that follow.

Thermodynamic Quantities for Selected Substances at 298.15 K (25°C)

Substance	ΔH°f (kJ/mol)	ΔG°f (kJ/mol)	S (J/K-mol)
Carbon			
C (s, diamond)	1.88	2.84	2.43
C (s, graphite)	0	0	5.69
C_2H_2 (g)	226.7	209.2	200.8
C_2H_4 (g)	52.30	68.11	219.4
C_2H_4 (g)	-84.68	-32.89	229.5
CO (g)	-110.5	-137.2	197.9
CO_2 (g)	-393.5	-394.4	213.6
Hydrogen			
H_2(g)	0	0	130.58
Oxygen			
O_2 (g)	0	0	205.0
H_2O (l)	-285.83	-237.13	69.91

1) The value of ΔS° for the catalytic hydrogenation of acetylene to ethene,

$$C_2H_2\ (g) + H_2\ (g) \rightarrow C_2H_4\ (g)$$

is __________ J/K.
A) +18.6
B) +550.8
C) +112.0
D) -112.0
E) -18.6
Answer: D
Diff: 3 Page Ref: Sec. 19.4

2) The combustion of acetylene in the presence of excess oxygen yields carbon dioxide and water:

$$2C_2H_2\ (g) + 5O_2\ (g) \rightarrow 4CO_2\ (g) + 2H_2O\ (l)$$

The value of ΔS° for this reaction is __________ J/K.
A) +689.3
B) +122.3
C) +432.4
D) -122.3
E) -432.4
Answer: E
Diff: 3 Page Ref: Sec. 19.4

3) The value of $\Delta S°$ for the reaction

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

is __________ J/K.
A) -185.9
B) +185.9
C) -9.5
D) +9.5
E) -195.7
Answer: B
Diff: 3 Page Ref: Sec. 19.4

4) The value of $\Delta S°$ for the catalytic hydrogenation of ethene to ethane,

$$C_2H_4\ (g) + H_2\ (g) \rightarrow C_2H_6\ (g)$$

is __________ J/K.
A) -101.9
B) -120.5
C) -232.5
D) +112.0
E) +101.9
Answer: B
Diff: 3 Page Ref: Sec. 19.4

5) The value of $\Delta S°$ for the catalytic hydrogenation of acetylene to ethane,

$$C_2H_2\ (g) + 2H_2\ (g) \rightarrow C_2H_6\ (g)$$

is __________ J/K.
A) -76.0
B) +440.9
C) -232.5
D) +232.5
E) +28.7
Answer: C
Diff: 3 Page Ref: Sec. 19.4

6) The value of $\Delta S°$ for the oxidation of carbon to carbon monoxide,

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

is __________ J/K. Carbon monoxide is produced in the combustion of carbon with limited oxygen.
A) -12.8
B) +408.6
C) -408.6
D) +179.4
E) +395.8
Answer: D
Diff: 3 Page Ref: Sec. 19.4

7) The value of ΔS° for the oxidation of carbon to carbon dioxide,

$$C\ (s, graphite) + O_2\ (g) \rightarrow CO_2\ (g)$$

is __________ J/K. The combustion of carbon, as in charcoal briquettes, in the presence of abundant oxygen produces carbon dioxide.
A) +424.3
B) +205.0
C) -205.0
D) -2.9
E) +2.9
Answer: E
Diff: 3 Page Ref: Sec. 19.4

8) The combustion of ethene in the presence of excess oxygen yields carbon dioxide and water:

$$C_2H_4\ (g) + 3O_2\ (g) \rightarrow 2CO_2\ (g) + 2H_2O\ (l)$$

The value of ΔS° for this reaction is __________ J/K.
A) -267.4
B) -140.9
C) -347.6
D) +347.6
E) +140.9
Answer: A
Diff: 3 Page Ref: Sec. 19.4

9) The combustion of ethane in the presence of excess oxygen yields carbon dioxide and water:

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

The value of ΔS° for this reaction is __________ J/K.
A) +718.0
B) -620.9
C) -718.0
D) -151.0
E) +151.0
Answer: B
Diff: 3 Page Ref: Sec. 19.4

10) The combustion of hydrogen in the presence of excess oxygen yields water:

$$2H_2\ (g) + O_2(g) \rightarrow 2H_2O\ (l)$$

The value of ΔS° for this reaction is __________ J/K.
A) +405.5
B) -405.5
C) -326.3
D) -265.7
E) +265.7
Answer: C
Diff: 3 Page Ref: Sec. 19.4

Use the table below to answer the questions that follow.

Thermodynamic Quantities for Selected Substances at 298.15 K (25°C)

Substance	ΔH°_f (kJ/mol)	ΔG°_f (kJ/mol)	S (J/K-mol)
Calcium			
Ca (s)	0	0	41.4
$CaCl_2$ (s)	-795.8	-748.1	104.6
Ca_2^+ (aq)	226.7	209.2	200.8
Chlorine			
Cl_2 (g)	0	0	222.96
Cl^- (aq)	-167.2	-131.2	56.5
Oxygen			
O_2 (g)	0	0	205.0
H_2O (l)	-285.83	-237.13	69.91
Phosphorus			
P_2 (g)	144.3	103.7	218.1
PCl_3 (g)	-288.1	-269.6	311.7
$POCl_3$ (g)	-542.2	-502.5	325
Sulfur			
S (s, rhombic)	0	0	31.88
SO_2 (g)	-269.9	-300.4	248.5
SO_3 (g)	-395.2	-370.4	256.2

11) The value of ΔS° for the oxidation of solid elemental sulfur to gaseous sulfur trioxide,

$$2S\text{ (s, rhombic)} + 3O_2\text{ (g)} \rightarrow 2SO_3\text{ (g)}$$

is __________ J/K.
A) +19.3
B) -19.3
C) +493.1
D) -166.4
E) -493.1
Answer: D
Diff: 3 Page Ref: Sec. 19.4

12) The value of ΔS° for the oxidation of solid elemental sulfur to gaseous sulfur dioxide,

$$S\ (s,\ rhombic) + O_2\ (g) \rightarrow SO_2\ (g)$$

is __________ J/K.
A) +485.4
B) +248.5
C) -11.6
D) -248.5
E) +11.6
Answer: E
Diff: 3   Page Ref: Sec. 19.4

13) The value of ΔS° for the decomposition of gaseous sulfur trioxide to solid elemental sulfur and gaseous oxygen,

$$2SO_3\ (g) \rightarrow 2S\ (s,\ rhombic) + 3O_2\ (g)$$

is __________ J/K.
A) +19.3
B) -19.3
C) +493.1
D) +166.4
E) -493.1
Answer: D
Diff: 3   Page Ref: Sec. 19.4

14) The value of ΔS° for the decomposition of gaseous sulfur dioxide to solid elemental sulfur and gaseous oxygen,

$$SO_2\ (g) \rightarrow S\ (s,\ rhombic) + O_2\ (g)$$

is __________ J/K.
A) +485.4
B) +248.5
C) -11.6
D) -248.5
E) +11.6
Answer: C
Diff: 3   Page Ref: Sec. 19.4

15) The value of ΔS° for the formation of $POCl_3$ from its constituent elements,

$$P_2\ (g) + O_2\ (g) + 3Cl_2\ (g) \rightarrow 2POCl_3\ (g)$$

is __________ J/K.
A) -442
B) +771
C) -321
D) -771
E) +321
Answer: A
Diff: 3   Page Ref: Sec. 19.4

16) The value of ΔS° for the decomposition of $POCl_3$ into its constituent elements,

$$2POCl_3\ (g) \rightarrow P_2\ (g) + O_2\ (g) + 3Cl_2\ (g)$$

is __________ J/K.
A) +771
B) +442
C) -321
D) -771
E) +321
Answer: B
Diff: 3 Page Ref: Sec. 19.4

17) The value of ΔS° for the formation of phosphorous trichloride from its constituent elements,

$$P_2\ (g) + 3Cl_2\ (g) \rightarrow 2PCl_3\ (g)$$

is __________ J/K.
A) -311.7
B) +311.7
C) -263.7
D) +129.4
E) -129.4
Answer: C
Diff: 3 Page Ref: Sec. 19.4

18) The value of ΔS° for the decomposition of phosphorous trichloride into its constituent elements,

$$2PCl_3\ (g) \rightarrow P_2\ (g) + 3Cl_2\ (g)$$

is __________ J/K.
A) -311.7
B) +311.7
C) +263.7
D) +129.4
E) -129.4
Answer: C
Diff: 3 Page Ref: Sec. 19.4

19) The value of ΔS° for the formation of calcium chloride from its constituent elements,

$$Ca\ (s) + Cl_2\ (g) \rightarrow CaCl_2\ (s)$$

is __________ J/K.
A) -104.6
B) +104.6
C) +369.0
D) -159.8
E) +159.8
Answer: D
Diff: 3 Page Ref: Sec. 19.4

20) The value of ΔS° for the decomposition of calcium chloride into its constituent elements,

$$CaCl_2\ (s) \rightarrow Ca\ (s) + Cl_2\ (g)$$

is __________ J/K.
A) -104.6
B) +104.6
C) +369.0
D) -159.8
E) +159.8
Answer: E
Diff: 3 Page Ref: Sec. 19.4

21) The value of ΔH° for the oxidation of solid elemental sulfur to gaseous sulfur trioxide,

$$2S\ (s,\ rhombic) + 3O_2\ (g) \rightarrow 2SO_3\ (g)$$

is __________ kJ/mol.
A) +790.4
B) -790.4
C) +395.2
D) -395.2
E) +105.1
Answer: B
Diff: 3 Page Ref: Sec. 19.5

22) The value of ΔH° for the decomposition of gaseous sulfur trioxide to its component elements,

$$2SO_3\ (g) \rightarrow 2S\ (s,\ rhombic) + 3O_2\ (g)$$

is __________ kJ/mol.
A) +790.4
B) -790.4
C) +395.2
D) -395.2
E) +105.1
Answer: A
Diff: 3 Page Ref: Sec. 19.5

23) The value of ΔH° for the oxidation of solid elemental sulfur to gaseous sulfur dioxide,

$$S\ (s,\ rhombic) + O_2\ (g) \rightarrow SO_2\ (g)$$

is __________ kJ/mol.
A) +269.9
B) -269.9
C) +0.00
D) -11.6
E) +11.6
Answer: B
Diff: 3 Page Ref: Sec. 19.5

24) The value of ΔH° for the decomposition of gaseous sulfur dioxide to solid elemental sulfur and gaseous oxygen,

SO_2 (g) → S (s, rhombic) + O_2 (g)

is __________ kJ/mol.
A) +0.0
B) +135.0
C) -135.90
D) -269.9
E) +269.9
Answer: E
Diff: 3 Page Ref: Sec. 19.5

25) The value of ΔH° for the formation of $POCl_3$ from its constituent elements,

P_2 (g) + O_2 (g) + $3Cl_2$ (g) → $2POCl_3$ (g)

is __________ kJ/mol.
A) -1228.7
B) -397.7
C) -686.5
D) +1228.7
E) +686.5
Answer: A
Diff: 3 Page Ref: Sec. 19.5

26) The value of ΔH° for the decomposition of $POCl_3$ into its constituent elements,

$2POCl_3$ (g) → P_2 (g) + O_2 (g) + $3Cl_2$ (g)

is __________ kJ/mol.
A) -1,228.7
B) +1,228.7
C) -940.1
D) +940.1
E) +0.00
Answer: B
Diff: 3 Page Ref: Sec. 19.5

27) The value of ΔH° for the formation of phosphorous trichloride from its constituent elements,

P_2 (g) + $3Cl_2$ (g) → $2PCl_3$ (g)

is __________ kJ/mol
A) -288.1
B) +432.4
C) -720.5
D) +720.5
E) -432.4
Answer: C
Diff: 3 Page Ref: Sec. 19.5

28) The value of $\Delta H°$ for the decomposition of phosphorous trichloride into its constituent elements,

$$2PCl_3 (g) \rightarrow P_2 (g) + 3Cl_2 (g)$$

is __________ kJ/mol.
A) +576.2
B) -288.1
C) +720.5
D) +288.1
E) -720.5
Answer: C
Diff: 3 Page Ref: Sec. 19.5

29) The value of $\Delta H°$ for the formation of calcium chloride from its constituent elements,

$$Ca (s) + Cl_2 (g) \rightarrow CaCl_2 (s)$$

is __________ kJ/mol.
A) +0.00
B) -397.9
C) +397.9
D) -795.8
E) +795.8
Answer: D
Diff: 3 Page Ref: Sec. 19.5

30) The value of $\Delta H°$ for the decomposition of calcium chloride into its constituent elements,

$$CaCl_2 (s) \rightarrow Ca (s) + Cl_2 (g)$$

is __________ kJ/mol.
A) -0.00
B) -397.9
C) +397.9
D) -795.8
E) +795.8
Answer: E
Diff: 3 Page Ref: Sec. 19.5

31) The value of $\Delta G°$ at 25 °C for the oxidation of solid elemental sulfur to gaseous sulfur trioxide,

$$2S (s, rhombic) + 3O_2 (g) \rightarrow 2SO_3 (g)$$

is __________ kJ/mol.
A) +740.8
B) -370.4
C) +370.4
D) -740.8
E) +185.2
Answer: D
Diff: 4 Page Ref: Sec. 19.5

32) The value of ΔG° at 25 °C for the oxidation of solid elemental sulfur to gaseous sulfur dioxide,

$$S\ (s, \text{rhombic}) + O_2\ (g) \rightarrow SO_2\ (g)$$

is __________ kJ/mol.
A) +395.2
B) +269.9
C) -269.9
D) +300.4
E) -300.4
Answer: E
Diff: 4 Page Ref: Sec. 19.5

33) The value of ΔG° at 25 °C for the decomposition of gaseous sulfur trioxide to solid elemental sulfur and gaseous oxygen,

$$2SO_3\ (g) \rightarrow 2S\ (s, \text{rhombic}) + 3O_2\ (g)$$

is __________ kJ/mol.
A) +740.8
B) -370.4
C) +370.4
D) -740.8
E) +185.2
Answer: A
Diff: 4 Page Ref: Sec. 19.5

34) The value of ΔG° at 25 °C for the decomposition of gaseous sulfur dioxide to solid elemental sulfur and gaseous oxygen,

$$SO_2\ (g) \rightarrow S\ (s, \text{rhombic}) + O_2\ (g)$$

is __________ kJ/mol.

A) +395.2
B) +269.9
C) -269.9
D) +300.4
E) -300.4
Answer: D
Diff: 4 Page Ref: Sec. 19.5

35) The value of ΔG° at 25 °C for the formation of $POCl_3$ from its constituent elements,

$$P_2\ (g) + O_2\ (g) + 3Cl_2\ (g) \rightarrow 2POCl_3\ (g)$$

is __________ kJ/mol.
A) -1,109
B) +1,109
C) -606.2
D) +606.2
E) -1,005
Answer: A
Diff: 4 Page Ref: Sec. 19.5

36) The value of ΔG° at 25 °C for the decomposition of $POCl_3$ into its constituent elements,

$$2POCl_3 (g) \rightarrow P_2 (g) + O_2 (g) + 3Cl_2 (g)$$

is __________ kJ/mol.
A) -1,109
B) +1,109
C) -606.2
D) +606.2
E) -1,005
Answer: B
Diff: 4 Page Ref: Sec. 19.5

37) The value of ΔG° at 25 °C for the formation of phosphorous trichloride from its constituent elements,

$$P_2 (g) + 3Cl_2 (g) \rightarrow 2PCl_3 (g)$$

is __________ kJ/mol.
A) -539.2
B) +539.2
C) -642.9
D) +642.9
E) -373.3
Answer: C
Diff: 4 Page Ref: Sec. 19.5

38) The value of ΔG° at 25 °C for the decomposition of phosphorous trichloride into its constituent elements,

$$2PCl_3 (g) \rightarrow P_2 (g) + 3Cl_2 (g)$$

is __________ kJ/mol.
A) -539.2
B) +539.2
C) -642.9
D) +642.9
E) -373.3
Answer: D
Diff: 4 Page Ref: Sec. 19.5

39) The value of ΔG° at 25 °C for the formation of calcium chloride from its constituent elements,

$$Ca (s) + Cl_2 (g) \rightarrow CaCl_2 (s)$$

is __________ kJ/mol.
A) -795.8
B) +795.8
C) +763.7
D) +748.1
E) -748.1
Answer: E
Diff: 4 Page Ref: Sec. 19.5

40) The value of $\Delta G°$ at 25 °C for the decomposition of calcium chloride into its constituent elements,

$$CaCl_2 (s) \rightarrow Ca (s) + Cl_2 (g)$$

is __________ kJ/mol.
A) -795.8
B) +795.8
C) +763.7
D) +748.1
E) -748.1
Answer: D
Diff: 4 Page Ref: Sec. 19.5

41) The value of $\Delta G°$ at 373 °K for the oxidation of solid elemental sulfur to gaseous sulfur dioxide,

$$S (s, rhombic) + O_2 (g) \rightarrow SO_2 (g)$$

is __________ kJ/mol. At 298K, $\Delta H°$ for this reaction is -269.9 kJ/mol, and $\Delta S°$ is +11.6 J/K.
A) -300.4
B) +300.4
C) -4,597
D) +4,597
E) -274.2
Answer: E
Diff: 4 Page Ref: Sec. 19.5

Use the table below to answer the questions that follow.

Thermodynamic Quantities for Selected Substances at 298.15 K (25°C)

Substance	$\Delta H°_f$ (kJ/mol)	$\Delta G°_f$ (kJ/mol)	S (J/K-mol)
Calcium			
Ca (s)	0	0	41.4
$CaCl_2$ (s)	-795.8	-748.1	104.6
Ca_2^+ (aq)	226.7	209.2	200.8
Chlorine			
Cl_2 (g)	0	0	222.96
Cl- (aq)	-167.2	-131.2	56.5
Oxygen			
O_2 (g)	0	0	205.0
H_2O (l)	-285.83	-237.13	69.91
Phosphorus			
P_2 (g)	144.3	103.7	218.1
PCl_3 (g)	-288.1	-269.6	311.7
$POCl_3$ (g)	-542.2	-502.5	325
Sulfur			
S (s, rhombic)	0	0	31.88
SO_2 (g)	-269.9	-300.4	248.5
SO_3 (g)	-395.2	-370.4	256.2

42) The value of $\Delta G°$ at 373 K for the oxidation of solid elemental sulfur to gaseous sulfur trioxide,

$$2S \text{ (s, rhombic)} + 3O_2 \text{ (g)} \rightarrow 2SO_3 \text{ (g)}$$

is __________ kJ/mol.
A) +740.8
B) -61.3
C) -740.8
D) -728.3
E) +61.3
Answer: D
Diff: 4   Page Ref: Sec. 19.6

43) Given the thermodynamic data in the table below, calculate the equilibrium constant for the reaction:

$$2\ SO_2\ (g) + O_2\ (g) \rightleftharpoons 2SO_3\ (g)$$

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

A) 2.32×10^{24}
B) 1.06
C) 1.95
D) 3.82×10^{23}
E) More data are needed.
Answer: A
Diff: 4 Page Ref: Sec. 19.7

44) The equilibrium constant for a reaction is 0.48 at 25 °C. What is the value of ΔG° (kJ/mol) at this temperature?
A) 1.8
B) -4.2
C) 1.5×10^2
D) 4.2
E) More information is needed.
Answer: A
Diff: 4 Page Ref: Sec. 19.7

45) The equilibrium constant for the following reaction is 5.0×10^8 at 25 °C.

$$N_2\ (g) + 3H_2\ (g) \rightleftharpoons 2NH^3\ (g)$$

The value of ΔG° for this reaction is __________ kJ/mol.
A) 22
B) -4.2
C) -25
D) -50
E) -22
Answer: D
Diff: 4 Page Ref: Sec. 19.7

46) Consider the reaction:

$NH^3 (g) + HCl (g) \rightarrow NH_4Cl (s)$

Given the following table of thermodynamic data at 298 ^oK:

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

The value of K for the reaction at 25 °C is __________.
A) 150
B) 9.3×10^{15}
C) 8.4×10^{4}
D) 1.1×10^{-16}
E) 1.4×10^{8}
Answer: B
Diff: 4 Page Ref: Sec. 19.7

47) Consider the reaction:

$FeO (s) + Fe (s) + O_2 (g) \rightarrow Fe_2O_3 (s)$

Given the following table of thermodynamic data at 298 ^oK:

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

The value K for the reaction at 25 °C is __________.
A) 370
B) 5.9×10^{4}
C) 3.8×10^{-14}
D) 7.1×10^{85}
E) 8.1×10^{19}
Answer: D
Diff: 4 Page Ref: Sec. 19.7

48) Consider the reaction:

$$Ag^{+}\,(aq) + Cl^{-}\,(aq) \rightarrow AgCl\,(s)$$

Given the following table of thermodynamic data at 298 ^{o}K:

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

The value of K for the reaction at 25 °C is __________.
A) 810
B) 5.4×10^{9}
C) 1.8×10^{4}
D) 3.7×10^{10}
E) 1.9×10^{-10}
Answer: B
Diff: 4   Page Ref: Sec. 19.7

Multiple-Choice

49) The first law of thermodynamics can be given as __________.
A) $\Delta E = q + w$
B) $\Delta H^{\circ}_{rxn} = \sum n\Delta H^{\circ}_{f}\,(\text{products}) - \sum m\Delta H^{\circ}_{f}\,(\text{reactants})$
C) for any spontaneous process, the entropy of the universe increases
D) the entropy of a pure crystalline substance at absolute zero is zero
E) $\Delta S = q_{rev}/T$ at constant temperature
Answer: A
Diff: 1   Page Ref: Sec. 19.1

50) A reaction that is spontaneous as written __________.
A) is very rapid
B) will proceed without outside intervention
C) is also spontaneous in the reverse direction
D) has an equilibrium position that lies far to the left
E) is very slow
Answer: B
Diff: 1   Page Ref: Sec. 19.1

51) Of the following, only __________ is not a state function.
A) S
B) H
C) q
D) E
E) T
Answer: C
Diff: 2   Page Ref: Sec. 19.1

52) When a system is at equilibrium, __________.
A) the reverse process is spontaneous but the forward process is not
B) the forward and the reverse processes are both spontaneous
C) the forward process is spontaneous but the reverse process is not
D) the process is not spontaneous in either direction
E) both forward and reverse processes have stopped
Answer: D
Diff: 1 Page Ref: Sec. 19.1

53) A reversible process is one that __________.
A) can be reversed with no net change in either system or surroundings
B) happens spontaneously
C) is spontaneous in both directions
D) must be carried out at low temperature
E) must be carried out at high temperature
Answer: A
Diff: 2 Page Ref: Sec. 19.1

54) The thermodynamic quantity that expresses the degree of disorder in a system is __________.
A) enthalpy
B) internal energy
C) bond energy
D) entropy
E) heat flow
Answer: D
Diff: 1 Page Ref: Sec. 19.2

55) For an isothermal process, ΔS = __________.
A) q
B) q_{rev}/T
C) $q$rev
D) Tq_{rev}
E) $q + w$
Answer: B
Diff: 2 Page Ref: Sec. 19.2

56) Which one of the following is always positive when a spontaneous process occurs?
A) ΔS_{system}
B) $\Delta S_{surroundings}$
C) $\Delta S_{universe}$
D) $\Delta H_{universe}$
E) $\Delta H_{surroundings}$
Answer: C
Diff: 2 Page Ref: Sec. 19.2

57) The entropy of the universe is __________.
A) constant
B) continually decreasing
C) continually increasing
D) zero
E) the same as the energy, E
Answer: C
Diff: 1 Page Ref: Sec. 19.2

58) A system that doesn't exchange matter or energy with its surroundings is called an __________ system.
A) adiabatic
B) isolated
C) isothermal
D) isobaric
E) isotonic
Answer: B
Diff: 2 Page Ref: Sec. 19.2

59) The second law of thermodynamics states that __________.
A) $\Delta E = q + w$
B) $\Delta H^\circ_{rxn} = \sum n\Delta H^\circ_f \text{(products)} - \sum m\Delta H^\circ_f \text{ (reactants)}$
C) for any spontaneous process, the entropy of the universe increases
D) the entropy of a pure crystalline substance is zero at absolute zero
E) $\Delta S = q_{rev}/T$ at constant temperature
Answer: C
Diff: 1 Page Ref: Sec. 19.2

60) ΔS is positive for the reaction __________.
A) $2H_2$ (g) + O_2 (g) → $2H_2O$ (g)
B) $2NO_2$ (g) → N_2O_4 (g)
C) CO_2 (g) → CO_2 (s)
D) BaF_2 (s) → Ba^{2+} (aq) + $2F^-$ (aq)
E) 2Hg (l) + O_2 (g) → 2HgO (s)
Answer: D
Diff: 2 Page Ref: Sec. 19.3

61) Which one of the following processes produces a decrease in the entropy of the system?
A) boiling water to form steam
B) dissolution of solid KCl in water
C) mixing of two gases into one container
D) freezing water to form ice
E) melting ice to form water
Answer: D
Diff: 2 Page Ref: Sec. 19.3

62) ΔS is positive for the reaction __________.
A) CaO (s) + CO_2 (g) → $CaCO_3$ (s)
B) N_2 (g) + $3H_2$ (g) → $2NH_3$ (g)
C) $2SO_3$ (g) → $2SO_2$ (g) + O_2 (g)
D) Ag^+ (aq) + Cl^- (aq) → AgCl (s)
E) H_2O (l) → H_2O (s)
Answer: C
Diff: 2 Page Ref: Sec. 19.3

63) Which reaction produces a decrease in the entropy of the system?
A) $CaCO_3$ (s) → CaO (s) + CO_2 (g)
B) 2C (s) + O_2 (g) → 2CO (g)
C) CO_2 (s) → CO_2 (g)
D) $2H_2$ (g) + O_2 (g) → $2H_2O$ (l)
E) H_2O (l) → H_2O (g)
Answer: D
Diff: 2 Page Ref: Sec. 19.3

64) Which reaction produces an increase in the entropy of the system?
A) $Ag^+ (aq) + Cl^- (aq) \rightarrow AgCl (s)$
B) $CO_2 (s) \rightarrow CO_2 (g)$
C) $H_2 (g) + Cl_2 (g) \rightarrow 2 HCl (g)$
D) $N_2 (g) + 3 H_2 (g) \rightarrow 2 NH_3 (g)$
E) $H_2O (l) \rightarrow H_2O (s)$
Answer: B
Diff: 2 Page Ref: Sec. 19.3

65) Which one of the following processes produces a decrease of the entropy of the system?
A) dissolving sodium chloride in water
B) sublimation of naphthalene
C) dissolving oxygen in water
D) boiling of alcohol
E) explosion of nitroglycerine
Answer: C
Diff: 2 Page Ref: Sec. 19.3

66) ΔS is negative for the reaction __________.
A) $2SO_2 (g) + O_2 (g) \rightarrow 2SO_3 (g)$
B) $NH_4Cl (s) \rightarrow NH_3 (g) + HCl (g)$
C) $PbCl_2 (s) \rightarrow Pb^{2+} (aq) + 2Cl^- (aq)$
D) $2C (s) + O_2 (g) \rightarrow 2CO_2 (g)$
E) $H_2O (l) \rightarrow H_2O (g)$
Answer: A
Diff: 2 Page Ref: Sec. 19.3

67) Consider a pure crystalline solid that is heated from absolute zero to a temperature above the boiling point of the liquid. Which of the following processes produces the greatest increase in the entropy of the substance?
A) melting the solid
B) heating the liquid
C) heating the gas
D) heating the solid
E) vaporizing the liquid
Answer: E
Diff: 3 Page Ref: Sec. 19.3

68) Which one of the following correctly indicates the relationship between the entropy of a system and the number of different arrangements, W, in the system?
A) $S = kW$
B) $S = \frac{k}{W}$
C) $S = \frac{W}{k}$
D) $S = k \ln W$
E) $S = Wk$
Answer: D
Diff: 3 Page Ref: Sec. 19.3

69) Of the following, the entropy of __________ is the largest.
A) HCl (l)
B) HCl (s)
C) HCl (g)
D) HBr (g)
E) HI (g)
Answer: E
Diff: 2 Page Ref: Sec. 19.4

70) Of the following, the entropy of gaseous __________ is the largest at 25 °C and 1 atm.
A) H_2
B) C_2H_6
C) C_2H_2
D) CH_4
E) C_2H_4
Answer: B
Diff: 2 Page Ref: Sec. 19.4

71) The standard Gibbs free energy of formation of __________ is zero.

(a) H_2O (l)
(b) O (g)
(c) H_2 (g)

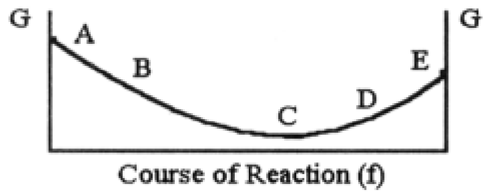
A) (a) only
B) (b) only
C) (c) only
D) (b) and (c)
E) (a), (b), and (c)
Answer: C
Diff: 2 Page Ref: Sec. 19.5

72) The standard Gibbs free energy of formation of __________ is zero.

(a) H_2O (l)
(b) Na (s)
(c) H_2 (g)

A) (a) only
B) (b) only
C) (c) only
D) (b) and (c)
E) (a), (b), and (c)
Answer: D
Diff: 2 Page Ref: Sec. 19.5

73) The equilibrium position corresponds to which letter on the graph of G vs. f (course of reaction) below?



A) A
B) B
C) C
D) D
E) E
Answer: C
Diff: 2 Page Ref: Sec. 19.5

74) For the reaction

$$C(s) + H_2O\ (g) \rightarrow CO(g) + H_2\ (g)$$

$\Delta H° = 131.3$ kJ/mol and $\Delta S° = 133.6$ J/K · mol at 298 K. At temperatures greater than __________°C this reaction is spontaneous under standard conditions.
A) 273
B) 325
C) 552
D) 710
E) 983
Answer: D
Diff: 4 Page Ref: Sec. 19.6

75) For the reaction

$$C_2H_6\ (g) \rightarrow C_2H_4\ (g) + H_2\ (g)$$

$\Delta H°$ is +137 kJ/mol and $\Delta S°$ is +120 J/ K · mol. This reaction is __________.
A) spontaneous at all temperatures
B) spontaneous only at high temperature
C) spontaneous only at low temperature
D) nonspontaneous at all temperatures
Answer: B
Diff: 4 Page Ref: Sec. 19.6

76) A reaction that is not spontaneous at low temperature can become spontaneous at high temperature if ΔH is __________ and ΔS is __________.
A) +, +
B) -, -
C) +, -
D) -, +
E) +, 0
Answer: A
Diff: 3 Page Ref: Sec. 19.6

77) For a reaction to be spontaneous under standard conditions at all temperatures, the signs of ΔH° and ΔS° must be __________ and __________, respectively.
A) +, +
B) +, -
C) -, +
D) -, -
E) +, 0
Answer: C
Diff: 3 Page Ref: Sec. 19.6

78) Given the following table of thermodynamic data,

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

complete the following sentence. The vaporization of PCl_3 (l) is __________.

A) nonspontaneous at low temperature and spontaneous at high temperature
B) spontaneous at low temperature and nonspontaneous at high temperature
C) spontaneous at all temperatures
D) nonspontaneous at all temperatures
E) not enough information given to draw a conclusion
Answer: A
Diff: 5 Page Ref: Sec. 19.6

79) Given the following table of thermodynamic data,

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

complete the following sentence. The vaporization of $TiCl_4$ is __________.

A) spontaneous at all temperatures
B) spontaneous at low temperature and nonspontaneous at high temperature
C) nonspontaneous at low temperature and spontaneous at high temperature
D) nonspontaneous at all temperatures
E) not enough information given to draw a conclusion
Answer: C
Diff: 5 Page Ref: Sec. 19.6

80) Consider the reaction:

$$Ag^{+}\,(aq) + Cl^{-}\,(aq) \rightarrow AgCl\,(s)$$

Given the following table of thermodynamic data,

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

determine the temperature (in °C) above which the reaction is nonspontaneous under standard conditions.

A) 1235
B) 150.5
C) 432.8
D) 133.0
E) 1641
Answer: E
Diff: 4 Page Ref: Sec. 19.6

81) Consider the reaction:

$$NH_3\,(g) + HCl\,(g) \rightarrow NH_4Cl\,(s)$$

Given the following table of thermodynamic data,

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

determine the temperature (in °C) above which the reaction is nonspontaneous.

A) This reaction is spontaneous at all temperatures.
B) 618.1
C) 432.8
D) 345.1
E) 1235
Answer: D
Diff: 4 Page Ref: Sec. 19.6

82) Consider the reaction:

$$FeO\ (s) + Fe\ (s) + O_2\ (g) \rightarrow Fe_2O_3\ (s)$$

Given the following table of thermodynamic data,

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

determine the temperature (in °C) above which the reaction is nonspontaneous.

A) This reaction is spontaneous at all temperatures.
B) 618.1
C) 756.3
D) 2439
E) 1235
Answer: D
Diff: 4 Page Ref: Sec. 19.6

83) With thermodynamics, one cannot determine __________.
A) the speed of a reaction
B) the direction of a spontaneous reaction
C) the extent of a reaction
D) the value of the equilibrium constant
E) the temperature at which a reaction will be spontaneous
Answer: A
Diff: 2 Page Ref: Sec. 19.7

84) If ΔG° for a reaction is greater than zero, then __________.
A) K = 0
B) K = 1
C) K > 1
D) K < 1
E) More information is needed.
Answer: D
Diff: 2 Page Ref: Sec. 19.7

85) Which one of the following statements is true about the equilibrium constant for a reaction if ΔG° for the reaction is negative?
A) K = 0
B) K = 1
C) K > 1
D) K < 1
E) More information is needed.
Answer: C
Diff: 2 Page Ref: Sec. 19.7

Short Answer

1) Calculate $\Delta G°$ (in kJ/mol) for the following reaction at 1 atm and 25°C:

$$C_2H_6\ (g) + O_2\ (g) \rightarrow CO_2\ (g) + H_2O\ (l)$$

$\Delta G_f°$ C_2H_6 (g) = -32.89 kJ/mol; $\Delta G_f°$ CO_2 (g) = -394.4 kJ/mol; $\Delta G_f°$ H_2O (l) = -237.2 kJ/mol
Answer: -2935.0
Diff: 4 Page Ref: Sec. 19.5

2) Calculate $\Delta G°$ (in kJ/mol) for the following reaction at 1 atm and 25°C:

$$C_2H_6\ (g) + O_2\ (g) \rightarrow CO_2\ (g) + H_2O\ (l)$$

$\Delta H_f°$ C_2H_6 (g) = -84.7 kJ/mol; S° C_2H_6 (g) = 229.5 J/K · mol; $\Delta H_f°$ CO_2 (g) = -393.5 kJ/mol;
S° CO_2 (g) = 213.6 J/K · mol; $\Delta H_f°$ H_2O (l) = -285.8 kJ/mol; S° H_2O (l) = 69.9 J/K · mol
Answer: -2935.0
Diff: 5 Page Ref: Sec. 19.5

3) Find the temperature above which a reaction with a ΔH of 123 .0 kJ/mol and a ΔS of 90.00 J/K·mol becomes spontaneous.
Answer: 1367 K
Diff: 5 Page Ref: Sec. 19.6

4) Find the temperature above which a reaction with a ΔH of 53 .00 kJ/mol and a ΔS of 100.0 J/K·mol becomes spontaneous.
Answer: 530 K
Diff: 5 Page Ref: Sec. 19.6

5) Calculate $\Delta G°$ for the autoionization of water at 25°C. $K_w = 1.0 \times 10^{-14}$
Answer: 80 kJ/mol
Diff: 4 Page Ref: Sec. 19.7

True/False

1) The melting of a substance at its melting point is an isothermal process.
Answer: TRUE
Diff: 1 Page Ref: Sec. 19.2

2) The vaporization of a substance at its boiling point is an isothermal process
Answer: TRUE
Diff: 1 Page Ref: Sec. 19.2

3) The quantity of energy gained by a system equals the quantity of energy gained by its surroundings.
Answer: FALSE
Diff: 1 Page Ref: Sec. 19.2

4) The entropy of a pure crystalline substance at 0 °C is zero.
Answer: FALSE
Diff: 2 Page Ref: Sec. 19.3

5) The more negative $\Delta G°$ is for a given reaction, the larger the value of the corresponding equilibrium constant, K.
Answer: TRUE
Diff: 2 Page Ref: Sec 19.7

Algorithmic Questions

1) A common name for methanol (CH_3OH) is wood alcohol. The normal boiling point of methanol is 64.7 °C and the molar enthalpy of vaporization if 71.8 kJ/mol. The value of ΔS when 2.15 mol of CH_3OH (l) vaporizes at 64.7 °C is ________ J/K.
A) 0.457
B) 5.21×10^7
C) 457
D) 2.39×10^3
E) 2.39
Answer: C
Diff: 4 Page Ref: Sec. 19.2

2) The value of $\Delta G°$ at 100.0 °C for the oxidation of solid elemental sulfur to gaseous sulfur dioxide,

$$S\ (s,\ rhombic) + O_2\ (g) \rightarrow SO_2\ (g)$$

is __________ kJ/mol. At 25.0 °C for this reaction, $\Delta H°$ is -269.9 kJ/mol, $\Delta G°$ is -300.4kJ/mol, and $\Delta S°$ is +11.6 J/K.
A) -265.6
B) -1,430
C) -4,598
D) -271.1
E) -274.2
Answer: E
Diff: 4 Page Ref: Sec. 19.5

3) The value of $\Delta G°$ at 141.0 °C for the formation of phosphorous trichloride from its constituent elements,

$$P_2\ (g) + 3Cl_2\ (g) \rightarrow 2PCl_3\ (g)$$

is __________ kJ/mol. At 25.0 °C for this reaction, $\Delta H°$ is -720.5 kJ/mol, $\Delta G°$ is -642.9kJ/mol, and $\Delta S°$ is -263.7J/K.
A) -611.3
B) 3.65×10^4
C) 1.08×10^5
D) -683.3
E) -829.7
Answer: A
Diff: 4 Page Ref: Sec. 19.5

4) The value of $\Delta G°$ at 100.0 °C for the formation of calcium chloride from its constituent elements:

$Ca\ (s) + Cl_2\ (g) \rightarrow CaCl_2\ (s)$

is __________ kJ/mol. At 25.0 °C for this reaction, $\Delta H°$ is -795.8 kJ/mol, $\Delta G°$ is -748.1 kJ/mol, and $\Delta S°$ is -159.8 J/K.
A) -855.4
B) -736.2
C) 5.88×10^4
D) -779.8
E) 1.52×10^4
Answer: B
Diff: 4 Page Ref: Sec. 19.5

5) For a given reaction, ΔH = -19.9 kJ/mol and ΔS = -55.5 J/K-mol. The reaction will have $\Delta G = 0$ at ________K. Assume that ΔH and ΔS do not vary with temperature.
A) 359
B) 2789
C) 298
D) 2.79
E) 0.359
Answer: A
Diff: 4 Page Ref: Sec. 19.6

6) For a given reaction, ΔH = + 35.5 kJ/mol and ΔS = + 83.6 J/K-mol. The reaction is spontaneous __________. Assume that ΔH and ΔS do not vary with temperature.
A) at T < 425 K
B) at T > 425 K
C) at all temperatures
D) at T > 298 K
E) at T < 298 K
Answer: B
Diff: 4 Page Ref: Sec. 19.6

7) In the Haber process, ammonia is synthesized from nitrogen and hydrogen:

$N_2\ (g) + 3H_2\ (g) \rightarrow 2NH_3\ (g)$

$\Delta G°$ at 298 °K for this reaction is -33.3 kJ/mol. The value of ΔG at 298 K for a reaction mixture that consists of 1.9 atm N_2, 1.6 atm H_2, and 0.65 atm NH_3 is __________.
A) -1.8
B) -3.86×10^3
C) -7.25×10^3
D) -104.5
E) -40.5
Answer: E
Diff: 5 Page Ref: Sec. 19.7

8) Phosphorous and chlorine gases combine to produce phosphorous trichloride:

$$P_2\ (g) + 3Cl_2\ (g) \rightarrow 2PCl_3\ (g)$$

$\triangle G°$ at 298 °K for this reaction is -642.9 kJ/mol. The value of $\triangle G$ at 298 K for a reaction mixture that consists of 1.5 atm P_2, 1.6 atm Cl_2, and 0.65 atm PCl_3 is __________.

A) -44.2
B) -3.88×10^3
C) -7.28×10^3
D) -708.4
E) -649.5
Answer: E
Diff: 5 Page Ref: Sec. 19.7

Chemistry, 11e (Brown)
Chapter 20: Electrochemistry

Multiple-Choice and Bimodal

1) The gain of electrons by an element is called __________.
A) reduction
B) oxidation
C) disproportionation
D) fractionation
E) sublimation
Answer: A
Diff: 1 Page Ref: Sec. 20.1

2) __________ is reduced in the following reaction:

$$Cr_2O_7^{2-} + 6S_2O_3^{2-} + 14H^+ \rightarrow 2Cr^{3+} + 3S_4O_6^{2-} + 7H_2O$$

A) $Cr_2O_7^{2-}$
B) $S_2O_3^{2-}$
C) H^+
D) Cr^{3+}
E) $S_4O_6^{2-}$
Answer: A
Diff: 1 Page Ref: Sec. 20.1

3) __________ is the oxidizing agent in the reaction below.

$$Cr_2O_7^{2-} + 6S_2O_3^{2-} + 14H^+ \rightarrow 2Cr^{3+} + 3S_4O_6^{2-} + 7H_2O$$

A) $Cr_2O_7^{2-}$
B) $S_2O_3^{2-}$
C) H^+
D) Cr^{3+}
E) $S_4O_6^{2-}$
Answer: B
Diff: 1 Page Ref: Sec. 20.1

4) Which substance is serving as the reducing agent in the following reaction?

$$14H^+ + Cr_2O_7^{2-} + 3Ni \rightarrow 3Ni^{2+} + 2Cr^{3+} + 7H_2O$$

A) Ni
B) H^+
C) $Cr_2O_7^{2-}$
D) H_2O
E) Ni^{2+}
Answer: A
Diff: 1 Page Ref: Sec. 20.1

5) Which substance is the reducing agent in the reaction below?

$$Pb + PbO_2 + 2H_2SO_4 \rightarrow 2PbSO_4 + 2H_2O$$

A) Pb
B) H_2SO_4
C) PbO_2
D) $PbSO_4$
E) H_2O
Answer: A
Diff: 1 Page Ref: Sec. 20.1

6) What is the oxidation number of chromium in $Cr_2O_7^{2-}$ ion?

A) +3
B) +12
C) +7
D) +6
E) +14
Answer: D
Diff: 1 Page Ref: Sec. 20.1

7) What is the oxidation number of potassium in $KMnO_4$?
A) 0
B) +1
C) +2
D) -1
E) +3
Answer: B
Diff: 1 Page Ref: Sec. 20.1

8) What is the oxidation number of manganese in the MnO_4^{1-} ion?

A) +1
B) +2
C) +5
D) +4
E) +7
Answer: E
Diff: 1 Page Ref: Sec. 20.1

9) What is the oxidation number of manganese in MnO_2?
A) +3
B) +2
C) +1
D) +4
E) +7
Answer: D
Diff: 1 Page Ref: Sec. 20.1

10) __________ electrons appear in the following half-reaction when it is balanced.

$S_4O_6^{2-} \rightarrow 2S_2O_3^{2-}$

A) 6
B) 2
C) 4
D) 1
E) 3
Answer: B
Diff: 2 Page Ref: Sec. 20.2

11) The balanced half-reaction in which chlorine gas is reduced to the aqueous chloride ion is a __________ process.
A) one-electron
B) two-electron
C) four-electron
D) three-electron
E) six-electron
Answer: B
Diff: 1 Page Ref: Sec. 20.2

12) The balanced half-reaction in which dichromate ion is reduced to chromium metal is a __________ process.
A) two-electron
B) six-electron
C) three-electron
D) four-electron
E) twelve-electron
Answer: E
Diff: 2 Page Ref: Sec. 20.2

13) The balanced half-reaction in which dichromate ion is reduced to chromium(III) ion is a __________ process.
A) four-electron
B) twelve-electron
C) three-electron
D) six-electron
E) two-electron
Answer: D
Diff: 1 Page Ref: Sec. 20.2

14) The balanced half-reaction in which sulfate ion is reduced to sulfite ion is a __________ process.
A) four-electron
B) one-electron
C) two-electron
D) three-electron
E) six-electron
Answer: C
Diff: 1 Page Ref: Sec. 20.2

15) The electrode at which oxidation occurs is called the __________.
A) oxidizing agent
B) cathode
C) reducing agent
D) anode
E) voltaic cell
Answer: D
Diff: 1   Page Ref: Sec. 20.3

16) The half-reaction occurring at the anode in the balanced reaction shown below is __________.

$$3MnO_4\text{-}\ (aq) + 24H^+\ (aq) + 5Fe\ (s) \rightarrow 3Mn^{2+}\ (aq) + 5Fe^{3+}\ (aq) + 12H_2O\ (l)$$

A) Mn O_4- (aq) + $8H^+$ (aq) + $5e^-$ → Mn^{2+} (aq) + $4H_2O$ (l)
B) $2MnO_4$- (aq) + $12H^+$ (aq) + $6e^-$ → $2Mn^{2+}$ (aq) + 3 H_2O (l)
C) Fe (s) → Fe^{3+} (aq) + $3e^-$
D) Fe (s) → Fe^{2+} (aq) + $2e^-$
E) Fe^{2+} (aq) → Fe^{3+} (aq) + e^-
Answer: C
Diff: 1   Page Ref: Sec. 20.3

17) In a voltaic cell, electrons flow from the __________ to the __________.
A) salt bride, anode
B) anode, salt bridge
C) cathode, anode
D) salt bridge, cathode
E) anode, cathode
Answer: E
Diff: 1   Page Ref: Sec. 20.3

18) The reduction half reaction occurring in the standard hydrogen electrode is __________.
A) H_2 (g, 1 atm) → $2H^+$ (aq, 1M) + $2e^-$
B) $2H^+$ (aq) + $2OH^-$ → H_2O (l)
C) O_2 (g) + $4H^+$ (aq) + $4e^-$ → $2H_2O$ (l)
D) $2H^+$ (aq, 1M) + $2e^-$ → H_2 (g, 1 atm)
E) $2H^+$ (aq, 1M) + Cl_2 (aq) → 2HCl (aq)
Answer: D
Diff: 1   Page Ref: Sec. 20.4

19) 1V = __________.
A) 1 amp X s
B) 1 J/s
C) 96485 C
D) 1 J/C
E) 1 C/J
Answer: D
Diff: 1   Page Ref: Sec. 20.4

20) The more __________ the value of $E°_{red}$, the greater the driving force for reduction.
A) positive
B) negative
C) exothermic
D) endothermic
E) extensive
Answer: A
Diff: 1 Page Ref: Sec. 20.4

Table 20.2

21) The standard cell potential ($E°_{cell}$) for the voltaic cell based on the reaction below is __________ V.

$$Sn^{2+} (aq) + 2Fe^{3+} (aq) \rightarrow 2Fe^{2+} (aq) + Sn^{4+} (aq)$$

A) +0.46
B) +0.617
C) +1.39
D) -0.46
E) +1.21
Answer: B
Diff: 1 Page Ref: Sec. 20.4

22) The standard cell potential ($E°_{cell}$) for the voltaic cell based on the reaction below is __________ V.

$$Cr (s) + 3Fe^{3+} (aq) \rightarrow 3Fe^{2+} (aq) + Cr^{3+} (aq)$$

A) -1.45
B) +2.99
C) +1.51
D) +3.05
E) +1.57
Answer: C
Diff: 1 Page Ref: Sec. 20.4

23) The standard cell potential ($E°_{cell}$) for the voltaic cell based on the reaction below is __________ V.

$$2Cr (s) + 3Fe^{2+} (aq) \rightarrow 3Fe (s) + 2Cr^{3+} (aq)$$

A) +0.30
B) +2.80
C) +3.10
D) +0.83
E) -0.16
Answer: A
Diff: 1 Page Ref: Sec. 20.4

24) The standard cell potential ($E°_{cell}$) for the voltaic cell based on the reaction below is __________ V.

$$3Sn^{4+} (aq) + 2Cr (s) \rightarrow 2Cr^{3+} (aq) + 3Sn^{2+} (aq)$$

A) +1.94
B) +0.89
C) +2.53
D) -0.59
E) -1.02
Answer: B
Diff: 1 Page Ref: Sec. 20.4

25) The relationship between the change in Gibbs free energy and the emf of an electrochemical cell is given by __________.

A) $\Delta G = \frac{-nF}{E}$
B) $\Delta G = \frac{-E}{nF}$
C) $\Delta G = -nFE$
D) $\Delta G = -nRTF$
E) $\Delta G = \frac{-nF}{ERT}$
Answer: C
Diff: 1 Page Ref: Sec. 20.5

26) The standard cell potential ($E°_{cell}$) of the reaction below is +0.126 V. The value of $\Delta G°$ for the reaction is __________ kJ/mol.

$$Pb (s) + 2H^{+} (aq) \rightarrow Pb^{2+} (aq) + H_2 (g)$$

A) -24
B) +24
C) -12
D) +12
E) -50
Answer: A
Diff: 1 Page Ref: Sec. 20.5

27) The standard cell potential ($E°_{cell}$) for the reaction below is +0.63 V. The cell potential for this reaction is __________ V when $[Zn^{2+}] = 1.0$ M and $[Pb^{2+}] = 2.0 \times 10^{-4}$ M.

$$Pb^{2+} (aq) + Zn (s) \rightarrow Zn^{2+} (aq) + Pb (s)$$

A) 0.52
B) 0.85
C) 0.41
D) 0.74
E) 0.63
Answer: A
Diff: 1 Page Ref: Sec. 20.6

28) The standard cell potential ($E°_{cell}$) for the reaction below is +1.10 V. The cell potential for this reaction is __________ V when the concentration of [Cu2+] = 1.0×10^{-5} M and [Zn^{2+}] = 1.0 M.

$$Zn\ (s) + Cu^{2+}\ (aq) \rightarrow Cu\ (s) + Zn^{2+}\ (aq)$$

A) 1.40
B) 1.25
C) 0.95
D) 0.80
E) 1.10
Answer: C
Diff: 2 Page Ref: Sec. 20.6

29) The lead-containing reactant(s) consumed during recharging of a lead-acid battery is/are __________.
A) Pb (s) only
B) PbO_2 (s) only
C) $PbSO_4$ (s) only
D) both PbO_2 (s) and $PbSO_4$ (s)
E) both Pb (s) and PbO_2 (s)
Answer: C
Diff: 1 Page Ref: Sec. 20.7

30) Galvanized iron is iron coated with __________.
A) magnesium.
B) zinc.
C) chromium.
D) phosphate.
E) iron oxide.
Answer: B
Diff: 1 Page Ref: Sec. 20.8

31) Corrosion of iron is retarded by __________.
A) the presence of salts
B) high pH conditions
C) low pH conditions
D) both the presence of salts and high pH conditions
E) both the presence of salts and low pH conditions
Answer: B
Diff: 1 Page Ref: Sec. 20.8

32) How many minutes will it take to plate out 2.19 g of chromium metal from a solution of Cr^{3+} using a current of 35.2 amps in an electrolyte cell __________ ?
A) 5.77
B) 346
C) 115
D) 1.92
E) 17.3
Answer: A
Diff: 2 Page Ref: Sec. 20.9

33) What current (in A) is required to plate out 1.22 g of nickel from a solution of Ni^{2+} in 1.0 hour __________?
A) 65.4
B) 4.01×10^3
C) 1.11
D) 12.9
E) 2.34
Answer: C
Diff: 2 Page Ref: Sec. 20.9

34) How many grams of Ca metal are produced by the electrolysis of molten $CaBr_2$ using a current of 30.0 amp for 10.0 hours __________?
A) 22.4
B) 448
C) 0.0622
D) 224
E) 112
Answer: D
Diff: 2 Page Ref: Sec. 20.9

35) How many grams of CuS are obtained by passing a current of 12 A through a solution of $CuSO_4$ for 15 minutes __________?
A) 0.016
B) 3.6
C) 7.1
D) 14
E) 1.8
Answer: B
Diff: 2 Page Ref: Sec. 20.9

36) How many seconds are required to produce 1.0 g of silver metal by the electrolysis of a $AgNO_3$ solution using a current of 30 amps __________?
A) 2.7×10^4
B) 3.2×10^3
C) 30
D) 3.7×10^{-5}
E) 60
Answer: C
Diff: 2 Page Ref: Sec. 20.9

37) How many grams of copper will be plated out by a current of 2.3 A applied for 25 minutes to a 0.50-M solution of copper(II) sulfate __________?
A) 1.8×10^{-2}
B) 2.2
C) 1.1
D) 0.036
E) 0.019
Answer: C
Diff: 2 Page Ref: Sec. 20.9

Multiple-Choice

38) Which element is oxidized in the reaction below?

$$Fe(CO)_5\ (l) + 2HI\ (g) \rightarrow Fe(CO)_4I_2\ (s) + CO\ (g) + H_2\ (g)$$

A) Fe
B) C
C) O
D) H
E) I
Answer: A
Diff: 1   Page Ref: Sec. 20.1

39) Which of the following reactions is a redox reaction?

(a) $K_2CrO_4 + BaCl_2 \rightarrow BaCrO_4 + 2KCl$
(b) $Pb_2^{2+} + 2Br^- \rightarrow PbBr$
(c) $Cu + S \rightarrow CuS$

A) (a) only
B) (b) only
C) (c) only
D) (a) and (c)
E) (b) and (c)
Answer: C
Diff: 1   Page Ref: Sec. 20.1

40) Which one of the following reactions is a redox reaction?
A) $NaOH + HCl \rightarrow NaCl + H_2O$
B) $Pb^{2+} + 2Cl^- \rightarrow PbCl_2$
C) $AgNO_3 + HCl \rightarrow HNO_3 + AgCl$
D) $H_2O + NaCl \rightarrow NaOH + HCl$
E) None of the above is a redox reaction.
Answer: E
Diff: 2   Page Ref: Sec. 20.1

41) Which substance is the reducing agent in the following reaction?

$$Fe_2S_3 + 12HNO_3 \rightarrow 2Fe(NO_3)_3 + 3S + 6NO_2 + 6H_2O$$

A) HNO_3
B) S
C) NO_2
D) Fe_2S_3
E) H_2O
Answer: D
Diff: 1   Page Ref: Sec. 20.1

42) What is the coefficient of the permanganate ion when the following equation is balanced?

$MnO_4^- + Br^- \rightarrow Mn^{2+} + Br_2$ (acidic solution)

A) 1
B) 2
C) 3
D) 5
E) 4
Answer: B
Diff: 2 Page Ref: Sec. 20.2

43) What is the coefficient of Fe^{3+} when the following equation is balanced?

$CN^- + Fe^{3+} \rightarrow CNO^- + Fe^{2+}$ (basic solution)

A) 1
B) 2
C) 3
D) 4
E) 5
Answer: B
Diff: 2 Page Ref: Sec. 20.2

44) Which transformation could take place at the anode of an electrochemical cell?
A) $Cr_2O_7^{2-} \rightarrow Cr^{2+}$
B) F_2 to F^-
C) O_2 to H_2O
D) $HAsO_2$ to As
E) None of the above could take place at the anode.
Answer: E
Diff: 1 Page Ref: Sec. 20.3

45) The purpose of the salt bridge in an electrochemical cell is to __________.
A) maintain electrical neutrality in the half-cells via migration of ions.
B) provide a source of ions to react at the anode and cathode.
C) provide oxygen to facilitate oxidation at the anode.
D) provide a means for electrons to travel from the anode to the cathode.
E) provide a means for electrons to travel from the cathode to the anode.
Answer: A
Diff: 1 Page Ref: Sec. 20.3

46) Which transformation could take place at the anode of an electrochemical cell?
A) $NO \rightarrow NO_3^-$
B) $CO_2 \rightarrow C_2O_4^{2-}$
C) $VO^{2+} \rightarrow VO^{2+}$
D) $H_2AsO_4 \rightarrow H_3AsO_3$
E) $O_2 \rightarrow H_2O_2$
Answer: A
Diff: 1 Page Ref: Sec. 20.3

47) Which transformation could take place at the cathode of an electrochemical cell?
A) $MnO_2 \rightarrow MnO_4^-$
B) $Br_2 \rightarrow BrO_3^-$
C) $NO \rightarrow HNO_2$
D) $HSO_4^- \rightarrow H_2SO_3$
E) $Mn^{2+} \rightarrow MnO_4^-$
Answer: D
Diff: 1 Page Ref: Sec. 20.3

Table 20.1

Half Reaction	E°(V)
F_2 (g) + $2e^- \rightarrow 2F^-$ (aq)	+2.87
Cl_2 (g) + $2e^- \rightarrow 2Cl^-$ (aq)	+1.359
Br_2 (l) + $2e^- \rightarrow 2Br^-$ (aq)	+1.065
O_2 (g) + $4H^+$ (aq) + $4e^- \rightarrow 2H_2O$ (l)	+1.23
$Ag^+ + e^- \rightarrow Ag$ (s)	+0.799
Fe^{3+} (aq) + $e^- \rightarrow Fe^{2+}$ (aq)	+0.771
I_2 (s) + $2e^- \rightarrow 2I^-$ (aq)	+0.536
$Cu^{2+} + 2e^- \rightarrow Cu$ (s)	+0.34
$2H^+ + 2e^- \rightarrow H_2$ (g)	0
$Pb^{2+} + 2e^- \rightarrow Pb$ (s)	-0.126
$Ni^{2+} + 2e^- \rightarrow Ni$ (s)	-0.28
$Li^+ + e^- \rightarrow Li$ (s)	-3.05

48) Which of the halogens in Table 20.1 is the strongest oxidizing agent?
A) Cl_2
B) Br_2
C) F_2
D) I_2
E) All of the halogens have equal strength as oxidizing agents.
Answer: C
Diff: 1 Page Ref: Sec. 20.4

49) Which one of the following types of elements is most likely to be a good oxidizing agent?
A) alkali metals
B) lanthanides
C) alkaline earth elements
D) transition elements
E) halogens
Answer: E
Diff: 1 Page Ref: Sec. 20.4

50) Which one of the following is the best oxidizing agent?
A) H_2
B) Na
C) O_2
D) Li
E) Ca
Answer: C
Diff: 1 Page Ref: Sec. 20.4

Table 20.1

Half Reaction	E°(V)
F_2 (g) + $2e^-$ → $2F^-$ (aq)	+2.87
Cl_2 (g) + $2e^-$ → $2Cl^-$ (aq)	+1.359
Br_2 (l) + $2e^-$ → $2Br^-$ (aq)	+1.065
O_2 (g) + $4H^+$ (aq) + $4e^-$ → $2H_2O$ (l)	+1.23
Ag^+ + e^- → Ag (s)	+0.799
Fe^{3+} (aq) + e^- → Fe^{2+} (aq)	+0.771
I_2 (s) + $2e^-$ → $2I^-$ (aq)	+0.536
Cu^{2+} + $2e^-$ → Cu (s)	+0.34
$2H^+$ + $2e^-$ → H_2 (g)	0
Pb^{2+} + $2e^-$ → Pb (s)	-0.126
Ni^{2+} + $2e^-$ → Ni (s)	-0.28
Li^+ + e^- → Li (s)	-3.05

51) Using Table 20.1, which substance can be oxidized by O_2 (g) in acidic aqueous solution?
A) Br_2 (l)
B) Ag (s)
C) Cu^{2+} (aq)
D) Ni^{2+} (aq)
E) Br^- (aq)
Answer: A
Diff: 2 Page Ref: Sec. 20.4

52) Using Table 20.1, which substance can oxidize I^- (aq) to I_2 (s)?
A) Br_2 (l)
B) Ag (s)
C) Cu^{2+} (aq)
D) Ni^{2+} (aq)
E) Br^- (aq)
Answer: A
Diff: 1 Page Ref: Sec. 20.4

Table 20.2

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

53) Which of the following reactions will occur spontaneously as written?
A) Sn^{4+} (aq) + Fe^{3+} (aq) → Sn^{2+} (aq) + Fe^{2+} (aq)
B) 3Fe (s) + $2Cr^{3+}$ (aq) → 2Cr (s) + $3Fe^{2+}$ (aq)
C) Sn^{4+} (aq) + Fe^{2+} (aq) → Sn^{2+} (aq) + Fe (s)
D) $3Sn^{4+}$ (aq) + 2Cr (s) → $2Cr^{3+}$ (aq) + $3Sn^{2+}$ (aq)
E) $3Fe^{2+}$ (aq) → Fe (s) + $2Fe^{3+}$ (aq)
Answer: D
Diff: 2 Page Ref: Sec. 20.5

54) Which of the following reactions will occur spontaneously as written?
A) $3Fe^{2+}$ (aq) + Cr^{3+} (aq) → Cr (s) + $3Fe^{3+}$ (aq)
B) $2Cr^{3+}$ (aq) + $3Sn^{2+}$ (aq) → $3Sn^{4+}$ (aq) + 2Cr (s)
C) Sn^{4+} (aq) + Fe^{2+} (s) → Sn^{2+} (aq) + Fe (s)
D) Sn^{2+} (aq) + Fe^{2+} (s) → Sn^{4+} (aq) + Fe^{3+} (aq)
E) 2Cr (s) + $3Fe^{2+}$ (s) → 3Fe (s) + $2Cr^{3+}$ (aq)
Answer: E
Diff: 1 Page Ref: Sec. 20.5

55) Consider an electrochemical cell based on the reaction:

$$2H^{+} (aq) + Sn (s) \rightarrow Sn^{2+} (aq) + H_2 (g)$$

Which of the following actions would change the measured cell potential?
A) increasing the pH in the cathode compartment
B) lowering the pH in the cathode compartment
C) increasing the [Sn^{2+}] in the anode compartment
D) increasing the pressure of hydrogen gas in the cathode compartment
E) Any of the above will change the measure cell potential.
Answer: E
Diff: 1 Page Ref: Sec. 20.6

56) Consider an electrochemical cell based on the reaction:

$$2H^{+} (aq) + Sn (s) \rightarrow Sn^{2+} (aq) + H_2 (g)$$

Which of the following actions would not change the measured cell potential?
A) lowering the pH in the cathode compartment
B) addition of more tin metal to the anode compartment
C) increasing the tin (II) ion concentration in the anode compartment
D) increasing the pressure of hydrogen gas in the cathode compartment
E) Any of the above will change the measured cell potential.
Answer: B
Diff: 1 Page Ref: Sec. 20.6

57) What is the anode in an alkaline battery __________?
A) MnO_2
B) KOH
C) Zn powder
D) Mn_2O_3
E) Pt
Answer: C
Diff: 1 Page Ref: Sec. 20.7

58) In a lead-acid battery, the electrodes are consumed. In this battery,
A) the anode is Pb.
B) the anode is $PbSO_4$.
C) the anode is PbO_2.
D) the cathode is $PbSO_4$.
E) the cathode is Pb.
Answer: A
Diff: 1 Page Ref: Sec. 20.7

59) Cathodic protection of a metal pipe against corrosion usually entails
A) attaching an active metal to make the pipe the anode in an electrochemical cell.
B) coating the pipe with another metal whose standard reduction potential is less negative than that of the pipe.
C) attaching an active metal to make the pipe the cathode in an electrochemical cell.
D) attaching a dry cell to reduce any metal ions which might be formed.
E) coating the pipe with a fluoropolymer to act as a source of fluoride ion (since the latter is so hard to oxidize).
Answer: C
Diff: 2 Page Ref: Sec. 20.8

60) One of the differences between a voltaic cell and an electrolytic cell is that in an electrolytic cell __________.
A) an electric current is produced by a chemical reaction
B) electrons flow toward the anode
C) a nonspontaneous reaction is forced to occur
D) O_2 gas is produced at the cathode
E) oxidation occurs at the cathode
Answer: C
Diff: 1 Page Ref: Sec. 20.9

Short Answer

1) The most difficult species to reduce and the poorest oxidizing agent is __________.
Answer: lithium ion; Li^+
Diff: 1 Page Ref: Sec 20.5

2) At constant temperature and pressure the Gibbs free energy value is a measure of the __________ of a process.
Answer: spontaneity
Diff: 1 Page Ref: Sec 20.5

3) In the formula $\Delta G = -nFE$, F is the __________.
Answer: Faraday constant or the charge on one mole of electrons
Diff: 1 Page Ref: Sec 20.5

4) The dependence of cell emf on concentration is expressed in the __________.
Answer: Nernst equation
Diff: 1 Page Ref: Sec 20.6

5) A voltaic cell can be constructed of the same species as long as the __________ are different.
Answer: concentrations
Diff: 1 Page Ref: Sec 20.6

6) The potential (E) to move K^+ from the extracellular fluid to the intracellular fluid necessitates work. The sign for this potential is __________.
Answer: negative
Diff: 1 Page Ref: Sec 20.6

7) The anode of the alkaline battery is powdered zinc in a gel that contacts __________.
Answer: KOH; potassium hydroxide
Diff: 1 Page Ref: Sec 20.7

8) The major product of a hydrogen fuel cell is __________.
Answer: water
Diff: 1 Page Ref: Sec 20.7

9) When iron is coated with a thin layer of zinc to protect against corrosion, the iron is said to be __________ .
Answer: galvanized
Diff: 1 Page Ref: Sec 20.7

10) The quantity of charge passing a point in a circuit in one second when the current is one ampere is called a __________.
Answer: coulomb
Diff: 1 Page Ref: Sec 20.9

11) Calculate the number of grams of aluminum produced in 30 minutes by electrolysis of $AlCl_3$ at a current of 12 A.
Answer: 2.01 g
Diff: 1 Page Ref: Sec 20.9

True/False

1) In the equation $2H_2 (g) + O_2 (g) \rightarrow 2H_2O (l)$, hydrogen gives up electrons and is a reductant.
Answer: TRUE
Diff: 1 Page Ref: Sec 20.3

2) The electode where reduction occurs is called the anode.
Answer: FALSE
Diff: 1 Page Ref: Sec 20.3

3) In a voltaic cell electrons flow from the anode to the cathode.
Answer: TRUE
Diff: 1 Page Ref: Sec 20.3

4) When the cell potential is negative in a voltaic cell the cell reaction will not proceed spontaneously.
Answer: TRUE
Diff: 1 Page Ref: Sec 20.4

5) The standard reduction potential, E^{o}_{red}, is proportional to the stoichiometric coefficient.

Answer: FALSE
Diff: 1 Page Ref: Sec 20.4

6) E^{o}_{cell} is the difference between the reduction potential at the cathode and the potential at the anode.

Answer: TRUE
Diff: 1 Page Ref: Sec 20.4

7) The lithium ion battery has more energy per unit mass than nickel-cadmiun batteries.
Answer: TRUE
Diff: 1 Page Ref: Sec 20.7

8) In a half reaction the amount of a substance that is reduced or oxidized is directly proportional to the number of electrons generated in the cell.
Answer: TRUE
Diff: 1 Page Ref: Sec 20.9

9) The standard reduction potential of X is 1.23 V and that of Y is -0.44 V therefore X is oxidized by Y.
Answer: FALSE
Diff: 1 Page Ref: Sec 20.8

10) Disadvantages of the methanol fuel cell compared to the hydrogen fuel cell are consumption of catalyst and environmentally safe product.
Answer: TRUE
Diff: 1 Page Ref: Sec 20.7

11) A positive number for maximum useful work in a spontaneous process (voltaic cell) indicates that the cell will perform work on its surroundings.
Answer: FALSE
Diff: 1 Page Ref: Sec 20.9

Algorithmic Questions

1) The standard cell potential (E°) of a voltaic cell constructed using the cell reaction below is 0.76 V:

$$Zn\ (s) + 2H^+\ (aq) \rightarrow Zn^{2+}\ (aq) + H_2\ (g)$$

With PH_2 = 1.0 atm and $[Zn^{2+}]$ = 1.0 M, the cell potential is 0.66 V. The concentration of H^+ in the cathode compartment is __________ M.
A) 2.0×10^{-2}
B) 4.2×10^{-4}
C) 1.4×10^{-1}
D) 4.9×10^{1}
E) 1.0×10^{-12}
Answer: A
Diff: 3 Page Ref: Sec. 20.6

2) A voltaic cell is constructed with two silver-silver chloride electrodes, where the half-reaction is

$$AgCl\ (s) + e^- \rightarrow Ag\ (s) + Cl^-\ (aq) \qquad E° = +0.222\ V$$

The concentrations of chloride ion in the two compartments are 0.0222 M and 2.22 M, respectively. The cell emf is __________ V.
A) 0.212
B) 0.118
C) 0.00222
D) 22.2
E) 0.232
Answer: B
Diff: 1 Page Ref: Sec. 20.6

3) A voltaic cell is constructed with two Zn^{2+}-Zn electrodes, where the half-reaction is

$$Zn^{2+} + 2e^- \rightarrow Zn\ (s) \qquad E° = -0.763\ V$$

The concentrations of zinc ion in the two compartments are 5.50 M and 1.11×10^{-2} M, respectively. The cell emf is __________ V.
A) -1.54×10^{-3}
B) -378
C) 0.0798
D) 0.160
E) -0.761
Answer: C
Diff: 1 Page Ref: Sec. 20.6

4) The standard emf for the cell using the overall cell reaction below is +2.20 V:

$$2Al\ (s) + 3I_2\ (s) \rightarrow 2Al^{3+}\ (aq) + 6I^-\ (aq)$$

The emf generated by the cell when $[Al^{3+}] = 4.5 \times 10^{-3}$ M and $[I^-] = 0.15$ M is ________V.
A) 2.20
B) 2.30
C) 2.10
D) 2.39
E) 2.23
Answer: B
Diff: 2   Page Ref: Sec. 20.6

5) The standard emf for the cell using the overall cell reaction below is +0.48 V:

$$Zn\ (s) + Ni^{2+}\ (aq) \rightarrow Zn^{2+}\ (aq) + Ni\ (s)$$

The emf generated by the cell when $[Ni^{2+}] = 2.50$ M and $[Zn^{2+}] = 0.100$ M is ________V.
A) 0.40
B) 0.50
C) 0.52
D) 0.56
E) 0.44
Answer: C
Diff: 2   Page Ref: Sec. 20.6

6) How many kilowatt-hours of electricity are used to produce 3.00 kg of magnesium in the electrolysis of molten $MgCl_2$ with an applied emf of 4.50 V?
A) 0.0336
B) 0.0298
C) 7.4
D) 29.8
E) 14.9
Answer: D
Diff: 2   Page Ref: Sec. 20.9

7) The most useful ore of aluminum is bauxite, in which Al is present as hydrated oxides, $Al_2O_3 \cong H_2O$. The number of kilowatt-hours of electricity required to produce 4.0 kg of aluminum from electrolysis of compounds from bauxite is __________ when the applied emf is 5.00 V.
A) 0.0168
B) 0.0596
C) 39.7
D) 19.9
E) 59.6
Answer: E
Diff: 2   Page Ref: Sec. 20.9

8) The town of Natrium, West Virginia, derives its name from the sodium produced in the electrolysis of molten sodium chloride (NaCl) mined from ancient salt deposits. The number of kilowatt-hours of electricity required to produce 4.60 kg of metallic sodium from the electrolysis of molten NaCl(s) is __________ when the applied emf is 4.50 V.
A) 24.1
B) 0.0414
C) 0.0241
D) 48.3
E) 12.1
Answer: A
Diff: 3   Page Ref: Sec. 20.9

9) The electrolysis of molten $AlCl_3$ for 3.25 hr with an electrical current of 15.0 A produces ________g of aluminum metal.
A) 147
B) 0.606
C) 4.55×10^{-3}
D) 16.4
E) 49.1
Answer: D
Diff: 1   Page Ref: Sec. 20.9

10) How many seconds are required to produce 4.00 g of aluminum metal from the electrolysis of molten $AlCl_3$ with an electrical current of 12.0 A?
A) 27.0
B) 9.00
C) 1.19×10^3
D) 2.90×10^5
E) 3.57×10^3
Answer: E
Diff: 2   Page Ref: Sec. 20.9

Chemistry, 11e (Brown)
Chapter 21: Nuclear Chemistry

Multiple-Choice and Bimodal

1) What percentage of electricity generated in the U.S. is from commercial nuclear plants __________?
A) 1%
B) 10%
C) 20%
D) 50%
E) 90%
Answer: C
Diff: 1 Page Ref: Ch. 21 Intro.

2) By what process does thorium-230 decay to radium-226 __________?
A) gamma emission
B) alpha emission
C) beta emission
D) electron capture
E) positron emission
Answer: B
Diff: 1 Page Ref: Sec. 21.1

3) The alpha decay of what isotope of what element produces lead-206?
A) polonium-210
Answer: A
Diff: 2 Page Ref: Sec. 21.1

4) In balancing the nuclear reaction $^{293}_{92}\text{U} \rightarrow {}^{234}_{90}\text{E} + {}^{4}_{2}\text{He}$, the identity of element E is __________.
A) Pu.
B) Np.
C) U.
D) Pa.
E) Th.
Answer: E
Diff: 2 Page Ref: Sec. 21.1

5) This reaction is an example of __________.

$$^{210}_{84}\text{Po} \rightarrow {}^{206}_{82}\text{Pb} + \_\_\_\_\_\_\_\_\_\_$$

A) alpha decay
B) beta emission
C) gamma emission
D) positron emission
E) electron capture
Answer: A
Diff: 1 Page Ref: Sec. 21.1

6) The missing product from this reaction is

$$^{121}_{53}I \rightarrow ^{121}_{52}Te + \_\_\_\_\_\_\_\_\_\_$$

A) $^{4}_{2}He$
B) $^{0}_{-1}e$
C) $^{1}_{0}n$
D) $^{0}_{1}e$
E) $^{0}_{0}\gamma$
Answer: D
Diff: 1 Page Ref: Sec. 21.1

7) This reaction is an example of __________.

$$^{41}_{20}Ca \rightarrow ^{41}_{19}K + \_\_\_\_\_\_\_\_\_\_$$

A) alpha decay
B) beta decay
C) positron decay
D) electron capture
E) gamma emission
Answer: C
Diff: 3 Page Ref: Sec. 21.1

8) The missing product in this reaction would be found in which group of the periodic table?

$$^{24}_{11}Na \rightarrow ^{0}_{-1}e + \_\_\_\_\_\_\_\_\_\_$$

A) 1A
B) 2A
C) 3A
D) 8A
E) 7A
Answer: B
Diff: 1 Page Ref: Sec. 21.1

9) The missing product in this reaction combines with oxygen to form a compound with the formula.

$$^{42}_{19}K \rightarrow \ ^{0}_{-1}e + \_\_\_\_\_\_\_\_\_\_$$

A) M_2O
B) MO
C) MO_2
D) M_2O_3
E) M_3O_2
Answer: B
Diff: 1 Page Ref: Sec. 21.1

10) Radium undergoes alpha decay. The product of this reaction also undergoes alpha decay. What is the product of this second decay reaction __________?
A) Po
B) Rn
C) U
D) Th
E) Hg
Answer: A
Diff: 1 Page Ref: Sec. 21.1

11) 41Ca decays by electron capture. The product of this reaction undergoes alpha decay. What is the product of this second decay reaction __________?
A) Ti
B) Ca
C) Ar
D) Cl
E) Sc
Answer: D
Diff: 2 Page Ref: Sec. 21.1

12) What is the mass number of a neutron __________?
A) 2
B) 1
C) 3
D) 4
E) 0
Answer: B
Diff: 1 Page Ref: Sec. 21.1

13) Nuclei above the belt of stability can lower their neutron-to-proton ratio by________.
A) beta emission.
B) gamma emission.
C) positron emission.
D) electron capture.
E) Any of the above processes will lower the neutron-to-proton ratio.
Answer: A
Diff: 1 Page Ref: Sec. 21.2

14) What is the largest number of protons that can exist in a nucleus and still be stable __________?
A) 206
B) 50
C) 92
D) 83
E) 84
Answer: D
Diff: 1 Page Ref: Sec. 21.2

15) The three radioactive series that occur in nature end with what element __________?
A) Bi
B) U
C) Po
D) Pb
E) Hg
Answer: D
Diff: 1 Page Ref: Sec. 21.2

16) The largest number of stable nuclei have an __________ number of protons and an __________ number of neutrons.
A) even, even
B) odd, odd
C) even, odd
D) odd, even
E) even, equal
Answer: A
Diff: 1 Page Ref: Sec. 21.2

17) In the nuclear transmutation represented by $^{16}_{8}O$ (p, α) $^{13}_{7}N$, the emitted particle is __________.

A) a beta particle.
B) an alpha particle.
C) a proton.
D) a positron.
E) a neutron.
Answer: B
Diff: 1 Page Ref: Sec. 21.3

18) Bombardment of uranium-235 with a neutron generates tellurium-135, 3 neutrons, and __________.
A) zirconium-98.
B) krypton-101.
C) krypton-103.
D) strontium-99.
E) zirconium-99.
Answer: A
Diff: 3 Page Ref: Sec. 21.3

19) The reaction shown below is responsible for creating ^{14}C in the atmosphere. What is the bombarding particle __________?

$$^{14}_{7}N + \_\_\_\_\_\_\_\_\_\_ \rightarrow {}^{14}_{6}C + {}^{1}_{1}H$$

A) alpha particle
B) electron
C) neutron
D) positron
E) proton
Answer: C
Diff: 1   Page Ref: Sec. 21.3

20) How many neutrons are emitted when a californium-249 nucleus (Z=98) is bombarded with a carbon-12 nucleus to produce a $^{257}_{104}Rf$ nucleus __________?

A) one
B) three
C) two
D) four
E) zero
Answer: D
Diff: 1   Page Ref: Sec. 21.3

21) How many neutrons are emitted when a californium-249 nucleus (Z=98) is bombarded with a nitrogen-15 nucleus to produce a $^{260}_{105}Db$ nucleus __________?

A) two
B) three
C) four
D) one
E) zero
Answer: C
Diff: 1   Page Ref: Sec. 21.3

22) What order process is radioactive decay __________?
A) zeroth
B) first
C) second
D) third
E) fourth
Answer: B
Diff: 1   Page Ref: Sec. 21.4

23) ^{131}I has a half-life of 8.04 days. Assuming you start with a 1.53 mg sample of ^{131}I, how many mg will remain after 13.0 days __________?
A) 0.835
B) 0.268
C) 0.422
D) 0.440
E) 0.499
Answer: E
Diff: 2   Page Ref: Sec. 21.4

24) The decay of a radionuclide with a half-life of 4.3×10^5 years has a rate constant (in yr^{-1}) equal to __________.
A) 6.2×10^5
B) 1.6×10^{-6}
C) 2.3×10^{-6}
D) 2.8×10^3
E) 5.9×10^{-8}
Answer: B
Diff: 1 Page Ref: Sec. 21.4

25) Due to the nature of the positron, __________ is actually detected in positron emission tomography.
A) alpha radiation.
B) beta radiation.
C) gamma radiation.
D) x-ray emission.
E) neutron emission.
Answer: C
Diff: 1 Page Ref: Sec. 21.5

26) The mass of a proton is 1.00728 amu and that of a neutron is 1.00867 amu. What is the mass defect (in amu) of a $^{60}_{27}Co$ nucleus? (The mass of a cobalt-60 nucleus is 59.9338 amu.)
A) 27.7830
B) 0.5489
C) 0.5405
D) 0.0662
E) 0.4827
Answer: B
Diff: 2 Page Ref: Sec. 21.6

27) What is the typical percent of uranium-235 in the enriched UO_2 pellets used in nuclear reactors __________?
A) 0.7
B) 1
C) 3
D) 5
E) 14
Answer: C
Diff: 1 Page Ref: Sec. 21.7

28) On average, __________ neutrons are produced by every fission of uranium-235.
A) 4
B) 3.5
C) 1
D) 2.4
E) 2
Answer: D
Diff: 1 Page Ref: Sec. 21.7

29) What drives the turbine in a nuclear power plant __________?
A) the moderator
B) steam
C) the control rods
D) the primary coolant
E) UF_6 gas
Answer: B
Diff: 1 Page Ref: Sec. 21.7

30) Who is credited with first achieving fission of uranium-235 __________?
A) Fermi
B) Rutherford
C) Curie
D) Dalton
E) Faraday
Answer: A
Diff: 1 Page Ref: Sec. 21.7

31) When ionizing radiation enters the body, what is the predominant free radical produced __________?
A) H
B) H_3O
C) protein
D) OH
E) H_2O
Answer: D
Diff: 1 Page Ref: Sec. 21.9

32) The nuclear disintegration series of __________ is the source of radon-222 in soil.
A) ^{235}U
B) ^{238}U
C) ^{236}Pb
D) ^{235}Th
E) ^{14}C
Answer: B
Diff: 1 Page Ref: Sec. 21.9

Multiple-Choice

33) All atoms of a given element have the same
A) mass number.
B) number of nucleons.
C) atomic mass.
D) number of neutrons.
E) atomic number.
Answer: E
Diff: 1 Page Ref: Sec. 21.1

34) Atoms containing radioactive nuclei are called
A) radionuclides.
B) radioisotopes.
C) nucleons.
D) nuclides.
E) radioisophores.
Answer: B
Diff: 1 Page Ref: Sec. 21.1

35) What happens to the mass number and the atomic number of an element when it undergoes beta decay?
A) Neither the mass number nor the atomic number change.
B) The mass number decreases by 4 and the atomic number decreases by 2.
C) The mass number does not change and the atomic number increases by 1.
D) The mass number does not change and the atomic number decreases by 2.
E) The mass number increases by 2 and the atomic number increases by 1.
Answer: C
Diff: 1 Page Ref: Sec. 21.1

36) Which one of the following is a correct representation of a beta particle?
A) $^{4}_{2}e$
B) $^{1}_{0}\beta$
C) $^{0}_{1}e$
D) $^{0}_{-1}e$
E) $^{2}_{4}\beta$
Answer: D
Diff: 1 Page Ref: Sec. 21.1

37) Which one of the following processes results in an increase in the atomic number?
A) gamma emission
B) positron emission
C) beta emission
D) alpha emission
E) corrosion
Answer: C
Diff: 1 Page Ref: Sec. 21.1

38) Of the following processes, which one changes the atomic number?
A) alpha emission
B) beta emission
C) electron capture
D) positron emission
E) All of these processes change the atomic numbers.
Answer: E
Diff: 1 Page Ref: Sec. 21.1

39) Which type of radioactive decay results in no change in mass number and atomic number for the starting nucleus?
A) alpha
B) beta
C) positron emission
D) electron capture
E) gamma
Answer: E
Diff: 1 Page Ref: Sec. 21.1

40) Alpha decay produces a new nucleus whose __________ than those respectively of the original nucleus.
A) atomic number is 2 less and mass number is 2 less
B) atomic number is 1 less and mass number is 2 less
C) atomic number is 2 less and mass number is 4 less
D) atomic number is 2 more and mass number is 4 more
E) atomic number is 2 more and mass number is 2 less
Answer: C
Diff: 2 Page Ref: Sec. 21.1

41) What is the missing product from this reaction?

$$^{32}_{15}P \rightarrow ^{32}_{16}S + \_\_\_\_\_\_\_\_\_\_$$

A) $^{4}_{2}He$

B) $^{0}_{-1}e$

C) $^{0}_{0}\gamma$

D) $^{0}_{1}e$

E) $^{0}_{1}p$

Answer: B
Diff: 1 Page Ref: Sec. 21.1

42) What is the atomic number of a neutron __________?
A) 3
B) 1
C) 2
D) 0
E) 4
Answer: D
Diff: 1 Page Ref: Sec. 21.1

43) What happens to the mass number and the atomic number of an element when it emits gamma radiation?
A) The mass number remains unchanged while the atomic number decreases by one.
B) The mass number decreases by four and the atomic number decreases by two.
C) The mass number increases by four and the atomic number increases by two.
D) The mass number remains unchanged while the atomic number increases by one.
E) The mass number and atomic numbers remain unchanged.
Answer: E
Diff: 1 Page Ref: Sec. 21.1

44) Atoms with the same atomic number and different mass numbers
A) do not exist.
B) are isomers.
C) are isotopes.
D) are allotropes
E) are resonance structures.
Answer: C
Diff: 1 Page Ref: Sec. 21.1

45) How many radioactive decay series exist in nature?
A) 0
B) 1
C) 2
D) 3
E) 10
Answer: D
Diff: 1 Page Ref: Sec. 21.2

46) At approximately what number of protons, or neutrons, does the 1:1 ratio of protons to neutrons start to produce unstable nuclei?
A) 10
B) 20
C) 30
D) 50
E) 80
Answer: B
Diff: 1 Page Ref: Sec. 21.2

47) Which of these nuclides is most likely to be radioactive?
A) $^{39}_{19}K$
B) $^{27}_{13}Al$
C) $^{127}_{53}I$
D) $^{243}_{95}Am$
E) $^{209}_{83}Bi$
Answer: D
Diff: 1 Page Ref: Sec. 21.2

48) What is required for a nuclear transmutation to occur?
A) very high temperature
B) a corrosive environment
C) a particle to collide with a nucleus
D) spontaneous nuclear decay
E) gamma emission
Answer: C
Diff: 1 Page Ref: Sec. 21.3

49) In the nuclear transmutation, $^{16}_{8}O(p, \alpha)^{13}_{7}N$, what is the bombarding particle?
A) an alpha particle
B) a beta particle
C) a gamma photon
D) a proton
E) a phosphorus nucleus
Answer: D
Diff: 1 Page Ref: Sec. 21.3

50) In the nuclear transmutation represented by $^{14}_{7}N(^{1}_{0}n, ^{1}_{1}p)$?, what is the bombarding particle?
A) electron
B) proton
C) alpha particle
D) neutron
E) positron
Answer: D
Diff: 1 Page Ref: Sec. 21.3

51) What is emitted in the nuclear transmutation, ${}^{27}_{13}\text{Al}(n, ?)\,{}^{24}_{11}\text{Na}$?

A) an alpha particle
B) a beta particle
C) a neutron
D) a proton
E) a gamma photon
Answer: A
Diff: 1 Page Ref: Sec. 21.3

52) In the nuclear transmutation represented by ${}^{239}_{94}\text{Pu}({}^{4}_{2}\text{He}, {}^{1}_{0}\text{n})$?, what is the product?

A) uranium-242
B) curium-245
C) curium-242
D) uranium-245
E) uranium-243
Answer: C
Diff: 2 Page Ref: Sec. 21.3

53) In the nuclear transmutation represented by ${}^{14}_{7}\text{N}({}^{1}_{0}\text{n}, {}^{1}_{1}\text{p})$?, what is the emitted particle?

A) neutron
B) proton
C) positron
D) alpha particle
E) electron
Answer: B
Diff: 1 Page Ref: Sec. 21.3

54) In the nuclear transmutation represented by ${}^{14}_{7}\text{N}({}^{1}_{0}\text{n}, {}^{1}_{1}\text{p})$?, what is the product?

A) carbon-12
B) carbon-16
C) carbon-14
D) nitrogen-16
E) nitrogen-15
Answer: C
Diff: 1 Page Ref: Sec. 21.3

55) Which one of the following requires a particle accelerator to occur?
A) ${}^{59}_{26}\text{Fe} \rightarrow {}^{59}_{27}\text{Co} + {}^{0}_{-1}\text{e}$
B) ${}^{59}_{27}\text{Co} + {}^{1}_{0}\text{n} \rightarrow {}^{60}_{27}\text{Co}$
C) ${}^{239}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{239}_{93}\text{Np} + {}^{0}_{-1}\text{e}$
D) ${}^{239}_{94}\text{Pu} + {}^{4}_{2}\text{He} \rightarrow {}^{242}_{96}\text{Cm} + {}^{1}_{0}\text{n}$
E) none of the above
Answer: D
Diff: 1 Page Ref: Sec. 21.3

56) What are the "dees" ion a particle accelerator?
A) vibration places
B) transmutated bees
C) electrodes
D) magnets
E) targets
Answer: C
Diff: 1 Page Ref: Sec. 21.3

57) Bombardment of uranium-238 with a deuteron (hydrogen-2) generates neptunium-237 and __________ neutrons.
A) 1
B) 2
C) 3
D) 4
E) 5
Answer: C
Diff: 2 Page Ref: Sec. 21.3

58) Which of the following correctly represents the transmutation in which neptunium-239 is produced via bombardment of uranium-238 with a neutron?
A) ${}^{238}_{92}\text{U}({}^{1}_{0}\text{n}, {}^{0}_{-1}\text{e})\,{}^{239}_{93}\text{Np}$
B) ${}^{238}_{92}\text{U}({}^{1}_{0}\text{n}, {}^{1}_{1}\text{p})\,{}^{239}_{93}\text{Np}$
C) ${}^{238}_{92}\text{U}({}^{1}_{1}\text{n}, \gamma)\,{}^{239}_{93}\text{Np}$
D) ${}^{238}_{92}\text{U}({}^{1}_{0}\text{n}, {}^{4}_{2}\alpha)\,{}^{239}_{93}\text{Np}$
E) ${}^{238}_{92}\text{U}({}^{1}_{0}\text{n}, {}^{1}_{0}\text{n})\,{}^{239}_{93}\text{Np}$
Answer: A
Diff: 1 Page Ref: Sec. 21.3

59) Which of the following correctly represents the transmutation in which a curium-242 nucleus is bombarded with an alpha particle to produce a californium-245 nucleus?
A) ${}^{242}_{96}\text{Cm}({}^{4}_{2}\text{He}, {}^{1}_{0}\text{n})\,{}^{245}_{98}\text{Cf}$
B) ${}^{242}_{96}\text{Cm}({}^{4}_{2}\text{He}, {}^{1}_{1}\text{p})\,{}^{245}_{98}\text{Cf}$
C) ${}^{242}_{96}\text{Cm}({}^{4}_{2}\text{He}, {}^{1}_{-1}\text{e})\,{}^{245}_{98}\text{Cf}$
D) ${}^{242}_{96}\text{Cm}({}^{1}_{0}\text{n}, {}^{4}_{2}\text{He})\,{}^{245}_{98}\text{Cf}$
E) ${}^{242}_{96}\text{Cm}({}^{4}_{2}\text{He}, 2\,{}^{1}_{1}\text{p})\,{}^{245}_{98}\text{Cf}$
Answer: A
Diff: 1 Page Ref: Sec. 21.3

60) Which one of the following can be done to shorten the half-life of the radioactive decay of uranium-238?
A) freeze it
B) heat it
C) convert it to UF_6
D) oxidize it to the +2 oxidation state
E) none of the above
Answer: E
Diff: 1 Page Ref: Sec. 21.4

61) The beta decay of cesium-137 has a half-life of 30 years. How many years must pass to reduce a 25 mg sample of cesium 137 to 8.7 mg?
A) 46
B) 32
C) 3.2
D) 50
E) 52
Answer: A
Diff: 1 Page Ref: Sec. 21.4

62) The half-life for beta decay of strontium-90 is 28.8 years. A milk sample is found to contain 10.3 ppm strontium-90. How many years would pass before the strontium-90 concentration would drop to 1.0 ppm?
A) 92.3
B) 0.112
C) 186
D) 96.9
E) 131
Answer: D
Diff: 2 Page Ref: Sec. 21.4

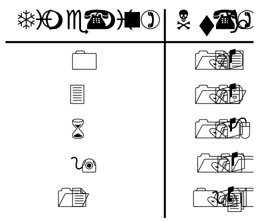
63) The carbon-14 dating method can be used to determine the age of a
A) flint arrowhead.
B) papyrus scroll.
C) stone axe head.
D) clay pot.
E) rock.
Answer: B
Diff: 1 Page Ref: Sec. 21.4

64) The basis for the carbon-14 dating method is that
A) the amount of carbon-14 in all objects is the same.
B) carbon-14 is very unstable and is readily lost from the atmosphere.
C) the ratio of carbon-14 to carbon-12 in the atmosphere is a constant.
D) living tissue will not absorb carbon-14 but will absorb carbon-12.
E) All of the above are correct.
Answer: C
Diff: 1 Page Ref: Sec. 21.4

65) ^{210}Pb has a half-life of 22.3 years and decays to produce ^{206}Hg. If you start with 7.50 g of ^{210}Pb, how many grams of ^{206}Hg will you have after 17.5 years?
A) 4.35
B) 3.15
C) 3.09
D) 0.0600
E) 1.71
Answer: C
Diff: 3 Page Ref: Sec. 21.4

66) The half-life of a radionuclide
A) is constant.
B) gets shorter with passing time.
C) gets longer with passing time.
D) gets shorter with increased temperature.
E) gets longer with increased temperature.
Answer: A
Diff: 1   Page Ref: Sec. 21.4

Consider the following data for a particular radionuclide:



67) What is the rate constant (in min^{-1}) for the decay of this radionuclide?
A) 44.64
B) 30.9
C) 0.0242
D) 0.0324
E) 0.0224
Answer: E
Diff: 2   Page Ref: Sec. 21.4

68) What is the half-life (in min) of this radionuclide?
A) 0.0242
B) 0.0224
C) 30.9
D) 0.0324
E) 44.64
Answer: C
Diff: 2   Page Ref: Sec. 21.4

69) Cesium-137 undergoes beta decay and has a half-life of 30 years. How many beta particles are emitted by a 14.0-g sample of cesium-137 in three minutes?
A) 6.1×10^{13}
B) 6.2×10^{22}
C) 8.4×10^{15}
D) 1.3×10^{-8}
E) 8.1×10^{15}
Answer: E
Diff: 4   Page Ref: Sec. 21.4

70) What is a phosphor?
A) an oxide of phosphorus
B) a substance that thermally reduces to phosphorus
C) a bioluminescent substance
D) a substance that emits light when excited by radiation
E) an alkali metal phosphide
Answer: D
Diff: 1   Page Ref: Sec. 21.5

71) Which one of the following devices converts radioactive emissions to light for detection?
A) Geiger counter
B) photographic film
C) scintillation counter
D) none of the above
E) radiotracer
Answer: C
Diff: 1 Page Ref: Sec. 21.5

72) Which one of the following is used as a radiotracer to study blood?
A) iron-59
B) technetium-99
C) sodium-23
D) iodine-131
E) phosphorus-32
Answer: A
Diff: 1 Page Ref: Sec. 21.5

73) Which one of the following is true?
A) Some spontaneous nuclear reactions are exothermic.
B) Some spontaneous nuclear reactions are endothermic.
C) All spontaneous nuclear reactions are exothermic.
D) There is no relationship between exothermicity and spontaneity in nuclear reactions.
E) All spontaneous nuclear reactions are endothermic.
Answer: C
Diff: 1 Page Ref: Sec. 21.6

74) The mass of a proton is 1.673×10^{-24} g. The mass of a neutron is 1.675×10^{-24} g. The mass of the nucleus of an ^{56}Fe atom is 9.289×10^{-23} g. What is the nuclear binding energy (in J) for ^{56}Fe? ($c = 3.00 \times 10^8$ m/s)
A) 2.57×10^{-16}
B) 7.72×10^{-8}
C) 8.36×10^{-9}
D) 7.72×10^{-11}
E) 6.07×10^{6}
Answer: D
Diff: 2 Page Ref: Sec. 21.6

75) When two atoms of ^2H are fused to form one atom of ^4He, the total energy evolved is 3.38 × 10-12 J. What is the total change in mass (in kg) for this reaction? ($c = 3.00 \times 10^8$ m/s)
A) 1.28×10^{-17}
B) 4.26×10^{-26}
C) 3.45×10^{8}
D) 1.15
E) 4.26×10^{-29}
Answer: E
Diff: 2 Page Ref: Sec. 21.6

76) The mass of a proton is 1.00728 amu and that of a neutron is 1.00867 amu. What is the binding energy (in J) of a $^{60}_{27}$Co nucleus? (The mass of a cobalt-60 nucleus is 59.9338 amu.)
A) 2.735×10^{-19}
B) 9.117×10^{-28}
C) 4.940×10^{-13}
D) 8.206×10^{-11}
E) 2.735×10^{-16}
Answer: D
Diff: 2 Page Ref: Sec. 21.6

77) The mass of a proton is 1.00728 amu and that of a neutron is 1.00867 amu. What is the binding energy per nucleon (in J) of a $^{60}_{27}$Co nucleus? (The mass of a cobalt-60 nucleus is 59.9338 amu.)
A) 1.368×10^{-12}
B) 3.039×10^{-12}
C) 2.487×10^{-12}
D) 9.432×10^{-13}
E) 7.009×10^{-14}
Answer: A
Diff: 2 Page Ref: Sec. 21.6

78) The mass of a proton is 1.00728 amu and that of a neutron is 1.00867 amu. What is the mass defect (in amu) of a $^{60}_{29}$Ni nucleus? (The mass of a nickel-60 nucleus is 59.9308 amu.)
A) 0.5449
B) 1.2374
C) 0.5505
D) 28.7930
E) 1.3066
Answer: C
Diff: 2 Page Ref: Sec. 21.6

79) What type of reaction is known as a thermonuclear reaction?
A) fission
B) fusion
C) transmutation
D) beta emission
E) neutron emission
Answer: B
Diff: 1 Page Ref: Sec. 21.8

80) In terms of binding energy, what element divides fission and fusion processes?
A) H
B) He
C) C
D) Fe
E) U
Answer: D
Diff: 1 Page Ref: Sec. 21.6

81) The main scientific difficulty in achieving a controlled fusion process is the
A) enormous repulsion between nuclei being fused.
B) enormous repulsion between the electrons of atoms being fused.
C) very large number of positrons emitted.
D) very large number of x-rays emitted.
E) very large number of gamma rays emitted.
Answer: A
Diff: 1 Page Ref: Sec. 21.8

82) What exposure level to radiation is fatal to most humans?
A) 100 rem
B) 200 rem
C) 600 rem
D) 300 rem
E) 1000 rem
Answer: C
Diff: 1 Page Ref: Sec. 21.9

83) Which one of the following is not true concerning radon?
A) It decays by alpha emission.
B) It decays to polonium-218, an alpha emitter.
C) It is chemically active in human lungs.
D) It has been implicated in lung cancer.
E) It is generated as uranium decays.
Answer: C
Diff: 1 Page Ref: Sec. 21.9

84) The curie is a measure of the
A) number of disintegrations per second of a radioactive substance.
B) total energy absorbed by an object exposed to a radioactive source.
C) lethal threshold for radiation exposure.
D) number of alpha particles emitted by exactly one gram of a radioactive substance.
E) None of the above is correct.
Answer: A
Diff: 1 Page Ref: Sec. 21.9

85) Which one of the following forms of radiation can penetrate the deepest into body tissue?
A) alpha
B) beta
C) gamma
D) positron
E) proton
Answer: C
Diff: 1 Page Ref: Sec. 21.9

Short Answer

1) What happens in the nucleus of an atom that undergoes positron emission?
Answer: A proton is converted to a neutron and a positron.
Diff: 1 Page Ref: Sec. 21.1

2) What happens to the atomic mass number and the atomic number of a radioisotope when it undergoes alpha emission?
Answer: The mass number drops by 4 and the atomic number decreases by 2.
Diff: 1 Page Ref: Sec. 21.1

3) High speed electrons emitted by an unstable nucleus are __________.
Answer: beta particles
Diff: 1 Page Ref: Sec 21.1

4) ${}^{0}_{-1}e$ represents __________.
Answer: beta emission
Diff: 1 Page Ref: Sec 21.1

5) The only element with no neutrons is __________.
Answer: hydrogen; H
Diff: 1 Page Ref: Sec 21.1

6) What isotope of what element is produced if krypton-81 undergoes beta decay?
Answer: rubidium-81
Diff: 1 Page Ref: Sec. 21.1

7) Stable nuclei with low atomic numbers, up to 20, have a neutron to proton ratio of approximately __________.
Answer: 1
Diff: 1 Page Ref: Sec. 21.2

8) The first nuclear transmutation resulted in the conversion of nitrogen-14 to __________.
Answer: oxygen-17
Diff: 1 Page Ref: Sec. 21.3

9) Conversion of one nucleus into another was first demonstrated in 1919 by __________.
Answer: Rutherford
Diff: 1 Page Ref: Sec 21.3

10) The half-life for the beta decay of potassium-40 is 1.3×10^9 years. What is the rate constant for this decay?
Answer: $t_{1/2} = 0.693/k$
1.3×10^9 years = $0.693/k$
$k = 5.3 \times 10^{-10}$ year^{-1}
Diff: 1 Page Ref: Sec. 21.4

11) The initial element used to make cobalt-60 for cancer radiation therapy is __________.
Answer: iron; Fe
Diff: 1 Page Ref: Sec 21.4

12) __________ discovered radioactivity.
Answer: Becquerel
Diff: 1 Page Ref: Sec 21.5

13) Carbon-11, fluorine-18, oxygen-15 and nitrogen-13 are all used in the clinical diagnostic technique known as __________.
Answer: positron emission tomography; PET
Diff: 1 Page Ref: Sec 21.6

14) What is the source of the tremendous energies produced by nuclear reactions?
Answer: conversion of matter to energy, mass loss
Diff: 1 Page Ref: Sec. 21.6

15) Control rods in a nuclear reactor are composed of boron and __________.
Answer: cadmiun
Diff: 1 Page Ref: Sec 21.7

16) The amount of fissionable material necessary to maintain a chain reactions is called the __________.
Answer: critical mass
Diff: 1 Page Ref: Sec 21.7

17) What was the purpose of the Manhattan project?
Answer: to build a bomb based on nuclear fission
Diff: 1 Page Ref: Sec. 21.7

18) When living tissue is irradiated most of the energy is absorbed by __________.
Answer: water
Diff: 1 Page Ref: Sec 21.9

19) The relative biological effectiveness (RBE) values of beta rays, gamma rays, and alpha rays are, respectively.
Answer: 1, 1, 10
Diff: 1 Page Ref: Sec. 21.9

20) The major type of cancer caused by radiation is _________.
Answer: leukemia
Diff: 1 Page Ref: Sec 21.9

21) Radioactive seeds that are implanted into a tumor are coated with __________ to stop alpha and beta ray penetration.
Answer: platinum
Diff: 1 Page Ref: Sec 21.9

True/False

1) Gamma radiation only changes the atomic number but not the mass number of a nucleus.
Answer: FALSE
Diff: 1 Page Ref: Sec 21.1

2) Positron emission causes a decrease of one in the atomic number.
Answer: TRUE
Diff: 1 Page Ref: Sec 21.1

3) The neutron/proton ratio of stable nuclei increases with increasing atomic number.
Answer: TRUE
Diff: 1 Page Ref: Sec 21.2

4) Charged particles are accelerated because the faster they move there is a greater chance of producing a nuclear reaction.
Answer: TRUE
Diff: 1 Page Ref: Sec 21.3

5) Radioactive decay is a first order kinetic process.
Answer: TRUE
Diff: 1 Page Ref: Sec 21.4

6) In radioactive dating the ratio of carbon-12 to carbon-14 is related to the time of death of the animal or plant under investigation.
Answer: FALSE
Diff: 1 Page Ref: Sec 21.4

7) In the formula $k=0.693/t_{1/2}$, k is the decay constant.
Answer: TRUE
Diff: 1 Page Ref: Sec 21.4

8) The energy produced by the sun is the result of nuclear fusion.
Answer: TRUE
Diff: 1 Page Ref: Sec 21.8

9) The SI unit of an absorbed dose of radiation is the gray.
Answer: TRUE
Diff: 1 Page Ref: Sec 21.9

10) The relative biological effectiveness (RBE) is 10 fold greater for gamma radiation than for alpha radiation.
Answer: FALSE
Diff: 1 Page Ref: Sec 21.9

Essay

1) Electrons do not exist in the nucleus, yet beta emission is ejection of electrons from the nucleus. How does this happen?
Answer: A neutron breaks apart to produce a proton and an electron in the nucleus. The proton remains in the nucleus and the electron is ejected.
Diff: 1 Page Ref: Sec. 21.1

2) List the common particles and their symbols used in descriptions of radioactive decay and nuclear transformations.
Answer:

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

Diff: 2 Page Ref: Sec. 21.1

3) When an isotope undergoes electron capture, what happens to the captured electron?
Answer: It combines with a proton in the nucleus to form a neutron.
Diff: 1 Page Ref: Sec. 21.1

4) The use of radioisotopes in tracing metabolism is possible because __________
Answer: all isotopes of an element have identical chemical properties
Diff: 1 Page Ref: Sec 21.5

Algorithmic Questions

1) The half-life of cobalt-60 is 5.2 yr. How many milligrams of a 2.000-mg sample remains after 6.55 years?
A) 0.837
B) 3.23×10^{-15}
C) 4.779
D) 1.588
E) 1.163
Answer: A
Diff: 3 Page Ref: Sec. 21.4

2) Strontium-90 is a byproduct in nuclear reactors fueled by the radioisotope uranium-235. The half-life of strontium-90 is 28.8 yr. What percentage of a strontium-90 sample remains after 75.0 yr?
A) 68.1
B) 16.5
C) 7.40
D) 38.4
E) 2.60
Answer: B
Diff: 3 Page Ref: Sec. 21.4

3) Carbon-11 is used in medical imaging. The half-life of this radioisotope is 20.4 min. What percentage of a sample remains after 60.0 min?
A) 71.2
B) 5.28
C) 13.0
D) 34.0
E) 2.94
Answer: C
Diff: 3 Page Ref: Sec. 21.4

4) A rock contains 0.313 mg of lead-206 for each milligram of uranium-238. The half-life of for the decay of uranium-238 to lead-206 is 4.5×10^9 yr. The rock was formed __________ yr ago.
A) 1.41×10^9
B) 1.08×10^9
C) 1.39×10^9
D) 2.00×10^9
E) 1.56×10^9
Answer: D
Diff: 4 Page Ref: Sec. 21.4

5) Potassium-40 decays to argon-40 with a half-life of 1.27×10^9 yr. The age of a mineral sample that has a mass ratio of ^{40}Ar to ^{40}K of 0.812 is __________ yr.
A) 1.56×10^9
B) 1.02×10^9
C) 1.47×10^9
D) 7.55×10^8
E) 1.09×10^9
Answer: E
Diff: 4 Page Ref: Sec. 21.4

6) If we start with 1.000 g of strontium-90, 0.908 g will remain after 4.00 yr. This means that the half-life of strontium-90 is __________ yr.
A) 3.05
B) 4.40
C) 28.8
D) 3.63
E) 41.6
Answer: C
Diff: 4 Page Ref: Sec. 21.4

7) If we start with 1.000 g of cobalt-60, 0.675 g will remain after 3.00 yr. This means that the half-life of cobalt-60 is __________ yr.
A) 3.08
B) 4.44
C) 2.03
D) 5.30
E) 7.65
Answer: D
Diff: 4 Page Ref: Sec. 21.4

8) A freshly prepared sample of curium-243 undergoes 3312 disintegrations per second. After 6.00 yr, the activity of the sample declines to 2755 disintegrations per second. The half-life of curium-243 is
A) 4.99
B) 32.6
C) 7.21
D) 0.765
E) 22.6
Answer: E
Diff: 4 Page Ref: Sec. 21.4

9) Carbon-11 decays by positron emission:

$$^{11}_{6}\mathrm{C} \rightarrow {}^{11}_{5}\mathrm{B} + {}^{0}_{1}\mathrm{e}$$

The decay occurs with a release of 2.87×10^{11} J per mole of carbon-11. When 4.00 g of carbon-11 undergoes this radioactive decay, __________ g of mass is converted to energy.
A) 1.16×10^{-3}
B) 3.48×10^{5}
C) 1.16×10^{-6}
D) 8.62×10^{2}
E) 1.28×10^{-2}
Answer: A
Diff: 5 Page Ref: Sec. 21.6

10) How much energy is produced when 0.082 g of matter is converted to energy?
A) 7.4×10^{18}
B) 7.4×10^{12}
C) 2.5×10^{4}
D) 7.4×10^{15}
E) 2.5×10^{7}
Answer: B
Diff: 4 Page Ref: Sec. 21.6

Chemistry, 11e (Brown)
Chapter 22: Chemistry of the Nonmetals

Multiple-Choice and Bimodal

1) Of the atoms below, __________ is the most effective in forming π bonds.
A) C
B) P
C) N
D) Si
E) Ge
Answer: A
Diff: 1 Page Ref: Sec. 22.1

2) The most common isotope of hydrogen is sometimes referred to as __________.
A) deuterium
B) protium
C) tritium
D) heavy hydrogen
E) common hydrogen
Answer: B
Diff: 1 Page Ref: Sec. 22.2

3) In metallic hydrides, the oxidation number of hydrogen is considered to be __________.
A) -2
B) -1
C) 0
D) +1
E) +2
Answer: B
Diff: 1 Page Ref: Sec. 22.2

4) Hydrogen can form hydride ions. Elements in group __________ typically form ions with the same charge as the hydride ion.
A) 1A
B) 2A
C) 6A
D) 7A
E) 3A
Answer: D
Diff: 1 Page Ref: Sec. 22.2

5) Hydrogen can combine with __________ to form a metallic hydride.
A) an element from group 5A
B) an element from group 7A
C) an element from group 8A
D) an element from group 1B
E) an element from group 6A
Answer: D
Diff: 1 Page Ref: Sec. 22.2

6) Hydrogen can have oxidation states of __________.
A) +1 only
B) -1, 0, and +1
C) 0 and +1 only
D) -1 and +1 only
E) 0 only
Answer: B
Diff: 1 Page Ref: Sec. 22.2

7) __________ has the lowest boiling point of any substance known.
A) Ne
B) He
C) Ar
D) Kr
E) Rn
Answer: B
Diff: 1 Page Ref: Sec. 22.3

8) The electron-pair geometry and molecular geometry of $XeFe_2$ are __________ and __________, respectively.
A) trigonal bipyramidal; bent
B) trigonal bipyramidal; linear
C) trigonal bipyramidal; bent
D) octahedral; linear
E) octahedral; bent
Answer: B
Diff: 1 Page Ref: Sec. 22.3

9) Hybridization of Xe in XeF_4 is __________ and in XeF_2 is __________.
A) sp^3d^2, sp^3d^2
B) sp^3d, sp^3d^2
C) sp^3d^2, sp^3d
D) sp^3, sp^3d
E) sp^3, sp^3d^2
Answer: C
Diff: 2 Page Ref: Sec. 22.3

10) The number of electrons in the valence shell of Xe in $XeFe_6$ is __________
A) 10
B) 12
C) 14
D) 6
E) 8
Answer: C
Diff: 1 Page Ref: Sec. 22.3

11) What is the oxidation state of xenon in XeO_2F_2 __________?
A) 0
B) +4
C) +8
D) +2
E) +6
Answer: E
Diff: 2 Page Ref: Sec. 22.3

12) What is the oxidation state of xenon in XeO_4 __________?
A) +8
B) +6
C) +4
D) +2
E) 0
Answer: A
Diff: 2 Page Ref: Sec. 22.3

13) Br_2 can be prepared by combining NaBr with __________.
A) Cl_2
B) HBr
C) HCl
D) NaCl
E) I_2
Answer: A
Diff: 1   Page Ref: Sec. 22.4

14) The silver salt of __________ is used extensively in production of photographic film.
A) fluorine
B) chlorine
C) bromine
D) iodine
E) astatine
Answer: C
Diff: 1   Page Ref: Sec. 22.4

15) Which halogen can react with fluorine to form the compound XF_7 __________?
A) bromine
B) fluorine
C) chlorine
D) iodine
E) astatine
Answer: D
Diff: 2   Page Ref: Sec. 22.4

16) Which halogen forms an oxyacid with the formula HXO_2 __________?
A) bromine
B) fluorine
C) chlorine
D) iodine
E) astatine
Answer: C
Diff: 1   Page Ref: Sec. 22.4

17) The primary commercial use of oxygen is __________.
A) for the treatment of respiratory distress
B) in oxyacetylene welding
C) as a household bleach
D) as an oxidizing agent
E) to charge oxygen-containing cylinders used by deep-sea divers
Answer: D
Diff: 1   Page Ref: Sec. 22.5

18) The most active metals react with oxygen to form __________.
A) oxides
B) superoxides
C) peroxides
D) ozonides
E) water
Answer: B
Diff: 1   Page Ref: Sec. 22.5

19) The dissolution of 1.0 mol of __________ to 1.0 L of water at 25°C would yield the most acidic solution.
A) SO_3
B) CO_2
C) CO
D) MgO
E) CaO
Answer: A
Diff: 1 Page Ref: Sec. 22.6

20) The nitride ion is a strong Brønsted-Lowry base. Mg_3N_2 reacts with water to produce __________.
A) N_2
B) N_2O
C) NO
D) NO_2
E) NH_3
Answer: E
Diff: 1 Page Ref: Sec. 22.7

21) The primary commercial use of elemental nitrogen is in the manufacture of __________.
A) plastics
B) explosives
C) nitrogen-containing fertilizers
D) rubber
E) chlorine bleach
Answer: C
Diff: 1 Page Ref: Sec. 22.7

22) What is the coefficient of NO_2 when the following disproportionation reaction is balanced __________ ?

$$NO_2\,(g) + H_2O\,(l) \rightarrow H^+\,(aq) + NO_3^-\,(aq) + NO\,(g)$$

A) 1
B) 2
C) 3
D) 5
E) 4
Answer: C
Diff: 1 Page Ref: Sec. 22.7

23) Of the following substances, __________ is both a strong acid and a strong oxidizing agent.
A) HNO_3
B) H_2SO_4
C) HCl
D) H_3PO_4
E) HF
Answer: A
Diff: 1 Page Ref: Sec. 22.7

24) The Haber process is used to make __________ from __________.
A) HNO_3, N_2
B) O_2, $KClO_3$
C) NH_3, N_2
D) NO_2, O_2
E) NO, N_2
Answer: C
Diff: 1 Page Ref: Sec. 22.7

25) Most mined phosphate rock is __________.
A) used as a strong acid
B) used as a reducing agent
C) used as a detergent
D) converted to fertilizer
E) discarded as a by-product
Answer: D
Diff: 1 Page Ref: Sec. 22.8

26) The white allotropic form of __________ bursts into flame when exposed to air.
A) phosphorus
B) carbon
C) sulfur
D) selenium
E) oxygen
Answer: A
Diff: 1 Page Ref: Sec. 22.8

27) The two allotropic forms of phosphorus are __________ and __________.
A) black and red
B) white and black
C) white and yellow
D) white and red
E) black and yellow
Answer: D
Diff: 1 Page Ref: Sec. 22.8

28) The principal combustion products of compounds containing carbon and hydrogen in the presence of excess O_2 are __________.
A) CO_2 and H_2O
B) CO_2 and H_2O_2
C) CO_2 and H
D) C(graphite) and H_2
E) CO_2 and H_2
Answer: A
Diff: 1 Page Ref: Sec. 22.9

29) __________ is produced when coal is heated strongly in the absence of air.
A) Buckminsterfullerene
B) Carbon black
C) Sulfur dioxide
D) Coke
E) Charcoal
Answer: D
Diff: 1 Page Ref: Sec. 22.9

30) To produce carbon black, __________.
A) diamond is exposed to extremely high pressures and temperatures
B) wood is strongly heated in the absence of oxygen
C) coal is strongly heated in the absence of oxygen
D) hydrocarbons such as methane are heated in a very limited supply of oxygen
E) graphite is cooled to -273°C
Answer: D
Diff: 1 Page Ref: Sec. 22.9

31) The major commercial use of carbon dioxide is __________.
A) manufacture of washing soda
B) manufacture of baking soda
C) refrigeration
D) production of carbonated beverages
E) production of fertilizers
Answer: D
Diff: 1 Page Ref: Sec. 22.9

32) Although $CaCO_3$ is essentially insoluble in pure water, it dissolves slowly in acidic ground water due to formation of __________.
A) insoluble $Ca(OH)_2$
B) soluble $Ca(OH)_2$
C) insoluble $Ca(HCO_3)_2$
D) soluble $Ca(HCO_3)_2$
E) soluble CaO
Answer: D
Diff: 1 Page Ref: Sec. 22.9

33) The compound whose formula is CaC_2 is __________.
A) calcium carbide
B) carborundum
C) carbon calcide
D) calcium dicarbon
E) limestone
Answer: A
Diff: 1 Page Ref: Sec. 22.9

34) The addition of solid potassium cyanide to aqueous hydrochloric acid will produce __________.
A) H_2O
B) HCN
C) NH_3
D) K_2CO_3
E) K_2C_2
Answer: B
Diff: 1 Page Ref: Sec. 22.9

35) An example of a form of pure carbon that contains only sp^3 hybridized carbon atoms is __________.
A) diamond
B) charcoal
C) graphite
D) carbon black
E) carborundum
Answer: A
Diff: 1 Page Ref: Sec. 22.9

36) What is the oxidation state of carbon in the carbonate ion __________?
A) +4
B) +2
C) 0
D) -2
E) -4
Answer: A
Diff: 1 Page Ref: Sec. 22.9

37) The correct name of H_2CO_3 is __________.
A) hydrogen carbide
B) hydrogen carbonate ion
C) carbonate ion
D) carbonic acid
E) carboxylic acid
Answer: D
Diff: 1 Page Ref: Sec. 22.9

38) The most common oxidation state of silicon is __________.
A) -4
B) +2
C) +6
D) -2
E) none of the above
Answer: E
Diff: 3 Page Ref: Sec. 22.10

39) Pyrex® glass is formed by adding an oxide of __________ to soda-lime glass.
A) lead
B) cobalt
C) boron
D) silver
E) phosphorous
Answer: C
Diff: 1 Page Ref: Sec. 22.10

40) SiO_4^{4-} is the __________ ion.
A) orthosilicate ion
B) silicate ion
C) thiosilicate ion
D) silicon tetroxide ion
E) siliconate ion
Answer: A
Diff: 1 Page Ref: Sec. 22.10

41) The oxidation of silicon in SiO_4^{4-} is __________.
A) 0
B) +6
C) +2
D) +4
E) -4
Answer: D
Diff: 1 Page Ref: Sec. 22.10

42) The disilicate ion is __________.
A) $Si_2O_8^{8-}$
B) $Si_2O_7^{6-}$
C) $Si_2O_8^{4-}$
D) $Si_2O_8^{6-}$
E) $Si_2O_7^{2-}$
Answer: B
Diff: 2 Page Ref: Sec. 22.10

43) Glass is __________ whereas quartz is __________.
A) hard, soft
B) crystalline, amorphous
C) amorphous, crystalline
D) pure SiO_2, a mixture of SiO_2 and carbonates
E) breakable, not breakable
Answer: C
Diff: 1 Page Ref: Sec. 22.10

44) What is the formula of borax __________?
A) H_3BO_3
B) $H_2B_4O_7$
C) P_5O_8
D) B_2O_3
E) $Na_2B_4O_7 \cdot 10H_2O$
Answer: E
Diff: 1 Page Ref: Sec. 22.11

45) Which group 3A element is a metalloid __________?
A) B
B) Al
C) Ga
D) In
E) Tl
Answer: A
Diff: 1 Page Ref: Sec. 22.11

46) Tetraboric acid, $H_2B_4O_7$, is prepared by heating boric acid, H_3BO_3 (a condensation reaction involving water loss). If 400 mmol H_3BO_3 are used, what mass (g) of H_2O is formed, assuming quantitative stoichiometric conversion __________?
A) 5.77
B) 0.500
C) 0.320
D) 7.21
E) 9.01
Answer: E
Diff: 1 Page Ref: Sec. 22.11

47) Diborane is __________.
A) $B_{10}H_{14}$
B) H_2O_3
C) BH_3
D) B_2H_6
E) H_3BO_3
Answer: D
Diff: 1 Page Ref: Sec. 22.11

48) Boric oxide is __________.
A) B_2O
B) BO_2
C) BO
D) B_2O_3
E) B_2O_4
Answer: D
Diff: 1   Page Ref: Sec. 22.11

49) The correct name for the BH_4^- ion is __________.
A) borate.
B) boride.
C) borohydride.
D) borite.
E) hydroboride.
Answer: C
Diff: 1   Page Ref: Sec. 22.11

Multiple-Choice

50) In a group of nonmetals, which element(s) is (are) most likely to be form stable π bonds?
A) the bottom element
B) the top element
C) the middle element
D) the second element
E) None of them, nonmetals do not do this.
Answer: B
Diff: 1   Page Ref: Sec. 22.1

51) How many oxygen atoms are bonded to each silicon atom in SiO_2?
A) 1
B) 2
C) 3
D) 4
E) none
Answer: B
Diff: 1   Page Ref: Sec. 22.1

52) The least electronegative of the elements below is __________.
A) I
B) Cl
C) H
D) F
E) Br
Answer: C
Diff: 1   Page Ref: Sec. 22.1

53) In the following chemical equation

$$Na_3P + 3H_2O \rightarrow$$

the products (when the equation is balanced) are
A) H_2PO_3 + 3NaH
B) NaOH + 3PH
C) 3NaH + POH_3
D) 3NaO + PH_6
E) 3NaOH + PH_3
Answer: E
Diff: 1   Page Ref: Sec. 22.1

54) Which one of the following is false concerning tritium?
A) It is radioactive, emitting alpha particles with a half-life of 12.3 yr.
B) It can be produced by neutron bombardment of lithium-6.
C) It is formed continuously in the upper atmosphere.
D) It has the same chemical properties as protium but reacts more slowly.
E) The atomic number of tritium is 1.
Answer: A
Diff: 1   Page Ref: Sec. 22.2

55) What method is used to produce the most hydrogen gas in the United States?
A) electrolysis of water
B) reaction of zinc with acid
C) reaction of methane with steam
D) reaction of coke (carbon) with steam
E) reaction of metallic sodium with water
Answer: C
Diff: 1   Page Ref: Sec. 22.2

56) What is the primary commercial use of hydrogen in the United States?
A) as a rocket fuel, especially on the space shuttle
B) hydrogenation of vegetable oils
C) manufacture of methanol
D) manufacture of ammonia by the Haber process
E) as an automobile fuel
Answer: D
Diff: 1   Page Ref: Sec. 22.2

57) Of the following, which is an ionic hydride?
A) BaH_2
B) LiH
C) CaH_2
D) SrH_2
E) all of the above
Answer: E
Diff: 1   Page Ref: Sec. 22.2

58) Which compound would produce an acidic aqueous solution?
A) KH
B) CaH_2
C) H_2S
D) NH_3
E) H_2O
Answer: C
Diff: 1 Page Ref: Sec. 22.2

59) Which compound would produce a basic aqueous solution?
A) MgH_2
B) H_2S
C) HCl
D) HI
E) CH_3OH
Answer: A
Diff: 1 Page Ref: Sec. 22.2

60) Isotopes of hydrogen
A) have the same atomic number and different mass numbers.
B) have the same atomic number and the same mass number.
C) have different atomic numbers and different mass numbers.
D) have different atomic numbers and the same mass number.
E) are exactly alike.
Answer: A
Diff: 1 Page Ref: Sec. 22.2

61) Which of the following would produce a basic solution?

Na_2O MgO CO CO_2 BeH_2

A) CO and CO_2
B) Na_2O and MgO
C) Na_2O, MgO, and BeH_2
D) BeH_2O only
E) CO, CO_2, and BeH_2
Answer: C
Diff: 1 Page Ref: Sec. 22.2

62) Which of the following would produce an acidic solution?

Na_2O MgO CO CO_2 BeH_2

A) Na_2O and MgO
B) Na_2O, MgO, and BeH_2
C) CO_2 only
D) BeH_2 only
E) CO, CO_2, and BeH_2
Answer: C
Diff: 1 Page Ref: Sec. 22.2

63) How are the oxygen-containing compounds of xenon made?
A) by direct combination of the elements
B) by reaction of xenon with peroxide
C) by thermal decomposition of the xenon hydroxide
D) by reaction of the corresponding xenon fluoride with water
E) Xenon is inert and does not form compounds with oxygen.
Answer: D
Diff: 1 Page Ref: Sec. 22.3

64) Of the following compounds, which is the most stable?
A) XeF_6
B) $XeOF_4$
C) XeO_3
D) XeO_2F_2
E) XeF_2
Answer: A
Diff: 1 Page Ref: Sec. 22.3

65) What is the F–Xe–F bond angle in XeF_2?
A) 90°
B) 109°
C) 180°
D) 120°
E) 60°
Answer: C
Diff: 1 Page Ref: Sec. 22.3

66) Consider the following xenon compounds:

(i) XeF_2 (ii) XeF_4 (iii) XeO_4 (iv) $XeOF_4$ (v) XeO_3

Which of the compounds is(are) polar?
A) (i) only
B) (ii) and (iii)
C) (iv) only
D) (iii) and (iv)
E) (iv) and (v)
Answer: E
Diff: 1 Page Ref: Sec. 22.3

67) The heavier noble gases are more reactive than the lighter ones because
A) the lighter noble gases exist as diatomic molecules.
B) the lighter noble gases have complete octets.
C) the heavier noble gases are more abundant.
D) the heavier noble gases have low ionization energies relative to the lighter ones.
E) the heavier noble gases have greater electron affinities.
Answer: D
Diff: 1 Page Ref: Sec. 22.3

68) Which noble gas is known to form a variety of binary compounds?
A) Xe
B) He
C) Ne
D) Ar
E) Kr
Answer: A
Diff: 1 Page Ref: Sec. 22.3

69) Interhalogen compounds __________.
A) are exceedingly reactive
B) contain halogens in both positive and negative oxidation states
C) that contain fluorine are powerful oxidizing agents
D) are very active fluorinating agents
E) all of the above
Answer: E
Diff: 1 Page Ref: Sec. 22.4

70) Which elemental halogen(s) can be used to prepare I_2 from NaI?
A) F_2 only
B) Cl_2 only
C) Br_2 only
D) both Cl_2 and Br_2, but not F_2
E) F_2, Cl_2, and Br_2
Answer: E
Diff: 1 Page Ref: Sec. 22.4

71) Which equation correctly represents the reaction between elemental fluorine and sodium iodide?
A) $F + NaI \rightarrow I + NaF$
B) $F^- + NaI \rightarrow I^- + NaF$
C) $F_2 + 2NaI \rightarrow I_2 + 2NaF$
D) $F + NaI \rightarrow 1/2I_2 + NaF$
E) $F_2 + NaI \rightarrow NaF_2 + I^-$
Answer: C
Diff: 1 Page Ref: Sec. 22.4

72) The interhalogen compound ICl_3 can form but $BrCl_3$ cannot form. This is because
A) iodine is large enough to accommodate three chlorine atoms around itself
B) bromine is not electronegative enough to react with chlorine.
C) bromine is too electronegative to react with chlorine.
D) iodine can have a positive oxidation state but bromine cannot.
E) iodine can have a negative oxidation state but bromine cannot.
Answer: A
Diff: 1 Page Ref: Sec. 22.4

73) Chlorine can have a positive oxidation state
A) if it combines with bromine or iodine.
B) if it combines with oxygen or fluorine.
C) if it combines with hydrogen.
D) if it combines with an alkali metal.
E) in its elemental form.
Answer: B
Diff: 2 Page Ref: Sec. 22.4

74) The oxidation state of fluorine in its compounds is
A) positive unless it combines with another halogen.
B) negative unless it combines with another halogen.
C) negative unless it combines with oxygen.
D) negative unless it combines with an active metal.
E) always negative.
Answer: E
Diff: 1 Page Ref: Sec. 22.4

75) The most stable allotrope of oxygen is __________.
A) H_2O
B) O_3
C) O_2
D) HClO
E) O
Answer: C
Diff: 1 Page Ref: Sec. 22.5

76) Nearly all commercial oxygen is obtained __________.
A) from air
B) by electrolysis of water
C) by thermal decomposition of potassium chlorate
D) by thermal cracking of petroleum
E) as a byproduct of the preparation of aluminum in the Hall process
Answer: A
Diff: 1 Page Ref: Sec. 22.5

77) Which of the following statements is false?
A) Ozone is a better reducing agent than O_2 (g).
B) Ozone is produced by passing electricity through dry O_2 (g).
C) Ozone oxidizes all of the common metals except gold and platinum.
D) Ozone decomposes to O_2 and O.
E) Ozone is an allotrope of oxygen.
Answer: A
Diff: 1 Page Ref: Sec. 22.5

78) Which one of the following compounds is peroxide?
A) Li_2O
B) H_2O
C) Na_2O_2
D) CsO_2
E) both Na_2O_2 and CsO_2
Answer: C
Diff: 1 Page Ref: Sec. 22.5

79) A disproportionation reaction is one in which
A) a single element is both oxidized and reduced.
B) a compound is separated into its constituent elements.
C) the ratio of combination of two elements in a compound changes.
D) aqueous ions combine to form an insoluble salt.
E) an insoluble salt separates into ions.
Answer: A
Diff: 1 Page Ref: Sec. 22.5

80) The oxidation state of oxygen in O_2F_2 is
A) 0
B) +2
C) +1
D) -1
E) -2
Answer: C
Diff: 1 Page Ref: Sec. 22.5

81) The oxidation state of oxygen in OF_2 is
A) +1
B) +2
C) 0
D) -1
E) -2
Answer: B
Diff: 1 Page Ref: Sec. 22.5

82) Metal oxides are typically __________ while nonmetal oxides are typically __________.
A) basic, amphoteric
B) basic, acidic
C) amphoteric, basic
D) acidic, basic
E) amphoteric, acidic
Answer: B
Diff: 1 Page Ref: Sec. 22.5

83) Which element in group 6A is not found in compounds with an expanded valence shell?
A) oxygen
B) selenium
C) tellurium
D) polonium
E) sulfur
Answer: A
Diff: 1 Page Ref: Sec. 22.6

84) Which group 6A element is not commonly found in a positive oxidation state?
A) sulfur
B) selenium
C) oxygen
D) tellurium
E) polonium
Answer: C
Diff: 1 Page Ref: Sec. 22.6

85) What is the major commercial source of elemental sulfur?
A) sulfide minerals
B) sulfate minerals
C) underground deposits of elemental sulfur
D) seawater
E) coal and petroleum
Answer: C
Diff: 1 Page Ref: Sec. 22.6

86) Which form of elemental sulfur is the most stable at room temperature?
A) rhombic sulfur
B) monoclinic
C) hexagonal
D) triclinic
E) tetraclinic
Answer: A
Diff: 1 Page Ref: Sec. 22.6

87) The molecular shape of the SF_6 molecule is __________.
A) tetrahedral
B) trigonal bipyramidal
C) octahedral
D) trigonal pyramidal
E) T-shaped
Answer: C
Diff: 1 Page Ref: Sec. 22.6

88) The prefix "thio" denotes
A) replacement of an oxygen atom by a sulfur atom.
B) a sulfur–sulfur double bond.
C) sulfur in a negative oxidation state.
D) a sulfur–oxygen double bond.
E) an allotropic form of sulfur.
Answer: A
Diff: 1 Page Ref: Sec. 22.6

89) The oxidation numbers of sulfur in the sulfate ion, sulfite ion, sulfur trioxide, and hydrogen sulfide are __________, __________, __________, and __________, respectively.
A) +4, -2, +4, +6
B) +6, +2, +4, +6
C) +6, +4, +6, -2
D) +4, +6, +4, -2
E) -2, +6, -2, 0
Answer: C
Diff: 1 Page Ref: Sec. 22.6

90) The pentahydrated salt of sodium thiosulfate, $Na_2S_2O_3 \cdot 5H_2O$, is used in photographic developing to convert __________.
A) insoluble AgBr to insoluble $Na_3[Ag(S_2O_3)_2]$
B) insoluble AgBr to soluble $Na_3[Ag(S_2O_3)_2]$
C) insoluble AgBr to insoluble $Ag_2S_2O_3$
D) insoluble AgBr to soluble $Ag_2S_2O_3$
E) soluble AgBr to insoluble $Ag_2S_2O_3$
Answer: B
Diff: 1 Page Ref: Sec. 22.6

91) Which one of the following is sodium thiosulfate?
A) Na_2SO_4
B) Na_2SO_3
C) $Na_2S_2O_3$
D) Na_2S4O_6
E) Na_2S
Answer: C
Diff: 1 Page Ref: Sec. 22.7

92) Which one of the following is false concerning pure hydrazine?
A) It is an oily, colorless liquid.
B) It can be made by reaction of hypochlorite and ammonia.
C) It is used as a rocket fuel.
D) Hydrazine is quite poisonous.
E) It is a clear, red liquid that is highly viscous.
Answer: E
Diff: 1 Page Ref: Sec. 22.7

93) The careful, thermal decomposition of solid ammonium nitrate will yield __________.
A) N_2O
B) NO
C) NO_2
D) N_2O_3
E) N_2O_5
Answer: A
Diff: 1 Page Ref: Sec. 22.7

94) The primary commercial use of nitric acid is __________.
A) in the manufacture of plastics
B) in the manufacture of explosives
C) in pool water maintenance
D) in the manufacture of fertilizers
E) in the manufacture of anti-depressant drugs
Answer: D
Diff: 1 Page Ref: Sec. 22.7

95) Which of the following is the nitride ion?
A) N^{3-}
B) N_3^-
C) NO_3^-
D) NO_2^-
E) N^-
Answer: A
Diff: 1 Page Ref: Sec. 22.7

96) Which of the following equations correctly represents the combustion of hydrazine?
A) N_2H_4 (l) + O_2 (g) → NH_3 (g) + HNO_2 (g)
B) N_2H_4 (l) + $2O_2$ (g) → $2NO_2$ (g) + $2H_2$ (g)
C) N_2H_4 (l) + O_2 (g) → $2H_2NO$ (g)
D) N_2H_4 (l) + O_2 (g) → N_2 (g) + $2H_2O$ (g)
E) N_2H_4 (l) + O_2 (g) → N_2 (g) + $2H_2$ (g) + O_2 (g)
Answer: D
Diff: 1 Page Ref: Sec. 22.7

97) Which pair of formula/name is incorrect?
A) NO / nitric oxide
B) N_2O / nitrous oxide
C) NO_2 / nitrogen dioxide
D) N_2O_4 / dinitrogen trioxide
E) N_2O_5 / dinitrogen pentoxide
Answer: D
Diff: 1 Page Ref: Sec. 22.7

98) The oxidation numbers of nitrogen in the nitride ion, hydrazine, ammonium cation, and nitrate ion are __________, __________, __________, and __________, respectively.
A) -3, -2, -3, +5
B) +3, -2, -3, +5
C) +3, -2, +1, +3
D) -3, +2, +1, +5
E) -3, +2, -3, +3
Answer: A
Diff: 2 Page Ref: Sec. 22.7

99) Which equation correctly represents what happens when NO_2 dissolves in water?
A) NO_2 (g) + H_2O (l) → $2H^+$ (aq) + NO_3^- (aq)
B) $3NO_2$ (g) + H_2O (l) → $2H^+$ (aq) + $2NO_3^-$ (aq) + NO (g)
C) NO_2 (g) + H_2O (l) → H_2O_2 (aq) + NO (g)
D) $2NO_2$ (g) + H_2O (l) → $2H^+$ (aq) + NO_4^{2-} (aq) + NO (g)
E) $2NO_2$ (g) + $2H_2O$ (l) → 2 HNO_2 (aq) + O_2 (g) + H_2 (g)
Answer: B
Diff: 1 Page Ref: Sec. 22.7

100) The reaction between nitrogen dioxide and water is a
A) decomposition
B) combustion
C) disproportionation
D) neutralization
E) replacement
Answer: C
Diff: 2 Page Ref: Sec. 22.7

101) In the reaction of phosphorus with chlorine to form a phosphorus chloride, whether PCl_3 or PCl_5 forms depends on
A) which allotropic form of phosphorus is used.
B) the amount of chlorine present.
C) whether the reaction is carried out in the gas phase or in solution.
D) whether the chlorine used is molecular or atomic.
E) the amount of moisture present.
Answer: B
Diff: 1 Page Ref: Sec. 22.8

102) Which of the following approaches will produce PF_3 reliably?
A) PF_5 (g) → PF_3 (g) + F_2 (g)
B) P (s) + (excess) F_2 (g) → PF_3 (g) + (excess) F_2 (g)
C) PCl_3 (l) + AsF_3 (l) → PF_3 (g) + $AsCl_3$ (l)
D) $2PCl_3$ (l) + (excess) F_2 (g) → $2PF_3$ (g) + $3Cl_2$ (g) + (excess) F_2 (g)
E) none of these approaches will produce PF_3
Answer: C
Diff: 2 Page Ref: Sec. 22.8

103) What are the products of the reaction of PF_3 (g) and water?
A) phosphorous acid and hydrofluoric acid
B) elemental phosphorus and hydrofluoric acid
C) phosphoric acid and fluorine gas
D) elemental phosphorus and fluorine gas
E) phosphoric acid and phosphorous acid
Answer: A
Diff: 1 Page Ref: Sec. 22.8

104) What are the products of the reaction of PCl_3 (g) and water?
A) phosphoric acid and phosphorous acid
B) elemental phosphorus and hydrochloric acid
C) phosphoric acid and chlorine gas
D) elemental phosphorus and chlorine gas
E) phosphoric acid and hydrochloric acid
Answer: E
Diff: 1 Page Ref: Sec. 22.8

105) Which one of the following is false concerning buckminsterfullerene?
A) It is the most recently discovered crystalline allotrope of carbon.
B) It consists of individual molecules like C_{60} and C_{70}.
C) It is a molecular form of carbon.
D) It is made up of Cl_2 molecules.
E) It is made up of molecules that resemble soccer balls.
Answer: D
Diff: 1 Page Ref: Sec. 22.9

106) Of the following, which is most likely to form interstitial carbides?
A) active metals
B) transition metals
C) boron and silicon
D) alkaline earth metals
E) alkali metals
Answer: B
Diff: 1 Page Ref: Sec. 22.9

107) Which of the following would produce the most strongly acidic aqueous solution?
A) HCO_3^-
B) CO
C) CO_2
D) CO_3^{2-}
E) $CaCO_3$
Answer: C
Diff: 1 Page Ref: Sec. 22.9

108) Which of the following is not an allotropic form of carbon?
A) graphite
B) diamond
C) carbide
D) buckminsterfullerene
E) All of the above are allotropic forms of carbon.
Answer: C
Diff: 1 Page Ref: Sec. 22.9

109) A carbonyl compound contains
A) a carbon-oxygen double bond
B) a carbon-oxygen triple bond
C) a carbon atom with a lone pair of electrons
D) a carbon-carbon triple bond
E) a carbon-carbon double bond
Answer: A
Diff: 1 Page Ref: Sec. 22.9

110) Carbon dioxide is produced
A) in blast furnaces when metal oxides are reduced with CO.
B) by combustion of carbon-containing substances in an excess of oxygen.
C) when carbonates are heated.
D) by fermentation of sugar during the production of ethanol.
E) by all of these processes.
Answer: E
Diff: 1 Page Ref: Sec. 22.9

111) Which of the following would produce the most strongly basic aqueous solution?
A) CO
B) CO_3^{2-}
C) CO_2
D) HCO_3^-
E) $NaHCO_3$
Answer: B
Diff: 1 Page Ref: Sec. 22.9

112) Which equation correctly represents the reaction between carbon dioxide and water?
A) $CO_2\ (aq) + H_2O\ (l) \rightarrow H_2CO_3\ (aq)$
B) $CO_2\ (aq) + H_2O\ (l) \rightarrow H_2\ (g) + CO\ (g) + O_2\ (g)$
C) $CO_2\ (aq) + H_2O\ (l) \rightarrow H_2O_2\ (aq) + CO\ (g)$
D) $CO_2\ (aq) + 2H_2O\ (l) \rightarrow CH_4\ (g) + 2O_2\ (aq)$
E) $CO_2\ (aq) + H_2O\ (l) \rightarrow H_2CO\ (aq) + O_2\ (g)$
Answer: A
Diff: 1 Page Ref: Sec. 22.9

113) What is the function of the carbon fibers in a composite?
A) to provide a structure to help the epoxy resin solidify in the desired shape
B) to transmit loads evenly in all directions
C) to provide resistance to oxidation
D) to provide ultraviolet protection
E) to "spread out" the epoxy so that it remains more flexible
Answer: B
Diff: 1 Page Ref: Sec. 22.9

114) The arrangement of oxygen atoms around a silicon atom in SiO_4^{4-} is
A) square planar
B) octahedral
C) linear
D) tetrahedral
E) trigonal pyramidal
Answer: D
Diff: 2 Page Ref: Sec. 22.10

115) Addition of B_2O_3 to soda-lime glass
A) imparts a greater ability to withstand temperature change.
B) imparts a deep blue color.
C) results in a denser glass with a higher refractive index.
D) results in a glass with a lower melting point.
E) results in opaque glass.
Answer: A
Diff: 1 Page Ref: Sec. 22.10

116) Replacement of Na_2O by K_2O in soda-lime glass results in
A) opaque glass.
B) a softer glass with a lower melting point.
C) glass with a deep blue color.
D) denser glass with a high refractive index.
E) a harder glass with a higher melting point.
Answer: E
Diff: 1 Page Ref: Sec. 22.10

117) Replacement of CaO by PbO in soda-lime glass results in
A) denser glass with a high refractive index.
B) glass with a deep blue color.
C) opaque glass.
D) a softer glass with a lower melting point.
E) a harder glass with a higher melting point.
Answer: A
Diff: 1 Page Ref: Sec. 22.10

118) Soda-lime glass contains
A) SiO_2 and aluminum
B) SiO_2, CaO, and Na_2O
C) SiO_2, CO_2, and citric acid
D) SiO_2, CO_2, Na_2O
E) pure SiO_2
Answer: B
Diff: 1 Page Ref: Sec. 22.10

119) Additives can be used in soda-lime glass to alter its __________.
A) ability to withstand temperature change
B) color
C) hardness
D) melting point
E) any of the above
Answer: E
Diff: 1 Page Ref: Sec. 22.10

120) Silicones are
A) chains of alternating silicon and oxygen atoms with attached organic groups.
B) three-dimensional covalent networks of SiO_4 tetrahedra.
C) three-dimensional covalent networks of silicon atoms.
D) flat sheets of silicon atoms.
E) flat sheets of silicon and hydrogen atoms.
Answer: A
Diff: 1 Page Ref: Sec. 22.10

121) Silicones can be oils or rubber-like materials depending on
A) the silicon-to-oxygen ratio.
B) the length of the chain and degree of cross-linking.
C) the percentage of carbon in the chain.
D) the percentage of sulfur in the chain.
E) the oxidation state of silicon in the chain.
Answer: B
Diff: 1 Page Ref: Sec. 22.10

122) Sodium borohydride, $NaBH_4$, is a strong reducing agent because __________.
A) Na^+ is easily reduced to Na (s).
B) boron easily changes its oxidation number from +3 to -3
C) boron is readily oxidized from -3 oxidation state to +3
D) hydrogen can be easily oxidized from -1 oxidation state to +1
E) hydrogen is easily reduced from +1 oxidation state to 0
Answer: D
Diff: 1 Page Ref: Sec. 22.11

123) Which one of the following is true concerning borax?
A) It is the hydrated sodium salt of tetraboric acid.
B) It is found in dry lake deposits in California.
C) Its aqueous solutions are alkaline.
D) It is commonly used in cleaning products.
E) All of the above are true.
Answer: E
Diff: 1 Page Ref: Sec. 22.11

124) A borane is a
A) compound containing only boron and oxygen.
B) compound containing only boron and aluminum.
C) compound containing only boron and hydrogen.
D) compound containing only boron and carbon.
E) three-dimensional covalent network of boron atoms.
Answer: C
Diff: 1 Page Ref: Sec. 22.11

125) Which of the following equations correctly represents the reaction of B_2H_6 with oxygen?
A) B_2H_6 (g) + $3O_2$ (g) → B_2O_3 (s) + $3H_2O$ (g)
B) B_2H_6 (g) + O_2 (g) → B_2O_2 (s) + $3H_2$ (g)
C) B_2H_6 (g) + $2O_2$ (g) → B_2H_2 (s) + $2H_2O_2$ (aq)
D) B_2H_6 (g) + $2O_2$ (g) → B_2O_2 (s) + $3H_2O$ + O_2 (g)
E) B_2H_6 (g) + O_2 (g) → $H_2B_2O_2$ (s) + $2H_2$ (g)
Answer: A
Diff: 1 Page Ref: Sec. 22.11

126) Boron can violate the octet rule in its compounds in that
A) it can have an expanded octet.
B) it can exist in a molecule with an odd number of electrons.
C) its compounds are all ionic.
D) it can have fewer than eight valence electrons.
E) boron cannot violate the octet rule.
Answer: D
Diff: 2 Page Ref: Sec. 22.11

127) B_2O_3 is the anhydride of
A) borous acid
B) diborane
C) tetraboric acid
D) boric acid
E) borax
Answer: D
Diff: 1 Page Ref: Sec. 22.11

128) Boric acid condenses to form tetraboric acid according to the equation
A) $4H_3BO_3$ (s) → $2H_2B_2O_7$ (s) + $3H_2O$ (g).
B) 2 H_3BO_3 (s) → HB_2O_2 (s) + $4H_2O$ (g).
C) 4 H_3BO_3 (s) → HB_4O_8 (s) + $4H_2O$ (g).
D) 2 H_3BO_3 (s) → $H_2B_4O_7$ (s) + $3H_2O$ (g).
E) 4 H_3BO_3 (s) → $H_2B_4O_7$ (s) + $5H_2O$ (g).
Answer: E
Diff: 1 Page Ref: Sec. 22.11

Short Answer

1) What are the three crystalline allotropes of carbon?
Answer: diamond, graphite, and buckminsterfullerene
Diff: 1 Page Ref: Sec. 22.1

2) Of Li, K, P and Ne which is the least electronegative?
Answer: K; potassium
Diff: 1 Page Ref: Sec 22.1

3) In a proton transfer reaction the weaker a Brønsted-Lowry acid the __________ is its conjugate.
Answer: stronger
Diff: 1 Page Ref: Sec 22.1

4) D_2O is known as __________.
Answer: heavy water
Diff: 1 Page Ref: Sec 22.2

5) H_2 is reacted with __________ to produce methanol.
Answer: CO; carbon monoxide
Diff: 1 Page Ref: Sec 22.2

6) What noble gas is radioactive?
Answer: radon
Diff: 1 Page Ref: Sec 22.3

7) Of the non radioactive halogens which is the largest?
Answer: iodine
Diff: 1 Page Ref: Sec 22.4

8) In a hypohalous acid the oxidation state of the halogen is __________.
Answer: +1
Diff: 1 Page Ref: Sec 22.4

9) Write the correctly balanced equation for the reaction between elemental fluorine and sodium iodide.
Answer: F_2 + 2 NaI → I_2 + 2NaF
Diff: 1 Page Ref: Sec. 22.4

10) Write the correctly balanced equation for the reaction between elemental iodine and sodium bromide.
Answer: I_2 + NaBr → no reaction
Diff: 1 Page Ref: Sec. 22.4

11) The acid and salts of which halogen-oxyanion are the most stable?
Answer: perchlorate
Diff: 2 Page Ref: Sec. 22.4

12) What anion containing Cl is used as a rocket fuel?
Answer: perchlorate
Diff: 1 Page Ref: Sec 22.4

13) Astatine decays by __________.
Answer: electron capture
Diff: 1 Page Ref: Sec 22.4

14) What is the oxidation state of oxygen in the superoxide ion?
Answer: + 1/2
Diff: 1 Page Ref: Sec 22.5

15) In a discussion of oxygen compounds, a disproportionation reaction is __________.
Answer: a reaction in which peroxides are simultaneously oxidized and reduced
Diff: 1 Page Ref: Sec. 22.5

16) What process repleniches O_2?
Answer: photosynthesis
Diff: 1 Page Ref: Sec 22.5

17) I am a highly polr, strongly hydrogen-bonded liquid with a density of 1.47 g/cm^3. I can decompose to form O_2. Who am I?
Answer: hydrogen peroxide
Diff: 1 Page Ref: Sec 22.5

18) If a metal forms more than one oxide, the acidic character of the oxide increases as the oxidation state of the metal __________.
Answer: increases
Diff: 1 Page Ref: Sec. 22.5

19) What sulfur gas is used to sterilize wine?
Answer: SO_2
Diff: 1 Page Ref: Sec 22.6

20) Write the balanced equation for the reaction of lithium nitride with water.
Answer: $Li_3N + 3H_2O \rightarrow NH_3 + 3LiOH$
Diff: 1 Page Ref: Sec. 22.7

21) The danger from mixing ammonia with bleach is the production of __________.
Answer: chloramine; NH_2Cl
Diff: 1 Page Ref: Sec 22.7

22) KNO_3 and $NaNO_3$ are also known as __________?
Answer: saltpeter
Diff: 1 Page Ref: Sec 22.7

23) What is the primary commercial source of elemental nitrogen?
Answer: fractional distillation of liquid air
Diff: 1 Page Ref: Sec. 22.7

24) What group 5A element is the most metallic?
Answer: bismuth
Diff: 1 Page Ref: Sec. 22.8

25) Why does calcium carbonate dissolve in water containing carbon dioxide?
Answer: because the dissolved carbon dioxide makes the water slightly acidic
Diff: 1   Page Ref: Sec. 22.9

26) What is an acetylide?
Answer: a carbide containing the C_2^{2-} ion
Diff: 2   Page Ref: Sec. 22.9

27) What is meant by the term "composite"?
Answer: a combination of two or more materials
Diff: 1   Page Ref: Sec. 22.9

28) What are the principal components used in making soda-lime glass?
Answer: calcium oxide, sodium oxide, and silicon dioxide
Diff: 1   Page Ref: Sec. 22.10

29) What effect does substitution of K_2O for Na_2O in making soda-lime glass have in its properties?
Answer: increases hardness and melting point
Diff: 1   Page Ref: Sec. 22.10

30) Compounds containing only boron and hydrogen are called __________.
Answer: boranes
Diff: 1   Page Ref: Sec. 22.11

31) Chains of silica tetrahedra are called __________.
Answer: asbestos
Diff: 1   Page Ref: Sec 22.10

True/False

1) Air containing 4% H_2 can be explosive.
Answer: TRUE
Diff: 1   Page Ref: Sec 22.2

2) The reduction of O_2 by sodium hydride produces lye.
Answer: TRUE
Diff: 1   Page Ref: Sec 22.2

3) Xenon can have oxidation states of 2, 4, 6, and 8.
Answer: TRUE
Diff: 1   Page Ref: Sec 22.3

4) The instability of xenon fluorides is due to its negative enthalpy of formation.
Answer: FALSE
Diff: 1   Page Ref: Sec 22.3

5) Ozone is a pale blue poisonous gas with an irritating odor.
Answer: TRUE
Diff: 1   Page Ref: Sec 22.5

6) All oxides are ionic compounds.
Answer: FALSE
Diff: 1   Page Ref: Sec 22.5

7) Oxides can react with water to form acids or bases.
Answer: TRUE
Diff: 1   Page Ref: Sec 22.5

8) The reduction of metal oxides uses carbon monoxide.
Answer: TRUE
Diff: 1   Page Ref: Sec 22.9

9) Calcium carbide is a solid source of acetylene.
Answer: TRUE
Diff: 1   Page Ref: Sec 22.9

Essay

1) Explain why silicon does not form any allotropes with structures analogous to that of graphite or buckminsterfullerenes, even though it is in the same group as carbon.
Answer: Silicon is large enough to prevent efficient sideways-overlap of p orbitals required for π-bond formation.
Diff: 1   Page Ref: Sec. 22.1

2) Explain why hydrofluoric acid etches glass.
Answer: Hydrofluoric acid forms a soluble hexafluorosilic acid (H_2SiF_6), removing silicon from glass and, consequently, destroying it.
Diff: 1   Page Ref: Sec. 22.4

3) Explain why HF (aq) is a relatively weak acid compared to other hydrohalic acids.
Answer: (i) Fluorine, being the smallest of the halogens, forms a very short, and hence strong, bond with hydrogen, making it more difficult for a proton to ionize from the fluoride anion.
(ii) Because fluorine is so much more electronegative than hydrogen, hydrogen has a large partial positive charge, while fluorine has a large negative partial charge. Due to the fact that there are three lone pairs of electrons on the fluorine atoms and the H–F bond is very polar, hydrogen bonding between HF molecules is also possible, making ionization of protons even more difficult.
Diff: 2   Page Ref: Sec. 22.4

4) What are the three steps in the Ostwald process of nitric acid synthesis?
Answer: 1. oxidation of ammonia to NO and water, 2. oxidation of NO to NO_2, 3. reaction of NO_2 with water.
Diff: 1   Page Ref: Sec. 22.7

5) Why are nitric acid solutions sometimes yellowish?
Answer: Photochemical decomposition of HNO_3 produces small amounts of NO_2.
Diff: 1   Page Ref: Sec. 22.7

6) What is meant by the statement that graphite is an isotropic?
Answer: Its properties are different in different directions through the solid.
Diff: 2   Page Ref: Sec. 22.9

7) Describe the major difference in the charge distribution in CH_4 and SiH_4.
Answer: Even though both C–H and Si–H bonds are polar, both CH_4 and SiH_4 are nonpolar due to their tetrahedral symmetry. Because carbon is more electronegative than hydrogen, bonding electrons are somewhat shifted towards carbon, leaving hydrogen atoms with positive partial charges. On the other hand, silicon is somewhat less electronegative than hydrogen and the bonding electrons are shifted towards hydrogen atoms, which adopt slightly negative charges.
Diff: 3   Page Ref: Sec. 22.9-10

8) Briefly explain why carbon and silicon can form oxides with such different physical properties, gaseous CO_2 and solid SiO_2.
Answer: Carbon atoms are small enough to form π bonds with oxygen due to the overlap of p orbitals, resulting in the formation of double C=O bonds. Consequently, CO_2 forms individual molecules that interact with each other via weak London dispersion forces. Silicon atoms are too large and form only single bonds with oxygen, four such bonds per each silicon atom, with each oxygen atom bridging between two silicon atoms, resulting in a covalent-network solid.
Diff: 2   Page Ref: Sec. 22.10

Chemistry, 11e (Brown)
Chapter 23: Metals and Metallurgy

Multiple-Choice and Bimodal

1) The oxidation state of copper in $Cu_2CO_3(OH)_2$ is __________.
A) 0
B) +1
C) +2
D) +4
E) -2
Answer: C
Diff: 2 Page Ref: Sec. 23.1

2) The oxidation state of copper in Cu_2S is __________.
A) +6
B) +2
C) +4
D) 0
E) +1
Answer: E
Diff: 2 Page Ref: Sec. 23.1

3) Melting an ore and causing the melt to separate into two or more layers is called __________
A) calcining.
B) roasting.
C) smelting.
D) slag.
E) alloying.
Answer: C
Diff: 1 Page Ref: Sec. 23.2

4) A thermal process that causes reactions between an ore and the atmosphere of the furnace is called __________
A) calcining.
B) roasting.
C) smelting.
D) slag.
E) refining.
Answer: B
Diff: 1 Page Ref: Sec. 23.2

5) A slag is formed when a basic metal oxide reacts with molten __________ at high temperatures.
A) Fe_2O_3
B) CaO
C) $CaSiO_3$
D) SiO_2
E) CO
Answer: D
Diff: 2 Page Ref: Sec. 23.2

6) Roasting HgS in the presence of oxygen produces the free metal and SO_2. What is the coefficient of HgS when the equation for this reaction is completed and balanced?
A) 1
B) 2
C) 3
D) 5
E) 4
Answer: A
Diff: 3 Page Ref: Sec. 23.2

7) Carbon monoxide is commonly used to produce free metals from their oxides. What is the coefficient of carbon monoxide in the balanced equation for the production of cobalt from Co_2O_3?
A) 1
B) 2
C) 3
D) 5
E) 4
Answer: C
Diff: 3 Page Ref: Sec. 23.2

8) Roasting ZnS in the presence of oxygen produces the metal oxide and SO_2. What is the coefficient of ZnS when the equation for this reaction is completed and balanced?
A) 1
B) 2
C) 3
D) 5
E) 4
Answer: B
Diff: 3 Page Ref: Sec. 23.2

9) At high temperatures, carbon can be used as a reducing agent for metal oxides. What is the coefficient of carbon in the balanced equation for the production of manganese and CO_2 from manganese(II) oxide?
A) 1
B) 2
C) 3
D) 5
E) 4
Answer: A
Diff: 3 Page Ref: Sec. 23.2

10) When carbon monoxide is used to reduce an ore as in a blast furnace, it is converted to __________.
A) graphite
B) carbon dioxide
C) methane
D) carbonate
E) methanol
Answer: B
Diff: 4 Page Ref: Sec. 23.2

11) When hydrogen gas is used to reduce an ore (as in a blast furnace), it is converted to __________.
A) ammonia
B) helium
C) hydrogen peroxide
D) water
E) hydroxide
Answer: D
Diff: 4 Page Ref: Sec. 23.2

12) The hydrometallurgical process used in refining gold ore entails converting metallic gold to a water-soluble complex. The formula of the complex is __________.
A) $Au(NH_3)_2^+$
B) $Au(CN)_4^{3-}$
C) $Au(CN)_2^-$
D) $Au(CO)_4^{2-}$
E) $Au(CO)_4^+$
Answer: C
Diff: 4 Page Ref: Sec. 23.3

13) What is the product of the following (unbalanced) equation?

$$Al_2O_3 \cdot H_2O\ (s) + H_2O\ (l) + OH^-\ (aq) \rightarrow$$

A) $Al_2 \cdot 2H_2O$ (s)
B) $Al(OH)_3$ (s)
C) $Al_2(OH)_6$ (s)
D) Al^{3+} (aq)
E) $Al(OH)_4^-$ (aq)
Answer: E
Diff: 4 Page Ref: Sec. 23.3

14) Selectively dissolving a metal-containing compound from an ore is called
A) converting.
B) sol formation.
C) refining.
D) oxidation.
E) leaching.
Answer: E
Diff: 2 Page Ref: Sec. 23.3

15) Processes used to reduce metal ores or to refine metals that are based on the process of electrolysis are collectively referred to as __________.
A) pyrometallurgy
B) hydrometallurgy
C) electrometallurgy
D) calcination
E) roasting
Answer: C
Diff: 4 Page Ref: Sec. 23.4

16) 18 karat gold contains __________% gold.
A) 18
B) 25
C) 89
D) 75
E) 100
Answer: D
Diff: 2 Page Ref: Sec. 23.6

17) 12 karat gold contains __________% gold.
A) 12
B) 25
C) 50
D) 75
E) 100
Answer: C
Diff: 2 Page Ref: Sec 23.6

18) 24 karat gold contains __________% gold.
A) 24
B) 25
C) 50
D) 75
E) 100
Answer: E
Diff: 2 Page Ref: Sec 23.6

19) 6 karat gold contains __________% gold.
A) 6
B) 25
C) 50
D) 75
E) 100
Answer: B
Diff: 2 Page Ref: Sec 23.6

20) The transition metals in group __________ have the highest melting points.
A) 4B
B) 3B
C) 6B
D) 8B
E) 2B
Answer: C
Diff: 3 Page Ref: Sec. 23.7

21) The maximum oxidation state in the first transition series is __________.
A) +2
B) +4
C) +5
D) +7
E) +8
Answer: D
Diff: 4 Page Ref: Sec. 23.7

22) In the second and third transition series, the maximum oxidation state is __________.
A) +2
B) +4
C) +5
D) +7
E) +8
Answer: E
Diff: 4 Page Ref: Sec. 23.7

23) Most of the compounds of copper in the __________ oxidation state are insoluble in water.
A) +1
B) +2
C) +3
D) +7
E) +6
Answer: A
Diff: 3 Page Ref: Sec. 23.8

24) What is the coefficient of Cl_2 when the following equation is completed and balanced?

$$Cr_2O_7^{2-}\ (aq) + Cl^-\ (aq) \rightarrow Cr^{3+}\ (aq) + Cl_2\ (g)$$
(acidic solution)

A) 1
B) 3
C) 5
D) 6
E) 4
Answer: B
Diff: 3 Page Ref: Sec. 23.8

25) What is the coefficient of Fe^{2+} when the following equation is completed and balanced?

$$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + H_2O$$
(acidic solution)

A) 1
B) 2
C) 3
D) 5
E) 4
Answer: B
Diff: 3 Page Ref: Sec. 23.8

26) The first step in the production of nickel from its ore, NiS, is to roast it in the presence of oxygen to form the metal oxide and SO_2. What is the coefficient of oxygen when the equation for this reaction is completed and balanced?
A) 1
B) 2
C) 3
D) 5
E) 4
Answer: C
Diff: 5 Page Ref: Sec. 23.8

27) CuS has a very low solubility in water. However, it will dissolve in nitric acid due to the following reaction.

$$CuS\,(s) + NO_3^-\,(aq) \rightarrow Cu^{2+}\,(aq) + S\,(s) + NO\,(g)$$
(acidic solution)

What is the coefficient of CuS when this equation is balanced?
A) 1
B) 2
C) 3
D) 5
E) 4
Answer: C
Diff: 3 Page Ref: Sec. 23.8

Multiple-Choice

28) A deposit that contains a metal in economically exploitable quantities is called a(n) __________.
A) mineral
B) ore
C) vein
D) comstock
E) metal
Answer: B
Diff: 1 Page Ref: Sec. 23.1

29) Which of the following are not commonly used as sources of metals?
A) oxides
B) silicates
C) sulfides
D) carbonates
E) All of the above are commonly used sources of metals.
Answer: B
Diff: 1 Page Ref: Sec. 23.1

30) Which statement below is true?
A) New mining techniques and relatively untapped ore fields mean that the environmental impacts of mineral extraction will decrease significantly in the future.
B) There exists little correlation between the abundance of an element in the lithosphere and its commercial extraction and use.
C) Most metallic elements are found in the lithosphere in oxidation state zero.
D) The most important commercial class of minerals is the silicates.
E) The United States has plentiful ore fields of all strategic metals.
Answer: B
Diff: 2 Page Ref: Sec. 23.1

31) Which one of the following metallic elements is most likely to be found as the free metal in nature?
A) Ca
B) Au
C) Al
D) Fe
E) Li
Answer: B
Diff: 2 Page Ref: Sec. 23.1

32) The undesirable material that is separated from an ore during the concentration process is called __________.
A) gangue
B) leachate
C) slag
D) flocculent
E) silicate
Answer: A
Diff: 1 Page Ref: Sec. 23.1

33) The lithosphere is the
A) deepest part of the ocean.
B) portion of the atmosphere closest to the Earth.
C) molten core of the Earth.
D) portion of the atmosphere furthest from the Earth.
E) solid surface of the Earth.
Answer: E
Diff: 1 Page Ref: Sec. 23.1

34) Which mineral contains aluminum?
A) bauxite
B) malachite
C) cinnabar
D) galena
E) magnetite
Answer: A
Diff: 2 Page Ref: Sec. 23.1

35) Gold and the platinum group metals are found in nature in metallic form because
A) they are solids at room temperature.
B) they are highly reactive.
C) they are soluble in water.
D) they are relatively inert.
E) they are relatively abundant.
Answer: D
Diff: 1 Page Ref: Sec. 23.1

36) A mineral is
A) a solid inorganic compound that contains one or more metals.
B) a vitamin.
C) metal in its elemental form.
D) a transition metal ion.
E) source of carbon.
Answer: A
Diff: 1 Page Ref: Sec. 23.1

37) An alloy is a
A) heterogeneous mixture of two metals.
B) pure metal.
C) metallic material that is composed of two or more elements.
D) nonmetal with some properties of a metal.
E) a mineral containing two or more metals.
Answer: C
Diff: 1 Page Ref: Sec. 23.1

38) Metallurgical processes that utilize high temperatures are collectively called
A) hydrometallurgy.
B) pyrometallurgy.
C) electrometallurgy.
D) alloying.
E) roasting.
Answer: B
Diff: 1 Page Ref: Sec. 23.2

39) The purpose of a converter in steel production is
A) to reduce the iron in the ore to elemental
B) to remove impurity elements by oxidation
C) to allow the formation of phosphides within the metal for added corrosion resistance
D) to allow the addition of nitrogen for increased strength
E) to allow slow solidification of the molten metal so it will purify as it crystallizes
Answer: B
Diff: 2 Page Ref: Sec. 23.2

40) What is produced when a carbonate is calcined?
A) the free metal and sodium carbonate
B) the free metal and sulfur dioxide
C) the metal oxide and carbon dioxide
D) water and the metal hydride
E) the free metal and carbon dioxide
Answer: C
Diff: 3 Page Ref: Sec. 23.2

41) During roasting, the metal reacts with
A) oxygen.
B) carbon monoxide.
C) sulfur.
D) the furnace atmosphere.
E) iron.
Answer: D
Diff: 3 Page Ref: Sec. 23.2

42) Why is either pure oxygen or oxygen diluted with argon used in a converter instead of air?
A) The carbon dioxide in air will cause the iron to oxidize and form rust.
B) The oxygen concentration is too low to function efficiently at removing impurities.
C) The carbon monoxide in air reacts with the iron to form a volatile, and toxic, iron carbonyl.
D) The nitrogen in air will react with iron to form iron nitride that will make the iron brittle.
E) Because it's cheaper.
Answer: D
Diff: 3 Page Ref: Sec. 23.2

43) What happens to the silicon that is a contaminant in crude iron in a converter?
A) it is converted to the tetrafluoride that bubbles out as a gas.
B) It is precipitated as sodium silicate.
C) It is converted to silicon dioxide and becomes part of the slag.
D) It is precipitated as the carbide.
E) It is precipitated as iron silicate.
Answer: C
Diff: 3 Page Ref: Sec. 23.2

44) Roasting of the disulfide of molybdenum in O_2 produces which products?
A) MoO_3 (s) + SO_2 (g)
B) Mo (s) + SO_2 (g)
C) MoO_4 (s) + SO_2 (g)
D) MoO_3 (s) + SO_3 (g)
E) Mo (s) + MoS (s) + SO_2 (g)
Answer: C
Diff: 3   Page Ref: Sec. 23.2

45) A basic slag is needed in steelmaking to
A) remove SiO_2 as silicates.
B) reduce any nitrogen-containing compounds to N_2.
C) react with any Brønsted-Lowry acids present.
D) provide CaO to remove phosphorus oxides as $Ca_3(PO_4)_2$.
E) oxidize any carbon-containing compounds to CO_2.
Answer: D
Diff: 3   Page Ref: Sec. 23.2

46) Smelting is
A) melting and subsequent reaction of molten ores resulting in the formation of layers.
B) heating an ore to make it react with a gas in a furnace.
C) thermal decomposition of an ore with elimination of a gaseous product.
D) addition of calcium to a molten ore.
E) cooling a molten metal to make it solidify.
Answer: A
Diff: 2   Page Ref: Sec. 23.2

47) Which of the following equations represents a calcination?

A) HgS (s) + O_2 (g) $\longrightarrow$ Hg (g) + SO_2 (g)

B) $PbCO_3$ (s) $\longrightarrow$ PbO (s) + CO_2 (g)

C) PbO (s) + CO (g) $\longrightarrow$ Pb (l) + CO_2 (g)

D) CaO (l) + SiO_2 (l) $\longrightarrow$ $CaSiO_3$ (l)
E) All of the above are calcination processes.
Answer: B
Diff: 3   Page Ref: Sec. 23.2

48) Which of the following equations represents the roasting of an ore?
A) All of these represent roasting processes.

B) HgS (s) + O_2 (g) $\longrightarrow$ Hg (g) + SO_2 (g)

C) PbO (s) + CO (g) $\longrightarrow$ Pb (l) + CO_2 (g)

D) 2ZnS (s) + $3O_2$ (g) $\longrightarrow$ 2ZnO (s) + $2SO_2$ (g)

E) $2MoS_2$ (s) + $7O_2$ (g) $\longrightarrow$ $2MoO_3$ (s) + $4SO_2$ (g)
Answer: A
Diff: 3   Page Ref: Sec. 23.2

49) The purpose of burning coke in a blast furnace is
A) to produce reducing gases.
B) to produce heat.
C) to produce carbon monoxide gas.
D) to produce hydrogen gas.
E) all of the above
Answer: E
Diff: 3 Page Ref: Sec. 23.2

50) A mixture of oxygen and argon are blown through molten iron that is produced in a blast furnace for the purpose of
A) completing the reduction of iron.
B) oxidizing the iron before it cools.
C) cooling the molten iron.
D) removing carbon, sulfur, and other impurities.
E) removing other metals.
Answer: D
Diff: 3 Page Ref: Sec. 23.2

51) Steel is
A) an alloy of iron.
B) pure iron.
C) oxidized iron.
D) a mixture of iron and silver.
E) a liquid at room temperature.
Answer: A
Diff: 2 Page Ref: Sec. 23.2

52) Which statement about steel is false?
A) It is a polymer.
B) It is an alloy of iron.
C) It can have different percentage of carbon.
D) In can be made so it resists rust.
E) none of the above
Answer: A
Diff: 2 Page Ref: Sec. 23.1, 23.6

53) Hydrometallurgy is
A) the use of water to cool molten metals.
B) the use of high temperature processes to concentrate and refine metals.
C) the use of water to locate underground ore deposits.
D) the use of aqueous solutions to extract metals from their ores.
E) the use of high temperature processes to make alloys.
Answer: D
Diff: 2 Page Ref: Sec. 23.3

54) What are the products of the following (unbalanced) leaching process?

$$Au\ (s) + CN^-\ (aq) + O_2\ (g) + H_2O\ (l) \rightarrow$$

A) $Au(CN)_3$ (s) and OH^- (aq)
B) AuCN (s) and OH^- (aq)
C) AuCN (s) and H_2O_2 (aq)
D) $Au(CN)_4^-$ (aq) and OH^- (aq)
E) $Au(CN)_2^-$ (aq) and OH^- (aq)
Answer: E
Diff: 3 Page Ref: Sec. 23.3

55) An advantage to leaching gold with aqueous solutions of cyanide ion is that
A) the process requires only one step.
B) the gold recovered in this way has higher purity than gold recovered in other ways.
C) the method can be used to locate underground gold deposits.
D) gold can be recovered from very low-grade ores by this method.
E) the process is environmentally safe.
Answer: D
Diff: 3 Page Ref: Sec. 23.3

56) A disadvantage to leaching gold with aqueous solutions of cyanide ion is that
A) it requires the use of ores with a very high concentration of gold.
B) the method does not produce gold of high enough purity.
C) the method is a potential environmental hazard.
D) sodium cyanide is very expensive.
E) it is a complicated process requiring more than two dozen separate steps.
Answer: C
Diff: 3 Page Ref: Sec. 23.3

57) The major impurities found in bauxite are __________.
A) SiO_2 and Fe_2O_3
B) Al_2O_3 and H_2O
C) Fe and H_2O
D) Al_2O_3 and OH^-
E) carbon and salicylic acid
Answer: A
Diff: 3 Page Ref: Sec. 23.3

58) Which one of the following is false concerning the Bayer Process?
A) It is a hydrometallurgical process.
B) It involves treatment of bauxite with cold, dilute sodium hydroxide solution.
C) In the process, aluminum is converted to a soluble aluminate ion.
D) It results in the separation of aluminum from iron and silicon.
E) It is used to purify bauxite.
Answer: B
Diff: 3 Page Ref: Sec. 23.3

59) Part of the Bayer process involves the digestion of crushed ore in concentrated aqueous sodium hydroxide. This process carried out at high pressure __________.
A) to prevent boiling
B) to prevent formation of iron hydroxide
C) to prevent formation of aluminum hydroxide
D) to accelerate formation of iron hydroxide
E) to lower the boiling temperature of the mixture
Answer: A
Diff: 3 Page Ref: Sec. 23.3

60) What is the purpose of adding zinc powder to a solution of $Au(CN)_2^-$?
A) to precipitate the cyanide-gold complex
B) to reduce the gold in the cyanide complex to gold metal
C) to precipitate the cyanide ion
D) to oxidize the gold in the cyanide complex to gold metal
E) to form a gold-zinc alloy
Answer: B
Diff: 3 Page Ref: Sec. 23.3

61) In the Bayer process, the purpose of filtration after the ore has been digested in concentrated sodium hydroxide is __________.
A) to separate the soluble aluminum complex from the insoluble iron impurities
B) to separate the insoluble aluminum oxide from the soluble iron impurity
C) to separate the aluminum metal from the hydroxide ions
D) to remove the sodium ions from the sodium hydroxide solution
E) to remove the anode sludge
Answer: A
Diff: 3 Page Ref: Sec. 23.3

62) In the Bayer process, the purpose of lowering the pH after the digested ore has been filtered is __________.
A) to precipitate the iron hydroxide
B) to precipitate the iron oxide
C) to precipitate the aluminum hydroxide
D) the dissolve the remaining ore
E) to dissolve the remaining impurities
Answer: C
Diff: 3 Page Ref: Sec. 23.3

63) The anode sludges from copper refining are important sources of what metal(s)?
A) gold
B) silver
C) aluminum
D) both a and b
E) all of the above
Answer: D
Diff: 3 Page Ref: Sec. 23.4

64) The Hall process is
A) the pyrometallurgic process used to produce iron.
B) the pyrometallurgic process used to produce aluminum.
C) the electrolytic process used to produce aluminum.
D) the hydrometallurgic process to produce aluminum.
E) the electrolytic process used to produce iron.
Answer: C
Diff: 3 Page Ref: Sec. 23.4

65) The product in the Hall electrometallurgical process is
A) copper.
B) iron.
C) aluminum.
D) gold.
E) silver.
Answer: C
Diff: 3 Page Ref: Sec. 23.4

66) The respective standard oxidation potentials for Cu → Cu^{2+}, Ni → Ni^{2+}, and Ag → Ag^{+} are (in V) -0.34, +0.28 and -0.80. Impure copper slabs at the anode are refined electrochemically, affording much purer metallic copper at the cathode. Which statement below is true?
A) Cu is oxidized preferentially over both Ni and Ag, so both Ni and Ag metals are separated as sludges below the anode.
B) Ni is oxidized preferentially over Cu, and Ni^{2+} is reduced much less readily than Cu^{2+}, so Ni is separated as Ni^{2+} in the electrolyte solution.
C) Ag is oxidized preferentially over Cu, and Ag^{+} is reduced much less readily than Cu^{2+}, so Ag is separated as Ag^{+} in the electrolyte solution.
D) Ag is oxidized preferentially over Cu, and Ag^{+} is reduced much more readily than Cu^{2+}, so Ag plates out with Cu at the cathode and cannot readily be removed from impure copper.
E) Both Ni and Ag are oxidized preferentially over Cu and Ni^{2+}, and Ag^{+} is reduced much less readily than Cu^{2+}, so Ni and Ag are separated as Ni^{2+} and Ag^{+} in the electrolyte solution.
Answer: B
Diff: 5 Page Ref: Sec. 23.4

67) In the Bayer process, what is the product of calcination of the aluminum hydroxide recovered from the digestion in base?
A) Al · x H_2O (s)
B) Al (s)
C) $Al(OH)_3$ (s)
D) Al_2O_3 (s)
E) $Al(OH)_4^-$ (aq)
Answer: D
Diff: 4 Page Ref: Sec. 23.4

68) Anhydrous aluminum oxide is dissolved in molten cryolite rather than simply melted because __________
A) the cryolite actually provides the aluminum that is to be reduced.
B) the cryolite provides a source of sodium ions.
C) the melting point of pure, anhydrous aluminum oxide is too high.
D) in pure, molten Al_2O_3, the aluminum would be oxidized rather than reduced.
E) the cryolite provides the necessary fluoride ions.
Answer: C
Diff: 4 Page Ref: Sec. 23.4

69) Calcium chloride is added to sodium chloride prior to melting it for electrolysis in a Downs cell __________.
A) to lower the melting point
B) to increase the concentration of chloride ions
C) to make the sodium ions easier to reduce
D) to make the chloride ions easier to oxidize
E) to provide calcium ions which serve as the cathode
Answer: A
Diff: 4 Page Ref: Sec. 23.4

70) Sodium metal cannot be produced by electrolysis of an aqueous solution of sodium chloride because __________

A) the carbon anode is more easily reduced than sodium ions.
B) water is more easily oxidized than sodium metal.
C) the production of chlorine gas interferes with the reduction of sodium ions.
D) the iron cathode would be corroded by the salt water.
E) water is more easily reduced than sodium ions.
Answer: E
Diff: 4 Page Ref: Sec. 23.4

71) Which property of metals cannot be explained with the *electron-sea model*?
A) shine
B) high thermal connectivity
C) high electric connectivity
D) malleability and ductility
E) trends in melting points
Answer: E
Diff: 3 Page Ref: Sec. 23.5

72) Which one of the following is a property of most metals?
A) low melting point
B) brittleness
C) high electronegativity
D) thermal conductivity
E) acidic oxides
Answer: D
Diff: 2 Page Ref: Sec. 23.5

73) The molecular-orbital model for Ge shows it to be
A) a conductor, because all the lower energy band orbitals are filled and the gap between the lower and higher bands is large.
B) an insulator, because all the lower energy band orbitals are filled and the gap between the lower and higher bands is large.
C) a semiconductor, because the gap between the filled lower and empty higher energy bands is relatively small.
D) a semiconductor, because the gap between the filled lower and empty higher energy bands is large.
E) a conductor, because its lower energy band orbitals are only partially filled.
Answer: C
Diff: 5 Page Ref: Sec. 23.5

74) If the electronic structure of a solid substance consists of a valence band that is completely filled with electrons and there is a large energy gap to the next set of orbitals, then this substance will be a(n) __________.
A) alloy
B) insulator
C) conductor
D) semiconductor
E) nonmetal
Answer: B
Diff: 4 Page Ref: Sec. 23.5

75) Silicon, doped with a group 5A element forms a(n) __________-type semiconductor. Silicon doped with a group 3A element forms a(n) __________-type semiconductor.
A) p, n
B) n, p
C) n, n
D) p, p
E) None of the above is correct.
Answer: B
Diff: 4 Page Ref: Sec. 23.6

76) For a substitutional alloy to form, the two metals combined must have similar
A) ionization potential and electron affinity.
B) number of valance electrons and electronegativity.
C) reduction potential and size.
D) atomic radii and chemical bonding properties.
E) band gap and reactivity.
Answer: D
Diff: 4 Page Ref: Sec. 23.6

77) What is the typical effect of the addition of an interstitial element on the properties of a metal?
A) increase in malleability and corrosion resistance
B) increase in hardness and strength, decrease in ductility
C) decrease in melting point and increase in ductility
D) decrease in conductivity and increase in brittleness
E) increased surface luster
Answer: B
Diff: 3 Page Ref: Sec. 23.6

78) Heterogeneous alloys
A) do not have uniform composition throughout.
B) have properties that depend on composition.
C) have properties that depend on the manner in which the melt is solidified.
D) have properties that depend on the manner in which the solid is formed.
E) All of the above are true.
Answer: D
Diff: 3 Page Ref: Sec. 23.6

79) Intermetallic compounds are examples of
A) homogeneous alloys.
B) heterogeneous alloys.
C) interstitial alloys.
D) solution alloys.
E) ionic compounds.
Answer: A
Diff: 2 Page Ref: Sec. 23.6

80) Which of the following is not an alloy?
A) brass
B) steel
C) sterling silver
D) dental amalgam
E) ceramic
Answer: E
Diff: 3 Page Ref: Sec. 23.6

81) Alloys generally differ from compounds in that
A) the former always contain some carbon.
B) the former always contain some iron.
C) the former always have semiconductor properties.
D) the atomic ratios of the constituent elements in the former are not fixed and may vary over a wide range.
E) the former never contain a transition element.
Answer: D
Diff: 3 Page Ref: Sec. 23.6

82) Which element is typically not added to steel to modify its properties?
A) carbon
B) vanadium
C) chromium
D) nitrogen
E) nickel
Answer: D
Diff: 3 Page Ref: Sec. 23.6

83) Shape memory alloys __________.
A) change their structure as the temperature changes
B) in their lower temperature phase have a flexible arrangement between atoms
C) in their higher temperature phase have strong and fixed bonds between atoms
D) are more pliable when cold than when warm
E) all of the above
Answer: E
Diff: 3 Page Ref: Sec. 23.6

84) Of the following, which is a bulk property?
A) electron configuration
B) ionization energy
C) melting point
D) atomic radius
E) atomic number
Answer: C
Diff: 3 Page Ref: Sec. 23.7

85) What two oxidation states are more frequently observed in the first transition series than in the third?
A) +3 and +7
B) +2 and +3
C) +2 and +7
D) +5 and +6
E) +3 and +5
Answer: B
Diff: 4 Page Ref: Sec. 23.7

86) A substance with unpaired electrons will be
A) slightly attracted to a magnet.
B) slightly repelled by a magnet.
C) permanently magnetic.
D) brightly colored.
E) nonmetallic.
Answer: A
Diff: 3 Page Ref: Sec. 23.7

87) The lanthanide contraction is responsible for the fact that
A) Zr and Y have about the same radius.
B) Zr and Nb have similar oxidation states.
C) Zr and Hf have about the same radius.
D) Zr and Zn have similar oxidation states.
E) Zr and Hf have the same oxidation states.
Answer: C
Diff: 3 Page Ref: Sec. 23.7

88) Which one of the following is <u>not</u> true about transition metals?
A) They frequently have more than one common oxidation state.
B) Their compounds are frequently colored.
C) Their compounds frequently exhibit magnetic properties.
D) They are found in the d-block of the periodic table.
E) They typically have low melting points.
Answer: E
Diff: 3 Page Ref: Sec. 23.7

89) Reaction of iron with which one of the following acids will result in the direct production of Fe^{3+}?
A) HNO_3
B) HCl
C) HI
D) CH_3COOH
E) dilute H_2SO_4
Answer: A
Diff: 3 Page Ref: Sec. 23.8

90) Which one of the following copper compounds is black in color?
A) CuI
B) $CuSO_4$
C) $Cu(H_2O)_4^{2+}$
D) $CuCl_2$
E) CuO
Answer: E
Diff: 3 Page Ref: Sec. 23.8

91) Why do aqueous solutions of Cr^{2+} usually appear violet instead of blue?
A) The intensity of the color is so low it appears violet instead of blue.
B) Chromium(II) rapidly forms a complex ion with water and that ion is violet-colored.
C) Water usually contains enough chloride ion to form a complex ion containing chloride and that substance is violet-colored.
D) Chromium(II) reacts with water to form a hydroxide-containing complex ion that is violet-colored.
E) Chromium(II) is rapidly oxidized to chromium(III) by atmospheric oxygen.
Answer: E
Diff: 4 Page Ref: Sec. 23.8

92) A small amount of barium chloride solution is added to a blue solution. A white precipitate forms. The blue solution contains
A) $NiSO_4$
B) $CuCl_2$
C) $CuSO_4$
D) $Co(NO_3)_3$
E) $CoCl_2$
Answer: C
Diff: 4 Page Ref: Sec. 23.8

93) When copper(II) hydroxide is heated, __________ and __________ are formed.
A) Cu (s), H_2O (l)
B) CuO (s), H_2O (l)
C) Cu (s), OH^- (g)
D) CuOH (s) + H_2O (g)
E) CuH_2 (s) + O_2 (g)
Answer: B
Diff: 3 Page Ref: Sec. 23.8

94) Which one of the following compounds is yellow?
A) $Cr(NO_3)_3$
B) $CrCl_3$
C) K_2CrO_4
D) $(NH_4)_2Cr_2O_7$
E) CCl_2
Answer: C
Diff: 3 Page Ref: Sec. 23.8

95) An aqueous solution of $Fe(NO_3)_3$ will slowly form a red-brown precipitate due to the formation of __________.
A) $Fe(OH)_3$
B) Fe_3O_4
C) FeO
D) $Fe(OH)_2$
E) FeO_2
Answer: A
Diff: 3 Page Ref: Sec. 23.8

96) The hydrated nickel(II) ion is
A) orange.
B) blue.
C) yellow.
D) green.
E) colorless.
Answer: D
Diff: 3 Page Ref: Sec. 23.8

97) The hydrated manganese(II) ion is
A) orange.
B) blue.
C) yellow.
D) violet.
E) colorless.
Answer: E
Diff: 3 Page Ref: Sec. 23.8

Short Answer

1) Give the name and formula of the two important ores of iron.
Answer: hematite, Fe_3O_3, and magnetite, Fe_3O_4
Diff: 2 Page Ref: Sec. 23.1

2) What is the name and the formula of the most useful ore of aluminum?
Answer: bauxite, $Al_2O_3 \cdot xH_2O$
Diff: 2 Page Ref: Sec. 23.1

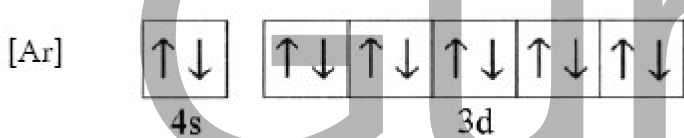
3) Write the two reactions that are used to control the temperature in a blast furnace and indicate which provides heat and which cools.
Answer: $2C\ (s) + O_2\ (g) \rightarrow 2CO\ (g)$, provides heat
$C\ (s) + H_2O\ (g) \rightarrow CO\ (g) + H_2\ (g)$, cools
Diff: 4 Page Ref: Sec. 23.2

4) A material that contains more than one element and has the characteristic properties of metals is called a(an) __________.
Answer: alloy
Diff: 2 Page Ref: Sec 23.6

5) What two metals are alloyed to produce sterling silver?
Answer: silver and copper
Diff: 4 Page Ref: Sec. 23.6

6) Most of the metals in the third transition series have about the same atomic radius as the elements above them in second transition series. This is a result of __________.
Answer: the lanthanide contraction
Diff: 4 Page Ref: Sec. 23.7

7) Draw a diagram of the short-hand ground state electron configuration of zinc.
Answer:



Diff: 4 Page Ref: Sec. 23.7

8) Most transition metal ions contain partially occupied __________ subshells.
Answer: d
Diff: 3 Page Ref: Sec. 23.7

9) __________ arises when the unpaired electrons of the atoms or ions in a solid are influenced by the orientations of the electrons of their neighbors.
Answer: Ferromagnetism
Diff: 3 Page Ref: Sec. 23.8

True/False

1) Gangue is the unwanted material that accompanies an ore when it is mined.
Answer: TRUE
Diff: 1 Page Ref: Sec. 23.1

2) Calcining is the heating an ore to bring about the elimination of calcium salts.
Answer: FALSE
Diff: 2 Page Ref: Sec. 23.2

3) The purpose of the limestone used in a blast furnace is to form slag.
Answer: TRUE
Diff: 2 Page Ref: Sec. 23.2

4) In a blast furnace, coke is used to provide the needed heat and to provide carbon monoxide to act as a reducing agent.
Answer: TRUE
Diff: 2 Page Ref: Sec. 23.2

5) Many metals are ductile, which means that they can be hammered into thin sheets.
Answer: FALSE
Diff: 2 Page Ref: Sec. 23.5

6) Chromium is in the +6 oxidation state in both chromate and dichromate anions.
Answer: TRUE
Diff: 3 Page Ref: Sec. 23.8

Chemistry, 11e (Brown)
Chapter 24: Chemistry of Coordination Compounds

Multiple-Choice and Bimodal

1) The coordination numbers of cobalt(III) and of chromium(III) in their complexes are always __________.
A) 4
B) 5
C) 2
D) 3
E) 6
Answer: E
Diff: 1 Page Ref: Sec. 24.1

2) The coordination number of platinum in complexes is always __________.
A) 4
B) 5
C) 2
D) 3
E) 6
Answer: A
Diff: 1 Page Ref: Sec. 24.1

3) During the formation of a coordination compound, the metal acts as a __________.
A) Lewis acid
B) Brønsted acid
C) Arrhenius acid
D) Brønsted base
E) Lewis base
Answer: E
Diff: 1 Page Ref: Sec. 24.1

4) During the formation of a coordination compound, ligands act as __________.
A) Lewis bases
B) Arrhenius bases
C) Brønsted bases
D) Lewis acids
E) Arrhenius acids
Answer: A
Diff: 1 Page Ref: Sec. 24.1

5) The coordination sphere of a complex consists of __________.
A) the central metal ion only
B) the ligands
C) the central metal ion and the ligands bonded to it
D) the primary and secondary valencies
E) coordination and steric numbers
Answer: C
Diff: 1 Page Ref: Sec. 24.1

6) In the following reaction, Ni^{2+} is acting as a(n) __________.

$$Ni^{2+}\ (g) + 6H_2O\ (l) \rightarrow Ni(H_2O)_6^{\ 2+}\ (aq)$$

A) oxidizing agent
B) Lewis acid
C) precipitating agent
D) solvent
E) ligand
Answer: B
Diff: 1   Page Ref: Sec. 24.1

7) How many d electrons are in the cobalt ion of $K_3[Co(CN)_6]$ __________?
A) 3
B) 5
C) 6
D) 7
E) 4
Answer: C
Diff: 1   Page Ref: Sec. 24.1

8) What is the charge on the complex ion in $Mg_2[FeCl_6]$ __________?
A) 2-
B) 2+
C) 3-
D) 3+
E) 4-
Answer: E
Diff: 1   Page Ref: Sec. 24.1

9) What is the oxidation number of chromium in $[Cr(NH_3)_4Cl_2]Cl$ __________?
A) -3
B) +3
C) +2
D) -2
E) 0
Answer: B
Diff: 1   Page Ref: Sec. 24.1

10) What is the ligand in $Ca_3[Fe(CN)_6]_2$ __________?
A) Ca^{2+}
B) Fe^{3+}
C) CN^-
D) $Fe(CN)_6^{\ 3-}$
E) Fe^{2+}
Answer: C
Diff: 1   Page Ref: Sec. 24.1

11) What is the charge of the central metal ion in $Ca_3[Fe(CN)_6]_2$ __________?
A) 0
B) 1+
C) 2+
D) 3+
E) 6+
Answer: D
Diff: 1   Page Ref: Sec. 24.1

12) What is the oxidation number of cobalt in $[Co(NH_3)_4F_2]$ __________?
A) -3
B) +2
C) +1
D) +3
E) +6
Answer: B
Diff: 1   Page Ref: Sec. 24.1

13) The charge of the complex ion in $[Zn(H_2O)_3Cl]Cl$ is __________.
A) 0
B) 1-
C) 2+
D) 1+
E) 2-
Answer: D
Diff: 1   Page Ref: Sec. 24.1

14) The coordination number for $[Zn(H_2O)_3Cl]Cl$ is __________.
A) 5
B) 4
C) 2
D) 1
E) 6
Answer: B
Diff: 2   Page Ref: Sec. 24.1

15) What is the oxidation state of iron in $CaNa[Fe(CN)_6]$ __________?
A) 0
B) +2
C) +3
D) +4
E) +6
Answer: A
Diff: 1   Page Ref: Sec. 24.1

16) What is the coordination number of iron in $CaNa[Fe(CN)_6]$ __________?
A) 2
B) 8
C) 4
D) 6
E) 12
Answer: D
Diff: 1   Page Ref: Sec. 24.1

17) What is the coordination number of cobalt in $[Co(NH_3)_5Cl](NO_3)_2$ __________?
A) 12
B) 8
C) 4
D) 2
E) 6
Answer: E
Diff: 1 Page Ref: Sec. 24.1

18) What is the oxidation state of chromium in $[Cr(H_2O)_4Cl_2]^+$ __________?
A) 0
B) +2
C) +3
D) -2
E) -3
Answer: C
Diff: 1 Page Ref: Sec. 24.1

19) What is the coordination number of chromium in $[Cr(H_2O)_4Cl_2]^+$ __________?
A) 8
B) 6
C) 4
D) 2
E) 12
Answer: B
Diff: 1 Page Ref: Sec. 24.1

20) The "dentation" of a ligand is defined by __________.
A) how many "dents" or "deceptions" there are in the coordination sphere of a complex species it forms
B) how many electron donor atoms it utilizes to form coordinate bonds to the central metal ion
C) the total number of lone pairs of electrons it possesses
D) how many metal ions it can sequester from solution
E) none of the above
Answer: B
Diff: 1 Page Ref: Sec. 24.2

21) EDTA is __________-dantate ligand.
A) mono
B) bi
C) tri
D) tetra
E) hexa
Answer: E
Diff: 1 Page Ref: Sec. 24.2

22) What is the metal ion in the porphyrin of heme __________?
A) iron
B) calcium
C) molybdenum
D) magnesium
E) chlorophyll
Answer: A
Diff: 1 Page Ref: Sec. 24.2

23) How many iron atoms are coordinated in a hemoglobin molecule __________?
A) 1
B) 2
C) 3
D) 4
E) 5
Answer: D
Diff: 1 Page Ref: Sec. 24.2

24) The names of complex anions end in __________.
A) -o
B) -ium
C) -ate
D) -ous
E) -ic
Answer: C
Diff: 1 Page Ref: Sec. 24.3

25) The formula for potassium dibromodicarbonylrhodate(II) is __________.
A) $K_2[Rh(Co)_2Br_2]$
B) $K[Rh(Co)_2Br_2]$
C) $K_3[Rh(Co)_2Br_2]$
D) $K[Rh(Co)_2Br_2]_2$
E) $K_3[Rh(Co)_2Br_2]_2$
Answer: A
Diff: 1 Page Ref: Sec. 24.3

26) The correct name for $Na_3[CoF_6]$ is __________.
A) trisodium hexakisfluorocobalt(III)
B) trisodium hexakisfluorocobalt(II)
C) trisodium hexakisfluorocobalt(IV)
D) sodium hexafluorocobaltate(III)
E) sodium hexafluorocobaltate(IV)
Answer: D
Diff: 1 Page Ref: Sec. 24.3

27) Triphenylphosphine is often given the abbreviated formula PPh_3. The correct name for $Rh(PPh_3)_3Cl$ is __________.
A) chlorotriphenylphosphinerhodium
B) chlorotriphenylphosphinerhodium(I)
C) tris(triphenylphosphine)chlororhodium(I)
D) chlorotris(triphenylphosphine)rhodium(I)
E) chlorotris(triphenylphosphine)rhodate(-I)
Answer: D
Diff: 1 Page Ref: Sec. 24.3

28) The correct name for $[Ni(NH_3)_6](NO_3)_3$ is __________.
A) dinitrohexaamminenickel (II)
B) hexaamminenickel (III) trinitrate
C) dinitrohexaamminenickelate (III)
D) hexaamminenickel (II) nitrate
E) hexaamminenickel (III) nitrate
Answer: E
Diff: 1 Page Ref: Sec. 24.2

29) In __________, the bonds are the same but the spatial arrangement of the atoms is different.
A) structural isomers
B) linkage isomers
C) coordination-sphere isomers
D) stereo isomers
E) resonance structures
Answer: D
Diff: 1 Page Ref: Sec. 24.4

30) A geometrical isomer with like groups located on opposite sides of the metal atom is denoted with the prefix __________.
A) cis-
B) trans-
C) bis-
D) tetrakis
E) d-
Answer: B
Diff: 1 Page Ref: Sec. 24.4

31) The complex $[Zn(NH_3)_2Cl_2]^{2+}$ does not exhibit cis-trans-isomerism. The geometry of this complex must be __________.
A) tetrahedral
B) trigonal bipyramidal
C) octahedral
D) square planar
E) either tetrahedral or square planar
Answer: A
Diff: 1 Page Ref: Sec. 24.4

32) How many isomers exist for the octahedral complex ion $[Co(NH_3)_4F_2]^+$ __________?
A) 1
B) 2
C) 3
D) 4
E) 5
Answer: B
Diff: 1 Page Ref: Sec. 24.4

33) Trans-$[Fe(H_2O)_2Cl_4]^{2-}$ must be __________.
A) tetrahedral
B) octahedral
C) square planar
D) trigonal bipyramidal
E) linear
Answer: B
Diff: 1 Page Ref: Sec. 24.4

34) Linkage isomerism can only occur __________.
A) in cis-isomers of octahedral complexes
B) with cobalt complexes
C) with coordination number 6
D) with tetrahedral complexes
E) with ligands that have more than one possible donor atom
Answer: E
Diff: 1 Page Ref: Sec. 24.4

35) Which geometry does not exhibit cis- trans-isomerism __________?
A) octahedral
B) square planar
C) tetrahedral
D) linear
E) All geometries can exhibit cis- trans-isomerism.
Answer: C
Diff: 1 Page Ref: Sec. 24.4

36) Metals with __________ electron configurations characteristically form diamagnetic, square planar complexes.
A) d^0
B) d^9
C) d^6
D) d^8
E) d^{10}
Answer: D
Diff: 1 Page Ref: Sec. 24.6

37) What transition metal is responsible for the color of ruby __________?
A) manganese
B) cobalt
C) titanium
D) gold
E) chromium
Answer: E
Diff: 1 Page Ref: Sec. 24.6

38) What transition metal is responsible for the color of amethyst __________?
A) manganese
B) cobalt
C) titanium
D) gold
E) chromium
Answer: A
Diff: 1 Page Ref: Sec. 24.6

39) What transition metal is responsible for the color of topaz __________?
A) manganese
B) cobalt
C) iron
D) gold
E) chromium
Answer: C
Diff: 1 Page Ref: Sec. 24.6

Multiple-Choice

40) Formation of a complex species of M^{n+} metal ion with ligands often __________.
A) "masks" original chemical properties of both the M^{n+} ion and the ligands
B) reduces availability of the free M^{n+} ions in solution
C) may cause changes in the ease with which M^{n+} is reduced or oxidized
D) alters original physical properties of M^{n+}
E) all of the above
Answer: E
Diff: 1 Page Ref: Sec. 24.1

41) What is the most common geometry found in four-coordinate complexes?
A) square planar
B) octahedral
C) tetrahedral
D) icosahedral
E) trigonal bipyramidal
Answer: C
Diff: 1 Page Ref: Sec. 24.1

42) Changes in the coordination sphere of a complex compound may lead to changes in __________.
A) color
B) physical properties
C) chemical properties
D) stability
E) all of the above
Answer: E
Diff: 1 Page Ref: Sec. 24.1

43) In the compound, $CaNa[Fe(CN)_6]$, what ligands are in the coordination sphere?
A) Ca^{2+}
B) Na^+
C) CN^-
D) H_2O
E) none of the above
Answer: C
Diff: 1 Page Ref: Sec. 24.1

44) What are the respective central-metal oxidation state, coordination number, and overall charge on the complex ion in

$Na_2[Cr(NH_3)_2(NCS)_4]$?

A) +3; 6; -1
B) +3; 6; +1
C) +2; 6; -2
D) +2; 4; -1
E) +1; 6; -2
Answer: C
Diff: 2 Page Ref: Sec. 24.1

45) Which one of the following species is paramagnetic?
A) Cu^+
B) Cr^{3+}
C) Zn
D) Ca
E) Ag^+
Answer: B
Diff: 1 Page Ref: Sec. 24.1

46) What is the charge on the complex ion in $Ca_2[Fe(CN)_6]$?
A) 3-
B) 2+
C) 2-
D) 1-
E) 4-
Answer: E
Diff: 3 Page Ref: Sec. 24.1

47) A ligand with a single donor atom is called __________.
A) a chelon
B) a chelate
C) polydentate
D) monodentate
E) bidentate
Answer: D
Diff: 1 Page Ref: Sec. 24.2

48) Which of the following is not a chelating agent?
A) chloride anion
B) EDTA
C) porphine
D) ethylenediamine
E) oxalate anion
Answer: A
Diff: 1 Page Ref: Sec. 24.2

49) What is the purpose of adding EDTA to prepared foods?
A) to keep ions such as Ca^{2+} in solution so the foods look good
B) to complex trace metal ions that catalyze decomposition reactions
C) to complex iron(III) ions so they can catalyze protein decomposition on cooking
D) to aid in browning of the surface during cooking
E) to prevent dissolution of the container in the food when stored for long periods of time
Answer: B
Diff: 1 Page Ref: Sec. 24.2

50) What purpose would sodium tripolyphosphate serve in a detergent formulation?
A) to aid in removal of rust stains from surfaces and from clothes
B) to aid in keeping the inside of washing machines clean and free from corrosion
C) to improve the flow characteristics of the detergent in the box
D) to complex and hence sequester metal ions in hard water
E) to reduce bacterial growth in the detergent upon storage
Answer: D
Diff: 1 Page Ref: Sec. 24.2

51) What are the donor atoms in a porphine molecule?
A) N
B) O
C) S
D) Br
E) F
Answer: A
Diff: 1 Page Ref: Sec. 24.2

52) What metal is complexed in chlorophyll?
A) iron
B) chromium
C) manganese
D) vanadium
E) magnesium
Answer: E
Diff: 1 Page Ref: Sec. 24.2

53) What form of hemoglobin is purplish-red?
A) oxyhemoglobin
B) deoxyhemoglobin
Answer: B
Diff: 1 Page Ref: Sec. 24.2

54) How many bonds can ethylenediamine form to a metal ion?
A) 1
B) 2
C) 3
D) 4
E) 6
Answer: B
Diff: 1 Page Ref: Sec. 24.2

55) Based on entropy considerations alone, which homogeneous aqueous equilibrium would be expected to lie to the right?
A) $AgI_2^- + 2Br^- \Leftrightarrow AgBr_2^- + 2I^-$
B) $Ni(H_2NC_2H_4NH_2)_3^{2+} + 6NH_3 \Leftrightarrow Ni(NH_3)_6^{2+} + 3H_2NC_2H_4NH_2$
C) $CoCl_4^{2+} + 6H_2O \Leftrightarrow Co(H_2O)_6^{2+} + 4Cl^-$
D) $Fe(NH_3)_6^{2+} + C_{20}H_{10}N_4^{2-} \Leftrightarrow Fe(NH_3)_2(C_{20}H_{10}N_4) + 4NH_3$
E) $Cu(NH_3)_4^{2+} + 6H_2O \Leftrightarrow Cu(H_2O)_6^{2+} + 4NH_3$
Answer: D
Diff: 4 Page Ref: Sec. 24.2

56) The chelate effect is best attributed to considerations of which type?
A) hydration
B) enthalpy
C) entropy
D) hydrogen bonding
E) resonance
Answer: C
Diff: 1 Page Ref: Sec. 24.2

57) Which one of the following species is a potential polydentate ligand (chelating agent)?
A) NH_3
B) Cl^-
C) CN^-
D) H_2O
E) $C_2O_4^{2-}$
Answer: E
Diff: 1 Page Ref: Sec. 24.2

58) A complex of correctly written formula $[Pt(NH_3)_3Br]Br \cdot H_2O$ has which set of ligands in its inner coordination sphere?
A) 3 NH_3
B) 3 NH_3 and 2 Br^-
C) 3 NH_3 and 1 Br^-
D) 3 NH_3, 1 Br^--, and 1 H_2O
E) 3 NH_3, 2 Br^-, and 1 H_2O
Answer: C
Diff: 1 Page Ref: Sec. 24.3

59) Which one of the following is the correct formula for potassium diaquatetrachloromolybdate (III)?
A) $K_2[Mo(H_2O)_2Cl_4]$
B) $K[Mo(H_2O)_2Cl_2]Cl_2$
C) $K[Mo(H_2O)_2Cl_4]$
D) $Mo[K(H_2O)_2]Cl_4$
E) $K_3[Mo(H_2O)_2Cl_4]$
Answer: C
Diff: 1 Page Ref: Sec. 24.3

60) What are the donor atoms in ferrichrome and how many of them are in one molecule?
A) Cr, 5
B) N, 4
C) O, 6
D) Fe, 4
E) S, 6
Answer: C
Diff: 1 Page Ref: Sec. 24.2

61) Which of the following complexes has a coordination number of 6?
A) $[Co(en)_2Cl_2]^+$
B) $[Pt(NH_3)_2Cl_2]$
C) $[Cu(NH_3)_4]^{2+}$
D) $[Ag(NH_3)_2]^+$
E) None of these complexes has coordination number 6.
Answer: A
Diff: 2 Page Ref: Sec. 24.1

62) How many ligands are there in the coordination sphere of $[Co(en)_2Cl_2]^+$?
A) 3
B) 6
C) 4
D) 1
E) 0
Answer: C
Diff: 1 Page Ref: Sec. 24.1

63) Which of the following is a polydentate ligand?
A) ammonia
B) oxalate ion
C) chloride ion
D) water
E) hydroxide ion
Answer: B
Diff: 1 Page Ref: Sec. 24.2

64) Which one of the following geometries does not exhibit geometrical isomerism?
A) square planar
B) octahedral
C) trigonal bipyramidal
D) tetrahedral
E) linear
Answer: D
Diff: 1 Page Ref: Sec. 24.4

65) Does either or both cis- or trans-$[Mn(en)_2Br_2]$ have optical isomers?
A) cis only
B) trans only
C) both cis and trans
D) neither cis nor trans
E) $[Mn(en)_2Br_2]$ does not exhibit cis-trans-isomerism.
Answer: A
Diff: 1 Page Ref: Sec. 24.4

66) Linkage isomerism would most likely occur when which of the following ligands is present?
A) H_2O
B) NH_3
C) Cl^-
D) PF_3
E) NCS^-
Answer: E
Diff: 1 Page Ref: Sec. 24.4

67) Which of the following will display optical isomerism?
A) square-planar $Rh(CO)_2Cl_2^-$
B) square-planar $Pt(H_2NC_2H_4NH_2)_2^{2+}$
C) octahedral $Co(NH_3)_6^{3+}$
D) octahedral $Co(NH_3)_5Cl^{2+}$
E) octahedral $Co(H_2NC_2H_4NH_2)_3^{3+}$
Answer: E
Diff: 2 Page Ref: Sec. 24.4

68) Which one of the following complexes would most likely have tetrahedral geometry?
A) $[NiCl_4]^{2-}$
B) $[Co(H_2O)_6]^{2+}$
C) $[Cr(NH_3)_6]^{3+}$
D) $[Fe(CN)_6]^{3}$
E) $[Pt(NH_3)_2Cl_2]$
Answer: A
Diff: 1 Page Ref: Sec. 24.4

69) Which one of the following complexes can exhibit geometrical isomerism?
A) $[Pt(NH_3)_2Cl_2]$ (square planar)
B) $[Zn(NH_3)_2Cl_2]$ (tetrahedral)
C) $[Cu(NH_3)_4]^{2+}$ (square planar)
D) $[Cu(NH_3)_5Cl]^{2+}$ (octahedral)
E) All of the above can exhibit geometrical isomerism.
Answer: A
Diff: 1 Page Ref: Sec. 24.4

70) Coordination sphere isomers
A) have the same formula and coordination number.
B) have the same formula but different coordination numbers.
C) have different formulas but the same coordination number.
D) have different formulas and different coordination numbers.
E) are the same as resonance structures.
Answer: A
Diff: 2 Page Ref: Sec. 24.4

71) A racemic mixture is
A) an equal mixture of both enantiomers of an optically active species.
B) a mixture of an optically active species with an optically inactive species.
C) an equal mixture of cis- and trans-isomers.
D) a mixture of metal ions and ligands in equilibrium.
E) a mixture of structural isomers.
Answer: A
Diff: 1 Page Ref: Sec. 24.4

72) Complexes containing metals with d^0 electron configurations are typically colorless because
A) there is no d electron that can be promoted via the absorption of visible light.
B) the empty d orbitals absorb all of the visible wavelengths.
C) there are no d electrons to form bonds to ligands.
D) a complex must be charged to be colored.
E) d electrons must be emitted by the complex in order for it to appear colored.
Answer: A
Diff: 1 Page Ref: Sec. 24.6

73) Complexes containing metals with d^{10} electron configurations are typically __________.
A) violet
B) blue
C) green
D) yellow
E) colorless
Answer: E
Diff: 1 Page Ref: Sec. 24.6

74) Complexes containing metals with which one of the following electron configurations are usually colorless?
A) d^2
B) d^1
C) d^5
D) d^8
E) d^{10}
Answer: E
Diff: 1 Page Ref: Sec. 24.6

75) Based on electron configuration, which is most likely colorless?
A) $[Cu(NH_3)_4]^{2+}$
B) $[Cd(NH_3)_4]^{2+}$
C) $[Ni(NH_3)_6]^{2+}$
D) $[Cr(NH_3)_5Cl]^{2+}$
E) $[Cu(NH_3)_6]^{2+}$
Answer: B
Diff: 3 Page Ref: Sec. 24.5

76) Which one of the following substances has three unpaired d electrons?
A) $[Zn(NH_3)_4]^{2+}$
B) $[V(H_2O)_6]^{4+}$
C) $[Ag(NH_3)_2]^{+}$
D) $[Cu(NH_3)_4]^{2+}$
E) $[Cr(CN)_6]^{3-}$
Answer: E
Diff: 2 Page Ref: Sec. 24.5, 24.6

77) Which one of the following complex ions will be paramagnetic?
A) $[Fe(H_2O)_6]^{2+}$ (low spin)
B) $[Fe(H_2O)_6]^{3+}$ (low spin)
C) $[Co(H_2O)_6]^{3+}$ (low spin)
D) $[Zn(H_2O)_4]^{2+}$
E) $[Zn(NH_3)_4]^{2+}$
Answer: B
Diff: 2 Page Ref: Sec. 24.5, 24.6

78) Which one of the following is a strong-field ligand?
A) Cl^-
B) NH_3
C) H_2O
D) F^-
E) CN^-
Answer: E
Diff: 1 Page Ref: Sec. 24.6

79) Consider a complex in which manganese (III) is bonded to six identical ligands. Which one of the following ligands will result in the smallest value of Δ?
A) Cl^-
B) NH_3
C) H_2O
D) F^-
E) CN^-
Answer: A
Diff: 1 Page Ref: Sec. 24.6

80) Based on the crystal-field strengths F- < CH_2CN < NH_3 < NO_2^- < CN^- which Co(III) complex is most likely high-spin?
A) $[Co(NH_3)_6]^{3+}$
B) $[Co(NO_2)_6]^{3-}$
C) $[Co(CN)_6]^{3-}$
D) $[CoF_6]^{3-}$
E) $[Co(CH_3CN)_6]^{3+}$
Answer: D
Diff: 1 Page Ref: Sec. 24.6

81) Which complex below has 2 unpaired electrons?
A) square-planar $[Ni(CN)_4]^{2-}$
B) low-spin octahedral $[Fe(CN)_6]^{3-}$
C) tetrahedral $[CoCl_4]^{2-}$
D) octahedral $[Ni(NH_3)_6]^{2+}$
E) tetrahedral $[FeI_4]^{2-}$
Answer: D
Diff: 1 Page Ref: Sec. 24.6

82) Based on the crystal-field strengths Cl- <F- < H_2O < NH_3 < $H_2NC_2H_4NH_2$, which octahedral Ti(III) complex below has its d-d electronic transition at shortest wavelength?
A) $[Ti(NH_3)_6]^{3+}$
B) $[Ti(H_2NC_2H_4NH_2)_3]_{3+}$
C) $[Ti(H_2O)_6]^{3+}$
D) $[TiCl_6]^{3-}$
E) $[TiF_6]^{3-}$
Answer: B
Diff: 1 Page Ref: Sec. 24.6

83) Which one of the following ions cannot form both a high spin and a low spin octahedral complex ion?
A) Fe^{3+}
B) Co^{2+}
C) Cr^{3+}
D) Mn^{3+}
E) Cr^{2+}
Answer: C
Diff: 2 Page Ref: Sec. 24.6

84) Using the following abbreviated spectrochemical series, determine which complex ion is most likely to absorb light in the red region of the visible spectrum.

small splitting $Cl^- < H_2O < NH_3 < CN^-$ large splitting

A) $[CuCl_4]^{2-}$
B) $[Cu(H_2O)_4]^{2+}$
C) $[Cu(NH_3)_4]^{2+}$
D) $[Cu(CN)_4]^{2-}$
E) not enough information given to determine
Answer: A
Diff: 1 Page Ref: Sec. 24.6

85) Which one of the following coordination compounds would be paramagnetic?
A) $[Zn(NH_3)_4]Cl_2$
B) $K[FeCl_4]$ (low spin)
C) $[Cu(H_2O)_4]Br$
D) $Na[CoCl_6]$ (low spin)
E) $[Cd(H_2O)_6]SO_4$
Answer: B
Diff: 2 Page Ref: Sec. 24.6

86) Which of the following cannot form both high- and low-spin octahedral complexes?
A) Mn^{2+}
B) V^{2+}
C) Co^{3+}
D) Cr^{2+}
E) All of the above can form both high- and low-spin complexes.
Answer: B
Diff: 2 Page Ref: Sec. 24.6

87) Which of the following can form both high- and low-spin octahedral complexes?
A) Cr^{2+}
B) Cr^{3+}
C) Zn^{2+}
D) Cu^{+}
E) All of the above can form either high- or low-spin complexes.
Answer: A
Diff: 1   Page Ref: Sec. 24.6

Short Answer

1) What is the oxidation state of the iron atom in $CaNa[Fe(CN)_6]$?
Answer: +3
Diff: 2   Page Ref: Sec. 24.1

2) The most common coordination numbers are __________.
Answer: 4 and 6
Diff: 1   Page Ref: Sec. 24.1

3) What is the coordination number of the iron atom in $CaNa[Fe(CN)_6]$?
Answer: 6
Diff: 1   Page Ref: Sec. 24.1

4) Six-coordinate complexes generally have __________ geometry.
Answer: octahedral
Diff: 1   Page Ref: Sec. 24.1

5) Define the chelate effect.
Answer: Chelate effect = an increased stability of complex compounds formed with chelating (polydentate) ligands compared to those formed with monodentate ligands.
Diff: 1   Page Ref: Sec. 24.2

6) List three of the seven transition metals required for human life.
Answer: Any three of: Co, Cu, Cr, Fe, Mn, V, Zn
Diff: 1   Page Ref: Sec. 24.2

7) Two compounds have the same formula and contain an SCN^- ligand. In one compound the SCN^- ligand is bonded to the metal atom via the N atom and in the other it is bonded via the S atom. These two compounds are examples of __________ isomers.
Answer: linkage
Diff: 1   Page Ref: Sec. 24.4

8) How can high-spin and low-spin transition metal complexes be distinguished from each other?
Answer: Magnetic properties and absorption spectra can be compared.
Diff: 1   Page Ref: Sec. 24.6

9) Werner's theory of primary and secondary valences for transition metal complexes has given us the concepts of __________ and __________.
Answer: oxidation state and coordination number
Diff: 1   Page Ref: Sec 24.1

10) Transition metal ions with empty valence orbitals act as __________.
Answer: Lewis bases
Diff: 1   Page Ref: Sec 24.1

11) What is the oxidation number of the central metal in $[Mo(H_2O)_5NO_3]Cl_2$
Answer: +3
Diff: 1 Page Ref: Sec 24.1

12) A large difference in formation constant (K_f) is a poly- versus monodentate ligand is called __________.
Answer: chelate effect
Diff: 1 Page Ref: Sec 24.2

13) A compound that can occupy two coordination sites is a (an) __________.
Answer: bidentate ligand
Diff: 1 Page Ref: Sec 24.2

14) The porphyrin compound that contrains Mg(II) is called __________.
Answer: chlorophyll
Diff: 1 Page Ref: Sec 24.2

15) The transport of iron into bacteria is facilitated by the formation of the complex __________.
Answer: ferrichrome
Diff: 1 Page Ref: Sec 24.2

16) Name $Na[Ru(H_2O)_2(C_2O_4)_2]$
Answer: sodium diaquadioxalatoruthenate (II)
Diff: 1 Page Ref: Sec 24.3

17) The cis geometric isomer of what compound is a powerful anti cancer agent?
Answer: cisplatin
Diff: 1 Page Ref: Sec 24.4

18) Non superimposable isomers are __________ isomers.
Answer: optical
Diff: 1 Page Ref: Sec 24.4

True/False

1) If chloride is a ligand to a transition metal it will not be precipitated by silver nitrate.
Answer: TRUE
Diff: 1 Page Ref: Sec 24.1

2) The chelate effect must always occur with positive enthalpy change.
Answer: FALSE
Diff: 1 Page Ref: Sec 24.2

3) The color of hemoglobin changes from purple to red when water displaces oxygen on the molecule.
Answer: FALSE
Diff: 1 Page Ref: Sec 24.2

4) The heme unit of myoglobin is bound to the protein via a nitrogen containing ligand.
Answer: TRUE
Diff: 1 Page Ref: Sec 24.4

5) An enzyme must contain a metal ion to be chiral.
Answer: FALSE
Diff: 1 Page Ref: Sec 24.4

6) To separate racemic mixtures the isomers must be in a chiral environment.
Answer: TRUE
Diff: 1 Page Ref: Sec 24.4

7) Green and orange are complementary colors.
Answer: FALSE
Diff: 1 Page Ref: Sec 24.5

8) Transition metal complexes, whose metal ions have the same number of unpaired electrons, are paramagnetic
Answer: TRUE
Diff: 1 Page Ref: Sec 24.5

9) The energy of a metal ligand complex is higher than the energy of the separated components.
Answer: FALSE
Diff: 1 Page Ref: Sec 24.6

10) Transition metal complexes are colored because of the energy gap between the d orbitals.
Answer: TRUE
Diff: 1 Page Ref: Sec 24.6

Essay

1) What is the purpose of adding sodium tripolyphosphate to a detergent?
Answer: to sequester the metal ions in hard water to prevent their interference with the action of the detergent
Diff: 1 Page Ref: Sec. 24.2

2) What colors of light does chlorophyll-a absorb?
Answer: red and blue
Diff: 1 Page Ref: Sec. 24.2

3) What is meant by the prefix tetrakis-, and when is it used?
Answer: It means 4 and is used when there are 4 of a ligand whose name includes a Greek prefix.
Diff: 1 Page Ref: Sec. 24.3

4) Name the compound, $Ca[AlH_4]_2$.
Answer: calcium tetrahydroaluminate
Diff: 1 Page Ref: Sec. 24.3

5) Name the compound, $[Os(en)_3]_2[NiCl_2Br_2]_3$.
Answer: tris(ethylenediamine)osmium(III) dibromodichloronickelate(II)
Diff: 2 Page Ref: Sec. 24.3

6) Name the compound, $Cu(H_2O)_4{}^{2+}$.
Answer: tetraaquacopper(II)
Diff: 1 Page Ref: Sec. 24.3

7) How does an elevated body temperature deprive some bacteria in the body of iron?
Answer: in some bacteria, siderophore production decreases as temperature increases
Diff: 1 Page Ref: Sec. 24.2

8) What is a siderophore?
Answer: a ligand that forms an extremely stable water-soluble complex, called ferrichrome, with iron
Diff: 1 Page Ref: Sec. 24.2

9) In what two ways can an object appear blue?
Answer: absorb all wavelengths except blue and reflect or transmit only blue, or absorb the complementary color of blue and reflect or transmit all others
Diff: 1 Page Ref: Sec. 24.5

Chemistry, 11e (Brown)
Chapter 25: The Chemistry of Life: Organic and Biological Chemistry

Multiple-Choice and Bimodal

1) Hydrocarbons containing only single bonds between the carbon atoms are called __________.
A) alkenes
B) alkynes
C) aromatics
D) alkanes
E) ketones
Answer: D
Diff: 1 Page Ref: Sec. 25.2

2) What general class of compounds is also known as olefins __________?
A) alkenes
B) alkynes
C) aromatics
D) alkanes
E) ketones
Answer: A
Diff: 1 Page Ref: Sec. 25.2

3) The simplest alkyne is __________.
A) ethylene
B) ethane
C) acetylene
D) propyne
E) benzene
Answer: C
Diff: 1 Page Ref: Sec. 25.2

4) The melting and boiling points of hydrocarbons are determined by __________.
A) ion-dipole attraction
B) dipole-dipole attraction
C) London forces
D) hydrogen bonding
E) ionic bonding
Answer: C
Diff: 1 Page Ref: Sec. 25.2

5) Hydrocarbons containing carbon-carbon triple bonds are called __________.
A) alkanes
B) aromatic hydrocarbons
C) alkynes
D) alkenes
E) olefins
Answer: C
Diff: 1 Page Ref: Sec. 25.2

6) Alkynes always contain a __________.
A) $C=C$ bond
B) $C\equiv C$ bond
C) $C-C$ bond
D) $C=H$ bond
E) $C\equiv H$ bond
Answer: B
Diff: 1 Page Ref: Sec. 25.2

7) Alkenes always contain a __________.
A) C=C bond
B) C≡C bond
C) C–C bond
D) C=H bond
E) C≡H bond
Answer: A
Diff: 1 Page Ref: Sec. 25.2

8) The molecular geometry of each carbon atom in an alkane is __________.
A) octahedral
B) square planar
C) trigonal planar
D) tetrahedral
E) trigonal pyramidal
Answer: D
Diff: 1 Page Ref: Sec. 25.3

9) Hybridization of the carbon atom indicated by (*) in CH_3–*CH_2–CH_3, *CH=CH_2, and CH_3–C≡CH is __________, __________, and __________, respectively.
A) sp^3, sp^2, sp
B) sp^3, sp, sp^2
C) sp, sp^2, sp^3
D) sp, sp^3, sp^2
E) sp^2, sp^3, sp
Answer: A
Diff: 2 Page Ref: Sec. 25.2

10) The minimum number of carbons necessary for a hydrocarbon to form a branched structure is __________.
A) 4
B) 6
C) 3
D) 9
E) 12
Answer: A
Diff: 1 Page Ref: Sec. 25.3

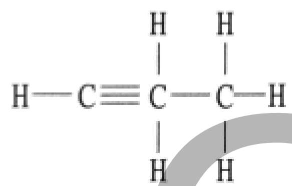
11) Cyclohexane has __________ fewer hydrogens than n-hexane.
A) 0
B) 1
C) 2
D) 3
E) 4
Answer: C
Diff: 1 Page Ref: Sec. 25.3

12) How many structural isomers of heptane exist __________?
A) 2
B) 4
C) 6
D) 8
E) 10
Answer: D
Diff: 2 Page Ref: Sec. 25.3

13) The general formula of an alkane is __________.
A) $C_{2n}H_{2n+2}$
B) C_nH_{2n}
C) C_nH_{2n+2}
D) C_nH_{2n-2}
E) C_nH_n
Answer: C
Diff: 1 Page Ref: Sec. 25.3

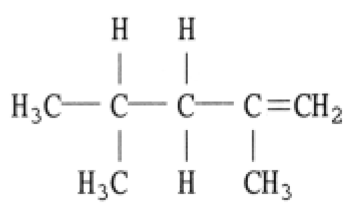
14) Alkenes have the general formula __________.
A) C_nH_{2n}
B) C_nH_{2n-2}
C) C_nH_{2n+2}
D) C_nH_n
E) $C_{2n}H_n$
Answer: A
Diff: 1 Page Ref: Sec. 25.3

15) The compound below is an __________.



A) alkyne
B) alkene
C) alkane
D) aromatic compound
E) olefin
Answer: A
Diff: 1 Page Ref: Sec. 25.3

16) What is the name of the compound below __________?



A) 2,4-methylbutene
B) 2,5-dimethylpentane
C) 2,4-ethylbutene
D) 2,4-dimethyl-1-pentene
E) 2,4-dimethyl-4-pentene
Answer: D
Diff: 1 Page Ref: Sec. 25.3

17) Alkanes with __________ to __________ carbons are found in straight-run gasoline.
A) 2, 3
B) 5, 12
C) 1, 5
D) 9, 15
E) 20, 60
Answer: B
Diff: 1 Page Ref: Sec. 25.3

18) Gasoline and water do not mix because gasoline is __________.
A) less dense than water
B) less viscous than water
C) nonpolar and water is polar
D) volatile and water is not
E) polar and water is nonpolar
Answer: C
Diff: 1 Page Ref: Sec. 25.3

19) Which substance would be the most soluble in gasoline __________?
A) water
B) $NaNO_3$
C) HCl
D) hexane
E) NaCl
Answer: D
Diff: 1 Page Ref: Sec. 25.3

20) Isooctane is assigned an octane number of 100, whereas __________ is assigned an octane number of 0.
A) methane
B) propane
C) benzene
D) heptane
E) nitrous oxide
Answer: D
Diff: 2 Page Ref: Sec. 25.3

21) The octane number of straight-run gasoline is about __________.
A) 0
B) 25
C) 50
D) 75
E) 93
Answer: C
Diff: 1 Page Ref: Sec. 25.3

22) The name of CH_3–CH=C=CH-CH–CH=CH–CH_3 is __________.
A) 2, 3, 5 - octatriene
B) 2, 5, 6 - octatriene
C) 2, 3, 6 - octatriene
D) 3, 5, 6 - octatriene
E) 3, 4, 7 - octatriene
Answer: C
Diff: 1 Page Ref: Sec. 25.4

23) __________ could be the formula of an alkene.
A) C_3H_8
B) C_3H_6
C) C_6H_6
D) $C_{17}H_{36}$
E) CH_8
Answer: B
Diff: 2 Page Ref: Sec. 25.4

24) In general, __________ are the most reactive hydrocarbons.
A) alkenes
B) alkynes
C) alkanes
D) cycloalkanes
E) olefins
Answer: B
Diff: 1 Page Ref: Sec. 25.4

25) The addition of HBr to 2-butene produces __________.
A) 1-bromobutane
B) 2-bromobutane
C) 1,2-dibromobutane
D) 2,3-dibromobutane
E) no reaction
Answer: B
Diff: 1 Page Ref: Sec. 25.4

26) Aromatic hydrocarbons __________.
A) readily undergo addition reactions like alkenes
B) contain a series of π bonds on several consecutive carbon atoms
C) undergo substitution reactions more easily than saturated hydrocarbons
D) have sp^2 hybridized carbon atoms
E) are stabilized by resonance
Answer: B
Diff: 1 Page Ref: Sec. 25.5

27) How many hydroxyl groups are in a glycerol molecule __________?
A) 0
B) 1
C) 2
D) 3
E) 4
Answer: D
Diff: 1 Page Ref: Sec. 25.5

28) The general formula for an ether is __________.
A) R–O–R'
B) R–CO–R'
C) R–CO–OH
D) R–OH
E) R–CO–H
Answer: A
Diff: 1 Page Ref: Sec. 25.5

29) Ethers can be made by condensation of two __________ molecules by splitting out a molecule of water.
A) alkyne
B) alcohol
C) ketone
D) aldehyde
E) olefin
Answer: B
Diff: 1 Page Ref: Sec. 25.5

30) The general formula of an aldehyde is __________.
A) R–O–R'
B) R–CO–R'
C) R–CO–OH
D) R–CHO
E) R–CO–OR'
Answer: D
Diff: 1 Page Ref: Sec. 25.6

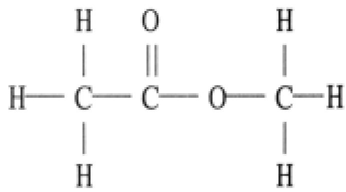
31) The general formula of a carboxylic acid is __________.
A) R–O–R'
B) R–CO–R'
C) R–CO–OH
D) R–H
E) R–CO–OR'
Answer: C
Diff: 1 Page Ref: Sec. 25.6

32) Carboxylic acids can be formed by oxidation of __________.
A) alkenes
B) benzene
C) ketones
D) primary alcohols
E) alkynes
Answer: D
Diff: 1 Page Ref: Sec. 25.6

33) The general formula of an ester is __________.
A) R–O–R'
B) R–CO–R'
C) R–CO–OH
D) R–OH
E) R–CO–OR'
Answer: E
Diff: 1 Page Ref: Sec. 25.6

34) $CH_3CH_2C(=O)NH_2$ is called a(n) __________.
A) amine
B) amide
C) ketone
D) aldehyde
E) ester
Answer: B
Diff: 1 Page Ref: Sec. 25.6

35) The compound below is a(n) __________.



A) carboxylic acid
B) ketone
C) aldehyde
D) ester
E) amine
Answer: D
Diff: 1   Page Ref: Sec. 25.6

36) The hybridization of the central carbon atom in an aldehyde is __________.
A) sp
B) sp^3
C) sp^2
D) d^2sp^3
E) sp^4
Answer: C
Diff: 1   Page Ref: Sec. 25.6

37) Optically active molecules that are mirror images of each other are called __________.
A) allotropes
B) geometrical isomers
C) enantiomers
D) cofactors
E) chiral compounds
Answer: C
Diff: 1   Page Ref: Sec. 25.7

38) Which amino acid is non-chiral __________?
A) leucine
B) histidine
C) arginine
D) glycine
E) All of the above are chiral.
Answer: D
Diff: 1   Page Ref: Sec. 25.9

39) The secondary structure of a protein is the result of __________ bonding.
A) covalent
B) peptide
C) ionic
D) hydrogen
E) none of the above
Answer: D
Diff: 1   Page Ref: Sec. 25.9

40) Starch, glycogen, and cellulose are made of repeating units of __________.
A) lactose
B) glucose
C) fructose
D) sucrose
E) amino acids
Answer: B
Diff: 1 Page Ref: Sec. 25.9

41) How many chiral atoms does the open-chain form of glucose have __________?
A) 1
B) 2
C) 3
D) 4
E) 5
Answer: D
Diff: 1 Page Ref: Sec. 25.10

42) __________ acts as a kind of energy bank in the body, and is found concentrated in muscles and liver.
A) Lactose
B) Starch
C) Cellulose
D) Glycogen
E) Sucrose
Answer: D
Diff: 1 Page Ref: Sec. 25.10

43) What forces hold the strands of DNA together __________?
A) covalent bonds
B) hydrogen bonding
C) ion-dipole attraction
D) coordinate covalent bonds
E) London dispersion forces
Answer: B
Diff: 1 Page Ref: Sec. 25.11

Multiple-Choice

44) Which one of the following could be a cyclic alkane?
A) C_5H_5
B) C_3H_6
C) C_4H_6
D) C_2H_6
E) C_9H_{20}
Answer: B
Diff: 2 Page Ref: Sec. 25.3

45) If each of the following represents an alkane, and a carbon atom is located at each vertex with the proper number of hydrogen atoms also bonded to it, which one is the most reactive?
A)

B)

C)

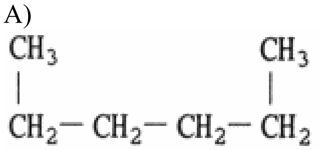
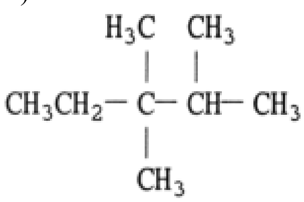
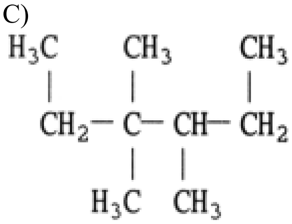
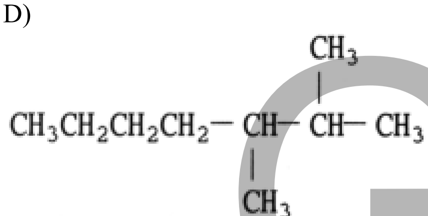
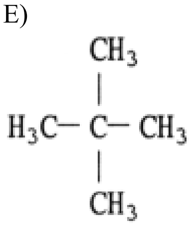
D)

E) They are all equally reactive since they are all alkanes.
Answer: D
Diff: 1   Page Ref: Sec. 25.3

46) How many isomers are possible for C_4H_{10}?
A) 1
B) 2
C) 3
D) 4
E) 10
Answer: B
Diff: 2   Page Ref: Sec. 25.3

47) How many isomers are possible for C_5H_{12}?
A) 1
B) 2
C) 3
D) 4
E) 10
Answer: C
Diff: 2   Page Ref: Sec. 25.3

48) The structure of 2,3-dimethylheptane is __________.

A)

B)

C)

D)

E)

Answer: D
Diff: 1 Page Ref: Sec. 25.3

49) When petroleum is distilled to separate the components by boiling point, the component with the highest boiling point is called __________.
A) gas
B) gasoline
C) kerosene
D) paraffin
E) asphalt
Answer: E
Diff: 2 Page Ref: Sec. 25.3

50) What type of compound has been used to replace tetraethyl lead ($(C_2H_5)_4Pb$) as an antiknock agent in gasoline?
A) aromatic compounds
B) olefins
C) fluorochlorocarbons
D) paraffins
E) oxygenated hydrocarbons
Answer: E
Diff: 1 Page Ref: Sec. 25.3

51) How many structural isomers (include all types except optical) can be drawn for C_5H_{10}?
A) 5
B) 6
C) 7
D) 11
E) 12
Answer: D
Diff: 3 Page Ref: Sec. 25.4

52) How many isomers of $C_2H_2Cl_2$ are polar?
A) none
B) 1
C) 2
D) 3
E) It is impossible to tell without more information.
Answer: C
Diff: 1 Page Ref: Sec. 25.4

53) Which statement about hydrocarbons is false?
A) The smallest alkane to have structural (constitutional) isomers has 4 carbon atoms.
B) Cyclic alkanes are structural isomers of alkenes.
C) Alkanes are more reactive than alkenes.
D) Alkanes can be produced by hydrogenating alkenes.
E) Alkenes can be polymerized.
Answer: C
Diff: 1 Page Ref: Sec. 25.4

54) Which statement about addition reactions between alkenes and HBr is false?
A) The addition occurs at the double bond.
B) Bromine attacks the alkene carbon atom possessing a positive partial charge.
C) A hydrogen atom attaches itself to the alkene carbon atom possessing a negative partial charge.
D) The π bond breaks in the course of the reaction.
E) The proposed mechanism involves radicals.
Answer: E
Diff: 1 Page Ref: Sec. 25.4

55) Benzene behaves differently from a hydrocarbon which simply contains three C=C bonds in that the latter would be expected to react much more readily with __________.
A) H_2
B) Cl_2
C) Br_2
D) HCl
E) all of the above
Answer: E
Diff: 1 Page Ref: Sec. 25.4

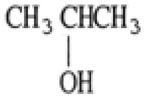
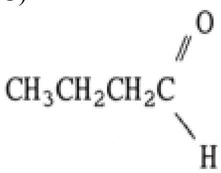
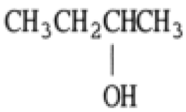
56) During World War II, Teflon™ was used __________.
A) as gasket material in the gaseous diffusion plant for separation of uranium isotopes
B) to form the tube to keep the separate parts of the critical mass apart until the time for detonation of the bomb
C) because its characteristic color change upon exposure to radiation made it an excellent indicator of radiation leaks
D) as a liner inside the atomic bomb to protect the guidance system from radiation
E) to package the shrapnel incorporated into the atomic bomb
Answer: A
Diff: 2 Page Ref: Sec. 25.4

57) Alcohols are hydrocarbon derivatives in which one or more hydrogens have been replaced by a hydroxyl functional group. __________ is the general formula of an alcohol.
A) R–O–R
B) R–CO–R
C) R–CO–OH
D) R–OH
E) R–CO–H
Answer: D
Diff: 1 Page Ref: Sec. 25.5

58) Consider the following statements about alcohols:
(i) Alcohols contain a polar O–H bond and hence mix well with polar solvents like water.
(ii) Alcohols form hydrogen bonds with water.
(iii) Alcohols have a higher boiling point compared to hydrocarbons with the same number of carbon atoms.
(iv) For the most part, alcohols are toxic.
Which statement(s) is(are) true?
A) none
B) (i) and (ii)
C) (iii) only
D) (i), (ii), and (iv)
E) all
Answer: E
Diff: 1 Page Ref: Sec. 25.5

59) Which one of the following is not an alcohol?
A) acetone
B) glycerol
C) ethanol
D) cholesterol
E) ethylene glycol
Answer: A
Diff: 1 Page Ref: Sec. 25.5

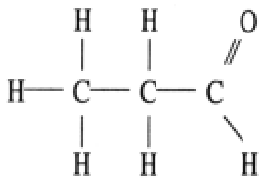
60) Which one of the following compounds is an isomer of $CH_3CH_2CH_2CH_2OH$?
A) $CH_3CH_2CH_2OH$

B)

C)

D)

E) CH_3OH
Answer: D
Diff: 1   Page Ref: Sec. 25.5

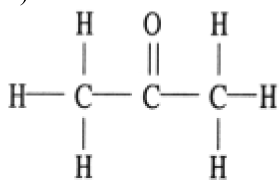
61) What is the general formula for a ketone?
A) R–O–R
B) R–CO–R'
C) R–CO–OH
D) R–OH
E) R–CHO
Answer: B
Diff: 1   Page Ref: Sec. 25.6

62) Which of the following compounds do not contain an sp^3 hybridized oxygen atom?
A) ketones
B) alcohols
C) ethers
D) esters
E) water
Answer: A
Diff: 1   Page Ref: Sec. 25.6

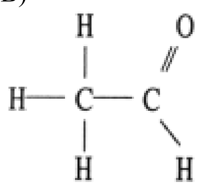
63) Of the compounds below, __________ is an isomer of



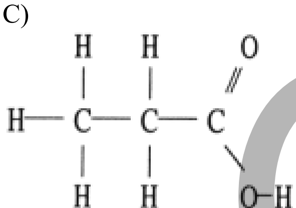
A)



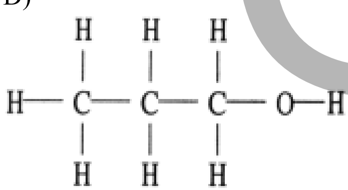
B)



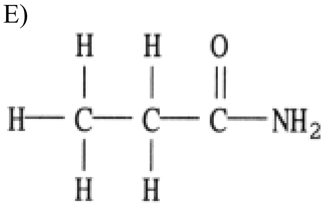
C)



D)



E)



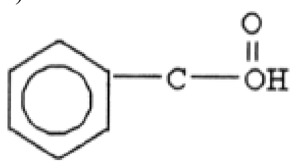
Answer: A
Diff: 1 Page Ref: Sec. 25.6

64) Which structure below represents a ketone?

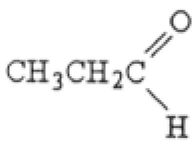
A)

$CH_3CH_2 — O — CH_2CH_3$

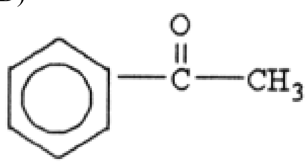
B)



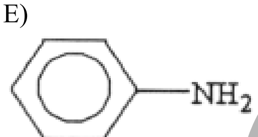
C)



D)



E)



Answer: D

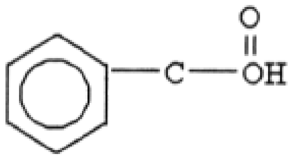
Diff: 1 Page Ref: Sec. 25.6

65) Which structure below represents an aldehyde?

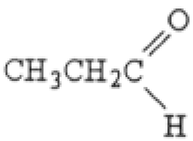
A)

$CH_3CH_2 — O — CH_2CH_3$

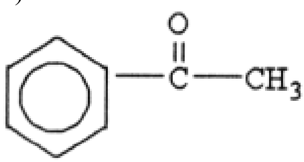
B)



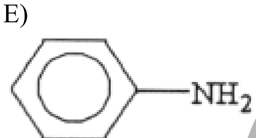
C)



D)

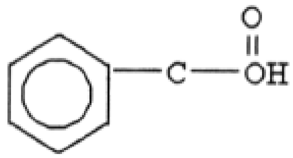
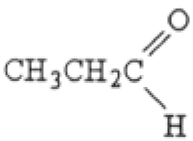
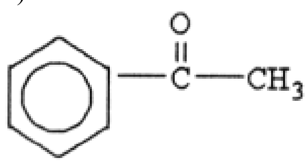


E)



Answer: C

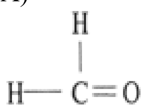
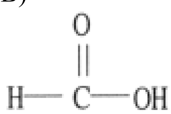
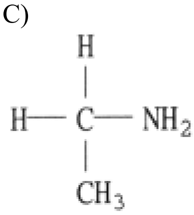
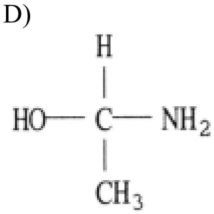
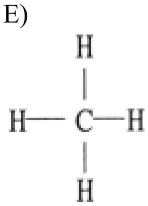
Diff: 1 Page Ref: Sec. 25.6

66) Which structure below represents an ether?
A)
$CH_3CH_2 - O - CH_2CH_3$
B)

C)

D)

E)

Answer: A
Diff: 1 Page Ref: Sec. 25.6

67) Which of the following compounds does not contain a C=O bond?
A) ketones
B) aldehydes
C) esters
D) amides
E) ethers
Answer: E
Diff: 1 Page Ref: Sec. 25.6

68) Which one of the following molecules is chiral?

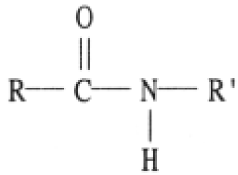
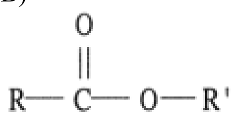
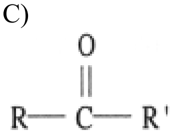
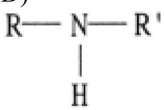
A)

B)

C)

D)

E)


Answer: D
Diff: 1 Page Ref: Sec. 25.7

69) How many chiral carbon atoms does the neopentane (2,2 - dimethylpropane) have?
A) 0
B) 1
C) 2
D) 3
E) 4
Answer: A
Diff: 1 Page Ref: Sec. 25.7

70) Proteins are biopolymers formed via multiple condensation coupling of which two functional groups?
A) ester and amine
B) amine and carboxylic acid
C) alcohol and carboxylic acid
D) alcohol and amine
E) ester and carboxylic acid
Answer: B
Diff: 1 Page Ref: Sec. 25.9

71) Which of the following contains a peptide linkage?

A)

B)

C)

D)

E) none of the above
Answer: A
Diff: 1   Page Ref: Sec. 25.9

72) Sugars are examples of what type of molecule?
A) proteins
B) carbohydrates
C) nucleic acids
D) amino acids
E) salts
Answer: B
Diff: 1   Page Ref: Sec. 25.10

73) __________ is a monosaccharide.
A) Sucrose
B) Maltose
C) Glucose
D) Lactose
E) Fructose
Answer: C
Diff: 1   Page Ref: Sec. 25.10

74) The principal difference between fructose and glucose is that __________.
A) fructose is a disaccharide and glucose is a monosaccharide
B) fructose is a monosaccharide and glucose is a disaccharide
C) fructose is chiral and glucose is not
D) glucose is chiral and fructose is not
E) fructose is a ketone sugar and glucose is an aldehyde sugar
Answer: E
Diff: 1   Page Ref: Sec. 25.10

75) Which one of the following is a monosaccharide?
A) fructose
B) lactose
C) sucrose
D) maltose
E) none of the above
Answer: A
Diff: 1 Page Ref: Sec. 25.10

76) Consider the following types of compounds:
(i) amino acid
(ii) nitrogen-containing organic base
(iii) phosphoric acid
(iv) five-carbon sugar
Which of the above compounds are the monomers of nucleic acids, called nucleotides?
A) none
B) (i) and (ii)
C) (ii) and (iv)
D) (ii), (iii), and (iv)
E) all
Answer: D
Diff: 1 Page Ref: Sec. 25.11

Short Answer

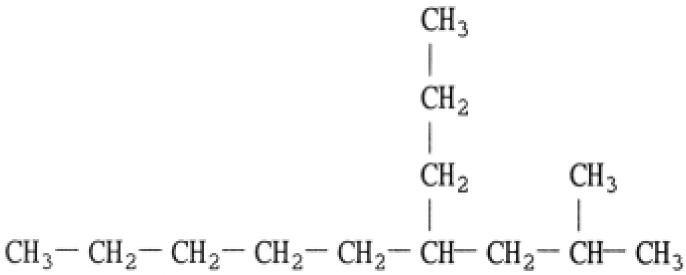
1) Electron pairs in alkanes are in a __________ arrangement.
Answer: trigonal planar
Diff: 1 Page Ref: Sec 25.1

2) The resistance of gasoline to engine knocking is referred to as its __________.
Answer: octane number
Diff: 1 Page Ref: Sec 25.3

3) Rotation around a carbon-carbon double bond is difficult, requiring energy but it is a key process in the chemistry of __________.
Answer: vision
Diff: 1 Page Ref: Sec 25.3

4) Why is cyclopropane more reactive than propane?
Answer: the small ring of cyclopropane forces the C–C–C bond angle to be significantly less than 109.5° of __________ the tetrahedral structure of C in propane.
Diff: 1 Page Ref: Sec. 25.3

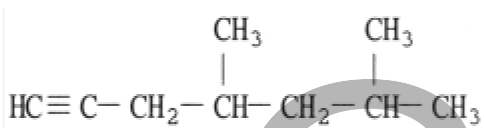
5) Write the formula for 2-methyl-4-propylnonane.
Answer:



Diff: 1 Page Ref: Sec. 25.3

6) What is the correct name for the compound, $CH_3CH_2CH{=}CHCH_2CH{=}CHCH$?
Answer: 2,5-octadiene
Diff: 1 Page Ref: Sec. 25.4

7) What is the name of the compound below?



Answer: 4,6-dimethyl-1-heptyne
Diff: 1 Page Ref: Sec. 25.4

8) Hydrogenation of an alkene requires high temperatures and a catalyst such as nickel. Why is this?
Answer: This is due to the large bond enthalpy of H_2.
Diff: 1 Page Ref: Sec. 25.4

9) Predict the product of the catalytic hydrogenation of 6-ethyl-3-decene.
Answer: 6-ethyldecane
Diff: 1 Page Ref: Sec. 25.4

10) Hydrogenation of what alkyne produces propane?
Answer: propyne
Diff: 1 Page Ref: Sec. 25.4

11) In the reaction of nitric acid with benzene, which isomer is formed when a second nitro group is substituted?
Answer: meta
Diff: 1 Page Ref: Sec 25.4

12) The addition of an alkyl halide to an aromatic ring compound is called the __________ reaction.
Answer: Freidel-Crafts
Diff: 1 Page Ref: Sec 25.4

13) The anaerobic conversion of carbohydrates to ethanol is driven by the presence of __________.
Answer: yeast
Diff: 1 Page Ref: Sec 25.4

14) What is the name of the compound $CH_3CH_2CH(OH)CH_2CH_2CH_3$?
Answer: 3-hexanol
Diff: 1 Page Ref: Sec. 25.5

15) What functional group is characteristic of carboxylic acids?
Answer: -COOH
Diff: 1 Page Ref: Sec. 25.6

16) In the oxidation of ethanol the intermediate formes is __________.
Answer: acetaldehyde
Diff: 1 Page Ref: Sec 25.6

17) The primary ingredient in vinegar is __________
Answer: acetic acid
Diff: 1 Page Ref: Sec 25.6

18) The aromas of different fruit are due to the chemical compounds known as __________
Answer: esters
Diff: 1 Page Ref: Sec 25.6

19) The hydrolysis of an ester in the presence of a base is called __________.
Answer: saponification
Diff: 1 Page Ref: Sec 25.6

20) Mirror-image isomers of a substance are called __________.
Answer: enantiomers
Diff: 1 Page Ref: Sec. 25.7

21) The doubly ionized form of an amino acid is called a __________
Answer: zwitterion
Diff: 1 Page Ref: Sec 25.8

22) Of the 20 amino acids found in our bodies, __________ of them must be ingested because our bodies cannot synthesize sufficient quantities of them.
Answer: 10
Diff: 1 Page Ref: Sec. 25.9

23) Large protein molecules that act as catalysts are called __________.
Answer: enzymes
Diff: 1 Page Ref: Sec. 25.9

24) In nature, __________ -amino acids dominate.
Answer: L
Diff: 1 Page Ref: Sec. 25.9

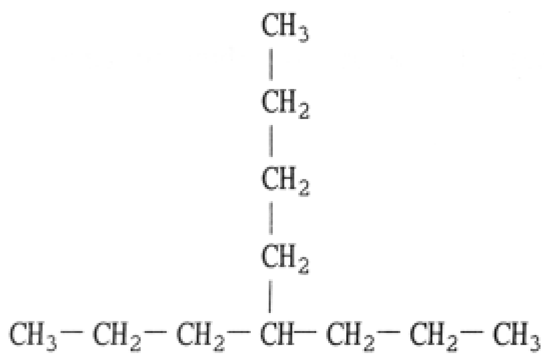
25) The condensation reaction of a carboxyl group of one amino acid and the amino group of a second amino acid results in the formation of a __________
Answer: peptide bond
Diff: 1 Page Ref: Sec 25.9

26) Lactose is a disaccharide of glucose and __________.
Answer: galactose
Diff: 1 Page Ref: Sec 25.10

27) The monomers of nucleic acids, called nucleotides, consist of three parts. These are __________.
Answer: phosphoric acid, a five-carbon sugar, and a nitrogen-containing organic base
Diff: 1 Page Ref: Sec. 25.11

28) In DNA adenine is always paired with __________
Answer: thymine
Diff: 1 Page Ref: Sec 25.11

29) What is the name of the compound below?



Answer: 4-propyloctane
Diff: 1 Page Ref: Sec. 25.3

True/False

1) The overall polarity of organic molecules is high.
Answer: FALSE
Diff: 1 Page Ref: Sec 25.1

2) Cyclobutane is more reactive butane.
Answer: TRUE
Diff: 1 Page Ref: Sec 25.3

3) The rate law for the addition of a halogen to an alkene is first order.
Answer: FALSE
Diff: 1 Page Ref: Sec 25.4

4) The stability of benzene is a major function of delocalized π bonding.
Answer: TRUE
Diff: 1 Page Ref: Sec 25.4

5) Aldehydes are less reactive than ketones.
Answer: FALSE
Diff: 1 Page Ref: Sec 24.5

6) A carbon with three or more attached groups will be chiral.
Answer: FALSE
Diff: 1 Page Ref: Sec 25.7

7) Racemic mixtures of enantiomers do not rotate polarized light.
Answer: TRUE
Diff: 1 Page Ref: Sec 25.7

8) The majority of glucose molecules exist in ring structure.
Answer: TRUE
Diff: 1   Page Ref: Sec 25.10

9) Humans digest starch but not cellulose because of differences in the type of linkage between the gluscose monomers of these substances
Answer: TRUE
Diff: 1   Page Ref: Sec 25.10

10) The DNA double helix is held together by hydrogen bonds and London dispersion forces.
Answer: TRUE
Diff: 1   Page Ref: Sec 25.11