Appendix E: Selected Answers

Chapter 1

26. 24 short blocks

27. 24 minutes

28. The order of the morning errands cannot vary, but the order of the afternoon errands can vary, as long as the haircut takes place before 3 pm.

29. Possible answers are to do an errand during his lunch hour or to extend the hours during which he does errands.

35. Chemistry concerns the changes that matter undergoes.

37. Carothers was doing pure chemistry because he did experiments to test the proposal of another chemist. His results led to applied chemistry—large-scale production of nylon.

39. A possible answer is that a firefighter needs to know which chemicals to use to fight different types of fires, and knowledge of chemistry will help a reporter gather information during an interview with a chemist.

41. Insulation acts as a barrier to heat flow. If heat flow is reduced, energy is conserved.

43. gene therapy and production of chemicals such as insulin

45. A pollutant is a material that can be found in air, soil, and water that is harmful to living organisms.

47. by analyzing the light they transmit to Earth

49. the scientific method

51. c

53. Repeat the experiment. If you get the same result, you must propose a new hypothesis.

55. to share knowledge across disciplines and to share resources between industries and universities

57. developing a plan and implementing the plan

59. 54 games (1/3 of 163)

61. 12 days

63. Answers will vary but should demonstrate an understanding that chemistry is the study of matter and the changes it undergoes.

65. You may choose biochemist because biochemistry is the study of processes that take place in organisms. However, you might choose physical chemist because physical chemistry includes the study of energy transfer as matter undergoes a change.

67. Your experiment may be correct, but your hypothesis may be wrong. You should reexamine your hypothesis and repeat the experiment.

69. Answers will vary but should reflect knowledge of the steps in a scientific method including making observations and testing hypotheses.

71. 300 miles

73. A possible answer is that scientists accept hypotheses that are supported by the results of experiments and reject hypotheses that are not supported by experimental results.

75. A person who is educated in the theories and practice of chemistry is more likely to recognize the significance of an accidental discovery and have the means and motivation to develop that accidental discovery into an important scientific contribution.

77. A theory can never be proven. It is a well-tested explanation of a broad set of observations. A theory may need to be changed in the future to explain new observations.

79. Your diagram should show one string that is threaded through both holes A and C. The string at hole B is a separate thread from the string passing through holes A and C.

81. 144,000 eggs

83. **a.** $1.00 per package
b. number of envelopes in a package

Chapter 2

9. Iron is magnetic; table salt is not. Table salt will dissolve in water; iron will not.

10. By lowering the temperature to below the boiling point of each gas, you could condense each substance and separate the gases.

18. Liquid A is probably a substance. Liquid B is a mixture.

19. The liquid was not an element because a solid was left when the liquid evaporated. A physical process, such as evaporation, cannot be used to break down a compound. Therefore, the liquid was a mixture.

35. An extensive property depends on the amount of matter in a sample; an intensive property depends on the type of matter in a sample. Extensive properties include mass and volume. Intensive properties include color, hardness, melting point, and boiling point.

37. melting point and boiling point

39. **a.** solid **b.** liquid **c.** gas
d. liquid **e.** gas **f.** liquid

41. The particles in a solid are packed tightly together in an orderly arrangement. The particles in a liquid are in close contact, but not in a rigid or orderly arrangement. The particles in a gas are relatively far apart.

43. Sharpening a pencil is an irreversible physical change. Making ice cubes is a reversible physical change.

45. one; solutions are homogeneous mixtures with uniform composition throughout.

47. The goal of a distillation is to separate the components of a solution. The solution is boiled to produce a vapor, which is then condensed into a liquid. Solids dissolved in the solution are left behind.

49. **a.** Hydrogen and oxygen are the elements that make up the compound water.
b. Nitrogen and oxygen are both elements present in the mixture air.
c. Sodium and chlorine are both elements in the compound sodium chloride (table salt).
d. Carbon is an element and water is a compound. They are the final products of heating table sugar (sucrose).

51. In the symbol W, the single letter is capitalized. In the two-letter symbol Hg, the first letter is a capital and the second letter is lowercase.

53. When heated, sulfur and iron react and form a new substance, iron sulfide. The composition of the reactants in a chemical change is different from the composition of the products. In a physical change, the chemical composition of a sample doesn't change.

55. chemical property

57. Mass is an extensive property, which depends only on the amount of matter in the sample, not on the composition of the sample.

59. Substances are classified as solids, liquids, or gases according to their state at room temperature, which in this book is 20°C.

61. neon

63. sulfur

65. In both the kitchen and park, you will see mostly mixtures.

67. **a.** physical **b.** physical **c.** physical
d. physical **e.** chemical

69. In photograph A, bubbles indicate the production of a gas. In photograph B, there is a color change and a precipitate.

71. A gas can be released during a physical change. For example, bubbles form when water boils.

73. A gas expands to fill any space; a gas has no shape or volume without a container. A solid has a definite shape and volume; a solid doesn't need a container to maintain its shape and volume.

75. Gallium will freeze first; mercury will freeze last.

77. Iron rusts when it reacts with oxygen in the air to form an oxide (Fe_2O_3). The mass of the rust is the sum of the mass of the iron and the oxygen that combined with the iron.

79. **a.** Yes; because the graph is a straight line, the proportion of iron to oxygen is a constant, which is true for a compound.
b. No; a point for the values given wouldn't fall on the line. The mass ratio of iron to oxygen is different.

81. **a.** mercury and sulfur
b. Sulfur melts at 113°C and boils at 445°C. Between 113°C and 445°C, it exists as a liquid. Mercury melts at −39°C, and boils at 357°C. In between these temperatures, it exists as a liquid.
c. Possibilities include by color, by boiling point, or in alphabetical order.

Chapter 3

1. **a.** 4 **b.** 4 **c.** 2 **d.** 5

2. **a.** 3 **b.** 2 **c.** 4 **d.** 4

3. **a.** 8.71×10^1 m **b.** 4.36×10^8 m
c. 1.55×10^{-2} m **d.** 9.01×10^3 m
e. 1.78×10^{-3} m **f.** 6.30×10^2 m

4. **a.** 9×10^1 m **b.** 4×10^8 m
c. 2×10^{-2} m **d.** 9×10^3 m
e. 2×10^{-3} m **f.** 6×10^2 m

5. **a.** 79.2 m **b.** 7.33 m
c. 11.53 m **d.** 17.3 m

6. 23.8 g

7. **a.** 1.8×10^1 m^2 **b.** 6.75×10^2 m
c. 5.87×10^{-1} min

8. 1.3×10^3 m^3

16. −196°C

17. melting point = 1234 K; boiling point = 2485 K

28. 1.0080×10^4 min

29. 1.44000×10^5 s

30. 67 students

31. 86.4°F

32. **a.** 44 m **b.** 4.6×10^{-3} g **c.** 10.7 cg

33. **a.** 1.5×10^{-2} L **b.** 7.38×10^{-3} kg
c. 6.7×10^3 ms **d.** 9.45×10^7 μg

34. 2.27×10^{-8} cm

35. 1.3×10^8 dm

36. 1.93×10^4 kg/m^3

37. 7.0×10^{12} RBC/L

46. density = 2.50 g/cm^3; no

47. 10.5 g/cm^3

48. **a.** 6.32 cm^3 **b.** 0.342 cm^3

49. See answers for problem 48.

57. Lissa: inaccurate and imprecise; Lamont: accurate and precise; Leigh Anne: inaccurate and precise.

59. **a.** 9.85×10^1 L **b.** 7.63×10^{-4} cg **c.** 5.70×10^1 m **d.** 1.22×10^1°C

61. **a.** 4.3×10^1 g **b.** 2.258×10^{-2} L **c.** 9.20×10^1 kg **d.** 3.24×10^1 m^3

63. **a.** second **b.** meter **c.** kelvin **d.** kilogram

65. **a.** 2.4 mm **b.** 14.33 cm **c.** 27.50 cm

67. conversion factor

69. The unit of the conversion factor in the denominator must be identical to the unit in the given measurement or the previous conversion factor.

71. **a.** 7.3 μL/s **b.** 78.6 mg/mm^2 **c.** 1.54 g/cm^3

73. **a.** 2.83×10^2 mg **b.** 0.283 g **c.** 2.83×10^{-4} kg **d.** 6.6 g **e.** 6.6×10^2 cg **f.** 6.6×10^{-3} kg **g.** 2.8×10^{-1} mg **h.** 2.8×10^{-2} cg **i.** 2.8×10^{-7} kg

75. Yes; neither mass nor volume changes with location.

77. The carbon dioxide-filled balloon would sink. The neon- and hydrogen-filled balloons would rise, the hydrogen at a much faster rate.

79. e, d, c, f, a, b

81. °F = 1.8°C + 32

83. $\frac{1\ \text{g}}{10^2\ \text{cg}}, \frac{10^2\ \text{cg}}{1\ \text{g}}, \frac{1\ \text{g}}{10^3\ \text{mg}}, \frac{10^3\ \text{mg}}{1\ \text{g}}, \frac{10^2\ \text{cg}}{10^3\ \text{mg}}, \frac{10^3\ \text{mg}}{10^2\ \text{cg}}$

85. 0.69–0.789 g/cm^3

87. 0.804 g/cm^3

89. 0.92 kg/L

91. 8.3 min

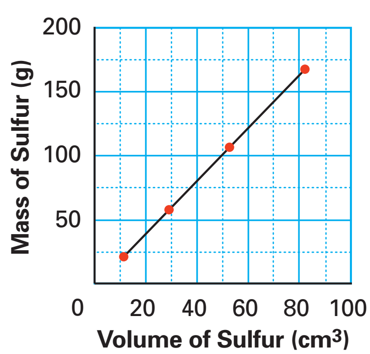
93. 5.52 kg/dm^3

95. Yes; the mass of an object is constant, but the weight of an object varies with location.

97. 31.1 m/s

99. Answers will vary. Lakes would freeze solid from the bottom up; aquatic life would be destroyed; possible climate changes.

101.



density of sulfur = 2.1 g/cm^3

103. Volume of iron cube = 45.1 cm^3; mass of lead cube = 514 g

105. 1.8×10^3 kg

107. 1.79 mL

Chapter 4

15. **a.** 19 **b.** B **c.** 5 **d.** 5 **e.** 16 **f.** 16 **g.** 23 **h.** 23

16. **a.** 9 protons and 9 electrons
b. 20 protons and 20 electrons
c. 13 protons and 13 electrons

17. **a.** 8 **b.** 16 **c.** 61 **d.** 45 **e.** 125

18. **a.** ${}^{12}_{6}C$ **b.** ${}^{19}_{9}F$ **c.** ${}^{9}_{4}Be$

19. ${}^{16}_{8}O$, ${}^{17}_{8}O$, ${}^{18}_{8}O$

20. Chromium-50 has 26 neutrons, chromium-52 has 28 neutrons, and chromium-53 has 29 neutrons.

21. boron-11

22. Silicon-28 must be by far the most abundant. The other two isotopes must be present in very small amounts.

23. 63.6 amu

24. 79.91 amu

35. Democritus's ideas were not helpful in explaining chemical behavior because they lacked experimental support.

37. The atoms are separated, joined, and rearranged.

39. repel

41. Atoms are neutral: number of protons = number of electrons. Loss of an electron means that the number of protons is greater than the number of electrons, so the remaining particle is positively charged.

43. Rutherford did not expect alpha particles to be deflected over a large angle.

45. protons and neutrons

47. the number of protons in the nucleus

49. The atomic number is the number of protons. The mass number is the sum of the protons and neutrons.

51. mass numbers, atomic masses, number of neutrons, relative abundance

53. which isotopes exist, their masses, and their natural percent abundance

55. The atomic mass is the weighted average of the masses of all the isotopes.

57. Sample answer: The table is set up so that chemical properties recur at regular intervals.

59. The nucleus is very small and very dense compared with the atom.

61. All atoms of the same element are not identical (isotopes). The atom is not the smallest particle of matter.

63. They are the same value.

65. 207 amu

67. Atoms are the smallest particle of an element that retains the properties of that element.

69. $^{14}_{7}N$: 14.003 amu; 99.63%; $^{15}_{7}N$: 15.000 amu; 0.37%; average atomic mass = 14.01 amu

71. Atomic number is the same as the number of protons and electrons; mass number minus atomic number equals number of neutrons.

73. The pattern repeats.

75. Change the metal used as a target and account for differences in deflection patterns.

77. The theory must be modified and then retested.

79. In a chemical change, atoms are neither created nor destroyed; instead, they are rearranged.

81. 92.5%

83. Pure chemistry involves the accumulation of scientific knowledge for its own sake; applied chemistry is accumulating knowledge to attain a specific goal.

85. **a.** element **b.** mixture
c. mixture **d.** mixture

87. 6.38×10^{7} cm^{3}

Chapter 5

8. **a.** $1s^22s^22p^2$
b. $1s^22s^22p^63s^23p^6$
c. $1s^22s^22p^63s^23p^63d^84s^2$

9. **a.** $1s^22s^22p^1$; one unpaired electron
b. $1s^22s^22p^63s^23p^2$ two unpaired electrons

14. 2.00×10^{-5} m; longer wavelength than red light

15. 6.00×10^{15} s^{-1}; ultraviolet

23. Bohr proposed that electrons traveled in circular paths around the nucleus.

25. An electron is found 90% of the time inside this boundary.

27. 3

29. **a.** 1 **b.** 2 **c.** 3 **d.** 4

31. The Aufbau principle states that electrons occupy the lowest possible energy levels. The Pauli exclusion principle states that an atomic orbital can hold at most two electrons. Hund's rule states that one electron occupies each of a set of orbitals with equal energies before any pairing of electrons occurs.

33. The *p* orbitals in the third quantum level have three electrons.

35. **a.** correct **b.** incorrect
c. incorrect **d.** correct

37. 2*s*, 3*p*, 4*s*, 3*d*

39. **a.** $1s^22s^22p^63s^23p^63d^{10}4s^24p^4$
b. $1s^22s^22p^63s^23p^63d^34s^2$
c. $1s^22s^22p^63s^23p^63d^8 4s^2$
d. $1s^22s^22p^63s^23p^64s^2$

41. Frequency is the number of wave cycles that pass a given point per unit time. Frequency units are cycles/s or reciprocal seconds or hertz. Wavelength and frequency are inversely related.

43. Classical physics views energy changes as continuous. In the quantum concept, energy changes occur in tiny discrete units called quanta.

45. **a.** v, vi, iv, iii, i, ii
b. It is the reverse.

47. The electron of the hydrogen atom is raised (excited) to a higher energy level.

49. visible spectrum, Balmer series

51. $1s^22s^22p^63s^23p^63d^{10}4s^24p^3$. The first three energy levels are full; the fourth energy level is partially filled.

53. $1s^22s^22p^3$ nitrogen; 3 unpaired electrons

55. **a.** 4.36×10^{-5} cm **b.** visible
c. 6.88×10^{14} s^{-1}

57. **a.** Na, sodium **b.** N, nitrogen
c. Si, silicon **d.** O, oxygen
e. K, potassium **f.** Ti, titanium

59. It is not possible to know both the position and the velocity of a particle at the same time.

61. c.

63. a.

65. An orbit confines the electron to a fixed circular path around the nucleus; an orbital is a region around the nucleus in which electrons are likely to be found.

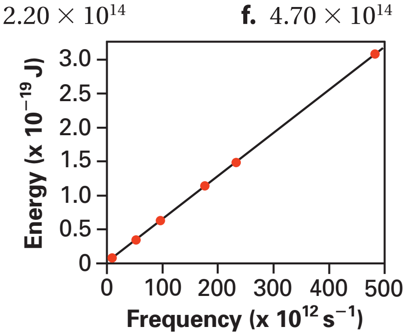
67. Answers will vary. The model of the atom uses the abstract idea of probability; light is considered a particle and a wave at the same time. Atoms and light cannot be compared to familiar objects or observations because humans cannot experience atoms or photons directly and because matter and energy behave differently at the atomic level than at the level humans can observe directly.

69. **a.** $n = 1$ level **b.** $n = 4$ level
c. $n = 4$ level **d.** $n = 1$ level

71. **a.** potassium, excited state, valence electron has been promoted from 4*s* to 5*p*
b. potassium, ground state, correct electron configuration
c. impossible configuration, 3*p* can hold a maximum of 6 electrons, not 7

73. **a.** **a.** 5.20×10^{12} **b.** 4.40×10^{13}
c. 9.50×10^{13} **d.** 1.70×10^{14}
e. 2.20×10^{14} **f.** 4.70×10^{14}

b.



c. 6.3×10^{-34} J/s
d. The slope is Planck's constant.

75. H: 1312 kJ/mol ($n = 1$); 328 kJ($n = 2$); Li^{2+}: 1.18×10^4 kJ ($n = 1$)

77. a. and b. are heterogeneous; c. is homogeneous.

79. A compound has constant composition; the composition of a mixture can vary.

81. 7.7×10^{-5} μm

83. the piece of lead

85. a. and b. are exact.

87. 8.92 g/cm^3

89. Helium gas is much less dense than the nitrogen gas and oxygen gas in the air.

91. accuracy–how close measured value is to true value; precision–how close a series of measurements are to one another

93. Neon-20 has 10 neutrons in the nucleus, neon-21 has 11 neutrons in the nucleus.

Chapter 6

8. a. $1s^22s^22p^2$
b. $1s^22s^22p^63s^23p^63d^{10}4s^24p^65s^2$
c. $1s^22s^22p^63s^23p^63d^34s^2$

9. a. B, Al, Ga, In, Tl **b.** F, Cl, Br, I, At
c. Ti, Zr, Hf, Rf

25. The close match between the predicted properties and the actual properties of gallium, which was discovered in 1875, helped gain wider acceptance for Mendeleev's periodic table.

27. Yes; both carbon and silicon are in Group 4A and each has four electrons in its highest occupied energy level.

29. Metalloids have properties that are similar to both metals and nonmetals. How a metalloid behaves depends on the conditions.

31. Na, Mg, Cl

33. aluminum

35. a. Ar: $1s^22s^22p^63s^23p^6$ **b.** Si: $1s^22s^22p^63s^23p^2$
c. Mg: $1s^22s^22p^63s^2$

37. The first ionization energy is the energy needed to remove a first electron from an atom. The second ionization energy is the energy needed to remove a second electron.

39. a. Sr, Mg, Be **b.** Cs, Ba, Bi **c.** Na, Al, S

41. The ionic radius of a cation is smaller than the atomic radius of the metal atom.

43. a. F **b.** N **c.** Mg **d.** As

45. a. O **b.** F **c.** O **d.** S

47. a. 1801 – 1850; 28 elements
b. Mendeleev's periodic table helped scientists predict the existence of undiscovered elements.
c. 75%

49. b. Nitrogen and phosphorus are in the same group (5A).

51. Nonmetals; The trend is for ionization energy to increase from left to right across a period.

53. a. H, Li, Na, K, Rb, Cs, Fr
b. O, S, Se, Te, Po
c. Zn, Cd, Hg, Uub

55. c

57. First ionization energy increases across a period.

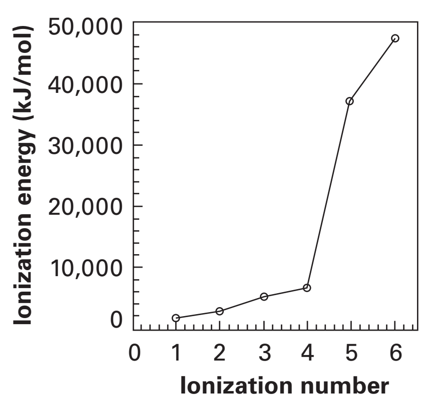
59. a. The atomic radius increases from top to bottom within the group.
b. Cations are smaller than their corresponding atoms. The attraction between the nucleus and any remaining electron is greater. There is one fewer occupied energy level.

61. a. As first ionization energy increases, so does electronegativity.
b. Both properties depend on the attraction between the nucleus and electrons. The attraction between the nucleus and the electrons in the highest occupied energy level increases across a period because the nuclear charge increases, but the shielding effect is constant.

63. a. Both electrons in Ca are removed from the same energy level. The second electron removed from a K atom is in a lower energy level.
b. Because Cs has a larger atomic radius than Li, the nuclear charge in a Cs atom has a smaller effect on the electrons in the highest occupied energy level.
c. It is relatively easy to remove all three electrons from an Al atom, but the third electron removed from a Mg atom is in a lower energy level.

65. The ionic radii would decrease from S^{2-} to Sc^{3+}. The number of electrons and the shielding effect do not change, but the number of protons increases from left to right in this series. So the ionic size decreases. The same is true for the series O^{2-} to Mg^{2+}.

67. a.



b. The largest increase is between ionization numbers 4 and 5 because carbon easily loses the first four electrons from the second energy level. The fifth electron is removed from the first energy level.

69. Electron affinity should increase (become more negative) from left to right across a period because the nuclear charge increases and the shielding effect is constant.

71. **a.** physical change **b.** chemical change **c.** physical change **d.** chemical change

73. 4

75. The density of the cube is 0.984 g/cm^3. The cube will float on water.

77. 5.2%

79. The density of the olive is 1.05 g/cm^3. The olive will sink in water.

81. The density of sulfur does not vary with mass. The density is constant.

83. 4.54 g/cm^3

85. **a.** silver, 62 neutrons
b. tin, 50 protons
c. molybdenum, 42 electrons
d. scandium, 21 electrons

Chapter 7

1. **a.** sulfide ion, S^{2-} **b.** aluminum ion, Al^{3+}

2. **a.** 2 electrons lost **b.** 3 electrons gained
c. 2 electrons lost

12. **a.** KI **b.** Al_2O_3

13. $CaCl_2$

31. **a.** gain of 1 electron **b.** loss of one electron
c. gain of 3 electrons **d.** loss of 2 electrons
e. loss of 1 electron **f.** gain of 1 electron

33. electrons in the highest occupied energy level

35. **a.** :C̈l· **b.** :S̈· **c.** ·Ȧl· **d.** Li·

37. **a.** Al^{3+} **b.** Li^+ **c.** Ba^{2+}
d. K^+ **e.** Ca^{2+} **f.** Sr^{2+}

39. **a.** S^{2-} **b.** Na^+ **c.** F^- **d.** P^{3-}

41. a, c, and e

43. The positive charges balance the negative charges.

45. **a.** K^+, Cl^- **b.** Ba^{2+}, SO_4^{2-}
c. Mg^{2+}, Br^- **d.** Li^+, CO_3^{2-}

47. Ions are free to move in molten $MgCl_2$

49. body-centered cubic: Na, K, Fe, Cr, or W; face-centered cubic: Cu, Ag, Au, Al, or Pb; hexagonal close-packed: Mg, Zn, or Cd

51. The properties of the steel will vary according to its composition. In addition to iron, steel can contain varying amounts of carbon and such metals as chromium, nickel, and molybdenum.

53. **a.** ·Ċ· **b.** ·Be· **c.** :Ö·
d. :F̈· **e.** Na· **f.** ·Ṗ·

55. It has lost valence electrons.

57. **a.** oxygen atom, sulfur atom, oxide ion, sulfide ion
b. sodium ion, potassium ion, sodium atom, potassium atom

59. **a.** $1s^22s^22p^63s^23p^63d^3$ **b.** $1s^22s^22p^63s^23p^63d^4$
c. $1s^22s^22p^63s^23p^63d^5$

61. **a.** Br^- **b.** H^- **c.** As^{3-} **d.** Se^{2-}

63. All are $1s^22s^22p^6$. All have the same configuration as neon.

65. **a.** $1s^22s^22p^63s^23p^6$ **b.** $1s^22s^22p^6$
Each has a noble gas electron configuration.

67. a, c, e, f

69. 12

71. Brass is a mixture of copper and zinc. The properties of a particular sample of brass will vary with the relative proportions of the two metals.

73. By gaining or losing electrons, the atoms of elements achieve a noble gas electron configuration.

75. No. Sodium chloride is composed of equal numbers of sodium ions and chloride ions. The ions are in a 1:1 ratio. Each sodium ion is surrounded by chloride ions and each chloride is surrounded by sodium ions.

77. The spheres are more closely packed in a.; there is less empty space in a., and a rough count shows 25 spheres in a. compared with 22 spheres in b..

79. Both metals and ionic compounds are composed of ions. Both are held together by electrostatic bonds. Metals always conduct electricity, and ionic compounds conduct only when melted or in water solution. Ionic compounds are composed of cations and anions, but metals are composed of cations and free-floating valence electrons. Metals are ductile, but ionic compounds are brittle.

81. Na^+ and Cs^+ differ greatly in size. Na^+ and Cl^- are similar in size to Mn^{2+} and S^{2-}.

83. **a.** copper and zinc
b. silver and copper
c. copper and tin
d. iron, chromium, nickel, and carbon
e. iron, chromium, nickel, and molybdenum
f. iron, chromium, and carbon

85. an analytical chemist

87. a, b, and d are chemical changes; c is a physical change.

89. **a.** liquid, vapor **b.** vapor **c.** liquid, vapor **d.** liquid, vapor

91. a

93. 27.0 cm^3

95. 14 amu

97. **a.** 1 **b.** 3 **c.** 1 **d.** 5

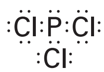
99. chlorine, Cl, $1s^22s^22p^63s^23p^5$

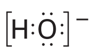
101. **a.** K, $1s^22s^22p^63s^23p^64s^1$
b. Al, $1s^22s^22p^63s^23p^1$
c. S, $1s^22s^22p^63s^23p^4$
d. Ba, $1s^22s^22p^63s^23p^63d^{10}4s^24p^64d^{10}5s^25p^66s^2$

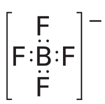
103. sodium (Na), cesium (Cs), rubidium (Rb), lithium (Li)

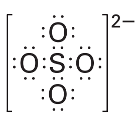
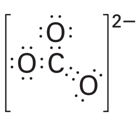
Chapter 8

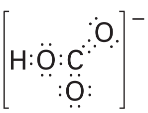
7. **a.**  **b.**  **c.** 

8. **a.**  **b.** 

9. 

10. 

11.  

12. 

30. **a.** moderately polar covalent
b. ionic
c. moderately to very polar covalent
d. moderately to very polar covalent
e. ionic
f. nonpolar covalent

31. c and d (tied), b, a

39. ionic

41. Nitrogen and oxygen achieve stability as diatomic molecules; argon exists as individual atoms because it has a stable noble gas electron configuration.

43. **a.** ionic **b.** ionic **c.** covalent **d.** covalent

45. A double covalent bond has four shared electrons (two bonding pairs); a triple covalent bond has six shared electrons (three bonding pairs).

47. One atom contributes both electrons to a coordinate covalent bond as in CO.

49. 

51. Bond dissociation energy is defined as the energy needed to break one covalent bond.

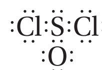
53. A pi bond is formed by the side-by-side overlap of two half-filled f *p* atomic orbitals to produce a pi molecular orbital. In a pi bond, the bonding electrons are most likely to be found in sausage-shaped regions above and below the bond. See Figure 8.15.

55. The 2*s* and the 2*p* orbitals form two sp^2 hybrid orbitals on the carbon atom. One sp^2 hybrid orbital forms a sigma bond with the carbon atom. Pi bonds between each oxygen atom and the carbon are formed by the unhybridized 2*p* orbitals.

57. The electronegativities of the two atoms will differ by about 0.4 to 2.0.

59. A hydrogen bond is formed by an electrostatic interaction between a hydrogen atom covalently bonded to a very electronegative atom and an unshared electron pair of a nearby atom.

61. More energy is required to separate the molecules.

63. 

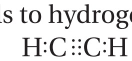
65. **a.** tetrahedral, 109.5° **b.** trigonal planar, 120° **c.** tetrahedral, 109.5° **d.** bent, 105°

67. **a.** 109.5° **b.** 120° **c.** 180°

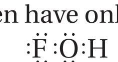
69. **a.** Phosphorus in PBr_5 has 10 valence electrons.

71. C, O, H, S, N, F, Cl, I, Br: These elements are all nonmetals.

73. **a.** two covalent bonds to hydrogen



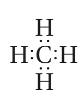
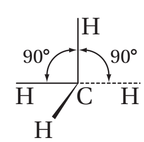
b. Fluorine and oxygen have only six electrons.

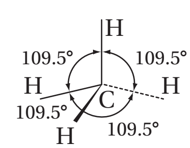


c. Halogens form one covalent bond, not three.

d. Nitrogens should be forming only three covalent bonds, not four.

75. **a.** bent **b.** tetrahedral **c.** pyramidal

77.  



The first sketch is tetrahedral. The second sketch is a tetrahedron. The bond angles in the first sketch are not all the same, with some being 90°. The bond angles in the second sketch are all 109.5°. The second sketch is correct. (Note: The wedge-shaped lines come out of the page; the dotted lines recede into the page.)

79. :O: (above C)
H:C:O:H

81. H:N::N::N: ↔ H:N:N:::N:

83. formation of a gas, a change in color or odor

85. **a.** 2 **b.** 2 **c.** 3 **d.** 3

87. Isotopes have the same number of protons and electrons, but different numbers of neutrons.

89. **a.** 6 **b.** 2 **c.** 5 **d.** 0

91. The *d* sublevel of the third principal energy level contains 5 electrons.

93. The anion is larger than the corresponding neutral atom.

95. **a.** K: $1s^22s^22p^63s^23p^64s^1$
b. Al: $1s^22s^22p^63s^23p^1$
c. S: $1s^22s^22p^63s^23p^4$
d. Ba: $1s^22s^22p^63s^23p^63d^{10}4s^24p^64d^{10}5s^25p^66s^2$

97. **e.** II and III only

99. **b.** cesium

101. **a.** $1s^22s^22p^6$ **b.** $1s^22s^22p^6$
c. $1s^22s^22p^6$ **d.** $1s^22s^22p^63s^23p^6$

Chapter 9

1. **a.** selenide ion, anion
b. barium ion, cation
c. phosphide ion, anion

2. **a.** three electrons lost
b. two electrons gained
c. one electron lost

10. **a.** BaS **b.** Li_2O **c.** Ca_3N_2 **d.** CuI_2

11. **a.** NaI **b.** $SnCl_2$ **c.** K_2S **d.** CaI_2

12. **a.** $(NH_4)_2SO_3$ **b.** $Ca_3(PO_4)_2$

13. **a.** $LiHSO_4$ **b.** $Cr(NO_2)_3$

34. 2:1

43. **a.** 2+ **b.** 2+ **c.** 3+ **d.** 1+

45. cyanide, CN^-, and hydroxide, OH^-

47. zero

49. Determine the charge of the anion, then work backwards to find the charge of the transition metal cation needed to give a net charge of zero for the formula unit.

51. a and b

53. NH_4NO_3 ammonium nitrate; $(NH_4)_2CO_3$ ammonium carbonate; NH_4CN ammonium cyanide; $(NH_4)_3PO_4$ ammonium phosphate; $Sn(NO_3)_4$ tin(IV) nitrate; $Sn(CO_3)_2$ tin(IV) carbonate; $Sn(CN)_4$ tin(IV) cyanide; $Sn_3(PO_4)_4$ tin(IV) phosphate; $Fe(NO_3)_3$ iron(III) nitrate; $Fe_2(CO_3)_3$ iron(III) carbonate; $Fe(CN)_3$ iron(III) cyanide; $FePO_4$ iron(III) phosphate; $Mg(NO_3)_2$ magnesium nitrate; $MgCO_3$ magnesium carbonate; $Mg(CN)_2$ magnesium cyanide; $Mg_3(PO_4)_2$ magnesium phosphate

55. **a.** tri- **b.** mono- **c.** di-
d. hexa- **e.** penta- **f.** tetra-

57. **a.** BCl_3 **b.** dinitrogen pentoxide
c. N_2H_4 **d.** carbon tetrachloride

59. No, to be an acid the compound must produce H^+ ions in water solution.

61. **a.** $Fe(OH)_2$ **b.** lead(II) hydroxide
c. $Cu(OH)_2$ **d.** cobalt(II) hydroxide

63. Whenever two elements form more than one compound, the different masses of one element that combine with the same mass of the other element are in the ratio of small whole numbers.

65. **a.** $KMnO_4$ **b.** $Ca(HCO_3)_2$ **c.** Cl_2O_7
d. Si_3N_4 **e.** NaH_2PO_4 **f.** PBr_5
g. CCl_4

67. **a.** sodium chlorate
b. mercury(I) bromide
c. potassium chromate
d. perchloric acid
e. tin(IV) oxide
f. iron(III) acetate
g. potassium hydrogen sulfate
h. calcium hydroxide
i. barium sulfide

69. **a.** magnesium permanganate
b. beryllium nitrate
c. potassium carbonate
d. dinitrogen tetrahydride
e. lithium hydroxide
f. barium fluoride
g. phosphorus triiodide
h. zinc oxide
i. phosphorous acid

71. binary molecular compound

73. $SnCl_4$

75. **a.** 9.85%
b. nitrogen, oxygen, and chlorine; 54.9 kg
c. 34.7%
d. H_2SO_4, N_2, O_2, NH_3, CaO, H_3PO_4, NaOH, Cl_2, Na_2CO_3, HNO_3

77. on the right hand side

79. The statement is true for the representative metals, but not for the transition metals, which often have multiple charges.

81. **a.** N_2O, dinitrogen monoxide
b. NO_2, nitrogen dioxide
c. NO, nitrogen monoxide
d. N_2O_4, dinitrogen tetroxide

83. **a.** The charges do not balance, CsCl.
b. The charges do not balance, ZnO.
c. Neon does not form compounds.
d. The subscripts are not the lowest whole-number ratio, BaS.

87. Answers will vary but may include: color (physical), solid (physical), magnetic (physical), malleable (physical), conducts electricity (physical), burns (chemical).

89. 5.2 cm

91. 0.538 g/cm^3

93. Both are in the nucleus and have a mass of about 1 amu. A proton is positively charged; a neutron has no charge.

95. **a.** 1 **b.** 6 **c.** 5
d. 2 **e.** 7 **f.** 8

97. **a.** cesium, potassium, sodium, lithium
b. lithium, boron, carbon, fluorine, neon

99. When metallic elements of Group 1A and 2A form ions, they lose all their outer shell electrons. This increases the attraction by the nucleus for the fewer remaining elections and results in ions that are smaller than the corresponding atoms. The electron that a Group 7A element gains in forming an ion enters the outer shell resulting in a decrease in the effective nuclear attraction of the increased number of electrons. The anion is larger than the corresponding atom.

101. **a.** 12 protons and 10 electrons
b. 35 protons and 36 electrons
c. 38 protons and 36 electrons
d. 16 protons and 18 electrons

103. b, d, and f

105. A hydrogen bond is an intermolecular force between a hydrogen atom covalently bonded to a very electronegative atom and an unshared pair of electrons from another electronegative atom.

Chapter 10

1. 5.0 kg

2. 672 seeds

3. 4.65 mol Si

4. 0.360 mol

5. 2.75×10^{24} atoms

6. 7.72 mol NO_2

7. 137.5 g/mol

8. 84.0 g $NaHCO_3$

16. 1.27 g $C_{20}H_{42}$

17. 225 g $Fe(OH)_2$

18. 3.43×10^{-2} mol B

19. 0.987 mol N_2O_3

20. **a.** 7.17×10^{-2} L CO_2 **b.** 82.9 L N_2

21. **a.** 28.0 L He **b.** 7.50 L C_2H_6

22. 80.2 g/mol

23. 3.74 g/L

32. 72.2% Mg, 27.8% N

33. 93.0% Hg, 7.0% O

34. **a.** 80.0% C, 20.0% H
b. 19.2% Na, 0.83% H, 26.7% S, 53.3% O

35. **a.** 82.4% N **b.** 35.0% N

36. **a.** OH **b.** $HgSO_4$

37. C_3H_8N

38. $C_2H_6O_2$

39. **a.** same empirical formula
b. different

47. number, mass, or volume; examples will vary.

49. **a.** 3 **b.** 2 **c.** 9 **d.** 10

51. 1.00 mol C_2H_6

53. **a.** 98.0 g **b.** 76.0 g **c.** 100.1 g
d. 132.1 g **e.** 89.0 g **f.** 159.8 g

55. Answers will vary but should include:
 1. Determine the moles of each atom from the formula.
 2. Look up the molar mass of each element.
 3. Multiply the number of moles of each atom by its molar mass.
 4. Sum these products.

57. Answers will vary. For example; if a particle is a 0.1-mm cube, how high would a stack of Avogadro's number of particles be? (6.02×10^{16} km)

59. **a.** 108 g C_5H_{12} **b.** 547 g F_2 **c.** 71.8 g $Ca(CN)_2$
d. 238 g H_2O_2 **e.** 224 g NaOH **f.** 1.88 g Ni

61. **a.** 1.96 g/L **b.** 0.902 g/L **c.** 2.05 g/L

63. **a.** 5.9% H, 94.1% S
b. 22.6% N, 6.5% H, 19.4% C, 51.6% O
c. 41.7% Mg, 54.9% O, 3.4% H
d. 42.1% Na, 18.9% P, 39.0% O

65. **d.** 77.7% Fe in FeO

67. **a.** molecular **b.** molecular **c.** empirical

69. **a.** H_2O_2 **b.** $C_6H_6O_4$

71. **a.** A, $C_2H_4O_2$; D, $C_5H_{10}O_5$; E, $C_6H_{12}O_6$
b. slope = 2.5/1 which is the ratio of the molar mass of the empirical formula to the mass of carbon in the empirical formula: 30/12 = 2.5/1.
c. mass of carbon = 36, molar mass = 90; mass of carbon = 48, molar mass = 120

73. **b.** 0.842 mol C_2H_4

75. **a.** CO **b.** $C_2O_2NH_5$ **c.** Cl_2OC

77. 3.01×10^{13} km

79. $C_3H_6O_3$

81. 2.73×10^{20} F atoms

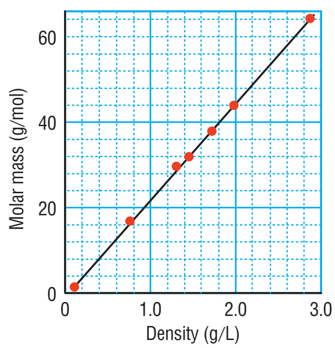
83. C_2H_6O

85. Sulfur atoms have 16 protons, 16 electrons, and 16 neutrons; carbon has 6 electrons, and 6 neutrons. Therefore, 6.02×10^{23} sulfur atoms will have a greater mass than the same number of carbon atoms.

87. a. $C_9H_{11}O_2N$ **b.** $C_9H_{11}O_2N$

89. 21.9 cm^3

91. a.



b. 22.4 L/mol
c. 24.6 g/mol
d. 2.5 g/L

93. 6.025×10^{23} formula units/mol

95. a. physical change **b.** chemical change
c. chemical change **d.** physical change
e. chemical change **f.** physical change

97. A molecule is composed of two or more atoms.

99. float; its density, 0.848 g/mL, is less than the density of water.

101. a. 40, 40, 50 **b.** 46, 46, 62
c. 35, 35, 46 **d.** 51, 51, 72

103. Magnesium and barium are both in group 2A and have 2 valence electrons.

105. For group A elements, the group number equals the number of valence electrons.

107. For single bond a single line connects the atoms (X—X). Atoms are connected by two lines in a double bond (X=X), and three lines in a triple bond (X≡X).

109. Calculate the electronegativity difference between two atoms. If the difference is small (0.0–0.4), the bond is nonpolar covalent. If the difference ≥ 2.0, the bond is most likely ionic. For values between 0.4 and 2.0, the bond is polar covalent.

111. a. iron(III) hydroxide **b.** ammonium iodide
c. sodium carbonate **d.** carbon tetrachloride

112. a. KNO_3 **b.** CuO **c.** Mg_3N_2 **d.** AgF

Chapter 11

1. When solid sodium is dropped into water, hydrogen gas and aqueous sodium hydroxide are produced.

2. $S(s) + O_2(g) \longrightarrow SO_2(g)$

3. a. $2AgNO_3 + H_2S \longrightarrow Ag_2S + 2HNO_3$
b. $3Zn(OH)_2 + 2H_3PO_4 \longrightarrow Zn_3(PO_4)_2 + 6H_2O$

4. a. $H_2 + S \longrightarrow H_2S$
b. $2FeCl_3 + 3Ca(OH)_2 \longrightarrow 2Fe(OH)_3 + 3CaCl_2$

5. a. $FeCl_3 + 3NaOH \longrightarrow Fe(OH)_3 + 3NaCl$
b. $CS_2 + 3Cl_2 \longrightarrow CCl_4 + S_2Cl_2$

6. $Ca(OH)_2 + H_2SO_4 \longrightarrow CaSO_4 + 2H_2O$

13. $2Be + O_2 \longrightarrow 2BeO$

14. $3Mg + N_2 \longrightarrow Mg_3N_2$

15. $2HI \longrightarrow H_2 + I_2$

16. HBr

17. a. $Fe(s) + Pb(NO_3)_2(aq) \longrightarrow Fe(NO_3)_2(aq) + Pb(s)$
b. $Cl_2(g) + 2NaI(aq) \longrightarrow 2NaCl(aq) + I_2(aq)$
c. $Ca(s) + 2H_2O(l) \longrightarrow Ca(OH)_2(aq) + H_2(g)$

18. a. $3NaOH(aq) + Fe(NO_3)_3(aq) \longrightarrow Fe(OH)_3(s) + 3NaNO_3(aq)$
b. $3Ba(NO_3)_2(aq) + 2H_3PO_4(aq) \longrightarrow Ba_3(PO_4)_2(s) + 6HNO_3(aq)$

19. a. $3KOH(aq) + H_3PO_4(aq) \longrightarrow K_3PO_4(aq) + 3H_2O(l)$
b. $3H_2SO_4(aq) + 2Al(OH)_3(aq) \longrightarrow Al_2(SO_4)_3(aq) + 6H_2O(l)$

20. a. $2HCOOH + O_2 \longrightarrow 2CO_2 + 2H_2O$
b. $C_7H_{16} + 11O_2 \longrightarrow 7CO_2 + 8H_2O$

21. $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$

28. $H^+(aq) + OH^-(aq) \longrightarrow H_2O(l)$

29. complete ionic equation:
$3Ca^{2+}(aq) + 6OH^-(aq) + 6H^+(aq) + 2PO_4^{3-}(aq) \longrightarrow Ca(PO_4)_2(s)$;
net ionic equation: same as complete ionic equation

37. Dalton said that the atoms of reactants are rearranged to form new substances as products.

39. a. Gaseous ammonia and oxygen react in the presence of a platinum catalyst to produce nitrogen monoxide gas and water vapor.
b. Aqueous solutions of sulfuric acid and barium chloride are mixed to produce a precipitate of barium sulfate and aqueous hydrochloric acid.
c. The gas dinitrogen trioxide reacts with water to produce an aqueous solution of nitrous acid.

41. a. $C + 2F + 2G \longrightarrow CF_2G_2$
b. $F + 3W + S + 2P \longrightarrow FW_3SP_2$

43. a. $2PbO_2 \longrightarrow 2\ PbO + O_2$
b. $2Fe(OH)_3 \longrightarrow Fe_2O_3 + 3H_2O$
c. $(NH_4)_2CO_3 \longrightarrow 2NH_3 + H_2O + CO_2$
d. $2NaCl + H_2SO_4 \longrightarrow Na_2SO_4 + 2HCl$

45. a. $2Mg + O_2 \longrightarrow 2MgO$
b. $4P + 5O_2 \longrightarrow 2P_2O_5$
c. $Ca + S \longrightarrow CaS$

47. a. $2Ag_2O \xrightarrow{\Delta} 4Ag + O_2$
b. $NH_4NO_3 \xrightarrow{\Delta} N_2O + 2H_2O$

49. a. $H_2C_2O_4(aq) + 2KOH(aq) \longrightarrow K_2C_2O_4(aq) + 2H_2O(l)$
b. $CdBr_2(aq) + Na_2S(aq) \longrightarrow CdS(s) + 2NaBr(aq)$

51. a. $C_4H_8 + 6O_2 \longrightarrow 4CO_2 + 4H_2O$
b. $C_3H_6O + 4O_2 \longrightarrow 3CO_2 + 3H_2O$

53. an ion that does not participate in the reaction

55. a. $2Al(s) + 6H^+(aq) \longrightarrow 2Al^{3+}(aq) + 3H_2(g)$
b. $H^+(aq) + OH^-(aq) \longrightarrow H_2O(l)$
c. no reaction

57. a. $Cl_2(g) + 2KI(aq) \longrightarrow I_2(aq) + 2KCl(aq)$
b. $2Fe(s) + 6HCl(aq) \longrightarrow 2FeCl_3(aq) + 3H_2(g)$
c. $P_4O_{10}(s) + 6H_2O(l) \longrightarrow 4H_3PO_4(aq)$

59. a. $Na_2O(s) + H_2O(l) \longrightarrow 2NaOH(aq)$
b. $H_2(g) + Br_2(g) \longrightarrow 2HBr(g)$
c. $Cl_2O_7(l) + H_2O(l) \longrightarrow 2HClO_4(aq)$

61. a. tube A
b. $2Na(s) + 2H_2O(l) \longrightarrow 2NaOH(aq) + H_2(g)$; single-replacement

63. a. $2Al_2O_3 \xrightarrow{\Delta} 4Al + 3O_2$
b. $Sn(OH)_4 \xrightarrow{\Delta} SnO_2 + 2H_2O$
c. $Ag_2CO_3 \xrightarrow{\Delta} Ag_2O + CO_2$

65. a. $CdS(s)$
b. $Na^+(aq)$ and $NO_3^-(aq)$
c. $Cd^{2+}(aq) + S^{2-}(aq) \longrightarrow CdS(s)$

67. a. $2K(s) + 2H_2O(l) \longrightarrow 2KOH(aq) + H_2(g)$
b. $C_2H_5OH(l) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(g)$
c. $2Bi(NO_3)_3(aq) + 3H_2S(g) \longrightarrow Bi_2S_3(s) + 6HNO_3(aq)$
d. $2Al(s) + 3Br_2(l) \longrightarrow 2AlBr_3(s)$
e. $2HNO_3(aq) + Ba(OH)_2(aq) \longrightarrow Ba(NO_3)_2(aq) + 2H_2O(l)$

69. a. $C_5H_{12} + 8O_2 \longrightarrow 5CO_2 + 6H_2O$; $C_9H_{20} + 14O_2 \longrightarrow 9CO_2 + 10H_2O$
b. $2C_{12}H_{26} + 37O_2 \longrightarrow 24CO_2 + 26H_2O$; $C_{17}H_{36} + 26O_2 \longrightarrow 17CO_2 + 18H_2O$
c. $n = CO_2$; $(n + 1) = H_2O$

71. a. (1) combination (2) single-replacement (3) combustion (4) double-replacement
b. (1) $2Al(s) + 3Br_2(l) \longrightarrow 2AlBr_3(s)$;
(2) $Cu(s) + 2AgNO_3(aq) \longrightarrow Cu(NO_3)_2(aq) + 2Ag(s)$;
(3) $C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(g)$;
(4) $Pb(NO_3)_2(aq) + 2KI(aq) \longrightarrow PbI_2(s) + 2KNO_3(aq)$

73. a. water **b.** water vapor in the air
c. physical change

75. 36.6 kg

77. a. $1s^22s^22p^63s^23p^64s^23d^{10}4p^6$
b. $1s^22s^22p^63s^23p^6$
c. $1s^22s^22p^63s^23p^63d^{10}$
d. $1s^22s^22p^63s^23p^63d^{10}$

79. a. incorrect; KBr **b.** correct
c. incorrect; Ca_3N_2 **d.** correct

81. a. 2.41 mol **b.** 6.91×10^{-2} mol
c. 0.934 mol **d.** 7.09 mol

83. $C_8H_{10}O_2N_4$

Chapter 12

1. 288 seats, 864 wheels, 576 pedals

2. Answers will vary but should include the correct number of parts to make the product.

3. 2 molecules H_2 + 1 molecule $O_2 \longrightarrow$ 2 molecules H_2O;
2 mol H_2 + 1 mol $O_2 \longrightarrow$ 2 mol H_2O;
44.8 L H_2 + 22.4 L $O_2 \longrightarrow$ 44.8 L H_2O

4. 2 mol C_2H_2 + 5 mol $O_2 \longrightarrow$ 4 mol CO_2 + 2 mol H_2O;
44.8 L C_2H_2 + 112 L $O_2 \longrightarrow$ 89.6 L CO_2 + 44.8 L H_2O;
212 g reactants $\longrightarrow$ 212 g products

11. a. $\frac{4 \text{ mol Al}}{3 \text{ mol } O_2}, \frac{3 \text{ mol } O_2}{4 \text{ mol Al}}, \frac{4 \text{ mol Al}}{2 \text{ mol } Al_2O_3}, \frac{2 \text{ mol } Al_2O_3}{4 \text{ mol Al}}, \frac{2 \text{ mol } Al_2O_3}{3 \text{ mol } O_2}, \frac{3 \text{ mol } O_2}{2 \text{ mol } Al_2O_3}$
b. 7.4 mol

12. a. 11.1 mol **b.** 0.52 mol

13. 2.03 g C_2H_2

14. 1.36 mol CaC_2

15. 4.82×10^{22} molecules O_2

16. 11.5 g NO_2

17. 1.93 L O_2

18. 0.28 L PH_3

19. 18.6 mL SO_2

20. 1.9 dL CO_2

25. O_2 is the limiting reagent.

26. HCl is the limiting reagent.

27. a. 5.40 mol H_2O is required, so C_2H_4 is the limiting reagent;
b. 5.40 mol H_2O

28. 43.2 g H_2O

29. 59.3 g Fe

30. 17.0 g Ag

31. 83.5%

32. 57.7%

37. a. 2 mol $KClO_3$ decompose to form 2 mol KCl and 3 mol O_2.
b. 4 mol NH_3 react with 6 mol NO to form 5 mol N_2 and 6 mol H_2O.
c. 4 mol K react with 1 mol O_2 to form 2 mol K_2O.

39. Answers will vary but should include the idea of writing a ratio using the coefficients of two substances from a balanced equation as the number of moles of each substance reacting or being formed.

41. a. 11.3 mol CO, 22.5 mol H_2
b. 112 g CO, 16.0 g H_2
c. 11.4 g H_2

43. The coefficients indicate the relative number of moles (or particles) of reactants and products.

45. The amount of the limiting reagent determines the maximum amount of product that can be formed. The excess reagent is only partially consumed in the reaction.

47. **a.** Al **b.** 3.0 mol $AlCl_3$ **c.** 0.8 mol Cl_2

49. **a.** 2.36 g H_3PO_4 **b.** 1.89 g CO_2

51. **a.** 7.0×10^2 L N_2 **b.** no reagent in excess

53. 10.7 kg $CaSO_4$

55. **a.** Initially, the amount of NaCl formed increases as the amount of Na used increases. For this part of the curve sodium is the limiting reagent. Beyond a mass of about 2.5g of Na, the amount of product formed remains constant because chlorine is now the limiting reagent.
b. Chlorine becomes the limiting reagent when the mass of sodium exceeds 2.5 g. This corresponds to a mass of about 3.9 g chlorine.

57. The percent yield is 115%; such a yield could be attributed to experimenter error, or to unreacted starting material, or to outside materials contaminating the product.

59. **a.** 29 frames **b.** 58 wheels
c. 174 pedals **d.** 87 seats

61. 13 days

63. 87.4% $CaCO_3$

65. **a.** 347 g Fe **b.** 239 g CO

67. **a.** 22 e^-, 22 p^+, 25 n^0 **b.** 50 e^-, 50 p^+, 70 n^0
c. 8 e^-, 8 p^+, 10 n^0 **d.** 12 e^-, 12 p^+, 14 n^0

69. **a.** sodium. **b.** arsenic **c.** cesium

71. c and d

73. Yes, an ionic compound with at least one polyatomic ion has covalent bonds.

75. **a.** phosphate ion **b.** aluminum ion
c. selenide ion **d.** ammonium ion

77. **a.** $Al_2(CO_3)_3$ **b.** NO_2 **c.** K_2S
d. $MnCrO_4$ **e.** NaBr

79. 7.38 g Be

81. **a.** 0.473 mol KNO_3 **b.** 9.91×10^{-2} mol SO_2
c. 3.74×10^{-2} mol PCl_3

83. **a.** $Ba(NO_3)_2(aq) + Na_2SO_4(aq) \longrightarrow BaSO_4(s) + 2NaNO_3(aq)$
b. $AlCl_3(aq) + 3AgNO_3(aq) \longrightarrow 3AgCl(s) + Al(NO_3)_3(aq)$
c. $H_2SO_4(aq) + Mg(OH)_2(aq) \longrightarrow MgSO_4(aq) + 2H_2O(l)$

85. **a.** sodium ion and nitrate ion
b. aluminum ion and nitrate ion
c. magnesium ion and sulfate ion

Chapter 13

1. 51.3 kPa, 0.507 atm

2. 33.7 kPa is greater than 0.25 atm

27. a, b, c, e, and f

29. 16.35 atm

31. The Kelvin temperature is directly proportional to the average kinetic energy.

33. STP stands for standard temperature (0°C) and standard pressure (101.3 kPa or 1 atm).

35. The average kinetic energy triples.

37. In both cases, particles with sufficient kinetic energy move from the liquid to the vapor phase. In a closed container, a dynamic equilibrium is set up between the contained liquid and its vapor.

39. More molecules have enough energy to escape the attractions within the liquid.

41. The average kinetic energy increases, which allows more vapor to form above the liquid, which increases the vapor pressure.

43. **a.** about 50 mm Hg
b. about 94°C
c. 760 mm Hg is standard pressure

45. Ionic compounds generally have higher melting points than do molecular solids.

47. The intermolecular attractions between molecules are weaker than the attractions between ions.

49. The temperature remains constant while the liquid boils because the energy that is added is used to vaporize the molecules.

51. **a.** 121°C **b.** chloroform **c.** chloroform
d. The external pressure on ethanol would have to increase; the external pressure on ethanoic acid would have to decrease.

53. Although some molecules are evaporating and an equal number of particles are condensing, the net amounts of vapor and liquid remain constant.

55. decrease; as the attractions become stronger, it is more difficult for molecules to overcome the attractions and vaporize.

57. about 77°C

59. As the temperature drops to −196°C, the average kinetic energy of particles in the air decreases drastically, as does the pressure. So the volume of the balloon, which is a flexible container, decreases. As the balloon warms back to room temperature, the average kinetic energy of the particles increases and the balloon expands to its previous volume.

61. Possible answer: Since the beaker is an open container, the water should boil at 100°C at or close to sea level. Your partner probably misread the thermometer and should recheck the value.

63. The average kinetic energy is the same because the temperature is the same.

65. Because the perspiration absorbs heat as it evaporates, the remaining perspiration and the skin are cooled.

67. The vapor pressure depends only on the kinetic energy of the escaping molecules, which depends on the temperature.

69. The kinetic energy of the molecules in the vapor is the same in both cases; so the vapor pressure is the same.

71. condensation of water vapor on a cold surface

73. **a.** orthorhombic **b.** rhombohedral **c.** tetragonal **d.** triclinic **e.** cubic

75. no; if (a) = (b) then water vapor will condense at the same rate as the liquid evaporates.

77. inversely

79. **a.** $1s^22s^22p^63s^23p^6$ **b.** $1s^22s^22p^63s^23p^6$ **c.** $1s^2$

81. a, c, b

83. **a.** CO **b.** PBr_3

85. **a.** 53.7% Fe **b.** 34.6% Al

87. **a.** 51.2 g Cl_2O_7 **b.** 30.6 mL H_2O

89. $H_2S(aq) + Cd(NO_3)_2(aq) \longrightarrow 2HNO_3(aq) + CdS(s)$

91. **a.** Mg **b.** Li

93. **a.** 198 g H_2O **b.** 23 mol **c.** 144 g C

95. 39.4 g FeS (0.448 mol)

Chapter 14

7. 6.48 L

8. 68.3 kPa

9. 3.39 L

10. 8.36 L

11. 2.58 kPa

12. 341 K (68°C)

13. 0.342 L

14. 1.29×10^2 kPa

23. 2.51×10^2 mol He(g)

24. 2.5 g air

31. $93.4 \times$ kPa

32. 3.3 kPa

39. The space between the particles is reduced.

41. The volume decreases. The molecules have less kinetic energy and cause less pressure on the inside of the balloon.

43. The pressure quadruples.

45. $V_1/T_1 = V_2/T_2$

V_1 and V_2 are the initial and final volumes; T_1 and T_2 are the initial and final temperatures.

47. 1.80 L

49. 846 K (573°C)

51. 1.10×10^3 kPa

53. Its particles have no volume, there are no attractions between them, and collisions are elastic. An ideal gas follows the gas laws at all temperatures and pressures.

55. 33.0 L

57. 3.60×10^2 kPa

59. The total pressure of a gaseous mixture is equal to the sum of the individual pressures of each gas.

61. Molecular oxygen

63. 3.08:1

65. Boiling the water fills the can with steam. When the can is plunged upside down into ice water, the steam is trapped and rapidly condenses, reducing gas pressure inside the can. The walls of the can are not strong enough to resist the comparatively high atmospheric pressure, which crushes the can.

67. High temperatures increase the pressure of the contents of the container and may cause it to explode.

69. Temperatures measured on the Kelvin scale are directly proportional to the average kinetic energy of the particles. Celsius temperatures are not.

71. The variables are directly proportional.

73. The particles in a real gas have a finite volume and are attracted to one another.

75. Helium atoms have a smaller molar mass than oxygen and nitrogen molecules and effuse faster through pores in the balloon.

77. 2.0×10^2 g

79. A vacuum contains no matter to allow the transfer of kinetic energy between molecules.

81. Helium gas is composed of small atoms with little attraction for each other.

83. **a.** 1.63×10^2 kPa **b.** 4.48×10^2 kPa

85. 2 mol KNO_3 for each 1 mol O_2

87. **a.** 2.0×10^{-3}% **b.** 2.0%

89. K = °C + 273

91. 82 protons, 82 electrons, 124 neutrons

93. a, tungsten

95. b, SO_2

97. 206 g

99. It is the volume occupied by 1 mol of a gas at STP.

101. **a.** single-replacement **b.** decomposition

103. 60.0% C, 13.3% H, 26.7% O

105. The motion of particles in a gas is constant, random, and rapid.

Chapter 15

6. 36.1% H_2O

7. 49.3% H_2O

23. Surface molecules are attracted to the liquid molecules below but not to the air. Molecules inside the liquid are attracted in all directions.

25. A surfactant is a wetting agent such as a soap or detergent. A surfactant interferes with hydrogen bonding between water molecules and reduces surface tension.

27. The water has low vapor pressure.

29. Bodies of water would freeze from the bottom up. This would kill many forms of aquatic life. Also, ice floats.

31. Solutions are homogeneous mixtures in which a solute is dissolved in a solvent. Aqueous solutions are solutions that have water as the solvent.

33. The polar water molecules attract ions and polar covalent molecules. Nonpolar compounds are unaffected because they have no charges.

35. Solvent molecules surround positively charged and negatively charged ions.

37. Water is polar and gasoline is nonpolar.

39. Its ions are free to move toward an electrode.

41. water in the crystal structure of a substance

43. **a.** tin(IV) chloride pentahydrate
b. iron(II) sulfate heptahydrate
c. barium bromide tetrahydrate
d. iron(III) phosphate tetrahydrate

45. Hygroscopic substances absorb water vapor from the air and create a dry environment in a sealed container.

47. Efflorescence is the loss of water of hydration that occurs when the hydrate has a higher vapor pressure than that of the water vapor in air.

49. solutions, colloids, suspensions

51. The molecules or ions are too small to have reflective surfaces.

53. Brownian motion and repulsion between like-charged ions adsorbed on colloidal particles' surfaces

55. the addition of an emulsifier

57. Water molecules at 4°C are tightly packed and have maximum density. Below 4°C the water molecules arrange in a regular network because of the attractions between them. As a result, ice has a lower density than water and floats on water.

59. **a.** Water expands when it freezes to ice.
b. Water is polar and wax is nonpolar, and water has a higher surface tension.
c. A network of hydrogen bonding between water molecules lowers the vapor pressure. Two ethanol molecules can hydrogen bond, but a network is not formed.

61. **a.** gasoline **b.** water
c. gasoline **d.** water

63. **a.** No, both form clear, colorless solutions.
b. dry to examine the crystals, test for electrical conductivity, do a flame test

65. No, nonpolar molecules do not dissolve in polar molecules.

67. **a.** sodium carbonate monohydrate, 14.5% H_2O
b. magnesium sulfate heptahydrate, 51.2% H_2O

69. $CaCl_2 \longrightarrow 2H_2O$

71. Liquid water contains some hydrogen-bonded structures similar to ice, in which the water molecules are spaced fairly wide apart. These structures are disrupted when ethyl alcohol is added because the alcohol competes for hydrogen bonds with water molecules and the water structure collapses. Thus, mixtures of water and ethyl alcohol have less volume than the sum of the volumes of the components. Mixing two liquids could result in a volume greater than the sum of the volumes of the components if the structural ordering in the mixture is greater than in the separated components.

73. Most of the important chemical reactions of life take place in aqueous solutions inside cells.

75. Particles in the atmosphere that are approximately the same size as the wavelengths of visible light cause light from the sun to scatter and split into individual components. Oxygen and nitrogen in the atmosphere scatter violet and blue light due to their small size. Thus the sky appears blue at midday, when the sun is closest to Earth. At sunrise and sunset, the sun is at its greatest distance from Earth. It shines through a layer of atmospheric aerosols consisting of small particles of dust and other pollutant particles mixed with air. The sunlight is reflected and absorbed by these particles. The shorter wavelengths (blue and violet) are scattered away from the path of the sun, but the longer wavelengths (yellow and red) pass through and are the most visible.

77. A surfactant helps to wet the burning material, so less water is needed to put out the fire. Thus less water carries pollutants into the environment.

79. Water enters cracks in pavement and expands when it freezes, creating larger cracks. Continuous freeze-thaw cycles cause pavement to break up and form potholes.

81. **a.** pink **b.** pink **c.** blue
d. 45.4% **e.** water or water vapor

83. **a.** 5 **b.** 2 **c.** 2 **d.** 4

85. $H^+ + H{:}\ddot{\underset{..}{O}}{:}H \rightarrow \left[H{:}\ddot{\underset{\underset{H}{..}}{O}}{:}H\right]^+$

87. **a.** $6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$
b. $2Na + 2H_2O \longrightarrow 2Na^+ + 2OH^- + H_2$

89. 3.60×10^{-2} g H_2O, 2.24×10^{-2} L O_2

91. 636 g C_2H_4O

93. **a.** hydrogen **b.** 0.048 g H_2O
c. oxygen **d.** 0.010 L

95. 1.27 atm

Chapter 16

1. 4.4×10^{-1} g/L

2. 2.6 atm

8. $1.0 \times 10^{-1}M$

9. $2.8M$

10. 1.42×10^{-1} mol NH_4NO_3

11. 5.0×10^{-1} mol $CaCl_2$; 5.6×10^1 g $CaCl_2$

12. 47.5 mL

13. Use a pipet to transfer 5.0×10^1 mL of the $1.0M$ solution to a 250-ml volumetric flask. Then add distilled water up to the mark.

14. 5.0% v/v

15. 1.2×10^1 mL

29. 1.26×10^1 g NaF

30. $2.85 \times 10^{-1}m$ NaCl

31. $X_{C_2H_5OH} = 0.190$; $X_{H_2O} = 0.810$

32. $X_{CCl_4} = 0.437$; $X_{CHCl_3} = 0.563$

33. 2.06°C

34. 44.1°C

35. 101.37°C

36. 115 g NaCl

43. Random collisions of the solvent molecules with the solute particles provide enough force to overcome gravity.

45. Particles of solute crystallize.

47. 5.6×10^2 g $AgNO_3$

49. **a.** 1.6×10^{-2} g/L **b.** 4.7×10^{-2} g/L

51. Molarity is the number of moles of solute dissolved in one liter of solution.
a. $1.3M$ KCl **b.** $3.3 \times 10^{-1}M$ $MgCl_2$

53. **a.** 5.0×10^{-1} mol NaCl, 29 g NaCl
b. 1.0 mol KNO_3, 1.0×10^{-2} g KNO_3
c. 2.5×10^2 mol $CaCl_2$, 2.8 g $CaCl_2$

55. **a.** 16% (v/v) ethanol
b. 63.6% (v/v) isopropyl alcohol

57. **a.** sea water **b.** $1.5M$ KNO_3 **c.** $0.100M$ $MgCl_2$

59. When vapor pressure is lowered relative to pure solvent, more energy must be supplied to reach the boiling point; therefore the boiling point is increased relative to pure solvent.

61. $1M$ solution: 1 mol of solute in 1 L of solution; $1m$ solution: 1 mol of solute in 1 kg of solvent

63. **a.** 100.26°C **b.** 101.54°C

65. **a.** −1.1°C **b.** −0.74°C **c.** −1.5°C

67. $\Delta T_f = -9.60$°C; $\Delta T_b = +4.74$°C

69. The mole fraction of $NaHCO_3$ is 0.020, and of water is 0.98. The solution is $1.1m$.

71. Add one crystal of KNO_3. If the solution is supersaturated, crystallization will occur. If saturated, the crystal will not dissolve. If unsaturated, the crystal will dissolve.

73. **a.** about 1.14 **b.** about −7.2°C **c.** about −9.5°C

75. $X_{C_2H_5OH} = 0.20$; $X_{H_2O} = 0.80$

77. **a.** 44.2 g KCl **b.** 5.8 g KCl

79. unsaturated

81. **a.** 7.5 g H_2O_2 **b.** $8.8 \times 10^{-1}M$

81. 85.5 g/mol

85. $CaCl_2$ produces three particles upon dissolving; NaCl produces two. Freezing point depression depends on the number of solute particle in the solvent.

87. 6.00 g $Ca(NO_3)_2$ in 30 g of water

89. 1.10×10^2 mL HNO_3

91. $9.0 \times 10^{-2}M$ Na_2SO_4

93. **a.** 1.98×10^2 g H_2O
b. 1.98×10^5 mg H_2O
c. 1.98×10^{-1} kg H_2O

95. Rutherford's model contains a nucleus.

97. Calcium permanganate is $Ca(MnO_4)_2$. Four formula units contain 4 Ca atoms, 8 Mn atoms, and 32 O atoms.

99. **a.** 55.8 g Fe, 63.5 g Cu, 201 g Hg, 32.1 g S
b. Each sample contains 6.02×10^{23} atoms.
c. 4.48×10^{-1} mol Fe, 3.93×10^{-1} mol Cu, 1.25×10^{-1} mol Hg, 7.80×10^{-1} mol S

101. **a.** combination **b.** decomposition
c. single-replacement **d.** combustion
e. single-replacement **f.** double-replacement

103. **a.** $NH_4Cl(s) \longrightarrow NH_4^+(aq) + Cl^-(aq)$
b. $Cu(NO_3)_2(s) \longrightarrow Cu^{2+}(aq) + 2NO_3^-(aq)$
c. $HNO_3(aq) \longrightarrow H^+(aq) + NO_3^-(aq)$
d. $HC_2H_3O_2(l) \longrightarrow H^+(aq) + C_2H_3O_2^-(aq)$
e. $Na_2SO_4(s) \longrightarrow 2Na^+(aq) + SO_4^{2-}(aq)$
f. $HgCl_2(s) \longrightarrow Hg^{2+}(aq) + 2Cl^-(aq)$

105. **a.** $:\ddot{\underset{\cdot\cdot}{\mathrm{I}}}\cdot$ **b.** $\cdot\ddot{\underset{\cdot\cdot}{\mathrm{Te}}}\cdot$ **c.** $:\dot{\underset{\cdot}{\mathrm{Sb}}}\cdot$ **d.** $\cdot\mathrm{Sr}\cdot$

107. The particles of an ideal gas have neither volume nor inter-particle interactions. Real gases have both.

109. Hydrogen chloride produces hydronium ions (H_3O^+) and chloride ions (Cl^-) that are stabilized by solvent shells of water in aqueous solution. Nonpolar solvents such as benzene have virtually no interaction with HCl.

Chapter 17

1. Heat flows from the system (paraffin) to the surroundings (air). The process is exothermic.

2. Since the beaker becomes cold, heat is absorbed by the system (chemicals within the beaker) from the surroundings (beaker and surrounding air). The process is endothermic.

3. 2.0 J/(g•°C)

4. 1.8 kJ

12. 1.46 kJ

13. 146 J

14. 6.63 kJ

15. 89.4 kJ

21. 3.34 kJ

22. 1.20 g ice

23. 1.44×10^2 kJ

24. 1.9×10^{-1} kJ

25. -3.01×10^2 kJ

26. 3.42 mol $NH_4NO_3(s)$

32. **a.** -3.091×10^1 kJ **b.** 1.784×10^2 kJ
c. -1.130×10^2 kJ

33. CO is a compound and not an element in its standard state.

39. Heat flows from the object at the higher temperature to the object at the lower temperature.

41. the chemical composition of the substance and its mass

43. **a.** 8.50×10^{-1} Calorie **b.** 1.86×10^3 J
c. 1.8×10^3 J **d.** 1.1×10^2 cal

45. A negative sign is given to heat flow from the system to the surroundings. A positive sign is given to heat flow to the system from the surroundings.

47. **a.** exothermic **b.** endothermic
c. exothermic **d.** endothermic

49. A calorimeter is an instrument used to measure heat changes in physical or chemical processes.

51. bomb calorimeter

53. amount of heat released or absorbed in a chemical change at constant pressure

55. **a.** -2.10×10^1 kJ **b.** -1.8×10^1 kJ
c. -5.56×10^2 kJ **d.** 6.5 kJ

57. Hess's law allows the calculation of the enthalpy change for a reaction from the known enthalpy changes for two or more other reactions.

59. 3.02×10^1 kJ

61. The statement is true, since stability implies lower energy. The greater the release of heat, the more stable is the compound relative to its elements (all of which have $\Delta H_f^0 = 0$).

63. 4.00×10^1 g water; 9.60×10^2 g ice

65. 2.44×10^4 cal; 1.02×10^5 J

67. **a.** -8.902×10^2 kJ **b.** -5.660×10^2 kJ

69. **a.** -2.21×10^2 kJ **b.** -1.96×10^2 kJ
c. -9.046×10^2 kJ

71. 2.36×10^1 kJ

73. 2.38×10^2 kJ

75. 6.71×10^1 kJ

77. **a.** 1.5×10^2 kJ
b. The refrigerator absorbs 1.5×10^2 kJ of heat.
c. assumes the mineral water has the same specific heat as chemically pure water, that no heat is lost by the refrigerator, and the volume of the water is exactly 2 L

79. When a solid reaches its melting point, additional heat must be absorbed to convert it to a liquid. Therefore, fusion of a solid is endothermic. This heat of fusion is released when a liquid freezes, so freezing is exothermic.

81. −1207 kJ

83. **a.** 3.24×10^1 kcal; 1.36×10^2 kJ
b. 8.13 kg

85. 9.6 g

87. The manipulated variable is the variable you change during an experiment. The responding variable is the variable you observe during an experiment.

89. **a.** 6.99 **b.** 10.68 **c.** 3.6×10^2 **d.** 4.44

91. 32.2 m

93. **a.** 2 **b.** 2 **c.** 3 **d.** 1

95. **a.** K_3N **b.** Al_2S_3 **c.** $Ca(NO_3)_2$ **d.** $CaSO_4$

97. $Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$

99. 1.18×10^1 g O_2

101. 11.1 L

103. solutions; suspensions

Chapter 18

6. **a.** reactants favored **b.** reactants favored
c. products favored **d.** products favored

7. $K_{eq} = 12$

8. $K_{eq} = 8.3 \times 10^{-2}$; one is the inverse of the other.

9. $K_{eq} = 1.6 \times 10^{-3}$

10. $K_{eq} = 0.79$

17. $2 \times 10^{-14} M$

18. $6.7 \times 10^{-5} M$

19. $2 \times 10^{-17} M$

20. $3.2 \times 10^{-6} M$

36. Rate = k[A]; rate is moles per liter per second. [A] is moles per liter. k = rate/[A]. $k = 1/s = s^{-1}$

37. 0.25 mol/L s; 0.125 mol/L s

43. Chemical reactions require collisions between reacting particles with sufficient energy to break and form bonds.

45. A catalyst increases the rate of reactions by providing an alternative reaction mechanism with lower activation energy.

47. Gas molecules and oxygen molecules mix readily but do not have enough energy to react at room temperature. The flame raises the temperature and the energy of collisions, so the reaction rate increases. The heat released by the reaction maintains the high temperature, and the reaction continues spontaneously.

49. The rates are equal.

51. **a.** $K_{eq} = \frac{[H_2S]^2 \times [CH_4]}{[H_2]^4 \times [CS_2]}$ **b.** $K_{eq} = \frac{[PCl_3] \times [Cl_2]}{[PCl_5]}$

53. **a.** $[Ni^{2+}][S^{2-}]$ **b.** $[Ba^{2+}][CO_3^{2-}]$

55. c, b, d, a

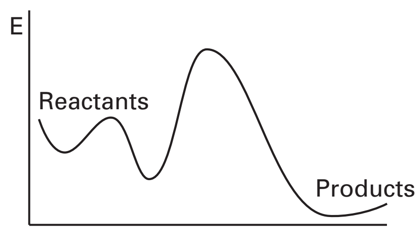
57. A spontaneous reaction has a negative free energy.

59. unfavorable

61. **a.** entropy increases **b.** entropy decreases

63. The favorable exothermic change of the condensation process offsets the unfavorable entropy change.

65. **a.** proportionality constant that relates concentrations of reactants to rate of reaction
b. reaction rate directly proportional to concentration of one reactant
c. expression of rate of reaction in terms of concentrations of reactants

67.


$2NO + O_2 \rightleftharpoons 2NO_2$

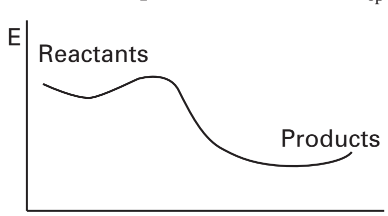
69. c

71. The change from Figure a to Figure b is spontaneous, favored by an increase in entropy. The change from Figure b to Figure c will not occur because it would result in a decrease in entropy and a nonspontaneous process.

73. increase in products

75. $K_{eq} = 6.59 \times 10^{-1}$

77. The product of the ion concentrations must be greater than the ion-product constant (K_{sp}).

79.


81. **a.** IO^-
b. No, the I^- is changed in the reaction. A catalyst does not appear in the reaction as a reactant, an intermediate, or a product.
c. two
d. the slow reaction
e. $2H_2O_2 \longrightarrow 2H_2O + O_2$

83. **a.** increase $[H_2O]$ **b.** decrease $[H_2O]$
c. decrease $[H_2O]$ **d.** no change in $[H_2O]$

85. Possible answers: used a blow dryer, flushed a toilet, mowed the lawn, cooked breakfast, drove a car, and simply breathed

87. first-order in NO_2, first order in NH_4^+, second-order overall

89. **a.** 3 g **b.** 1.3 g **c.** Rate decreases.

91. Potassium chloride is an ionic compound, not a molecular compound.

93. **a.** sodium perchlorate, ClO_4^-
b. potassium permanganate, MnO_4^-
c. calcium phosphate, PO_4^{3-}
d. magnesium carbonate, CO_3^{2-}
e. sodium sulfate, SO_4^{2-}
f. potassium dichromate, $Cr_2O_7^{2-}$

95. **a.** 251 g **b.** 45.9 g
c. 2.99×10^{-22} g **d.** 9.57 g

97. **a.** $2KClO_3(s) \xrightarrow{heat} 2KCl(s) + 3O_2(g)$
b. 1.91 g O_2

99. No; the boiling point is the temperature at which the vapor pressure of the liquid equals the atmospheric pressure; it changes if the atmospheric pressure changes.

101. 17.1 L

103. 19.5% H_2O

105. 1.58 mol

107. **a.** solute, ethanol; solvent, water.
b. below

109. exothermic

Chapter 19

1. **a.** H^+ is the Lewis acid; H_2O is the Lewis base.
b. $AlCl_3$ is the Lewis acid; Cl^- is the Lewis base.

2. a Lewis base; it has a non-bonding pair of electrons that it can donate.

9. **a.** basic **b.** basic **c.** acidic **d.** neutral

10. $1.0 \times 10^{-11}M$; basic

11. **a.** 4.0 **b.** 2.82

12. **a.** 12.00 **b.** 1.35

13. **a.** $1.0 \times 10^{-5}M$ **b.** $1.5 \times 10^{-13}M$

14. **a.** $1.0 \times 10^{-4}M$ **b.** $2.8 \times 10^{-12}M$

15. **a.** 9.63 **b.** 3.65

16. **a.** 4.30 **b.** 9.08

22. 1.8×10^{-4}

23. 4.86×10^{-6}

30. 4.68 mol KOH

31. 0.20 mol NaOH

32. 56 mL HCl

33. $0.129M\ H_3PO_4$

38. **a.** $HPO_4^{2-} + H^+ \longrightarrow H_2PO_4^-$
b. $H_2PO_4^- + OH^- \longrightarrow HPO_4^{2-} + H_2O$

39. $CH_3COO^- + H^+ \longrightarrow CH_3COOH$

45. **a.** base **b.** acid **c.** base
d. acid **e.** acid **f.** acid

47. **a.** $2Li + 2H_2O \longrightarrow 2LiOH + H_2$
b. $Ba + 2H_2O \longrightarrow Ba(OH)_2 + H_2$

49. **a.** HNO_3 with NO_3^-, H_2O with H_3O^+
b. CH_3COOH with CH_3COO^-, H_2O with H_3O^+
c. H_2O with OH^-, NH_3 with NH_4^+
d. H_2O with OH^-, CH_3COO^- with CH_3COOH

51. $H_2O \rightleftharpoons H^+ + OH^-$

53. the negative logarithm of the $[H^+]$

55. **a.** pH = 2.00, acidic **b.** pH = 12.00, basic
c. pH = 6.00, acidic

57. **a.** 5.62 **b.** $6.3 \times 10^{-14}M$

59. A strong acid is completely dissociated; *K*a must be large.

61. **a.** $K_a = \dfrac{[H^+][F^-]}{[HF]}$ **b.** $K_a = \dfrac{[H^+][HCO_3^-]}{[H_2CO_3]}$

63. **a.** $HNO_3 + KOH \longrightarrow KNO_3 + H_2O$
b. $2HCl + Ca(OH)_2 \longrightarrow CaCl_2 + 2H_2O$
c. $H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$

65. **a.** $1.40M$ **b.** $2.61M$

67. $HCO_3^-(aq) + H_2O\ (l) \longrightarrow H_2CO_3(aq) + OH^-(aq)$

69. **a.** basic **b.** acidic **c.** neutral
d. basic **e.** neutral **f.** acidic

71. yes; acids like acetic acid dissolve well but ionize poorly.

73. 4.6×10^{-4}

75. **a.** $HClO_2$, chlorous acid
b. H_3PO_4, phosphoric acid
c. H_3O^+, hydronium ion
d. NH_4^+, ammonium ion

77. $H_3PO_4 \rightleftharpoons H^+ + H_2PO_4^-$;
$H_2PO_4^- \rightleftharpoons H^+ + HPO_4^{2-}$;
$HPO_4^{2-} \rightleftharpoons H^+ + PO_4^{3-}$

79. **a.** HSO_4^- **b.** CN^- **c.** OH^- **d.** NH_3

81. **a.** $2HCl + Mg(OH)_2 \longrightarrow MgCl_2 + 2H_2O$
b. $2HCl + CaCO_3 \longrightarrow H_2O + CO_2 + CaCl_2$
c. $Al(OH)_3 + 3HCl \longrightarrow AlCl_3 + 3H_2O$

83. **a.** 8.73
b. phenolphthalein or phenol red

85. b, c, d, a

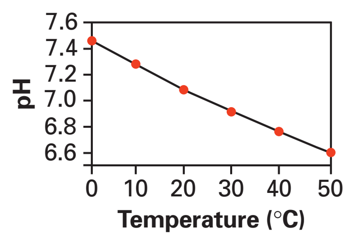
87. **a.** You may consider the Arrhenius theory the easiest to understand, and the Lewis theory the best because it is the most general. All three theories provide definitions and describe accepted behavior of a certain group of compounds. The Brønsted-Lowry theory includes a greater number of compounds than the Arrhenius theory because it is more general, and the Lewis theory includes the greatest number of compounds because it is the most general.
b. Each theory has advantages in certain circumstances.

89. The *y*-axis might correspond to $[H^+]$ because HCl is a strong acid.

91. **a.** false; an indicator determines a range of pH values.
b. false; an Arrhenius base dissociates to give hydroxide ions in aqueous solution. Ammonia does not do this.
c. false; strength is a measure of dissociation or ionization, not concentration.

93. pH = 10.66

95. **a.** 7.4721, 7.2675, 7.0835, 6.9165, 6.7675, 6.6310



b. 7.37 **c.** 35°C

97. 50.0 mL; the pH = 7 when $[H^+] = [OH^-]$. Because HCl is a strong acid that supplies one hydrogen ion per formula unit and NaOH is a strong base that supplies one hydroxide ion per formula unit, $[H^+] = [OH^-]$ when equal volumes of solutions of the same molarity are combined.

99. $[OH^-] = 4.6 \times 10^{-4}$; pH = 10.66

101. 131 g O_2

103. The total pressure in a mixture of gases is equal to the sum of the partial pressures of each gas in the mixture.

105. suspension

107. hydrogen bond

109. Dissolve 0.272 mol KOH(*s*) in water and add sufficient water to give 400.0 mL of solution.

111. b, c, and d

113. **a.** 144 J **b.** 1.0×10^3 kJ **c.** 82.9 cal

115. The product of the concentrations of the two ions must be greater than the solubility product.

117. $2.0 \times 10^{-8}M$

119. **a.** shift right **b.** no change **c.** shift right
d. shift right **e.** shift right

Chapter 20

1. a. Na: oxidized (reducing agent); S: reduced (oxidizing agent)
b. Al: oxidized (reducing agent); O_2: reduced (oxidizing agent)

2. a. oxidation **b.** reduction

9. a. S, +3; O, −2 **b.** Na, +1; O, −1
c. P, +5; O, −2 **d.** N, +5; O, −2

10. a. +5 **b.** 0 **c.** +7 **d.** +1

11. a. H_2 oxidized, O_2 reduced
b. N reduced, O oxidized

12. a. H_2 reducing agent, O_2 oxidizing agent
b. N oxidizing agent, O reducing agent

17. a. redox reaction; Mg is oxidized, Br_2 is reduced.
b. not a redox reaction

18. a. not a redox reaction
b. redox reaction; H_2 is oxidized, Cu is reduced.

19. a. 2, 2, 3 **b.** 2, 2, 2, 1, 2

20. a. 1, 8, 2, 2, 3, 4 **b.** 1, 2, 1, 2, 1

21. $4Zn + NO_3^- + 6H_2O + 7OH^- \longrightarrow 4Zn(OH)_4^{2-} + NH_3$

27. The oxidizing agent is reduced.

29. a. oxidation **b.** oxidation
c. oxidation **d.** oxidation

31. a. H_2 is oxidized; S is reduced.
b. N_2 is reduced; H_2 is oxidized.
c. S is oxidized; O_2 is reduced.
d. H_2 is oxidized; O_2 is reduced.

33. An oxidation number is the charge an atom would have if the electrons in each bond were assigned to the atoms of the more electronegative element.

35. a. +2 **b.** +3 **c.** Na, +1; Cr, +6
d. +5 **e.** +7

37. a. Al is oxidized; Mn is reduced.
b. K is oxidized; H is reduced.
c. Hg is reduced; O is oxidized.
d. P is oxidized; O is reduced.

39. redox: a, b, c, d, e

41. a. $4Al(s) + 3MnO_2(s) \longrightarrow 2Al_2O_3(s) + 3Mn(s)$
b. $2K(s) + 2H_2O(l) \longrightarrow 2KOH(aq) + H_2(g)$
c. $2HgO(s) \longrightarrow 2Hg(l) + O_2(g)$
d. $P_4(s) + 5O_2(g) \longrightarrow P_4O_{10}(s)$

43. a. +4 **b.** +5 **c.** +5
d. +3 **e.** +5 **f.** +3

45. a. Cl oxidized, Mn reduced, Mn oxidizing agent, reducing agent
b. Cu oxidized, N reduced, N oxidizing agent, Cu reducing agent
c. P oxidized, N reduced, N oxidizing agent, P reducing agent
d. Sn oxidized, Bi reduced, Bi oxidizing agent, Sn reducing agent

47. a. $16H^+(aq) + 2Cr_2O_7^{2-}(aq) + C_2H_5OH(aq) \longrightarrow 4Cr^{3+}(aq) + 2CO_2(g) + 11H_2O(l)$
b. oxidizing agent

49. a. oxidized
b. H is the oxidizing agent; Ag is the reducing agent.
c. $2Ag(s) + H_2S(s) \longrightarrow Ag_2S(s) + H_2(g)$

51. a. yes; the oxidation number of bismuth changes from +3 to zero; the oxidation number of carbon changes from zero to +2.
b. no; there is no change in oxidation number of any of the atoms in this reaction.
c. no; there is no change in oxidation number of any of the atoms in this reaction.

53. a. reactant, 0; product, +3
b. reactant, −2; product, −2
c. X
d. H

55. $1s^2 2s^2 2p^6 3s^2 3p^5$; A chlorine atom can lose its 7 valence electrons or it can gain one electron to complete the third energy level.

57. Double replacement reactions never involve the transfer of electrons; instead they involve the transfer of positive ions in aqueous solution.

59. a. SO_4^{2-} **b.** H_2O_2 **c.** NO_3^-
d. $Cr_2O_7^{2-}$ **e.** H_2O

61. a. $Rb(s) + I_2(s) \longrightarrow RbI_2(s)$; oxidizing agent is I
b. $Ba(s) + 2H_2O(l) \longrightarrow Ba(OH)_2(aq) + H_2(g)$; oxidizing agent is H
c. $2Al(s) + 3FeSO_4(aq) \longrightarrow Al_2(SO_4)_3(aq) + 3Fe(s)$; oxidizing agent is Fe
d. $C_4H_8(g) + 6O_2(g) \longrightarrow 4CO_2(g) + 4H_2O(l)$; oxidizing agent is O
e. $Zn(s) + 2HBr(aq) \longrightarrow ZnBr_2(aq) + H_2(g)$; oxidizing agent is H
f. $Mg(s) + Br_2(l) \longrightarrow MgBr_2(s)$; oxidizing agent is Br

63. MnO_4^-, because the manganese is at its highest oxidation state

65. 104 mL $K_2Cr_2O_7$

67. a. +5 **b.** −3 **c.** +3 **d.** +3
e. +1 **f.** −3 **g.** +2 **h.** +4

69. The nitride ion has the minimum oxidation number of −3, therefore it cannot gain additional electrons and be an oxidizing agent. It can lose electrons, however, and be a reducing agent. The nitrate ion has the maximum oxidation number of +5; therefore, it cannot lose additional electrons and be a reducing agent. It can gain electrons, however, and be an oxidizing agent.

71. a. a. 6.5 b. 4 c. 5 d. 8 e. 5 f. 6 g. 9.5 h. 6 i. 7
b. $C_xH_y + [x + (y/4)]O_2 \longrightarrow xCO_2 + (y/2)H_2O$

73. 1.8×10^2 kPa

75. a, c, and d

77. $Ca(NO_3)_2$; boiling point elevation is a colligative property that depends on the number of particles in solution. $Ca(NO_3)_2$ gives three particles per formula unit; LiF gives two particles per formula unit.

79. solubility: $PbBr_2 = 8.1 \times 10^{-3} M$

81. a. $1.0 \times 10^{-2} M$ **b.** $1.0 \times 10^{-11} M$ **c.** $1.6 \times 10^{-9} M$

83. a. NH_4^+ and NH_3; H_2O and H_3O^+
b. H_2SO_3 and HSO_3^-; NH_2^- and NH_3
c. HNO_3 and NO_3^-; I^- and HI

85. a. 5.00 **b.** 10.00 **c.** 13.00 **d.** 6.52

Chapter 21

9. nonspontaneous; $E^0_{cell} = -0.02\ V$

10. yes; $E^0_{cell} = +0.16\ V$

11. $2Al(s) + 3Cu^{2+}(aq) \longrightarrow 2Al^{3+}(aq) + 3Cu(s)$

12. $Cu(s) + 2Ag^+(aq) \longrightarrow Cu^{2+}(aq) + 2Ag(s)$

13. $E^0_{cell} = +2.00\ V$

14. $E^0_{cell} = +0.46\ V$

27. oxidation: $Al(s) \longrightarrow Al^{3+}(aq) + 3e^-$; reduction: $Cu^{2+}(aq) + 2e^- \longrightarrow Cu(s)$

29. a. Cu **b.** Ca **c.** Mg **d.** Sn **e.** Zn **f.** Al

31. The salt bridge allows ions to pass from one half-cell to the other but prevents the solutions from mixing.

33. Water is produced by the redox reaction and sulfuric acid is used up; water has a lower density than sulfuric acid.

35. Fuel cells cannot generate electricity as economically as more conventional forms of electrical generation.

37. It was arbitrarily set at zero.

39. The relative order is the same because both tables rank the elements according to their tendency to undergo oxidation/reduction.

41. a. nonspontaneous; $E^0_{cell} = -0.34\ V$
b. nonspontaneous; $E^0_{cell} = -1.24\ V$

43. A direct current flows in one direction only.

45. $2H_2O(l) \longrightarrow O_2(g) + 2H_2(g)$

47. Apparatus similar to that on page 687; the small spheres representing molecules of H_2 and Cl_2 will be in 1:1 ratio.

49. Two half-cells are needed because oxidation or reduction cannot occur in isolation. One half-cell gains electrons and one loses them, producing an electric current.

51. Some of the iron dissolves and the nail becomes coated with copper.
Overall reaction: $Fe(s) + CuSO_4(aq) \longrightarrow FeSO_4(aq) + Cu(s)$;
oxidation half-reaction: $Fe \longrightarrow Fe^{2+} + 2e^-$;
reduction half-reaction: $Cu^{2+} + 2e^- \longrightarrow Cu$

53. Lead(II) sulfate and lead dioxide are highly insoluble in sulfuric acid.

55. a. oxidation: $6Cl^-(l) \longrightarrow 3Cl_2(g) + 6e^-$ (anode);
reduction: $2Al(l) + 6e^- \longrightarrow 2Al(l)$ (cathode)
b. overall reaction: $2AlCl_3(l) \longrightarrow 2Al(l) + 3Cl_2(g)$
c. chlorine gas at anode; liquid aluminum at cathode

57. In each type of cell, oxidation occurs at the anode and reduction occurs at the cathode.

59. a. $Zn \longrightarrow Zn^{2+} + 2e^-$ **e.** $Fe \longrightarrow Fe^{2+} + 2e^-$
f. $Na \longrightarrow Na^+ + e^-$

61. a. +0.63 V **e.** +0.21 V **f.** +4.07 V

63. a. possible oxidation reactions at anode:
(i) $2Cl^-(aq) \longrightarrow Cl_2(g) + 2e^-$;
(ii) $2H_2O(l) \longrightarrow O_2(g) + 4H^+(aq) + 4e^-$
b. possible reduction reactions at cathode:
(i) $Na^+(aq) + e^- \longrightarrow Na(s)$;
(ii) $2H_2O(l) + 2e^- \longrightarrow H_2(g) + 2OH^-(aq)$
c. (i) Chloride ions are more readily oxidized to chlorine gas than water molecules are oxidized to water.
d. (ii) Water is reduced to produce hydrogen gas; sodium ions are not reduced to sodium metal because water molecules are more easily reduced than sodium ions.

65. Gold belongs near the bottom, below silver, because it is one of the least active metals.

67. The chemists' definition focuses on the electrons that are produced by oxidation at the anode of a voltaic cell; the dictionary definition is based on an electrolytic cell. The electrodes are defined by the battery terminals to which they are attached.

69. d; the voltage falls steadily.

71. As electrons flow from the anode to the cathode in the external circuit, anions must flow from the cathode compartment to the anode compartment to maintain neutrality in the electrolytes. Anions cannot flow through wire made of copper or any other metal; the cell will not function if the salt bridge is replaced with a metal wire.

73. oxidation: $2Cu(impure) + 2H_2SO_4 \longrightarrow 2Cu^{2+} + 2H_2 + SO_4^{2+}$;
reduction: $2Cu^{2+} + 2SO_4^{2+} + 2H_2O \longrightarrow 2Cu(pure) + 2H_2SO_4 + O_2$;
overall reaction: $2Cu(impure) + 2H_2O \longrightarrow 2Cu(pure) + 2H_2 + O_2$

75. The battery output would not be 12V .

77. 467 mL

79. a. 0.0125g NaCl **b.** 101g KNO_3

81. a. 4.32×10^2 kJ **b.** 2.55×10^5 cal **c.** 2.70×10^3 J

83. 267 kJ

85. $[N_2] \times [H_2]^3/[NH_3]^2$

87. a. $[OH^-] = 1 \times 10^{-7} M$ **b.** $[OH^-] = 1 \times 10^{-10} M$
c. $[OH^-] = 1 \times 10^{-6} M$

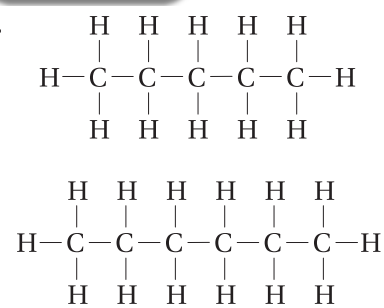
89. a. +6 **b.** −2 **c.** +4 **d.** +2 **e.** 0 **f.** +4

91. b (Ca is oxidized, Cl_2 is reduced) and d (Ca is oxidized, H is reduced)

93. **a.** Cr, +6 **b.** I, +5
c. Mn, +7 **d.** Fe, +3

Chapter 22

1.

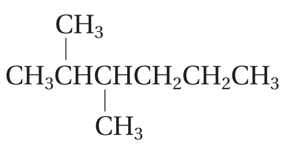


2. 10

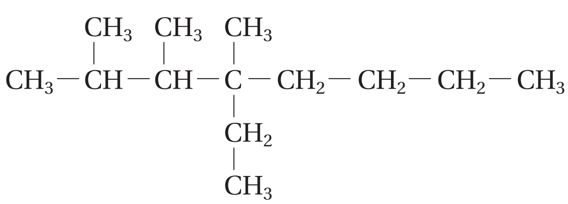
3. **a.** 3-ethylhexane **b.** 2-methylbutane

4. **a.** 2,3-dimethylpentane **b.** 2-methylpentane

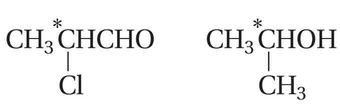
5.



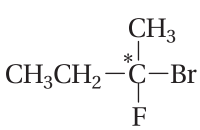
6.



18. Both a and b have an asymmetric carbon, denoted as C*.



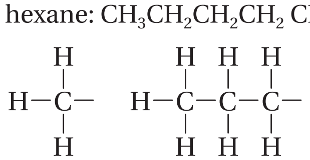
19. **a.** The asymmetric carbon is denoted as C*.



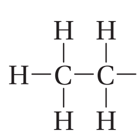
b. no asymmetric carbon

37. pentane: $CH_3CH_2CH_2CH_2CH_3$; hexane: $CH_3CH_2CH_2CH_2\ CH_2CH_3$

39.



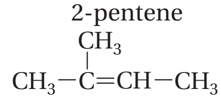
methyl propyl



ethyl

41. The carbon-carbon bonds are nonpolar and the carbon-hydrogen bonds are very weakly polar.

43. $CH_2{=}CHCH_2CH_2CH_3$
1-pentene
$CH_3CH{=}CHCH_2CH_3$
2-pentene

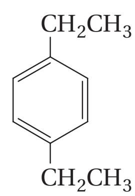


2-methyl-2-butene

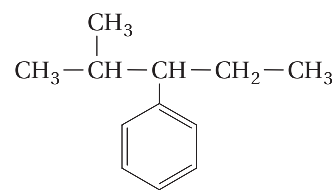
45. **a.** Accept any isomer with 5 carbons and 12 hydrogens.
b. Accept any isomer with 7 carbons and 16 hydrogens.

47. No; Only molecules with at least one asymmetric carbon have optical isomers.

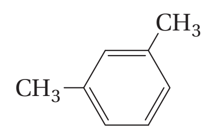
49. **a.**



b.



c.



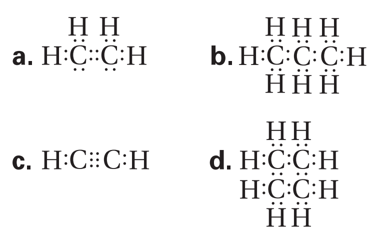
51. Catalysts are used during cracking to produce more short-chain components, including components that increase the performance of gasoline.

53. The combustion of sulfur in coal produces the air pollutants SO_2 and SO_3.

55. **a.** Ethyne (acetylene) has one triple carbon-carbon bond and two single carbon-hydrogen bonds.
b. All the bonds in propane are single bonds.
c. In methylbenzene, there are hybrid bonds within the ring and single bonds within the substituents and between the substituents and the ring.

57. propane, butane, pentane

59.

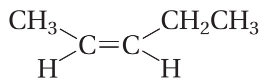


61. The middle structure is most stable due to resonance within the ring.

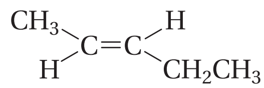
63. No; the structures are identical; one has been flipped over.

65. The amount of heat per carbon is higher for methane (−890 kJ/mol per mole of carbon burned) than for benzene (−545 kJ/mol per mole of carbon burned). Burning aromatic compounds produces more soot.

67. Because there is no rotation around the double bond, the methyl and ethyl groups can be on the same side of the bond or opposite sides.



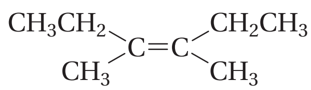
trans-2-pentene



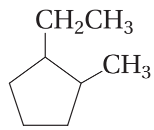
cis-2-pentene

69. $H_2C{=}C{=}CH_2$

71. a.

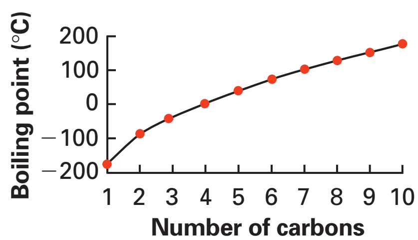


b.



73. Alkanes contain only C—C and C—H single bonds. Alkenes contain at least one C—C double bond. Aromatic hydrocarbons contain a benzene ring or a similar ring. Cycloalkanes contain aliphatic carbon chains linked end-to-end.

75. The graph is not a straight line. The estimated boiling point should be higher than 150°C. The boiling point of undecane is 196°C.



77. a. $C_6 = 5$, $C_7 = 9$, $C_8 = 18$, $C_9 = 35$, $C_{10} = 75$
b. As the number of carbon atoms increases, there is a dramatic increase in the number of ways that the carbon atoms can be arranged in the molecule.

79. a. 13.9 L **b.** 1 L **c.** 20 kPa

81. 1.13 mol KNO_3; 1.14×10^2 g KNO_3

83. 1 cal = 4.184 J; 4.184×10^3 J

85. a. favors reactants **b.** favors products

87. a. 10.00 **b.** 7.59 **c.** 12.00 **d.** 11.70

89. a. H_3PO_4 **b.** CsOH **c.** H_2CO_3 **d.** $Be(OH)_2$

91. a. Ca, +2; C, +4; O, −2 **b.** Cl, 0
c. Li, +1; I, +5; O, −2 **d.** Na, +1; S, +4; O, −2

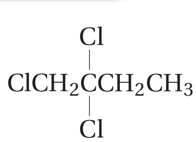
93. a. +4 **b.** +4 **c.** +3
d. +5 **e.** +5 **f.** +2

95. It is the cell potential when the ion concentrations in the half-cells are 1*M*, the temperature is 25°C, and the pressure of any gases present is 101.3 kPa.

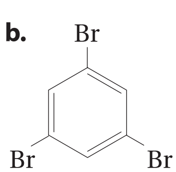
97. The reaction is nonspontaneous.

Chapter 23

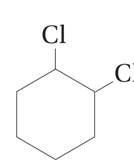
27. a.



b.

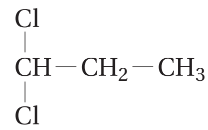


c.

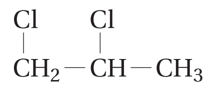


29.

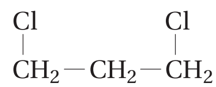
a.



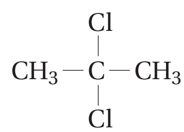
1, 1-dichloropropane



1, 2-dichloropropane

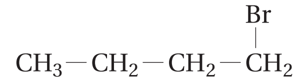


1, 3-dichloropropane

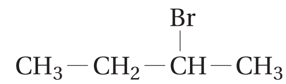


2, 2-dichloropropane

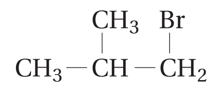
b.



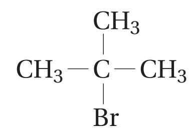
1-bromobutane



2-bromobutane



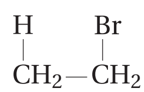
1-bromo-2-methylpropane



2-bromo-2-methylpropane

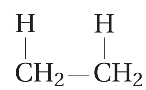
31. a. 2-propanol **b.** 1,2-propanediol

33. a.



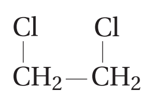
bromoethane

d.



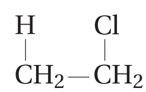
ethane

b.



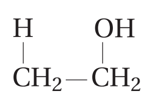
1, 2-dichloroethane

e.



chloroethane

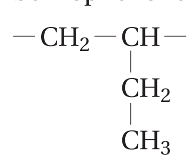
c.



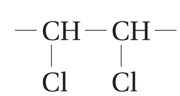
ethanol

35. a. propanone or acetone
b. 3-methylbutanal
c. 2-phenylethanal
d. ethanol or acetaldehyde
e. diphenylmethanone or diphenyl ketone or benzophenone

37. a.



b.



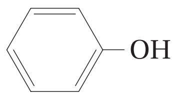
39. c, a, b

41. Both atoms in a carbon-carbon double bond have the same electronegativity, so the bond is nonpolar. Because oxygen is more electronegative than carbon, a carbon-oxygen bond is very polar.

43. a. phenol **b.** ether **c.** alcohol
d. phenol **e.** alcohol

45. **a.** carboxylic acid, ethanoic acid (acetic acid)
b. ketone carbonyl group, propanone (acetone)
c. ether, diethyl ether (ethyl ether)
d. alcohol, ethanol (ethyl alcohol)

47. **a.** $CH_3CH_2COO^-Na^+$, CH_3CH_2OH

b. $CH_3COO^-K^+$, 

c. CH_3CH_2COOH, $CH_3CH(CH_3)CH_2OH$

49. The chemical properties (and toxicity) of organic compounds are determined by the compound as a whole. As a substituent in a molecule, a phenyl group ring does not have the same properties as benzene.

51. The alcohol molecules form hydrogen bonds with one another, resulting in a higher boiling point. They also form hydrogen bonds with water molecules, causing 1-butanol to be more soluble than diethyl ether. (Although diethyl ether is polar, 1-butanol has greater polarity.)

53. The short-chain ethanoic acid has a higher water solubility.

55. $H_2NCH_2(CH_2)_3CH_2NH_2$ cadaverine; $H_2NCH_2(CH_2)_4CH_2NH_2$ putrescine; Both compounds are amines.

57. Cholesterol is an alcohol with a hydroxyl group on a cycloalkane. It has four nonaromatic rings. It has a double bond on one of its rings, as well as a large alkyl group, making it nonpolar.

59. Waving lotion reduces —S—S— bonds to —SH bonds. Hair can be placed in curlers to form the hair in the desired shape. The neutralizing agent is an oxidizing agent that re-forms —S—S— bonds, locking the hair into its curly shape. Similar steps could be used to straighten curly hair.

61. b. 3

63. 2.86 g SO_2

65. Anhydrous $Na_2CO_3(s)$ is the better value; the decahydrate is 63.0% water.

67. $0.117M$ $Ca(NO_3)_2$

69. 71 kJ

71. a, c, d, b

73. Oxidized: H of BH_4 Reduced: H of H_2O
Unaffected: Na, B, O

75. Reduction always occurs at the cathode. In the electrolytic cell, the cathode is the negative electrode.

77. coal

Chapter 24

37. A eukaryotic cell has a cell membrane, a nucleus, and various organelles including mitochondria, lysosomes, an endoplasmic reticulum, and ribosomes. Prokaryotic cells have a cell membrane, but lack organelles.

39. $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{energy}$

41. glucose and fructose

43. Glucose is an aldehyde; fructose is a ketone.

45. **a.** glucose **b.** glucose

47. peptide bond

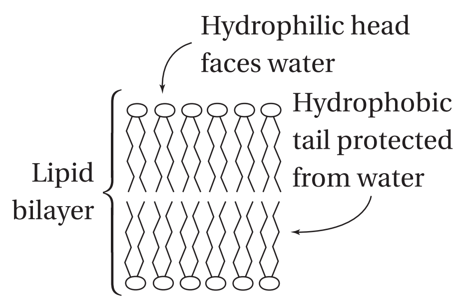
49. Peptide chains fold into helixes or into sheets in which peptide chains lie side by side.

51. Enzymes catalyze biological reactions.

53. At room temperature, animal fats are solid; plant oils are liquid.

55. alkali metal salt of a fatty acid

57.



59. protection from water loss and microorganisms in plants; pliability and waterproofing in animals

61. a phosphate group, a 5-carbon sugar unit, and a nitrogen base

63. hydrogen bonding

65. three

67. DNA sequences are unique for each individual.

69. $ATP + H_2O \longrightarrow ADP + P_i$

71. In catabolism, large biomolecules are broken down and energy is captured through the production of ATP. In anabolism, the products and energy from catabolism are used to make biomolecules.

73. products of catabolism

75. Catabolism of 1 mol glucose yields 2.82×10^3 kJ of energy.

77. The negatively charged hydrophilic phosphate heads interact favorably with water.

79. a. triglyceride **b.** glucose **c.** dipeptide

81. G C T A G G T

83. permit passage of nutrients into cells

85. many applications in medicine and agriculture

87. $30.5 \text{ kJ/mol} \times 38 \text{ mol}/2.82 \times 10^3 \text{ kJ/mol} \times 100\% = 41.4\%$

89. The shapes of the cellulose and starch molecules are different; humans lack enzymes necessary to cleave cellulose to glucose monomers.

91. Coenzymes must be present for an enzyme-catalyzed reaction to occur. Many water-soluble vitamins, such as B vitamins, are coenzymes.

93. a. iron(II) ion
b. iron(III) ion; methemoglobinemia

95. Photosynthesis provides the carbon compounds that plants and animals need to exist.

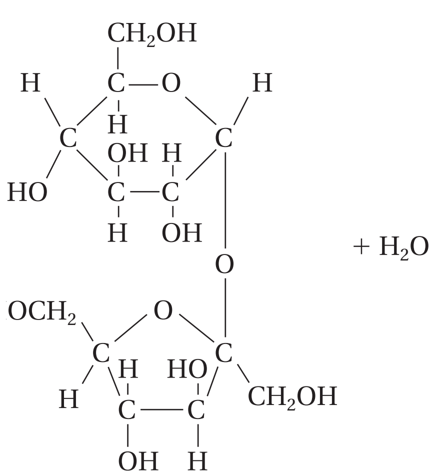
97. A carboxylic acid group of one amino acid and amino group of another amino acid undergo condensation polymerization to form an amide (peptide) bond.

99. Blanching the corn destroys most of the enzymes responsible for the conversion of glucose to starch. Freezing the corn slows down the action of any remaining starch-producing enzymes and prevents spoilage.

101. Inside the helix; strands must unwind

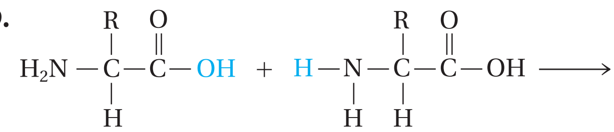
103. Bacteria necessary for nitrogen fixation might be killed by sterilization of the soil.

105.

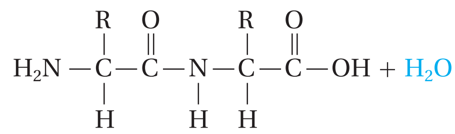


107. Sample answer: G T A A C A C C A G C A G G G; yes, because all four code words for proline differ by only 1 letter.

109.



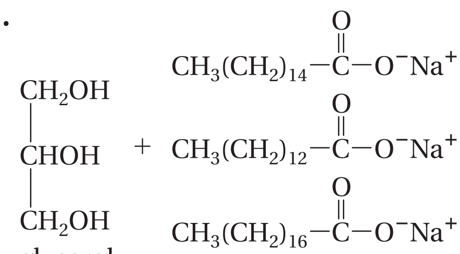
Amino acid Amino acid



Peptide

An amido group is formed.

111.



glycerol salts of fatty acids

113. hydrogen bonds between adjacent parts of folded chains and covalent bonds between side-chain groups of cysteine

115. The particles in real gases have volumes and are attracted to one another.

117. a. 0.519°C **b.** 0.209°C **c.** 0.238°C **d.** 0.227°C

119. Besides being composed of highly combustible material, the needles have a large surface area that increases their rate of combustion.

121. a. 4.15 **b.** 5.26 **c.** 12.79 **d.** 10.36

123. Oxidation always occurs at the anode. In the voltaic cell the anode is the negative electrode.

125. a. Cu **b.** Ni **c.** Ag
d. Fe **e.** Cd **f.** Cu

127. a. cyclopentane
b. 2-methyl-2-propanol (*tert*-butyl alcohol)
c. 3-pentanone

129. 1-chlorobutane, 2-chlorobutane, 1-chloro-2-methylpropane, 2-chloro-2-methylpropane

131. a. polytetrafluoroethene (Teflon or PTFE)
b. polyethylene
c. polyvinyl chloride (PVC)
d. polystyrene

Chapter 25

7. 0.063 mg Mn-56

8. No; one forth of the sample will remain.

27. ${}^{210}_{82}Pb \longrightarrow {}^{210}_{83}Bi + {}^{0}_{-1}e$

29. a. ${}^{218}_{92}U \longrightarrow {}^{234}_{90}Th + {}^{4}_{2}He$; thorium − 234
b. ${}^{230}_{90}Th \longrightarrow {}^{226}_{88}Ra + {}^{4}_{2}He$; radium − 226
c. ${}^{235}_{92}U \longrightarrow {}^{231}_{90}Th + {}^{4}_{2}He$; thorium − 231
d. ${}^{222}_{86}Rn \longrightarrow {}^{218}_{84}Po + {}^{4}_{2}He$; polonium − 218

31. a. mass number is unchanged; atomic number increases by 1
b. mass number decreases by 4; atomic number decreases by 2
c. mass number and atomic number are both unchanged

33. It undergoes radioactive decay.

35. a. ${}^{13}_{6}C$ **b.** ${}^{1}_{1}H$ **c.** ${}^{16}_{8}O$ **d.** ${}^{14}_{7}N$

37. so the person is exposed to radioactivity for a limited time

39. Natural radioactivity comes from elements in nature. Artificial radioactivity comes from elements created in nuclear reactors and accelerators.

41. The nuclei of certain isotopes are bombarded with neutrons. The nuclei break into two fragments and release more neutrons. Released neutrons hit other nuclei to start a chain reaction that releases large amounts of energy.

43. Fusion requires extremely high temperatures, making it difficult to start or contain the reaction.

45. The film badge measures radiation exposure; an exposed film badge indicates how much radiation a worker has received.

47. a. ${}^{30}_{15}P + {}^{0}_{-1}e \longrightarrow {}^{30}_{14}Si$ **b.** ${}^{13}_{6}C + {}^{0}_{1}n \longrightarrow {}^{14}_{6}C$
c. ${}^{131}_{53}I \longrightarrow {}^{131}_{54}Xe + {}^{0}_{-1}e$

49. a. ${}^{32}_{16}S$ **b.** ${}^{14}_{6}C$ **c.** ${}^{4}_{2}He$ **d.** ${}^{141}_{57}La$ **e.** ${}^{185}_{79}Au$

51. a. about 20% **b.** about 85 g
c. about 83 days **d.** about 25 days

53. a. Curie named radioactivity and discovered several radioactive elements.
b. Becquerel discovered natural radioactivity from uranium ores.
c. Chadwick discovered the neutron.
d. Rutherford artificially transmuted elements.

55. ${}^{215}_{85}At$

57. 11,460 years old

59. a. ${}^{231}_{91}Pa \longrightarrow {}^{227}_{89}Ac + {}^{4}_{2}He$
b. ${}^{241}_{95}Am \longrightarrow {}^{237}_{93}Np + {}^{4}_{2}He$
c. ${}^{226}_{88}Ra \longrightarrow {}^{222}_{86}Rn + {}^{4}_{2}He$
d. ${}^{252}_{99}Es \longrightarrow {}^{248}_{87}Bk + {}^{4}_{2}He$

61. 5730 years old

63. The organism would be exposed to less harmful radiation.

65. An alpha particle is much more likely than other kinds of radiation to collide with another particle and be stopped. At the atomic level, the larger the size of a particle, the greater is the chance of it striking another particle. The greater the magnitude of a particle's charge, the more strongly it will be attracted to particles of opposite charge.

67. one neutron

69. uranium; ${}^{239}_{94}Pu \longrightarrow {}^{235}_{92}U + {}^{4}_{2}He$

71. ${}^{18}_{8}O$

73. This graph shows the radioactive decay of carbon-14, along with the increase of the nitrogen product.

75. Bismuth-214 remains.

77. 4.2×10^2 cm^3

79. a. 26 protons and 33 neutrons
b. 92 protons and 143 neutrons
c. 24 protons and 28 neturons

81. a. covalent **b.** ionic **c.** covalent **d.** ionic

83. 9.22×10^3 cm^3 H_2; 0.412 mol H_2

85. 6.7 mL

87. a. propanoic acid **b.** propanal
c. 1-propanol **d.** 1-aminopropane
e. 1-chloropropane **f.** ethylmethyl ether

89. 1-propanol and ethanoic acid

91. a. (4) **b.** (3) **c.** (1) **d.** (4) **e.** (1) **f.** (2)
g. (3) **h.** (2) **i.** (4) **j.** (3)