APPENDIX III Answers to Selected Exercises

Chapter 1

33. **a.** theory **b.** observation
c. law **d.** observation

35. Several answers possible

37. **a.** mixture, homogeneous
b. pure substance, compound
c. pure substance, element
d. mixture, heterogeneous

39.

Substance	Pure or Mixture	Type
Aluminum	Pure	Element
Apple juice	Mixture	Homogeneous
Hydrogen peroxide	Pure	Compound
Chicken soup	Mixture	Heterogeneous

41. **a.** pure substance, compound
b. mixture, heterogeneous
c. mixture, homogeneous
d. pure substance, element

43. physical, chemical, physical, physical, physical

45. **a.** chemical **b.** physical
c. physical **d.** chemical

47. **a.** chemical **b.** physical
c. chemical **d.** chemical

49. **a.** physical **b.** chemical **c.** physical

51. **a.** 0 °C **b.** –321 °F
c. –78.3 °F **d.** 310.2 K

53. –89.2 °C, 184.0 K

55. **a.** 1.2 nm **b.** 22 fs
c. 1.5 Gg **d.** 3.5 ML

57. **a.** 4.5×10^{-9} s **b.** 1.8×10^{-14} s
c. 1.28×10^{-10} m **d.** 3.5×10^{-5} m

59.

1245 kg	1.245×10^{6} g	1.245×10^{9} mg
515 km	5.15×10^{6} dm	5.15×10^{7} cm
122.355 s	1.22355×10^{5} ms	0.122355 ks
3.345 kJ	3.345×10^{3} J	3.345×10^{6} mJ

61. **e.** 254.998 km **f.** 2.54998×10^{-1} Mm
g. 254998×10^{3} mm **h.** 254998×10^{2} cm

63. 10,000 1 cm squares

65. no

67. 1.26 g/cm^3

69. **a.** 463 g **b.** 3.7 L

71. $201. \times 10^{3}$ g

73. **a.** 73.7 mL **b.** 88.2 °C **c.** 647 mL

75. **a.** 1,050,501 **b.** 0.0020
c. 0.0000000000002 **d.** 0.001090

77. **a.** 3 **b.** ambiguous; without more information, assume three significant figures.
c. 3 **d.** 5
e. ambiguous; without more information, assume one significant figure.

79. **a.** not exact **b.** exact
c. not exact **d.** exact

81. **a.** 156.9 **b.** 156.8 **c.** 156.8 **d.** 156.9

83. **a.** 1.84 **b.** 0.033
c. 0.500 **d.** 34

85. **a.** 41.4 **b.** 133.5
c. 73.0 **d.** 0.42

87. **a.** 391.3 **b.** 1.1×10^{4}
c. 5.96 **d.** 5.93×10^{4}

89. 0.74 g/mL

91. **a.** 2.78×10^{4} cm^3 **b.** 1.898×10^{-3} kg
c. 1.98×10^{7} cm

93. **a.** 60.6 in **b.** 3.14×10^{3} g
c. 3.7 qt **d.** 4.29 in

95. 5.0×10^{1} min

97. 4.0×10^{1} mi/gal

99. **a.** 1.95×10^{-4} km^2 **b.** 1.95×10^{4} dm^2
c. 1.95×10^{6} cm^2

101. 0.680 mi^2

103. 0.95 mL

105. 3.1557×10^{7} s/solar year

107. **a.** extensive **b.** intensive
c. intensive **d.** intensive
e. extensive

109. –34 °F

111. $F = \text{kg}(\text{m/s}^2) = \text{N}$ (for newton), kN, pN

113. **a.** 2.2×10^{-6} **b.** 0.0159 **c.** 6.9×10^{4}

115. **a.** mass of can of gold $= 1.9 \times 10^{4}$ g
mass of can of sand $= 3.0 \times 10^{3}$ g
b. Yes, the thief sets off the trap because the can of sand is lighter than the gold cylinder.

117. 22 in^3

119. 7.6 g/cm^3

121. 3.11×10^{5} lb

123. 3.3×10^{2} km

125. 6.8×10^{-15}

127. 2.4×10^{19} km

129. 488 grams

131. 0.661 Ω

133. 0.492

135. 18.2 atm

137. $1\,\text{J} = 1\,\text{kg m}^2/\text{s}^2$
$m = \text{kg}, v^2 = (\text{m/s})^2\ mv = \text{kg m}^2/\text{s}^2$
$P = \text{N/m}^2 = \text{kg m/s}^2/\text{m}^2 = \text{kg/m s}^2$
$V = \text{m}^2\ PV = \text{kg m}^3/\text{m s}^2 = \text{kg m}^2/\text{s}^2$

139. 9.0×10^{1} mg CO

141. 13% increase

143. No. Since the container is sealed, the atoms and molecules can move around, but they cannot leave. If no atoms or molecules can leave, the mass must be constant.

145. 343 1 cm cubes

147. **a.** the dark block **b.** the light-colored block **c.** cannot tell

149. **a.** law **b.** theory **c.** observation **d.** law

155. **a.** 8.2% **c.** 24.4 million cubic kilometers

Chapter 2

29. 13.5 g

31. These results are not consistent with the law of definite proportions because sample 1 is composed of 11.5 parts Cl to 1 part C and sample 2 is composed of 9.05 parts Cl to 1 part C. The law of definite proportions states that a given compound always contains exactly the same proportion of elements by mass.

33. 23.8 g

35. For the law of multiple proportions to hold, the ratio of the masses of O combining with 1 g of O's in the compound should be a small whole number. 0.3369/0.168 = 2.00

37. Sample 1: 1.00 g O_2/1.00 g S;
Sample 2: 1.50 g O_2/1.00 g S
Sample 2/sample 1 = 1.50/1.00 = 1.50
3 O atoms/2 O atoms = 1.5

39. **a.** not consistent
b. consistent: Dalton's atomic theory states that the atoms of a given element are identical.
c. consistent: Dalton's atomic theory states that atoms combine in simple whole-number ratios to form compounds.
d. not consistent

41. **a.** consistent: Rutherford's nuclear model states that the atom is largely empty space.
b. consistent: Rutherford's nuclear model states that most of the atom's mass is concentrated in a tiny region called the nucleus.
c. not consistent **d.** not consistent

43. -2.3×10^{-19} C

45. 9.4×10^{13} excess electrons, 8.5×10^{-17} kg

47. **a, b, c**

49. 1.83×10^{3} e^-

51. **a.** Ag-107 **b.** Ag-109 **c.** U-238 **d.** H-2

53. **a.** 7 ^1_1p and 7 ^0_1n **b.** 11 ^1_1p and 12 ^0_1n
c. 86 ^1_1p and 136 ^0_1n **d.** 82 ^1_1p and 126 ^0_1n

55. 6 ^1_1p and 8 ^1_0n, $^{14}_6C$

57. **a.** 28 ^1_1p and 26 e^- **b.** 16 ^1_1p and 18 e^-
c. 35 ^1_1p and 36 e^- **d.** 24 ^1_1p and 21 e^-

59. **a.** 2– **b.** 1+ **c.** 3+ **d.** 1+

61.

Symbol	Ion Formed	Number of Electrons in Ion	Number of Protons in Ion
Ca	Ca^{2+}	18	20
Be	Be^{2+}	2	4
Se	Se^{2-}	36	34
In	In^{3+}	46	49

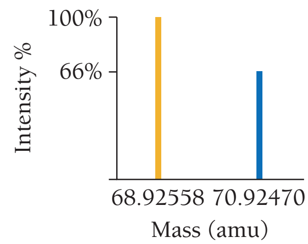
63. **a.** potassium, metal **b.** barium, metal
c. iodine, nonmetal **d.** oxygen, nonmetal
e. antimony, metalloid

65. **a** and **b** are main-group elements.

67. **a.** alkali metal
b. halogen
c. alkaline earth metal
d. alkaline earth metal
e. noble gas

69. Cl and F because they are in the same group or family. Elements in the same group or family have similar chemical properties.

71.



73. The fluorine-19 isotope must have a large percent abundance, which would make fluorine produce a large peak at this mass. Chlorine has two isotopes (Cl-35 and Cl-37). The atomic mass is simply the weighted average of these two, which means that there is no chlorine isotope with a mass of 35.45 amu.

75. 121.8 amu, Sb

77. Br-79 78.92, amu 50.96%

79. 152 amu

81. 3.32×10^{24} atoms

83. **a.** 0.295 mol Ar **b.** 0.0543 mol Zn
c. 0.144 mol Ta **d.** 0.0304 mol Li

85. 2.11×10^{22} atoms

87. **a.** 1.01×10^{23} atoms **b.** 6.78×10^{21} atoms
c. 5.39×10^{21} atoms **d.** 5.6×10^{20} atoms

89. **a.** 36 grams **b.** 0.187 grams
c. 62 grams **d.** 3.1 grams

91. 2.6×10^{21} atoms

93. 3.239×10^{-22} g

95. 1.50 g

97. C_2O_3

99. 4.82241×10^{7} C/kg

101. 207 amu

103. ^{237}Pa, ^{238}U, ^{239}Np, ^{240}Pu, ^{235}Ac, ^{234}Ra, etc.

105.

Symbol	Z	A	#p	#e^-	#n	Charge
O	8	16	8	10	8	2–
Ca^{2+}	20	40	20	18	20	2+
Mg^{2+}	12	25	12	10	13	2+
N^{3-}	7	14	7	10	7	3–

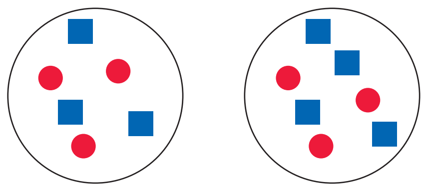
107. $V_n = 8.2 \times 10^{-8}$ pm^3, $V_a = 1.4 \times 10^{6}$ pm^3, 5.9×10^{-12}%

109. 6.022×10^{21} dollars total, 8.6×10^{11} dollars per person, billionaires

111. 15.985 amu

113. 4.76×10^{24} atoms

115. 3.56 cm
117. Li-6 = 7.494%, Li-7 = 92.506%
119. 75.0% gold
121. 106.91 amu
123. 1.66×10^{22} gold atoms
125. 1×10^{78} atoms/universe
127. 0.423
129. 63.67 g/mol
131. 25.06 g/mol
133. Li-6 Li-7



135. If the amu and mole were not based on the same isotope, the numerical values obtained for an atom of material and a mole of material would not be the same. If, for example, the mole were based on the number of particles in C-12 but the amu were changed to a fraction of the mass of an atom of Ne-20, the number of particles and the number of amu that make up one mole of material would no longer be the same. We would no longer have the relationship in which the mass of an atom in amu is numerically equal to the mass of a mole of those atoms in grams.
137. The different isotopes of the same element have the same number of protons and electrons, so the attractive forces between the nucleus and the electrons are constant and there is no difference in the radii of the isotopes. Ions, on the other hand, have a different number of electrons than the parent atom from which they are derived. Cations have fewer electrons than the parent atom. The attractive forces are greater because there is a larger positive charge in the nucleus than the negative charge in the electron cloud. So, cations are smaller than the atom they are derived from. Anions have more electrons than the parent. The electron cloud has a greater negative charge than the nucleus, so the anions have larger radii than the parent.
142. **a.** 2000, 0.24 $\mu g/m^3$; 2016, 0.017 $\mu g/m^3$
c. 2.9×10^{14} Pb atoms

Chapter 3

23. **a.** 3 Mg, 2 P, 8 O **b.** 1 Ba, 2 Cl
c. 1 Fe, 2 N, 4 O **d.** 1 Ca, 2 O, 2 H
25. **a.** NH_3 **b.** C_2H_6 **c.** SO_3
27. **a.** atomic **b.** molecular
c. atomic **d.** molecular
29. **a.** molecular **b.** ionic
c. ionic **d.** molecular
31. **a.** molecular element **b.** molecular compound
c. atomic element
33. **a.** CaO **b.** ZnS **c.** RbBr **d.** Al_2O_3
35. **a.** $Ca(OH)_2$ **b.** $CaCrO_4$
c. $Ca_3(PO_4)_2$ **d.** $Ca(CN)_2$
37. **a.** magnesium nitride **b.** potassium fluoride
c. sodium oxide **d.** lithium sulfide
e. cesium fluoride **f.** potassium iodide
39. **a.** tin(II) oxide **b.** chromium(III) sulfide
c. rubidium iodide **d.** barium bromide
41. **a.** copper(I) nitrite **b.** magnesium acetate
c. barium nitrate **d.** lead(II) acetate
43. **a.** $NaHSO_3$ **b.** $LiMnO_4$
c. $AgNO_3$ **d.** K_2SO_4
e. $RbHSO_4$ **f.** $KHCO_3$
45. **a.** cobalt(II) sulfate heptahydrate
b. $IrBr_3 \times 4\ H_2O$
c. magnesium bromate hexahydrate
d. $K_2CO_3 \times 2\ H_2O$
47. **a.** carbon monoxide **b.** nitrogen triiodide
c. silicon tetrachloride
d. tetranitrogen tetraselenide
49. **a.** PCl_3 **b.** ClO
c. S_2F_4 **d.** PF_5
51. **a.** hydroiodic acid **b.** nitric acid
c. carbonic acid
53. **a.** HF **b.** HBr **c.** H_2SO_3
55. **a.** strontium chloride **b.** tin(IV) oxide
c. diphosphorus pentasulfide
d. acetic acid
57. **a.** potassium chlorate **b.** diiodine pentoxide
c. lead(II) sulfate
59. **a.** 46.01 amu **b.** 58.12 amu
c. 180.16 amu **d.** 238.03 amu
61. **a.** 0.471 mol **b.** 0.0362 mol
c. 968 mol **d.** 0.279 mol
63. **a.** 0.554 mol **b.** 28.4 mol
c. 0.378 mol **d.** 1093 mol
65. **a.** 2.2×10^{23} molecules **b.** 7.06×10^{23} molecules
c. 4.16×10^{23} molecules **d.** 1.09×10^{23} molecules
67. **a.** 0.0790 g **b.** 0.84 g **c.** 2.992×10^{-22} g
69. 0.10 mg
71. **a.** 74.87% C **b.** 79.88% C
c. 92.24% C **d.** 37.23% C
73. NH_3: 82.27% N
$CO(NH_2)_2$: 46.65% N
NH_4NO_3: 35.00% N
$(NH_4)_2SO_4$: 21.20% N
NH_3 has the highest N content.
75. 20.8 g F
77. 196 μg KI
79. **a.** 2 : 1 **b.** 4 : 1 **c.** 6 : 2 : 1
81. **a.** 0.885 mol H **b.** 5.2 mol H
c. 29 mol H **d.** 33.7 mol H
83. **a.** 3.3 g Na **b.** 3.6 g Na
c. 1.4 g Na **d.** 1.7 g Na
85. 1.41×10^{23} F atoms
87. **a.** Ag_2O **b.** $Co_3As_2O_8$ **c.** $SeBr_4$
89. **a.** C_5H_7N **b.** $C_4H_5N_2O$
91. $C_{13}H_{18}O_2$
93. NCl_3
95. **a.** $C_{12}H_{14}N_2$ **b.** $C_6H_3Cl_3$ **c.** $C_{10}H_{20}N_2S_4$

97. CH_2
99. C_2H_4O
101. a. inorganic **b.** organic **c.** organic **d.** inorganic
103. a. alkene **b.** alkane **c.** alkyne **d.** alkane
105. a. $CH_3CH_2CH_3$
b. propane
c. $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$
d. pentane
107. a. functionalized hydrocarbon, alcohol
b. hydrocarbon
c. functionalized hydrocarbon, ketone
d. functionalized hydrocarbon, amine
109. 1.50×10^{24} molecules EtOH
111. a. K_2CrO_4, 40.27% K, 26.78% Cr, 32.95% O
b. $Pb_3(PO_4)_2$, 76.60% Pb, 7.63% P, 15.77% O
c. H_2SO_3, 2.46% H, 39.07% S, 58.47% O
d. $CoBr_2$, 26.94% Co, 73.06% Br
113. 1.80×10^2 g Cl_2/yr
115. M = Fe
117. estradiol = $C_{18}H_{24}O_2$
119. $C_{18}H_{20}O_2$
121. 7 H_2O
123. C_6H_9BrO
125. 1.87×10^{21} atoms
127. 92.93 amu
129. $x = 1, y = 2$
131. 41.7 mg
133. 0.224 g
135. 22.0% by mass
137. 1.6×10^7 kg Cl
139. 7.8×10^3 kg rock
141. $C_5H_{10}SI$
143. X_3Y_2
145. The sphere in the molecular models represents the electron cloud of the atom. On this scale, the nucleus would be too small to see.
147. The statement is incorrect because a chemical formula is based on the ratio of atoms combined, not the ratio of grams combined. The statement should read, "The chemical formula for ammonia (NH_3) indicates that ammonia contains three hydrogen atoms to each nitrogen atom."
149. O, S, H
154. a. Yes. **c.** 50.05%

Chapter 4

13. $2\,SO_2(g) + O_2(g) + 2\,H_2O(l) \longrightarrow 2\,H_2SO_4(aq)$
15. $2\,Na(s) + 2\,H_2O(l) \longrightarrow H_2(g) + 2\,NaOH(aq)$
17. $C_{12}H_{22}O_{11}(s) + H_2O(l) \longrightarrow 4\,C_2H_5OH(aq) + 4\,CO_2(g)$
19. a. $PbS(s) + 2\,HBr(aq) \longrightarrow PbBr_2(s) + H_2S(g)$
b. $CO(g) + 3\,H_2(g) \longrightarrow CH_4(g) + H_2O(l)$
c. $4\,HCl(aq) + MnO_2(s) \longrightarrow MnCl_2(aq) + 2\,H_2O(l) + Cl_2(g)$
d. $C_5H_{12}(l) + 8\,O_2(g) \longrightarrow 5\,CO_2(g) + 6\,H_2O(g)$
21. $Na_2CO_3(aq) + CuCl_2(aq) \longrightarrow CuCO_3(s) + 2\,NaCl(aq)$
23. a. $2\,CO_2(g) + CaSiO_3(s) + H_2O(l) \longrightarrow SiO_2(s) + Ca(HCO_3)_2(aq)$
b. $2\,Co(NO_3)_3(aq) + 3\,(NH_4)_2S(aq) \longrightarrow Co_2S_3(s) + 6\,NH_4NO_3(aq)$
c. $Cu_2O(s) + C(s) \longrightarrow 2\,Cu(s) + CO(g)$
d. $H_2(g) + Cl_2(g) \longrightarrow 2\,HCl(g)$
25. $2\,C_6H_{14}(g) + 19\,O_2(g) \longrightarrow 12\,CO_2(g) + 14\,H_2O(g)$, 68 mol O_2
27. a. 5.0 mol NO_2 **b.** 14. mol NO_2 **c.** 0.281 mol NO_2 **d.** 53.1 mol NO_2
29.

mol SiO_2	mol C	mol SiC	mol CO
3	9	3	6
2	6	2	4
5	15	5	10
2.8	8.4	2.8	5.6
0.517	1.55	0.517	1.03

31. 9.3 g HBr, 0.12 g H_2
33. a. 5.56 g $BaCl_2$
b. 6.55 g $CaCO_3$
c. 6.09 g Mg O
d. 6.93 g Al_2O_3
35. a. Na **b.** Na **c.** Br_2 **d.** Na
37. 3 molecules Cl_2
39. a. 2 mol **b.** 7 mol **c.** 9.40 mol
41. 0.5 mol O_2
43. a. 2.5 g **b.** 31.1 g **c.** 1.16 g
45. 2.91 grams CO remaining
47. limiting reactant: Pb^{2+} theoretical yield: 34.5 g $PbCl_2$ percent yield: 85.3%
49. limiting reactant: NH_3 theoretical yield: 240.5 kg CH_4N_2O, percent yield: 70.01%
51. a. $S(s) + O_2(g) \longrightarrow SO_2(g)$
b. $2\,C_3H_6(g) + 9\,O_2(g) \longrightarrow 6\,CO_2(g) + 6\,H_2O(g)$
c. $2\,Ca(s) + O_2(g) \longrightarrow 2\,CaO(g)$
d. $C_5H_{12}S(l) + 9\,O_2(g) \longrightarrow 5\,CO_2(g) + SO_2(g) + 6\,H_2O(g)$
53. $Sr(s) + I_2(g) \longrightarrow SrI_2(s)$
55. $2\,Li(s) + 2\,H_2O(l) \longrightarrow 2\,Li^+(aq) + 2\,OH^-(aq) + H_2(g)$
57. $H_2(g) + Br_2(g) \longrightarrow 2\,HBr(g)$
59. 3.1 kg
61. limiting reactant: $C_7H_6O_3$, theoretical yield: 1.63 g $C_9H_8O_4$ percent yield: 74.8%
63. b
65. 0.333 g PH_3
67. 30.8 kg CO_2
69. 1.6 g C_2H_2
71. 2.8 mol A
73. 96.6 g Mn
75. d. 1.5 g K, 0.38 g O_2
77. a)
81. a. Experiments 1, 2, and 3 **c.** 2 A + 1 B **e.** 2 C

Chapter 5

21. **a.** 1.17 M LiCl **b.** 0.123 M $C_6H_{12}O_6$ **c.** 0.00453 M NaCl

23. **a.** 0.150 M NO_3^- **b.** 0.300 M NO_3^- **c.** 0.450 M NO_3^-

25. **a.** 1.3 mol **b.** 1.5 mol **c.** 0.211 mol

27. 37 g

29. 0.27 M

31. 6.0 L

33. 37.1 mL

35. 2.1 L

37. lead nitrate, 3.75 g, 65.3%

39. **a.** yes **b.** no **c.** yes **d.** no

41. **a.** soluble Ag^+, NO_3^-
b. soluble Pb^{2+}, $C_2H_3O_2^-$
c. soluble K^+, NO_3^-
d. soluble NH_4^+, S^{2-}

43. **a.** NO REACTION
b. NO REACTION
c. $CrBr_2(aq) + Na_2CO_3(aq) \longrightarrow CrCO_3(s) + 2\,NaBr(aq)$
d. $3\,NaOH(aq) + FeCl_3(aq) \longrightarrow Fe(OH)_3(s) + 3\,NaCl(aq)$

45. **a.** $K_2CO_3(aq) + Pb(NO_3)_2(aq) \longrightarrow PbCO_3(s) + 2\,KNO_3(aq)$
b. $Li_2SO_4(aq) + Pb(C_2H_3O_2)_2(aq) \longrightarrow PbSO_4(s) + 2\,LiC_2H_3O_2(aq)$
c. $Cu(NO_3)_2(aq) + MgS(aq) \longrightarrow CuS(s) + Mg(NO_3)_2(aq)$
d. NO REACTION

47. **a.** Complete:
$H^+(aq) + Cl^-(aq) + Li^+(aq) + OH^-(aq) \longrightarrow H_2O(l) + Li^+(aq) + Cl^-(aq)$
Net: $H^+(aq) + OH^-(aq) \longrightarrow H_2O(l)$
b. Complete:
$Ca^{2+}(aq) + S^{2-}(aq) + Cu^{2+}(aq) + 2\,Cl^-(aq) \longrightarrow CuS(s) + Ca^{2+}(aq) + 2\,Cl^-(aq)$
Net: $Cu^{2+}(aq) + S^{2-}(aq) \longrightarrow CuS(s)$
c. Complete:
$Na^+(aq) + OH^-(aq) + HC_2H_3O_2(aq) \longrightarrow H_2O(l) + Na^+(aq) + C_2H_3O_2^-(aq)$
Net: $OH^-(aq) + HC_2H_3O_2(aq) \longrightarrow H_2O(l) + C_2H_3O_2^-(aq)$
d. Complete:
$6\,Na^+(aq) + 2\,PO_4^{3-}(aq) + 3\,Ni^{2+}(aq) + 6\,Cl^-(aq) \longrightarrow Ni_3(PO_4)_2(s) + 6\,Na^+(aq) + 6\,Cl^-(aq)$
Net: $3\,Ni^{2+}(aq) + 2\,PO_4^{3-}(aq) \longrightarrow Ni_3(PO_4)_2(s)$

49. Complete:
$Hg_2^{2+}(aq) + 2\,NO_3^-(aq) + 2\,Na^+(aq) + 2\,Cl^-(aq) \longrightarrow Hg_2Cl_2(s) + 2\,Na^+(aq) + 2\,NO_3^-(aq)$
Net: $Hg_2^{2+}(aq) + 2\,Cl^-(aq) \longrightarrow Hg_2Cl_2(s)$

51. Molecular:
$HBr(aq) + KOH(aq) \longrightarrow H_2O(l) + KBr(aq)$
Net ionic: $H^+(aq) + OH^-(aq) \longrightarrow H_2O(l)$

53. **a.** $H_2SO_4(aq) + Ca(OH)_2(aq) \longrightarrow 2\,H_2O(l) + CaSO_4(s)$
b. $HClO_4(aq) + KOH(aq) \longrightarrow H_2O(l) + KClO_4(aq)$
c. $H_2SO_4(aq) + 2\,NaOH(aq) \longrightarrow 2\,H_2O(l) + Na_2SO_4(aq)$

55. **a.** Complete ionic:
$H^+(aq) + Br^-(aq) + Na^+(aq) + OH^-(aq) \longrightarrow H_2O(l) + Na^+(aq) + Br^-(aq)$
Net ionic: $H^+(aq)\ OH^-(aq) \longrightarrow H_2O(l)$
b. Complete ionic:
$HF(aq) + Na^+(aq) + OH^-(aq) \longrightarrow H_2O(l) + Na^+(aq) + F^-(aq)$
Net ionic:
$HF(aq) + OH^-(aq) \longrightarrow H_2O(l) + F^-(aq)$
c. Complete ionic:
$HC_2H_3O_2(aq) + Rb^+(aq) + OH^-(aq) \longrightarrow H_2O(l) + Rb^+(aq) + C_2H_3O_2^-(aq)$
Net ionic:
$HC_2H_3O_2(aq) + OH^-(aq) \longrightarrow H_2O(l) + C_2H_3O_2^-(aq)$

57. 0.1810 M $HClO_4$

59. **a.** $2\,HBr(aq) + NiS(s) \longrightarrow H_2S(g) + NiBr_2(aq)$
b. $NH_4I(aq) + NaOH(aq) \longrightarrow H_2O(l) + NH_3(g) + NaI(aq)$
c. $2\,HBr(aq) + Na_2S(aq) \longrightarrow H_2S(g) + 2\,NaBr(aq)$
d. $2\,HClO_4(aq) + Li_2CO_3(aq) \longrightarrow H_2O(l) + CO_2(g) + 2\,LiClO_4(aq)$

61. **a.** Ag: 0 **b.** Ag: +1
c. Ca: +2, F: −1 **d.** H: +1, S: −2
e. C: +4, O: −2 **f.** Cr: +6, O: −2

63. **a.** +2 **b.** +6 **c.** +3

65. **a.** redox reaction, oxidizing agent: O_2 reducing agent: Li
b. redox reaction, oxidizing agent: Fe^{2+} reducing agent: Mg
c. not a redox reaction **d.** not a redox reaction

67. b and c occur spontaneously in the forward direction.

69. Fe, Cr, Zn, Mn, Al, Mg, Na, Ca, K, Li

71. Mg

73. 3.32 M

75. 1.1 g

77. **a.** $2\,HCl(aq) + Hg_2(NO_3)_2(aq) \longrightarrow Hg_2Cl_2(s) + 2\,HNO_3(aq)$
b. $KHSO_3(aq) + HNO_3(aq) \longrightarrow H_2O(l) + SO_2(g) + KNO_3(aq)$
c. $2\,NH_4Cl(aq) + Pb(NO_3)_2(aq) \longrightarrow PbCl_2(s) + 2\,NH_4NO_3(aq)$
d. $2\,NH_4Cl(aq) + Ca(OH)_2(aq) \longrightarrow 2\,NH_3(g) + 2\,H_2O(g) + CaCl_2(aq)$

79. 22 g

81. 6.9 g

83. Br is the oxidizing agent, Au is the reducing agent, 38.8 g $KAuF_4$.

85. Ca^{2+} and Cu^{2+} present in the original solution.
Net ionic for first precipitate:
$Ca^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow CaSO_4(s)$
Net ionic for second precipitate:
$Cu^{2+}(aq) + CO_3^{2-}(aq) \longrightarrow CuCO_3(s)$

87. 11.8 g AgI

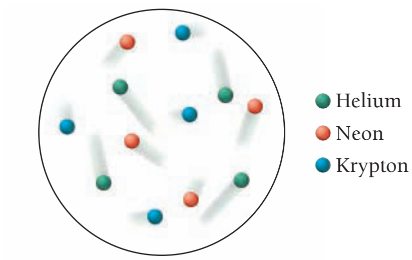
89. 5.5% by mass

91. a. Add 4 particles of solute.
b. Add 1 L solvent.
c. Add 0.3 L solvent.
93. b.
98. a. 10.3 ppb; 3.81 ppb, 1.69 ppb
c. If the water provider used first-draw samples, they would have been required to take action. If they used 2 min flush samples, they woud not have been required to take action. Residents probably don't flush their pipes before taking water, so the first-draw technique is probably closer to actual practice.

Chapter 6

25. a. 0.832 atm **b.** 632 mmHg
c. 12.2 psi **d.** 8.43×10^4 Pa
27. a. 809.0 mmHg **b.** 1.064 atm
c. 809.0 torr **d.** 107.9 kPa
29. a. 832 mmHg **b.** 718 mmHg
31. 4.4×10^2 mmHg
33. 58.9 mL
35. 4.22 L
37. 3.0 L. The volume would not be different if the gas was argon.
39. 1.16 atm
41. 2.1 mol
43. Yes, the final gauge pressure is 43.5 psi, which exceeds the maximum rating.
45. 16.2 L
47. 286 atm, 17.5 bottles purged
49. b
51. 4.76 atm
53. 37.3 L
55. 9.43 g/L
57. 44.0 g/mol
59. 4.00 g/mol
61. P_{tot} = 434 torr, $mass_{N_2}$ = 0.437 g, $mass_{O_2}$ = 0.237 g, $mass_{He}$ = 0.0340 g
63. 1.84 atm
65. $\chi_{N_2} = 0.627, \chi_{O_2} = 0.373$, $P_{N_2} = 0.687$ atm, $P_{O_2} = 0.409$ atm
67. $P_{H_2} = 0.921$ atm, $mass_{H_2}$ = 0.0539 g
69. 7.47×10^{-2} g
71. 38 L
73. $V_{H_2} = 48.2$ L, $V_{CO} = 24.1$ L
75. 22.8 g NaN_3
77. 60.4%
79. F_2, 2.84 g ClF_3
81. a. yes
b. no
c. No. Even though the argon atoms are more massive than the helium atoms, both have the same kinetic energy at a given temperature. The argon atoms therefore move more slowly and so exert the same pressure as the helium atoms.
d. He
83. $F_2: u_{rms} = 442$ m/s, $KE_{avg} = 3.72 \times 10^3$ J; $Cl_2: u_{rms} = 324$ m/s, $KE_{avg} = 3.72 \times 10^3$ J; $Br_2: u_{rms} = 216$ m/s, $KE_{avg} = 3.72 \times 10^3$ J; rankings: $u_{rms}: Br_2 < Cl_2 < F_2$, $KE_{avg}: Br_2 = Cl_2 = F_2$, rate of effusion: $Br_2 < Cl_2 <$ F2
85. rate $^{238}UF_6$/rate $^{235}UF_6$ = 0.99574
87. krypton
89. A has the higher molar mass, B has the higher rate of effusion.
91. That the volume of gas particles is small compared to the space between them breaks down under conditions of high pressure. At high pressure, the particles themselves occupy a significant portion of the total gas volume.
93. 0.05826 L (ideal); 0.0708 L (V.D.W.); difference because of high pressure, at which Ne no longer acts ideally
95. 97.8%
97. 27.8 g/mol
99. C_4H_{10}
101. 4.70 L
103. $2\,HCl(aq) + K_2S(s) \longrightarrow H_2S(g) + 2\,KCl(aq)$, 0.191 g $K_2S(s)$
105. 11.7 L
107. $mass_{air}$ = 8.56 g, $mass_{He}$ = 1.20 g, mass difference = 7.36 g
109. 4.76 L/s
111. total force = 6.15×10^3 pounds; no, the can cannot withstand this force.
113. 5.8×10^3 balloons
115. 4.0 cm
117. 77.7%
119. 0.32 gram
121. 311 K
123. 5.0 g
125. C_3H_8
127. 0.39 g Ar
129. 74.0 mmHg
131. 25% N_2H_4
133. 25%
135. $P_{CH_4} = 7.30 \times 10^{-2}$ atm, $P_{O_2} = 4.20 \times 10^{-1}$ atm, $P_{NO} = 2.79 \times 10^{-3}$ atm, $P_{CO_2} = 5.03 \times 10^{-3}$ atm, $P_{H_2O} = 5.03 \times 10^{-3}$ atm, $P_{NO_2} = 2.51 \times 10^{-2}$ atm, $P_{OH} = 1.01 \times 10^{-2}$ atm, $P_{tot} = 0.542$ atm
137. 0.42
139. Because helium is less dense than air, the balloon moves in a direction opposite the direction in which the air inside the car is moving due to the acceleration and deceleration of the car.
141. –29%
143. a. false **b.** false **c.** false **d.** true
145. four times the initial pressure
147. Although the velocity "tails" have different lengths, the average length of the tails on the helium atoms is longer than the average length of the tails on the neon atoms, which is in turn longer than the average length of the tails on the krypton atoms. The lighter the

atom, the faster the tails must move on average to have the same kinetic energy.



153. **a.** inverse relationship
c. 1.3×10^{-6} mol
e. Yes, because in these equations, 1 mole of O_3 reacts to form 1 mole of NO_2.

Chapter 7

33. **a.** 1.92×10^9 J **b.** 5.14×10^4 cal
c. 2.37×10^6 J **d.** 0.681 Cal
35. **a.** 9.987×10^6 J **b.** 9.987×10^3 kJ
c. 2.78 kWh
37. **d**
39. **a.** heat, + **b.** work, − **c.** heat, +
41. -7.27×10^2 kJ
43. 311 kJ
45. The drinks that went into cooler B had more thermal energy than the refrigerated drinks that went into cooler A. The temperature difference between the drinks in cooler B and the ice was greater than the difference between the drinks and the ice in cooler A. More thermal energy was exchanged between the drinks and the ice in cooler B, which resulted in more melting.
47. 4.7×10^5 J
49. **a.** 7.6×10^2 °C
b. 4.3×10^2 °C
c. 1.3×10^2 °C
d. 49 °C
51. -2.8×10^2 J
53. 489 J
55. $\Delta E = -3463$ kJ, $\Delta H = -3452$ kJ
57. **a.** exothermic, −
b. endothermic, +
c. exothermic, −
59. -4.30×10^3 kJ
61. 6.46×10^4 kJ
63. 1.0 kg CO_2
65. mass of silver 77.1 grams
67. final temperature 28.4 °C
69. specific heat capacity of substance A 1.10 J/g · °C
71. Measurement B corresponds to conditions of constant pressure. Measurement A corresponds to conditions of constant volume. When a fuel is burned under constant pressure, some of the energy released does work on the atmosphere by expanding against it. Less energy is manifest as heat due to this work. When a fuel is burned under constant volume, all of the energy released by the combustion reaction is evolved as heat.
73. -6.3×10^3 kJ/mol
75. -1.6×10^5 J
77. **a.** $-\Delta H_1$
b. $2\ \Delta H_1$
c. $-\frac{1}{2}\Delta H_1$
79. −23.9 kJ
81. −173.2 kJ
83. **a.** $N_2(g) + 3\ H_2(g) \longrightarrow 2\ NH_3(g)$, $\Delta H_f^\circ = -45.9$ kJ/mol
b. $C(s, \text{graphite}) + O_2(g) \longrightarrow CO_2(g)$, $\Delta H_f^\circ = -393.5$ kJ/mol
c. $2\ Fe(s) + 3/2\ O_2(g) \longrightarrow Fe_2O_3(s)$, $\Delta H_f^\circ = -824.2$ kJ/mol
d. $C(s, \text{graphite}) + 2\ H_2(g) \longrightarrow CH_4(g)$, $\Delta H_f^\circ = -74.6$ kJ/mol
85. −380.2 kJ/mol
87. **a.** −137.1 kJ **b.** −41.2 kJ
c. −137 kJ **d.** 290.7 kJ
89. $6\ CO_2(g) + 6\ H_2O(l) \longrightarrow C_6H_{12}O_6(s) + 6\ O_2(g)$, $\Delta H_{rxn}^\circ = 2803$ kJ
91. −113.0 kJ/mol
93. **a.** 5.49 g CO_2 **b.** 6.46 g CO_2
c. 6.94 g CO_2
Natural gas, $CH_4(g)$, contributes the least to global warming by producing the least $CO_2(g)$ per kJ of heat produced.
95. 2×10^{13} kg CO_2 produced per year, 150 years
97. $\Delta E = -1.7$ J, $q = -0.5$ J, $w = -1.2$ J
99. 78 g
101. $\Delta H = 6.0$ kJ/mol, 1.1×10^2 g
103. 26.1 °C
105. palmitic acid: 9.9378 Cal/g; sucrose: 3.938 Cal/g; fat contains more Cal/g than sugar.
107. $\Delta H = \Delta E + nR\Delta T$
109. 5.7 Cal/g
111. $\Delta E = 0$, $\Delta H = 0$, $q = -w = 3.0 \times 10^3$ J
113. −294 kJ/mol
115. 94.0 kJ
117. 23.9 °C
119. 7.3×10^3 g H_2SO_4
121. 7.2×10^2 g
123. 78.2 °C
125. $C_v = \frac{3}{2}R$, $C_p = \frac{5}{2}R$
127. $q = 1030$ kJ, $\Delta H = 1030$ kJ, $\Delta E = 952$ kJ, $w = -78$ kJ
129. −1292 kJ
131. **d**
133. **a.** At constant pressure, heat can be added and work can be done on the system. $\Delta E = q + w$; therefore, $q = \Delta E - w$.
135. The aluminum is cooler because it has a lower heat capacity (specific heat).
137. $q = -2418$ J, $w = -5$ kJ, $\Delta H = -2418$ J/mol, $\Delta E = -2423$ J/mol
139. **b.** $\Delta H > \Delta E$
144. **a.** $C_3H_8(g) + 5\ O_2(g) \longrightarrow 3\ CO_2(g) + 4\ H_2O(l)$
$C_3H_8(g) + 5\ O_2(g) \longrightarrow 3\ CO_2(g) + 4\ H_2O(g)$
c. LLV because the water formed is the gaseous state; 46.3×10^3 kJ

Chapter 8

35. 499 s

37. **i.** d, c, b, a
ii. a, b, c, d

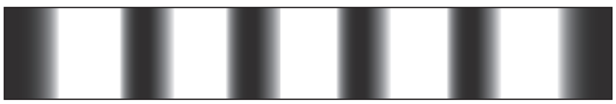
39. **a.** 4.74×10^{14} Hz
b. 5.96×10^{14} Hz
c. 5.8×10^{18} Hz

41. **a.** 3.14×10^{-19} J
b. 3.95×10^{-19} J
c. 3.8×10^{-15} J

43. 1.03×10^{16} photons

45. **a.** 79.8 kJ/mol
b. 239 kJ/mol
c. 798 kJ/mol

47.



49. 3.6×10^{6} m/s

51. 5.39 nm

53. 1.1×10^{-34} m. The wavelength of a baseball is negligible with respect to its size.

55. $\Delta v = 1.04 \times 10^{5}$ m/s

57. 2*s*

59. **a.** $l = 0$
b. $l = 0, 1$
c. $l = 0, 1, 2$
d. $l = 0, 1, 2, 3$

61. **c**

63. See **Figures 7.25** and **7.26**. The 2*s* and 3*p* orbitals would, on average, be farther from the nucleus and have more nodes than the 1*s* and 2*p* orbitals.

65. $n = 1$

67. $2p \longrightarrow 1s$

69. **a.** 122 nm, UV
b. 103 nm, UV
c. 486 nm, visible
d. 434 nm, visible

71. $n = 2$

73. 344 nm

75. 6.4×10^{17} photons/s

77. 0.0547 nm

79. 91.2 nm

81. **a.** 4
b. 9
c. 16

83. $n=4 \longrightarrow n=3, n=5 \longrightarrow n=3, n=6 \longrightarrow n=3$, respectively

85. $4.84 \times 10^{14}\ s^{-1}$

87. 11 m

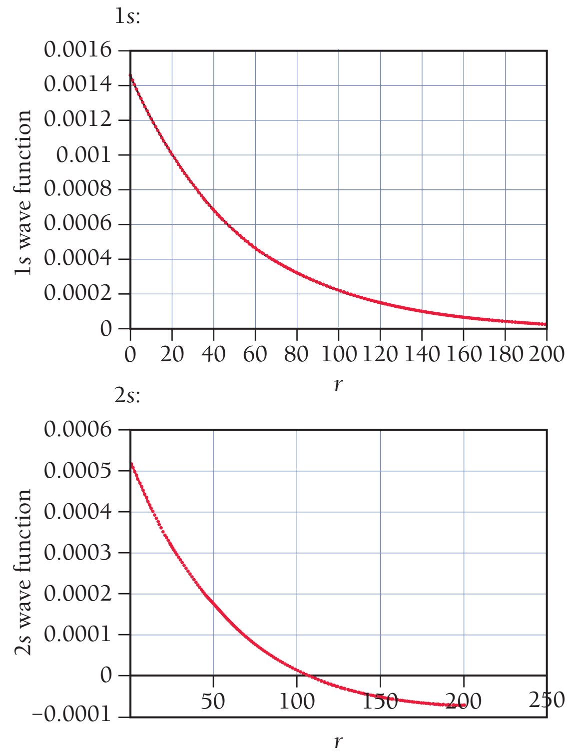
89. 6.78×10^{-3} J

91. 632 nm

93. 2.98×10^{-4} mol

95. **a.** $E_1 = 2.51 \times 10^{-18}$ J, $E_2 = 1.00 \times 10^{-17}$ J, $E_3 = 2.26 \times 10^{-17}$ J
b. 26.5 nm, UV; 15.8 nm, UV

97.



The plot for the 2*s* wave function extends below the *x*-axis. The *x*-intercept represents the radial node of the orbital.

99. 7.39×10^{5} m/s

101. $\Delta E = 1.1 \times 10^{-20}$ J, 7.0×10^{2} nm

103. 11 m

105. In the Bohr model, electrons exist in specific orbits encircling the atom. In the quantum-mechanical model, electrons exist in orbitals that are really probability density maps of where the electron is likely to be found. The Bohr model is inconsistent with Heisenberg's uncertainty principle.

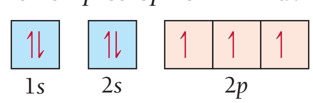
107. **a.** yes **b.** no **c.** yes **d.** no

114. **a.** 5.93×10^{-19} J **c.** 2-EHMC
e. 1.4×10^{7} J

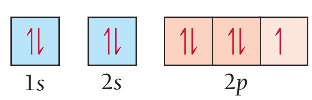
Chapter 9

39. **a.** $1s^22s^22p^63s^23p^2$ **b.** $1s^22s^22p^4$
c. $1s^22s^22p^63s^23p^64s^1$ **d.** $1s^22s^22p^6$

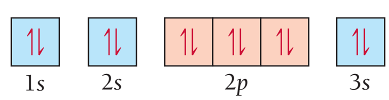
41. **a.**



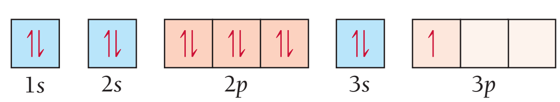
b.



c.



d.



43. **a.** $[\mathrm{Ne}]3s^23p^3$ **b.** $[\mathrm{Ar}]4s^23d^{10}4p^2$
c. $[\mathrm{Kr}]5s^24d^2$ **d.** $[\mathrm{Kr}]5s^24d^{10}5p^5$

45. **a.** 1 **b.** 10 **c.** 5 **d.** 2

47. **a.** V, As **b.** Se **c.** V **d.** Kr

49. **a.** 2 **b.** 1 **c.** 10 **d.** 6

51. reactive metal: **a**, reactive nonmetal: **c**

53. **c**

55. The valence electrons of nitrogen will experience a greater effective nuclear charge. The valence electrons of both atoms are screened by two core electrons, but N has a greater number of protons and therefore a greater net nuclear charge.

57. **a.** 1+ **b.** 2+ **c.** 6+ **d.** 4+

59. **a.** In **b.** Si **c.** Pb **d.** C

61. F, S, Si, Ge, Ca, Rb

63. **a.** [Ne] **b.** [Kr] **c.** [Kr]
d. $[\mathrm{Ar}]3d^6$ **e.** $[\mathrm{Ar}]3d^9$

65. **a.** [Ar] Diamagnetic

b. [Ar] | ↑ | ↑ | ↑ | | | Paramagnetic
$3d$

c. [Ar] | ↑↓ | ↑↓ | ↑↓ | ↑ | ↑ | Paramagnetic
$3d$

d. [Ar] | ↑ | ↑ | ↑ | ↑ | ↑ | Paramagnetic
$3d$

67. **a.** Li **b.** I^- **c.** Cr **d.** O^{2-}

69. O^{2-}, F^-, Na^+, Mg^{2+}

71. **a.** Br
b. Na
c. cannot tell based on periodic trends
d. P

73. In, Si, N, F

75. **a.** second and third **b.** fifth and sixth
c. sixth and seventh **d.** first and second

77. **a.** Na **b.** S **c.** C **d.** F

79. **a.** Sr **b.** Bi
c. cannot tell based on periodic trends
d. As

81. S, Se, Sb, In, Ba, Fr

83. $\mathrm{Br}:1s^22s^22p^63s^23p^64s^23d^{10}4p^5$
$\mathrm{Kr}:1s^22s^22p^63s^23p^64s^23d^{10}4p^6$
Krypton's outer electron shell is filled, giving it chemical stability. Bromine is missing an electron from its outer shell and subsequently has a high electron affinity. Bromine tends to be easily reduced by gaining an electron, giving the bromide ion stability due to the filled *p* subshell that corresponds to krypton's chemically stable electron configuration.

85. $\mathrm{V}:[\mathrm{Ar}]\,4s^23d^3$
$\mathrm{V}^{3+}:[\mathrm{Ar}]\,3d^2$
Both V and V^{3+} contain unpaired electrons in their $3d$ orbitals.

87. A substitute for K^+ would need to exhibit a 1+ electric charge and have similar mass and atomic radius. Na^+ and Rb^+ would not be good substitutes because their radii are significantly smaller and larger, respectively. Based on mass, Ca^+ and Ar^+ are the closest to K^+. Because the first ionization energy of Ca^+ is closest to that of K^+, Ca^+, is the best choice for a substitute. The difficulty lies in Ca's low second ionization energy, making it easily oxidized.

89. Si, Ge

91. **a.** $\mathrm{N}:[\mathrm{He}]\,2s^22p^3$, $\mathrm{Mg}:[\mathrm{Ne}]3s^2$, $\mathrm{O}:[\mathrm{He}]2s^22p^4$,%
$\mathrm{F}:[\mathrm{He}]\,2s^22p^5$, $\mathrm{Al}:[\mathrm{Ne}]\,3s^23p^1$%
b. Mg, Al, O, F, N
c. Al, Mg, O, N, F
d. Aluminum's first ionization energy is lower than Mg because its $3p$ electron is shielded by the $3s$ orbital. Oxygen's first ionization energy is lower than that of N because its fourth $2p$ electron experiences electron–electron repulsion by the other electron in its orbital.

93. For main-group elements, atomic radii decrease across a period because the addition of a proton in the nucleus and an electron in the outermost energy level increases Z_{eff}. This does not happen in the transition metals because the electrons are added to the $n_{\mathrm{highest}-1}$ orbital and the Z_{eff} stays roughly the same.

95. Noble gases are exceptionally unreactive due to the stability of their completely filled outer quantum levels and their high ionization energies. The ionization energies of Kr, Xe, and Rn are low enough to form some compounds.

97. 6A: ns^2np^4, 7A: ns^2np^5, group 7A elements require only one electron to achieve a noble gas configuration. Since group 6A elements require two electrons, their affinity for one electron is less negative because one electron will merely give them an np^5 configuration.

99. 85

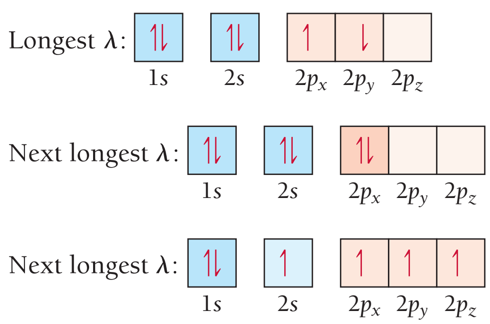
101. **a.** One If By Land (O, Ne, I, F, B, Y, La, Nd)
b. Atoms Are Fun (N, U, Fe, Ra, S, Mo, Ta backward)

103. 1.390×10^3 kJ/mol, 86.14 nm

105. **a.** F **b.** B **c.** B **d.** O

107. **a.** $d_{\mathrm{Ar}} \approx 2$ g/L, $d_{\mathrm{Xe}} \approx 6.5$ g/L
b. $d_{118} \approx 13$ g/L
c. mass $= 3.35 \times 10^{-23}$ g/Ne atom, density of Ne atom $= 2.3 \times 10^4$ g/L. The separation of Ne atoms relative to their size is immense.
d. Kr:2.69×10^{22} atoms/L, Ne:2.69×10^{22} atoms/L. It seems Ar will also have 2.69×10^{22} atoms/L. $d_{\mathrm{Ar}} = 1.78$ g/L. This corresponds to accepted values.

109. Density increases to the right because, though electrons are added successively across the period, they are added to the $3d$ subshell, which is not a part of the outermost principal energy level. As a result, the atomic radius does not increase significantly across the period, while mass does.

111. 

113. 168, noble gas

115. A relatively high effective nuclear charge is found in gallium with its completed $3d$ subshell and in thallium with its completed $4f$ subshell, accounting for the relatively high first ionization energies of these elements.

117. The second electron affinity requires the addition of an electron to something that is already negatively charged. The monoanions of both of these elements have relatively high electron density in a relatively small volume.

119. 120, 170

121. Fr, [Rn] $7s^1$, >265, <376, >1.879, <29
a. $Fr^+(aq)$, $OH^-(aq)$, $H_2(g)$
b. $Fr_2O(s)$
c. FrCl(s)

123. **a.** any group 6A element **b.** any group 5A element
c. any group 1A element

125. **a.** true **b.** true **c.** false **d.** true

127. Since Ca has valence electrons of $4s^2$, it has a relatively low ionization energy to lose two electrons. F has a highly exothermic electron affinity when gaining one electron but not a second electron because of its $2s^22p^5$ valence electrons. Therefore, calcium and fluoride combine in a 2:1 ratio.

133. **a.** First ionization energy generally increases as you move from left to right across period 3 because effective nuclear charge increases from left to right.
c. Electron affinity generally decreases (becomes more exothermic) from left to right across period 3 because effective nuclear charge increases from left to right.
e. The overall energy change is approximately 150 kJ/mol. The exchange is endothermic.

Chapter 10

35. $1s^2\underline{2s^22p^3}$ ·N̈:

37. **a.** Al **b.** Na^+ **c.** Cl **d.** $[Cl]^-$

39. **a.** $Na^+[F]^-$ **b.** $Ca^{2+}[O]^{2-}$
c. $Sr^{2+}2[Br]^-$ **d.** $2\,K^+[O]^{2-}$

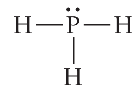
41. **a.** SrSe **b.** $BaCl_2$ **c.** Na_2S **d.** Al_2O_3

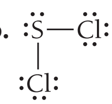
43. As the size of the alkaline earth metal ions increases, so does the distance between the metal cations and oxygen anions. Therefore, the magnitude of the lattice energy decreases accordingly because the potential energy decreases as the distance increases.

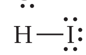
45. One factor of lattice energy is the product of the charges of the two ions. The product of the ion charges for CsF is −1, while that for BaO is −4. Because this product is four times greater, the lattice energy is also four times greater.

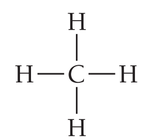
47. −708 kJ/mol

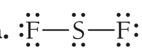
49. **a.** H:H, filled duets, 0 formal charge on both atoms
b. Cl—Cl, filled octets, 0 formal charge on both atoms
c. O═O, filled octets, 0 formal charge on both atoms
d. N≡N, filled octets, 0 formal charge on both atoms

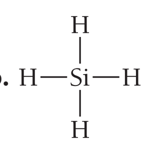
51. **a.** 

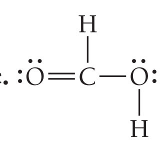
b. 

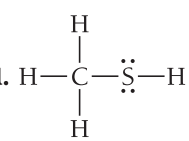
c. 

d. 

53. **a.** 

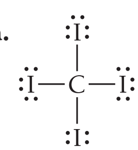
b. 

c. 

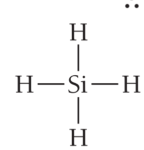
d. 

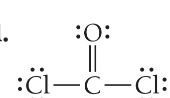
55. **a.** pure covalent
b. polar covalent
c. pure covalent
d. ionic bond

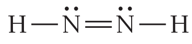
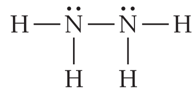
57. :C≡O:, 25%

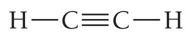
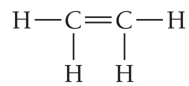
59. **a.** 

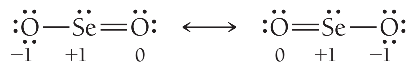
b. 

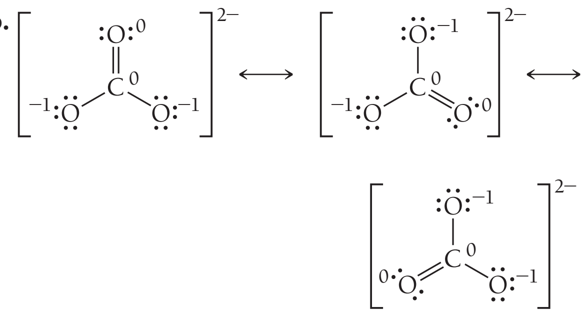
c. 

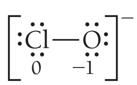
d. 

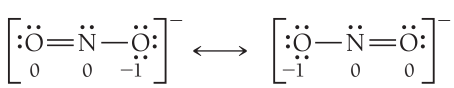
61. a.  **b.** 

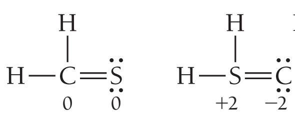
c.  **d.** 

63. a. 

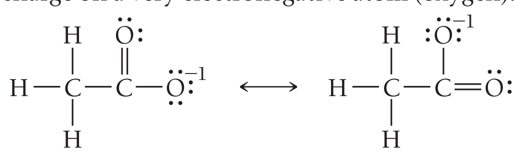
b. 

c. 

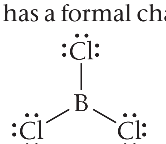
d. 

65.  H_2CS is the better structure.

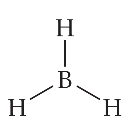
67. :O≡C—Ö: does not provide a significant contribution to the resonance hybrid as it has a +1 formal charge on a very electronegative atom (oxygen).

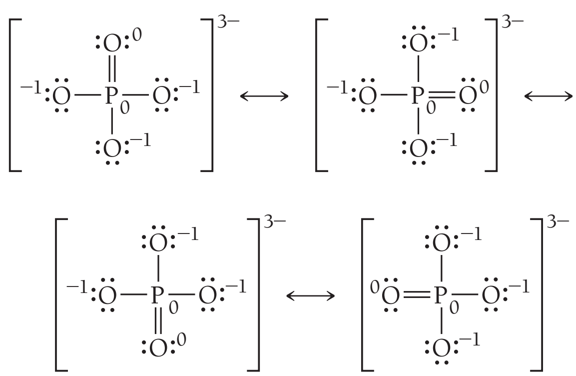
69. 

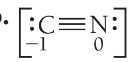
71. N has a formal charge of +1; O has a formal charge of −1.

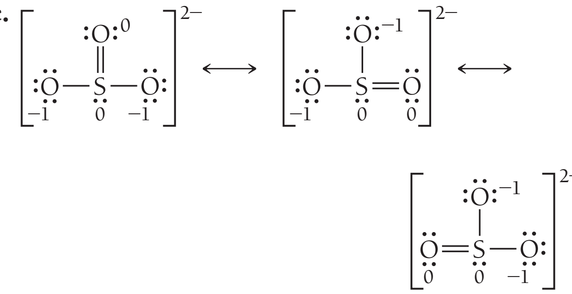
73. a. 

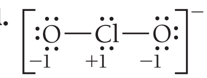
b. 

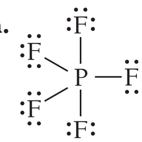
c. 

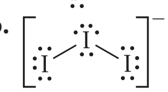
75. a. 

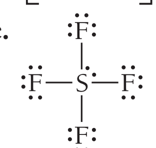
b. 

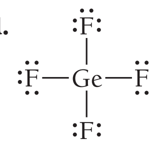
c. 

d. 

77. a. 

b. 

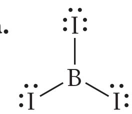
c. 

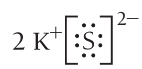
d. 

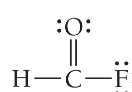
79. H_3CCH_3, H_2CCH_2, HCCH

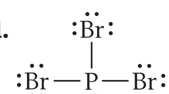
81. −128 kJ

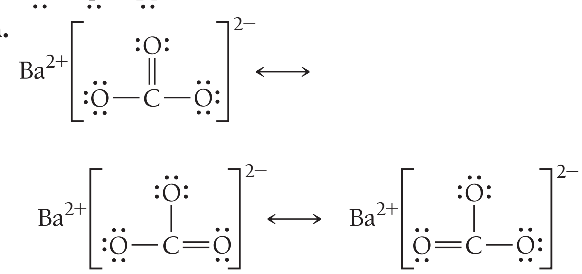
83. −2812 kJ

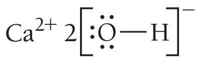
85. a. 

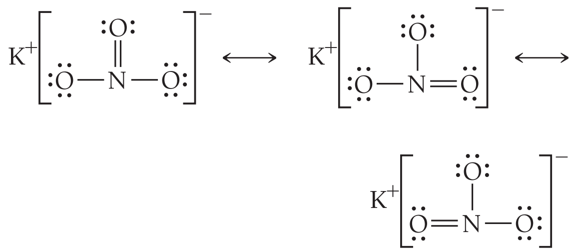
b. 

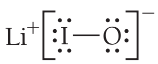
c. 

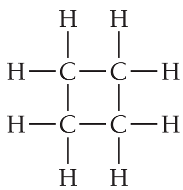
d. 

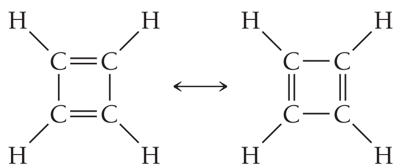
87. a. 

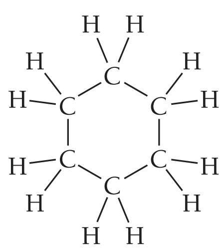
b. 

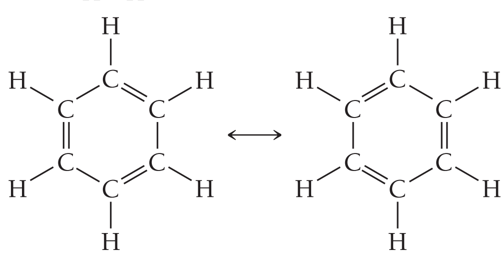
c. 

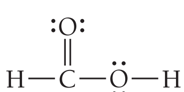
d. 

89. a. 

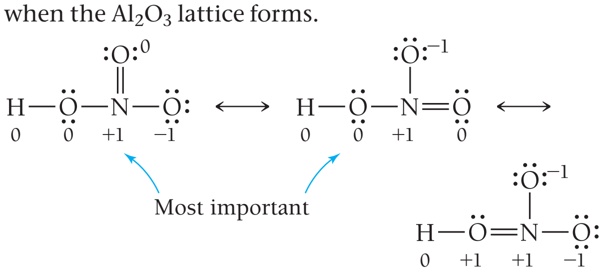
b. 

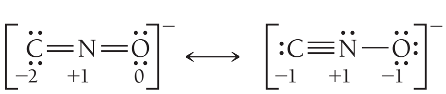
c. 

d. 

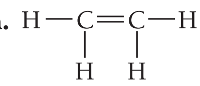
91. CH_2O_2, 

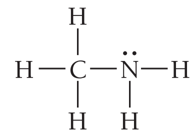
93. The reaction is exothermic due to the energy released when the Al_2O_3 lattice forms.

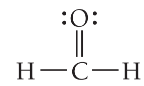
95. 

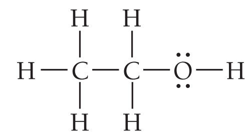
97. 

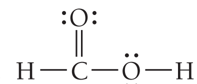
The fulminate ion is less stable because nitrogen is more electronegative than carbon and should therefore be terminal to accommodate the negative formal charge.

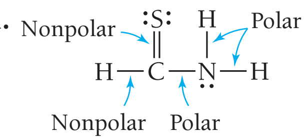
99. a. 

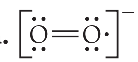
b. 

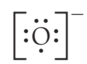
c. 

d. 

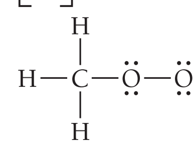
e. 

101. 

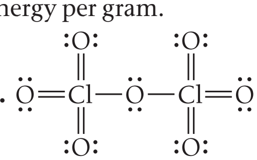
103. a. 

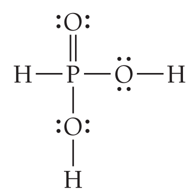
b. 

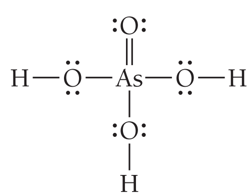
c. 

d. 

105. $\Delta H_{rxn(H_2)} = -243\ kJ/mol = -121\ kJ/g$
$\Delta H_{rxn(CH_4)} = -802\ kJ/mol = -50.0\ kJ/g$
CH_4 yields more energy per mole, while H_2 yields more energy per gram.

107. a. 

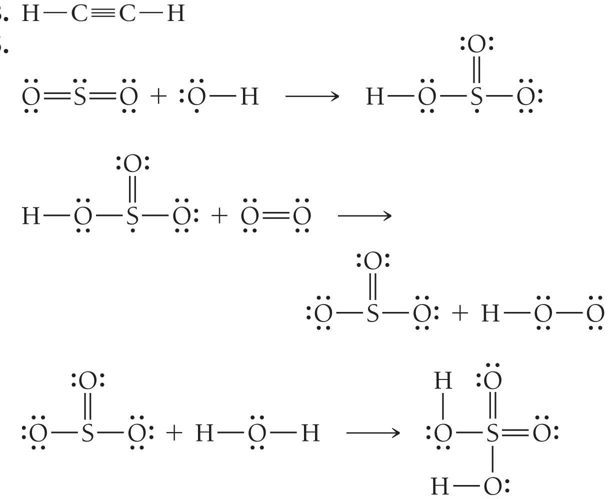
b. 

c. 

109. Na^+F^-, Na^+O^{2-}, $Mg^{2+}F^-$, $Mg^{2+}O^{2-}$, $Al^{3+}O^{2-}$

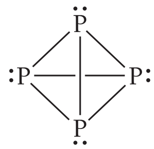
111. 333 kJ/mol

113. H—C≡C—H

115. 

$\Delta H_{rxn} = -172\ kJ$

117. $r_{HCl} = 113$ pm
$r_{HF} = 84$ pm
These values are close to the accepted values.

119. 

121. 126 kJ/mol

123. The oxidation number of the S atoms bonded directly to hydrogen atoms is −1. The oxidation number of interior S atoms is 0.

125. 536 kJ

127. The compounds are energy rich because a great deal of energy is released when these compounds undergo a reaction that breaks weak bonds and forms strong ones.

129. The theory is successful because it allows us to predict and account for many chemical observations. The theory is limited because electrons cannot be treated as localized "dots."

135. a. The lattice energy generally increases as you move across the period.
c. The increase in ionic radius between Cr^{2+} and Mn^{2+} results in a decrease in lattice energy.

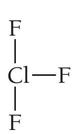
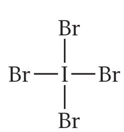
Chapter 11

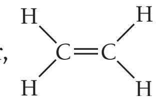
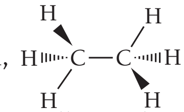
31. 4

33. a. 4 e^- groups, 4 bonding groups, 0 lone pair
b. 5 e^- groups, 3 bonding groups, 2 lone pairs
c. 6 e^- groups, 5 bonding groups, 1 lone pair

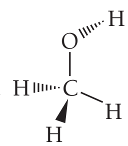
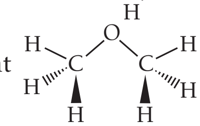
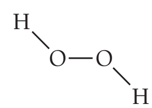
35. a. e^- geometry: tetrahedral molecular geometry: trigonal pyramidal idealized bond angle: 109.5°, deviation
b. e^- geometry: tetrahedral molecular geometry: bent idealized bond angle: 109.5°, deviation
c. e^- geometry: tetrahedral molecular geometry: tetrahedral idealized bond angle: 109.5°, deviation (due to large size of Cl compared to H)
d. e^- geometry: linear molecular geometry: linear idealized bond angle: 180°

37. H_2O has a smaller bond angle due to lone pair–lone pair repulsions, the strongest electron group repulsion.

39. a. seesaw, 
b. T-shape, 
c. linear, F—I—F
d. square planar, 

41. a. linear, H—C≡C—H
b. trigonal planar, 
c. tetrahedral, 

43. a. The lone pair will cause lone pair–bonding pair repulsions, pushing the three bonding pairs out of the same plane. The correct molecular geometry is trigonal pyramidal.
b. The lone pair should take an equatorial position to minimize 90° bonding pair interactions. The correct molecular geometry is seesaw.
c. The lone pairs should take positions on opposite sides of the central atom to reduce lone pair–lone pair interactions. The correct molecular geometry is square planar.

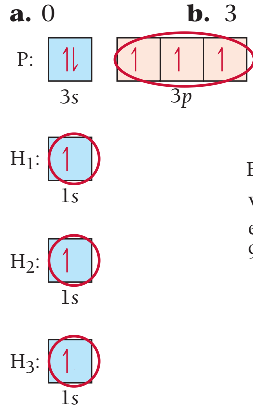
45. a. C: tetrahedral 
O: bent 
b. C's: tetrahedral
O: bent

c. O's: bent

47. The vectors of the polar bonds in both CO_2 and CCl_4 oppose each other with equal magnitude and sum to 0.

49. PF_3, polar%
SBr_2, nonpolar%
$CHCl_3$, polar%
CS_2, nonpolar%

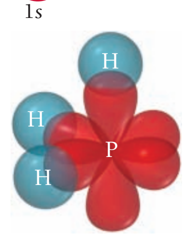
51. a. polar **b.** polar
c. nonpolar

53. a. 0 **b.** 3 **c.** 1

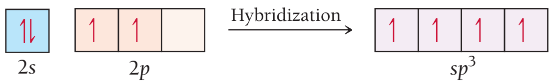
55. 

Expected bond angle = 90°

Valence bond theory is compatible with experimentally determined bond angle of 93.3° without hybrid orbitals.

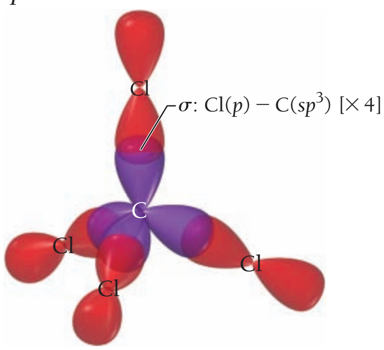


57.

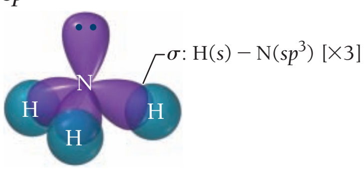


59. *sp*^{2}

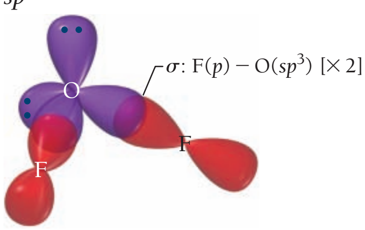
61. a. *sp*^{3}



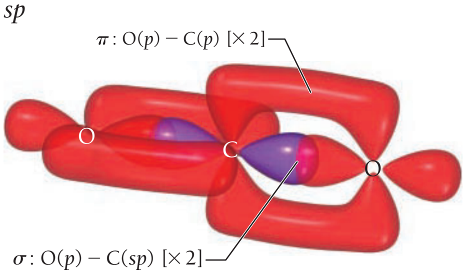
b. *sp*^{3}



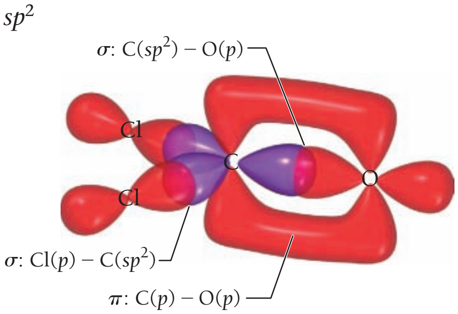
c. *sp*^{3}



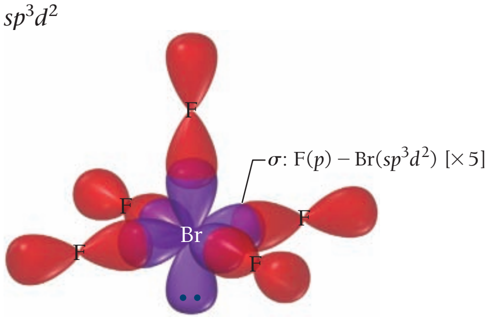
d. *sp*



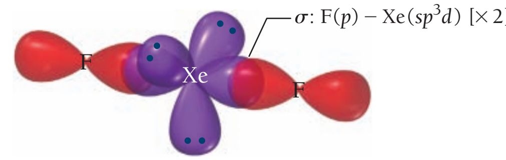
63. a. *sp*^{2}



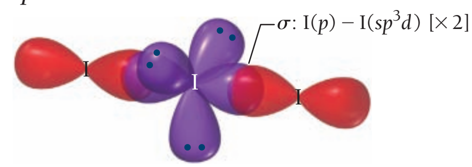
b. *sp*^{3}*d*^{2}



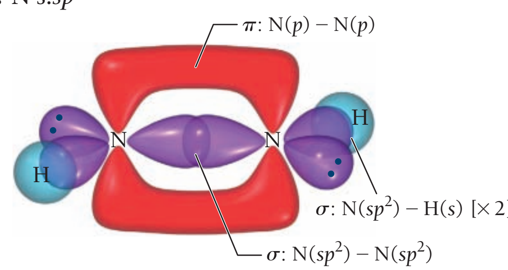
c. *sp*^{3}*d*



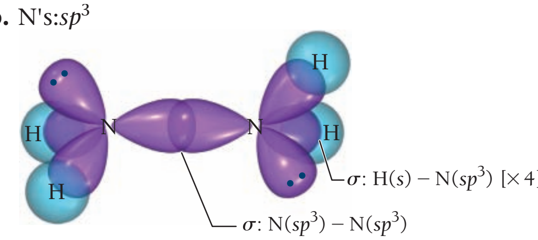
d. *sp*^{3}*d*



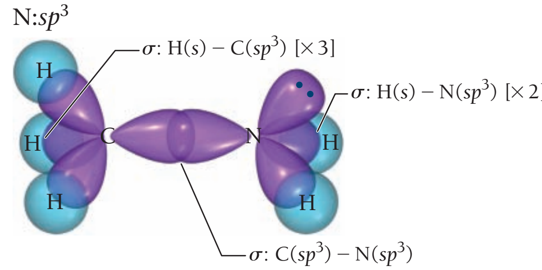
65. a. N's:*sp*^{2}



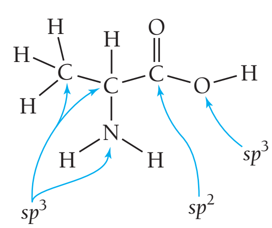
b. N's:*sp*^{3}



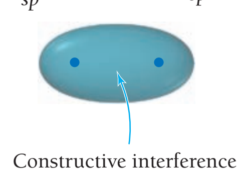
c. C:*sp*^{3}
N:*sp*^{3}

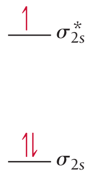


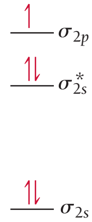
67.



69.



71. Be_2^+ 

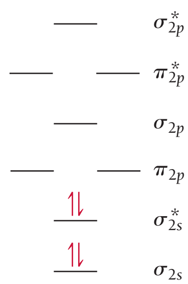
Be_2^- 

bond order $Be_2^+ = 1/2$
bond order $Be_2^- = 1/2$
Both will exist in gas phase.

73. Bonding

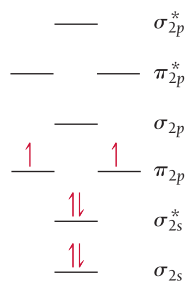
Antibonding

75. **a.**



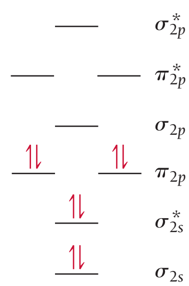
bond order = 0 diamagnetic

b.



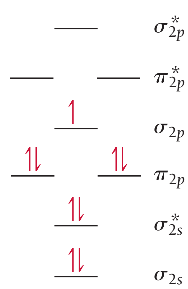
bond order = 1 paramagnetic

c.



bond order = 2 diamagnetic

d.

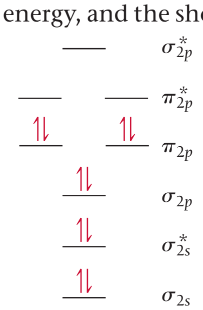


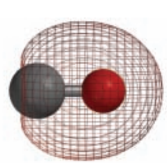
bond order = 2.5 paramagnetic

77. **a.** not stable **b.** not stable
c. stable **d.** not stable

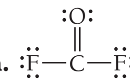
79. C_2^- has the highest bond order, the highest bond energy, and the shortest bond length.

81.





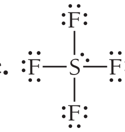
bond order = 3

83. **a.** 

trigonal planar polar C: sp^2

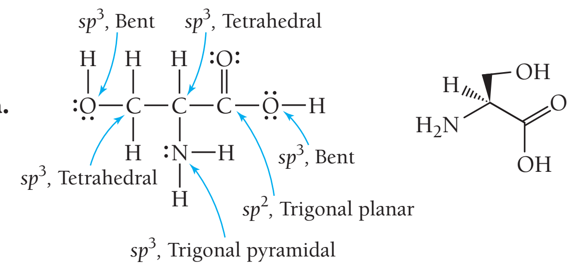
b. 

bent polar S's: sp^3

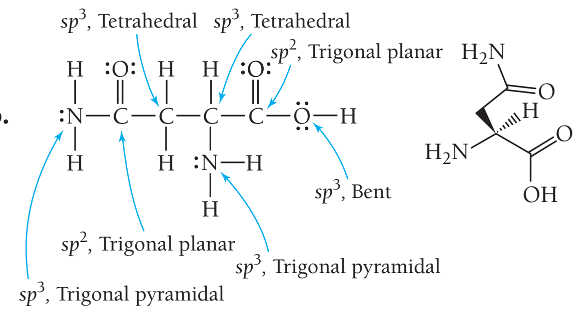
c. 

seesaw polar S: sp^3d

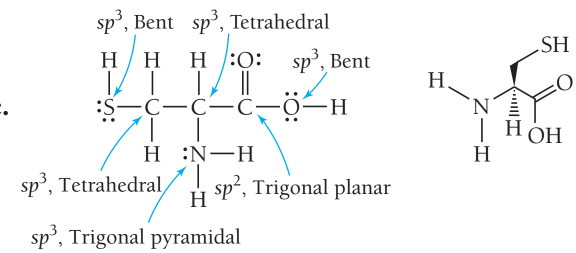
85. **a.**



b.



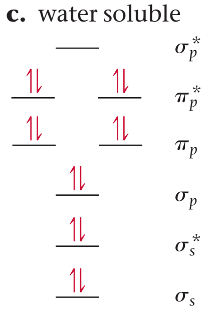
c.



87. σ bonds: 25
π bonds: 4
lone pairs: on O's and N (without methyl group): sp^2 orbitals
on N's (with methyl group): sp^3 orbitals

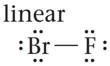
89. **a.** water soluble **b.** fat soluble
c. water soluble **d.** fat soluble

91.

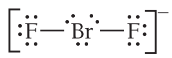


bond order = 1

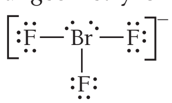
93. BrF, unhybridized, linear



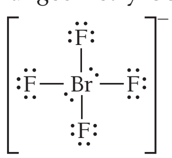
BrF_2^- has two bonds and three lone pairs on the central atom. The hybridization is sp^3d. The electron geometry is trigonal bipyramidal, with the three lone pairs equatorial. The molecular geometry is linear.



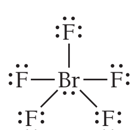
BrF_3 has three bonds and two lone pairs on the central atom. The hybridization is sp^3d. The electron geometry is trigonal bipyramidal, with the two lone pairs equatorial. The molecular geometry is T-shaped.



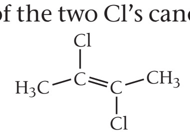
BrF_4^- has four bonds and two lone pairs on the central atom. The hybridization is sp^3d^2. The electron geometry is octahedral, with the two lone pairs on the same axis. The molecular geometry is square planar.



BrF_5 has five bonds and one lone pair on the central atom. The hybridization is sp^3d^2. The electron geometry is octahedral. The molecular geometry is square pyramidal.



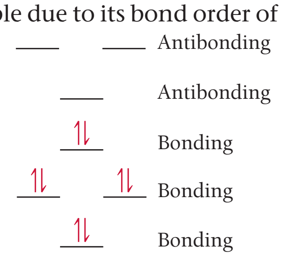
95. The moments of the two Cl's cancel.



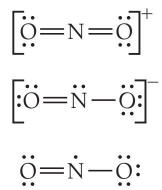
97. **a.** 10 **b.** 14 **c.** 2

99. According to valence bond theory, CH_4, NH_3, and H_2O are all sp^3 hybridized. This hybridization results in a tetrahedral electron group configuration with a 109.5° bond angle. NH_3 and H_2O deviate from this idealized bond angle because their lone electron pairs exist in their own sp^3 orbitals. The presence of lone pairs lowers the tendency for the central atom's orbitals to hybridize. As a result, as lone pairs are added, the bond angle moves further from the 109.5° hybrid angle and closer to the 90° unhybridized angle.

101. NH_3 is stable due to its bond order of 3.

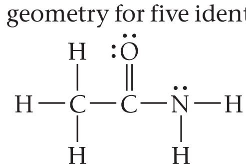


103. In NO_2^+, the central N has two electron groups, so the hybridization is sp and the ONO angle is 180°. In NO_2^- the central N has three electron groups, two bonds and one lone pair. The ideal hybridization is sp^2, but the ONO bond angle should close down a bit because of the lone pair. A bond angle around 115° is a good guess. In NO_2 there are three electron groups, but one group is a single electron. Again, the ideal hybridization would be sp^2, but since one unpaired electron must be much smaller than a lone pair or even a bonding pair, we predict that the ONO bond angle will spread and be greater than 120°. As a guess, the angle is probably significantly greater than 120°.

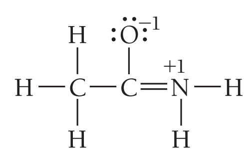


105. In addition to the 2*s* and the three 2*p* orbitals, one more orbital is required to make five hybrid orbitals. The closest in energy is the 3*s* orbital. So the hybridization is s^2p^3. VSEPR predicts trigonal bipyramidal geometry for five identical substituents.

107.



Lewis Structure

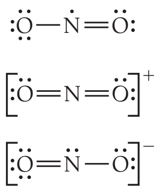


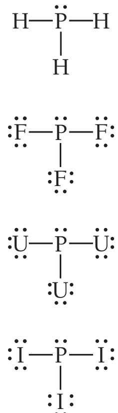
Resonance Structure

Terminal carbon is tetrahedral, central carbon is trigonal planar, and nitrogen is trigonal pyramidal (but resonance structure is trigonal planar).

109. **a.** This is the best.
b. This statement is similar to **a** but leaves out nonbonding lone-pair electron groups.
c. Molecular geometries are not determined by overlapping orbitals but rather by the number and type of electron groups around each central atom.

111. Lewis theory defines a single bond, double bond, and triple bond as a sharing of two electrons, four electrons, and six electrons, respectively, between two atoms. Valence bond theory defines a single bond as a sigma overlap of two orbitals, a double bond as a single sigma bond combined with a pi bond, and a triple bond as a double bond with an additional pi bond. Molecular orbital theory defines a single bond, double bond, and triple bond as a bond order of 1, 2, or 3, respectively, between two atoms.

118. a. 

c. 

e. The Lewis structures all have four electron groups, one lone pair, and three bonding groups. Based on VESPR, each of these molecules should have a bond angle of slightly less than 109.5 °. However, the atomic radius increases in the following order: H < Cl < I. The increasing radius from H to I can explain the increasing bond angle in these compounds.

Chapter 12

35. a. dispersion
b. dispersion, dipole–dipole, hydrogen bonding
c. dispersion, dipole–dipole
d. dispersion

37. a. dispersion, dipole–dipole
b. dispersion, dipole–dipole, hydrogen bonding
c. dispersion
d. dispersion

39. a, b, c, d, Boiling point increases with increasing intermolecular forces. The molecules increase in their intermolecular forces as follows: **a,** dispersion forces; **b,** stronger dispersion forces (broader electron cloud); **c,** dispersion forces and dipole–dipole interactions; **d,** dispersion forces, dipole–dipole interactions, and hydrogen bonding.

41. a. CH_3OH, hydrogen bonding
b. CH_3CH_2OH, hydrogen bonding
c. CH_3CH_3, greater mass, broader electron cloud causes greater dispersion forces.

43. a. Br_2, smaller mass results in weaker dispersion forces.
b. H_2S, lacks hydrogen bonding
c. PH_3, lacks hydrogen bonding

45. a. not homogeneous
b. homogeneous, dispersion, dipole–dipole, hydrogen bonding, ion–dipole
c. homogeneous, dispersion
d. homogeneous, dispersion, dipole–dipole, hydrogen bonding

47. Water. Surface tension increases with increasing intermolecular forces, and water can hydrogen-bond while acetone cannot.

49. compound A

51. When the tube is clean, water experiences adhesive forces with glass that are stronger than its cohesive forces, causing it to climb the surface of a glass tube. Water does not experience strong intermolecular forces with oil, so if the tube is coated in oil, the water's cohesive forces will be greater and it will not be attracted to the surface of the tube.

53. The water in the 12-cm dish will evaporate more quickly. The vapor pressure does not change, but the surface area does. The water in the dish evaporates more quickly because the greater surface area allows for more molecules to obtain enough energy at the surface and break free.

55. Water is more volatile than vegetable oil. When the water evaporates, the endothermic process results in cooling.

57. 0.405 L

59. 91 °C

61. $\Delta H_{vap} = 24.7$ kJ/mol, bp $= 239$ K

63. 41 torr

65. 27.5 kJ/mol

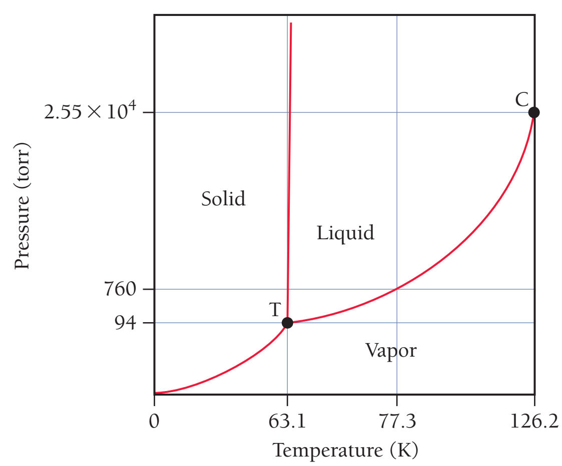
67. 22.0 kJ

69. 2.7 °C

71. 30.5 kJ

73. a. solid **b.** liquid
c. gas **d.** supercritical fluid
e. solid/liquid **f.** liquid/gas
g. solid/liquid/gas

75. N_2 has a stable liquid phase at 1 atm.



77. a. 0.027 mmHg **b.** rhombic

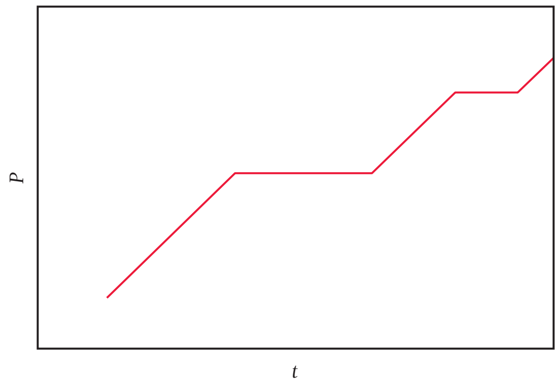
79. Water has strong intermolecular forces. It is polar and experiences hydrogen bonding.

81. Water's exceptionally high specific heat capacity has a moderating effect on Earth's climate. Also, its high ΔH_{vap} causes water evaporation and condensation to have a strong effect on temperature.

83. The general trend is that melting point increases with increasing mass. This is because the electrons of the larger molecules are held more loosely and a stronger dipole moment can be induced more easily. HF is the exception to the rule. It has a relatively high melting point due to hydrogen bonding.

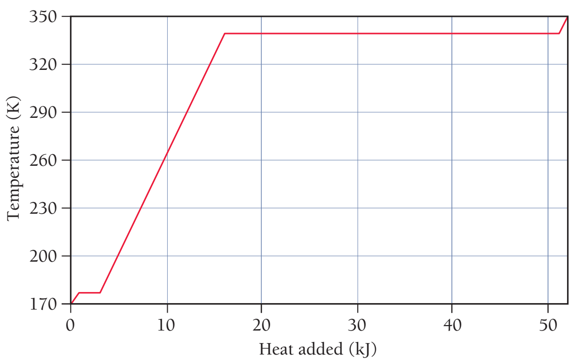
85. yes, 1.22 g

87. gas ⟶ liquid ⟶ solid



89. 26 °C

91.



93. 3.4×10^3 g H_2O

95. **a.** $CO_2(s) \longrightarrow CO_2(g)$ at 195 K

b. $CO_2(s) \longrightarrow$ triple point at 216 K $\longrightarrow CO_2(g)$ just above 216 K

c. $CO_2(s) \longrightarrow CO_2(l)$ at somewhat above 216 K $\longrightarrow CO_2(g)$ at around 250 K

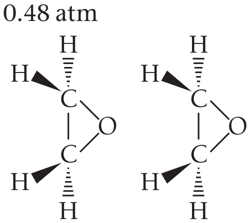
d. $CO_2(s) \longrightarrow CO_2(g) \longrightarrow$ supercritical fluid

97. Decreasing the pressure will decrease the temperature of liquid nitrogen. Because the nitrogen is boiling, its temperature must be constant at a given pressure. As the pressure decreases, the boiling point decreases, and therefore so does the temperature. If the pressure drops below the pressure of the triple point, the phase change will shift from vaporization to sublimation and the liquid nitrogen will become solid.

99. 70.7 L

101. 0.48 atm

103.



105. The water within a container with a larger surface area will evaporate more quickly because there is more surface area from which the molecules can evaporate. Vapor pressure is the pressure of the gas when it is in dynamic equilibrium with the liquid. The vapor pressure is dependent only on the substance and the temperature. The larger the surface area, the more quickly it will reach the dynamic state.

107. The triple point will be at a lower temperature since the fusion equilibrium line has a positive slope. This means that we will be increasing both temperature and pressure as we travel from the triple point to the normal melting point.

109. The liquid segment will have the least steep slope because it takes the most kJ/mol to raise the temperature of the phase.

111. There are substantial intermolecular attractions in the liquid but virtually none in the gas.

117. **a.** No. Although it does correlate for H_2S, H_2Se, and H_2Te, it does not correlate for H_2O.

c. Water has the highest dipole moment, that together with the small size of the hydrogen atom accounts for the anomalously high boiling point.

Chapter 13

27. 162 pm

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

31. 68%

33. $l = 393$ pm, $d = 21.3$ g/cm^3

35. 134.5 pm

37. 6.0×10^{23} atoms/mol

39. **a.** atomic **b.** molecular **c.** ionic **d.** atomic

41. LiCl(s). The other three solids are held together by intermolecular forces, while LiCl is held together by stronger coulombic interactions between the cations and anions of the crystal lattice.

43. **a.** $TiO_2(s)$, ionic solid

b. $SiCl_4(s)$, larger, stronger dispersion forces

c. Xe(s), larger, stronger dispersion forces

d. CaO, ions have greater charge and therefore stronger coulombic forces

45. TiO_2

47. Cs:1(1) = 1
Cl:8(1/8) = 1
1:1
CsCl
Ba:8(1/8) + 6(1/2) = 4
Cl:8(1) = 8
4:8 = 1:2
$BaCl_2$

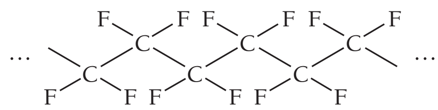
49. cesium chloride: none of these; barium(II) chloride: fluorite structure

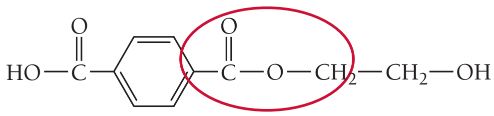
51. face-centered cubic

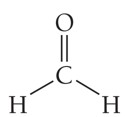
53. **a.** nonoxide **b.** silicate **c.** nonoxide

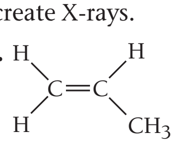
55. boron oxide, B_2O_3

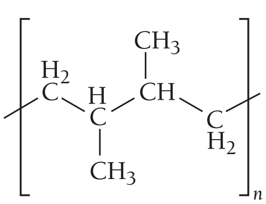
57. Ca: +2; Si: +2; O: −2

59. **a.** Zn(*s*)
61. 0.807 mol orbitals
63. insulator
65. **a.** p-type
b. n-type
67. Yes, it has sufficient energy.
69.


71.


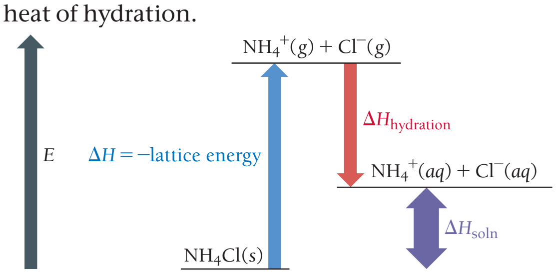
73. H—C ≡ C—H
75.


77. CsCl has a higher melting point than AgI because of its higher coordination number. In CsCl, one anion bonds to eight cations (and vice versa), while in AgI, one anion bonds to only four cations.
79. **a.** $4r$
$c^2 = a^2 + b^2 \; c = 4r, a = l, b = l$
$(4r)^2 = l^2 + l^2$
$16r^2 = 2l^2$
b. $8r^2 = l^2$
$l = \sqrt[3]{8r^2}$
$l = 2\sqrt{2r}$
81. 8 atoms/unit
83. 55.843 g/mol
85. 2.00 g/cm^3
87. body diagonal $= \sqrt{6}r$,
radius $= (\sqrt{3} - \sqrt{2})r/\sqrt{2} = 0.2247r$
89. The higher-level electron transitions with their smaller energy gaps would not give off enough energy to create X-rays.
91. **a.**


b.


To obtain this structure, the monomer from part a would react in a head-to-head (or tail-to-tail) addition as opposed to the head-to-tail addition that leads to the structure shown in Table 12.3.
93. Because the structure is a face-centered cubic, there are therefore four C_{60} molecules per unit cell. Thus, there must be 3 × 4 = 12 Rb atoms per unit cell, and all sites (tetrahedral and octahedral) are occupied.
95. The liquid must be cooled quickly in order to prevent the formation of an organized crystal structure and instead achieve an amorphous product.
97. Both structures may be viewed as having essentially a face-centered cubic unit cell with half of the tetrahedral holes filled. Diamond, however, consists of only one type of atom (C) and is covalently bound, whereas zinc blende has S^{2-} ions at the face-centered cubic sites and Zn^{2+} ions in the tetrahedral holes, and is held together by ionic forces.
99. **d.** All of the above would likely lead to an increase in electrical conductivity.
105. **a.** 20% Cr and 80% Ni; 1405°
a. 97% Cr and 3% Ni; body-centered cubic

Chapter 14

29. **a.** hexane, toluene, or CCl_4; dispersion forces
b. water, methanol; dispersion, dipole–dipole, hydrogen bonding
c. hexane, toluene, or CCl_4; dispersion forces
d. water, acetone, methanol, ethanol; dispersion, ion–dipole
31. $HOCH_2CH_2CH_2OH$
33. **a.** water; dispersion, dipole–dipole, hydrogen bonding
b. hexane; dispersion
c. water; dispersion, dipole–dipole
35. **a.** endothermic
b. The lattice energy is greater in magnitude than the heat of hydration.
c.


d. The solution forms because chemical systems tend toward greater entropy.
37. −797 kJ/mol
39. $\Delta H_{soln} = -6 \times 10^1$ kJ/mol, −7 kJ of energy evolved
41. unsaturated
43. About 31 g will precipitate.
45. Boiling water releases any O_2 dissolved in it. The solubility of gases decreases with increasing temperature.
47. As pressure increases, nitrogen will more easily dissolve in blood. To reverse this process, divers should ascend to lower pressures.
49. 1.1 g
51. 1.92 M, 2.0 *m*, 10.4%
53. 0.340 L
55. 1.6×10^2 g
57. 1.4×10^4 g
59. Add water to 7.31 mL of concentrated solution until a total volume of 1.15 L is acquired.
61. **a.** Add water to 3.73 g KCl to a volume of 100 mL.
b. Add 3.59 g KCl to 96.41 g H_2O.
c. Add 5.0 g KCl to 95 g H_2O.
63. **a.** 0.417 M **b.** 0.444 *m*
c. 7.41% by mass **d.** 0.00794
e. 0.794% by mole

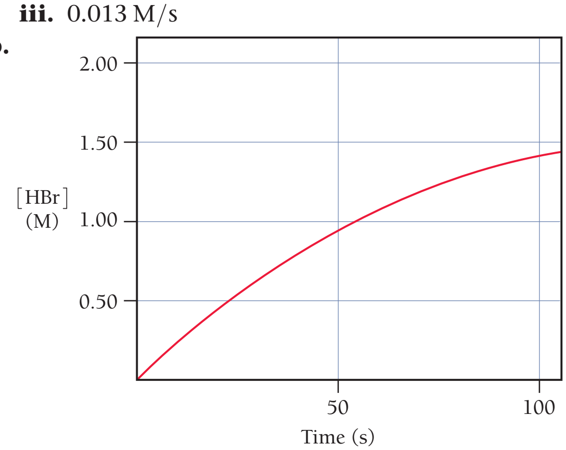
65. 0.89 M
67. 15 *m*, 0.22
69. The level has decreased more in the beaker filled with pure water. The dissolved salt in the seawater decreases the vapor pressure and subsequently lowers the rate of vaporization.
71. 30.7 torr
73. **a.** $P_{hep} = 24.4$ torr, $P_{oct} = 5.09$ torr
b. 29.5 torr
c. 80.8% heptane by mass, 19.2% octane by mass
d. The vapor is richer in the more volatile component.
75. $P_{chl} = 51.9$ torr, $P_{ace} = 274$ torr, $P_{tot} = 326$ torr. The solution is not ideal. The chloroform–acetone interactions are stronger than the chloroform–chloroform and acetone–acetone interactions.
77. freezing point (fp) = −1.27 °C, bp = 100.349 °C
79. freezing point (fp) = 1.0 °C, boiling point(bp) = 82.4 °C
81. 1.8×10^2 g/mol
83. 26.1 atm
85. 6.36×10^3 g/mol
87. **a.** fp = −0.558 °C, bp = 100.154 °C
b. fp = −1.98 °C, bp = 100.546 °C
c. fp = −2.5 °C, bp = 100.70 °C
89. 157 g
91. **a.** −0.632 °C **b.** 5.4 atm **c.** 100.18 °C
93. 2.3
95. 3.4
97. 23.0 torr
99. Chloroform is polar and has stronger solute–solvent interactions than nonpolar carbon tetrachloride.
101. $\Delta H_{soln} = 51$ kJ/mol, −8.7 °C
103. 2.2×10^{-3} M/atm
105. 1.3×10^4 L
107. 0.24 g
109. −24 °C
111. **a.** 1.1% by mass/*V* **b.** 1.6% by mass/*V*
c. 5.3% by mass/*V*
113. 2.484
115. 0.229 atm
117. χ_{CHCl_3}(original) = 0.657,
P_{CHCl_3}(condensed) = 0.346 atm
119. 1.74 M
121. $C_6H_{14}O_2$
123. 12 grams
125. 6.4×10^{-3} L
127. 22.4 glucose by mass, 77.6 sucrose by mass
129. $P_{iso} = 0.131$ atm, $P_{pro} = 0.068$ atm. The major intermolecular attractions are between the OH groups. The OH group at the end of the chain in propyl alcohol is more accessible than the one in the middle of the chain in isopropyl alcohol. In addition, the molecular shape of propyl alcohol is a straight chain of carbon atoms, while that of isopropyl alcohol is a branched chain and is more like a ball. The contact area between two ball-like objects is smaller than that of two chain-like objects. The smaller contact area in isopropyl alcohol means the molecules don't attract each other as strongly as do those of propyl alcohol. As a result of both of these factors, the vapor pressure of isopropyl alcohol is higher.
131. 0.005 *m*
133. Na_2CO_3 0.050 M, $NaHCO_3$ 0.075 M
135. The water should not be immediately cycled back into the river. As the water was warmed, dissolved oxygen would have been released, since the amount of a gas able to be dissolved into a liquid decreases as the temperature of the liquid increases. As such, the water returned to the river would lack dissolved oxygen if it was still hot. To preserve the dissolved oxygen necessary for the survival of fish and other aquatic life, the water must first be cooled.
137. **b.** NaCl
144. **a.** The salinity of seawater is generally higher near the equator and lower near the poles.
c. −2.3 °C

Chapter 15

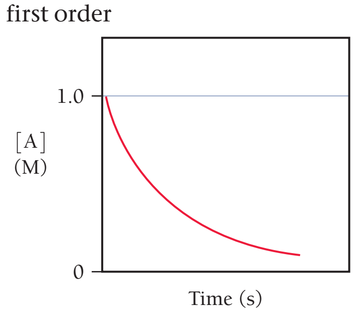
25. **a.** $\text{Rate} = -\frac{1}{2}\frac{\Delta[HBr]}{\Delta t} = \frac{\Delta[H_2]}{\Delta t} = \frac{\Delta[Br_2]}{\Delta t}$
b. 1.8×10^{-3} M/s
c. 0.040 mol Br_2
27. **a.** $\text{Rate} = -\frac{1}{2}\frac{\Delta[A]}{\Delta t} = -\frac{\Delta[B]}{\Delta t} = \frac{1}{3}\frac{\Delta[C]}{\Delta t}$
b. $\frac{\Delta[B]}{\Delta t} = -0.0500$ M/s, $\frac{\Delta[C]}{\Delta t} = 0.150$ M/s
29.

$\Delta[Cl_2]/\Delta t$	$\Delta[F_2]/\Delta t$	$\Delta[ClF_3]/\Delta t$	Rate
−0.012 M/s	−0.036 M/s	0.024 M/s	0.012 M/s

31. **a.** 0 ⟶ 10 s : Rate = 8.7×10^{-3} M/s
40 ⟶ 50 s : Rate = 6.0×10^{-3} M/s
b. 1.4×10^{-2} M/s
33. **a.** **i.** 1.0×10^{-2} M/s **ii.** 8.5×10^{-3} M/s
iii. 0.013 M/s
b.



35. **a.** first order
b.



c. Rate = $k[A]^1$, $k = 0.010$ s^{-1}