From Supplement Problems in back of text.

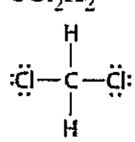
4. Determine the formula for ionic compounds composed of the following ions.
   a. copper(II) and acetate
      $Cu4(C_2H_3O_2)_2$
   b. ammonium and phosphate
      $(NH_4)_3PO_4$
   c. calcium and hydroxide
      $Ca(OH)_2$
   d. gold(III) and cyanide
      $Au(CN)_3$

5. Name the following compounds.
   a. $Co(OH)_2$
      cobalt(II) hydroxide
   b. $Ca(ClO_3)_2$
      calcium chlorate
   c. Na_3PO_4
      sodium phosphate
   d. $K_2Cr_2O_7$
      potassium dichromate
   e. SrI_2
      strontium iodide
   f. HgF_2
      mercury(II) fluoride

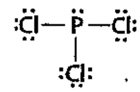
Chapter 8

Section 8.1

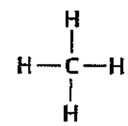
1. Draw the Lewis structure for each of the following molecules.
   a. CCl_2H_2



   b. HF
      H—F:
   c. PCl_3



   d. CH_4



p. 980 #2 & 3

Section 8.2

2. Name the following binary compounds.
   a. S_4N_2
      tetrasulfur dinitride
   b. OCl_2
      oxygen dichloride
   c. SF_6
      sulfur hexafluoride
   d. NO
      nitrogen monoxide
   e. SiO_2
      silicon dioxide
   f. IF_7
      iodine heptafluoride

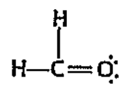
3. Name the following acids: H_3PO_4, HBr, HNO_3.
   phosphoric acid; hydrobromic acid; nitric acid

Section 8.3

p980 #4

4. Draw the Lewis structure for each of the following.
   a. CO
      :C≡O:

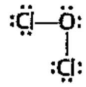
b. CH_2O



c. N_2O

:N═O═N:

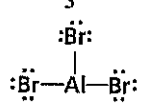
d. OCl_2



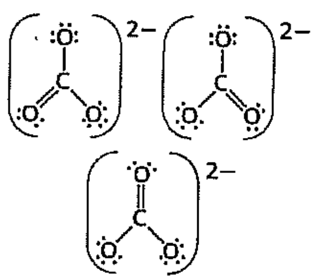
e. SiO_2

:O═Si═O:

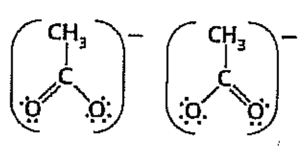
f. $AlBr_3$



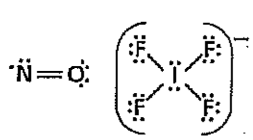
5. Draw the Lewis resonance structure for CO_3^{2-}.



6. Draw the Lewis resonance structure for $CH_3CO_2^-$.



7. Draw the Lewis structure for NO and IF_4^-.



Section 8.4

p. 980 #8

8. Determine the molecular geometry, ~~bond angles,~~ ~~and hybrid of~~ each molecule in question 4.

a. CO

linear, 180°, sp

b. CH_2O

trigonal planar, 120°, sp^2

c. N_2O

linear, 180°, sp

d. OCl_2

bent, 104.5°, sp^3

e. SiO_2

linear, 180°, sp

f. $AlBr_3$

trigonal planar, 120°, sp^2

Section 8.5

p980 #9

9. Determine whether each of the following molecules is polar or nonpolar.

a. CH_2O

The molecular shape is trigonal planar. The charge distribution is not symmetric due to the presence of more electronegative oxygen. The molecule is polar.

b. BF_3

The molecular shape is trigonal planar. The charge distribution is symmetric. The molecule is nonpolar.

c. SiH_4

The molecular shape is tetrahedral. The charge distribution is symmetric. The molecule is nonpolar.

d. H_2S

The molecular shape is bent. The charge distribution is not symmetric. The molecule is polar.

Chapter 9

Section 9.1

Write skeleton equations for the following reactions.

1. Solid barium and oxygen gas react to produce solid barium oxide.

   $Ba(s) + O_2(g) \rightarrow BaO(s)$

2. Solid iron and aqueous hydrogen sulfate react to produce aqueous iron(III) sulfate and gaseous hydrogen.

   $Fe(s) + H_2SO_4(aq) \rightarrow Fe_2(SO_4)_3(aq) + H_2(g)$

Write balanced chemical equations for the following reactions.

3. Liquid bromine reacts with solid phosphorus (P_4) to produce solid diphosphorus pentabromide.

   $5Br_2(l) + P_4(s) \rightarrow 2P_2Br_5(s)$

4. Aqueous lead(II) nitrate reacts with aqueous potassium iodide to produce solid lead(II) iodide and aqueous potassium nitrate.

   $Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$

5. Solid carbon reacts with gaseous fluorine to produce gaseous carbon tetrafluoride.

   $C(s) + 2F_2(g) \rightarrow CF_4(g)$

6. Aqueous carbonic acid reacts to produce liquid water and gaseous carbon dioxide.

   $H_2CO_3(aq) \rightarrow H_2O(l) + CO_2(g)$

7. Gaseous hydrogen chloride reacts with gaseous ammonia to produce solid ammonium chloride.

   $HCl(g) + NH_3(g) \rightarrow NH_4Cl(s)$

8. Solid copper(II) sulfide reacts with aqueous nitric acid to produce aqueous copper(II) sulfate, liquid water, and nitrogen dioxide gas.

   $CuS(s) + 8HNO_3(aq) \rightarrow CuSO_4(aq) + 4H_2O(l) + 8NO_2(g)$

Section 9.2

Classify each of the following reactions into as many types as possible.

9. $2Mo(s) + 3O_2(g) \rightarrow 2MoO_3(s)$

   synthesis; combustion

10. $N_2H_4(l) + 3O_2(g) \rightarrow 2NO_2(g) + 2H_2O(l)$

    combustion

Write balanced chemical equations for the following decomposition reactions.

11. Aqueous hydrogen chlorite decomposes to produce water and gaseous chlorine(III) oxide.

    $2HClO_2(aq) \rightarrow H_2O(l) + Cl_2O_3(g)$

12. Calcium carbonate(s) decomposes to produce calcium oxide(s) and carbon dioxide(g).

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

Use the activity series to predict whether each of the following single-replacement reactions will occur.

13. $Al(s) + FeCl_3(aq) \rightarrow AlCl_3(aq) + Fe(s)$

    Yes, aluminum is listed above iron.

14. $Br_2(l) + 2LiI(aq) \rightarrow 2LiBr(aq) + I_2(aq)$

    Yes, bromine is listed above iodine.

15. $Cu(s) + MgSO_4(aq) \rightarrow Mg(s) + CuSO_4(aq)$

    No, copper is listed below magnesium.

p 981 #16-17

Write chemical equations for the following chemical reactions.

16. Bismuth(III) nitrate(aq) reacts with sodium sulfide(aq), yielding bismuth(III) sulfide(s) plus sodium nitrate(aq).

    $2Bi(NO_3)_3(aq) + 3Na_2S(aq) \rightarrow Bi_2S_3(s) + 6NaNO_3(aq)$

17. Magnesium chloride(aq) reacts with potassium carbonate(aq), yielding magnesium carbonate(s) plus potassium chloride(aq).

    $MgCl_2(aq) + K_2CO_3(aq) \rightarrow MgCO_3(s) + 2KCl(aq)$

2. $2Al + 3CuSO_4 \rightarrow Al_2(SO_4)_3 + 3Cu$

2 atoms Al + 3 formula units $CuSO_4 \rightarrow$ 1 formula unit $Al_2(SO_4)_3$ + 3 atoms Cu

2 moles Al + 3 moles $CuSO_4 \rightarrow$ 1 mole $Al_2(SO_4)_3$ + 3 moles Cu

$$2 \text{ mol Al} \times \frac{26.98 \text{ g Al}}{1 \text{ mol Al}} = 53.96 \text{ g Al}$$

$$3 \text{ mol } CuSO_4 \times \frac{159.62 \text{ g } CuSO_4}{1 \text{ mol } CuSO_4} = 478.86 \text{ g } CuSO_4$$

$$1 \text{ mol } Al_2(SO_4)_3 \times \frac{342.17 \text{ g } Al_2(SO_4)_3}{1 \text{ mol } Al_2(SO_4)_3} = 342.17 \text{ g } Al_2(SO_4)_3$$

$$3 \text{ mol Cu} \times \frac{63.55 \text{ g Cu}}{1 \text{ mol Cu}} = 190.65 \text{ g Cu}$$

53.96 g Al + 478.86 g $CuSO_4 \rightarrow$ 342.17 g $Al_2(SO_4)_3$ + 190.65 g Cu

3. $Cu(NO_3)_2 + 2KOH \rightarrow Cu(OH)_2 + 2KNO_3$

1 formula unit $Cu(NO_3)_2$ + 2 formula units KOH $\rightarrow$ 1 formula unit $Cu(OH)_2$ + 2 formula units KNO_3

1 mole $Cu(NO_3)_2$ + 2 moles KOH $\rightarrow$ 1 mole $Cu(OH)_2$ + 2 moles KNO_3

$$1 \text{ mol } Cu(NO_3)_2 \times \frac{187.57 \text{ g } Cu(NO_3)_2}{1 \text{ mole } Cu(NO_3)_2} = 187.57 \text{ g } Cu(NO_3)_2$$

$$2 \text{ mol KOH} \times \frac{56.11 \text{ g KOH}}{1 \text{ mol KOH}} = 112.22 \text{ g KOH}$$

$$1 \text{ mol } Cu(OH)_2 \times \frac{97.56 \text{ g } Cu(OH)_2}{1 \text{ mol } Cu(OH)_2} = 97.57 \text{ g } Cu(OH)_2$$

$$2 \text{ mol } KNO_3 \times \frac{101.10 \text{ g } KNO_3}{1 \text{ mol } KNO_3} = 202.22 \text{ g } KNO_3$$

187.57 g $Cu(NO_3)_2$ + 112.22 g KOH $\rightarrow$ 97.57 g $Cu(OH)_2$ + 202.22 g KNO_3

4. Write and balance the equation for the decomposition of aluminum carbonate. Determine the possible mole ratios.

$Al_2(CO_3)_3(s) \rightarrow Al_2O_3(s) + 3CO_2(g)$

$$\frac{1 \text{ mol } Al_2(CO_3)_3}{1 \text{ mol } Al_2O_3} \quad \frac{1 \text{ mol } Al_2(CO_3)_3}{3 \text{ mol } CO_2}$$

$$\frac{1 \text{ mol } Al_2O_3}{1 \text{ mol } Al_2(CO_3)_3} \quad \frac{1 \text{ mol } Al_2O_3}{3 \text{ mol } CO_2}$$

$$\frac{3 \text{ mol } CO_2}{1 \text{ mol } Al_2(CO_3)_3} \quad \frac{3 \text{ mol } CO_2}{1 \text{ mol } Al_2O_3}$$

5. Write and balance the equation for the formation of magnesium hydroxide and hydrogen from magnesium and water. Determine the possible mole ratios.

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

$$\frac{1 \text{ mol Mg}}{2 \text{ mol } H_2O} \quad \frac{1 \text{ mol Mg}}{1 \text{ mol } Mg(OH)_2} \quad \frac{1 \text{ mol Mg}}{1 \text{ mol } H_2}$$

$$\frac{2 \text{ mol } H_2O}{1 \text{ mol Mg}} \quad \frac{2 \text{ mol } H_2O}{1 \text{ mol } Mg(OH)_2} \quad \frac{2 \text{ mol } H_2O}{1 \text{ mol } H_2}$$

$$\frac{1 \text{ mol } Mg(OH)_2}{1 \text{ mol Mg}} \quad \frac{1 \text{ mol } Mg(OH)_2}{2 \text{ mol } H_2O} \quad \frac{1 \text{ mol } Mg(OH)_2}{1 \text{ mol } H_2}$$

$$\frac{1 \text{ mol } H_2}{1 \text{ mol Mg}} \quad \frac{1 \text{ mol } H_2}{2 \text{ mol } H_2O} \quad \frac{1 \text{ mol } H_2}{1 \text{ mol } Mg(OH)_2}$$

Section 11.2

6. Some antacid tablets contain aluminum hydroxide. The aluminum hydroxide reacts with stomach acid according to the equation: $Al(OH)_3 + 3HCl \rightarrow AlCl_3 + 3H_2O$. Determine the moles of acid neutralized if a tablet contains 0.200 mol of $Al(OH)_3$.

$$0.200 \text{ mol } Al(OH)_3 \times \frac{3 \text{ mol HCl}}{1 \text{ mol } Al(OH)_3} = 0.600 \text{ mol HCl}$$

7. Chromium reacts with oxygen according to the equation: $4Cr + 3O_2 \rightarrow 2Cr_2O_3$. Determine the moles of chromium(III) oxide produced when 4.58 mol of chromium is allowed to react.

$$4.58 \text{ mol Cr} \times \frac{2 \text{ mol } Cr_2O_3}{4 \text{ mol Cr}} = 2.29 \text{ mol } Cr_2O_3$$

8. Space vehicles use solid lithium hydroxide to remove exhaled carbon dioxide according to the equation: $2LiOH + CO_2 \rightarrow Li_2CO_3 + H_2O$. Determine the mass of carbon dioxide removed if the space vehicle carries 42.0 mol of LiOH.

$$42.0 \text{ mol LiOH} \times \frac{1 \text{ mol } CO_2}{2 \text{ mol LiOH}} \times \frac{44.00 \text{ g } CO_2}{1 \text{ mol } CO_2}$$
$$= 924 \text{ g } CO_2$$

9. Some of the sulfur dioxide released into the atmosphere is converted to sulfuric acid according to the equation: $2SO_2 + 2H_2O + O_2 \rightarrow 2H_2SO_4$. Determine the mass of sulfuric acid formed from 3.20 mol of sulfur dioxide.

$$3.20 \text{ mol } SO_2 \times \frac{2 \text{ mol } H_2SO_4}{2 \text{ mol } SO_2} \times \frac{98.05 \text{ g } H_2SO_4}{1 \text{ mol } H_2SO_4}$$
$$= 314 \text{ g } H_2SO_4$$

10. How many grams of carbon dioxide are produced when 2.50 g of sodium hydrogen carbonate reacts with excess citric acid according to the equation: $3NaHCO_3 + H_3C_6H_5O_7 \rightarrow Na_3C_6H_5O_7 + 3CO_2 + 3H_2O$?

$$2.50 \text{ g } NaHCO_3 \times \frac{1 \text{ mol } NaHCO_3}{84.01 \text{ g } NaHCO_3}$$
$$\times \frac{3 \text{ mol } CO_2}{3 \text{ mol } NaHCO_3} \times \frac{44.00 \text{ g } CO_2}{1 \text{ mol } CO_2} = 1.31 \text{ g } CO_2$$

11. Aspirin ($C_9H_8O_4$) is produced when salicylic acid ($C_7H_6O_3$) reacts with acetic anhydride ($C_4H_6O_3$) according to the equation: $C_7H_6O_3 + C_4H_6O_3 \rightarrow C_9H_8O_4 + HC_2H_3O_2$. Determine the mass of aspirin produced when 150.0 g of salicylic acid reacts with an excess of acetic anhydride.

$$150.0 \text{ g } C_7H_6O_3 \times \frac{1 \text{ mol } C_7H_6O_3}{138.10 \text{ g } C_7H_6O_3}$$
$$\times \frac{1 \text{ mol } C_9H_8O_4}{1 \text{ mol } C_7H_6O_3} \times \frac{180.13 \text{ g } C_9H_8O_4}{1 \text{ mol } C_9H_8O_4}$$
$$= 195.7 \text{ g } C_9H_8O_4$$

Section 11.3

p.983 #12-13

12. Chlorine reacts with benzene to produce chlorobenzene and hydrogen chloride, $Cl_2 + C_6H_6 \rightarrow C_6H_5Cl + HCl$. Determine the limiting reactant if 45.0 g of benzene reacts with 45.0 g of chlorine, the mass of the excess reactant after the reaction is complete, and the mass of chlorobenzene produced.

$$45.0 \text{ g } C_6H_6 \times \frac{1 \text{ mol } C_6H_6}{78.11 \text{ g } C_6H_6} = 0.576 \text{ mol } C_6H_6$$

$$45.0 \text{ g } Cl_2 \times \frac{1 \text{ mol } Cl_2}{70.90 \text{ g } Cl_2} = 0.635 \text{ mol } Cl_2$$

The actual ratio of available moles of C_6H_6 and Cl_2 is $\frac{0.576 \text{ mol } C_6H_6}{0.635 \text{ mol } Cl_2} = \frac{0.907 \text{ mol } C_6H_6}{1 \text{ mol } Cl_2}$

According to the balanced equation, there must be a one-to-one mole ratio. Thus, benzene is the limiting reactant.

moles of excess reactant
$= 0.635 \text{ mol } Cl_2 - 0.576 \text{ mol } Cl_2 = 0.059 \text{ mol } Cl_2$

mass of excess reactant $= 0.059 \text{ mol } Cl_2$
$$\times \frac{70.90 \text{ g } Cl_2}{1 \text{ mol } Cl_2} = 4.2 \text{ g } Cl_2 \text{ is in excess}$$

mass of chlorobenzene produced

$$= 0.576 \text{ mol } C_6H_6 \times \frac{1 \text{ mol } C_6H_5Cl}{1 \text{ mol } C_6H_6}$$
$$\times \frac{112.56 \text{ g } C_6H_5Cl}{1 \text{ mol } C_6H_5Cl} = 64.8 \text{ g } C_6H_5Cl$$

13. Nickel reacts with hydrochloric acid to produce nickel(II) chloride and hydrogen according to the equation: $Ni + 2HCl \rightarrow NiCl_2 + H_2$. If 5.00 g of Ni and 2.50 g of HCl react, determine the limiting reactant, the mass of the excess reactant after the reaction is complete, and the mass of nickel(II) chloride produced.

$$5.00\ g\ Ni \times \frac{1\ mol\ Ni}{58.69\ g\ Ni} = 0.0852\ mol\ Ni$$

$$2.50\ g\ HCl \times \frac{1\ mol\ HCl}{36.46\ g\ HCl} = 0.0686\ mol\ HCl$$

The actual ratio of available moles of Ni and HCl is

$$\frac{0.0852\ mol\ Ni}{0.0686\ mol\ HCl} = \frac{1.24\ mol\ Ni}{1\ mol\ HCl}$$

According to the balanced equation, there must be a one-to-one mole ratio. Thus HCl is the limiting reactant.

moles of Ni needed for the reaction

$$= 0.0686\ mol\ HCl \times \frac{1\ mol\ Ni}{2\ mol\ HCl} = 0.0343\ mol\ Ni$$

moles of excess Ni = 0.0852 mol Ni given − 0.0343 mol Ni needed = 0.0509 mol Ni

mass of excess reactant

$$= 0.0509\ mol\ Ni \times \frac{58.69\ g\ Ni}{1\ mol\ Ni} = 2.99\ g\ Ni$$

mass of $NiCl_2$ produced

$$= 0.0343\ mol\ Ni \times \frac{1\ mol\ NiCl_2}{1\ mol\ Ni} \times \frac{129.59\ g\ NiCl_2}{1\ mol\ NiCl_2} = 4.44\ g\ NiCl_2$$

p. 983 # 14-15

Section 11.4

14. Tin(IV) iodide is prepared by reacting tin with iodine. Write the balanced chemical equation for the reaction. Determine the theoretical yield if a 5.00−g sample of tin reacts in an excess of iodine. Determine the percent yield if 25.0 g of SnI_4 was recovered.

$$Sn + 2I_2 \rightarrow SnI_4$$

$$\text{theoretical yield} = 5.00\ g\ Sn \times \frac{1\ mol\ Sn}{118.71\ g\ Sn} \times \frac{1\ mol\ SnI_4}{1\ mol\ Sn} \times \frac{626.31\ g\ SnI_4}{1\ mol\ SnI_4} = 26.4\ g\ SnI_4$$

$$\text{percent yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

$$= \frac{25.0\ g}{26.4\ g} \times 100 = 94.7\%\ \text{yield}$$

15. Gold is extracted from gold-bearing rock by adding sodium cyanide in the presence of oxygen and water, according to the reaction: $4\ Au(s) + 8\ NaCN(aq) + O_2(g) + 2H_2O(l) \rightarrow 4\ NaAu(CN)_2(aq) + NaOH(aq)$. Determine the theoretical yield of $NaAu(CN)_2$ if 1000.0 g of gold-bearing rock is used, which contains 3.00% gold by mass. Determine the percent yield of $NaAu(CN)_2$ if 38.790 g of $NaAu(CN)_2$ is recovered.

amount of gold in the rock

$$= 1000.0\ g\ rock \times \frac{3.00\ g\ Au}{100.0\ g\ rock} = 30.0\ g\ Au$$

$$\text{theoretical yield} = 30.0\ g\ Au \times \frac{1\ mol\ Au}{196.97\ g\ Au} \times \frac{4\ mol\ NaAu(Cn)_2}{4\ mol\ Au} \times \frac{271.99\ g\ NaAu(CN)_2}{1\ mol\ NaAu(CN)_2}$$

$$= 41.4\ g\ NaAu(CN)_2$$

$$\text{percent yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

$$= \frac{38.790\ g}{41.4\ g} \times 100 = 93.7\%\ \text{yield}$$

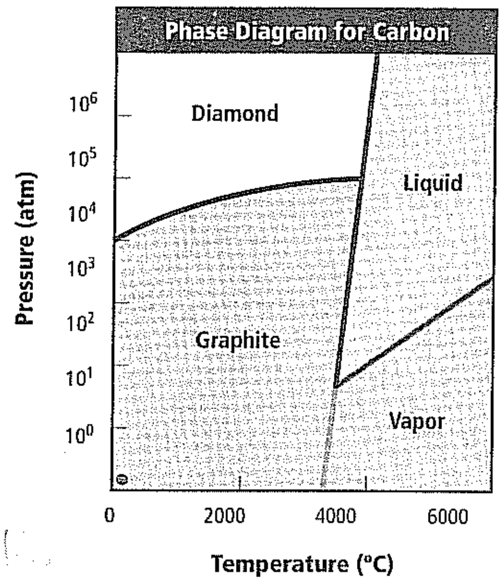
P.438 #5-8

5. Which does not affect the viscosity of a liquid?

a. intermolecular attractive forces
b. size and shape of molecules
c. temperature of the liquid
d. capillary action

d

Use the graph below to answer Questions 6–8.



6. Under what conditions is diamond most likely to form?

a. temperatures > 5000 K and pressures < 100 atm
b. temperatures > 6000 K and pressures > 25 atm
c. temperatures < 3500 K and pressures > 10^5 atm
d. temperatures < 4500 K and pressures < 10 atm

c

7. Find the point on the graph at which carbon exists in three phases: solid graphite, solid diamond, and liquid carbon. What are the temperature and pressure at that point?

a. 4700 K and 10^6 atm
b. 3000 K and 10^3 atm
c. 5100 K and 10^5 atm
d. 3500 K and 80 atm

d

8. In what form or forms does carbon exist at 6000 K and 10^5 atm?

a. diamond only
b. liquid carbon only
c. diamond and liquid carbon
d. liquid carbon and graphite

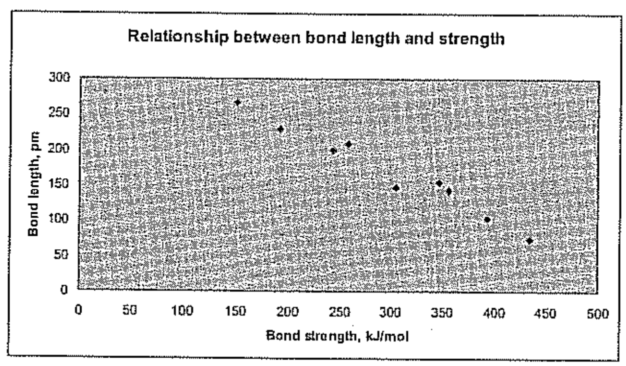
b

Use the table below to answer Questions 9–10.

Properties of Single Bonds

Bond	Strength (kJ/mol)	Length (pm)
H—H	435	74
Br—Br	192	228
C—C	347	154
C—H	393	104
C—N	305	147
C—O	356	143
Cl—Cl	243	199
I—I	151	267
S—S	259	208

9. Create a graph to show how bond length varies with bond strength. Place bond strength on the *x*-axis.



10. Summarize the relationship between bond strength and bond length.

As the bond strength increases, the bond length decreases.

K_{eq} v. Temperature			
700 K	800 K	900 K	1000 K
9.10×10^{97}	1.04×10^{66}	4.66×10^{54}	3.27×10^{45}

103. Write the equilibrium constant expression for this equilibrium.

$$K_{eq} = \frac{[N_2][CO_2]^2}{[N]^2[CO]^2}$$

104. Examine the relationship between K_{eq} and temperature. Use Le Chatelier's principle to deduce whether the forward reaction is exothermic or endothermic.

Because K_{eq} decreases with increasing temperature, the forward reaction is exothermic.

105. Explain how automobile radiators plated with the alloy might help reduce the atmospheric concentrations of NO and CO.

Automobile radiators operate at elevated temperatures, and automobiles effectively sweep large amounts of air as they travel from place to place. Therefore, automobile radiators plated with the alloy could convert significant volumes of the pollutants, NO and CO, to the less harmful substances N_2 and CO_2.

Standardized Test Practice

pages 630–631

Multiple Choice

1. Which describes a system that has reached chemical equilibrium?

a. No new product is formed by the forward reaction.
b. The reverse reaction no longer occurs in the system.
c. The concentration of reactants in the system is equal to the concentration of products.
d. The rate at which the forward reaction occurs equals the rate of the reverse reaction.

d

2. The reaction between persulfate ($S_2O_8^{2-}$) and iodide (I^-) ions is often studied in student laboratories because it occurs slowly enough for its rate to be measured:

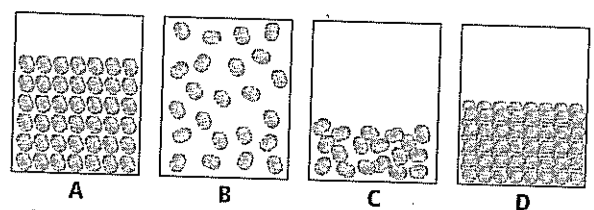
$$S_2O_8^{2-}(aq) + 2I^-(aq) \rightarrow 2SO_0^{2-}(aq) + I_2(aq)$$

This reaction has been experimentally determined to be first order in $S_2O_8^{2-}$ and first order in I^-. Therefore, what is the overall rate law for this reaction?

a. rate = $k[S_2O_8^{2-}]^2[I^-]$
b. rate = $k[S_2O_82^-][I^-]$
c. rate = $k[S_2O_82^-][I^-]^2$
d. rate = $k[S_2O_82^-]^2[I^-]^2$

b

Use the diagrams below to answer Question 3.



3. Which diagram shows the substance that has the weakest intermolecular forces?

a. A
b. B
c. C
d. D

b

p. 630
#3-4

p. 630 #4

4. Which type of intermolecular force results from a temporary imbalance in the electron density around the nucleus of an atom?

a. ionic bonds
b. London dispersion forces
c. dipole-dipole forces
d. hydrogen bonds

b

Use the table below to answer Questions 5–7.

Concentration Data for the Equilibrium System $MnCO_3(s) \rightarrow Mn^{2+}(aq) + CO_3^{2-}(aq)$ at 298 K

Trial	$[Mn^{21}]_0$ (M)	$[CO_3 2^2]_0$ (M)	$[Mn^{21}]_{eq}$ (M)	$[CO_3 2^2]_{eq}$ (M)
1	0.0000	0.00400	5.60×10^{-9}	4.00×10^{-3}
2	0.0100	0.0000	1.00×10^{-2}	2.24×10^{-9}
3	0.0000	0.0200	1.12×10^{-9}	2.00×10^{-2}

5. What is the K_{sp} for $MnCO_3$?

a. 2.24×10^{-11}
b. 4.00×10^{-11}
c. 1.12×10^{-9}
d. 5.60×10^{-9}

a

$MnCO_3(s) \longleftrightarrow Mn^{2+}(aq) + CO_3^{2-}(aq)$

$K_{sp} = [Mn^{2+}][CO_3^{2-}] = (5.6 \times 10^{-9})(4.00 \times 10^{-3})$
$= 2.24 \times 10^{-11})$

6. What is the molar solubility of $MnCO_3$ at 298 K?

a. $4.73 \times 10^{-6} M$
b. $6.32 \times 10^{-2} M$
c. $7.48 \times 10^{-5} M$
d. $3.35 \times 10^{-5} M$

a

$MnCO_3(s) \longleftrightarrow Mn^{2+}(aq) + CO_3^{2-}(aq)$

solubility $= s = [Mn^{2+}] = [CO_3^{2-}]$

$(s)(s) = s^2 = 2.24 \times 10^{-11}$

$s = \sqrt{2.24} \times 10^{-11} = 4.73 \times 10^{-6} M$

7. A 50.0-mL volume of $3.00 \times 10^{-6} M$ K_2CO_3 is mixed with 50.0 mL of $MnCl_2$. A precipitate of $MnCO_3$ will form only when the concentration of the $MnCl_2$ solution is greater than which of the following?

a. $7.47 \times 10^{-6} M$
b. $1.49 \times 10^{-5} M$
c. $2.99 \times 10^{-5} M$
d. $1.02 \times 10^{-5} M$

c

Because the volume of solution is doubled, $[CO_3^{2-}]$ in the mixed solution is $\frac{3.00 \times 10^{-6}\ M}{2}$ $= 1.5 \times 10^{-6} M$

$[Mn^{2+}][CO_3^{2-}] = [Mn^{2+}](1.5 \times 10^{-6})$ $= 2.24 \times 10^{-11}$

$[Mn^{2+}] = 1.49 \times 10^{-5} M = [Mn^{2+}]$ in the mixed solution. To form a precipitate, the concentration of the original solution of $MnCl_2$ $= 2(x) = 2(1.49 \times 10^{-5} M)$ $= 2.99 \times 10^{-5} M$

8. The kinetic-molecular theory describes the microscopic behavior of gases. One main point of the theory is that within a sample of gas, the frequency of collisions between individual gas particles and between the particles and the walls of their container increases if the sample is compressed. Which gas law states this relationship in mathematical terms?

a. Gay-Lussac's law
b. Charles's law
c. Boyle's law
d. Avogadro's law

c

9. $AB(s) + C_2(l) \longrightarrow AC(g) + BC(g)$

Which cannot be predicted about this reaction?

a. The entropy of the system decreases.
b. The entropy of the products is higher than that of the reactants.
c. The change in entropy for this reaction, ΔS_{rxn}, is positive.
d. The disorder of the system increases.

a

Chapter 12

Section 12.1

1. Calculate the ratio of effusion rates for methane (CH_4) and nitrogen.

$$\frac{Rate_A}{Rate_B} = \sqrt{\frac{\text{molar mass}_B}{\text{molar mass}_A}}$$

$$\frac{Rate_{methane}}{Rate_{nitrogen}} = \sqrt{\frac{28.01\ g/mol}{16.04\ g/mol}}$$

$$= \sqrt{1.75} = 1.32$$

The ratio of effusion rates is 1.32:1.

2. Calculate the molar mass of butane. Butane's rate of diffusion is 3.8 times slower than that of helium.

$$\frac{Rate_A}{Rate_B} = \sqrt{\frac{\text{molar mass}_B}{\text{molar mass}_A}}$$

$$\frac{Rate_{helium}}{Rate_{butane}} = \sqrt{\frac{\text{molar mass}_{butane}}{\text{molar mass}_{helium}}}$$

$$3.8 = \sqrt{\frac{\text{molar mass}_{butane}}{4.003\ g/mol}}$$

$$3.8^2 = \frac{\text{molar mass}_{butane}}{4.003\ g/mol}$$

$\text{molar mass}_{butane} = 58\ g/mol$

3. What is the total pressure in a canister that contains oxygen gas at a partial pressure of 804 mm Hg, nitrogen at a partial pressure of 220 mm Hg, and hydrogen at a partial pressure of 445 mm Hg?

$P_{total} = P_{O_2} + P_{N_2} + P_{H_2}$

$P_{total} = 804\ mm\ Hg + 220\ mm\ Hg + 445\ mm\ Hg = 1469\ mm\ Hg$

4. Calculate the partial pressure of neon in a flask that has a total pressure of 1.87 atm. The flask contains krypton at a partial pressure of 0.77 atm and helium at a partial pressure of 0.62 atm.

$P_{total} = P_{Kr} + P_{He} + P_{Ne}$

$P_{Ne} = P_{total} - P_{Kr} - P_{He}$
$= 1.87\ atm - 0.77\ atm - 0.62\ atm$
$= 0.48\ atm$

P. 984 #1-9

Chapter 13

Section 13.1

1. The pressure of air in a 2.25-L container is 1.20 atm. What is the new pressure if the sample is transferred to a 6.50-L container? Temperature is constant.

$$P_2 = \frac{P_1V_1}{V_2} = \frac{(2.25\ L)(1.20\ atm)}{6.50\ L} = 0.415\ atm$$

2. The volume of a sample of hydrogen gas at 0.997 atm is 5.00 L. What will be the new volume if the pressure is decreased to 0.977 atm? Temperature is constant.

$$V_2 = \frac{P_1V_1}{P_2} = \frac{(0.997\ atm)(5.00\ L)}{0.977\ atm} = 5.10\ L$$

3. A gas at 55.0°C occupies a volume of 3.60 L. What volume will it occupy at 30.0°C? Pressure is constant.

$T_C + 273 = T_K$

$55.0°C + 273 = 328\ K$

$30.0°C + 273 = 303\ K$

$$V_2 = \frac{V_1T_2}{T_1} = \frac{(3.60\ L)(303\ K)}{328\ K} = 3.33\ L$$

4. The volume of a gas is 0.668 L at 66.8°C. At what Celsius temperature will the gas have a volume of 0.942 L, assuming pressure remains constant?

$T_C + 273 = T_K$

$66.8°C + 273 = 340\ K$

$$T_2 = \frac{T_1V_2}{V_1} = \frac{(340\ K)(0.942\ L)}{0.668\ L} = 479\ K$$

$T_C + 273 = T_K$

$T_C = T_K - 273$

$= 479\ K - 273 = 206°C$

5. The pressure in a bicycle tire is 1.34 atm at 33.0°C. At what temperature will the pressure inside the tire be 1.60 atm? Volume is constant.

$T_C + 273 = T_K$

$33.0°C + 273 = 306\ K$

$$T_2 = \frac{P_2T_1}{P_1} = \frac{(1.60\ atm)(306\ K)}{1.34\ atm} = 365\ K$$

$T_C = T_K - 273$

$= 365\ K - 273 = 92°C$

6. If a sample of oxygen gas has a pressure of 810 torr at 298 K, what will be its pressure if its temperature is raised to 330 K?

$$P_2 = \frac{P_1T_2}{P_1} = \frac{(810\ torr)(330\ K)}{298\ K} = 9.0 \times 10^2\ torr$$

7. Air in a tightly sealed bottle has a pressure of 0.978 atm at 25.5°C. What will be its pressure if the temperature is raised to 46.0°C?

$T_C + 273 = T_K$

$25.5°C + 273 = 299\ K$

$46.0°C + 273 = 319\ K$

$$P_2 = \frac{P_1T_2}{T_1} = \frac{(0.978\ atm)(319\ K)}{299\ K} = 1.04\ atm$$

8. Hydrogen gas at a temperature of 22.0°C that is confined in a 5.00-L cylinder exerts a pressure of 4.20 atm. If the gas is released into a 10.0-L reaction vessel at a temperature of 33.6°C, what will be the pressure inside the reaction vessel?

$T_C + 273 = T_K$

$22.0°C + 273 = 295\ K$

$33.6°C + 273 = 307\ K$

$$P_2 = \frac{P_1V_1T_2}{V_2T_1} = \frac{(4.20\ atm)(5.00\ L)(307\ K)}{(10.0\ L)(295\ K)}$$

$= 2.19\ atm$

9. A sample of neon gas at a pressure of 1.08 atm fills a flask with a volume of 250 mL at a temperature of 24.0°C. If the gas is transferred to another flask at 37.2°C at a pressure of 2.25 atm, what is the volume of the new flask?

$T_C + 273 = T_K$

$24.0°C + 273 = 297\ K$

$37.2°C + 273 = 310\ K$

$$V_2 = \frac{P_1V_1T_2}{P_2T_1} = \frac{(1.08\ atm)(250\ mL)(310\ K)}{(2.25\ atm)(297\ K)}$$

$= 130\ mL$

Section 13.2

P. 984 #10-18

10. What volume of beaker contains exactly 2.23×10^{-2} mol of nitrogen gas at STP?

$$V = 2.23 \times 10^{-2}\ mol\ N_2 \times \frac{22.4\ L}{1\ mol\ N_2} = 0.500\ L$$

11. How many moles of air are in a 6.06-L tire at STP?

$$n = 6.06\ L \times \frac{1\ mol\ air}{22.4\ L} = 0.271\ mol\ air$$

12. How many moles of oxygen are in a 5.5-L canister at STP?

$$n = 5.5\ L \times \frac{1\ mol\ O_2}{22.4\ L} = 0.25\ mol\ O_2$$

13. What mass of helium is in a 2.00-L balloon at STP?

$$2.00\ L \times \frac{1\ mol\ He}{22.4\ L} \times \frac{4.00\ g\ He}{1\ mol\ He} = 0.357\ g\ He$$

14. What volume will 2.3 kg of nitrogen gas occupy at STP?

$$2.3\ kg\ N_2 \times \frac{10^3\ g\ N_2}{1\ kg\ N_2} \times \frac{1\ mol\ N_2}{28.01\ g\ N_2} \times \frac{22.4\ L\ N_2}{1\ mol\ N_2}$$

$= 1.8 \times 10^3\ L\ N_2$

15. Calculate the number of moles of gas that occupy a 3.45-L container at a pressure of 150 kPa and a temperature of 45.6°C.

$T_C + 273 = T_K$

$45.6°C + 273 = 319\ K$

$PV = nRT$

$n = \frac{PV}{RT} = \frac{(150\ kPa)(3.45\ L)}{(8.314\ L\cdot kPa/mol\cdot K)(319\ K)} = 0.20\ mol$

16. What is the pressure in torr that a 0.44-g sample of carbon dioxide gas will exert at a temperature of 46.2°C when it occupies a volume of 5.00 L?

$0.44\ g\ CO_2 \times \frac{1\ mol\ CO_2}{44.01\ g\ CO_2} = 1.0 \times 10^{-2}\ mol\ CO_2$

$T_C + 273 = T_K$

$46.2°C + 273 = 319\ K$

$PV = nRT$

$P = \frac{nRT}{V}$

$= \frac{(1.0 \times 10^{-2}\ mol)(62.4\ mm\ Hg\cdot L/mol\cdot K)(319\ K)}{(5.00\ L)}$

$= 4.0 \times 10^{1}\ mm\ Hg$

$4.0 \times 10^{1}\ mm\ Hg \times \frac{1\ torr}{1\ mm\ Hg} = 4.0 \times 10^{1}\ torr$

17. What is the molar mass of a gas that has a density of 1.02 g/L at 0.990 atm pressure and 37°C?

$T_C + 273 = T_K$

$37°C + 273 = 310\ K$

$M = \frac{DRT}{P}$

$= \frac{(1.02\ g/L)(0.0821\ L\cdot atm/mol\cdot K)(310\ K)}{0.990\ atm}$

$= 26\ g/mol$

18. Calculate the grams of oxygen gas present in a 2.50-L sample kept at 1.66 atm pressure and a temperature of 10.0°C.

$n = \frac{PV}{RT} = \frac{(1.66\ atm)(2.50\ L)}{(0.0821\ L\cdot atm/mol\cdot K)(283\ K)}$

$= 0.179\ mol$

$0.179\ mol\ O_2 \times \frac{32.00\ g\ O_2}{1\ mol\ O_2} = 5.72\ g\ O_2$

Section 13.3

19. What volume of oxygen gas is needed to completely combust 0.202 L of butane (C_4H_{10}) gas?

$2C_4H_{10}(g) + 13O_2(g) \rightarrow 8CO_2(g) + 10H_2O(g)$

$0.202\ L\ C_4H_{10} \times \frac{13\ mol\ O_2}{2\ mol\ C_4H_{10}} = 1.31\ L\ O_2$

20. Determine the volume of methane gas (CH_4) needed to react completely with 0.660 L of O_2 gas to form methanol (CH_3OH).

$2CH_4(g) + O_2(g) \rightarrow 2CH_3OH(g)$

$0.660\ L\ O_2 \times \frac{2\ L\ CH_4}{1\ L\ O_2} = 1.32\ L\ CH_4$

21. Calculate the mass of hydrogen peroxide needed to obtain 0.460 L of oxygen gas at STP. $2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$

$0.460\ L\ O_2 \times \frac{1\ mol\ O_2}{22.4\ L\ O_2} = 2.05 \times 10^{-2}\ mol\ O_2$

$2.05 \times 10^{-2}\ mol\ O_2 \times \frac{2\ mol\ H_2O_2}{1\ mol\ O_2} \times \frac{34.02\ H_2O_2}{1\ mol\ H_2O_2}$

$= 1.40\ g\ H_2O_2$

22. When potassium chlorate is heated in the presence of a catalyst such as manganese dioxide, it decomposes to form solid potassium chloride and oxygen gas: $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$. How many liters of oxygen will be produced at STP if 1.25 kg of potassium chlorate decomposes completely?

$1.25\ kg\ KClO_3 \times \frac{1000\ g}{1\ kg} \times \frac{1\ mol\ KClO_3}{122.55\ g\ KClO_3}$

$= 10.2\ mol\ KClO_3$

$10.2\ mol\ KClO_3 \times \frac{3\ mol\ O_2}{2\ mol\ KClO_3} \times \frac{22.4\ L\ O_2}{1\ mol\ O_2}$

$= 343\ L\ O_2$

Chapter 14

P 985 # 1-D

Section 14.2

1. What is the percent by mass of a sample of ocean water that is found to contain 1.36 grams of magnesium ions per 1000 g?

$\text{percent by mass} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 100$

$= \frac{1.36\ g\ Mg^{2+}}{1000.0\ g\ solution} \times 100 = 0.136\%$

2. What is the percent by mass of iced tea containing 0.75 g of aspartame in 250 g of water?

$\text{percent by mass} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 100$

$= \frac{0.75\ g\ aspartame}{250\ g\ water + 0.75\ g\ aspartame} \times 100$

$= 0.30\%$

3. A bottle of hydrogen peroxide is labeled 3%. If you pour out 50 mL of hydrogen peroxide solution, what volume is actually hydrogen peroxide?

$50\ mL\ H_2O_2 \times \frac{3\ mL\ H_2O_2}{100\ mL\ solution} = 2\ mL\ H_2O_2$

4. If 50 mL of pure acetone is mixed with 450 mL of water, what is the percent volume?

$\text{percent by volume} = \frac{\text{volume of solute}}{\text{volume of solution}} \times 100$

$= \frac{50\ mL}{50\ mL + 450\ mL} \times 100 = 10\%$

P. 985 # 5-6

5. Calculate the molarity of 1270 g K_3PO_4 in 4.0 L aqueous solution.

$1270\ g\ K_3PO_4 \times \frac{1\ mol\ K_3PO_4}{212.27\ g\ K_3PO_4} = 5.89\ mol\ K_3PO_4$

$\text{molarity} = \frac{\text{moles of solute}}{\text{liters of solution}}$

$= \frac{5.98\ mol\ K_3PO_4}{4.0\ L\ solution} = 1.5M\ K_3PO_4$

6. What is the molarity of 90.0 g NH_4Cl in 2.25 L aqueous solution?

$90.0\ g\ NH_4Cl \times \frac{1 mol\ NH_4Cl}{53.50\ g\ NH_4Cl} = 1.68\ mol\ NH_4Cl$

$\text{molarity} = \frac{\text{moles of solute}}{\text{liters of solution}}$

$= \frac{1.68\ mol\ NH_4Cl}{2.25\ L\ solution} = 0.747M\ NH_4Cl$

7. Which is more concentrated, 25 g NaCl dissolved in 500 mL of water or a 10% solution of NaCl (percent by mass)?

Percent by mass of 25 g NaCl in 500 mL of water:

$500\ mL\ H_2O \times \frac{1\ g\ H_2O}{1\ mL\ H_2O} = 500\ g\ H_2O$

mass of solution = mass of solute + mass of solvent = 25 g NaCl + 500 g H_2O = 525 g solution

$\text{percent by mass} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 100$

$= \frac{25\ g\ NaCl}{525\ g\ solution} \times 100$

$= 4.8\%$

10% solution of NaCl is more concentrated.

8. Calculate the mass of NaOH required to prepare a 0.343*M* solution dissolved in 2500 mL of water.

$2500\ mL\ solution \times \frac{0.343\ mol\ NaOH}{1000\ mL\ solution}$

$\times \frac{40.00\ g\ NaOH}{1\ mol\ NaOH} = 34\ g\ NaOH$

9. Calculate the volume required to dissolve 11.2 g $CuSO_4$ to prepare a 0.140*M* solution.

$11.2\ g\ CuSO_4 \times \frac{1\ mol\ CuSO_4}{159.62\ g\ CuSO_4}$

$\times \frac{1\ L}{0.140\ mol\ CuSO_4} \times \frac{10^3\ mL}{1\ L} = 501\ mL$

10. How would you prepare 500 mL of a solution that has a new concentration of 4.5*M* if the stock solution is 11.6*M*?

$M_1V_1 = M_2V_2$

$V_1 = \frac{M_2V_2}{M_1}$

$= \frac{(4.5M)(500.0\ mL)}{11.6M} = 194\ mL\ of\ stock\ solution$

194 mL of stock solution and 306 mL of water

21. Calculate the freezing point and boiling point of a solution containing 0.15 mol of the molecular compound naphthalene in 175 g of benzene (C_6H_6).

$$175\ \text{g } C_6H_6 \times \frac{1\ \text{kg } C_6H_6}{10^3\ \text{g } C_6H_6} = 0.175\ \text{kg } C_6H_6$$

$$\text{molality} = \frac{\text{moles of solute}}{\text{kg of solvent}}$$
$$= \frac{0.15\ \text{mol naphthalene}}{0.175\ \text{kg } C_6H_6} = 0.86m$$

$\Delta T_f = K_f m$
for benzene, $K_f = 5.12°C/m$
$\Delta T_f = (5.12°C/m)(0.86m) = 4.4°C$
freezing point = 5.5°C − 4.4°C = 1.1°C

$\Delta T_b = K_b m$
for benzene, $K_b = 2.53°C/m$
$\Delta T_b = (2.53°C/m)(0.86m) = 2.2°C$
boiling point = 80.1°C + 2.2°C = 82.3°C

Chapter 15

Section 15.1

1. What is the equivalent in joules of 126 Calories?

$$126\ \text{Calories} \times \frac{10^3\ \text{cal}}{1\ \text{Calorie}} \times \frac{4.184\ \text{J}}{1\ \text{cal}} = 5.27 \times 10^5\ \text{J}$$

2. Convert 455 kilojoules to kilocalories.

$$455\ \text{kJ} \times \frac{10^3\ \text{J}}{1\ \text{kJ}} \times \frac{1\ \text{cal}}{4.184\ \text{J}} \times \frac{1\ \text{kcal}}{10^3\ \text{cal}} = 109\ \text{kcal}$$

3. How much heat is required to warm 122 g of water by 23.0°C?

$q = cm\Delta T$
$= (4.184\ \text{J/g}\cdot°C)(122\ \text{g})(23.0°C)$
$= 1.17 \times 10^4\ \text{J}$

4. The temperature of 55.6 grams of a material decreases by 14.8°C when it loses 3080 J of heat. What is its specific heat?

$q = cm\Delta T$

$$c = \frac{q}{m\Delta T}$$
$$= \frac{3080\ \text{J}}{(55.6\ \text{g})(14.8°C)}$$
$= 3.74\ \text{J/(g}\cdot°C)$

5. What is the specific heat of a metal if the temperature of a 12.5-g sample increases from 19.5°C to 33.6°C when it absorbs 37.7 J of heat?

$q = cm\Delta T$

$c = q/m\Delta T$
$$= \frac{37.7\ \text{J}}{(12.5\text{g})(14.1°C)}$$
$= 0.214\ \text{J/(g}\cdot°C)$

Section 15.2

6. A 75.0-g sample of a metal is placed in boiling water until its temperature is 100.0°C. A calorimeter contains 100.00 g of water at a temperature of 24.4°C. The metal sample is removed from the boiling water and immediately placed in water in the calorimeter. The final temperature of the metal and water in the calorimeter is 34.9°C. Assuming that the calorimeter provides perfect insulation, what is the specific heat of the metal?

$\Delta T_{water} = 34.9°C - 24.4°C = 10.5°C$
$\Delta T_{metal} = 100.0°C - 34.9°C = 65.1°C$

The heat lost by the metal equals the heat gained by the water.

$q_{water} = cm\Delta T$
$= (4.184\ \text{J/g}\cdot°C)(100.0\ \text{g})(10.5°C)$
$= 4393\ \text{J}$

$$c_{metal} = \frac{q}{m\Delta T}$$
$$= \frac{4393\ \text{J}}{(75.0\ \text{g metal})(65.1°C)} = 0.900\ \text{J/(g}\cdot°C)$$

p. 986 #1-8

Section 15.3

7. Use **Table 15.4** to determine how much heat is released when 1.00 mole of gaseous methanol condenses to a liquid.

$\Delta H_{vap} = 35.2\ \text{kJ/mol}$

$$1\ \text{mol methanol} \times \frac{35.2\ \text{kJ}}{1\ \text{mol methanol}} = 35.2\ \text{kJ}$$

p986 #8

8. Use Table 15.4 to determine how much heat must be supplied to melt 4.60 grams of ethanol.

$\Delta H_{fus} = 4.94$ kJ/mol

$4.60 \text{ g } C_2H_5OH \times \frac{1 \text{ mol } C_2H_5OH}{46.08 \text{ g } C_2H_5OH}$
$= 0.100 \text{ mol } C_2H_5OH$

$0.100 \text{ mol } C_2H_5OH \times \frac{4.94 \text{ kJ}}{1 \text{ mol } C_2H_5OH} = 0.494 \text{ kJ}$

Section 15.4

9. Calculate ΔH_{rxn} for the reaction $2C(s) + 2H_2(g) \rightarrow C_2H_4(g)$ given the following thermochemical equations:

$2CO_2(g) + 2H_2O(l) \rightarrow C_2H_4(g) + 3O_2(g)$ $\Delta H = 1411$ kJ
$C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H = -393.5$ kJ
$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ $\Delta H = -572$ kJ

$2CO_2(g) + 2H_2O(l) \rightarrow C_2H_4(g) + 3O_2(g)$ $\Delta H = 1411$ kJ
$2[C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H = -393.5$ kJ]
$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ $\Delta H = -572$ kJ

$2C(s) + 2H_2(g) \rightarrow C_2H_4(g)$

$\Delta H = 1411 \text{ kJ} + 2(-393.5 \text{ kJ}) + (-572 \text{ kJ}) = 52 \text{ kJ}$

10. Calculate ΔH_{rxn} for the reaction $HCl(g) + NH_3(g) \rightarrow NH_4Cl(s)$ given the following thermochemical equations:

$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$ $\Delta H = -184$ kJ
$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$ $\Delta H = -92$ kJ
$N_2(g) + 4H_2(g) + Cl_2(g) \rightarrow 2NH_4Cl(s)$ $\Delta H = -628$ kJ

$2HCl(g) \rightarrow H_2(g) + Cl_2(g)$ $\Delta H = 184$ kJ
$2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$ $\Delta H = 92$ kJ
$N_2(g) + 4H_2(g) + Cl_2(g) \rightarrow 2NH_4Cl(s)$ $\Delta H = -628$ kJ

$2HCl(g) + 2NH_3(g) \rightarrow 2NH_4Cl(s)$ $\Delta H = -352$ kJ

$\frac{1}{2}[2HCl(g) + 2NH_3(g) \rightarrow 2NH_4Cl(s)$ $\Delta H = -352$ kJ]

$HCl(g) + NH_3(g) \rightarrow NH_4Cl(s)$ $\Delta H = -176$ kJ

Use standard enthalpies of formation from Table 15.5 and Table R.11 to calculate ΔH°_{rxn} for each of the following reactions.

11. $2HF(g) \rightarrow H_2(g) + F_2(g)$

$\Delta H^\circ_f(HF) = -273$ kJ

$\Delta H^\circ_f(HF_2) = 0.0$ kJ

$\Delta H^\circ_f(F_2) = 0.0$ kJ

$\Delta H^\circ_{rxn} = \Sigma\Delta H^\circ_f(\text{products}) - \Sigma\Delta H^\circ_f(\text{reactants})$

$\Delta H^\circ_{rxn} = (0.0 \text{ kJ} + 0.0 \text{ kJ}) - 2(-273 \text{ kJ}) = 546 \text{kJ}$

12. $2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(l) + 2SO_2(g)$

$\Delta H^\circ_f(H_2S) = -21$ kJ

$\Delta H^\circ_f(O_2) = 0.0$ kJ

$\Delta H^\circ_f(H_2O) = -286$ kJ

$\Delta H^\circ_f(SO_2) = -297$ kJ

$\Delta H^\circ_{rxn} = \Sigma\Delta H^\circ_f(\text{products}) - \Sigma\Delta H^\circ_f(\text{reactants})$

$\Delta H^\circ_{rxn} = [2(-286 \text{ kJ}) + 2(-297 \text{ kJ})] - [2(-21 \text{ kJ}) + (0.0 \text{ kJ})] = -1124 \text{ kJ}$

Section 15.5

Predict the sign of ΔS_{system} for each reaction or process.

13. $FeS(s) \rightarrow Fe^{2+}(aq) + S^{2-}(aq)$

Ion formation in an aqueous solution increases entropy. ΔS_{system} is positive.

14. $SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$

Dissolving a gas in a solvent decreases entropy. ΔS_{system} is negative.

P. 611 #15-16

15. Decide whether higher or lower temperatures will produce more CH_3CHO in the following equilibrium: $C_2H_2(g) + H_2O(g) \longleftrightarrow CH_3CHO(g)$ $\Delta H° = -151$ kJ

$\Delta H°$ is negative, so the reaction is exothermic and heat is released as a product. Decreasing a product (lowering the temperature) causes the reaction to shift to the right and produce more products. Thus, more CH_3CHO will be produced at lower temperatures.

16. Demonstrate **Table 17.4** shows the concentrations of substances A and B in two reaction mixtures. A and B react according to the equation $2A \longleftrightarrow B$; $K_{eq} = 200$. Are the two mixtures at different equilibrium positions?

Concentration Data in mol/L

Reaction	[A]	[B]
1	0.0100	0.0200
2	0.0500	0.500

Reaction 1: $\frac{[B]}{[A]^2} = \frac{(0.0200)}{(0.0100)^2} = 200$

Reaction 2: $\frac{[B]}{[A]^2} = \frac{(0.500)}{(0.0500)^2} = 200$

The two mixtures are at the same equilibrium position.

17. Design a concept map that shows ways in which Le Chatelier's principle can be applied to increase the products in a system at equilibrium and to increase the reactants in such a system.

Concepts maps should show that products can be increased by increasing the concentration of the reactants, by removing products, or by raising or lowering the temperature depending upon whether the reaction is exothermic or endothermic.

Section 17.3 Using Equilibrium Constants

pages 612–622

Practice Problems

pages 613–619

18. At a certain temperature, $K_{eq} = 10.5$ for the equilibrium $CO(g) + 2H_2(g) \longleftrightarrow CH_3OH(g)$.

Calculate the following concentrations.

a. [CO] in an equilibrium mixture containing 0.933 mol/L H_2 and 1.32 mol/L CH_3OH

$$K_{eq} = \frac{[CH_3OH]}{[CO][H_2]^2}$$

$$10.5 = \frac{(1.32)}{[CO](0.933)^2}$$

$[CO] = 0.144M$

b. $[H_2]$ in an equilibrium mixture containing 1.09 mol/L CO and 0.325 mol/L CH_3OH

$$K_{eq} = \frac{[CH_3OH]}{[CO][H_2]^2}$$

$$10.5 = \frac{(0.325)}{(1.09)[H_2]^2}$$

$[H_2] = 0.169M$

c. $[CH_3OH]$ in an equilibrium mixture containing 0.0661 mol/L H_2 and 3.85 mol/L CO.

$$K_{eq} = \frac{[CH_3OH]}{[CO][H_2]^2}$$

$$10.5 = \frac{[CH_3OH]}{(3.85)(0.0661)^2}$$

$[CH_3OH] = (10.5)(3.85)(0.0661)^2 = 0.177M$

47. Suppose you have a cube of pure manganese metal measuring 5.25 cm on each side. You find that the mass of the cube is 1076.6 g. What is the molar concentration of manganese in the cube?

Volume of the cube = $(5.25\ cm)^3 = 145\ cm^3$

$$145\ \cancel{cm^3} \times \frac{1\ L}{1000\ \cancel{cm^3}} = 0.145\ L$$

Molar mass of manganese = 54.94 g/mol

$$1076.6\ \cancel{g\ Mn} \times \frac{1\ mol\ Mn}{54.94\ \cancel{g\ Mn}} = 19.596\ mol\ Mn$$

$$\frac{19.596\ mol}{0.145\ L} = 135\ mol/L\ Mn$$

48. K_{eq} is 3.63 for the reaction A + 2B ↔ C. **Table 17.5** shows the concentrations of the reactants and product in two different reaction mixtures at the same temperature. Determine whether both reactions are at equilibrium.

Concentrations of A, B, and C

A (mol/L)	B (mol/L)	C (mol/L)
0.500	0.621	0.700
0.250	0.525	0.250

Calculate K_{eq} using the two sets of data.

$$K_{eq} = \frac{[C]}{[A][B]^2} = 3.63$$

$$\frac{(0.700)}{(0.500)(0.621)^2} = 3.63$$

$$\frac{(0.250)}{(0.250)(0.525)^2} = 3.63$$

Both reactions are at equilibrium.

49. When steam is passed over iron filings, solid iron(III) oxide and gaseous hydrogen are produced in a reversible reaction . Write the balanced chemical equation and the equilibrium constant expression for the reaction, which yields iron(III) oxide and hydrogen gas.

$2Fe(s) + 3H_2O(g) \leftrightarrow Fe_2O_3(s) + 3H_2(g)$

$$K_{eq} = \frac{[H_2]^3}{[H_2O]^3}$$

Section 17.2

p. 626 #53-55

Mastering Concepts

50. What is meant by a stress on a reaction at equilibrium?

A stress on a reaction at equilibrium is any change in concentration, volume (pressure), or temperature which causes the equilibrium to shift.

51. How does Le Châtelier's principle describe an equilibrium's response to a stress?

Le Châtelier's principle states that an equilibrium will shift in the direction that relieves a stress.

52. Why does removing a reactant cause an equilibrium shift to the left?

In order to restore the equilibrium ratio of rectants and products, the equilibrium shifts in the direction of the reactants.

53. When an equilibrium shifts to the right, what happens to each of the following?

a. the concentrations of the reactants

b. the concetrations of the products

The concentrations of the reactants decrease; the concentrations of the products increase.

54. Carbonated Beverages Use Le Châtelier's principle to explain how a shift in the equilibrium $H_2CO_3(aq) \longleftrightarrow H_2O(l) + CO_2(g)$ causes a soft drink to go flat when its container is left open.

Because $CO_2(g)$ continually escapes from the open container, the equilibrium shifts to the right until $H_2CO_3(aq)$ is depleted.

Section 18.3 Hydrogen Ions and pH

pages 650–658

Practice Problems

pages 651–657

P651 #22 a-d

22. The concentration of either the H^+ ion or the OH^- ion is given for four aqueous solutions at 298 K. For each solution, calculate $[H^+]$ or $[OH^-]$. State whether the solution is acidic, basic, or neutral.

a. $[H^+] = 1.0 \times 10^{-13}M$

$K_w = [H^+][OH^-]$

$1.0 \times 10^{-14} = (1.0 \times 10^{-13})[OH^-]$

$$\frac{1.0 \times 10^{-14}}{1.0 \times 10^{-13}} = \frac{(1.0 \times 10^{-13})[OH^-]}{1.0 \times 10^{-13}}$$

$[OH^-] = 1.0 \times 10^{-1}M$

$[OH^-] > [H^+]$, the solution is basic.

b. $[OH^-] = 1.0 \times 10^{-7}M$

$K_w = [H^+][OH^-]$

$$\frac{1.0 \times 10^{-14}}{1.0 \times 10^{-7}} = \frac{[H^+](1.0 \times 10^{-7})}{1.0 \times 10^{-7}}$$

$[H^+] = 1.0 \times 10^{-7}M$

$[OH^-] = [H^+]$, the solution is neutral.

c. $[OH^-] = 1.0 \times 10^{-3}M$

$K_w = [H^+][OH^-]$

$1.0 \times 10^{-14} = [H^+](1.0 \times 10^{-3})$

$$\frac{1.0 \times 10^{-14}}{1.0 \times 10^{-3}} = \frac{[H^+](1.0 \times 10^{-3})}{1.0 \times 10^{-3}}$$

$[H^+] = 1.0 \times 10^{-11}M$

$[OH^-] > [H^+]$, the solution is basic.

d. $[H^+] = 4.0 \times 10^{-5}M$

$K_w = [H^+][OH^-]$

$1.0 \times 10^{-14} = (4.0 \times 10^{-5})[OH^-]$

$$= \frac{1.0 \times 10^{-14}}{4.0 \times 10^{-5}} = \frac{(4.0 \times 10^{-5})[OH^-]}{(4.0 \times 10^{-5})}$$

$[OH^-] = 2.5 \times 10^{-10}M$

$[H^+] > [OH^-]$, the solution is acidic

23. Challenge Calculate the number of H^+ ions and the number of OH^- ions in 300 mL of pure water at 298 K.

At 298 K, $[H^+] = [OH^-] = 1.0 \times 10^{-7}M$

$$\text{Mol } H^+ = \frac{1.0 \times 10^{-7}\text{ mol}}{1L} \times \frac{1\text{ L}}{1000\text{ mL}} \times$$
$$300\text{ mL} = 3.0 \times 10^{-8}\text{ mol}$$

$$3.0 \times 10^{-8}\text{ mol } H^+\text{ ions} \times \frac{6.02\times10^{23}\ H^+\text{ ions}}{1\text{ mol}} =$$
1.8×10^{16} H^+ ions

Number of H^+ = number of OH^- =
1.8×10^{16} ions

p.653 #24-25

24. Calculate the pH of solutions having the following ion concentrations at 298 K.

a. $[H^+] \times 1.0 \times 10^{-2}M$

pH = $-\log [H^+]$

pH = $-\log(1.0 \times 10^{-2})$

pH = 2.00

b. $[H^+] = 3.0 \times 10^{-6}M$

pH = $-\log [H^+]$

pH = $-\log(3.0 \times 10^{-6})$

pH = 5.52

25. Calculate the pH of aqueous solutions having the following $[H^+]$ at 298 K.

a. $[H^+] = 0.0055M$

pH = $-\log [H^+]$

pH = $-\log 0.0055$

pH = 2.26

b. $[H^+] = 0.000084M$

pH = $-\log [H^+]$

pH = $-\log 0.000084$

pH = 4.08

17. Does a precipitate form when equal volumes of $1.2 \times 10^{-4} M$ $AlCl_3$ and $2.0 \times 10^{-3} M$ NaOH are mixed? If so, identify the precipitate.

Predict the precipitate is $Al(OH)_3$ because NaOH is soluble in water.

$Al(OH)_3(s) \rightleftharpoons Al^{3+}(aq) + 3OH^-(aq)$

$K_{sp} = 4.6 \times 10^{-33}$

$[Al3^+] = \frac{1}{2}(1.2 \times 10^{-4}M) = 6.0 \times 10^{-5}M$

$[OH^-] = (\frac{1}{2})(2.0 \times 10^{-7}M) = 1.0 \times 10^{-7}M$

$Q_{sp} = [Al^{3+}][OH^-]^3 = (6.0 \times 10^{-5})(1.0 \times 10^{-7})^3 = 6.0 \times 10^{-26}$

$Q_{sp} > K_{sp}$, a precipitate of $Al(OH)_3$ will form.

Chapter 18

Section 18.1

1. Write the balanced formula equation for the reaction between zinc and nitric acid.

$Zn(s) + 2HNO_3(aq) \rightarrow Zn(NO_3)_2(aq) + H_2(g)$

2. Write the balanced formula equation for the reaction between magnesium carbonate and sulfuric acid.

$MgCO_3(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2O(l) + CO_2(g)$

3. Identify the base in the reaction $H_2O(l) + CH_3NH_2(aq) \rightarrow OH^-(aq) + CH_3NH_3^+(aq)$.

The base is CH_3NH_2.

4. Identify the conjugate base described in the reaction in Practice Problems 1 and 2.

OH^-

5. Write the steps in the complete ionization of hydrosulfuric acid.

$H_2S(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HS^-(aq)$

$HS^-(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + S^{2-}(aq)$

6. Write the steps in the complete ionization of carbonic acid.

$H_2CO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCO_3^-(aq)$

$HCO_3^-(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CO_3^{2-}(aq)$

Section 18.2

7. Write the acid ionization equation and ionization constant expression for formic acid (HCOOH).

$$K_a = \frac{[H^+][COOH^-]}{[HCOOH]}$$

8. Write the acid ionization equation and ionization constant expression for the hydrogen carbonate ion (HCO^{3-}).

$$K_a = \frac{[H^+][CO_3^{2-}]}{[HCO_3^-]}$$

9. Write the base ionization constant expression for ammonia.

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]}$$

10. Write the base ionization expression for aniline ($C_6H_5NH_2$).

$$K_b = \frac{[C_6H_5NH_3^+][OH^-]}{[C_6H_5NH_2]}$$

p. 989 #11-12

Section 18.3

11. Is a solution in which $[H^+] = 1.0 \times 10^{-5}M$ acidic, basic, or neutral?

$K_w = [H^+][OH^-] = 1.0 \times 10^{-14}$

$$[OH^-] = \frac{K_w}{[H^+]} = \frac{1.0 \times 10^{-14}}{1.0 \times 10^{-5}} = 1.0 \times 10^{-9}M$$

$[H^+] > [OH^-]$

The solution is acidic.

p. 989 #11-12

12. Is a solution in which $[OH^-]$ 5 $1.0 \times 10^{-11}M$ acidic, basic, or neutral?

$K_w = [H^+][OH^-] = 1.0 \times 10^{-14}$

$[H^+] = \frac{K_w}{[OH^-]} = \frac{1.0 \times 10^{-14}}{1.0 \times 10^{-11}} = 1.0 \times 10^{-3}M$

$[H^+] > [OH^-]$

The solution is acidic.

p. 989 #13-15

13. What is the pH of a solution in which $[H^+]$ 5 $4.5 \times 10^{-4}M$?

$pH = -\log(4.5 \times 10^{-4}) = -(\log 4.5 + \log 10^{-4})$
$= 3.35$

14. Calculate the pH and pOH of a solution in which $[OH^-]$ 5 $8.8 \times 10^{-3}M$.

$pOH = -\log(8.8 \times 10^{-3}) = -(\log 8.8 + \log 10^{-3})$
$= 2.06$

$pH + pOH = 14$

$pH = 14 - 2.06 = 11.94$

15. Calculate the pH and pOH of a solution in which $[H^+]$ 5 $2.7 \times 10^{-6}M$.

$pH = -\log(2.7 \times 10^{-6}) = -(\log 2.7 + \log 10^{-6})$
$= 5.57$

$pH + pOH = 14$

$pOH = 14 - 5.57 = 8.43$

16. What is $[H^+]$ in a solution having a pH of 2.92?

$pH = -\log[H^+]$

$2.92 = -\log[H^+]$

$[H^+] = \text{antilog}(-2.92) = 1.2 \times 10^{-3}M$

17. What is $[OH^-]$ in a solution having a pH of 13.56?

$pH + pOH = 14$

$pOH = 14 - 13.56 = 0.44$

$pOH = -\log[OH^-]$

$0.44 = -\log[OH^-]$

$[OH^-] = \text{antilog}(-0.44) = 3.6 \times 10^{-1}M$

18. What is the pH of a $0.00067M$ H_2SO_4 solution?

$pH = -\log(0.00067) = 3.17$

19. What is the pH of a $0.000034M$ NaOH solution?

$pOH = -\log(0.000034) = 4.47$

$pH + pOH = 14$

$pH = 14 - 4.47 = 9.53$

20. The pH of a $0.200M$ HBrO solution is 4.67. What is the acid's K_a?

$pH = -\log[H^+]$

$4.67 = -\log[H^+]$

$[H^+] = \text{antilog}(-4.67) = 2.1 \times 10^{-5}M$

$[BrO^-] = [H^+] = 2.1 \times 10^{-5}M$

$[HBrO] = 0.200M - 2.1 \times 10^{-5}M = 0.200M$

$K_a = \frac{[H^+][BrO^-]}{[HBrO]} = \frac{(2.1 \times 10^{-5})(2.1 \times 10^{-5})}{0.200}$
$= 2.2 \times 10^{-9}$

21. The pH of a $0.030M$ C_2H_5COOH solution is 3.20. What is the acid's K_a?

$pH = -\log[H^+]$

$3.20 = -\log[H^+]$

$[H^+] = \text{antilog}(-3.20) = 6.3 \times 10^{-4}M$

$[C_2H_5COO^-] = [H^+] = 6.3 \times 10^{-4}M$

$[C_2H_5COOH] = 0.030M - 6.3 \times 10^{-4}M = 0.029M$

$K_a = \frac{[H^+][C_2H_5COO^-]}{[C_2H_5COOH]}$
$= \frac{(6.3 \times 10^{-4})(6.3 \times 10^{-4})}{0.029} = 1.4 \times 10^{-5}$

Section 18.4

22. Write the formula equation for the reaction between hydroiodic acid and beryllium hydroxide.

$2HI(aq) + Be(OH)_2(aq) \rightarrow BeI_2(aq) + 2H_2O(l)$

23. Write the formula equation for the reaction between perchloric acid and lithium hydroxide.

$HClO_4(aq) + LiOH(aq) \rightarrow LiClO_4(aq) + H_2O(l)$

24. In a titration, 15.73 mL of 0.2346*M* HI solution neutralizes 20.00 mL of a LiOH solution. What is the molarity of the LiOH?

$M_1V_1 = M_2V_2$

$$M_2 = \frac{(0.2346M)(15.73\text{ mL})}{20.00\text{ mL}} = 0.1845M$$

25. What is the molarity of a caustic soda (NaOH) solution if 35.00 mL of solution is neutralized by 68.30 mL of 1.250*M* HCl?

$M_1V_1 = M_2V_2$

$$M_2 = \frac{(1.250M)(68.30\text{ mL})}{35.00\text{ mL}} = 2.439M$$

26. Write the chemical equation for the hydrolysis reaction that occurs when sodium hydrogen carbonate is dissolved in water. Is the resulting solution acidic, basic, or neutral?

$HCO_3^-(aq) + H_2O(l) \rightarrow CO_3^{2-}(aq) + OH^-(aq)$; basic

27. Write the chemical equation for any hydrolysis reaction that occurs when cesium chloride is dissolved in water. Is the resulting solution acidic, basic, or neutral?

No reaction; neutral

Chapter 19

Section 19.1

Identify the following information for each problem. What element is oxidized? Reduced? What is the oxidizing agent? Reducing agent?

p. 990 #1-3

1. $2P + 3Cl_2 \rightarrow 2PCl_3$

P is oxidized, Cl is reduced

Cl_2 is the oxidizing agent

P is the reducing agent

2. $C + H_2O \rightarrow CO + H_2$

C is oxidized, H is reduced

H_2O is the oxidizing agent

C is the reducing agent

3. $ClO_3^- + AsO_2^- \rightarrow AsO_4^{3-} + Cl^-$

As is oxidized, Cl is reduced

Cl is the oxidizing agent

As is the reducing agent

4. Determine the oxidation number for each element in the following compounds.

a. Na_2SeO_3

+1, +4, −2

b. $HAuCl_4$

+1, +3, −1

c. H_3BO_3

+1, +3, −2

5. Determine the oxidation number for the following compounds or ions.

a. P_4O_8

+4, −2

b. Na_2O_2 (Hint: this is like H_2O_2.)

+1, −1

c. AsO_4^{-3}

+5, −2

Section 19.2

6. How many electrons will be lost or gained in each of the following half-reactions? Identify whether it is an oxidation or reduction.

a. $Cr \rightarrow Cr^{3+}$

loss of 3 electrons, oxidation

b. $O_2 \rightarrow O^{2-}$

gain of 2 electrons, reduction

c. $Fe^{+2} \rightarrow Fe^{3+}$

loss of 1 electron, oxidation