# QUESTIONS AND PROBLEMS

## Chemical Reactions

### 6.1 Determine whether each of the following equations is balanced or not balanced:

- **a.** \( S(s) + O_2(g) \rightarrow SO_3(g) \)
- **b.** \( 2Al(s) + 3Cl_2(g) \rightarrow 2AlCl_3(s) \)
- **c.** \( H_2(g) + O_2(g) \rightarrow H_2O(g) \)
- **d.** \( C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g) \)

### 6.2 Determine whether each of the following equations is balanced or not balanced:

- **a.** \( PCl_3(s) + Cl_2(g) \rightarrow PCl_5(s) \)
- **b.** \( CO(g) + 2H_2(g) \rightarrow CH_3OH(g) \)
- **c.** \( 2KClO_3(s) \rightarrow 2KCl(s) + O_2(g) \)
- **d.** \( Mg(s) + N_2(g) \rightarrow Mg_3N_2(s) \)

### 6.3 Balance the following equations:

- **a.** \( N_2(g) + O_2(g) \rightarrow NO(g) \)
- **b.** \( HgO(s) \rightarrow Hg(l) + O_2(g) \)
- **c.** \( Fe(s) + O_2(g) \rightarrow Fe_2O_3(s) \)
- **d.** \( Na(s) + Cl_2(g) \rightarrow NaCl(s) \)

### 6.4 Balance the following equations:

- **a.** \( Ca(s) + Br_2(l) \rightarrow CaBr_2(s) \)
- **b.** \( P_4(s) + O_2(g) \rightarrow P_4O_{10}(s) \)
- **c.** \( Sb_2S_3(s) + HCl(aq) \rightarrow SbCl_3(s) + H_2S(g) \)
- **d.** \( Fe_2O_3(s) + C(s) \rightarrow Fe(s) + CO(g) \)

### 6.5 Balance the following equations:

- **a.** \( Mg(s) + AgNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + Ag(s) \)
- **b.** \( Al(s) + CuSO_4(aq) \rightarrow Cu(s) + Al_2(SO_4)_3(aq) \)
- **c.** \( Pb(NO_3)_2(aq) + NaCl(aq) \rightarrow PbCl_2(s) + NaNO_3(aq) \)
- **d.** \( Al(s) + HCl(aq) \rightarrow AlCl_3(aq) + H_2(g) \)

### 6.6 Balance the following equations:

- **a.** \( Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g) \)
- **b.** \( Al(s) + H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + H_2(g) \)
- **c.** \( K_2SO_4(aq) + BaCl_2(aq) \rightarrow BaSO_4(s) + KCl(aq) \)
- **d.** \( CaCO_3(s) \rightarrow CaO(s) + CO_2(g) \)

## Learning Goal

Identify a chemical reaction as a combination, decomposition, single replacement, or double replacement reaction.

## 6.2 Types of Reactions

A great number of reactions occur in nature, in biological systems, and in the laboratory. However, some general patterns among all reactions help us to classify them. Most fall into four general reaction types.
Gain of electrons  |  Loss of oxygen
Electrons are a  |  Gain of hydrogen
reactant

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**QUESTIONS AND PROBLEMS**

### Oxidation–Reduction Reactions

**6.13** Indicate whether each of the following is an oxidation or a reduction reaction:

- **a.** $\text{Na}^+(aq) + e^- \rightarrow \text{Na}(s)$
- **b.** $\text{Ni}(s) \rightarrow \text{Ni}^{2+}(aq) + 2e^-$
- **c.** $\text{Cr}^{3+}(aq) + 3e^- \rightarrow \text{Cr}(s)$
- **d.** $2\text{H}^+(aq) + 2e^- \rightarrow \text{H}_2(g)$

**6.14** Indicate whether each of the following is an oxidation or a reduction reaction:

- **a.** $\text{O}_2(g) + 4e^- \rightarrow 2\text{O}^2- (aq)$
- **b.** $\text{Al}(s) \rightarrow \text{Al}^{3+}(aq) + 3e^-$
- **c.** $\text{Fe}^{3+}(aq) + e^- \rightarrow \text{Fe}^{2+}(aq)$
- **d.** $2\text{Br}^-(aq) \rightarrow \text{Br}_2(g) + 2e^-$

**6.15** In the following reactions, identify which reactant is oxidized and which is reduced:

- **a.** $\text{Zn}(s) + \text{Cl}_2(g) \rightarrow \text{ZnCl}_2(s)$
- **b.** $\text{Cl}_2(g) + 2\text{NaBr}(aq) \rightarrow 2\text{NaCl}(aq) + \text{Br}_2(g)$
- **c.** $2\text{PbO}(s) \rightarrow 2\text{Pb}(s) + \text{O}_2(g)$
- **d.** $2\text{Fe}^{3+}(aq) + \text{Sn}^{2+}(aq) \rightarrow 2\text{Fe}^{2+}(aq) + \text{Sn}^{4+}(aq)$

**6.16** In the following reactions, identify which reactant is oxidized and which is reduced:

- **a.** $2\text{Li}(s) + \text{F}_2(g) \rightarrow 2\text{LiF}(s)$
- **b.** $\text{Cl}_2(g) + 2\text{KI}(aq) \rightarrow 2\text{KCl}(aq) + \text{I}_2(g)$
- **c.** $\text{Zn}(s) + \text{Cu}^{2+}(aq) \rightarrow \text{Zn}^{2+}(aq) + \text{Cu}(s)$
- **d.** $\text{Fe}(s) + \text{CuSO}_4(aq) \rightarrow \text{FeSO}_4(aq) + \text{Cu}(s)$

**6.17** In the mitochondria of human cells, energy for the production of ATP is provided by the oxidation and reduction reactions of the iron ions in the cytochromes of the electron transport chain. Identify each of the following reactions as oxidation or reduction:

- **a.** $\text{Fe}^{3+} + e^- \rightarrow \text{Fe}^{2+}$
- **b.** $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + e^-$

**6.18** Chlorine ($\text{Cl}_2$) is a strong germicide used to disinfect drinking water and to kill microbes in swimming pools. If the product $\text{Cl}^-$ was the $\text{Cl}_2$ oxidized or reduced?
6.26 Consider the formula for $\text{Al}_2(\text{SO}_4)_3$, which is used in anti-perspirants.
   a. How many moles of sulfur are present in 3.0 moles of $\text{Al}_2(\text{SO}_4)_3$?
   b. How many moles of aluminum ions are present in 0.40 mole of $\text{Al}_2(\text{SO}_4)_3$?
   c. How many moles of sulfate ions ($\text{SO}_4^{2-}$) are present in 1.5 moles of $\text{Al}_2(\text{SO}_4)_3$?

6.27 Calculate each of the following:
   a. number of C atoms in 0.500 mole of C
   b. number of $\text{SO}_2$ molecules in 1.28 moles of $\text{SO}_2$
   c. moles of Fe in $5.22 \times 10^{22}$ atoms of Fe
   d. moles of $\text{C}_2\text{H}_5\text{OH}$ in $8.50 \times 10^{24}$ molecules of $\text{C}_2\text{H}_5\text{OH}$

6.28 Calculate each of the following:
   a. number of Li atoms in 4.5 moles of Li
   b. number of $\text{CO}_2$ molecules in 0.0180 mole of $\text{CO}_2$
   c. moles of Cu in $7.8 \times 10^{21}$ atoms of Cu
   d. moles of $\text{C}_2\text{H}_6$ in $3.754 \times 10^{23}$ molecules of $\text{C}_2\text{H}_6$

6.29 Calculate each of the following quantities in 2.00 moles of $\text{H}_3\text{PO}_4$:
   a. moles of H
   b. moles of O
   c. atoms of P
   d. atoms of O

6.30 Calculate each of the following quantities in 0.185 mole of $(\text{C}_2\text{H}_2)_2\text{O}$:
   a. moles of C
   b. moles of O
   c. atoms of H
   d. atoms of C

6.5 Molar Mass

Learning Goal

Determine the molar mass of a chemical compound from its formula.

A single atom or molecule is much too small to weigh, even on the most accurate balance. In fact, it takes a large number of atoms or molecules to make even a gram of substance visible. The molar mass is a way of measuring the mass of a single mole of a substance. It is equal to the sum of the atomic masses of the constituent elements. For example, the molar mass of water ($\text{H}_2\text{O}$) is $18.015 \text{ g/mol}$ because the atomic masses of hydrogen and oxygen are approximately $1.0079 \text{ u}$ and $15.999 \text{ u}$, respectively, and there are two hydrogen atoms and one oxygen atom in a molecule of water.
Molar Mass

6.31 Calculate the molar mass for each of the following:
   a. KCl (salt substitute)
   b. Fe₂O₃ (rust)
   c. Li₂CO₃ (antidepressant)
   d. Al₂(SO₄)₃ (antiperspirant)
   e. Mg(OH)₂ (antacid)
   f. C₁₆H₁₉N₃O₅S (amoxicillin, an antibiotic)

6.32 Calculate the molar mass for each of the following:
   a. FeSO₄ (iron supplement)
   b. Al₂O₃ (absorbent and abrasive)
   c. C₇H₅NO₃S (saccharin)
   d. C₃H₈O (rubbing alcohol)
   e. (NH₄)₂CO₃ (baking powder)
   f. Zn(C₂H₃O₂)₂ (dietary supplement)

6.33 Calculate the mass in grams in each of the following:
   a. 2.00 moles of Na
   b. 2.80 moles of Ca
   c. 0.125 mole of Sn
   d. 1.76 moles of Cu

6.34 Calculate the mass in grams in each of the following:
   a. 1.50 moles of K
   b. 2.5 moles of C
   c. 0.25 mole of P
   d. 12.5 moles of He

6.35 Calculate the mass in grams in each of the following:
   a. 0.500 mole of NaCl
   b. 1.75 moles of Na₂O
   c. 0.225 mole of H₂O
   d. 4.42 moles of CO₂

6.36 Calculate the mass in grams in each of the following:
   a. 2.0 moles of MgCl₂
   b. 3.5 moles of C₃H₈
   c. 5.00 moles of C₂H₆O
   d. 0.488 mole of C₃H₆O₃

6.37 a. The compound MgSO₄ is called Epsom salts. How many grams will you need to prepare a bath containing 5.00 moles of Epsom salts?
   b. In a bottle of soda, there is 0.25 mole of CO₂. How many grams of CO₂ are in the bottle?

6.38 a. Cyclopropane, C₃H₆, is an anesthetic given by inhalation. How many grams are in 0.25 mole of cyclopropane?
   b. The sedative Demerol hydrochloride has the formula C₁₅H₂₂ClNO₂. How many grams are in 0.025 mole of Demerol hydrochloride?

6.39 How many moles are contained in each of the following?
   a. 50.0 g of Ag
   b. 0.200 g of C
   c. 15.0 g of NH₃
   d. 75.0 g of SO₂

6.40 How many moles are contained in each of the following?
   a. 25.0 g of Ca
   b. 5.00 g of S
   c. 40.0 g of H₂O
   d. 12.2 g of O₂

6.41 How many moles of S are in each of the following quantities?
   a. 25 g of S
   b. 125 g of SO₂
   c. 2.0 moles of Al₂S₃

6.42 How many moles of C are in each of the following quantities?
   a. 75 g of C
   b. 0.25 mole of C₂H₆
   c. 88 g of CO₂

6.43 How many atoms of N are in each of the following quantities?
   a. 40.0 g of N
   b. 1.5 moles of N₂O₄
   c. 2.0 moles of N₂

6.44 How many atoms of Ag are in each of the following quantities?
   a. 5.0 g of Ag
   b. 0.40 mole of Ag₂S
   c. 0.75 g of AgCl
Energy in Chemical Reactions

6.73 a. Why do chemical reactions require activation energy?
   
   b. In an exothermic reaction, is the energy of the products higher or lower than the reactants?
   
   c. Draw an energy diagram for an exothermic reaction.

6.74 a. What is measured by the heat of reaction?
   
   b. In an endothermic reaction, is the energy of the products higher or lower than the reactants?
   
   c. Draw an energy diagram for an endothermic reaction.

6.75 Classify the following as exothermic or endothermic reactions:
   
   a. 55 kcal is released.
   
   b. The energy level of the products is higher than the reactants.
   
   c. The metabolism of glucose in the body provides energy.

6.76 Classify the following as exothermic or endothermic reactions:
   
   a. The energy level of the products is lower than the reactants.
   
   b. In the body, the synthesis of proteins requires energy.
   
   c. 12 kcal is absorbed.

6.77 Classify the following as exothermic or endothermic reactions and give ΔH for each:
   
   a. gas burning in a Bunsen burner:
      \[ \text{CH}_4(g) + 2\text{O}_2(g) \rightarrow \text{CO}_2(g) + 2\text{H}_2\text{O}(g) + 210 \text{ kcal} \]
   
   b. dehydrating limestone:
      \[ \text{Ca(OH)}_2(s) + 65.3 \text{ kJ} \rightarrow \text{CaO}(s) + \text{H}_2\text{O}(l) \]
   
   c. formation of aluminum oxide and iron from aluminum and iron(III) oxide:
      \[ 2\text{Al}(s) + \text{Fe}_2\text{O}_3(s) \rightarrow \text{Al}_2\text{O}_3(s) + 2\text{Fe}(s) + 205 \text{ kcal} \]

6.78 Classify the following as exothermic or endothermic reactions and give ΔH for each of the following:
   
   a. combustion of propane:
      \[ \text{C}_3\text{H}_8(g) + 5\text{O}_2(g) \rightarrow 3\text{CO}_2(g) + 4\text{H}_2\text{O}(g) + 530 \text{ kcal} \]
   
   b. formation of “table” salt:
      \[ 2\text{Na}(s) + \text{Cl}_2(g) \rightarrow 2\text{NaCl}(s) + 196 \text{ kcal} \]
   
   c. decomposition of phosphorus pentachloride:
      \[ \text{PCl}_3(g) + 67 \text{ kJ} \rightarrow \text{PCl}_3(g) + \text{Cl}_2(g) \]

6.79 The equation for the formation of silicon tetrachloride from silicon and chlorine is
   
   \[ \text{Si}(s) + 2\text{Cl}_2(g) \rightarrow \text{SiCl}_4(g) \quad \Delta H = -157 \text{ kcal} \]

   How many kilocalories are released when 125 g of Cl₂ reacts with silicon?

6.80 Methanol (\text{CH}_3\text{OH}), which is used as a cooking fuel, undergoes combustion to produce carbon dioxide and water:
   
   \[ 2\text{CH}_3\text{OH}(l) + 3\text{O}_2(g) \rightarrow 2\text{CO}_2(g) + 4\text{H}_2\text{O}(l) \quad \Delta H = -726 \text{ kJ} \]

   How many kilojoules are released when 75.0 g of methanol is burned?
6.100 Ibuprofen, the anti-inflammatory ingredient in Advil, has the formula $C_{13}H_{18}O_2$.

6.101 Calculate the molar mass of each of the following:
   a. FeSO$_4$, iron(II) sulfate, iron supplement
   b. Ca(IO$_3$)$_2$, calcium iodate, iodine source in table salt
   c. C$_5$H$_8$NNaO$_4$, monosodium glutamate, flavor enhancer

6.102 Calculate the molar mass of each of the following:
   a. Mg(HCO$_3$)$_2$, magnesium hydrogen carbonate
   b. Au(OH)$_3$, gold(III) hydroxide, used in gold plating
   c. C$_{18}$H$_{34}$O$_2$, oleic acid from olive oil

6.103 How many grams are in 0.150 mole of each of the following?
   a. K
   b. Cl$_2$
   c. Na$_2$CO$_3$

6.104 How many grams are in 2.25 moles of each of the following?
   a. N$_2$
   b. NaBr
   c. C$_6$H$_{14}$

6.105 How many moles are in 25.0 g of each of the following compounds?
   a. CO$_2$
   b. Al(OH)$_3$
   c. MgCl$_2$

6.106 How many moles are in 4.00 g of each of the following compounds?
   a. NH$_3$
   b. Ca(NO$_3$)$_2$
   c. SO$_3$
### CHALLENGE QUESTIONS

6.121 Write a balanced equation for each of the following reaction descriptions and identify each type of reaction:

a. An aqueous solution of lead(II) nitrate is mixed with aqueous sodium phosphate to produce solid lead(II) phosphate and aqueous sodium nitrate.

b. Gallium metal heated in oxygen gas forms solid gallium(III) oxide.

c. When solid sodium nitrate is heated, solid sodium nitrite and oxygen gas are produced.

d. Solid bismuth(III) oxide and solid carbon react to form bismuth metal and carbon monoxide gas.

6.122 A toothpaste contains 0.24% by mass sodium fluoride (NaF) used to prevent dental caries and 0.30% by mass triclosan, C12H7Cl2O2, a preservative and antigingivitis agent. One tube contains 119 g of toothpaste.

a. How many moles of NaF are in the tube of toothpaste?

b. How many fluoride ions (F\(^-\)) are in the tube of toothpaste?

c. How many grams of sodium ion (Na\(^+\)) are in 1.50 g of toothpaste?

d. How many molecules of triclosan are in the tube of toothpaste?

6.123 A gold bar is 2.31 cm long, 1.48 cm wide, and 0.0758 cm thick.

a. If gold has a density of 19.3 g/mL, what is the mass of the gold bar?

b. How many atoms of gold are in a bar?

c. When the same mass of gold combines with oxygen, the oxide product has a mass of 3.61 g. How many moles of O are combined with the gold?

d. What is the formula of the oxide product?

6.124 The gaseous hydrocarbon acetylene, C2H2, used in welders’ torches, releases a large amount of heat when it burns according to the following equation:

\[ 2\text{C}_2\text{H}_2(g) + 5\text{O}_2(g) \rightarrow 4\text{CO}_2(g) + 2\text{H}_2\text{O}(g) \]

a. How many moles of water are produced from the complete reaction of 64.0 g of oxygen?

b. How many moles of oxygen are needed to react completely with 2.25 \times 10^{24} molecules of acetylene?

6.125 Acetylene, C2H2, used in welders’ torches, burns according to the following equation:

\[ 2\text{C}_2\text{H}_2(g) + 5\text{O}_2(g) \rightarrow 4\text{CO}_2(g) + 2\text{H}_2\text{O}(g) \]

a. How many molecules of oxygen are needed to react with 22.0 g of acetylene?

b. How many grams of carbon dioxide could be produced from the complete reaction of the acetylene in part a?

c. If the reaction in part a. produces 64.0 g of CO2, what is the percent yield for the reaction?

6.126 Consider the equation for the reaction of sodium and nitrogen to form sodium nitride:

\[ \text{Na}(s) + \text{N}_2(g) \rightarrow \text{Na}_3\text{N}(s) \]

a. Balance the equation.

b. If 80.0 g of sodium is mixed with 20.0 g of nitrogen gas, what mass of sodium nitride forms?

c. If the reaction in part b. has a percent yield of 75.0%, how much sodium nitride is actually produced?

6.127 Consider the following equation:

\[ \text{Al}(s) + \text{O}_2(g) \rightarrow \text{Al}_2\text{O}_3(s) \]

a. Balance the equation.

b. Identify the type of reaction.

c. How many moles of oxygen must react with 4.50 moles of Al?

d. How many grams of aluminum oxide are produced when 50.2 g of aluminum reacts?

e. When 0.900 mole of aluminum is reacted in a closed container with 8.00 g of oxygen, how many grams of aluminum oxide can form?

f. If 45.0 g of aluminum and 62.0 g of oxygen undergo a reaction that has a 70.0% yield, what mass of aluminum oxide forms?

### ANSWERS

#### ANSWERS TO STUDY CHECKS

6.1 \[ 3\text{Fe}(s) + 2\text{O}_2(g) \rightarrow \text{Fe}_3\text{O}_4(s) \]

6.2 \[ 2\text{NO}(g) + \text{O}_2(g) \rightarrow 2\text{NO}_2(g) \]

6.3 Lithium is oxidized: \[ 2\text{Li}(s) \rightarrow 2\text{Li}^+(s) + 2e^- (s) \]

Fluorine is reduced: \[ \text{F}_2(g) + 2e^- \rightarrow 2\text{F}^- (s) \]

6.4 0.432 mole of H2O

6.5 0.120 mole of aspirin

6.6 138.0 g of salicylic acid

6.7 24.4 g of Au

6.8 0.00621 mole of CaCO3, 0.00550 mole of MgCO3

6.9 0.90 mole of Fe3S3

6.10 44.0 g of NO

6.11 27.5 g of CO2

6.12 84.7% (1.152 g of Cu)

6.13 13.4 g of SiC

6.14 a. endothermic

b. 10.5 kJ

#### ANSWERS TO SELECTED QUESTIONS AND PROBLEMS

6.1 a. not balanced

b. balanced

c. not balanced

d. balanced

6.3 a. \[ \text{N}_2(g) + \text{O}_2(g) \rightarrow 2\text{NO}(g) \]

b. \[ 2\text{HgO}(s) \rightarrow 2\text{Hg}(l) + \text{O}_2(g) \]

c. \[ 4\text{Fe}(s) + 3\text{O}_2(g) \rightarrow 2\text{Fe}_3\text{O}_4(s) \]

d. \[ 2\text{Na}(s) + \text{Cl}_2(g) \rightarrow 2\text{NaCl}(s) \]
6.5 a. $\text{Mg(s)} + 2\text{AgNO}_3(aq) \rightarrow \text{Mg(NO}_3)_2(aq) + 2\text{Ag(s)}$
   b. $2\text{Al(s)} + 3\text{CuSO}_4(aq) \rightarrow 3\text{Cu(s)} + \text{Al}_2(\text{SO}_4)_3(aq)$
   c. $\text{Pb(NO}_3)_2(aq) + 2\text{NaCl}(aq) \rightarrow \text{PbCl}_2(s) + 2\text{NaNO}_3(aq)$
   d. $2\text{Al(s)} + 6\text{HCl}(aq) \rightarrow 2\text{AlCl}_3(aq) + 3\text{H}_2(g)$

6.7 a. A single reactant breaks into two simpler substances (elements).
   b. One element in the reacting compound is replaced by the other reactant.

6.9 a. combination reaction
   b. single replacement reaction
   c. decomposition reaction
   d. double replacement reaction

6.11 a. $\text{Mg(s)} + \text{Cl}_2(g) \rightarrow \text{MgCl}_2(s)$
   b. $2\text{HBr(g)} \rightarrow \text{H}_2(g) + \text{Br}_2(g)$
   c. $\text{Mg(s)} + \text{Zn(NO}_3)_2(aq) \rightarrow \text{Zn(s)} + \text{Mg(NO}_3)_2(aq)$
   d. $2\text{K}_2\text{S(aq)} + \text{Pb(NO}_3)_2(aq) \rightarrow 2\text{KNO}_3(aq) + \text{PbS(s)}$

6.13 a. reduction  b. oxidation
   c. reduction  d. reduction

6.15 a. Zn is oxidized; Cl₂ is reduced.
   b. Br⁻ in NaBr is oxidized; Cl₂ is reduced.
   c. The O²⁻ in PbO is oxidized; the Pb²⁺ is reduced.
   d. Sn⁴⁺ is oxidized; Fe³⁺ is reduced.

6.17 a. reduction  b. oxidation

6.19 Linoleic acid gains hydrogen atoms and is reduced.

6.21 1.00 mole contains $6.02 \times 10^{23}$ atoms of an element, molecules of a covalent substance, or formula units of an ionic substance.

6.23 a. $1.20 \times 10^{23}$ atoms of Ag
   b. $4.52 \times 10^{23}$ molecules of C₃H₇O
   c. 0.478 mole of Au

6.25 a. 24 moles of H
   b. $1.0 \times 10^5$ moles of C
   c. 0.0404 mole of N

6.27 a. $3.01 \times 10^{23}$ atoms of C
   b. $7.71 \times 10^{23}$ molecules of SO₂
   c. 0.0867 mole of Fe
   d. 14.1 molecules of C₂H₂O₂

6.29 a. 6.00 moles of H
   b. 8.00 moles of O
   c. $1.20 \times 10^{24}$ atoms of P
   d. $4.82 \times 10^{24}$ atoms of O

6.31 a. 74.6 g/mole  b. 159.8 g/mole
   c. 73.8 g/mole  d. 342.3 g/mole
   e. 58.3 g/mole  f. 365.1 g/mole

6.33 a. 46.0 g  b. 112 g
   c. 14.8 g  d. 112 g

6.35 a. 29.3 g  b. 109 g
   c. 4.05 g  d. 194 g

6.37 a. 602 g  b. 11 g

6.39 a. 0.463 mole  b. 0.0167 mole
   c. 0.882 mole  d. 1.17 moles

6.41 a. 0.78 mole of S
   b. 1.95 moles of S
   c. 6.0 moles of S

6.43 a. $1.72 \times 10^{24}$ atoms of N
   b. $1.8 \times 10^{24}$ atoms of N
   c. $2.4 \times 10^{24}$ atoms of N

6.45 a. $2\text{moles SO}_2$ and $1\text{mole O}_2$
   b. $2\text{moles SO}_3$
   c. $1\text{mole O}_2$
   d. $2\text{moles SO}_3$

   a. $4\text{moles P}$
   b. $5\text{moles O}_2$
   c. $4\text{moles P}$
   d. $5\text{moles O}_2$

6.47 a. 1.0 mole of O₂
   b. 10.0 moles of H₂
   c. 5.0 moles of H₂O

6.49 a. 1.25 moles of C
   b. 0.96 mole of CO
   c. 1.0 mole of SO₂
   d. 0.50 mole of CS₂

6.51 a. 77.5 g of Na₂O
   b. 6.26 g of O₂
   c. 19.4 g of O₂

6.53 a. 192 g of O₂
   b. 3.79 g of N₂
   c. 54.0 g of H₂O

6.55 a. 3.65 g of H₂O
   b. 0.43 g of O₂
   c. 7.53 g of HNO₃

6.57 a. 2PbS(s) + 3O₂(g) → 2PbO(s) + 2SO₂(g)
   b. 6.00 g of O₂
   c. 17.4 g of SO₂
   d. 137 g of PbS

6.59 a. 70.9%  b. 63.2%

6.61 70.8 g of Al₂O₃

6.63 60.4%

6.65 a. 8 taxis can be used to pick up passengers.
   b. 7 taxis can be driven.

6.67 a. 5.0 moles of H₂
   b. 4.0 moles of H₂
   c. 3.0 moles of N₂

6.69 a. 2.00 moles of SO₃
   b. 0.500 mole of Fe₃O₄
   c. 1.27 moles of CO₂

6.71 a. 0.188 mole of AlCl₃
   b. 0.750 mole of H₂O
   c. 0.417 mole of SO₂

6.73 a. The activation energy is the energy required to break the bonds of the reacting molecules.
   b. In exothermic reactions, the energy of the products is lower than the reactants.

6.75 a. exothermic  b. endothermic
   c. exothermic

6.77 a. exothermic $ΔH = -210$ kcal
   b. endothermic $ΔH = 65.3$ kJ
   c. exothermic $ΔH = -205$ kcal
138 kcal

6.81 a. 1, 1, 2 combination reaction
b. 2, 2, 1 decomposition reaction

c. 2NO(g) + O_2(g) \rightarrow 2NO_2(g)

a. combination reaction
b. decomposition reaction

c. 2NH_3(s) \rightarrow N_2(g) + 3I_2(g)

a. 2Cl_2(g) + O_2(g) \rightarrow 2OCl_2(g)

b. combination reaction

c. S_2Cl_2
b. 135.2 g/mole
c. 0.0740 mole

c. C_6H_6
b. 78.0 g/mole
c. 0.128 mole

c. 252.2 g/mole
b. 0.0991 mole
c. 0.991 mole of C

c. 47.1 g of CuO
b. 0.296 mole of O_2

c. NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)

b. Fe_3O_4(s) + 4H_2(g) \rightarrow 3Fe(s) + 4H_2O(g)

Single replacement

c. 2Sb(s) + 3Cl_2(g)_3(s)

 Combination

d. 2NCl(s) \rightarrow N_2(g) + 3I_2(g)

Decomposition

e. 2KBr(aq) + Cl_2(aq) \rightarrow 2KCl(aq) + Br_2(l)

Single replacement

f. Al_2(SO_4)_3(aq) + 6NaOH(aq) \rightarrow

3Na_2SO_4(aq) + 2Al(OH)_3(s)

Double replacement

6.97 a. reduction
b. oxidation
c. oxidation
d. reduction

6.99 a. 90.0 g/mole
b. 3.01 \times 10^{23} \text{ molecules}
c. 2.71 \times 10^{24} \text{ atoms of C}
d. 220 g of lactic acid

6.101 a. 152.0 g/mole
b. 389.9 g/mole
c. 169.0 g/mole

6.103 a. 5.87 g
b. 10.7 g
c. 15.9 g

6.105 a. 0.568 mole
b. 0.321 mole
c. 0.262 mole

6.107 a. 1.35 moles of glucose
b. 123 g of ethanol

6.109 2NH_3(g) + 5F_2(g) \rightarrow N_2F_4(g) + 6HF(g)
a. 1.33 moles of NH_3 and 3.33 moles of F_2
b. 143 g of F_2
c. 10.4 g of N_2F_4

6.111 a. 682 g of Cl_2
b. 365 g of HCl

6.113 81.4%

6.115 a. 48 g of C_4H_12
b. 27.5 g of CO_2
c. 92.8 g of CO_2

6.117 16.8 g of NaCl

6.119 a. 1.08 kcal
b. 2NO(g) \rightarrow N_2(g) + O_2(g) + 21.6 kcal
c. 1.80 kcal

6.121 a. 3Pb(NO_3)_2(aq) + 2Na_3PO_4(aq) \rightarrow

Pb_3(PO_4)_2(s) + 6NaNO_3(aq)

b. 4Ga(s) + 3O_2(g) \rightarrow 2Ga_2O_3(s)

Combination
c. 2NaNO_3(s) \rightarrow 2NaNO_2(s) + O_2(g)

Decomposition
d. Bi_2O_3(s) + 3C(s) \rightarrow 2Bi(s) + 3CO(g)

Single replacement

6.123 a. 5.00 g of gold
b. 1.53 \times 10^{22} \text{ Au atoms}
c. 0.038 mole of oxygen
d. Au_2O_3

6.125 a. 1.27 \times 10^{24} \text{ molecules of O}_2
b. 74.5 g of CO_2

c. 85.9% yield

6.127 a. 4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)

b. This is a combination reaction.
c. 3.38 moles of oxygen
d. 94.8 g of aluminum oxide
e. 17.0 g of aluminum oxide
f. 59.5 g of aluminum oxide