Chapter 8 - Chemical Equations and Reactions

8-1 Describing Chemical Reactions

I. Introduction

A. Reactants

1. Original substances entering into a chemical rxn

B. Products

1. The resulting substances from a chemical rxn

Reactants → Products

C. Chemical Equation

1. Represents with symbols and formulas, the identities and relative amounts of the reactants and products in a chemical rxn

II. Indications of a Chemical Reaction

A. Evolution of Heat and Light

1. Evidence of energy being released (exothermic rxn)

B. Production of a Gas

1. CO_2, H_2, H_2S are some gases produced by chemical rxns

$$FeS(aq) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2S(g)$$

C. Formation of a Precipitate

1. Precipitate is a solid that is produced as a result of a chemical rxn in solution

$BaCl_2(aq) + Na_2SO_4(aq) \rightarrow 2NaCl(aq) + BaSO_4(s)$

III. Characteristics of Chemical Equations

A. The equation must represent known facts

1. This can be done with a word equation

"hydrogen reacts with oxygen to form water"

Hydrogen + Oxygen → Water

B. The equation must contain the correct formulas for reactants and products

1. This is done with a formula equation

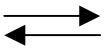
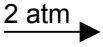
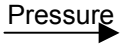
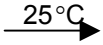
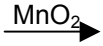
$$H_2 + O_2 \rightarrow H_2O$$

C. The law of conservation of atoms must be satisfied

1. Balancing is done with coefficients - small whole numbers that appear in front of a formula

$$2H_2 + O_2 \rightarrow 2H_2O$$

D. Additional symbols used in Chemical equations

Table 8-2	**Symbols Used in Chemical Equations**
Symbol	*Explanation*
	"yields" ; indicates result of a rxn
	Used in place of a single arrow to indicate a reversible rxn
(s)	Reactant or product in the solid state. Also a precipitate
(l)	Reactant or product in the liquid state.
(aq)	Reactant or product in an aqueous solution (dissolved in water)
(g)	Reactant or product in the gaseous state
	Can symbolize the formation of a gas, as an alternative to the (g) symbol
	Can symbolize the formation of a precipitate, as an alternative to the (s) symbol
	Reactants are heated
	Pressure at which the rxn is carried out, in this case 2 atmospheres
	Pressure at which rxn is carried out exceeds normal atmospheric pressure
	Temperature at which the rxn is carried out, in this case 25 °C
	Formula of catalyst, in this case manganese dioxide, used to alter the rate of the reaction

IV. Significance of a Chemical Reaction

A. Quantitative Information

1. # of moles, atoms, molecules in a reaction
2. Equality exists in each direction
3. The fact that a rxn can be written does not mean that the rxn can take place

V. Balancing Chemical Equations

A. Identify the names of reactants and products, and write a word equation
B. Write a formula equation by substituting correct formulas for the names of the reactants and the products
C. Balance the formula equation according to the law of conservation of atoms
D. Count atoms to be sure that the equation is balanced

8-2 Types of Chemical Reactions

I. Synthesis Reactions (Composition Rxns)

A. Synthesis Rxns

1. Two or more substances combine to form a more complex substance

$$A + X \rightarrow AX$$

B. Types of Synthesis Rxns

1. Metals react with oxygen to form oxides

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

2. Metals react with sulfur to form

$$8Ba(s) + S_8(s) \rightarrow 8BaS(s)$$

3. Nonmetals react with oxygen to form oxides

$$C(s) + O_2(g) \rightarrow CO_2(g)$$

4. Metals react with halogens to form salts (halogen means "salt maker")

$$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$$

5. Active metal oxides react with water to form metallic hydroxides

$$MgO(s) + H_2O(l) \rightarrow Mg(OH)_2(s)$$

6. Nonmetal oxides react with water to form oxyacids (acid rain)

$$SO_2(g) + H_2O \rightarrow H_2SO_3(aq)$$

II. Decomposition Reactions

A. Decomposition Rxns

1. One substance breaks down to form two or more simpler substances

$$AX \rightarrow A + X$$

B. Six Kinds of Decomposition Rxns

1. Metallic carbonates, when heated, form metallic oxides and carbon dioxide

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

2. Metallic hydroxides , when heated, decompose into metallic oxides and water

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

3. Metallic chlorates, when heated, decompose into metallic chlorides and oxygen

$$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$

4. Some acids, when heated, decompose into nonmetallic oxides and water

$$H_2SO_4(aq) \rightarrow H_2O(l) + SO_3\ (g)$$

5. A few oxides, when heated, decompose

$$2PbO_2(s) \rightarrow 2PbO(s) + O_2\ (g)$$

6. Some decomposition rxns are produced by an electric current

$$2NaCl(s) \rightarrow 2Na(s) + Cl_2\ (g)$$

III. Single-Replacement Reactions

A. Single-Replacement Rxns I

1. One substance is replaced in its compound by another substance

$$A + BX \rightarrow AX + B$$
$$Y + BX \rightarrow BY + X$$

B. Four Types of Decomposition Rxns

1. Replacement of a metal in a compound by a more active metal
   $Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$
2. Replacement of hydrogen in water by active metals
   $Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(g)$
3. Replacement of hydrogen in acids by metals
   $Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$
4. Replacement of halogens by more active halogens
   $Cl_2(g) + 2KBr(aq) \rightarrow 2KCl(aq) + Br_2(g)$

IV. <u>Double-Replacement Reactions</u>

A. Double-Replacement Rxn

1. The ions of two compounds exchange places in an aqueous solution to form two new compounds

B. Types of Double-Replacement Rxns

1. Formation of a Precipitate
   $BaCl_2(aq) + Na_2SO_4(aq) \rightarrow 2NaCl(aq) + BaSO_4(s)$
2. Formation of a Gas
   $FeS(aq) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2S(g)$
3. Formation of Water
   $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

V. <u>Combustion Reactions</u>

A. Combustion Rxns

1. A substance combines with oxygen, releasing a large amount of energy in the form of light and heat
   $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

B. Hydrocarbon combustion always produces carbon dioxide and water
   $2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(g)$

8-3 Activity Series of the Elements

A. Activity Series

1. A list of elements organized according to the ease with which the elements undergo certain chemical rxns
2. Each element in the list displaces from a compound any of the elements below it. The larger the interval between elements in a series, the more vigorous the replacement rxn.
3. Metals may replace other metals
4. Halogens may replace other halogens

B. Using the Activity Series (Table 8-3 in your book)

1. All metals above hydrogen displace hydrogen from hydrochloric acid or dilute sulfuric acid

2. Metals above magnesium vigorously displace hydrogen from water. Magnesium displaces hydrogen from steam.
3. Metals above silver combine directly with oxygen; those near the top do so rapidly
4. Metals below mercury form oxides only indirectly.
5. Oxides of metals below mercury decompose with mild heating.
6. Oxides of metals below chromium easily undergo reduction to metals by heating with hydrogen
7. Oxides of metals above iron resist reduction by heating with hydrogen
8. Elements near the top of the series are never found free in nature
9. Elements near the bottom of the series are often found free in nature.

Table 8-3 **Activity Series of the Elements**		
Activity of metals		*Activity of halogens*
Li	React with cold H2O and acids, replacing hydrogen. React with oxygen, forming oxides.	F_2
Rb		Cl_2
K		Br_2
Ba		I_2
Sr		
Ca		
Na		
Mg	React with steam (but not cold water) and acids, replacing hydrogen. React with oxygen, forming oxides.	
Al		
Mn		
Zn		
Cr		
Fe		
Cd		
Co	Do not react with water. React with acids, replacing hydrogen. React with oxygen, forming oxides.	
Ni		
Sn		
Pb		
H_2	React with oxygen, forming oxides.	
Sb		
Bi		
Cu		
Hg		
Ag	Fairly unreactive, forming oxides only indirectly.	
Pt		
Au		