Honors Chemistry Chapter 8 Chemical Equations and Reactions

Section 1: Describing Chemical Reactions pgs. 261-275

Objectives:

1. **List three observations that suggest that a chemical reaction has taken place.**
2. **List three requirements for a correctly written chemical equation.**
3. **Write a word equation and a formula equation for a given chemical reaction.**
4. **Balance a formula equation by inspection.**

Vocabulary: Define the following.

1. **chemical equation--**

2. **precipitate--**

3. **coefficient--**

4. **word equation--**

5. **formula equation--**

6. **reversible reaction--**

A chemical equation represents with symbols and formulas, the identities and relative molecular or molar amounts of the reactants and products in a chemical reaction.

Indications of a Chemical Reaction

Four of the indicators of a chemical reaction are:

1. **Production of energy as heat and light.**
2. **Production of a gas.**
3. **Formation of a precipitate. A precipitate is a solid that drops out of a solution.**
4. **Color change.**

Characteristics of Chemical Equations

1. **All reactants and products must be identified.**
2. **The correct formulas for the reactants must be written correctly, (chapter 7). Beware the 7 diatomic elements!**
3. **The same number of atoms of each element must appear on each side of the equation. Coefficients are numbers placed in front of a formula and multiplies everything within that but no other formula.**

Word and Formula Equations

A word equation represents reactants and products using words.
A formula equation represents reactants and products using symbols or formulas.

A chemical reaction occurs when a substance or substances called reactant(s) change or combine to yield new substances called products.

reactant(s) → products
yield

In chemical reactions new substances are produced as bonds are broken, atoms are rearranged, and new bonds are formed. Energy in some form is usually necessary to begin a chemical reaction. Energy is also absorbed or given off in a chemical reaction.

Chemical Equations and Balancing

A chemical equation describes in words or formulas what has occurred in the reaction. The equation must be in accordance with The Law of Conservation of Matter, which means that the number of atoms on both sides of the equation must be equal.
Use the reaction of calcium hydroxide with hydrochloric acid to produce calcium chloride and water as an example for writing and balancing a chemical equation.

Step 1

The skeleton reaction is written first. The chemical and molecular formulas of the substances must be written correctly before you can proceed.

$Ca(OH)_2 + HCl \rightarrow CaCl_2 + H_2O$

Reactants yield Products

Step 2

Separate the equation into a left and right side. Count the number of atoms in each substance correctly. This area below the equation is considered scratch paper. Anytime a change is made on a side, the number of atoms on that side must be recalculated.

$Ca(OH)_2 + HCl \rightarrow CaCl_2 + H_2O$

Ca = 1	Ca = 1
O = 2	Cl = 2
H = 2 + 1 = 3	H = 2
Cl = 1	O = 1

Step 3

Changes can only be made to the numbers in front of each substance called coefficients. If there is no number a 1 is taken to be there. In the skeletons there are usually no coefficients written; meaning each has a coefficient of 1.
*****Subscripts can never be changed in the equation. Only coefficients can be changed.**
As you look at the scratch paper above, it is apparent that the number of calcium atoms is the same on each side of the equation. Leave the Ca alone for now. Notice that the numbers of O, Cl, and H atoms are not equal.
It is best to ignore in the beginning any element that is present in more than one compound on the same side. This eliminates the H for the moment.
This leaves us with either the O or the Cl to manipulate. At this point it is your choice and doesn't matter which one you choose.
Whichever element is chosen, begin by changing the coefficient by increments of one.
*****Always choose the side that is lower and change the coefficient in front of the compound where the element is found. Let's try a 2 in front of HCl.**

$Ca(OH)_2 + 2\,HCl \rightarrow CaCl_2 + H_2O$

Now recount the left hand side in the scratch column.

Ca = 1	**Ca = 1**
O = 2	**Cl = 2**
H = 2 + 2 = 4	**H = 2**
Cl = 2	**O = 1**

Now the Ca and Cl are OK on both sides, but the O and H are still unbalanced. Since we want to leave the H alone as long as possible, let's try working with the O.
The O is lower on the right side so increase the coefficient by one by placing a 2 in front of the H_2O.

$Ca(OH)_2$ + 2 HCl → $CaCl_2$ + <u>2</u> H_2O

Recount the atoms on the right side in the scratch area.

Ca = 1	**Ca = 1**
O = 2	**Cl = 2**
H = 4	**H = 4**
Cl = 2	**O = 2**

Congratulations you have successfully balanced the equation!!!!
Now try balancing the following equations:

1. **Hydrogen peroxide (H_2O_2) decomposes to produce water and oxygen.**

2. **Hydrochloric acid reacts with tin to produce tin (II) chloride and hydrogen.**

3. **Carbon reacts with zinc oxide to produce zinc and carbon dioxide.**

4. **Bromine reacts with sodium iodide to produce sodium bromide and iodine.**

5. **Phosphorus reacts with bromine to produce phosphorus tribromide.**

6. **Calcium hydride reacts with water to produce calcium hydroxide and hydrogen gas.**

7. Methane (CH_4) combusts with oxygen to produce carbon dioxide and water.

8. Aluminum nitrate reacts with iron (II) chloride to produce iron(II) nitrate and aluminum chloride.

9. Ammonia reacts with hydrogen chloride to form ammonium chloride.

10. Ethane (C_2H_6) burns in oxygen to produce carbon dioxide and water.

<u>Writing chemical Equations with Physical States</u>

When writing chemical equations, it is often desirable to indicate the physical state of the substance or if it is dissolved in water When writing physical states the following symbols are used.
(s)--solid, (l)--liquid, (g)--gas, and (aq)--aqueous for a substance dissolved in water.
Example: Magnesium strips react with hydrochloric acid to produce hydrogen gas and magnesium chloride.

$$Mg(s) + 2HCl(aq) \rightarrow H_2(g) + MgCl_2(s)$$

<u>Additional Symbols</u>

↔ A double arrow pointing in opposite directions. Indicates a reversible reaction.
↓ Indicates a precipitate.
↑ Indicates a gas being produced.

$\xrightarrow{\Delta}$ A triangle over an arrow indicates heat. The triangle may be replaced with the word heat.

$\xrightarrow{Pt}$ An element or compound written over an arrow indicates a catalyst. A catalyst is a substance that increases the speed of a reaction but is not used up or changed in any way.

A pressure or temperature may also be written over an arrow to indicate these types of conditions at which a reaction takes place.

For each of the following equations, write a sentence that describes the reaction, including the physical states and reaction conditions(s).

1. $Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

2. $CaCl_2(aq) + Na_2CO_3(aq) \rightarrow CaCO_3(s) + 2NaCl(aq)$

3. $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

4. $CaCO_3 \xrightarrow{\Delta} CaO(s) + CO_2(g)$

Significance of a Chemical Equation

1. The coefficients in a chemical equation show relative, not absolute amounts. This means that only the smallest number is shown, but any ratio of these coefficients can be used for higher amounts.
2. The relative masses of the reactants and products can be determined from the coefficients. In other words each coefficient represents the number of moles.
3. The reverse reaction has the same relative amounts as the forward reaction.

Chemical equations do not tell if the reaction will actually occur. Whether the reaction will occur or not is discussed in section 3.

Section 2 Types of Chemical Reactions pgs. 276-284.

Objectives:

1. **Define and give general equations for synthesis, decomposition, single-displacement, and double-displacement reactions.**
2. **Classify a reaction as a synthesis, decomposition, single-displacement, double-displacement, or combustion reaction.**
3. **List three kinds of synthesis reactions and five kinds of decomposition reactions.**
4. **List four kinds of single-displacement and three kinds of double-displacement reactions.**
5. **Predict the products of simple reactions given the reactants.**

Vocabulary: Define the following.

1. **synthesis reaction--**

2. decomposition reaction--

3. electrolysis--

4. single-displacement reaction--

5. double-displacement reaction--

6. combustion--

I. Synthesis Reactions

A synthesis reaction is also known as a composition reaction. In a synthesis reaction 2 or more substances combine to form a new substance. The two substances that combine may be two elements, or an element and a compound, or two compounds.
*******The key to determining if a synthesis reaction has occurred is that only one product is formed.***
The general equation is:

$$A + X \rightarrow AX$$

The three types of synthesis reactions discussed in this text are:

1. Synthesis Reactions of Elements with Oxygen and Sulfur

In these types of reactions M is used to indicate the metal. Since both oxygen and sulfur contain a negative two ion charge, (O^{-2}, and S^{-2}), the reaction with a group 1 alkali metal will give M_2O or M_2S, and the reaction with a group 2 alkaline earth metal will give MO and MS respectively. The product is a single oxide or sulfide.

Remember, some transition metals have two ion charges and can form two different oxides and sulfides. For example, copper has two charges $Cu^{+1,+2}$ and can therefore form Cu_2O and CuO with oxygen and Cu_2S, and CuS with sulfur.
Write the four names of the compounds formed above using the stock system

1. Cu_2O _____

2. CuO _____

3. Cu_2S _____

4. CuS _____

Both oxygen and sulfur can also form compounds with nonmetals. Recall that the element that has the smaller group number is given first and if both elements are in the same group, the element whose period number is greater is given first. For example, NO_2 is nitrogen dioxide and SO_2 is sulfur dioxide.

2. Synthesis of Metals with Halogens

Halogens react with group 1 and group 2 metals to form ionic or covalent compounds (mostly ionic). Using M to represent the metal and X to represent the halogen, the general formulas are MX and MX_2.
Halogens also react with transition metals.
Mentioned in the text are the reactions of fluorine to form NaF and cobalt (III) fluoride, CoF_3 in the fluoridation of water to prevent tooth decay.

3. Synthesis Reactions with Oxides

Oxides of metals react with water to produce metal hydroxides which are bases.
Example:

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

Many oxides of nonmetals react with water to form oxyacids.
Example:

$$SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq) \text{ (sulfurous acid)}$$

The further reaction of sulfurous acid with oxygen produces acid rain in the form of sulfuric acid.

$$2\,H_2SO_3(aq) + O_2(g) \rightarrow 2H_2SO_4(aq)$$

II. Decomposition Reactions

In a decomposition reaction, a single compound undergoes a reaction that produces two or more simpler substances.
*****The key to identifying a decomposition reaction is that there is only one reactant.***
The general equation is:

$$AX \rightarrow A + X$$

Most decomposition reactions require the addition of energy in the form of electricity or heat for the reaction to occur.
If electricity is the energy source the reaction is called electrolysis.
For example the equation for the electrolysis of water (also called hydrolysis) represents an example of decomposition of a binary compound:

1. Decomposition of a Binary Compound

$$2\,H_2O\,(l) \xrightarrow{\text{electricity}} 2H_2(g) + O_2(g)$$

Write an example of the following decompositions reactions.

2. Decomposition of a Metal Carbonate

Example:

3. Decomposition of Metal Chlorates

Example:

4. Decomposition of Metal Hydroxides

Example:

5. Decomposition of Acids

Example:

III. Single-Displacement Reactions

Single-Displacement reactions are also known as replacement reactions. In this type of reaction one element replaces a similar element in a compound. Most of these reactions occur in water.
*********The key to identifying a single-displacement reaction is that there is an element and a compound on both sides of the equation.***
The general formula for a single-displacement reaction is:

$$A + BX \rightarrow AX + B$$

Please Note: In the next section of this chapter you will be given an activity series of metals that will tell which metal will replace another metal in a displacement reaction and which metal will not replace another in this type of reaction.

Write and example for each type of single-displacement reaction from your text.

1. Displacement of a Metal in a Compound by Another Metal

Example:

2. Displacement of Hydrogen in Water by a Metal

Example:

3. Displacement of Hydrogen in an Acid by a Metal

Example:

4. Displacement of Halogens Note: The most reactive halogens are above the others and will replace those below it but not the other way around.

Example:

IV. Double-Displacement Reactions

In a double-displacement reaction the ions of two compounds exchange places in an aqueous solution to form two new compounds.
Indications: a. a precipitate b. a gas or c. a molecular compound usually water.

*******The key to identifying this type of reaction is that there are <u>two compounds on both sides</u> of the equation.***

The general equation is:

$$AX + BY \rightarrow AY + BX$$

Write an example of the types of double-displacement reactions from your text.

<u>1. Formation of a Precipitate</u>

A precipitate forms when the cations of one reactant combine with the anions of another reactant to form an insoluble or slightly soluble compound.

<u>Example</u>:

What does insoluble mean?

<u>Answer:</u>

<u>2. Formation of a Gas</u>

Another indication of a double-displacement reaction is the formation of an insoluble gas.

<u>Example</u>:

<u>3. Formation of Water</u>

Sometimes a stable molecular compound such as water is formed.

<u>Example</u>:

The example above as given in your text is also known as a neutralization reaction in which an acid combines with a base producing a salt and water.

<u>V. Combustion Reactions</u>

In a combustion reaction a substance combines with oxygen, releasing large amounts of energy in the form of heat and light.

*******The key to identifying this reaction is the presence of oxygen as a reactant. If the other reactant is a hydrocarbon such as CH_4, then the products are CO_2 and water.***

Write two examples from your text. One of the examples should be the combustion of a hydrocarbon.

<u>Example</u>:

<u>Example:</u>

Answer the following <u>section review</u> questions from your textbook on pg. 284.

2. a.

b.

c.

d.

3. a.

b.

c.

d.

4. a.

b.

c.

d.

<u>Section 3 Activity Series of the Elements pgs. 285-288.</u>

<u>Objectives:</u>

1. Explain the significance of an activity series.

2. Use an activity series to predict whether a given reaction will occur and what the products will be.

Vocabulary: Define the following.

1. activity series--

Some elements will react with other elements while others will not. The usual method to determine the order in which some elements will replace another in a compound is by means of single-displacement reactions.

For metals this means how easily they can lose electrons in relationship to another metal and in nonmetals this is determined by the ease at which they gain electrons.

***********_**In the activity series of elements the more reactive element is placed on top and can replace any element below it in a single-displacement reaction. The element below this reactive element however cannot replace any element above it.**_

The activity series of elements is found on pg. 286 in your text and should be copied here in your notes AND on the back of your periodic table.

Activity Series of the Elements

Activity of Metals **Activity of Halogen**

********The activity series determines both if the reaction will occur and if so the new compound formed.**

Examples of how this occurs are found on pg. 286 Sample Problem F with the solutions given on page 287.

After review of these examples answer the following questions from your textbook on pg. 287. Based on the activity series, predict whether each of the following possible reactions will occur, and if the reactions do occur write the products and balance the equation.

1. $Ni(s) + H_2O(l) \rightarrow$

2. $Br_2(l) + KI(aq) \rightarrow$

3. $Au(s) + HCl(aq) \rightarrow$

4. $Cd(s) + HCl(aq) \rightarrow$

5. $Mg(s) + Co(NO_3)_2 \rightarrow$