CHEMISTRY 101 NOTES: CHAPTER 8: CHEMICAL EQUATIONS
Pgs. 143 - 167

The Chemical Equation

A chemical equation concisely shows the initial (reactants) and final (products) results of a chemical or physical change along with the amounts of each involved. ***Symbols are used as abbreviations.***

SEE TABLE 8.1 pg. 145 for COMMONLY USED SYMBOLS.

Example 1

$$C_{(s)} + O_{2(g)} + H_2O_{(l)} \rightarrow H_2CO_{3(aq)}$$

(s), (g), (l), and (aq) indicate phases each substance is in. The arrow indicates yields or produces and always follows the reactants. Any substance to the left of the arrow is a reactant, to the right a product.

Sometimes other symbols are present above the arrow such as the Greek letter Δ which indicates heating was done to speed up or initiate the reaction or the formula for a substance that acts as a catalyst to speed up reaction is sometimes seen written above the arrow.

WRITING AND BALANCING EQUATIONS

Equations are balanced in order to obey the *law of conservation of matter.* The same number of atoms for each substance must appear on the reactant (left) and product (right) side of the equation. Balancing involves placing coefficients (whole numbers, never left as fractions) in front of the formulas for substances involved in the reaction as needed.

NOTE: It is not always necessary to change the coefficients of an equation in order to balance it.

Balance the following equations:

a. $Na_{(s)} + H_2O_{(l)} \rightarrow H_{2(g)} + NaOH_{(aq)}$

b. $Li_{(s)} + Cl_{2(aq)} \rightarrow LiCl_{(s)}$

c. $Ca(NO_3)_{2(aq)} + KOH_{(aq)} \rightarrow Ca(OH)_{2(s)} + KNO_{3(aq)}$

d. $Ag_2O_{(s)} \rightarrow Ag_{(s)} + O_{2(g)}$

e. $Ag^{+}_{(aq)} + S^{2-}_{(aq)} \rightarrow Ag_2S_{(s)}$

NOTE: In e., ions were balanced. This is normal and often occurs for reactions of ions in solutions.

Balancing equations takes practice!

Useful Information Equations Give

When looking at the formulas involved in a balanced equation, several types of information can be determined:

a. atoms or molecules of a substance involved.

Example: $2\ Na + Cl_2 \rightarrow 2\ NaCl$

The coefficients indicate that for every 2 atoms of Na, 2 formula units of NaCl are formed. Also, 1 molecule of Cl_2 is required to react.

b. moles of substances involved

Example: $6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2$

For every 6 moles of CO_2 and 6 moles of H_2O used up, 1 mole of $C_6H_{12}O_6$ and 6 moles of O_2 are produced.

c. grams of a substance involved

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

For every 4.04 g of H_2 and 32.00 g of O_2 consumed, 36.04 g of water are produced.

NOTE: Check to see if it obeys law of conservation of mass:

4.04 g of H_2 and 32.00 g of O_2 = 36.04 g of water? YES!

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

2 molecules	**1 molecule**	**2 molecules**
2 moles	**1 mole**	**2 moles**
4.04 g	**32.00 g**	**36.04 g**

Classification of Chemical Reactions

There are 4 main types of chemical reactions that can easily be classified.

NOTE: MANY CHEMICAL REACTIONS DO NOT FIT INTO THESE 4 CATEGORIES.

1. **SYNTHESIS OR COMBINATION: As the name implies, this involves 2 or more substances combining chemically to produce a new compound.**

Examples: $2\ Na_{(S)} + Cl_{2(g)} \rightarrow 2\ NaCl_{(s)}$

$2\ H_{2(g)} + O_{2(g)} \rightarrow 2\ H_2O_{(l)}$

The form of each of these equations is A + B → AB.

2. DECOMPOSITION: The reverse of a synthesis reaction. One substance breaks down into two or more substances. Usually this is accomplished using heat, electricity, or shock.

Examples: $2\ Ag_2O_{(s)} \rightarrow 4\ Ag_{(S)} + O_{2(g)}$ **(heat)**

$2\ H_2O_{(l)} \rightarrow 2\ H_{2(g)} + O_{2(g)}$ **(electricity)**

$2\ NaN_{3(s)} \rightarrow 2\ Na_{(l)} + N_{2(g)}$ **(heat or shock)**

The form of each of these equations is AB → A + B.

3. SINGLE-REPLACEMENT OR DISPLACEMENT: One element replaces (displaces) another element from a compound. The element replaced is then set free as the native element.

Examples: $Zn_{(s)} + CuSO_{4(aq)} \rightarrow ZnSO_{4(aq)} + Cu_{(s)}$

$Cl_{2(g)} + 2\ NaBr_{(l)} \rightarrow Br_{2(g)} + 2\ NaCl_{(l)}$

The form of each equation is A + BC → B + AC.

***NOTE*: The reverse reactions of the 2 examples above would NOT occur spontaneously. Reactions occur spontaneously in one direction only. Outside energy would need to be added to cause the reverse reactions to occur (termed endothermic).**

How can one determine whether or not a reaction that is single replacement will be spontaneous or not? THE ACTIVITY SERIES IS USED FOR THIS. **See Table 8.2 on pg. 154.**

If no reaction occurs, write "no reaction" after the arrow.

4. DOUBLE DISPLACEMENT OR DOUBLE DECOMPOSITION:

Two <u>*ionic*</u> compounds dissolved in water displace ions from each other twice and form a solid precipitate or weak electrolyte.

<u>Examples</u>: $Ca(NO_3)_{2(aq)} + Na_2CO_{3(aq)} \rightarrow CaCO_{3(s)} + 2\ NaNO_{3(aq)}$

To determine which of the products the solid would be, see the Solubility Table in Appendix V, pg. A-17.

<u>Example</u>: $NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

This reaction is a neutralization reaction. A base (NaOH) reacted with an acid (HCl) to yield a salt (NaCl) and water.

It is double displacement because H^+ goes with OH- and Na^+ goes with Cl-.

<u>Thermal Energy (Heat) changes are always involved in chemical reactions. The terms used for this are endothermic or exothermic.</u>

In endothermic reactions, heat is absorbed when reaction occurs and the temperature of the system drops. ***Energy is required to start reaction.***

In exothermic reactions, heat is released when reaction occurs and ***the temperature of the system increases*****.**

Examples of endothermic reactions: photosynthesis, decomposing sugar, water, or table salt

Examples of exothermic reactions: combustion, rusting (slow combustion), decomposing nitroglycerin, TNT

Why is energy released in an exothermic reaction?

Each substance involved in a chemical reaction has a certain heat content or enthalpy. When a reaction occurs, products form that do not have the same heat content as the original reactants. If the heat content for the products added together is less than the total heat content of the original reactants, then heat has to be released (exothermic) in order to obey the ***law of conservation of energy*****. Conversely, heat is absorbed in an endothermic reaction as the enthalpy of the products is greater than that of the original reactants.**