Types of Reactions

Chemical reactions can be categorized into a variety of types. Five common types that we will study are **synthesis**, **decomposition**, **combustion**, **single replacement** and **double replacement**. Be familiar enough with the description of each type so that you are able to classify a reaction if given a chemical equation or verbal description.

**Synthesis:**
Synthesis reactions involve the formation of more complex compounds (many atoms) from simpler compounds and/or elements. The most common synthesis reaction involves the formation of a compound from its elements.

Examples:
- \(2 \text{H}_2(g) + \text{O}_2(g) \rightarrow 2 \text{H}_2\text{O}(g)\)
- \(3 \text{H}_2(g) + \text{N}_2(g) \rightarrow 2 \text{NH}_3(g)\)
- General: \(A + B \rightarrow AB\)

Synthesis reactions are also referred to as combination, formation, and addition reactions.

**Decomposition:**
Decomposition reactions involve the breaking down of more complex compounds (larger, more atoms) into simpler compounds and/or elements. These reactions can often be thought of as being the opposite of synthesis reactions. Decomposition reactions often require heating in order to occur.

Examples:
- \(2 \text{H}_2\text{O}(l) \rightarrow 2 \text{H}_2(g) + \text{O}_2(g)\)
- \(2 \text{KClO}_3(s) \rightarrow 2 \text{KCl}(s) + 3 \text{O}_2(g)\)
- General: \(AB \rightarrow A + B\)

**Combustion:**
Combustion reactions involve the reaction of a substance with oxygen gas (\(\text{O}_2\)). It is often referred to as burning. The products of the reaction are oxides of the elements in the reactants. Hydrocarbon combustion leads to the formation of carbon dioxide gas and water vapor.

Examples:
- \(2 \text{Mg}(s) + \text{O}_2(g) \rightarrow 2 \text{MgO}(s)\)
- \(\text{CH}_4(g) + 2 \text{O}_2(g) \rightarrow \text{CO}_2(g) + 2 \text{H}_2\text{O}(g)\)
- General: \(AB + O_{2g} \rightarrow A_xO_y + B_wO_z\)

Some combustion reactions are also synthesis reactions. For instance, the combustion of magnesium leads to the formation of magnesium oxides.

Artwork taken from an unknown source (a worksheet acquired second-hand many years ago).
**Single Replacement:**
Single replacement reactions involve the reaction of an element with an ionic compound. The single element replaces one of the ions in the compound. If the lone element is a metal, then it will replace the positive ion in the compound. If the lone element is a nonmetal, then it will replace the negative ion.

Examples:

- \[ 2 \text{Al}(s) + 3 \text{CuCl}_2(aq) \rightarrow 3 \text{Cu}(s) + 2 \text{AlCl}_3(aq) \]
- \[ 2 \text{NaCl}(s) + F_2(g) \rightarrow \text{Cl}_2(g) + 2 \text{NaF}(s) \]

General: \[ A + BC \rightarrow AC + B \text{ (if A is a metal)} \]
- \[ A + BC \rightarrow BA + C \text{ (if A is a nonmetal)} \]

Single replacement reactions are also referred to as single displacement reactions.

**Double Replacement:**
Double replacement reactions involve the reaction of two ionic compounds to form two different ionic compounds. The positive ion in one compound replaces the positive ion in the other compound.

Examples:

- \[ 2\text{KI}(aq) + \text{Pb(NO}_3)_2(aq) \rightarrow \text{PbI}_2(s) + 2\text{KNO}_3(aq) \]
- \[ \text{HCl}(aq) + \text{NaOH}(aq) \rightarrow \text{NaCl}(aq) + \text{H}_2\text{O}(l) \]

General: \[ AB + CD \rightarrow AD + BC \]

Double replacement reactions are also referred to as double displacement reactions, and less commonly as metathesis reactions.

Many double replacement reactions involve the formation of a precipitate. The two reactants and one of the products are aqueous solutions of ionic salts and the other product is an ionic salt that is not soluble in water. It is seen as a precipitating solid. This is sometimes termed a precipitation reaction.

Some double replacement reactions involve the reaction of an acid with a base; these are a special case of double replacement reactions known as acid-base neutralization reactions.