Notes – Types of Chemical Reactions

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Chemists classify chemical reaction by their similarities. We will examine five types of chemical reactions. Skill: given a chemical equation, assign it as one of the five types of chemical reactions.

1. Synthesis Reaction
    a. Definition: In a **synthesis reaction**, also known as a composition reaction, two or more substances combine to form a new compound
    b. General formula: A + X → AX
    c. A or X can be elements or compounds, but AX is a compound.
        i. 2Mg(s) + O2(g) → 2MgO(s) is a synthesis reaction using a diatomic element and a monotomic element.
        ii. $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(s)$ is a synthesis reaction between two compounds
    d. Demo: Burning Magnesium metal
        i. $2Mg(s) + O_2(g) \longrightarrow 2MgO(s)$
        ii. Materials: Magnesium ribbon, tings, pie tin, lighter
        iii. Hazards: Do not look directly at flame
        iv. Question: Where does the oxygen come from? What is left? Why is there smoke. **What evidence do we have that a chemical reaction took place?**
        v. Often used in fireworks.

2. Decomposition reaction
    a. Definition: In a **decomposition reaction**, a single compound undergoes a reaction that produces two or more simpler substances or compounds.
    b. General formula: AX → A + X
    c. A or X can be elements or compounds, but AX is a compound
        i. $H_2CO_3(aq) \rightarrow CO_2(g) + H_2O(l)$
        ii. The decomposition of a substance by an electric current is called **electrolysis**
            1. $2H_2O(l) \xrightarrow{\text{electricity}} 2H_2(g) + O_2(g)$
    d. Demo: Decomposition of sucrose with 15M sulfuric acid.
        i. $C_{12}H_{22}O_{11}(s) + \cancel{11H_2SO_4} \rightarrow 12C(s) + 11\cancel{H_2SO_4}\,H_2O(g)$
        ii. Note that the Sulfuric acid (H_2SO_4) is not used up in the reaction, but rather allows the reaction to progress.

iii. Questions: where is the water? What is the black stuff? **What evidence do we have that a chemical reaction took place?**

3. Single-displacement
    a. Definition: In a **single-displacement reaction,** also known as a replacement reaction, one element replaces a similar element in a compound
    b. General formula: $A + BX \rightarrow AX + B$ or $Y + BX \rightarrow BY + X$
        i. A, B, X are elements and any combinations are compounds
        ii. $2Al(s) + 3Pb(NO_3)_2(aq) \rightarrow 3Pb(s) + 2Al(NO_3)_3(aq)$
        iii. $Mg(s) + 2HCl(aq) \rightarrow H_2(g) + MgCl_2(aq)$
        iv. Note that bonds must be BOTH broken AND formed
    c. Demo: $Fe(s) + CuSO_4(aq) \rightarrow FeSO_4(aq) + Cu(s)$
        i. **What evidence do we have that a chemical reaction took place?** Note the color change, that is one of the criteria for deciding whether a reaction has take place. Also there is a copper precipitate.
4. Double-replacement
    a. Definition: In **double-displacement** reactions, the ions of two compounds exchange places in aqueous solution to form two new compounds.
    b. General Formula: $AX + BY \rightarrow AY + BX$
        i. A, B, X, and Y are ions. AY and BX are compounds (ionic of molecular). AX and BY are ionic compounds.
        ii. Example: $FeS(s) + 2HCl(aq) \rightarrow H_2S(g) + FeCl_2(aq)$
        iii. Demo: $2KI(aq) + Pb(NO_3)_2(aq) \rightarrow PBI_2(s) + 2KNO_3(aq)$
5. Combustion reaction
    a. Definition: In a **combustion reaction**, a substance combines with oxygen, releasing a large amount of energy in the form of light and heat.
    b. General Formula: (something combustible, like a hydrocarbon) + $O_2(g)$ $\rightarrow$ $H_2O(g)$ + (whatever's left)
        i. Ex: $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$
        ii. Demo: $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$