Introduction to Chemical Reactions and Equations

A **chemical reaction** is a process that rearranges the atomic structure of substances, creating new substances with different properties. The original substances are called **reactants**, and the new substances formed are called **products**. A **chemical equation** is a symbolic representation of a chemical reaction, using chemical formulas and symbols to show the reactants and products involved. The arrow (→) shows the direction of the reaction.

Characteristics of Chemical Reactions

You can tell a chemical reaction has occurred by observing these changes:

- **Change in State**: Reactants can be in a different physical state (solid, liquid, or gas) than the products. For example, solid candle wax melts and then reacts with oxygen to form gaseous carbon dioxide and water vapor.
- **Change in Color**: A new substance with a different color is formed. A classic example is the reaction between iron and copper sulfate, where the blue solution of copper sulfate turns green as iron sulfate is formed.
- **Evolution of a Gas**: Gas bubbles may be released during the reaction. When zinc reacts with dilute hydrochloric acid, hydrogen gas is evolved.

- **Change in Temperature**: Reactions can either release heat (**exothermic**) or absorb heat (**endothermic**). For example, the reaction of calcium oxide (quicklime) with water is exothermic, producing a lot of heat.
- **Formation of a Precipitate**: An insoluble solid, called a **precipitate**, may form from a solution. When you mix solutions of lead nitrate and potassium iodide, a yellow precipitate of lead iodide forms.

Balancing Chemical Equations

According to the **Law of Conservation of Mass**, matter cannot be created or destroyed in a chemical reaction. Therefore, the total mass of the reactants must equal the total mass of the products. To satisfy this law, chemical equations must be **balanced**, meaning the number of atoms of each element on the reactant side must be equal to the number of atoms of that same element on the product side.

Steps for Balancing an Equation:

1. Write the unbalanced chemical equation, also known as a **skeletal chemical equation**.
2. Count the number of atoms of each element on both sides of the equation.
3. Add coefficients (whole numbers placed in front of the chemical formulas) to balance the elements. **Never change the subscripts** within a chemical formula.

Changing a subscript changes the substance itself (e.g., H_2O is water, but H_2O_2 is hydrogen peroxide).

4. It's often a good strategy to balance the elements that appear in only one reactant and one product first. Save hydrogen and oxygen for last.
5. Re-check the atom count on both sides to ensure the equation is balanced.

Example: Balancing the equation for the formation of water.

$H_2 + O_2 \rightarrow H_2O$ (Unbalanced)

- **Reactants**: 2 H atoms, 2 O atoms
- **Products**: 2 H atoms, 1 O atom

To balance the oxygen, put a '2' in front of H_2O:

$H_2 + O_2 \rightarrow 2H_2O$ (Partially balanced)

- **Reactants**: 2 H atoms, 2 O atoms
- **Products**: 4 H atoms, 2 O atoms

Now the hydrogen is unbalanced. Put a '2' in front of H_2:

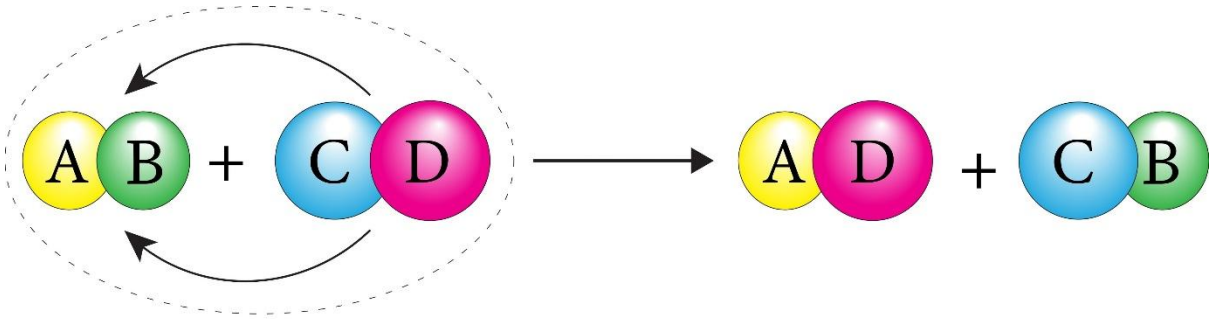
$2H_2 + O_2 \rightarrow 2H_2O$ (Balanced)

- **Reactants**: 4 H atoms, 2 O atoms
- **Products**: 4 H atoms, 2 O atoms

The equation is now balanced.

Types of Chemical Reactions

1. **Combination Reaction**: Two or more reactants combine to form a single product.
    - General form: $A+B \rightarrow AB$
    - Example: $2H_2+O_2 \rightarrow 2H_2O$
2. **Decomposition Reaction**: A single compound breaks down into two or more simpler substances. This often requires energy in the form of heat, light, or electricity.
    - General form: $AB \rightarrow A+B$
    - Example: $CaCO_3(s) \xrightarrow{heat} CaO(s)+CO_2(g)$
3. **Displacement Reaction**: A more reactive element displaces a less reactive element from its compound.
    - General form: $A+BC \rightarrow AC+B$
    - Example: $Fe(s)+CuSO_4(aq) \rightarrow FeSO_4(aq)+Cu(s)$
4. **Double Displacement Reaction**: Two compounds exchange ions to form two new compounds.
    - General form: $AB+CD \rightarrow AD+CB$
    - Example: $AgNO_3(aq)+NaCl(aq) \rightarrow AgCl(s)\downarrow+NaNO_3(aq)$



$$AB+CD \longrightarrow AD+CB$$

5. **Oxidation and Reduction Reactions (Redox)**:
    - **Oxidation**: A substance **gains oxygen** or **loses hydrogen**. It also refers to the **loss of electrons**.
    - **Reduction**: A substance **loses oxygen** or **gains hydrogen**. It also refers to the **gain of electrons**.
    - **Redox Reaction**: Oxidation and reduction occur simultaneously. The substance being oxidized is the **reducing agent**, and the substance being reduced is the **oxidizing agent**.