Metals and Nonmetals

Lecture Notes on Chemical Properties of Metals and Nonmetals

1. Formation of Positive Ions

- **Definition**: Metals tend to lose electrons to form positive ions (cations) during chemical reactions.
- **Process**:
  - Metals have a low ionization energy, making it easier for them to lose electrons.
  - Example: Sodium (Na) loses one electron to form a sodium ion (Na^+).

$$\mathrm{Na} \rightarrow \mathrm{Na}^+ + e^-$$

- **Nonmetals**: Typically gain electrons to form negative ions (anions) during chemical reactions.
  - Example: Chlorine (Cl) gains one electron to form a chloride ion (Cl^-).

$$\mathrm{Cl} + e^- \rightarrow \mathrm{Cl}^-$$

2. Reaction with Oxygen

- **Metals**: When metals react with oxygen, they form metal oxides. These reactions are often exothermic.
  - **General Reaction**:

$$\mathrm{Metal} + \mathrm{Oxygen} \rightarrow \mathrm{Metal\ Oxide}$$

  - **Example**: Magnesium burns in oxygen to form magnesium oxide.

$$2\mathrm{Mg} + \mathrm{O_2} \rightarrow 2\mathrm{MgO}$$

- **Nonmetals**: Nonmetals react with oxygen to form nonmetal oxides, which are usually acidic.
  - **Example**: Sulfur reacts with oxygen to form sulfur dioxide.

$$\mathrm{S} + \mathrm{O_2} \rightarrow \mathrm{SO_2}$$

3. Reaction with Water

- **Metals**: Metals react with water to form metal hydroxides and hydrogen gas. The reactivity varies among different metals.
  - **General Reaction**:

$$\text{Metal} + \text{Water} \rightarrow \text{Metal Hydroxide} + \text{Hydrogen}$$

- **Example**: Sodium reacts vigorously with water.

$$2Na + 2H_2O \rightarrow 2NaOH + H_2$$

- **Nonmetals**: Nonmetals generally do not react with water under normal conditions.

4. Reaction with Acids

- **Metals**: Metals react with acids to form a salt and hydrogen gas.
  - **General Reaction**:

$$\text{Metal} + \text{Acid} \rightarrow \text{Salt} + \text{Hydrogen}$$

  - **Example**: Zinc reacts with hydrochloric acid.

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

- **Nonmetals**: Nonmetals generally do not react with dilute acids. However, some nonmetals like sulfur can react with concentrated acids.

5. Reactivity Series

- **Definition**: The reactivity series is a list of metals arranged in order of decreasing reactivity.
- **Purpose**: Helps predict how metals will react with other substances such as water, acids, and oxygen.
- **Example**: Potassium and sodium are highly reactive, whereas gold and platinum are least reactive.

  Reactivity Series (from most reactive to least reactive):

  - Potassium (K)
  - Sodium (Na)
  - Calcium (Ca)
  - Magnesium (Mg)
  - Aluminum (Al)
  - Zinc (Zn)
  - Iron (Fe)
  - Lead (Pb)
  - Copper (Cu)
  - Silver (Ag)
  - Gold (Au)

6. Alloys

- **Definition**: An alloy is a mixture of two or more elements, where at least one element is a metal.

- **Purpose**: Alloys are created to enhance the properties of metals, such as strength, durability, and resistance to corrosion.

- **Examples**:

    - **Brass**: An alloy of copper and zinc, used in musical instruments and decorative items.
    - **Steel**: An alloy of iron and carbon, widely used in construction and manufacturing.

- **Properties of Alloys**:

    - **Increased Strength**: Alloys are often stronger than pure metals.
    - **Resistance to Corrosion**: Many alloys are designed to resist corrosion.
    - **Enhanced Hardness**: Alloys can be made harder than the constituent metals.

By understanding these chemical properties, we can predict and explain the behavior of metals and nonmetals in various chemical reactions, and utilize alloys to meet specific needs in industrial applications.