Rate of Reaction

The **rate of reaction** is defined as the change in the concentration of a reactant or product per unit time during a chemical reaction. It is a measure of how quickly reactants are converted into products. Chemical reactions do not all proceed at the same speed; some occur almost instantaneously, while others may require hours, days, or even years to reach completion. The study of reaction rates helps in understanding reaction mechanisms, designing industrial processes, and optimizing reaction conditions. The rate of a reaction depends on several factors, including the nature of the reactants, their concentration, temperature, pressure (for gaseous reactions), surface area of solid reactants, and the presence of a catalyst.

General Chemical Reaction

Consider a general chemical reaction:

$$aA + bB \rightarrow cC + dD$$

The rate of reaction can be expressed in terms of either the decrease in the concentration of reactants or the increase in the concentration of products with time.

Mathematical Expression of Rate of Reaction

The average rate of reaction is given by:

$$\text{Rate} = -\frac{\Delta[\text{Reactant}]}{\Delta t} = \frac{\Delta[\text{Product}]}{\Delta t}$$

For the general reaction:

$$aA + bB \rightarrow cC + dD$$

$$\text{Rate} = -\frac{1}{a}\frac{\Delta[A]}{\Delta t} = -\frac{1}{b}\frac{\Delta[B]}{\Delta t} = \frac{1}{c}\frac{\Delta[C]}{\Delta t} = \frac{1}{d}\frac{\Delta[D]}{\Delta t}$$

The negative sign is used for reactants because their concentration decreases as the reaction proceeds, whereas the positive sign is used for products because their concentration increases with time. Dividing by the stoichiometric coefficients ensures that the rate of reaction remains the same regardless of which reactant or product is used for its calculation.