Unit 4

Chemical Kinetics

- **Chemical kinetics** is the branch of chemistry which addresses the question "How fast do reactions go?" Chemical kinetics includes investigations of how different experimental conditions can influence the speed of a chemical reaction and yield information about the reaction's mechanism and transition states.

RATE OF CHEMICAL REACTION

- The rate of reaction is the change in the concentration of any one of the reactants or products per unit time.

$$\text{Rate of reaction} = \frac{\text{decrease in conc. of reactant}}{\text{time taken}}$$

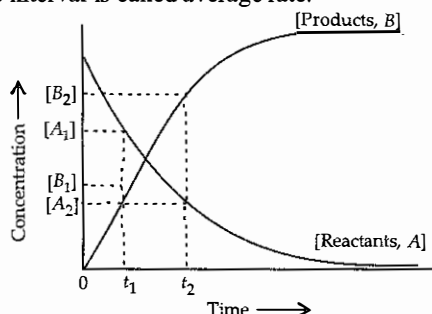$$= \frac{\text{increase in conc. of product}}{\text{time taken}}$$

Consider a reaction : $A + B \longrightarrow C + D$
Then rate of reaction

$$= -\frac{\Delta[A]}{\Delta t} = -\frac{\Delta[B]}{\Delta t} = \frac{\Delta[C]}{\Delta t} = \frac{\Delta[D]}{\Delta t}$$

Negative sign shows decrease in concentration with time and positive sign shows increase in concentration with time.
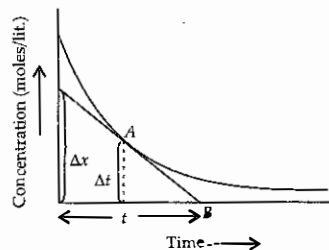
- **Unit :** Rate $= \dfrac{\text{concentration}}{\text{time}} = \dfrac{\text{mol / litre}}{s}$

  $= \text{mol litre}^{-1}\ s^{-1}$

- **Average rate of reaction :** The rate measured over a long time interval is called average rate.

$$\text{Average rate of reaction} = \frac{-\Delta[A]}{\Delta t} = \frac{\Delta[B]}{\Delta t}$$

$$r_{avg} = -\frac{[A_2]-[A_1]}{t_2-t_1} = \frac{[B_2]-[B_1]}{t_2-t_1}$$

- **Instantaneous rate :** The rate of change of concentration of any one of the reactants or products over a very small interval of time.

$$r_{inst.} = \lim_{\Delta t \to 0} -\frac{\Delta[A]}{\Delta t} = -\frac{d[A]}{dt}$$

$$r_{inst.} = \frac{\text{Intercept along coordinate}}{\text{Intercept along abscissa}} = \frac{\Delta x}{\Delta t}$$

Factors Affecting Rate of Reaction

- **Concentration of reactants :** As the concentration of reactants increases, the reaction rate increases. A higher concentration of reactants lead to more effective collisions per unit time, which leads to an increasing reaction rate (except for zero order reactions).

- **Catalysts :** Catalyst is a substance that increases the rate of a reaction but is not consumed in the reaction. It does so by lowering the activation energy (E_a). Possible ways of lowering the E_a of a reaction :

  ➤ Increase the frequency of collisions between the reactant molecules.

  ➤ Change the relative orientation of the reactant molecules.

  ➤ Provide an alternate pathway or mechanism for the reaction. For equilibrium reactions, both the forward and reverse reaction rates are affected by the catalyst. *i.e.,* E_a for both directions is decreased.
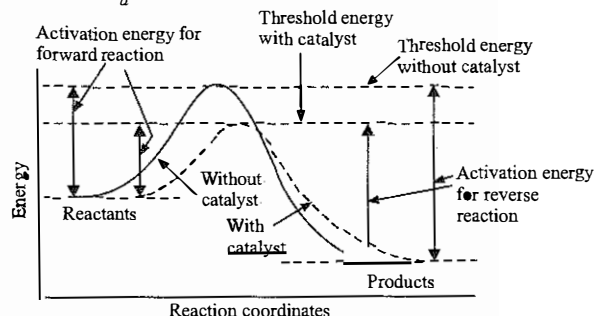

Fig : Effect of catalyst on the rate of reaction