# REACTION KINETICS

**Class XII**

**CONCEPT MAP**

Apart from playing an important role in industries and study of biological processes, kinetics also plays a role in environmental and atmospheric chemistry as part of an effort to understand a variety of issues ranging from the fate of prescription pharmaceutical in waste water to cascade of reactions involved in the ozone cycle.

## Rate of Reaction

Change in concentration of reactants or products as function of time (Unit : mol $L^{-1}$ $s^{-1}$ or M $s^{-1}$)

### Differential Rate Equation

$aA + bB \longrightarrow cC + dD$

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

### Instantaneous Rate

$$r_{ins} = -\frac{d[R]}{dt} = \frac{d[P]}{dt}$$

### Average Rate

$$r_{av} = -\frac{\Delta R}{\Delta t} = \frac{\Delta P}{\Delta t}$$

### Rate Law/Rate Equation

- The expression of rate in terms of molar concentration of reactants.
  For reaction, $aA + bB \longrightarrow cC + dD$
  Rate $= k[A]^x[B]^y$
  Where, $k$ = rate constant or specific reaction rate.
- Depends only upon temperature.
- Unit of $k = \left(\frac{\text{mol}}{\text{L}}\right)^{1-n} s^{-1}$
  where, $n$ = order of reaction.

### Order of Reaction

- Sum of powers of concentration terms in the rate law expression.
  e.g., Rate $= k[A][B]^2$
  $\therefore$ Order $= 1 + 2 = 3$
- For $n^{th}$ order, $t_{1/2} \propto \frac{1}{a^{n-1}}$
- Experimental concept and can be zero or fractional.
- Depends upon pressure and temperature.

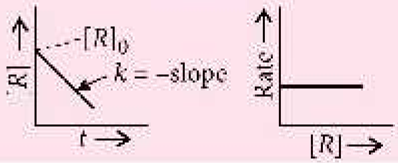
### Molecularity of Reaction

- The number of molecules of reactants taking part in elementary step of a reaction.
- Theoretical concept and can never be zero or fractional.
- Independent of pressure and temperature.

## Integrated Rate Equation

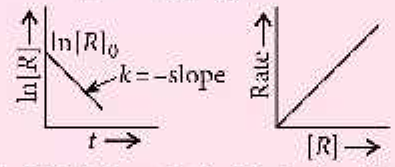
### Zero Order Reaction

- Rate $= k$ or $kt = [R]_0 - [R]$
- Unit of $k$ = mol $L^{-1}s^{-1}$
- $t_{1/2}$ (half-life) $= \frac{[R]_0}{2k}$




### First Order Reaction

- Rate $= k[R]$ or $k = \frac{2.303}{t}\log\frac{[R]_0}{[R]}$
- Unit of $k = s^{-1}$
- $t_{1/2} = 0.693/k$
- In terms of pressure,
  $$k = \frac{2.303}{t}\log\frac{p_i}{2p_i - p_t}$$

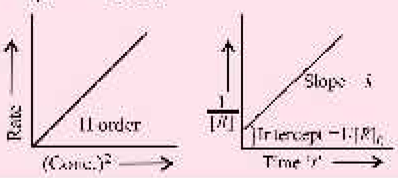



**Useful Relations for First Order Reaction**

$t_{75\%} = 2t_{1/2}, t_{87.5\%} = 3t_{1/2}, t_{93.75\%} = 4t_{1/2}, t_{96.87\%} = 5t_{1/2}, t_{99.9\%} = 10t_{1/2}$

### Second Order Reaction

- Rate $= k[R]^2$ or $1/[R]_t = kt + 1/[R]_0$
- Unit of $k$ = L $mol^{-1}$ $s^{-1}$
- $t_{1/2} = 1/k[R]_0$




### $n^{th}$ Order Reaction

- Rate $= k[R]^n$
  or $(n-1)kt = \frac{1}{[R]^{n-1}} - \frac{1}{[R]_0^{n-1}}$
- Unit of $k = (\text{mol } L^{-1})^{1-n} s^{-1}$
- $t_{1/2} = 2^{n-1} - 1 / k(n-1)[R]_0^{n-1}$

## Dependency of Rate on Temperature

### Arrhenius Equation

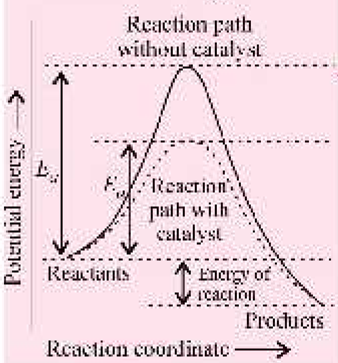
- $k = Ae^{-E_a/RT}$
  Here, $A$ = pre-exponential factor
  $R$ = Gas constant
  $E_a$ = Activation energy
- $\log\frac{k_2}{k_1} = \frac{E_a}{2.303R}\left(\frac{T_2 - T_1}{T_1T_2}\right)$

### Activation Energy ($E_a$)

- Energy required by the reactant molecules for effective collisions to form products.
- The slope of ln $k$ vs $1/T$ has the value $-E_a/R$ and is used to calculate value of $E_a$.

### Effect of Catalyst on Activation Energy

- A catalyst increases the rate of reaction by providing a path of lower activation energy.




### Temperature Coefficient

- It is the ratio of $k_{298}$ to $k_{308}$.
- For every 10° rise in temperature the rate becomes double.

### Collision Theory

Rate $= P \cdot Z_{AB}e^{-E_a/RT}$