## Rate of Chemical Reaction

Change in concentration of reactants or product in unit time
Unit : $mol\ L^{-1}\ s^{-1}$ or $atm\ s^{-1}$

$$R \rightarrow P$$

**Rate of disappearance of R =**

$$\frac{\text{Decrease in concentration of R}}{\text{Time taken}} \quad \frac{-\Delta[R]}{\Delta t}$$

**Rate of appearance of P =**

$$\frac{\text{Increase in concentration of P}}{\text{Time taken}} \quad \frac{\Delta[P]}{\Delta t}$$

## Instantaneous Rate

Rate of change in concentration of reactant/product at a particular time

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

## Average Rate

Appearance of products or disappearance of reactants over a long time interval.

$$r_{avg} = \frac{d[P]}{dt} = slope$$

$$r_{avg} = \frac{-d[R]}{dt} = -slope$$

## Rate Law

Expression in which reaction rate in given in terms of molar concentration of reactants with each term raised to power which may or may not be same as stoichiometric coefficient of reactants in a balanced chemical equation

$$aA + bB \quad cC + dD$$
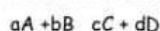
$$Rate = K[A]^x[B]^y = \frac{d[R]}{dt}$$

## Factors Influencing

**Concentration** : Higher the concentration of reactants, faster is the rate of reaction **Temperature** : Increases with increase in temperature. becomes almost double with $10°C$ rise.

**Presence of Catalyst** : Increases with a catalyst.

**Surface Area** : Greater is the surface area, faster is the rate of reaction.

**Activation Energy** : Lower the activation energy, faster is the reaction.

## Order of a Reaction

Sum of powers of concentration of the reactants in the Rate Law
**Rate Constant**: Rate of a reaction when concentration of each of the reactant is Unity

| Order | Unit |
|-------|------|
| 0 | $mol\ L^{-1}s^{-1}$ |
| 1 | $s^{-1}$ |
| 2 | $mol^{-1}Ls^{-1}$ |

## Molecularity of a Reaction

Number of reacting species taking part in an elementary reaction colliding to bring out a reaction.

## Integrated Rate Equation

Integration of differential rate equation to give a relation between concentrations at different times and rate constant.

| Order | Integrated Rate Law | Straight Plot | Units (K) |
|-------|---------------------|---------------|-----------|
| 0 | $kt = [R]_0 - [R]$ | $[R]$ vs t | $mol\ L^{-1}s^{-1}$ |
| 1 | $kt = \ln\{[R]_0/[R]\}$ | $\ln[R]$ vs t | $s^{-1}$ |

## Half Life of a Reaction

Time in which the concentration of a reactant is reduced to one half of its initial concentration

1st order

$$t_{1/2} = \frac{0.693}{K}$$

2nd order

$$t_{1/2} = \frac{[R]_0}{2K}$$
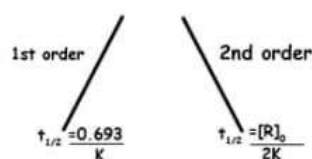
## Psedo First Order Reaction

- Are not truly of first order but under certain conditions behave as first order reaction
- Acid hydrolysis of ethyl acetate
- Inversion of sugar

## Arrhenius Equation

$$K = Ae^{-Ea/RT}$$

$$\log k = \log A - \frac{Ea}{2.303RT}$$

$$\log = \frac{k_2}{k_1} = \frac{Ea}{2.303RT}\left[\frac{T_2-T_1}{T_1T_2}\right]$$

**Activation Energy, Ea:** Energy required to form an intermediate called activated complex (c)
Ea = Threshold energy - Average Kinetic energy of reacting molecules

## Collision Theory

Rate of reaction depends on the collision frequency and effective collisions

### Effective Collisions

Collision in which molecules collide with sufficient kinetic energy and proper orientation for breaking of bonds and formation of new bonds.

### Collisions Frequency

Number of reacting species taking part in an elementary reaction colliding

### Rate

$$Rate = PZ_{AB}e^{-Ea/RT}$$

P is Steric or Probability factor

Ea and proper orientation of the molecules determine the criteria for an effective collision.