Class ⇒ B.Sc.(Hons.) Part-1
Subject ⇒ Chemistry
Chapter ⇒ Chemical Kinetics
Topic ⇒ Examples of Second order reaction, Half-life period, unit of rate constants.

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Examples of Second order Reaction

(1) Hydrolysis of an Ester by NaOH
or
Saponification of esters ⇒

$$CH_3COOC_2H_5 + NaOH \longrightarrow CH_3COONa + C_2H_5OH$$

Ethyl acetate → Sodium Acetate, Ethanol

(2) Benzoin Condensation ⇒

$$C_6H_5-\underset{H}{C}=O + H-\overset{O}{\overset{\|}{C}}-C_6H_5 \xrightarrow{KCN} C_6H_5-\overset{OH}{\underset{H}{C}}-\overset{O}{\overset{\|}{C}}-C_6H_5$$

Benzoin

(3) Conversion of ammonium cyanate to form urea ⇒

$$NH_4CNO \longrightarrow NH_2-\overset{O}{\overset{\|}{C}}-NH_2$$

Ammonium cyanate → Urea

(4) Thermal decomposition of N_2O

$$2N_2O \longrightarrow 2N_2 + O_2$$

(5) Conversion of O_3 into O_2 at 100°C

$$2O_3 \xrightarrow{100^\circ C} 3O_2$$

(6) Thermal decomposition of Cl_2O to Cl_2 and O_2 at 200°C.

$$2Cl_2O \xrightarrow{200^\circ C} 2Cl_2 + O_2$$

Half-life period

The time required for the reaction to be half completed is called Half-life period.

OR

The time required for the concentration of a reactant to decrease to half its initial value is called Half-life period of a reaction.

Half life period is denoted by $t_{1/2}$.

$t_{1/2}$ for a first order Reaction.

$x = a/2$ and $t = t_{1/2}$

from first order rate equation

$$K = \frac{1}{t_{1/2}} \ln \frac{a}{a-(a/2)}$$

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

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

i.e. Half-life period for a 1st order reaction is independent of the initial concentration.

$t_{1/2}$ for a Second order Reaction

$t_{1/2}$ for 2nd order reaction $x = a/2$, $t = t_{1/2}$

Putting this value in 2nd order Rekn

$$K = \frac{1}{t_{1/2}}\left[\frac{a/2}{a(a-a/2)}\right] = \frac{1}{t_{1/2}} \times \frac{a/2}{a(a/2)} = \frac{1}{a\,t_{1/2}}$$

$$\therefore t_{1/2} = \frac{1}{Ka}$$

Thus $t_{1/2}$ of a second order reaction is inversely proportional to the initial concentration of

the reactant and thus, it does not remain constant as the reaction proceeds.

Units of Rate Constant

The units of rate constant for different orders are different

Unit of zero order Rate Constant

for zero order Reaction, the rate Constant

$$K = \frac{d[A]}{dt} = \frac{mol}{litre} \times \frac{1}{time}$$

$\therefore$ unit of $K = mol\ l^{-1}\ time^{-1}$

⇒ Time may be given in seconds, minutes, days or years

Unit of first order Rate Constant

The rate constant of a first order reaction is given by

$$K = \frac{2.303}{t} \log \frac{[A]_0}{[A]_t}$$

Thus the rate constant for the 1st order reaction is independent of the concentration. It has the unit

$time^{-1}$

Unit of 2nd order Rate Constant

The rate constant for a second order reaction is expressed as

$$K = \frac{1}{t} \times \frac{x}{[A]_0([A]_0 - x)}$$

$$\text{or} \quad K = \frac{\text{concentration}}{\text{concentration} \times \text{concentration}} \times \frac{1}{\text{time}}$$

$$\text{or} \quad K = \frac{1}{\text{Concentration}} \times \frac{1}{\text{time}}$$

$$\text{or} \quad K = \frac{1}{\text{mol/litre}} \times \frac{1}{\text{time}}$$

$\therefore K = mol^{-1} t ime^{-1}$

Thus, the unit of K for a second order reaⁿ,

$mol^{-1} t ime^{-1}$

Ans.