* Expression of rate Constant for 3rd order Reaction:-

$$3A \longrightarrow \text{Product.}$$

Initial Conc^n	a mole/litre	0
after t sec.	$(a-x)$ mole/litre	x

It is a 3rd order reaction.

$$\therefore \quad \frac{dx}{dt} \propto [A]^3$$

$$\text{or} \quad \frac{dx}{dt} = K(a-x)^3$$

Where K = rate Constant of 3rd order reaction.

On rearranging and intigrating —

$$\int \frac{dx}{(a-x)^3} = K\int dt$$

$$\text{or} \quad \frac{1}{(a-x)^2} = Kt + I \qquad \text{——— (1)}$$

Where, I = Intigration Constant.

When $t=0 \quad x=0$

$\therefore$ Eq^n — (1) becomes —

$$I = \frac{1}{a^2}$$

putting the value of I in Eq^n — (1) we get —

$$\frac{1}{(a-x)^2} = kt + \frac{1}{a^2}$$

$$kt = \frac{1}{(a-x)^2} - \frac{1}{a^2}$$

$$\Rightarrow kt = \frac{a^2 - a^2 - x^2 + 2ax}{(a-x)^2 a^2}$$

$$\Rightarrow kt = \frac{(2a-x)x}{2a^2(a-x)^2}$$

$$\Rightarrow \boxed{k = \frac{1}{t} \times \frac{(2a-x)x}{2a^2(a-x)^2}} \quad \text{---} (2)$$

Eq^n – (2) is the expression of rate constant for 3rd Order reaction.

characteristics of 3rd Order reaction –

(1) Half life time ($t_{1/2}$) –

from, 3rd order Kinetics –

$$k = \frac{1}{t} \times \frac{(2a-x)x}{2a^2(a-x)^2}$$

When $t = t_{1/2}$, $x = a/2$

$$k = \frac{1}{t_{1/2}} \times \frac{(2a - a/2)\,a/2}{2a^2(a - a/2)^2}$$

$$\therefore \quad t_{1/2} = \frac{1}{k} \times \frac{3a/2 \times a/2}{2a^2 \times \left(\frac{a}{2}\right)^2}$$

$$\therefore \quad \boxed{t_{1/2} = \frac{1}{k} \frac{3}{2a^2}}$$

$$\therefore \quad t_{1/2} \propto \frac{1}{a^2}$$

Thus, half life period of 3rd order reaction is inversly proportional to the square of the initial concentration.

(2) Unit of 3rd order reaction –

$$k = \frac{1}{t} \times \frac{(2a-x)x}{2a^2(a-x)^2}$$

$$k = \frac{1}{sec} \times \frac{Conc^1 \times Conc^1}{(Conc^1)^2 \times (Conc^1)^2}$$

$$k = \frac{1}{sec} \times \frac{1}{(mol/L)^2}$$

$$\boxed{k = mol^{-2}\ Liter^2\ sec^{-1}}$$

(3) Examples of 3rd order reaction –

(i) Reduction of ferric chloride to stanous chloride –

$$2FeCl_3 + SnCl_2 \longrightarrow 2FeCl_2 + SnCl_2 + Cl_2$$

(2) Oxidation of nitric oxide-

$$2NO + O_2 \longrightarrow 2NO_2$$

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