* 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 $t=0 \quad x=0$

$\therefore$ eqn — (1) becomes —

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

putting the value of I in eqn — (1) we get —

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

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

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

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

$$\therefore \boxed{K = \frac{1}{t} \times \frac{(2a-x)x}{2a^2\,(a-x)^2}} \quad \text{—— (2)}$$

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

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

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

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

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

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

(2) Unit of 3rd order reaction –

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

$$K = \frac{1}{sec} \times \frac{Conc^3 \times Conc^3}{(Conc^3)^2 \times (Conc^3)^2}$$

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

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

(3) Examples of 3rd order reaction –

(i) Reduction of ferric chloride to Stanous chloride –

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

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(2) Oxidation of nitric oxide-

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

—x—

From

Dr. A. R. Gupta.

chemistry.

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