B.SC.I, PAPER-IA, Chemistry

Rate constant for second order reaction

When rate of reaction is determined by the change of two concentration in terms of two reactant or square of concentration of single reactant, it is called second order reaction.

Let us consider these two type of second order reactions.

(i) $2A \longrightarrow$ Products.

(ii) $A + B \longrightarrow C + D$.

Now consider reaction

(1)

	$2A$	$\longrightarrow$	Products
$t=0$	a	—	0
t	$a-x$	—	x

According to rate law eqn.

$$\frac{dx}{dt} \propto (a-x)(a-x).$$

or,
$$\frac{dx}{dt} = K_2(a-x)^2$$

K_2 = rate constant.

or,
$$\frac{dx}{(a-x)^2} = K_2 dt$$

Integrating we get

$$\int \frac{dx}{(a-x)^2} = \int K_2 dt$$

or $\frac{1}{a-x} = K_2 t + C$ —— (i)

C = Integration constant

At $t=0$, $x=0$

Then equation (i) is

$\frac{1}{a} = K_2 \times 0 + C$ —— (ii)

Substituting value of C in (i)

$\frac{1}{a-x} = K_2 t + \frac{1}{a}$

or $K_2 t = -\frac{1}{a} + \frac{1}{a-x} = \frac{-a+x+a}{a(a-x)}$

$$\boxed{K_2 = \frac{1}{t} \frac{x}{a(a-x)}}$$

This is rate constant of second order reaction of type

$2A \longrightarrow$ products.

Unit of second order rate constant

$K = \frac{1}{sec} \times \frac{concentration}{concentration \times concentration}$

or $K = sec^{-1} conc^{-1}$

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

Half life period:— At half life period $t_{1/2}$ the initial concentration will $\frac{a}{2}$

hence $K = \frac{1}{t_{1/2}} \cdot \frac{a/2}{a/2\,[a - \frac{a}{2}]}$

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or

$$t_{1/2} = \frac{1}{K} \cdot \frac{1}{\frac{a}{2}} = \frac{1}{K} \times \frac{2}{a}$$

or $t_{1/2} \propto \frac{1}{a}$

The half life period of second order reaction will be inversely proportional to initial concentration of reactant.

The rate constant for second order reaction of type $A + B \longrightarrow$ products

	A	B	products
$t=0$	a	b	0
t	$a-x$	$b-x$	x

Rate of reaction $\propto (a-x)(b-x)$.

$$\frac{dx}{dt} = K_2 (a-x)(b-x)$$

or

$$\frac{dx}{(a-x)(b-x)} = K_2\, dt$$

Integrating we get

$$K_2 = \frac{2.303}{(a-b)t}\left[\log \frac{(a-x)b}{(b-x)a}\right]$$

Note:- It is not essential to write while integration process. which is mathematical derivation not chemistry. therefore Integration process is omitted.