# Expression of rate Constant for Second Order reaction

## (1) When the Concentration of both the reactants are same :-

$$2A \longrightarrow \text{Product}$$

| | | |
|---|---|---|
| initial concentration | 'a' mole/L | 0 |
| Concentration after time 't' sec. | $(a-x)$ | $x$ |

The rate of reaction $\frac{dx}{dt} = K(a-x)^2$

where K = rate constant of 2nd Order reaction.

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

taking Intigration on both sides —

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

or $\frac{1}{(a-x)} = Kt + I$ ——— (1)

Where, I = Intigration Constant

When $t = 0$ , $x = 0$

putting these value in eqn — (1)

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

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

$$\frac{1}{(a-x)} = Kt + 1/a$$

or, $$Kt = \frac{1}{(a-x)} - \frac{1}{a}$$

or $$Kt = \frac{a-a+x}{a(a-x)} = \frac{x}{a(a-x)}$$

or $$\boxed{K = \frac{1}{t} \times \frac{x}{a(a-x)}} \quad \text{--- (2)}$$

eqⁿ — (2) is the expression of rate constant of 2nd order reaction.

(2) When the concentration of both the reactants are differents :-

$$A + B \longrightarrow \text{Product}$$

| | A | B | Product |
|---|---|---|---|
| Initial Concⁿ | a mole/L | b mole/L | 0 |
| after time 't' sec. | (a-x) mole/L | (b-x) mole/L | |

The rate of reaction —

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

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

taking intigration on both sides —

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

$$\text{or} \quad \frac{1}{(a-b)} \int \left[ \frac{1}{(b-x)} - \frac{1}{(a-x)} \right] dx = kt + I \quad \text{—— (1)}$$

where, $I$ = Integration Constant.

$$\text{or} \quad \frac{1}{(a-b)} \int \frac{dx}{(b-x)} - \frac{dx}{(a-x)} = kt + I$$

$$\text{or} \quad \frac{1}{(a-b)} \left[ -\ln(b-x) - \{ \ln(a-x) \} \right] = kt + I$$

$$\text{or} \quad \frac{1}{(a-b)} [\ln(a-x) - \ln(b-x) = kt + I$$

$$\text{or} \quad \frac{1}{(a-b)} \ln \frac{(a-x)}{(b-x)} = kt + I \quad \text{—— (2)}$$

When $t = 0$ $x = 0$

$$I = \frac{1}{(a-b)} \ln \frac{a}{b}$$

putting the value of $I$ in eqn – (2) we get

$$\frac{1}{(a-b)} \ln \left\{ \frac{a-x}{b-x} \right\} = kt + \frac{1}{(a-b)} \ln \frac{a}{b}$$

$$\text{or} \quad \frac{1}{(a-b)} \left[ \ln \frac{(a-x)}{(b-x)} - \ln \frac{a}{b} = kt \right.$$

$$\text{or} \quad \frac{1}{(a-b)} \ln \frac{(a-x)}{(b-x)} \Big/ \frac{a}{b} = kt$$

or $Kt = \frac{1}{(a-b)} \ln \frac{b(a-x)}{a(b-x)}$

or $$K = \frac{2.303}{t(a-b)} \log \frac{b(a-x)}{a(b-x)} \quad \text{--- (3)}$$

Eqⁿ – (3) is the expression of rate constant when the concentration of both the reactants are different.

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