Second order reaction :→ In this case there are two reacting species whose concentration changes with respect to time. this change in concentration is written as power of reacting species, and the sum of this power is called order i-e 2 (Two), hence the reaction is said to be second order reaction. To calculate rate constant in second order reaction, there are two conditions i-e
1) When the initial concentrations of A & B are same
ii) When initial concentrations of A & B are different.

1. Calculation of rate constant when the initial concentration of both the reactant A & B are same :→

	A	$+ B$	$\longrightarrow$ Product.
Initial Conc^n	a	a	0
After time 't'	$(a-x)$	$(a-x)$	$2x$

According to rate law the rate of reaction is directly proportional to the left concentration after time 't'.

So, $$\frac{dx}{dt} \propto (a-x) \times (a-x)$$

or $$\frac{dx}{dt} \propto (a-x)^2$$

or $$\frac{dx}{(a-x)^2} \propto dt$$

Integrate both sides we have:

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

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

Where 'k' is constant called rate constant and 'c' is constant called integration constant

When $t = 0$, $x = 0$, then $c = \frac{1}{a}$ —— II

Now we put the value of 'c' from Equation II to I we have:

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

or $$k = \frac{1}{t}\left(\frac{1}{a-x} - \frac{1}{a}\right)$$

$$\boxed{k = \frac{x}{t \cdot a(a-x)}}$$

<u>Unit of k</u>: litre mol^{-1} sec^{-1} or litre mol^{-1} $time^{-1}$

<u>Note</u> Instead of ~~sec~~ we can use time.

(2)

II Calculations of rate Constant (K) when initial Concentrations of reactants A & B are different:-

$$A + B \longrightarrow Prod.$$

	A	B	Prod.
Initial Concn	a	b	0
Final Concn	$(a-x)$	$(b-x)$	$2x$

According to rate rate the rate of reacting Species are directly proportional to the left Concentration or Final Concentration.

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

or $$\frac{dx}{(a-x)(b-x)} \cancel{\propto} \cancel{dt}$$

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

Integrate both Side by partial fraction method.

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

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

or $$\frac{1}{(a-b)} \left[\frac{dx}{(b-x)} - \frac{dx}{(a-x)} \right] = K \int dt$$

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

Where k is rate constant & c is integration constant.

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

If $t = 0$, $x = 0$,
then from equation I $\frac{1}{(a-b)} \ln \frac{a}{b} = c$ —— II

Now we put the value of 'c' from equation II to equation I, we have:

$\frac{1}{(a-b)} \ln \frac{a-x}{b-x} \Rightarrow kt + \frac{1}{(a-b)} \ln \frac{a}{b}$

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

or $\boxed{k = \frac{2.303}{(a-b)} \log_{10} \frac{b(a-x)}{a(b-x)}}$

Unit of k: litre mol^{-1} time^{-1}
or litre mol^{-1} sec^{-1}.