SUBJECT - CHEMISTRY
CLASS - BSc(Hons) PART-I
PAPER - II
GROUP - A
TOPIC - 1st order reaction

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Q Derive expression for the rate Constant of 1st order reaction. what is the unit of its rate Constant?

Ans 1st order reaction: The reaction in which rate is determined by the variation of only one concentration term is called 1st order reaction Let us Consider the following 1st order reaction:

$$A \longrightarrow \text{products}$$

Let initial Concentration = a

Concentration after time 't' = a-x

Since x moles have been reacted in time t, then the rate,.

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

on integration we get

$$\int \frac{dx}{a-x} = Kdt, \quad \text{Let } z = a-x; \quad \therefore dz = -dx \quad \therefore \int \frac{dz}{z} = \ln$$

Hence - $\ln(a-x) = Kt + I$. when $t=0$ $x=0$ then $I = -\ln a$

putting the value of I in above equation, we get

$$-\ln(a-x) = Kt - \ln a$$

$$\text{Rate Constant } K = \frac{1}{t} \ln \frac{a}{a-x} = \frac{2.303}{t} \log \frac{a}{a-x}$$

Therefore unit of $K = \frac{2.303}{Sec} \log \frac{mole/litre}{mole/litre} = Sec^{-1}$

half-life period of a reaction?

Half-life period ($t_{0.5}$) of chemical reaction is the time during which initial Concentration (a) is reduced to half ($a/2$) the rate Constant (K) for the 1st order reaction is given by the expression

$$K = \frac{2.303}{t} \log \frac{a}{a-x}$$

where a = initial Concentration of reactant and $a-x$ = Concentration of reactent after time t,

The reaction can also be shown as $t = \frac{2.303}{K} \log \frac{a}{a-x}$

When $t = t_{0.5}$, then $x = a/2$ and thus the above equation becomes

$$t_{0.5} = \frac{2.303}{K} \log \frac{a}{a-a/2} = \frac{2.303}{K} \log 2 = \frac{0.693}{K}$$

or $t_{0.5} \propto 1/K$

In other words, $t_{1/2}$ is inversely proportional to K and is independent of the initial Concentration of the reactant.