

SUBJECT - CHEMISTRY
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TOPIC - 1st order reaction

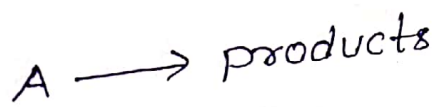
Dr. Harimohan Prasad Singh

Department of Chemistry

Dr. L.K.V.D. College Tarapur Samastipur

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:



Let initial concentration = a

Concentration after time ' t ' = $a - x$

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

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

On integration we get

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

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 $k = \frac{2.303}{\text{Sec}} \log \frac{\text{mole/litre}}{\text{mole/litre}} = \text{Sec}^{-1}$

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 reactant 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

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

$$\text{or } t_{0.5} \propto 1/k$$

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