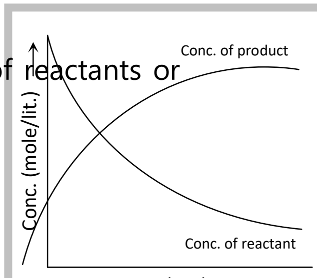
Rate of reaction.



Change of concentration with increase in time

"The rate (speed or velocity) of reaction is the rate of change in concentration of reactants or products in unit time."

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

When,	$t = 0$	a	0
After,	$t = t$	(a–x)	x

Where *a* is the initial concentration and (*a-x*) is concentration of reactant after time *t* and *x* will be the concentration of product after time *t*.

$$\boxed{\text{Rate of reaction} = \frac{\text{Total change in concentration of reactants or products}}{\text{Change in time (in sec.)}}}$$

If dx is the change in concentration in time interval dt then,

The reaction rate for reactants = $-\frac{dx}{dt}$; the reaction rate for products = $+\frac{dx}{dt}$

- The negative sign indicates that the concentration of reactant **decreases** with time.
- The positive sign indicates that the concentration of products **increases** with time.
- The concentration change may be positive or negative but the rate of reaction is always **positive**.
- The rate of chemical reaction decreases as the reaction proceeds.
- The concept of mechanical speed or velocity cannot be used in measuring rate of reaction. Rate of reaction depends on molar concentration.

(1) **Types of rate of reactions:** There are two types of rate of reactions.

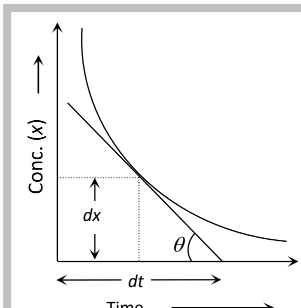
(i) **Average rate of reaction**: The average rate is defined as the change in the concentration (active mass) of reactants or products over a long time interval.

Consider the general chemical reaction, $aA + bB + ... \longrightarrow cC + dD + ...$

Average rate = Amount of reactant consumed (or product formed)/time interval.

Average rate = $-\frac{\Delta[A]}{a\Delta t} = -\frac{\Delta[B]}{b\Delta t}.......... = +\frac{\Delta[C]}{c\Delta t} = +\frac{\Delta[D]}{d\Delta t} = +........$

The average rate over the time interval Δt approaches the instantaneous rate as Δt approaches zero.



(ii) **Instantaneous rate of reaction:** The instantaneous rate of reaction gives the tendency of the reaction at a particular instant. The term Δt becomes smaller and eventually approaches zero, then the rate of reaction at a particular moment called the instantaneous rate (R_t) is given by,

Instantaneous rate = (Average rate)$_{\Delta t \to 0}$

$$R_t = \left(\frac{-\Delta[A]}{\Delta t}\right)_{\Delta t \to 0} = \left(\frac{\Delta[B]}{\Delta t}\right)_{\Delta t \to 0} \text{ or } R_t = -\frac{d[A]}{dt} = \frac{d[B]}{dt}$$

Where, $d[A], d[B]$ and dt being infinitesimally small changes in the concentration of A and B, that of time respectively. Instantaneous rate of reaction at any instant of time is obtained by finding the slope of the tangent to the curve (which is obtained by plotting concentration of any suitable reactant or product versus time) at the point corresponding to that instant of time. Rate of reaction = $\tan\theta = \frac{dx}{dt}$

(2) **Unit of rate of reaction:** Unit of rate of reaction = $\frac{\text{Unit of concentrat ion}}{\text{Unit of time}}$ = mole liter^{-1} time $^{-1}$

(i) If reactants and products are in gaseous state then the pressure may be taken in place of concentration thus rate will have unit of atm sec^{-1} or atm min^{-1}

(ii) The unit of time can be second, minute, hours, days and years so the unit of rate of reaction may be expressed as follows: mol/liter sec $(mol\ l^{-1} s^{-1})$ or mol/liter min ($mol\ l^{-1}\ \min^{-1}$) or mol/liter hour$(mol\ l^{-1} h^{-1})$ or mol/liter day $(mol\ l^{-1} d^{-1})$ or mol/liter year $(mol\ l^{-1}\ y^{-1})$