# CHEMICAL KINETICS

# RATE OF A CHEMICAL REACTION

## ❖ Rate of reactions (types of reaction):-

**Rate of reaction:**

The change in concentration of either reactant or product per unit time.

Formula: $v = \pm \frac{dc}{dt}$

- dc = change in concentration in a small interval dt.
- [−] sign is used when we refer to reactant concentration.
- [+] sign is used when we refer to product concentration.

**Ex.** $N2 + 3H2 \rightarrow 2NH3$

1. Rate of formation of ammonia $= + \frac{d[NH_3]}{dt}$
2. Rate of disappearance of nitrogen $= - \frac{d[N_2]}{dt}$
3. Rate of disappearance of hydrogen $= - \frac{d[H_2]}{dt}$
4. Rate of reaction $= + \frac{1}{2}\frac{d[NH_3]}{dt} = - \frac{d[N_2]}{dt} = - \frac{1}{3}\frac{d[H_2]}{dt}$

Thus, Rate of reaction $= - \frac{d[N_2]}{dt} = \frac{1}{2}\frac{d[NH_3]}{dt}$

or rate of formation of ammonia = Twice the rate of disappearance of nitrogen

i.e. $\frac{d[NH_3]}{dt} = \frac{2}{3}[- \frac{d[H_2]}{dt}]$

### Average velocity of reaction :-

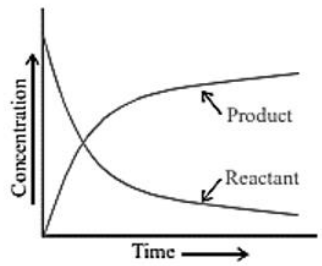
Change in the concentration of reactants or products per unit time is called average reaction velocity.

If $\Delta$c is the change in the concentration of reactants and product in $\Delta$t time, then

Average velocity $= \pm \frac{\Delta c}{\Delta t}$

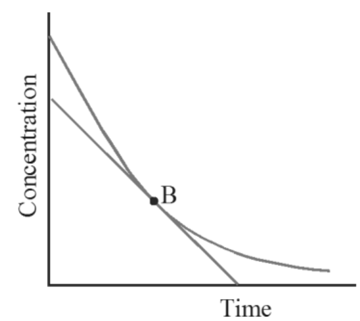
Average velocity $= \frac{(-)\text{ Change in the concentration of reactants}}{\text{Time}}$

$= \frac{(+)\text{ Change in the concentration of reactants}}{\text{Time}}$




Unit of average velocity $= \frac{\text{Unit of concentration}}{\text{Unit of time}} = \frac{\text{gram mole}}{\text{liter} \times \text{Second}} =$ gram mole liter$^{-1}$ second$^{-1}$

### Rate of reactions (instantaneous reactions) :-




**Instantaneous rate of the reaction:**

The rate of reaction determined at specified concentration or specified time is called instantaneous rate.

The instantaneous rate of the reaction can be determined

By measuring concentration of reactant or product at a instant of time and plotting concentration versus time.

The instantaneous rate at any time is determined by the slope of the tangent at a point on the time-concentration curve corresponding to the specified time. The slope of the tangent at a point is the limiting value of. $\frac{\Delta c}{\Delta t}$

$\text{Lim}_{\Delta t \to 0} \frac{\Delta c}{\Delta t} = \frac{dc}{dt}$

In terms of the concentration of reactant, the rate of the reaction $= -\frac{dc}{dt}$

The –sign indicates that the concentration of reactant decreases with time.

In terms of the concentration of product, the rate of the reaction $= +\frac{dc}{dt}$ The +sign indicates that the concentration of product increases with time. In the reaction if at a time t the concentration of product is x and at time $t + dt$, the concentration becomes $x + dx$ then the reaction rate $= \frac{dx}{dt}$.

For example the rate of reaction: $N_2 + 3H_2 \rightarrow 2NH_3$

in terms of the concentrations of $N_2, H_2$ and $NH_3$ can be expressed as :

$$-\frac{d[N_2]}{dt}, -\frac{1}{3}\frac{d[H_2]}{dt}, +\frac{1}{2}\frac{d[NH_3]}{dt}$$