RATE OF A CHEMICAL REACTION

Rate /Speed of Velocity of Reaction/ Type of Rate

Rate of Reaction (Types of Reaction)

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

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

- dc represents the change in concentration over a small-time interval dt.
- [+] sign is used when we refer to product concentration.
- [–] sign is used when we refer to reactant concentration.

Ex. $N_2 + 3H_2 \rightarrow 2NH_3$

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

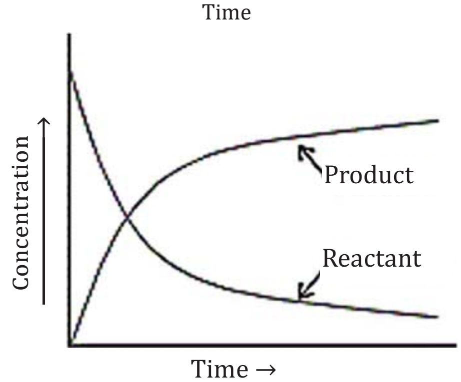
Rate of Reactions (Average Rate of Reactions)

The average reaction velocity is defined as the change in the concentration of reactants or products per unit time. If Δc represents the change in concentration within a time interval Δt, then...

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

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

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

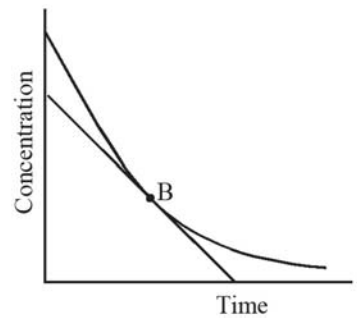


$$\text{Unit of Average Velocity} = \frac{\text{Unit of concentration}}{\text{Unit of time}} = \frac{\text{gram mole}}{\text{liter} \times \text{Second}} = \text{gram mole liter}^{-1}\ \text{second}^{-1}$$

Rate of reactions (Instantaneous Reactions)

Instantaneous Rate of the Reaction

The rate of reaction measured at a specific concentration or a particular time is referred to as the instantaneous rate. The instantaneous rate can be calculated by assessing the concentration of the reactant or product at an exact moment in time and creating a plot of concentration against time. The instantaneous rate at any given time is ascertained by the slope of the tangent at a specific point on the time-concentration curve corresponding to the designated time.



The slope of the tangent at a point is the limiting value of. $\frac{\Delta c}{\Delta t}$

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

Expressed in terms of the concentration of the reactant, the rate of the reaction is given by $-\frac{dc}{dt}$, where the negative sign indicates a decrease in the concentration of the reactant over time. Conversely, in terms of the concentration of the product, the rate of the reaction is $+\frac{dc}{dt}$, with the positive sign indicating an increase in the concentration of the product over time.

For instance, in the reaction $N_2 + 3H_2 \rightarrow 2NH_3$, if the concentration of the product is x at time t and x + dx at time t + dt, then the reaction rate can be expressed as $\frac{dx}{dt}$.

in terms of the concentrations of N_2, H_2 and NH_3 can be expressed as: $-\frac{d[N_2]}{dt}, -\frac{1}{3}\frac{d[H_2]}{dt}, +\frac{1}{2}\frac{d[NH_3]}{dt}$.