CHEMICAL KINETICS

for Class XII
BOARD EXAMS

These notes have been verified by CBSE Science Toppers & reputated faculties

We have integrated Previous Year Q.'s in the notes

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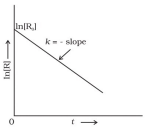
Flow Chart



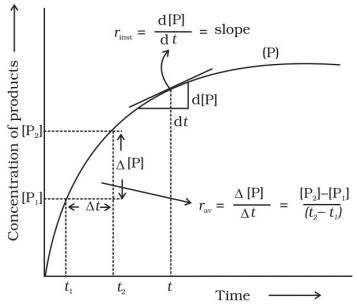
Chemical Kinetics

Introduction

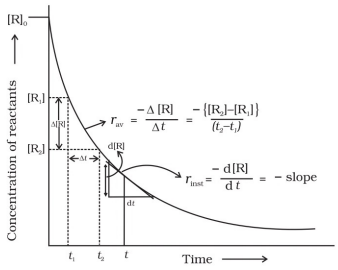
Need of Kinetics

Rate of Reaction

- Average Rate
- Instantaneous Rate



Factors affecting Rate

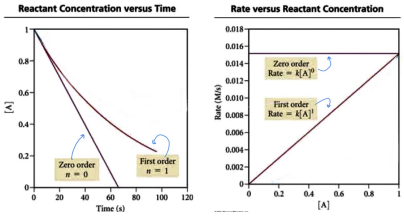


Integrated Rate Equation

Order and molecularity of a reaction

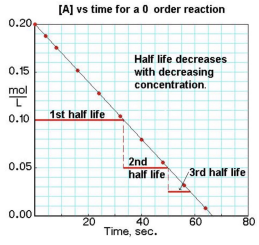
Zero order Reaction

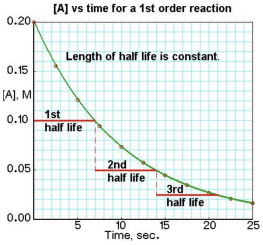
A → Products



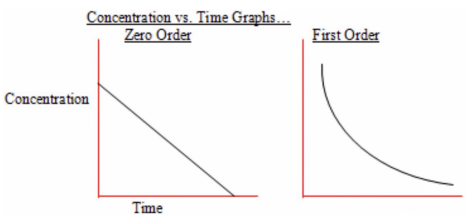
First order Reaction

Half life of a Reaction





Pseudo first order Reaction



Chemical Kinetics

→ For a chemical reaction R → P : Three questions are important.

(i) Reaction will happen or not ? : Thermodynamics : Reaction is feasible only if $\Delta G < 0$.

(ii) To which extent reaction will happen ? : Chemical Equilibrium

(iii) What is the speed of chemical reaction ? : Chemical Kinetics : Concept of rate of a reaction.

Rate of reaction –: [Velocity of reaction]

(1M) [CBSE 2010 | 2015 | Delhi 2010]

The rate of change of concentration of any species taking part in a chemical reaction with time is known as rate of reaction.

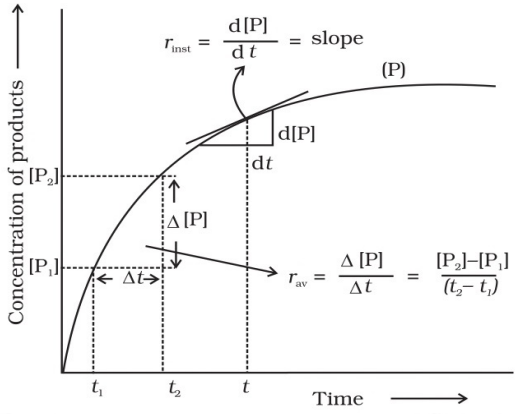
→ For a reaction R ⟶ P $\quad$ rate $= \dfrac{\text{Change in concentration}}{\text{time}} = \dfrac{\Delta C}{\Delta t}$

→ Unit : $\dfrac{(\text{mol/L})}{s}$ or $\dfrac{(\text{atm})}{s}$ → For gaseous reactant or product.

Types of rate –:

[CBSE 2010C] (2M)

(i) Average Rate –: $R_{av} = \dfrac{\text{Total change in conc}^n}{\text{Total time taken}}$



$$\text{Rate} = -\frac{\Delta[\text{Reactant}]}{\Delta t} = \frac{\Delta[\text{Product}]}{\Delta t} = \frac{C_2 - C_1}{t_2 - t_1} = \frac{\Delta C}{\Delta t}$$

→ R ⟶ P

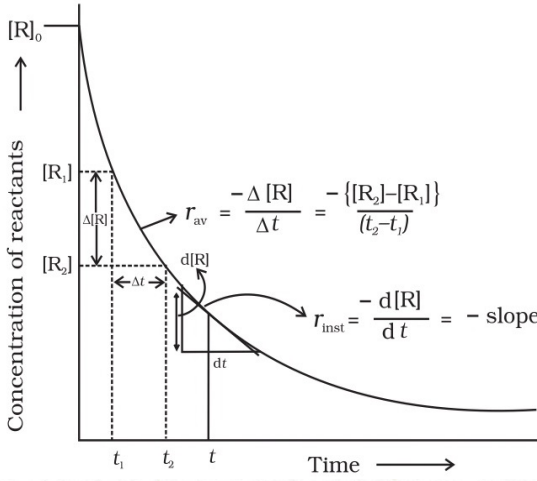
at time t_1 : C_1 [Concentration of product after time t_1]

at time t_2 : C_2

(ii) Instantaneous Rate –: Rate at a given time

$$R_{inst} = \lim_{\Delta t \to 0} R_{av} = \lim_{\Delta t \to 0} \frac{\Delta C}{\Delta t} = \frac{dc}{dt}$$

= Slope of Concentration and time graph.



#Rate of appearance and rate of disappearance :–

Let us consider a reaction R ⟶ P

At time t_1 : R_1 P_1

t_2 : R_2 P_2

$\Delta R = R_2 - R_1$

$\Delta P = P_2 - P_1$

$\Delta t = t_2 - t_1$

→ Rate of disappearance of R = $\frac{\text{Decrease in [R]}}{\text{Time taken}} = -\frac{\Delta[R]}{\Delta t}$

→ Rate of appearance of P = $\frac{\text{Increase in [P]}}{\text{Time taken}} = \frac{\Delta[P]}{\Delta t}$

Example :- $Hg(l) + Cl_2(g) \longrightarrow HgCl_2(s)$

→ Rate of reaction = Rate of disappearance of $Hg \mid Cl_2$ = Rate of appearance of $HgCl_2$

$$= -\frac{\Delta[Hg]}{\Delta t} = -\frac{\Delta[Cl_2]}{\Delta t} = \frac{\Delta[HgCl_2]}{\Delta t}$$

Note :- If stoichiometric coefficients of reactants or products are not equal to one, then rate of disappearance of any of the reactants or rate of appearance of products is divided by their respective stoichiometric coefficients.

→ $aA + bB \longrightarrow cC + dD$

Rate of reaction = $\frac{-1}{a}\frac{\Delta[A]}{\Delta t} = -\frac{1}{b}\frac{\Delta[B]}{\Delta t} = \frac{1}{c}\frac{\Delta[C]}{\Delta t} = \frac{1}{d}\frac{\Delta[D]}{\Delta t}$

Example :- (i) $2HI(g) \longrightarrow H_2(g) + I_2(g)$

→ Rate of disappearance of HI = 2 × Rate of appearance of $H_2 \mid I_2$

→ Rate of reaction = Rate of appearance of $H_2 \mid I_2 = \frac{1}{2}$ Rate of disappearance of HI.

$$= \frac{\Delta[H_2]}{\Delta t} = \frac{\Delta[I_2]}{\Delta t} = -\frac{1}{2}\frac{\Delta[HI]}{\Delta t}$$

(ii) $5Br^-(aq.) + BrO_3^-(aq.) + 6H^+(aq.) \longrightarrow 3Br_2(aq.) + 3H_2O(l)$

Rate of reaction = $-\frac{1}{5}\frac{\Delta[Br^-]}{\Delta t} = -\frac{\Delta[BrO_3^-]}{\Delta t} = -\frac{1}{6}\frac{\Delta[H^+]}{\Delta t}$

Question :- For the reaction $2N_2O_5(g) \longrightarrow 4NO_2(g) + O_2(g)$, the rate of formation of $NO_2(g)$ is $2.8 \times 10^{-3}\ M\ s^{-1}$. Calculate the rate of disappearance of $N_2O_5(g)$? [CBSE 2018] (2M)

Answer :- $2N_2O_5(g) \longrightarrow 4NO_2(g) + O_2(g)$

Rate of Reaction = $\frac{-1}{2}\frac{\Delta[N_2O_5]}{\Delta t} = \frac{1}{4}\frac{\Delta[NO_2]}{\Delta t}$

→ Rate of disappearance of $N_2O_5 = -\frac{\Delta[N_2O_5]}{\Delta t} = 2 \times \frac{1}{4} \frac{\Delta[NO_2]}{\Delta t}$

[Given that rate of formation of $NO_2 = \frac{\Delta[NO_2]}{\Delta t} = 2.8 \times 10^{-3}$ MS^{-1}]

$= \frac{1}{2} \times 2.8 \times 10^{-3} MS^{-1}$

$= 1.4 \times 10^{-3} MS^{-1}$

Question –: The decomposition of N_2O_5 in CCl_4 at 318 K has been studied by monitoring the concentration of N_2O_5 in the solution. Initially the concentration of N_2O_5 is 2.33 mol L^{-1} and after 184 minutes, it is reduced to 2.08 mol L^{-1}. Calculate the average rate of this reaction and what is the rate of production of NO_2 during this period?

$$2\,N_2O_{5(g)} \longrightarrow 4\,NO_{2(g)} + O_{2(g)}$$

Answer –: Average Rate $= -\frac{1}{2}\frac{\Delta[N_2O_5]}{\Delta t} = -\frac{1}{2}\left[\frac{(2.08 - 2.33)\ mol\ L^{-1}}{184\ min}\right]$

$= 6.79 \times 10^{-4}$ mol L^{-1} / min $= \frac{6.79 \times 10^{-4}\ mol\ L^{-1}}{60\ s}$

→ Rate $= \frac{1}{4}\left[\frac{\Delta[NO_2]}{\Delta t}\right] = 6.79 \times 10^{-4} \frac{mol\ L^{-1}}{min}$ $= 1.13 \times 10^{-5}$ mol L^{-1} s^{-1}

→ $\frac{\Delta[NO_2]}{\Delta t} = 4 \times 6.79 \times 10^{-4} = 2.79 \times 10^{-3}$ mol L^{-1} min^{-1} = Rate of production of NO_2

Factors influencing rate of a reaction –: [Delhi 2010C] (2M) [CBSE 2015] (1M)

(i) **Concentration :-** Rate of reaction increases with concentration of reactant.
↳ Liquid / Aqueous Medium

→ In case of gases, pressure ↑ ⇒ Rate ↑

(ii) **Temperature –:** Rate of a reaction increases with increase of temperature.

(iii) **Nature of reactants –:** Different reactant require different amount of energies for breaking of old bonds and for formation of new bonds.

(iv) **Catalyst :-** It changes the rate of reaction, without being used (consumed) in the reaction.

Rate Law / Rate Equation / Rate Expression :- [Dependence of rate on conc^n]

→ Rate law is expression in which reaction rate is given in terms of molar Conc^n of reactants with each term raised to some power. [CBSE 2011 / Delhi 2011/2012] (1M)