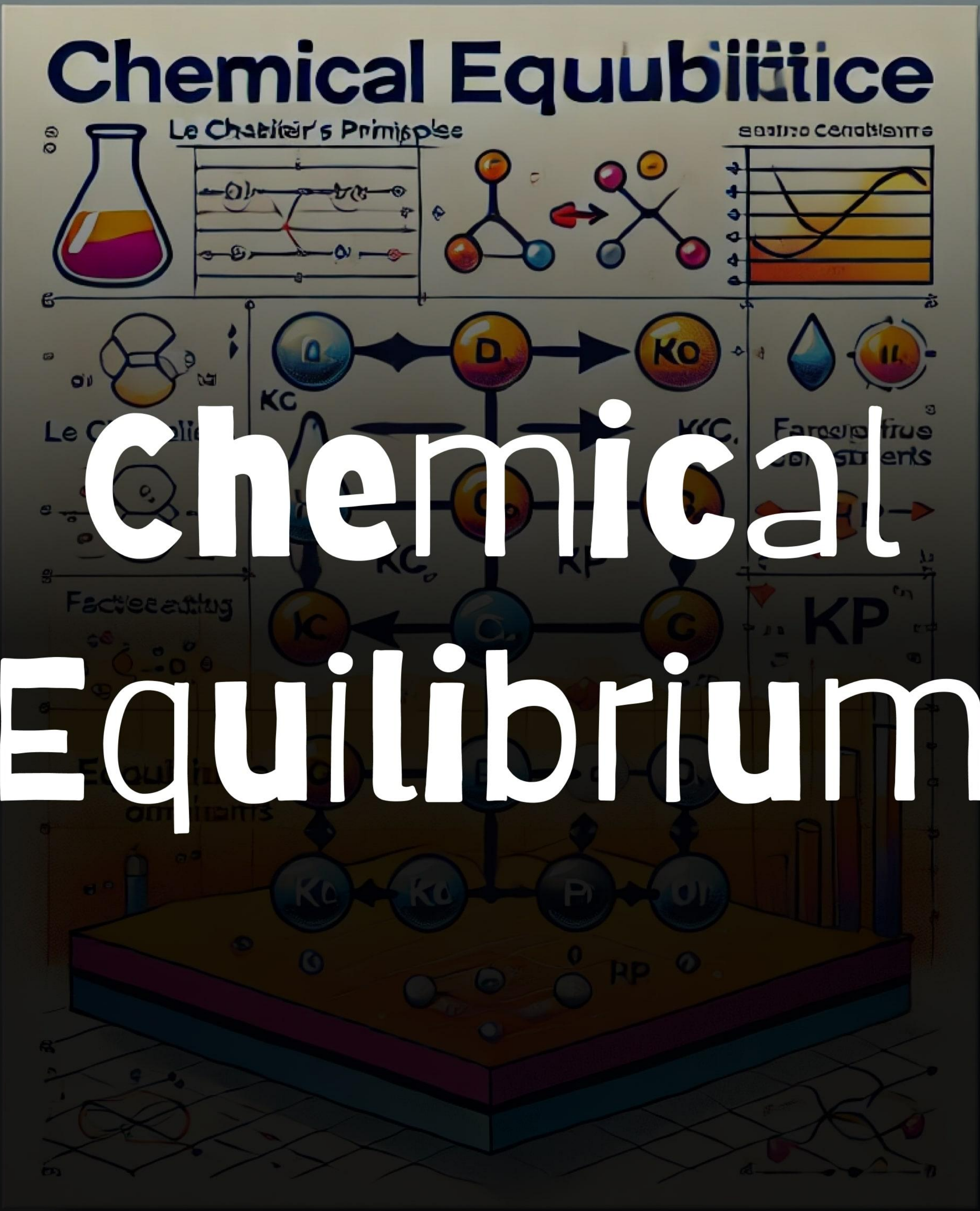
Chemical Equilibrium



Chemical Equilibrium

① Conceptual Approach of Equilibrium
② Numerical approach of Kc and Kp.
③ Applications of Kc and Kp ; Relation between Kc and ΔG.
④ Le-chattlier principle theoritical questions.

- Based on the direction :

① Irreversible reaction.

\- Chemical rxn : Reactants directly converted products
Means : product cant be converted back to Reactants.

a) process only in one direction.
b) Generally open vessel.
c) Equilibrium concept not applicable.
d) Reaction completed (R ⟶ P) 100%

ex: All ionic Rxn, All Neutralisation, All ppt Reactions.

① $BaO_2 + H_2SO_4 \longrightarrow H_2O_2 + BaSO_4$ (Ionic)
② $2NaCl + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O$ (Ionic)
③ $NaOH + HCl \longrightarrow NaCl + 2HCl$ (Neu)
④ $AgNO_3 + NaCl \longrightarrow AgCl\downarrow + NaNO_3$ (ppt)

② Reversible reaction

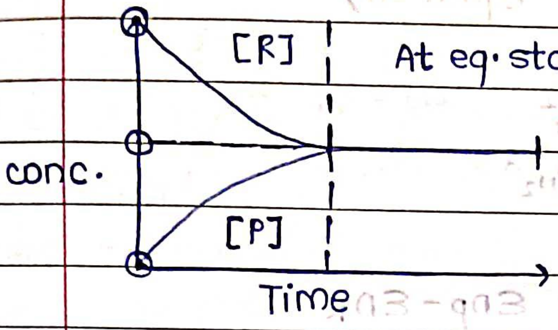
Chemical Rxn : Takes place from both sides.
i.e. Reactants converted to products
products also converted to reactants.

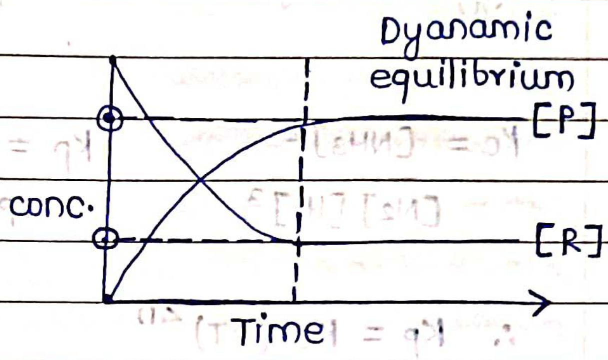
a) FR and BR takes place.
b) Possible into close vessel.
c) Equilibrium concept — meant For Rev. Rxn.
d) Reaction never be completed.

Means : continue process of $R \rightleftarrows P$
ie. In a vessel R and P both are present.

- Equilibrium state :

① The stage at which constant conc. R and P.
② The stage at which $r_{FR} = r_{BR}$





- Characteristics of equilibrium :

① conc. of R and P ⟶ always constant
② $r_{FR} = r_{BR}$
③ No. of moles of Reactant converted to product.
same no. of moles of product converted to reactant.
④ eq. state is exist — a) when we start with R.
b) when we start with P.
c) when we start with both R and P.
⑤ If catalyst used eq. state reaches quickly.
⑥ All measurable properties [Temp, conc, colour, density etc] can't change at eq. state.

- Law of mass action :

↓
Reversible
↓
At eq. state
→ Kc : eq. constant w.r.to conc of R and P
→ Kp : eq. constant w.r.to partial pressure of R and P.

① $K_c = \frac{[Pro]}{[Reac]}$ ② $K_p = \frac{P_{Pro}}{P_{Rec}}$ • $K_c = \frac{K_{FR}}{K_{BR}}$

③ $K_p = K_c(RT)^{\Delta n}$ $\Delta n = \Sigma n_P - \Sigma n_R$ • $R = 0.0821$

④ $\Delta n = -ve$; $K_c > K_p$
$\Delta n = +ve$; $K_p > K_c$
$\Delta n = 0$; $K_p = K_c$

• In heterochemical eq,
[Any solid] = 1 [Any liquid] = 1
$P_{\text{any solid}} = 1$ $P_{\text{any liquid}} = 1$

• Question Kc and Kp :

- Kc depends on
① Temp
② Mode of Representation of Reaction
③ No. of moles of R and P

a) conc. of R/P change ⟶ No change Kc
Moles of R/P change ⟶ change Kc
Mode of Reaction change ⟶ change Kc

b) If Rxn is reversed ⟶ $\frac{1}{K_c}$

c) If Rxn is multiplied by n ⟶ K_c^n

d) If Rxn is divided by n ⟶ $K_c^{1/n}$

e) Rxn get by multiple steps ⟶ $K_{C1} : K_{C2} \cdot K_{C3} \cdot K_{C4} \cdot \ldots$

• Applications of Kc and Kp :

- Predict the extent of Reaction :

$Kc = \frac{[Pro]}{[Rec]}$ $\qquad Kc \propto [Pro]$ $\qquad Kc \propto \frac{1}{[Rec]}$

① If $Kc > 10^3$ — Towards Forward

② If $Kc < 10^{-3}$ — Towards Backward

③ If $Kc = 10^{-3}$ to 10^3 [FR/BR] —

$r_{FR} \neq r_{BR}$

④ If $Kc = 1$ At eq. state —— $r_{FR} = r_{BR}$

- Predict the direction of Reaction :

Kc = eq. constant [used exactly at eq. state]

Qc = Reaction Quotent [at any state of RXN]

$Kc = Qc = \frac{[Pro]}{[Rec]}$ $\qquad Kp = Qp = \frac{P \cdot Pro}{P \cdot Rec}$

① $Qc < Kc$ $\quad Qp < Kp$ [Forward]

② $Qc = Kc$ $\quad Qp = Kp$ [at eq. state] $r_{FR} = r_{BR}$

③ $Qc > Kc$ $\quad Qp > Kp$ [Backward]

- Relation Between ΔG and Kc :

① $\Delta G = \Delta G^0 + RT \ln Q$

② $\Delta G^\circ = -RT \ln Kc$ $\qquad$ [at eq. state $\Delta G = 0$ and $Q = Kc$]

$\Delta G^\circ = -2.303\, RT \log Kc$

③ $Kc = e^{-\frac{\Delta G^\circ}{RT}}$

① For spontaneous —— $\Delta G < 0$ $K_c > 1$

For FR $\Delta G = -ve$

For extent of Rxn

② For non spontaneous —— $\Delta G > 0$ $K_c < 1$

For BR $\Delta G = +ve$

③ At eq. state — $\Delta G = 0$ $K_c = 1$

where $r_{FR} = r_{BR}$

- Le-chatelier's principle ::

- If system is at eq. is subjected to stress, disturbance then eq. shift in a direction to reduce the stress and eq. state is regenerated.

① conc. of R and P

[Rec] ↑ = FR [Rec] ↓ = BR

[Pro] ↑ = BR [Pro] ↓ = FR

② Effect of pressure

P↑ – eq shift towards 'n' dec side

P↓ – eq shift towards 'n' Inc side

③ Effect of Temp

ENDO —— T ↑ FR T ↓ BR $\Delta H = +ve$

EXO —— T ↑ BR T ↓ FR $\Delta H = -ve$

- Addition of catalyst : → FR and BR = move quickly
  eq. state exist = quickly
  → But it can't explain whether the RXn $\longrightarrow$ FR/BR

- Addition of Inert gas / He/Ne/Ar :

At const V : no effect of eq.

At const P : eq. moves towards 'n' inc. side.