CHEMICAL EQUILLIBRIUM

Reversible Rxn:- which can proceed in both the direction $R \rightleftharpoons P$
- → Never go for a completion
- → No Role for LR
- → Only in closed container.

Irreversible Rxn:- which only proceed in one direction.
- → Always go for a completion
- → Involve L.R. $R \longrightarrow P$, $P \longrightarrow R$

CHEMICAL EQUILIBRIUM

Reversible Rxn:-

Haber's process:- $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

FD = $N_2 + 3H_2 \longrightarrow 2NH_3$

BD = $2NH_3 \longrightarrow N_2 + 3H_2$

Note:- at eqᵇ $(ROR)_{FD} = (ROR)_{BD}$

Characteristics:-
- → dynamic in nature
- → Pressure, Concⁿ and moles are cont
- → Catalyst have no effect on eqᵇ.
- → $\Delta G = 0$ (gibb's free energy).

LAW OF MASS ACTION:-

→ ROR is proportional to product of active masses of reaction species raised to the power its their stoichiometric coeffᵉ

Eq - $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

$$K_{eq} = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

Note:- active mass of solid and liquid is taken as unity.

Eq - $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$

$$K_{eq} = \frac{[CaO]^1[CO_2]}{[CaCO_3]^1} = [CO_2]$$ Ans

TYPES OF EQᵇ CONSTANT

(a) **Concentration** :- molarity (M)

Eq - $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

$$K_c = \frac{[PCl_3]^1[Cl_2]^1}{[PCl_5]^1}$$ Ans

(b) **Partial pressure** :-

Eq - $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

$$K_p = \frac{[P_{PCl_3}]^1[P_{Cl_2}]^1}{[P_{PCl_5}]^1}$$

Note:- K_p is valid only if one of the reactant or product is gas.

Eq - $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$

$K_p = [CO_2]^1$ Ans

RELATION b/w K_p & K_c:-

$$K_p = K_c(RT)^{\Delta ng}$$

R = universal gas constant

T = Temperature

Δng = sum of moles of gaseous pro° − sum of moles of gaseous Reac

Eq - $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

$\Delta ng = 2 - 4 = -2$

Note:-

$\Delta ng > 0$	$\Delta ng < 0$	$\Delta ng = 0$
$K_p > K_c$	$K_p < K_c$	$K_p = K_c$

Units of K_p and K_c ?

$K_c = (mol/L)^{\Delta ng}$ & $K_p = (atm)^{\Delta ng}$

***Characteristic of eqᵇ constant :-**

If Rxn is reversed;

1° $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

2° $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$

$K_{c_1} = \frac{[HI]^2}{[H_2][I_2]}$ $\quad K_{c_2} = \frac{1}{K_{c_1}}$

If Rxn is multiplied :-

→ $A+B \rightleftharpoons C$ $\quad K_{eq} = K_c$

→ $2A+2B \rightleftharpoons 2C$ $\quad K_{eq} = K_c'$

$$K_c' = [K_c]^n$$

n → the no° by which whole Rxn is multiplied.

If eqⁿ are added :- the eqᵇ constant are multiplied.

$A + B \rightleftharpoons 2C \quad K_1$

$2C \rightleftharpoons 3D \quad K_2$

$A+B \rightleftharpoons 3D \quad K_3$

$$K_3 = K_1 \times K_2$$

APPLICATIONS OF EQᴮ CO°

→ Predict the extinct of Rxn. $R \rightleftharpoons P$

$K_{eq} \uparrow = K_f \uparrow \Rightarrow$ forward

$K_{eq} \downarrow = K_b \uparrow \Rightarrow$ backward

→ $K_{eq} > 10^3$ = product will dominate

→ $K_{eq} < 10^{-3} = K_b > K_f \Rightarrow$ Reactant dominat

→ $10^{-3} < K_{eq} < 10^3$ = No one is dominating

RELATIONSHIP b/w EQUILIBRIUM CONSTANTS AND GIBB'S FREE ENERGY :-

Spontaneous eqᵇ = $\Delta G < 0$

Non-spontaneous = $\Delta G > 0$

equilibrium = $\Delta G = 0$

$$\{\Delta G = \Delta G° + RT\ln Q\}_b$$

- $\Delta G°$ ↓ standard state; T = 298K, P = 1atm
- Q → Reaction Quotient

$0 = \Delta G° + RT\ln K$

$-\Delta G° = -2.303RT\log K$ (−) (−) (+) (+) (+) (+)

$\Delta G° < 0 \rightarrow \log K > 0 \quad K > 1$ spontaneous

$\Delta G° > 0 \rightarrow \log K < 0 \quad K < 1$ non-spontaneous

LE CHATLIER PRINCIPLE:-

→ oppose the change in Rxn.

1- on the basis of Concentration :-

Effect	le-chatlier	Result
[R]↑	[R]↓	forward
[R]↓	[R]↑	Backward
[P]↑	[P]↓	Backward
[P]↓	[P]↑	forward

2- On the basis temperature :-

exothermic → Heat absorb ⇒ ΔH = +ve

endothermic → Heat Rearas ⇒ ΔH = -ve

$R \rightleftharpoons P + Heat$ $\quad$ $Heat + R \rightleftharpoons P$

Temp ↑ → Heat ↑ $\quad$ Temp ↑ → Heat ↑

P = Heat ↓ $\quad$ forward

Backward

3- effect on pressure :-

Effect	le-Chatlier	Result
[P] ↑	[P]↓ = moles↓	mole decrease
[P]↓	[P]↑ = moles↑	mole increase

Eq:- $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

P↑ → [P]↓ = moles↓ = No change

Eq:- $N_2 + 3H_2 \rightleftharpoons 2NH_3$

P↑ → [P]↓ → moles↓ = Forward

4° Effect of Inert gases :-

→ Do not participate in any Rxns on ground state.

Case I

At const volume

↳ No change in eqᵇ

Case II

at const pressure

↳ Rxn will move in direction where moles increase

5- Effect of Catalyst :-

→ No change in eqᵇ.

DEGREE OF DISSOCIATION

→ No of moles dissociate or reacting from 1 mole.

α $\quad A + B \rightleftharpoons C$

t=0 $\quad$ a mole $\quad$ b mole

∴ x React $\quad$ x react

∴

∴

t = eqᵇ $\quad \frac{(a-x)}{v} + \frac{(b-x)}{v} \rightarrow \frac{2x}{v}$

left $\quad$ left $\quad$ formed