CHEMICAL EQUILIBRIUM

* **Equilibrium state:-** property of reversible reaction.

* **Active mass:-** Molarity or concentration

→ $[\ ]$ or $M = \frac{n^{\text{moles}}}{V_L} = \frac{n}{V_{mL}} \times 1000$

$$M = \frac{w}{mw \times V_{mL}} \times 1000$$

$$M = \frac{g \times 1000}{Mw}$$

- Active mass of solid → 1
- Active mass of pure liquid → 1
- Active mass of liquid in excess → 1

Q. Find the active mass of 1.56gm/ml of C_6H_6.

→ $M = \frac{g \times 1000}{Mw} = \frac{1.56 \times 1000}{78}$

$M = 20$

Q. 2g $CaCO_3$ is present in 100mL vessel. Find out the active mass.

→ $CaCO_3$ ↓ solid $M = \frac{2}{100 \times 100} \times$

↳ So, active mass → 1

Q. 5g molecule of N_2 in 5 litre vessel. Active mass = ?

↳ $[\ ] = \frac{5}{5} = 1 \text{ mol } L^{-1}$.

* **Partial Pressure**

Gas A — nA

$P_A = \chi_A \times P_T$ ← Total pressure.
↳ mole fraction

Gas B — nB

$P_B = \chi_B \times P_T$

$P_A = \frac{n_A}{n_A + n_B} \times P_T$

$\frac{n_A}{n_A + n_B}$ → mole fraction of A

$P_B = \frac{n_B}{n_A + n_B} \times P_T$

$\frac{n_B}{n_A + n_B}$ → mole fraction of B

$P_A + P_B = P_T$

$X_A + X_B = 1$ $\quad \Sigma X = 1$

$PV = nRT$

$P_A \times V = n_A \times RT$

$P_A = \frac{n_A \times RT}{V}$ — kelvin, litre

$P_B = \frac{n_B \times RT}{V}$ — kelvin, litre

$R = 0.0821 = \frac{1}{12}$ atm $l\ K^{-1}\ mol^{-1}$

At 0°C,

$RT = 0.082 \times 273$

$= 22.4$

At 27°C

$RT = 0.082 \times 300$

$= 24.6$

Q. Equal moles of H_2 and N_2 were mixed. If total pressure is 12 atm. Find out the partial pressure of species.

$P_{H_2} = ?$ $\quad P_{N_2} = ?$

$\frac{n_{H_2}}{n_{H_2} + n_{N_2}} = \frac{1}{1+1}$

$\therefore P_{H_2} = \frac{1}{2} \times 12$

$= 6$ atm

$\therefore P_{N_2} = \frac{1}{1+1} \times 12$

$= 6$ atm

Q. Equal wt of H_2 and N_2 were mixed. Find out the partial pressure of H_2.

$n_{H_2} = \frac{x}{2}$

$n_{N_2} = \frac{x}{28}$

$P_{H_2} = \frac{\frac{x}{2}}{\frac{x}{2} + \frac{x}{28}} \times P_T$

$= \frac{\frac{x}{2}}{\frac{15x}{28}} \times P_T$

$= \frac{14}{15} P.$

$\therefore P_{N_2} = \frac{1}{15} P_T$

Q. 1.4g N_2 and 3.2g O_2 were mixed in 10L vessel at 0°c. Find out the partial pressure of N_2.

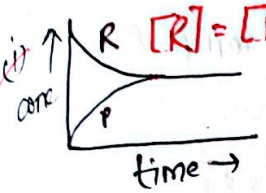
$$PV = nRT$$

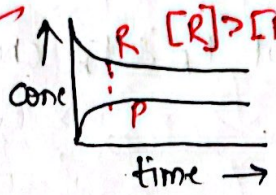
$$P_{N_2} \times V = n_{N_2} \times R \times T$$

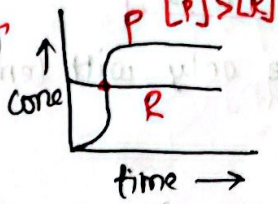
$$P_{N_2} \times 10 = \frac{1.4}{28} \times 22.4$$

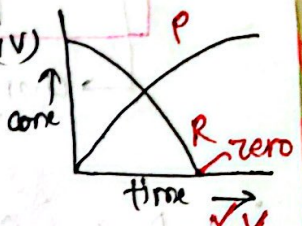
$$= 0.112 \text{ atm.}$$

Q. Which graph defines equilibrium state.

(i) 

(ii) 

(iii) 

(iv) 

Q. At equilibrium:—

(i) $[R] = [P]$ (ii) $[R] > [P]$ (iii) $[R] < [P]$ (iv) Any can be possible

Q. At equilibrium: — ⇌ equal rate of equi. state

(a) $r_F = r_b$ (b) $r_F > r_b$ (c) $r_F < r_b$ (d) All can be possible

Law of Mass action

→ given by Guldberg and Waage.

→ Alc to this law, $R_F \propto$ product of active mass of reactant.

R_F → Rate of Forward rxn

$R_b \propto$ product of active mass of product.

R_b → Rate of backward rxn

$$xA + yB \rightleftharpoons C + D$$

A, B → Reactant; C, D → product

→ $r_F \propto [A]^x[B]^y = K_F[A][B]$, K_F → rate constant or vel. constant or specific rxn rate for forward rxn.

→ $r_b \propto [C]^x[D]^y = K_b[C][D]$

→ rate constant or vel. constant or specific rxn rate for backward rxn

At equilibrium

$$r_F = r_b$$

$$K_F[A][B] = K_b[C][D]$$

$$\frac{K_F}{K_b} = \frac{[C][D]}{[A][B]}$$

K_{eq} → equilibrium constant.

So, $$K_{eq} = \frac{[C][D]}{[A][B]}$$

→ change only with temp^r. but K_F & K_b change with temp^r & catalyst.

$$aA + bB \rightleftharpoons cC + dD$$

$$K_{eq} = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

Forms of equilibrium constant:

① K_c → in terms of concentration (Active mass).

② K_p → in terms of partial pressure.

Q. $3A + 2B \rightleftharpoons 5C + 2D$, $K_c = ?$

$$K_c = \frac{[C]^5[D]^2}{[A]^3[B]^2}$$

$$K_p = \frac{p_C^5 p_D^2}{p_A^3 p_B^2}$$

Q. For the reaction, $A \rightleftharpoons B$, $K_F = 100$, $K_b = 20$, $K_{eq} = ?$

$$K_{eq} = \frac{K_F}{K_b}$$

$$= \frac{100}{20}$$

$$K_{eq} = 5$$

8. Equilibrium constant is given by:-

(a) $\frac{K_b}{K_f}$ (b) $K_f \times K_b$ (c) $\frac{1}{K_f \times K_b}$ (d) $\frac{K_f}{K_b}$

$$aA + bB \rightleftharpoons cC + dD$$

$$K_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

$$= \frac{\left(\frac{mol}{L}\right)^c \left(\frac{mol}{L}\right)^d}{\left(\frac{mol}{L}\right)^a \left(\frac{mol}{L}\right)^b} = (mol\ L^{-1})^{(c+d)-(a+b)}$$

$= (mol\ L^{-1})^{\Delta ng}$ ← unit

↳ unit of K_c.

Δng = total moles of gaseous product − total moles of gaseous reactant.

$$K_p = \frac{P_C^c \cdot P_D^d}{P_A^a \cdot P_B^b} = (atm)^{\Delta ng}$$

↳ unit of K_p.

* Reaction Quotient (Q)

Let a reversible reaction,

$$aA + bB \rightleftharpoons cC + dD$$

$$Q_t = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

Note: Reaction Quotient (Q_t) can be calculated at each point of reversible reaction. K_p/K_c can be calculated only at equilibrium.

→ Condition:-

1. $Q_t > K_c$ or K_p → backward
2. $Q_t = K_c$ or K_p → equilibrium
3. $Q_t < K_c$ or K_p → Formation

Q. Rxn: $A + B \rightleftharpoons C + D$. $K_c = 10$, conc. of A = 1, B = 2, C = 3, D = 4.
Find direction of reaction.

$$Q_t = \frac{[C]^3[D]^4}{[A]^1[B]^2} = \frac{3 \times 4}{1 \times 2} = \frac{12}{2} = 6.$$

$\therefore Q_t < K_c$ so, rxn is forward.

Q. Rxn: $2A + B \rightleftharpoons 3C$. $K_c = 15$. mole of A = 0.1, B = 0.2, C = 0.3 present in 100 ml vessel. Find out direction of rxn.

$$[A] = \frac{0.1}{100} \times 1000 = 1 \text{ mol/L}$$

$$[B] = \frac{0.2}{100} \times 1000 = 2 \text{ mol/L}$$

$$[C] = \frac{0.3}{100} \times 1000 = 3 \text{ mol/L}$$

$$Q_t = \frac{[C]^3}{[A]^2[B]} = \frac{[3]^3}{[1]^2[2]} = \frac{27}{2} = 13.5$$

$\therefore Q_t < K_c$, so, rxn is forward.

Q. Rxn: $A + B \rightleftharpoons 2C + D$. $K_p = 1$. If 1 mole of A, 2 mole of B, 1 mole of C, 2 mole of D are present then find out direction of rxn. $P_T = 12$.

$$P_A = \chi \times P_T = \frac{1}{1+2+1+2} \times 12 = 2$$

$$P_B = \frac{2}{6} \times 12 = 4$$

$$P_C = \frac{1}{6} \times 12 = 2$$

$$P_D = \frac{2}{6} \times 12 = 4$$

$$Q_p = \frac{P_C^2 \times P_D}{P_A \times P_B} = \frac{2^2 \times 4}{2 \times 4}$$

$Q_p = 2$.

$\therefore Q_p > K_p$, so, rxn is backward.

Relation between K_p & K_c

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

8. $N_2 + 3H_2 \rightleftharpoons 2NH_3$.

$K_c = \dfrac{[NH_3]^2}{[N_2][H_2]^3}$, $K_p = \dfrac{P_{NH_3}^2}{P_{N_2} \cdot P_{H_2}^3}$, $\Delta ng = 2-4 = -2$.

9. $NH_4COONH_2(s) \rightleftharpoons 2NH_3(g) + CO_2(g)$ (active mass = 1.)

$K_c = [NH_3]^2[CO_2]$, $K_p = P_{NH_3}^2 \cdot P_{CO_2}$, $\Delta ng = (2+1) - 0 = 3$. (solid)

$K_p = K_c [RT]^{\Delta ng}$

T → Kelvin

R → 0.0821 lit atm $mol^{-1} K^{-1}$ (1/12)

At 0°C, $RT = 22.4$

at 27°C, $RT = 24.6$

→ At (12 K_n) K_p is always equal to K_c.

Cases :-

① If $\Delta ng = 0$, $K_p = K_c$.

② If $\Delta ng > 0$, $K_p > K_c$.

③ If $\Delta ng < 0$, $K_p < K_c$

10. $3Fe(s) + 4H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4H_2(g)$

11. $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$

$\Delta ng = 1$

12. $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ $\Delta ng = 0$

(a) $K_p = K_c$ (b) $K_p - K_c = 0$ (c) $\frac{K_p}{K_c} = 1$ (d) ~~$K_p K_c$~~ $K_c - K_p = 1$

(e) All

Q. $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

(a) $K_p > K_c$ (b) $K_p - K_c$ (c) $\frac{K_p}{K_c} > 1$ (d) $K_c = K_p < 0$ (e) All

$\Delta n_g = (1+1) - 1 = 1.$

So, $K_p > K_c$.

Q. Write relation between K_p and K_c unit of K_p and K_c.

(1) $NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$

$\Delta n_g = 2.$

$\rightarrow K_p > K_c.$ $\quad K_p = K_c [RT]^{\Delta n_g}$

unit of $K_c = (mol\ L^{-1})^{\Delta n_g}$

$= (mol\ L^{-1})^2 = (mol^2\ L^{-2})$

unit of $K_p = (mol\ L^{-1})^{\Delta n_g} (atm)^{\Delta n_g}$

$= (atm)^2.$

(2) $2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g)$

$\Delta n_g = 1.$

$K_p \geq K_c.$ $\quad \because K_p = K_c [RT]^1$

unit of $K_c = (mol\ L^{-1})^1$

unit of $K_p = (atm)^1 = atm.$

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

$\Delta n_g = 2 - (3+1) = -2.$

$K_p = K_c [RT]^{-2}$

$K_p < K_c.$

unit of $K_c = (mol\ L^{-1})^{-2} = mol^{-2} L^2$

unit of $K_p = (atm)^{-2} = \frac{1}{atm^2}$

$2A(g) + 3B(g) + C(s) \rightleftharpoons D(s) + 4E(g)$

$\Delta ng = 4 - (2+3) = -1.$

$K_p = K_c [RT]^{-1}$

$K_c = (\text{mol } L^{-1})^{-1} = (L/\text{mol})$

$K_p = (\text{atm})^{-1} = \frac{1}{\text{atm}}$

8. At 527°C, $NH_3(g) \rightleftharpoons \frac{1}{2}N_2(g) + \frac{3}{2}H_2(g)$. If $K_c = 4$, $K_p = ?$

(a) $16 \times (800K)^2$ (b) $\left(\frac{800R}{4}\right)^{-2}$ (c) $\left(\frac{1}{4 \times 800R}\right)^2$ (d) None

$\Delta ng = \left(\frac{3}{2} + \frac{1}{2}\right) - 1$

$= 1.$

$T = 527 + 273$

$= 800$

$K_p = K_c [RT]^1$

$K_p = 4 \times 800R$

9. $2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$. If K_c at 427°C is 3×10^{-6} mol/Lit.

The value of K_p is :-

(a) 7.5×10^5 (b) 25×10^5 (c) 2.5×10^{-4} (d) 1.72×10^{-4}

$\Delta ng = 1.$

$K_p = K_c [RT]^1$

$= 3 \times 10^{-6} [0.082 \times 700]$

$= 3 \times 10^{-6} \times 5.6$

$= 1.7 \times 10^{-4}$

Q. For reaction,

$SO_2(g) + \frac{1}{2} O_2(g) \rightleftharpoons SO_3(g)$

If $K_p = K_c [RT]^x$. $x = ?$

$\because x = 1 - (1 + \frac{1}{2})$

$= -\frac{1}{2}$.

Q. For the reaction,

$2NO_2(g) \rightleftharpoons 2NO(g) + O_2(g)$, $K_c = 1.8 \times 10^{-6}$ at 184°C.

~~Find Kp~~. When K_p & K_c are compared at 184°C it is found that:

(a) $K_p < K_c$ (b) $K_p > K_c$ (c) $K_p = K_c$ (d) None

$\Delta ng = 1$.

(at 12K.)

(less than 12K.)

$K_p = K_c [RT]^{1}$

So, $K_p > K_c$.

Q. $N_2 + 3H_2 \rightleftharpoons 2NH_3$ at 300K. $K_p = 0.4$, $K_c = ?$

$\Delta ng = 2 - (3+1) = -2$.

$K_p = K_c [RT]^{-2}$

$0.4 = K_c [24.6]^{-2}$

$K_c = 0.4 \times (24.6)^2$

$= 242$ Ans

Factors affecting equilibrium constant

① Mode of representation :-

(a) If rxn is reversed :-

$A \rightleftharpoons B$, $K = \frac{[B]}{[A]}$

$B \rightleftharpoons A$, $K' = \frac{[A]}{[B]} = \frac{1}{\frac{[B]}{[A]}} = \frac{1}{K}$

$\therefore \boxed{K' = \frac{1}{K}}$

(b) If a reaction is multiplied by 'n' factor.

$A \rightleftharpoons B$, $K = \frac{[B]}{[A]}$ $\times 2$

$2A \rightleftharpoons 2B$, $K' = \frac{[B]^2}{[A]^2} = \frac{[B]}{[A]} \cdot \frac{[B]}{[A]} = K^2$

$\therefore \boxed{K' = K^2}$

- If rxn is multiplied by n, then $\boxed{K' = K^n}$

(c) If rxns are added.

$A \rightleftharpoons B$, $K_1 = \frac{[B]}{[A]}$

$B \rightleftharpoons C$ $K_2 = \frac{[C]}{[B]}$

$A \rightleftharpoons C = ?$ $K_3 = \frac{[C]}{[A]}$

$A + B \rightleftharpoons B + C$

$A \rightleftharpoons C.$

$\because \boxed{K_3 = K_1 \times K_2}$

$= \frac{[B]}{A} \times \frac{[C]}{B} = \frac{[C]}{[A]}$

(d) If rxns are substracted:-

$$\boxed{K_3 = \frac{K_1}{K_2}}$$

Q. $A \rightleftharpoons B$, $K_1 = 4$,

$B \rightleftharpoons C$, $K_2 = 3$

$C \rightleftharpoons D$, $K_3 = 2$ Find out ~~equation~~ eqm constant for $A \rightleftharpoons D = ?$

$A + B + C \rightleftharpoons B + C + D$

$A \rightleftharpoons D$

$K' = K_1 \times K_2 \times K_3$

$= 4 \times 3 \times 2$

$= 24.$

Q. For, $N_2 + 3H_2 \rightleftharpoons 2NH_3$; $K_c = 25$. find out eqm constant for :

(i) $2NH_3 \rightleftharpoons N_2 + 3H_2$.

↳ reversed, $K_c' = \frac{1}{K_c} = \frac{1}{25}$

(ii) $2N_2 + 6H_2 \rightleftharpoons 4NH_3$

↳ $K_c' = (25)^2 = 625$.

(iii) $\frac{1}{2}N_2 + \frac{3}{2}H_2 \rightleftharpoons NH_3$

$K_c' = (25)^{1/2} = 5$.

(iv) $4NH_3 \rightleftharpoons 2N_2 + 6H_2$

↳ reversed, ×2. $K_c' = \left(\frac{1}{25}\right)^2 = \frac{1}{625}$

(v) $NH_3 \rightleftharpoons \frac{1}{2}N_2 + \frac{3}{2}H_2$

↳ $K_c = \frac{1}{(25)^{1/2}} = \frac{1}{5}$

Q. $A \rightleftharpoons 2B + C$, $K_1 = 16$ ×½

$D \rightleftharpoons \frac{C}{2} + E$, $K_2 = 9$ - reverse. $\frac{1}{9}$.

$\frac{1}{2}A + E \rightleftharpoons B + D$, $K = ?$

↳ $\frac{1}{2}A \rightleftharpoons B + \frac{C}{2}$ → $K = (16)^{1/2} = 4$.

$\frac{1}{2}A + \frac{C}{2} + E \rightleftharpoons B + \frac{C}{2} + D$ → ~~⇌~~ $4 \times \frac{1}{9}$

↳ $\frac{1}{2}A + E \rightleftharpoons B + D = 4/9$.

$K = 4/9$

$N_2 + O_2 \rightleftharpoons 2NO$, $K_1 = 3$

$N_2 + 2O_2 \rightleftharpoons 2NO_2$, $K_2 = 12$

$2NO + O_2 \rightleftharpoons 2NO_2$, $K_3 = ?$

→ $2NO \rightleftharpoons N_2 + O_2$, $= \frac{1}{3}$

$2NO + N_2 + 2O_2 \rightleftharpoons N_2 + O_2 + 2NO_2$

$2NO + O_2 \rightleftharpoons 2NO_2 \quad = \frac{1}{3} \times 12 = 4$

Q. $N_2 + 2O_2 \rightleftharpoons 2NO_2$, $K_c = 100$

$NO_2 \rightleftharpoons \frac{1}{2}N_2 + O_2$, $K' = ?$

reverse & half ∴ $K' = \left(\frac{1}{100}\right)^{1/2} = \frac{1}{10}$

Q. $A \rightleftharpoons B$, $K_1 = 3$

$3B \rightleftharpoons 3C$, $K_2 = 27$ → $B \rightleftharpoons C = \left(\frac{1}{27}\right)^{1/3} = \frac{1}{3}$

$D \rightleftharpoons C$, $K_3 = 2$ → $C \rightleftharpoons D = \frac{1}{2}$

$A \rightleftharpoons D$, $K = ?$

$K = 3 \times 3 \times \frac{1}{2} = \frac{9}{2} = 4.5$

② Temperature :—

Endothermic

$\Delta H = +ve$

① $A \rightarrow B$, $\Delta H = +2$ kJ/mol

② $A \rightarrow B$, -20 KJ, $Q = -20$ kJ

↳ $A + 20 \rightarrow B$

add

③ $A + 40$ KJ $\rightarrow B + 20$

→ $40 - 20 = 20$ KJ (add)

Exothermic

$\Delta H = -ve$.

① $C \rightarrow D$, $\Delta H = -20$ kJ/mol.

② $C \rightarrow D$, $+20$ kJ, or, $Q = +20$ kJ.

↳ $C - 20 \rightarrow D$

remove — exo

③ $C + 20 \rightarrow D + 40$

↳ $C - 20 \rightarrow D$ — exo

→ Dissociation rxn → endothermic

$PCl_5 \rightarrow PCl_3 + Cl_2$

→ Ionization rxn → endothermic

$NaCl \longrightarrow Na^+ + Cl^-$

④ $C \longrightarrow D + \underline{heat}$ (exo.)

→ Association rxn → exothermic

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

⑤ A; 10KJ ⟶ B

(add..)

→ For a given reaction, K_c / K_p only depend upon temperature.

- $A + C \rightleftharpoons C + D$, $K_c = 10$

~ Concn. of A↑ → K_c same

~ Pressure of A↑ → K_c same

but T↑ or T↓ → K_c change

Endothermic

$K_c \propto T$

$(T\uparrow, K_c\uparrow), (T\downarrow, K_c\downarrow)$

Exothermic

$K_c \propto \frac{1}{T}$

$T\uparrow, K_c\downarrow$

$T\downarrow, K_c\uparrow$.

Q. $A + B \rightleftharpoons C + D$, $-40KJ$ (↳ B.)

→ endothermic rxn.

So, T↑ K_c ↑.

Q. $A + B \rightleftharpoons C + D$, $\Delta H = -40kJ/mol$.

→ exothermic,

So, T↑, K_c↓.

Non-affecting Factors of eqm constant:-

1. conc / mole
2. volume
3. Pressure
4. Addition of inert gas
5. catalyst

Q. On the addition (or removal) of 2 moles of A (g) at equilibrium. K_c → same

Q. volume → half / double or pressure → double / half or conc double / half → K_c → same

Q. addition of He → K_c = same.

Le-chatelier's principle

→ If any equilibrium state is subjected to any change in temperature, pressure or concentration. The equilibrium shifts to that direction in which the effect of applied change is nullified.

* effect of concentration

$$A + B \rightleftharpoons C + D$$

(a) if concentration of reactant ↑ → reactant rxn shifts forward. →

if concentration of reactant ↓ → rxn backward. ←

(b) If concentration of product ↑ → reaction backward ←

If conc. of product ↓ → reaction forward →

Note:- If in a reaction solid / liquid present then it is not effected. If only changes in gaseous state.

* Effect of temperature

Endo	Exo
T ↑ → Forward	T ↑ → backward
T ↓ → backward	T ↓ → Forward

* Pressure / volume ($P \propto \frac{1}{V}$)

P ↑ / V ↓ →

e.g. $2A_{(g)} \rightleftharpoons B_{(g)}$. $P \propto$ no. of moles → P ↑ → forward

P ↓ ← no. of moles ↓

$V\uparrow \longrightarrow P\downarrow$ → no. of moles decrease → backward

Q. $3A_{(g)} \rightleftharpoons 6B_{(g)}$. $V\downarrow \rightarrow P\uparrow \Rightarrow P\downarrow$ → Forward.

Q. $H_2 + I_2 \rightleftharpoons 2HI$

$\Delta ng = 0$, so, no change.

Q $PCl_5 \rightleftharpoons PCl_3 + Cl_2$

endo ; $T\uparrow \rightarrow$ Forward.

* Inert gas
  - at constant volume → No effect
  - at constant pressure → $V\uparrow \Rightarrow P\downarrow \Rightarrow P\uparrow$. no of moles ↑ . → Forward

* Catalyst → No effect.

Q. $A_{(s)} + B_{(g)} \rightleftharpoons 2C_{(g)}$, $\Delta H = -ve$

exothermic rxn.

(i) $[A]\uparrow$ → no effect (solid).

(ii) $[B]\uparrow$ → Forward.
$[B]\downarrow$ → backward.

(iii) $[C]\uparrow$ → backward
$[C]\downarrow$ → Forward

(iv) $P\uparrow$ → backward.

(v) volume ↑ → $P\downarrow = P\uparrow$ → Forward

(vi) Catalyst → no effect

(vii) inert gas at const vol → no effect
at const pressure → $P\downarrow = P\uparrow$ → Forward

(ix) Temp ↑ → backward

Q. $CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$, $\Delta H = +ve$ (endothermic)

(i) Temp ↓ → backward.

(ii) Pressure ↓ → Forward.

(iii) Volume ↑ → Pressure ↓ → Forward

(iv) Mixing of inert gas → at constant volume (no effect)

(iv) Mixing of 1 mole of CaO = no effect (solid.)

(v) ↑ mole of CO_2 → backward (product.)

(vi) ↓ conc. of $CaCO_3$ → no effect (solid.)

Q. $NaNO_3$ (s) was heated in a closed vessel then obtained products are $NaNO_2$ (s) & O_2(g).

→ $NaNO_3(s) \rightleftharpoons NaNO_2(s) + \frac{1}{2}O_2(g)$, ΔH = +ve endo.

(i) Temp ↑ → forward.

(ii) Pressure ↑ → P ↓ तिर जाएगा → so, backward.

(iii) Mixing of inert gas at constant pressure →

V ↑ → P ↓ ⇒ P ↑ तिर जाएगा so, forward

(iv) ↓ the conc. of $NaNO_2$ → No effect (solid.)

(v) ↓ partial pressure of O_2 → forward (product. ~~back~~ in conc.)

(vi) ↓ quantity of $NaNO_3$ → No effect (solid.)

Q. $CO_2 + H_2O \rightleftharpoons H^+ + HCO_3^-$ If at eqm position, some amount of CO_2 is removed pH of mixture will be:-

(a) ↑ (b) ↓ (c) no change (d) ~~then~~ All

CO_2 (reactant.) → rxn → backward जाएगा / और H^+ भी कम होंगे so, pH ↑.

Q. Which of the following is a characteristics of a reversible rxn?

(a) No. of moles of reactant and products are equal

(b) It can be influenced by a catalyst

(c) It can never proceed to completion.

(d) None

Q. For a reversible reaction, if conc^n of the reactants is doubled, the equilibrium constant will be:-

(a) one-fourth (b) halved (c) doubled (d) same

Q. The molar conc. of 32 g of oxygen in 10 litre is:-

(a) 3.2 moles L^{-1} (b) 3.2 g L^{-1} (c) 1.00 mole L^{-1} (d) 0.10 mole L^{-1}

Q. Active mass of 56 g of N_2 contained in 2 litre flask is:-

(a) 16 moles L^{-1} (b) 32 moles L^{-1} (c) 1.00 mole L^{-1} (d) 0.1 mole L^{-1}

Q. What is the active mass of 5.6 lit O_2 at S.T.P?

(a) $\frac{0.5}{5.6}$ (b) $\frac{0.25}{5.6}$ (c) $\frac{8}{5.6}$ (d) $\frac{32}{5.6}$

Q. The active mass of 10 g of $CaCO_3$:-

(a) 0.1 (b) 1 (c) 10 (d) 100

Q. Which of the following reaction favours the reverse reaction in chemical equilibrium?

(a) increasing the conc of the reactants
(b) Removal of at least one of the products at regular interval.
(c) Increasing the conc. of one or more of the products
(d) Increasing the pressure.

Q. For a reaction, $N_2 + 3H_2 \rightleftharpoons 2NH_3$. the value of K_c would depend upon:-

(a) initial conc of reactant (b) pressure (c) temp (d) All.

Q. What is the eqm expression for the reaction?

$$P_4(s) + 5O_2(g) \rightleftharpoons P_4O_{10}(s)$$

(a) $K_c = \frac{[P_4O_{10}]}{[P_4][O_2]^5}$ (b) $K_c = \frac{1}{[O_2]^5}$

(c) $K_c = [O_2]^5$ (d) $K_c = \frac{[P_4O_{10}]}{5[P_4][O_{10}]}$

At a given temp^r, the equilibrium constant for the reaction:-

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

is 2.4×10^{-3}. At the same temp^r, the equilibrium constant for the reaction

$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$ is:

(a) 2.4×10^{-3} (b) -2.4×10^{-3} (c) 4.2×10^{2} (d) 4.0×10^{-2}

$K_c = 2.4 \times 10^{-3}$

$\therefore K_c' = \frac{1}{K_c} = \frac{1}{2.4 \times 10^{-3}} = \frac{10 \times 10^2}{2.4}$

Consider the two gaseous equilibria involving SO_2 and the corresponding equilibrium constants at 298 K.

$SO_2(g) + \frac{1}{2} O_2(g) \rightleftharpoons SO_3(g)$; K_1

$2SO_3 \rightleftharpoons 2SO_2(g) + O_2(g)$; K_2

The values of the equilibrium constant are related by:-

(a) $K_2 = K_1$ (b) $K_2 = K_1^2$ (c) $K_2 = 1/K_1^2$ (d) $K_2 = 1/K_1$

$K_2 = \left(\frac{1}{K_1}\right)^2 = \frac{1}{K_1^2}$

I.M

If K_1 & K_2 are the equilibrium constants for the rxn (1) & (2) respectively.

$N_2 + O_2 \rightleftharpoons 2NO$ — (1) K_1

$NO \rightleftharpoons \frac{1}{2} N_2 + \frac{1}{2} O_2$ — (2) K_2

reverse $\times \frac{1}{2}$ mult.

$K_2 = \left(\frac{1}{K_1}\right)^{1/2}$

Then:- So, $K_1 = \left(\frac{1}{K_2}\right)^2$

(a) $K_1 = \left(\frac{1}{K_2}\right)^2$ (b) $K_1 = (K_2)^2$ (c) $K_1 + \frac{1}{K_2}$ (d) $K_1 = K_2$

The equilibrium constant for the rxn $N_2 + 3H_2 \rightleftharpoons 2NH_3$ is K then the equilibrium constant for the equilibrium:-

$NH_3 \rightleftharpoons \frac{1}{2} N_2 + \frac{3}{2} H_2$ is:

reverse $\times 1/2$: $K_2 = \left(\frac{1}{K_1}\right)^{1/2} = \frac{1}{\sqrt{K}}$

(a) $1/K$ (b) $1/K^2$ (c) $\sqrt{K}$ (d) $\frac{1}{\sqrt{K}}$

The reaction quotient Q for the rxn, $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ is given $Q = \frac{[NH_3]^2}{[N_2][H_2]^3}$. The rxn will proceed from right to left if:-

(a) $Q < K_c$ (b) $Q > K_c$ (c) $Q = 0$ (d) $Q = K_c$

Q. If $N_2 + 3H_2 \rightleftharpoons 2NH_3$ $-K$ & $\times 2$
$2N_2 + 6H_2 \rightleftharpoons 4NH_3 - K'$ then K' will be $K' = K^2$

(a) K^2 (b) $\sqrt{K}$ (c) $1/\sqrt{K}$ (d) $1/K^2$

Q. expr of K_c $\frac{1}{2}A(g) + \frac{1}{3}B(g) \rightleftharpoons \frac{2}{3}C(g)$

$$K_c = \frac{[C]^{2/3}}{[A]^{1/2}[B]^{1/3}}$$

Q. For the homogenous gas rxn,
$4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$, the eqm constant K_c has the units of :-

(a) $conc^{+10}$ (b) $conc^{+1}$ (c) $conc^{-1}$ (d) No dimension

$(conc)^{\Delta ng} = (conc)^{10-9} = conc^{+1}$

M.I.
Q. In a reversible chemical rxn, having 2 reactants in eqm, if the conc. of the reactants are doubled then the eqm constant will be :-

(a) also be doubled (b) Be halved (c) be one fourth (d) same

Q. In the rxn, $H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$; $\Delta ng = 0$.

(a) $K_p = K_c$ (b) $K_p \neq K_c$ (c) $K_p > K_c$ (d) $K_p < K_c$

Q. Which of the following is coirect for the rxn:-
$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $K_p = K_c(RT)^{-2}$

(a) $K_p > K_c$ (b) $K_p < K_c$ (c) $K_p = K_c$
(d) None

Q. In which of the following, K_p & K_c are not equal :-

(a) $2C(s) + O_2(g) \rightleftharpoons 2CO_2(g)$ $\Delta ng = -1$.
(b) $2NO(g) \rightleftharpoons N_2(g) + O_2(g)$
(c) $SO_2(g) + NO_2(g) \rightleftharpoons SO_3(g) + NO(g)$
(d) $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

Select the correct expr, regarding the relation between K_p & K_c for the rxn:

$$aX + bY \rightleftharpoons bZ + aW$$

(a) $K_p = K_c [RT]^{a+b}$ (b) $K_p = \frac{K_c}{(a+b)^2}$ (c) $K_p = K_c RT$

(d) $K_p = K_c$

$\Delta n_g = b + a - a - b = 0.$

At room temp, for the rxn:-

$$NH_4SH(s) \rightleftharpoons NH_3(g) + H_2S(g), \quad \Delta n_g = 2 - 0 = 2$$

(a) $K_p = K_c$ (b) $K_p > K_c$ (c) $K_p < K_c$ (d) K_p & K_c not relate

The active mass of 64 gm of HI in two litre flask would be:-

(a) 2 (b) 1 (c) 5 (d) 0.25

mole = $\frac{64}{128} = \frac{1}{2}$ active mass = $\frac{1/2}{2} = \frac{1}{4}$

The unit of equilibrium constant for the reversible rxn:-

$$H_2 + I_2 \rightleftharpoons 2HI \text{ is:-}$$

(a) mol^{-1} litre (b) mol^{-2} litre (c) mol litre^{-1} (d) None

$\Delta n_g = 0$, unitless

To the system, $H_2 + I_2 \rightleftharpoons 2HI$ in equilibrium, some N_2 gas was added at constant volume. Then,

→ both K_p & K_c remain constant.

K_p/K_c for the rxn, $CO(g) + \frac{1}{2}O_2(g) \rightleftharpoons CO_2(g)$

(a) 1 (b) RT (c) $\frac{1}{RT}$ (d) $(RT)^{1/2}$

$\Delta n_g = 1 - (1 + \frac{1}{2}) = -\frac{1}{2}$

$\frac{K_p}{K_c} = (RT)^{1/2}$

$CO(g) + Cl_2(g) \rightleftharpoons COCl_2(g)$ then K_p/K_c is equal to:-

$\Delta n_g = -1$

$\frac{K_p}{K_c} = \frac{1}{RT}$.

Numerical Section

- α → degree of dissociation ~~equilibrium~~

$$(\%\alpha) = \frac{\text{no. of moles / conc / pressure dissociated at eqm}}{\text{initial mole / conc / pressure}}$$

Q. $2A + B \rightleftharpoons 3C$

A → y mole dissociate.

$A_{(2)} \longrightarrow B_{(1)}$

$1 \longrightarrow 1/2$

	2A	B	3C
t=0,	5	4	0
t=eqm	$5-y$	$4-\frac{y}{2}$	$\frac{3}{2}\times y$

Q. $2A + B \rightleftharpoons 3C$, at eqm 3x mole of A is dissociated.

	2A	B	3C
t=0	5	4	0
t=eqm	$5-3x$	$4-\frac{1}{2}\times 3x$	$\frac{3}{2}\times 3x$

$$K_c = \frac{[C]^3}{[A]^2[B]} = \frac{(9x/2)^3}{(5-3x)^2\left(4-\frac{1}{2}\times 3x\right)}$$

Q. $2A + B \rightleftharpoons 5C$, at eqm, 2x mole of A is dissociated.

	2A	B	5C
t=0,	6	5	0
t=eqm,	$6-2x$	$5-\frac{1}{2}\times 2x$	$\frac{5}{2}\times 2x$

$$K_c = \frac{[C]^5}{[A]^2[B]} = \frac{(5x)^5}{[6-2x]^2(5-x)}$$

$\therefore \alpha_A = \frac{2x}{6}$

$\alpha_B = \frac{x}{5}$

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

4 | 7 | 0

At eqm. 1 mole of N_2 is dissociated

3 | $\frac{3}{1} \times 1$ dissociated | $\frac{2}{1} \times 1 = 2$ | $K_c = ?$

$(7-3)$ बाकी | $(7-2)$ बाकी

$\alpha_{N_2} = \frac{\text{moles dissociated}}{\text{initial}}$ $\quad \alpha_{H_2} = \frac{3}{7}$

$= \frac{1}{4}$

$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{2^2}{3^3 \times (7-3)^3} = \frac{2 \times 2}{3 \times 64 \times 16} = \frac{1}{48}$

Q. $3A + 4B + 2C \rightleftharpoons 5D + 5E$. At eqm, $a\alpha$ mole of A is dissociated.

t=0 | 2 | 3 | 5 | 0 | 0

t=eqm | $2-a\alpha$ | $\frac{4}{3} \times a\alpha$ | $\frac{2}{3} \times a\alpha$ | $\frac{5}{3} \times 2a\alpha$ | $\frac{5}{3} \times 2a\alpha$

$3 - \frac{4}{3} \times a\alpha$ | $5 - \frac{2}{3} a\alpha$ बाकी

Q. $3A + 4B + 2C \rightleftharpoons 5D + 5E$. At eqm, x mole of B is dissociated.

t=0 | 2 | 3 | 5 | 0 | 0

t=eqm | $\frac{3}{4} \times x$ dissociated | $3-x$ | $\frac{2}{4} \times x$ | $\frac{5}{4} \times x$ | $\frac{5}{4} \times x$

$2 - \frac{3}{4} \times x$ बाकी | $5 - \frac{2}{4} x$

Q. $3A + 2B \rightleftharpoons 5C$. At eqm, $2y$ mole of A is dissociated.

t=0, | 5 | 2 | 0

$3(5-2y)$ | $\frac{2}{3} \times 2y$ dissociated | $\frac{5}{3} \times 2y$

$\alpha_B = \frac{\frac{4}{3}y}{2} = \frac{4}{6}y$

$\left(2 - \frac{2}{3} \times 2y\right)$ बाकी | $\alpha_A = \frac{2y}{5}$

$K_c = \frac{(C)^5}{(A)^3 (B)^2} = \frac{\left(\frac{10y}{3}\right)^5}{(5-2y)^3 \left(2 - \frac{4y}{3}\right)^2}$

Q. $3P + 2Q \rightleftharpoons R + 4S$ At eqm, 3 moles of P is dissociated.

	P	Q	R	S
$t=0$,	4	3	0	0
$t=eqm$	$(4-3)$	$\left(\frac{2}{3}\times 3\right)$	$\left(\frac{1}{3}\times 3\right)$	$\left(\frac{4}{3}\times 3\right)$
	1	$(3-2)$	(1)	(4)

$K_c = ?$ $\quad \alpha_P = \frac{3}{4}$, $\quad \alpha_Q = \frac{2}{2} = 1$.

$$K_c = \frac{[R][S]^4}{[P]^3[Q]^2} = \frac{(1)(4)^4}{(1)^3(1)^2} = 4^4 \text{ Ans}$$

$\therefore \boxed{K_c = 4^4}$

Q. $3A + 2B \rightleftharpoons 4C$ at eqm, y mole of A is dissociated.

	A	B	C
$t=0$,	4	5	0
$t=eqm$	$4-y$	$\frac{2}{3}xy$	$\frac{4}{3}xy$

$\alpha_B = ?$

$$\therefore \boxed{\alpha_B = \frac{\frac{2}{3}y}{5} = \frac{2}{15}y}$$

$$K_c = \frac{[C]^4}{[A]^3[B]^2} = \frac{\left(\frac{4}{3}y\right)^4}{(4-y)^3\left(5-\frac{2}{3}y\right)^2}$$

Q. $3O_2(g) \rightleftharpoons 2O_3(g)$ $\quad K_c = 2\times 10^{-5}$ $\quad [O_3]_{eqm} = ?$ $\quad [O_2]_{eqm} = 1.6\times 10^{-2}$

$$K_c = \frac{[O_3]^2}{[O_2]^3}$$

$$2\times 10^{-5} = \frac{x^2}{(1.6\times 10^{-2})^3}$$

$$x^2 = (2\times 10^{-5}) \times (1.6\times 10^{-2})^3$$

$2A \rightleftharpoons B + 3C$ V = Volume $K_c = 16$ find V ?

$\left(\frac{2}{V}\right)\left(\frac{2}{V}\right)$

$K_c = \frac{[B][C]^3}{[A]^2} = \frac{\left(\frac{2}{V}\right)\left(\frac{2}{V}\right)^3}{\left(\frac{2}{V}\right)^2} = \frac{4}{V^2}$

$16 = \frac{4}{V^2}$

$V^2 = \frac{4}{16}$

$V = \frac{1}{2}$ litre

or, $K_c = \frac{[B][C]^3}{[A]^2} \times \frac{1}{V^2}$ → power balance से

$16 = \frac{2 \times 2^3}{2^2} \times \frac{1}{V^2}$

$V = \frac{1}{2}$ Litre.

$3A + 4B \rightleftharpoons 5D$ Vol. = V, K_c = ?

4 3 2

$\therefore K_c = \frac{[D]^5}{[A]^3[B]^4} \times \frac{V^2}{1}$ ← vol. adjust

$K_c = \frac{2^5}{4^3 \times 3^4} \times \frac{V^2}{1}$

Q. At T = 1120K, mole of N_2, H_2, NH_3 at eqm are 2, 1, 3 and Total pressure at eqm = 12 atm. Find out K_p for $N_2 + 3H_2 \rightleftharpoons 2NH_3$ at same T.

$K_p = \frac{P_{NH_3}^2}{P_{N_2} \times P_{H_2}^3}$

$P_{NH_3} = \frac{3}{2+1+3} \times 12 = \frac{1}{2} \times 12 = 6$

$P_{N_2} = \frac{2}{6} \times 12 = \frac{1}{3} \times 12 = 4$

$P_{H_2} = \frac{1}{6} \times 12 = 2$

$= \frac{6^2}{(4)(2)^3}$

$= \frac{36}{32} = \frac{9}{8}$

Trick

$$K_p = \frac{3^2}{2 \times 1^3} \times \frac{(n_{total})^2}{P^2}$$ - volmathy मा-थ्यो भने, P लाग्दैन।

Q. $2A + B \rightleftharpoons 3C$ $\Delta ng = 0$.
eqm 2 2 2 , V = 5li

$$K_p = K_c = \frac{[C]^3}{[A]^2[B]} = \frac{2^3}{2^2 \times 2} = 1$$

Q) $2A + B \rightleftharpoons C$. The eqm conc of A, B & C are 4, 2 & 2 respectively. Find K_c.

(a) 0.0625 (b) 0.625 (c) 6.28 (d) 6.25

$$K_c = \frac{[C]^1}{[A]^2[B]^1} = \frac{2}{4^2 \times 2} = \frac{1}{16} = 0.0625$$

Q. $H_2 + I_2 \rightleftharpoons 2HI$
int. a b 0
eqm $\frac{(a-x)}{V}$ $\frac{(b-x)}{V}$ $\frac{(2x)}{V}$

H_2 को x mole dissociate भयो then, K_c = ?

$$K_c = \frac{(HI)^2}{[H_2][I_2]} = \frac{\left(\frac{2x}{V}\right)^2}{\left(\frac{a-x}{V}\right) \times \left(\frac{b-x}{V}\right)} = \frac{4x^2}{(a-x)(b-x)}$$

[Note:- If $\Delta ng = 0$, then volume आउँदैन conc. नै mole मा लेखे पनि हुन्छ।]

Q. $PCl_5 \rightleftharpoons PCl_3 + Cl_2$
int. a 0 0
eqm a-x x x

$$K_c = \frac{[PCl_3][Cl_2]}{[PCl_5]} \times \frac{1}{V} = \frac{x \times x}{(a-x)} \times \frac{1}{V} = \frac{x^2}{V(a-x)}$$

$K_p = \frac{P_{PCl_3} \times P_{Cl_2}}{P_{PCl_5}} = \frac{x \times x}{(a-x)} \times \frac{P}{(a-x+x+x)}$

8. $N_2 + O_2 \rightleftharpoons 2NO$, 4 moles each of N_2 & O_2 are taken in 1lit vessel. At eqm, 2 moles of NO is formed, find K_c.

	N_2	$+ O_2$	$\rightleftharpoons$	$2NO$
in.	4	4		0
eqm	4-x	4-x		2x
	4-1	4-1		(2)
	=3	=3		

$\therefore 2x = 2$
$x = 1$

$K_c = \frac{2^2}{3^1 \times 3^1} = \frac{4}{9}$ Ans

$(\Delta n_g = 0)$

8. $2A + 3B \rightleftharpoons 4C$. At eqm, 6 moles of C formed, $K_c = ?$

	$2A$	$+ 3B$	$\rightleftharpoons$	$4C$
in.	4	5		0
eqm	4-x	$(\frac{5}{2}-x)$ diss.		$\frac{4x}{2}$
		$5-\frac{3}{2}x$ remain		$= 2x$
	(1)	$(\frac{1}{2})$		(6)

$\therefore 2x = 6$
$x = 3$.

$K_c = \frac{[C]^4}{[A]^2[B]^3} = \frac{6^4}{1^2 \times (\frac{1}{2})^3}$

Q. $5A + 3B + 2C \rightleftharpoons 9E + 7F$

	$5A$	$+ 3B$	$+ 2C$	$\rightleftharpoons$	$9E$	$+ 7F$
in.	3	2	5		0	0
eqm	3-5x	2-3x	5-2x		9x	7x

Q. $A_{(s)} + B_{(g)} \rightleftharpoons 2D_{(g)}$. Partial pres. of B & D at eqm are 2 & 4 atm. find K_p.

	$A_{(s)}$	$+ B_{(g)}$	$\rightleftharpoons$	$2D_{(g)}$
	x			

$K_p = \frac{P_D^2}{P_B^1} = \frac{4^2}{2} = 8.$

Q. At 200K, 2 moles of H_2, 4 moles of I_2 mixed in 10Lit containers. If at eqm, moles of HI and HI are same. Find K_c.

Sol.

	H_2	+	I_2	⇌	2HI
int.	2		4		0
eqm	2−x		4−x		2x
	↓		↓		↓
	4/3		4/3		4/3

$\therefore 2-x = 2x$

$x = 2/3$

$K_p = K_c = \frac{[HI]^2}{[H_2][I_2]} = \frac{(4/3)^2}{\frac{4}{3} \times \frac{10}{3}} = \frac{4}{10} = \frac{2}{5}$

$(\Delta ng = 0)$

Q. HI is taken in a closed container of 1L and allowed to dissociate acc to reaction:- $2HI \rightleftharpoons H_2 + I_2$. If 1/3rd of HI dissociated at eqm. find K_p.

ⓐ 1/2 ⓑ 1/8 ⓒ 1/4 ⓓ 1/16

	2HI	⇌	H_2	+	I_2
int.	1		0		0
eqm.	1−1/3		1/2 × 1/3		1/2 × 1/3
	2/3		1/6		1/6

$K_c = \frac{\frac{1}{6} \times \frac{1}{6}}{(\frac{2}{3})^2} = \frac{\frac{1}{36}}{\frac{4}{9}} \times \frac{9}{4} = \frac{1}{16}$

Q. $2A + 3B + 5C \rightleftharpoons 4E + 3D$. V = 2Lit.

	2A	+	3B	+	5C	⇌	4E	+	3D
int.	a		b		c		0		0
eqm.	a−2x		b−3x		c−5x		4x		3x

At eqm, moles of C & D is equal. find K_c?

$\therefore c - 5x = 3x$

$K_c = \frac{[D]^3[E]^4}{[A]^2[B]^3[C]^5} = \frac{(3x)^3 \times (4x)^4}{(a-2x)^2 (b-3x)^3 (c-5x)^5} \times \frac{V^3}{1}$

$K_p = K_c \times \frac{(\text{Total mole})^3}{D^3}$

$A + B \rightleftharpoons C + D$. If init. conc. of A was 3n and B = n. At eqm conc. of C was found to be equal with conc. of B. Find conc of D at eqm.

	A	+ B	⇌	C	+ D
in.	3n	n		0	0
eqm	3n−x	n−x		x	x

$n - x = x$

$2x = n$

$\therefore x = n/2$

$3A + 2B \rightleftharpoons 3C$. At eqm. mole of C = 6 mole. find K_c = ? $V = 10$ lit.

	3A	+ 2B	⇌	3C
	8	7		0
eqm	8−3x	7−2x		3x
	⇓	⇓		
	2	3		6

$\because 3x = 6$

$x = 2$

$$K_c = \frac{[C]^3}{[A]^3[B]^2} \times \frac{V^2}{1}$$

$$= \frac{6^3}{2^3 \times 3^2} \times 10^2$$

$$= \frac{6 \times 6 \times 6^3}{2 \times 3 \times 2 \times 3 \times 2} \times 10 \times 10$$

$$= 300$$

$$K_p = 2 \times \frac{(11)^2}{p^2}$$

Q. Rxn: $A + B \rightleftharpoons 3C$. Initial 2 moles of A & 2 moles of B were mixed in 1L vessel. If at eqm, $\alpha_C = 0.5$, $K_c = ?$

	A + B ⇌	3C
t=0,	2	2	0
eqm,	2-x	2-x	3x
	↓	↓	↓
	1.2	1.2	2.4

$$K_c = \frac{[C]^3}{[A][B]} = \frac{2.4^3}{1.2 \times 1.2}$$

$$= 9.6$$

$\because \alpha_C = 0.5 \Rightarrow$ 3 + 5

$$\text{or, } \frac{3x}{2-x+2-x+3x} = 0.5$$

$$\therefore 3x = 4 \times 0.5 + 0.5 \times 3x$$

$$\therefore x = 4/5 = 0.8$$

Degree of Dissociation (α)

$$\alpha = \frac{\text{moles dissociated}}{\text{initial mole}}$$

$$\alpha = \frac{x}{a}$$

$$\therefore \boxed{x = a\alpha}$$

Q. $2A + B \rightleftharpoons 3C$ · DOD of $A = \alpha$,

	2A + B ⇌	3C
int.	a	b	0
eqm.	$a - a\alpha$	$b - \frac{1}{2}a\alpha$	$\frac{3}{2}a\alpha$

Q. $3A + 2B \rightleftharpoons C$. Initial moles of A & B are 8 & 4 resp. and at eqm, total moles are 10.4. Find DOD of A & B = ?

$\alpha_A = ?$

$\alpha_B = ?$

	3A + 2B ⇌	C
t=0,	8	4	0
eqm.	8-3x	4-2x	x
	↓	↓	↓
	1.2	0.8	0.4

$\therefore 8 - 3x + 4 - 2x + x = 10.4$

$x = 0.4$

$$\alpha_A = \frac{1.2}{8}$$

$$\alpha_B = \frac{0.8}{4}$$

1. In 0.25 lit. flask, 4 moles of NO placed. If dod(α) of NO is 10%. K_p=?

$(\alpha = 0.1)$

$$2NO \rightleftharpoons N_2 + O_2 \quad (1.0 = y)$$

	4	0	0
eqm.	$4-4\alpha$	$\frac{1}{2}\times 4\alpha$	$\frac{1}{2}\times 4\alpha$
	⇓	⇓	⇓
	3.6	0.2	0.2

$$K_p = K_c = \frac{[0.2]\,[0.2]}{[3.6]\,[3.6]} = \frac{1.0}{18\times 18} = \frac{1}{324}$$ Ans

2. $2HI \rightleftharpoons H_2 + I_2$. DOD of HI = 30%., $(\alpha = 0.3)$ K_c = ?

	1	0	0
eqm.	$1-0.3$	$\frac{1}{2}\times 0.3$	$\frac{1}{2}\times 0.3$

$$K_c = K_p = \frac{\frac{0.3}{2}\times\frac{0.3}{2}}{0.7\times 0.7} = \frac{9}{196}$$ Ans

3. 5 moles of PCl_5 is taken at 2L container. At equilibrium, 40% of PCl_5 gets dissociated at 27°C. Find K_p & K_c.

$\alpha = 0.4$

$$PCl_5 \rightleftharpoons PCl_3 + Cl_2$$

	5	0	0
eqm.	$5-5\times 0.4$	5×0.4	5×0.4
	⇓	↓	↓
	3	2	2

$$K_c = \frac{2\times 2}{3}\times\frac{2}{V} = \frac{4}{3}\times\frac{1}{2} = \frac{2}{3}$$

$$K_p = \frac{2\times 2}{3}\times\left(\frac{P}{7}\right)\frac{4P}{21}$$

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

$$= \frac{2}{3}\times(24.6)^1 = \frac{49.2}{3}.$$

Q. $N_2O_4 \rightleftharpoons 2NO_2$. Deg of N_2O_4 is 20%. Find K_c = ?

$(\alpha = 0.2)$

	$N_2O_4 \rightleftharpoons$	$2NO_2$
i.e.	0 1	0
Eqm	$1-0.2$	2×0.2
	$= 0.8$	$= 0.4$

$$K_c = \frac{0.4\times0.4}{0.8} = 0.2 \text{ Am}$$

Q. $2A + B \rightleftharpoons 3C$,

$\alpha_A = ?$

$\alpha_B = ?$

t=0,	5	4	0
teq.	4	3.5	1.5
	(5-1)	(4-3.5)	

$$\alpha_A = \frac{5-4}{5} = \frac{1}{5}$$

$$\alpha_B = \frac{4-3.5}{4} = \frac{0.5}{4} = \frac{1}{2}$$

Q. $5A + 3B \rightleftharpoons 4C + 9D$ $\quad \alpha_A = \alpha$

t=0,	a	b	0	0
eqm	$a-a\alpha$	$b-\frac{3}{5}a\alpha$	$\frac{4}{5}\times a\alpha$	$\frac{9}{5}\times a\alpha$

Q. $A_{(g)} \rightleftharpoons 3B_{(g)}$, If initial conc of A was a mol/L. If α is degree of dissociation of A. Then total conc at eqm is:- $(\alpha = x)$

	$A_{(g)} \rightleftharpoons$	$3B_{(g)}$
t=0,	a	0
eqm.	$a-ax$	$3ax$

$\therefore$ total conc $= a - ax + 3ax$

$= (a + 2ax)$

$2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$; $V = 500ml$, $NH_3 = 2mole$.

at eqm. NH_3 is 1mole, $K_c = ?$

$2NH_3 \rightleftharpoons N_2 + 3H_2$

in.	2	0	0
eqm.	$2-2x$	x	$3x$
	⇓	⇓	⇓
	1	0.5	1.5

$\therefore 2-2x = 1$

$2x = 1$

$x = \frac{1}{2} = 0.5$

$V = 0.5li.$

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

$$= \frac{(1.5)^3 \times 0.5}{1^2} \times \frac{1}{V^2}$$

$$= \frac{1.5 \times 1.5 \times 1.5 \times 0.5}{0.5 \times 0.5} = \frac{3}{2} \times \frac{3}{2} \times \frac{3}{1}$$

$$= \frac{27}{4}.$$

Q. $A + B \rightleftharpoons C + D$. Initial conc. of A is double than B and at eqm conc of C is triple than B. Find out K_c.

Soln:- $A + B \rightleftharpoons C + D$

in.	2	1	0	0
eqm.	$2-x$	$1-x$	x	$x-\frac{3}{4}$
	⇓	⇓	⇙	
	$\frac{5}{4}$	$\frac{1}{4}$	$\frac{3}{4}$	

$C = 3B$

$x = 3(1-x)$

$x = 3/4.$

$$K_c = \frac{(C)(D)}{A \times B} = \frac{\frac{3}{4} \times \frac{3}{4}}{\frac{5}{4} \times \frac{1}{4}}$$

$$= \frac{9}{5}$$

$$= 1.8$$

Q. Rxn:- $2SO_2 + O_2 \rightleftharpoons 2SO_3$. If at eqm, conc. of SO_2, O_2 & SO_3 are 0.8, 0.6 & 0.4 mol/L. Find out initial conc of SO_2 & O_2.

Soln:- $2SO_2 + O_2 \rightleftharpoons 2SO_3$

t=0	a	b	0
eqm.	$a-2x$	$b-x$	$2x$

$2x = 0.4$

$x = 0.2$

$\therefore a - 2x = 0.8$

$a = 0.8 + 2x$

$= 0.8 + 0.4$

$a = 1.2$

$b - x = 0.6$

$b = 0.8$

Q- $A + B \rightleftharpoons 2C + D$; at eqm moles of C is double than B and total pressure is 5 atm. Initial mole, A=1, B=1, find K_p = ?

	A	+ B	⇌	2C	+ D
i.d.	1	1		0	0
eqm.	1-x	1-x		2x	x
	↓	↓		↓	↓
	1/3	1/3		2/3	1/3

$C = 2B$

$2x = 2(1-x)$

$2x = 2 - 2x$

$x = 2/4 = 1/2$

$K_p = \frac{(2/3)^2 (2/3)}{(1/3)(1/3)} \times 5$

$K_p = \frac{(1)^2 \times 0.5}{0.5 \times 0.5} \times \frac{5 \text{ — total pressure}}{2.5 \text{ — total no. of moles}}$

$= 4$ Ans

Q. The compounds A & B are mixed in equimolar proportions to form the product C & D; $A + B \rightleftharpoons C + D$. At eqm, one third of A & B are consumed. The eqm constant for the rxn is;-

(a) 0.5 (b) 4.0 (c) 2.5 (d) 0.25

	A	+ B	⇌	C	+ D
t=0	1	1		0	0
eqm.	1-1/3	1-1/3		1/3	1/3
	=2/3	2/3			

$K_c = \frac{1/3 \times 1/3}{2/3 \times 2/3} = \frac{1}{4}$

Q. $A(g) + 3B(g) \rightleftharpoons 4C(g)$; Initial conc of A is equal to that of B. The eqm conc of A & C are equal. K_c is equal to;-

(a) 0.08 (b) 0.8 (c) 8 (d) 80 (e) 1/8

$$A + 3B \rightleftharpoons 4C$$

$t=0$, 1 1 0

eqm, $1-x$ $1-3x$ $4x$

$\because t = x = x$

$1 - 3x = 4x$

$\therefore x = \frac{1}{7}$.

$$K_c = \frac{(\frac{4}{7})^4}{(\frac{4}{7})^3 \times \frac{6}{7}} = \frac{4}{6} = \frac{2}{3}$$

$$K_c = \frac{(\frac{1}{2})^4}{(\frac{1}{2})^3 \times \frac{1}{2}}$$

=

Q. Phosphorus pentachloride dissociates as follows in a closed vessel,

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

If total pressure at eqm of the rxn mixture is P & degree of dissociation of PCl_5 is x, the partial pressure of PCl_5 will be:-

(a) $\left(\frac{x}{1-x}\right)P$ (b) $\left(\frac{x}{x+1}\right)P$ (c) $\left(\frac{2x}{1-x}\right)P$ (d) $\left(\frac{x}{x-1}\right)P$

$$PCl_5 \rightleftharpoons PCl_3 + Cl_2$$

$t=0$, 1 0 0

eqm, $1-x$ x x

$(1+x)$ = total mole.

$$P_{p.} = \left(\frac{x}{1+x}\right)P$$

$$2A + 3B \rightleftharpoons 4C$$

5 4 0

$5-5x$ $4-\frac{3}{2}\times 5x$ $\frac{4}{2}\times 5x$