Equilibrium

1) Physical Equilibrium
State changes.
eg:- $H_2O(l) \rightleftharpoons H_2O(g)$
at 373K.
solid $\rightleftharpoons$ liquid
liquid $\rightleftharpoons$ gas
gas $\rightleftharpoons$ solid
at fixed temp.

*

reversible

→ lid vessel → close (tea with cover)
gas to liquid
→ A ⟶ B
B ⟶ A
→ speed / rate of formation equal to rate of backward.
⇑
EQUILIBRIUM

2) Chemical Equilibrium $\rightleftharpoons$

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

* Active Concentration = Molarity = $\frac{mol}{Volume} = M$
or
Active mass = [ ]
= concentration (c)
= solubility. (s)

$M = \frac{mol}{volume}$

$= \frac{mass\ (g) \times 1000}{molar\ mass \times V\ (in\ ml)}$

3) Ionic Equilibrium.

$H_2O \rightleftharpoons H^+ + OH^-$

$q_{rev} = \Delta H_{vap.}$
$\Delta H_{con.}$
$\Delta H_{form.}$

Irreversible.

→ lid vessel → open.
$CaCO_3 \rightarrow CaO_{(s)} + CO_2(g)$
↓
exhaust.
→ rate of forward is not equal to rate of backward reaction.

$M = \frac{n}{V}$

unit = mol lit^{-1}

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

⇒ gram molecule in lit
⇒ Effective concentration.
or Molarity (liquid / solid)

Pressure → only for gases.

"Dalton's partial Pressure Rule"

A + B + C + D

$P_A = X_A \cdot P_T$ $\quad X_A$ = mole fraction of A. $\quad P_T$ = Total pressure.

Q) A = 2mol, B = 3mol, C = 4mol, D = 5mol & Pressure = 2 atm.

$P_A = \frac{2}{14} \times 2 \Rightarrow 0.2857$ atm.

$P_B = \frac{3}{14} \times 2$ atm.

$P_{TOTAL} \Rightarrow P_A + P_B + P_C + P_D$ ← this the Rule.

the total pressure of the gases.

* Relationship b/w concentration & Pressure.

$PV = nRT$

$P = \frac{n}{V} RT \quad \therefore \frac{n}{V} = M$ or $[\,]$

$P_A = [A]RT$

* Equilibrium :- ⇒ $r_f = r_b$.

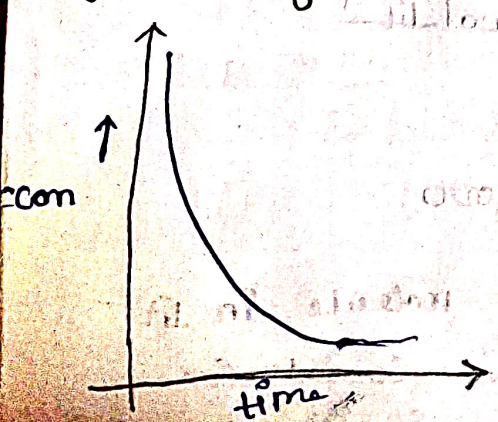
$A \rightleftharpoons B$

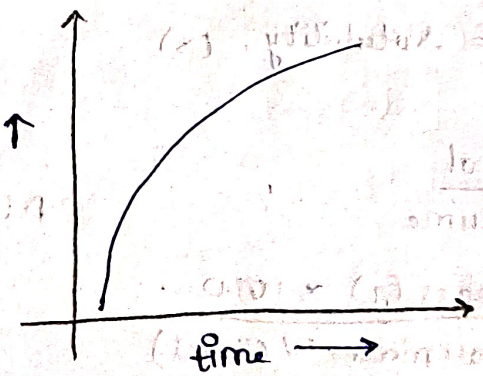
at $t=0$ 100% A_0 0% B_0

$t = t_1$ A_1, $t = t_2$ A_2, $t = t_3$ A_3 } decreases

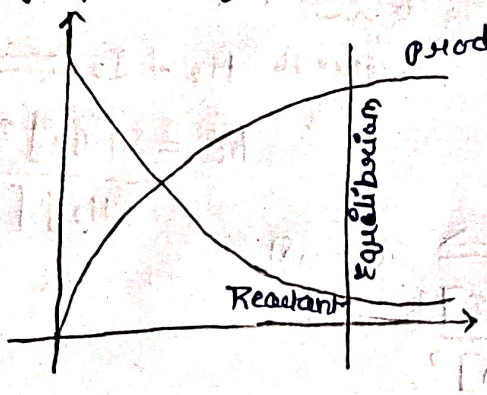
B_1, B_2, B_3 } increases

* graphs of A → Reactant & B → Product.





→ combine graph of A & B.



$A \rightleftharpoons B$.

* RATE's LAW law of mass action.

$A \rightleftharpoons B$

$r_f = k_f [A]$ — (1)

↓ rate of forward rxn ↓ rate constant

$r_b = k_b [B]$ — (2)

Equilibrium.

$r_f = r_b$.

$k_f [A] = k_b [B]$

$$\frac{k_f}{k_b} = \frac{[B]}{[A]}$$

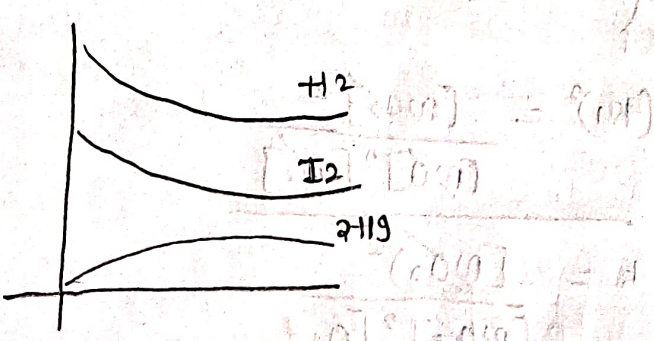
$$K_c = \frac{k_f}{k_b} = \frac{[B]}{[A]}$$

↓ equilibrium constant for concentration.

$aA + bB \longrightarrow cC + dD$

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

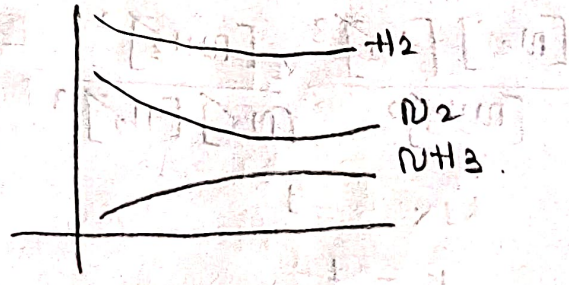
eg: $H_2 + I_2 \rightleftharpoons 2HI$



eg: $2SO_2 + O_2 \rightleftharpoons 2SO_3$

$$K_c = \frac{[SO_3]^2}{[SO_2]^2 [O_2]}$$

eg: $3H_2 + N_2 \rightleftharpoons 2NH_3$



Calculation of K_c.

Que° 1) $N_2 + 3H_2 \rightleftharpoons 2NH_3$

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

Que° 2) $H_2 + I_2 \rightleftharpoons 2HI$

$$K_c = \frac{[HI]^2}{[H_2][I_2]}$$

Hypothetical rxn. $2A + 4B \rightleftharpoons 5C + 8D$.

$$K_c = \frac{[C]^5[D]^8}{[B]^4[A]^2}$$

*Homogenous Rxn.

$H_{2(g)} + Cl_{2(g)} \rightleftharpoons HCl_{(g)}$ ✓

$CaCO_3 \rightleftharpoons CaO + CO_2$ ✗

Heterogenous ✓

Hydrolysis of ester:

$C_2H_5COOCH_3 + H_2O \longrightarrow C_2H_5OH_{(l)} + CH_3OH_{(l)}$

($C_2H_5COOCH_3$ (l), H_2O (l))

Homogenous - A reactn in which the all the reactant & product are in same phase. is called Homogenous eqⁿ/rxn.

Heterogenous - A rxn in which (equilibrium) all the reactant & product are not in the same phase.

eg 1) $2NH_3 \rightleftharpoons N_2 + 3H_2$ — (1)

$K_c = K_1$

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

$$K_1 = \frac{[H_2]^3[N_2]}{[NH_3]^2}$$

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

$K_1 \times K = 1$

$$\frac{[N_2][H_2]^3}{[NH_3]^2} \times \frac{[NH_3]^2}{[N_2][H_2]^3} = 1.$$

$K_1 \times K = 1$

$$K = \frac{1}{K_1}.$$

eg 2) $2NO + O_2 \rightleftharpoons 2NO_2 \Rightarrow K = K$

$NO + \frac{1}{2}O_2 \rightleftharpoons NO_2 \quad K = K'$

$K' = ?$

$$K = \frac{[NO_2]^2}{[NO]^2[O_2]} \quad — (1)$$

$$\left(K' = \frac{[NO_2]}{[NO][O_2]^{1/2}}\right)^2 \quad — (2).$$

$$(K')^2 = \frac{[NO_2]^2}{[NO]^2[O_2]}$$

$$K = \frac{[NO_2]^2}{[NO]^2[O_2]}$$

$$\frac{(K')^2}{K} = 1$$

$K'^2 = K$

$K' = (K)^{1/2}$.

eg3) $2NO + O_2 \rightleftharpoons 2NO_2 \rightarrow K = k$

$NO + \frac{1}{2}O_2 \rightleftharpoons NO_2 \rightarrow K = k'$ to

eg3) $H_2 + I_2 \rightleftharpoons 2HI \quad K_c = 64$

$HI \rightleftharpoons \frac{1}{2}H_2 + \frac{1}{2}I_2 \quad K_c = ?$

$\Rightarrow K_c = \frac{[HI]^2}{[H_2][I_2]}$ — (1) $= 64$

$\Rightarrow \left(K_c = \frac{[I_2]^{1/2}[H_2]^{1/2}}{[HI]} \right)^2$ — (2)

$\Rightarrow K_c^2 = \frac{[I_2][H_2]}{[HI]^2} \Rightarrow 64 \times K_c^2 = \frac{[I_2][H_2]}{[HI]^2} \times \frac{[HI]^2}{[H_2][I_2]}$

$\Rightarrow 64 \times K_c^2 = 1$

$\Rightarrow K_c = \sqrt{\frac{1}{64}} = \frac{1}{8} = 0.125.$

* Complex Rxn / Elementary Rxn

multiple steps / single steps.

$2A \rightarrow C \quad K_c = ? \quad K_c = \frac{[C]}{[A]^2}$

$A \rightarrow B \rightarrow k_1$

$2B \rightarrow D \rightarrow k_2$

$D \rightarrow C \rightarrow k_3$

$\Rightarrow k_1^2 \times k_2 \times k_3 = \frac{[C][B]^2[D]}{[D][A]^2[B]^2}$

$\Rightarrow k_1^2 \times k_2 \times k_3 = \frac{[C]}{[A]^2}$

$\rightarrow \boxed{K_c = k_1^2 \times k_2 \times k_3}$

$k_3 = \frac{[C]}{[D]}$

$\rightarrow (k_1)^2 = \left(\frac{[B]}{[A]}\right)^2$

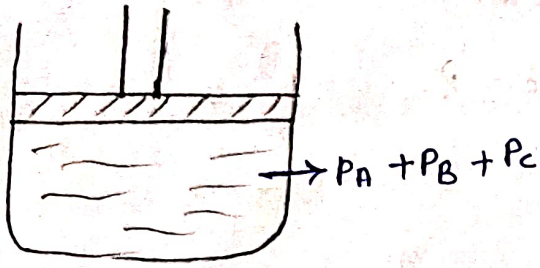
$\rightarrow k_1^2 = \frac{[B]^2}{[A]^2}$

$\rightarrow k_3 \times k_1^2 = \frac{[C][B]^2}{[D][A]^2}$

$\rightarrow k_2 = \frac{[D]}{[B]^2}$.

* For HOMOGENOUS GASEOUS Equation

* Calculation of k_p



→ $A + B \rightarrow C$ (gases)

→ $k_p = \dfrac{P_C}{P_A \times P_B}$

$aA_{(g)} + bB_{(g)} \rightleftharpoons cC_{(g)} + dD_{(g)}$ ← Homogenous.

$$k_p = \frac{(P_C)^c (P_D)^d}{(P_A)^a (P_B)^b}$$

$CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$

liquid / solid = k_p = unity = 1

$$k_p = \frac{P_{CO_2} \times 1}{1}$$

$$k_p = P_{CO_2}$$

* Relationship K_p & K_c.

$aA + bB \rightleftharpoons cC + dD$

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

$$k_p = \frac{[P_C]^c [P_D]^d}{[P_A]^a [P_B]^b}$$

$PV = nRT$

$P = \frac{n}{V} RT.$

$P_A = [\,]RT$

$P_A = [A]RT$ — (1)

$P_B = [B]RT$ — (2)

$P_C = [C]RT$ — (3)

$P_D = [D]RT$ — (4)

$$\Rightarrow k_p = \frac{[P_C]^c [P_D]^d}{[P_A]^a [P_B]^b}$$

$$k_p = \frac{([C]RT)^c ([D]RT)^d}{([A]RT)^a ([B]RT)^b}$$

$$\Rightarrow k_p = \frac{[C]^c [D]^d (RT)^{c+d}}{[A]^a [B]^b (RT)^{a+b}}$$

$$k_p = k_c (RT)^{(c+d)-(a+b)}$$

$(c+d) - (a+b) = (P-R)$ gas $= \Delta n_g$.

$$k_p = k_c (RT)^{\Delta n_g}$$

* Three cases :-

Δng = value for K_p / K_c

Case - I

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

$\Delta ng = +ve$

Assume $\Delta ng = 1$

eg :- $2SO_{3(g)} \rightleftharpoons 2SO_{2(g)} + (O_2)_g$

$\Delta ng = 3 - 2 = 1$

$K_p = K_c (RT)^1$

$K_p = K_c$

$100 = 50 \times 2$.

$K_p > K_c$ — (1)

Case - II

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

If $\Delta ng = -ve$

$K_p =$

eg :- $N_2 + 3H_2 \rightleftharpoons 2NH_3$ (all g)

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

$K_p = K_c (RT)^{-2}$

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

Assumed,

$25 = \frac{100}{(2)^2} = K_p < K_c$ — (2)

Case - III

$\Delta ng = 0$

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

$K_p = K_c (RT)^0 = 1$.

$K_p = K_c$ — (3)

Summary

1) $\Delta ng = +ve$ $K_p > K_c$

2) $\Delta ng = -ve$ $K_c > K_p$

3) $\Delta ng = 0$ $K_p = K_c$.

* acc^{n} to the law (mass actn)

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

taking both side ln,

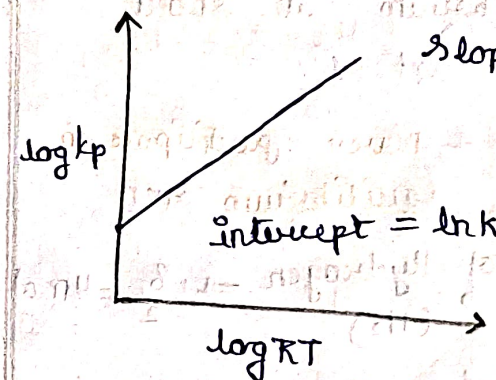
$\ln K_p = \ln (K_c (RT)^{\Delta ng})$

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

$\ln K_p = \ln K_c + \Delta ng \times \ln (RT)$

$y = x + mx$.

GRAPH



Que. PYQ given equation.

$2A + 3B \rightleftharpoons 2C$

which rxn are correct.

1) $\log \frac{K_p}{K_c} - \log \frac{1}{RT} = 0$

2) $\log \frac{K_p}{K_c} - 3 \log \frac{1}{RT} = 0$

3) $\log \frac{K_p}{K_c} + 3 \log \frac{1}{RT} = 0$

4) $\log \frac{K_p}{K_c} + 2 \log \frac{1}{RT} = 0$

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

$\Delta ng = 2 - 5 = -3$

Solution) $K_p = K_c (RT)^{-3}$

$$\log \frac{K_p}{K_c} = \log (RT)^{-3}$$

$$\log \frac{K_p}{K_c} = 3 \log (RT)^{-1}$$

$$\log \frac{K_p}{K_c} = \frac{3 \log}{RT}$$

$$\boxed{\log \frac{K_p}{K_c} - \frac{3 \log}{RT} = 0}$$ opt-2 ✓

DPP-01 pg-19

Que-1) $x \rightleftharpoons y$.

$r_f = r_b$ option = 4.

Que-2) equilibrium in short time opt-1.

Catalyst – never participate in equilibrium rxn

Que-3) mole of Hydrogen (H₂) $\Rightarrow \frac{8}{2} = 4$ mol

$$M = \frac{\text{mol}}{V} = \frac{4}{1} = 4 \text{ mol L}^{-1}$$

Que-4) Wall = 58.5 g.

$$\frac{w}{mw} = \frac{40}{58.5}$$

Wall is solid.

Active mass of solid = 1

Que-5) $\frac{0.745}{74.5}$ g

0.01 = mol

$$\frac{0.01 \text{ mol} \times 1000}{1000}$$

$$= 0.01 \text{ mol L}^{-1} //$$

DPP-02 pg-20

Que-1) Ans to Dalton's partial pressure rule.

$$P_{Total} = P_A + P_B + P_C$$

Que-2) New concept

- A gases which can react with each other do not obey dalton's rule

Que-3) $P_T = P_{Li} + P_H$ Li = Lighter, H = Higher.

$$P_{Li} = \frac{n_{Li}}{n_{Li} + n_H} \times P_T$$

$$\frac{\frac{m}{4}}{\frac{m}{4} + \frac{m}{40}} = \frac{\frac{1}{4}}{\frac{10+1}{40}}$$

$$P_{Li} = X_{Li} \times P_{Total}$$

$$P_{Li} = \frac{10}{11} \times 1.1 = 1 \text{ atm}.$$

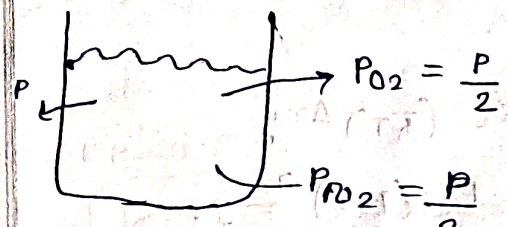
Que-4) no. of moles of $O_2 = n_A$.

no. of moles of $N_2 = n_A$.

$$P_{O_2} = \frac{n_{O_2}}{n_{O_2} + n_{N_2}} \times P_T$$

$\therefore P_T = P_{atm}$.

$$= \frac{n_A}{n_A + n_A} \times P = \frac{1}{2} P$$



Que° 5) 4g $O_2 = \frac{4}{32} = \frac{1}{8} = 0.125$

2g of $H_2 = \frac{2}{2} = 1$ mol.

Total mol = 1 + 0.125
= 1.125.

$PV = nRT$

$P = \frac{n}{V} RT$ $\quad T = 0°C = 273K.$

$P = \frac{1.125}{1} \times 0.0821 \times 273$

P = 25.21 atm

as ans. is in atm.

DPP-03 pg - 21

Que° 1) kp & kc

Δng = +ve

option - 1 = 3 - 2 = +ve.

Que° 2) $k_p = k_c (RT)^{\Delta ng}$

$\frac{PV}{nT} = R$ (atm L / mol K)

$k_p = k_c (atm)^{\Delta ng}$

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

$k_p = (atm)^2$ //

Que° 3) $k_c = \frac{k_f}{k_b}$

$1.5 = \frac{k_f}{1.5 \times 10^{-4}}$

$k_f = 1.5 \times 7.5 \times 10^{-4}$

$= 11.25 \times 10^{-4}$

$= 1.125 \times 10^{-3}$ //

Que° 4) $n_f = n_b$.

$A \rightleftharpoons B$

$k_f [A]_e = k_b [B]_e$

$$[B]_e = \frac{k_f}{k_b} [A]_e$$

$= k_f \times k_b^{-1} [A]_e$.

Que° 5) option - 3 = 2 - 2 = 0

$k_p = k_c$.

Que° 6) T = 1000

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

4 - 3 = +1

$k_p = 0.05$ atm

$k_p = k_c (RT)^{\Delta ng}$

$\Delta ng = 1$

$\frac{0.05}{RT} = \frac{0.05 \text{ atm}}{R \times 1000}$

$= 5 \times 10^{-5} R^{-1}$

DPP-04 pg - 23.

Que 1) $A + B \rightleftharpoons C + 2D = K_1$

$A + E \rightleftharpoons C + F = K_2$

$2D + E \rightleftharpoons B + F = K_3$?

$K_3 = \frac{K_2}{K_1} = \frac{[A][B]}{[C][D]^2} \times \frac{[F][C]}{[A][E]}$

$\Rightarrow \frac{[B][F]}{[E][D]^2}$.

$K_3 = \frac{[F][B]}{[E][D]^2}$.

Ans 2) $2NH_3 \rightleftharpoons N_2 + 3H_2$

$$K_1 = \frac{[N_2][H_2]^3}{[NH_3]^2} \qquad K = 0.5, \quad T = 1100\ K.$$

$N_2 + 3H_2 \rightleftharpoons 2NH_3$. $K = ?$

$$k_2 = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

$$K_1 \times K_2 = \frac{[NH_3]^2}{[N_2][H_2]^3} \times \frac{[N_2][H_2]^3}{[NH_3]^2}$$

$K_1 \times K_2 = 1$

$0.5 \times K_2 = 1$

$K_2 = 2$ //

Ans 3) $HI \rightleftharpoons \frac{1}{2} H_2 + \frac{1}{2} I_2$.

$K = 7.4$

$2HI \rightleftharpoons H_2 + I_2 = ?$

$K_{new} = K^2 = (7.4)^2 = 54.76$ //

* DEGREE OF DISSOCIATION :-

α , x

$1A \longrightarrow 1B$

at $t=0$ 1 mole $\quad 1 \times \alpha$

at $t = t$ $1(1-\alpha)$ → degree of dissociation

no. of moles / max value of $\alpha = 1$

α = unitless

α = max 1

$\alpha = 100\%$

Ans 4) $A \rightleftharpoons B \quad K_1 = 2$

$B \rightleftharpoons C \quad K_2 = 4$

$C \rightleftharpoons D \quad K_3 = 6$

$K_C \longrightarrow A \longrightarrow D$

$K_C = 2 \times 4 \times 6 = 48$

$$K_1 = \frac{[B]}{[A]} \qquad K_2 = \frac{[C]}{[B]}$$

$$K_3 = \frac{[D]}{[C]}$$

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

$$K = \frac{[D]}{[A]}.$$

Ans 5) $K \rightarrow$ high $\rightarrow$ product more stable

K - low $\rightarrow$ Reactant more stable

Nitrogen $\rightarrow$ Reactant $\rightarrow$ K low

6.7×10^{16} $\rightarrow$ least option-1 //.

$2A \longrightarrow 4B$

at $t=0$ 1 $\quad$ 0

$(1-2\alpha) \quad 4\alpha$

$3A + 4B \longrightarrow 5C$

at $t=0$ 1 $\quad$ 1 $\quad$ 0

$1-3\alpha \quad 1-4\alpha \quad 5\alpha$

DPP-05

Que 1) $A \rightleftharpoons B$

at $t=0$ 4 $\quad$ 0

$t=t \quad 4-\alpha \quad 4\alpha$

α = moles dissociated / initial mole.

$= \frac{0.8}{4} = 0.2$

Que.2) K_p = pressure only depend upon pressure. not ~~o~~ value.

Que.3) Catalyst → equilibrium equivalent No change

Que.4) $PCl_5 \rightleftharpoons PCl_3 + Cl_2$

4 mol	0	0
$4(1-\alpha)$	$4 \times \alpha$	$4 \times \alpha$
$4(1-0.5)$	4×0.5	4×0.5
$4-2$	2	2
2 mol	2 mol	2 mol

$= 6$ mol

$\alpha = 0.5$

$PCl_3 \rightleftharpoons PCl_3 + Cl_2$

4 mol		
$4-\alpha$	α	α
$4-0.5$	0.5	0.5
3.5	0.5	0.5
4.5		

Que.) $2CO_2 \rightleftharpoons 2CO + O_2$

2 mol $\quad 2\alpha \quad \alpha$

$2 - 2\alpha$ → coefficient

no. of moles

$2 - 2\alpha + 2\alpha + \alpha$

$2 + \alpha = 2 + 0.4 = 2.4$

no. of moles coefficient equal.

Que.) $2A + 4B \longrightarrow 5C$

$2-2\alpha \quad 4-4\alpha \quad 5\alpha$

Que.) $N_2 + 3H_2 \rightleftharpoons 2NH_3$

1	3	0
$1-\alpha$	$3-3\alpha$	2α

Que.) $2SO_2 + O_2 \rightleftharpoons 2SO_3$

at $t=0$	2	1	0
	$2-2\alpha$	$1-\alpha$	2α

eg 1) $H_2(g) + Cl_2(g) \longrightarrow 2HCl(g)$

at $t=0$	1	1	0	$\Delta ng = 0$
$t=t$	$1-\alpha$	$1-\alpha$	2α	– moles
concn	$\frac{1-\alpha}{v}$	$\frac{1-\alpha}{v}$	$\frac{2\alpha}{v}$	
pressure	$\frac{1-\alpha}{2} \times P$	$\frac{1-\alpha \times P}{2}$	$\frac{2\alpha \times P}{2}$	

$$K_c = \frac{[HCl]^2}{[H_2][Cl_2]} = \frac{[2\alpha]^2}{v} \Big/ \left(\frac{1-\alpha}{v}\right)\left(\frac{1-\alpha}{v}\right) = \frac{4\alpha^2}{(1-\alpha)^2}$$

$$K_p = \frac{[P_{HCl}]^2}{[P_{H_2}][P_{Cl_2}]} = \frac{\left[\frac{2\alpha}{2}P\right]^2}{\left(\frac{1-\alpha P}{2}\right)\left(\frac{1-\alpha}{2} \times P\right)} = \frac{4\alpha^2}{(1-\alpha)^2}$$

$K_p = K_c$ since $\Delta ng = 0$

eg 2) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $\quad \Delta ng = -ve$

at $t=0$	1	3	0	
at $t=t$	$1-\alpha$	$3-3\alpha$	2α	
conc	$\frac{1-\alpha}{v}$ (moles ↑ coefficient of atom)	$\frac{3-3\alpha}{v}$	$\frac{2\alpha}{v}$	
pressure	$\frac{1-\alpha P}{4-2\alpha}$	$\left(\frac{3-3\alpha}{4-2\alpha}\right)P$	$\frac{2\alpha}{4-2\alpha}P$	

$$K_c = \frac{[NH_3]^2}{[H_2]^3[N_2]} = \frac{\left[\frac{2\alpha}{v}\right]^2}{\left[\frac{3-3\alpha}{v}\right]^3\left[\frac{1-\alpha}{v}\right]}$$

$K_c \propto v^2$

$v \propto \sqrt{K_c}$

$$K_p = \frac{(P_{NH_3})^2}{[P_{H_2}]^3 * [P_{N_2}]} \Rightarrow \frac{\left[\frac{2\alpha}{4-2\alpha}P\right]^2}{\left(\frac{3-3\alpha P}{4-2\alpha}\right)^3\left(\frac{1-\alpha}{4-2\alpha}P\right)}$$

3 pels
4 mole.
$4(1-3\alpha)$
$4-3\alpha$.

$K_p \propto \frac{1}{P^2}$

$K_c > K_p$.

Qu.1) $2PCl_5 \rightleftharpoons 2PCl_3 + 2Cl_2$

	$2PCl_5$	$2PCl_3$	$2Cl_2$
	$2-2\alpha$	2α	2α
	$2-2\times0.4$	2×0.4	2×0.4
mol	$2-2\times0.4$	2×0.4	2×0.4
Conc^n	$\frac{1.2}{2}$	$\frac{0.8}{2}$	$\frac{0.8}{2}$
	0.6	0.4	0.4

$$K_c = \frac{(0.4)(0.4)}{0.6} = 0.266 //$$

Qu.2) $A + B \rightleftharpoons C + D$

	A	B	C	D
	$1-\alpha$	$1-\alpha$	α	α
Conc^n	$\frac{1-\alpha}{V}$	$\frac{1-\alpha}{V}$	$\frac{\alpha}{V}$	$\frac{\alpha}{V}$

$$\frac{\alpha}{V} = \frac{2(1-\alpha)}{V}$$

$$\alpha = 2 - 2\alpha$$

$$3\alpha = 2$$

$$\alpha = \frac{2}{3}$$

$$K_c = \frac{\frac{\alpha}{2}\,\frac{\alpha}{V}}{\left(\frac{1-\alpha}{V}\right)^2} = \frac{\frac{2}{3}\times\frac{2}{3}}{\left(1-\frac{2}{3}\right)^2} = \frac{\frac{2}{3}\times\frac{2}{3}}{\frac{1}{3}\times\frac{1}{3}} = 4 //$$

Qu.3) $PCl_5 \rightleftharpoons PCl_3 + Cl_2$

	PCl_5	PCl_3	Cl_2
at $t=0$	0.1	0.2	0.2
	$\frac{0.1}{10}$	$\frac{0.2}{10}$	$\frac{0.2}{10}$

$$K_c = \frac{\frac{0.2}{10}\times\frac{0.2}{10}}{\frac{0.1}{10}} = \frac{0.04}{10\times0.1} = 0.04 //$$

Qu.4) $H_2 + I_2 \rightleftharpoons 2HI$

	H_2	I_2	$2HI$
	0.3	0.3	0
	$\frac{0.3-\alpha}{10}$	$\frac{0.3-\alpha}{10}$	$\frac{2\alpha}{10}$

$$K_c = \frac{\left(\frac{2\alpha}{10}\right)^2}{\left(\frac{0.3-\alpha}{10}\right)^2}$$

$$\sqrt{64} = \left(\frac{2\alpha}{0.3-\alpha}\right)^2$$

$$8 = \frac{2\alpha}{0.3-\alpha}$$

$$0.3\times8 - 8\alpha = 2\alpha$$

$$10\alpha = 2.4$$

$$\alpha = 0.24$$

Unreacted $= 0.3 - \alpha$

$= 0.3 - 0.24$

$= 0.06 //$

Qu·5) $N_2 + 3H_2 \rightleftharpoons 2NH_3$

Start	1	3	2
	$\frac{28}{28}\,1$	$\frac{6}{2} = 3$	0
	1 mol	3 mol	0
	$1-\alpha$	$3-3\alpha$	2α

$2\alpha = \frac{27.54}{17} = 1.62$

$\alpha = \frac{1.62}{2} = 0.81$

	$1-0.82$	$3-3\times0.81$	2×0.81
mol	~~0.9~~ 0.19	0.57	1.62
Concn :-	$\frac{0.19}{1}$	$\frac{0.57}{1}$	$\frac{1.62}{1}$

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

$= \frac{[1.62]^2}{[0.19][0.57]^3}$

$K_c = 74.58$ if SI unit then $mol^{-2}L^2$

Qu·6) $A + 2B \longrightarrow 2C$

	2 mol	3 mol	2 mol
	$\frac{2-\alpha}{2}$	$\frac{3-2\alpha}{2}$	$\frac{2+2\alpha}{2}$
	$1+0.5\times0.5$	$1.5+0.5$	$1-0.5$
	$1+0.25$	2	0.5
	$\Rightarrow 1.25$		

$1 + \alpha = 0.5 \quad \alpha = 0.5 - 1$

$\alpha = -0.5$

$K_c = \frac{[C]^2}{[A][B]^2} = \frac{[0.5]^2}{1.25 \times (2)^2}$

$K_c = 0.05$ //

Qu·7) $A + B \rightleftharpoons C + D$

	$1-\alpha$	$1-\alpha$	α	α
	$1-\frac{2}{3}$	$1-\frac{2}{3}$	$\frac{2}{3}$	$\frac{2}{3}$
Con =	$\frac{1}{\frac{3}{V}}$	$\frac{1}{\frac{3}{V}}$	$\frac{\frac{2}{3}}{V}$	$\frac{\frac{2}{3}}{V}$

as. $\alpha = 2(1-\alpha)$

$\alpha = 2 - 2\alpha$

$3\alpha = 2$

$\alpha = \frac{2}{3}$.

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

$= \frac{\frac{2}{3}\,\frac{2}{3}}{\frac{1}{3}\,\frac{1}{3}} = 4$ Ans.

Qu·8) $H_2 + I_2 \rightleftharpoons 2HI$

at $t=0$	4.5	4.5	0
$t=t$	$4.5-\alpha$	$4.5-\alpha$	2α
	$4.5-1.5$	$4.5-1.5$	2×1.5
	$\frac{3}{10}$	$\frac{3}{10}$	$\frac{3}{10}$

$2\alpha = 3$

$\alpha = \frac{3}{2} = 1.5$

$K_c = \frac{[HI]^2}{[H_2][I_2]}$

$= \frac{\frac{3}{10} \times \frac{3}{10}}{\frac{3}{10} \times \frac{3}{10}}$

$K_c = 1$.

Que·9) $2H_2S \rightleftharpoons 2H_2 + S_2$

$t=t$ 0.5 0.1 0.4

$$K_c = \frac{[S_2][H_2]^2}{[H_2S]^2}$$

$$= \frac{0.4 \times (0.1)^2}{(0.5)^2} = 0.016$$

Que·10) $2CO_2 \rightleftharpoons 2CO + O_2$

at $t=t$ 0.6 0.4 0.2

$$K_p = \frac{(P_{CO})^2 (P_{O_2})}{(P_{CO_2})^2}$$

$$= \frac{(0.4)^2 (0.2)}{(0.6)^2} = 0.089.$$

Que·11) $2HI \rightleftharpoons 2H_2 + I_2$

only 50% HI

to find K_c.

at $t=0$ $2-2\alpha$ α α

$2 - 2\times0.5$ 0.5 0.5

$\frac{1}{v}$ $\frac{0.5}{v}$ $\frac{0.5}{v}$

$$K_c = \frac{[H_2][I_2]}{[HI]^2}$$

$$K_c = \frac{\frac{0.5}{v} \times \frac{0.5}{v}}{\left(\frac{1}{v}\right)^2}$$

$K_c = 0.25$.

Que·12) $A + B \rightleftharpoons 2C$

3 1

$\frac{3-\alpha}{v}$ $\frac{1-\alpha}{v}$ $\frac{2\alpha}{v}$

$3-0.75$ $1-0.75$ 2×0.75

$\frac{2.25}{v}$ $\frac{0.25}{v}$ $\frac{1.5}{v}$

1.5 mol $= 2\alpha$

$\alpha = 0.75$.

$$K_c = \frac{[C]^c}{[A][B]} = \frac{(1.5)^2}{2.25 \times 0.25}$$

$K_c = 4.0 = 4$ //

Que·13) $N_2 + 3H_2 \rightleftharpoons 2NH_3$

at $t=t$ 2M 3M ?

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

$K_c = 2.37 \times 10^{-3}$

$$2.37 \times 10^{-3} = \frac{[NH_3]^2}{(2)(3)^3}$$

$$\sqrt{2.37 \times 10^{-3} \times 54} = [NH_3]$$

$0.3577 = [NH_3]$

$0.358M = [NH_3]$ //

Que·14) $A + B \rightleftharpoons 2C$

0.20M 0.20M 0.60M.

$$K_c = \frac{[C]^2}{[A][B]} = \frac{(0.60)^2}{(0.20)(0.20)}$$

$K_c = \frac{0.60 \times 0.60}{0.20 \times 0.20} \Rightarrow 3 \times 3 \Rightarrow 9$.

Que·15) $H_2 + I_2 \rightleftharpoons 2HI$

$t=0$ 15 mol 5.2 mol 0 mol

$15-\alpha$ $5.2-\alpha$ 2α

$15-5$ $5.2-5$ 2×5

10 0.2 10

at eq = 10 mol $HI = 2\alpha$

$\alpha = 5$ mol.

$$K_c = \frac{[HI]^2}{[H_2][I_2]} = \frac{[10]^2}{(10)(0.2)} = \frac{100}{10 \times 0.2} = 50 = K_c$$ //

* Extension of Equilibrium :-

1) $A + B \longrightarrow C$

$\frac{1-\alpha}{v}$ $\frac{1-\alpha}{v}$ $\frac{\alpha}{v}$

$\frac{1-\alpha}{v} \cdot P$ $\frac{1-\alpha}{v} P$ $\frac{\alpha}{2-\alpha} P$.

$1 - \alpha$
$1 - \alpha$
$+ \alpha$
$2 - \alpha = v$

$$K_c = \frac{\frac{k}{v}}{\frac{1-\alpha}{v} \quad \frac{1-\alpha}{v}}$$

$$K_c = \frac{\alpha v}{(1-\alpha)^2}$$

$K_c \propto v$

$$K_p = \frac{\frac{\alpha}{2-\alpha} P}{\frac{1-\alpha}{2-\alpha} P \quad \frac{1-\alpha}{2-\alpha} P} = K_p \propto \frac{1}{P}$$

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

$$K_p = \frac{[C][C]}{[B][B]}$$

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

$$K_p = \frac{[]^2}{[]^3[]} = \frac{[]^2}{[]^4} = []^{-2} = [\text{mol } L^{-1}]^2 = \text{mol}^2 L^{-2}.$$

$$K_p = \text{mol}^{-2} L^2.$$

APP-07 $pg = 29$

Que-1) $K_c \propto$

$K_c \propto (v)^2$

$K_c \propto v^2$

Que-2) $N_2O_4 \rightleftharpoons 2NO_2$

$\frac{1-\alpha}{v}$ $\frac{2\alpha}{v}$

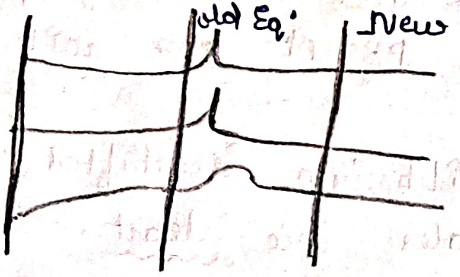
$$K_c \Rightarrow \frac{\left(\frac{2\alpha}{v}\right)^2}{\left(\frac{1-\alpha}{v}\right)} = \frac{4\alpha^2}{v^2} \times \frac{v}{1-\alpha}$$

$$\Rightarrow \frac{4\alpha^2}{(1-\alpha)v}. \qquad K_c \propto \frac{1}{v}.$$

* Le Chatelier's Principle :-

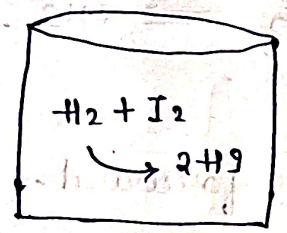
"According to this, if a system are in equilibrium then if you change the conc° pressure & temperature then the equilibrium shifted to that direction where the changes must be least & is shifted such a way so as to neglect or nullify the effect of the changes"

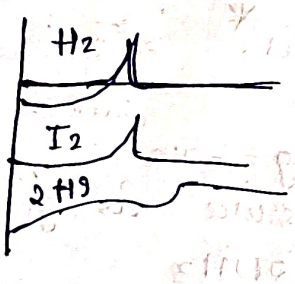
$3H_2 + N_2 \rightleftharpoons 2NH_3$.



1) Effect of Concentration.
2) Effect of Temperature
3) Effect of Pressure.
4) Mixing of Inert Gases.
5) Presence of Catalyst.

1) Effect of Concentration. :-





decrease
-11-
increases

1) If we ↑ conn of reactant Rxn goes to the forward diren.
2) If we ↓ conn of Rxn goes to the forward direction.
   └ product

Reactant ↑ → forward.
Reactant ↓ → backward

~~Reactant~~ for
Product ↓ → backward.
Product ↑ → backward.

$A + B \rightleftharpoons C + D$.

→ In an equilibrium the increases in concentration of reactant result is shifting the equilibrium in favour of product. While increasing the conn of the product result is shifted the equilibrium in the favour of the Reactant.

2) Effect of Temperature – If the temp° of the system equilibrium is increases then rexn will proceed in that direction where heat can be used thus, increase in temperature will favour the forward rxn for ENDOTHERMIC & backward rxn for EXOTHERMIC.

$A + B \longrightarrow C + D + q$ $\Delta H = -ve$

q = heat.

$q + A + B \longrightarrow C + D$ $\Delta H = +ve$

$\Delta H = -ve$	$\Delta H = +ve$
heat eliminated.	heat absorbed.
low temp → forward.	high temp → forward.
high temp → backward.	low temp → backward.

eg = Roti.

2) Effect of Pressure - When the Pressure ↑ of the system is increases the volume ↓ decreases to its proportional then the no. of moles present per unit volume increases.

Acc^{n} to Le Chatliers Equilibrium is shifted to that direction where the no. of moles are least.

When $\Delta ng = 0$, then no effect of pressure in the rxn.

Δng = only for gas* eg :- $H_2 + I_2 \rightleftharpoons 2HI$

$A_{(g)} + B_{(g)} \rightleftharpoons C_{(g)}$ $\Delta ng = -ve$

$\Delta ng = -ve$ → high pressure is good for forward.

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

In the rxn $H_2 + I_2 \rightleftharpoons 2HI$

$\Delta ng = 0$

then there is no effect of Pressure in this rxn.

$2SO_3 \rightleftharpoons 2SO_2 + O_2$

$\Delta ng = +ve$

then here, low pressure is good for forward yield. (↑ मात्रा)

** ADDING OF INERT GAS :-

1) At constant pressure -

to maintain constant pressure, the Volume After adding of inert gas volume must be increases so partial pressure of each gas decreases & the equilibrium shifted to that direction where more moles are present.

Δng = no effect

$\Delta ng \neq 0$ then the equilibrium shifted to that direction where the no. of moles are less.

ii) At Constant Volume :-

Adding of inert gase will have no effect of equilibrium so there is no change in the pressure in the system. This is because the partial pressure of the gas remains unchanged.

5) Effect of Catalyst :-(No effect on Equilibrium state)

Catalyst increases or decreases the rxn in same rate for forward & backward rxn. This is because the partial pressure of the gases. ↓ it just help to attending equilibrium state in lesser time.