MANZIL
FOR JEE ASPIRANTS

CHEMISTRY

Chemical Equilibrium

In One Shot

FAISAL RAZAQ

Topics to be covered

1. Introduction
2. Equilibrium constant
3. Factors affecting Equilibrium Constant
4. Types of chemical Equilibrium

FOR NOTES & DPP CHECK DESCRIPTION

Topics to be covered

5. Degree of dissociation
6. Le Chatelier's Principle
7. Relation between α and Vapour density.

FOR NOTES & DPP CHECK DESCRIPTION

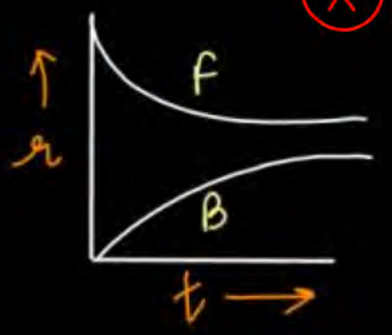
PW MANZIL IIT

TELEGRAM CHANNEL

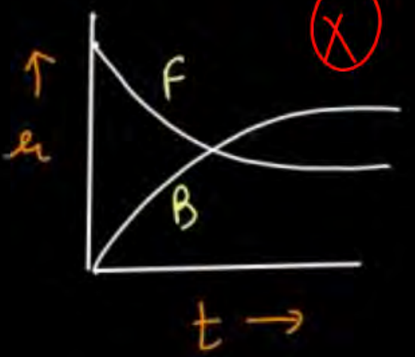
@PWJEEWALLAH

Question Which of these curves define equilibrium situation?

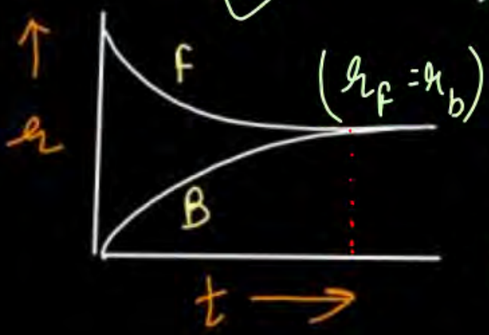
rate Vs time



(a) ✗



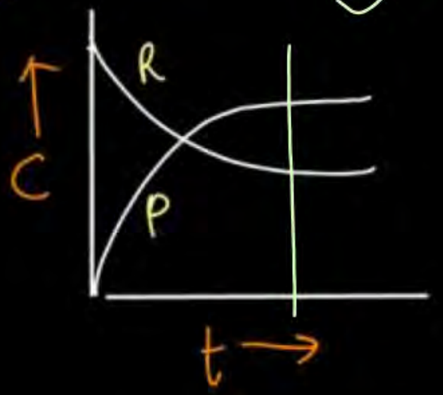
(b) ✗



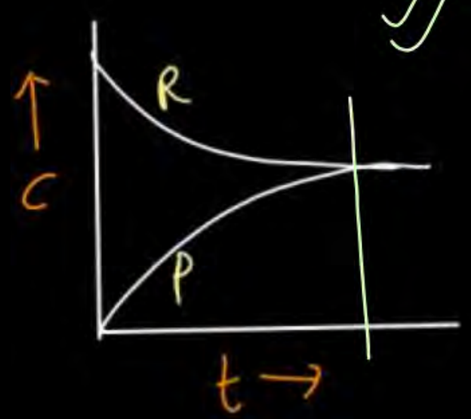
(c) ✓

r = rate
t = time
f = forward
b = backward
R = reactant
P = Product

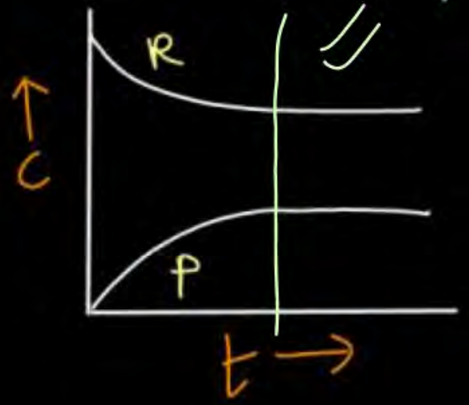
conc Vs time



(d) ✓



(e) ✓



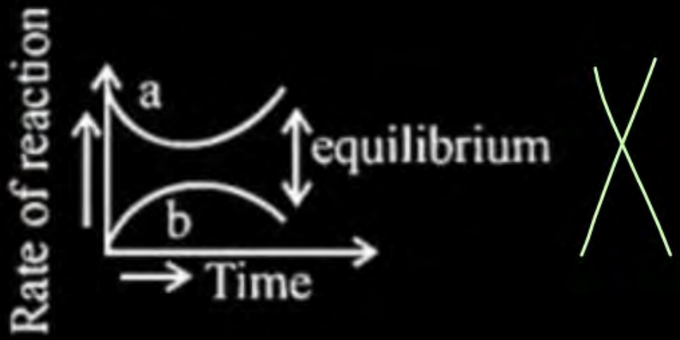
(f) ✓

(c, d, e, f)

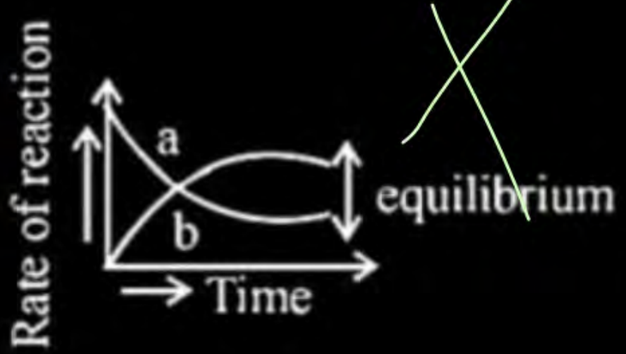
Q. **JEE Main-4sept, 2020 (shift-I)**

For the equilibrium $A \rightleftharpoons B$, the variation of the rate of the forward (a) and reverse (b) reaction with time is given by:

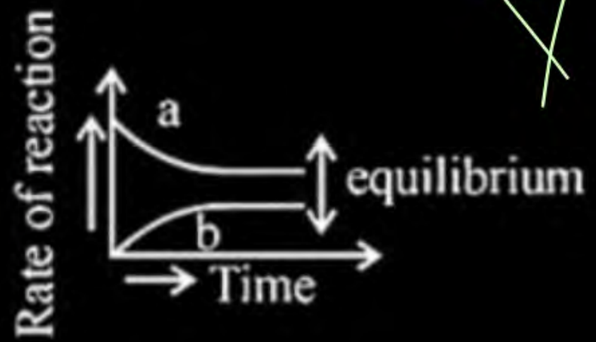
A



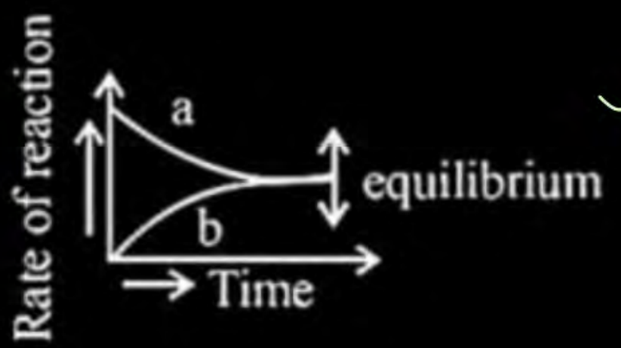
B



C



D



Important Points

* quantities of reactant and product become constant.
* Chemical equilibrium are dynamic in nature. $\rightleftharpoons$ quasi static
* Equilibrium is the most stable state of the system.
* Any disturbance caused by external agent, system tends to achieve its equilibrium state again.

Question In a reaction $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$, 4 mole of N_2 and 8 moles of H_2 are taken in 1 lt container. At eqbm $NH_{3(g)}$ has 2 moles. Make a concentration and time curve for all the species.

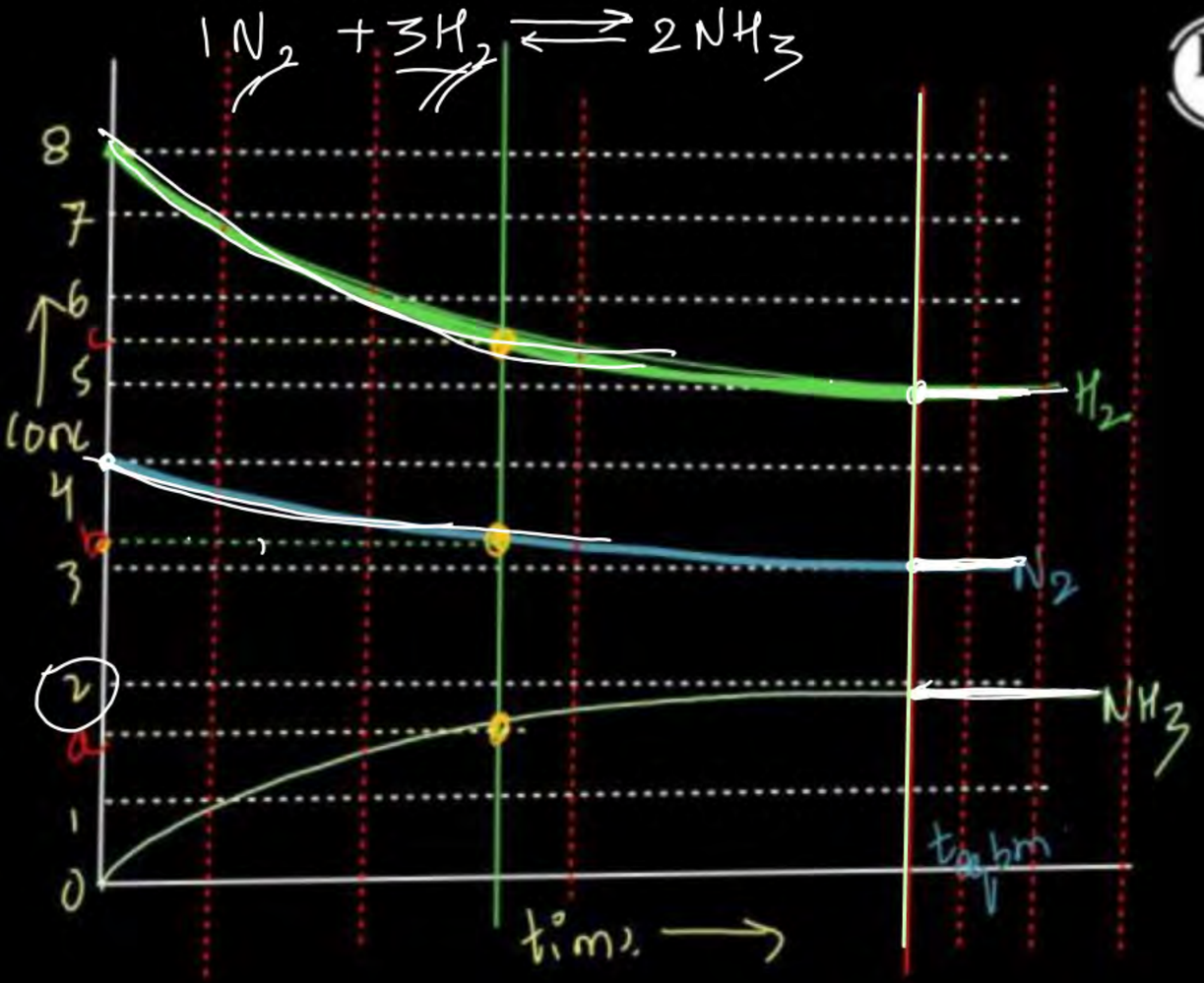
	$N_{2(g)}$	+ $3H_{2(g)}$	$\rightleftharpoons 2NH_{3(g)}$
$t=0$	4 mol	8 mol	0
$t=t^{eq}$	$4-x$	$8-3x$	$2x=2 \Rightarrow x=1$
	$4-1=3$ mol	$8-3=5$ mol	2 mol

$$\text{concentration (M)} = \frac{\text{mole}}{\text{vol.}}$$

$$[N_2]_{eq} = \frac{3}{1} = 3 \text{ mol/Lt}$$

$$[H_2]_{eq} = \frac{5}{1} = 5 \text{ mol/Lt}$$

$$[NH_3]_{eq} = \frac{2}{1} = 2 \text{ mol/Lt}$$



Question

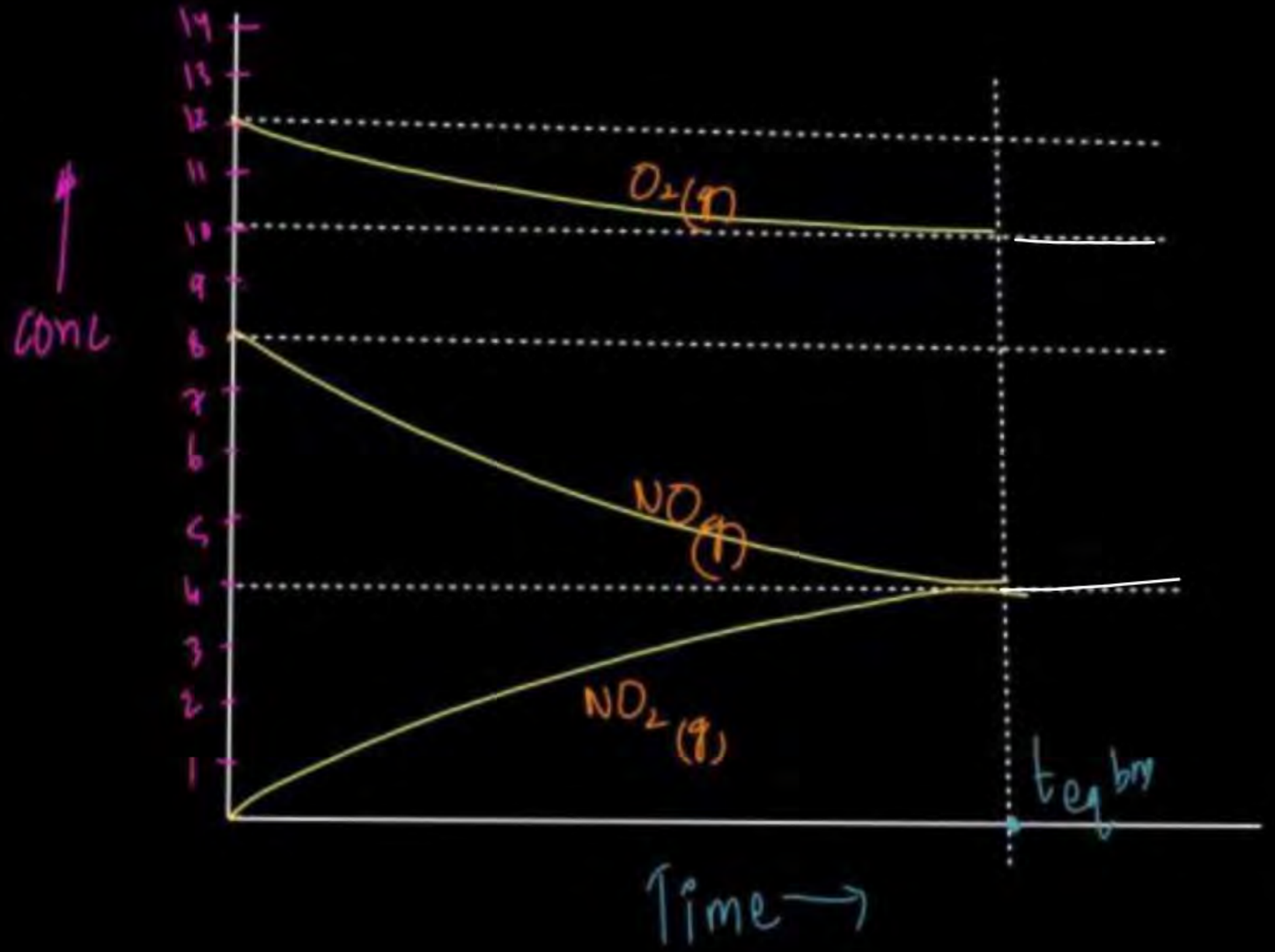
$$\underline{2}NO_{(g)} + \underline{1}O_{2(g)} \longrightarrow 2NO_{2(g)}$$

H.W.

Initially 4 mol of $NO_{(g)}$ and 6 mol of $O_{2(g)}$ are taken in 0.5 lt container. At eqbm 2 mol of $NO_{2(g)}$ is present. Plot conc Vs time curve.

$$\text{Conc} = \frac{\text{mole}}{\text{vol.}}$$

Expected

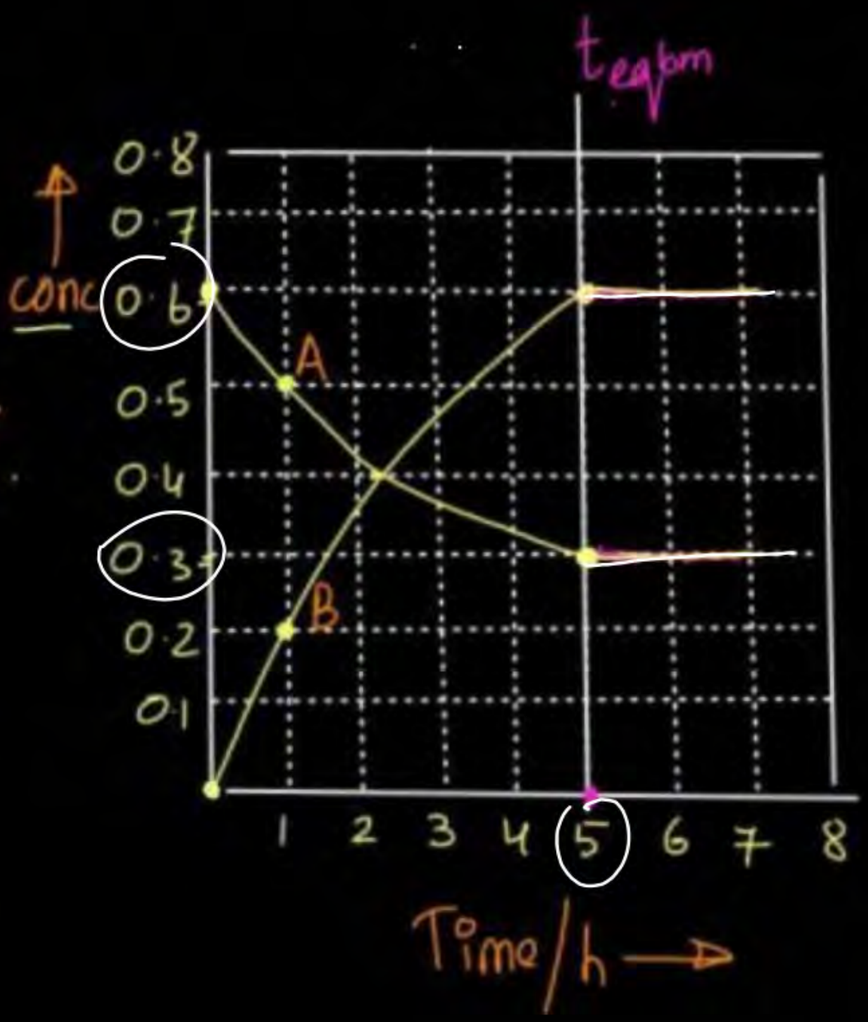


Question (JEE-Adv)

The progress of reaction

$$A \rightleftharpoons nB$$

with time is represented in fig. Determine the value of 'n'.



	$1A$	$\rightleftharpoons$	nB
$t=0$	0·6		0
$t=t_{eqbm}$	0·6−x		nx
	=		=
	0·3		0·6

$$n = 2$$

Law of Mass Action

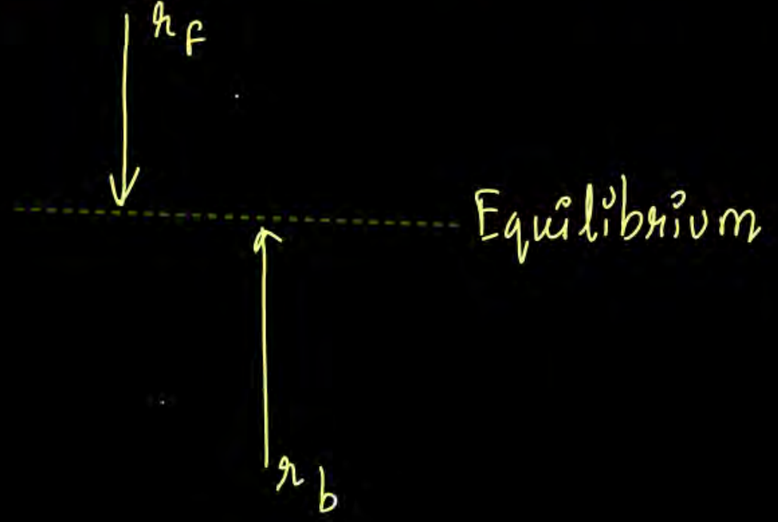
$$1A + 1B \underset{k_b}{\overset{k_f}{\rightleftharpoons}} 1C + 2D$$

(active mass)

s.c

k_f = rate const of forward

k_b = rate const of backward



$$\text{rate} \propto [\text{conc}]$$

$$(\text{rate})_{\text{forward}} \propto [A]^1 [B]^1$$

$$\boxed{(\text{rate})_{\text{forward}} = k_f [A]^1 [B]^1}$$

$$(\text{rate})_{\text{backward}} \propto [C]^1 [D]^2$$

$$\boxed{(\text{rate})_{\text{backward}} = k_b [C]^1 [D]^2}$$

At Equilibrium

$$(\text{rate})_{\text{forward}} = (\text{rate})_{\text{backward}}$$

$$k_f[A][B] = k_b[C][D]^2$$

rate const

$$\frac{k_f}{k_b} = \frac{[C][D]^2}{[A][B]} = K_{eq}$$

Question

Expected

Forward rate constant $= 2 \times 10^{-3}$

Backward rate constant $= 3 \times 10^{-2}$

Find out the equilibrium constant.

$$K_{eq} = \frac{k_f}{k_b} = \frac{2 \times 10^{-3}}{3 \times 10^{-2}} = \frac{2}{30} = \frac{1}{15}$$

Question

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

Volume = 1 lt.

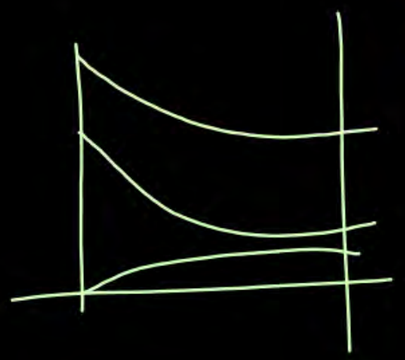
if at eqbm $n_{NH_3} = 2$ mole

then find of K_{eq}.

	N_2	H_2	NH_3
$t = 0$	4 mol	8 mol	0 mol
$t = t_{eq}$	$4 - x$	$8 - 3x$	$2x$
	3 mol	5 mol	$2x = 2 \Rightarrow x = 1$, 2 mol

$$K_{eq} = \frac{k_f}{k_b} = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{(2/1)^2}{(3/1)(5/1)^3} = \left(\frac{4}{375}\right)\left(\frac{mol}{L}\right)^{-2}$$

Question Write down the expression of equilibrium const—



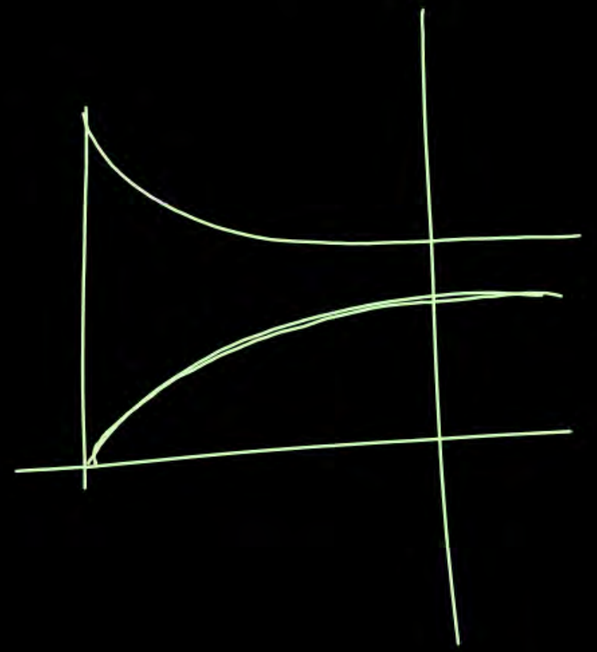
i) $2A_{(g)} + B_{(g)} \rightleftharpoons C_{(g)} + 3D_{(g)}$

$$K_{eq} = \frac{[C][D]^3}{[A]^2[B]^1} = K_C$$

$$\text{conc} = \frac{\text{mol}}{\text{vol}}$$

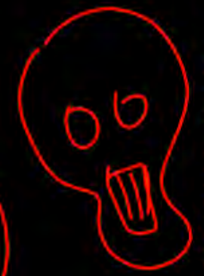
ii) $PCl_{5(g)} \rightleftharpoons {}^{1}PCl_{3(g)} + {}^{1}Cl_{2(g)}$

$$K_{eq} = \frac{[PCl_3][Cl_2]}{[PCl_5]} = K_C$$



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

$$K_C = \frac{[B][C]^2[D]}{[A]}$$



$$K_C = [B][C]^2$$

K_C ke expression mein $\Rightarrow$ gas, soln.

Let initially $W_A = W$ g

$$\text{conc} = \frac{\text{mol}}{\text{vol}} = \frac{\frac{W}{M}}{\frac{W}{d}} = \frac{d}{M}$$

at Eqbm $W_A = \frac{W}{10}$ g

$$\text{conc} = \frac{\text{mol}}{\text{vol}} = \frac{\left(\frac{W}{10}\right)/M}{\left(\frac{W}{10}\right)/d} = \frac{d}{M}$$

Write down the expression for K_c –

1) $NH_2COONH_4(s) \rightleftharpoons 2NH_3(g) + CO_2(g)$

$$K_c = [NH_3]^2[CO_2]$$

2) $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$

$$K_c = [CO_2]$$

3) $A(g) + B(g) + C(soln) \rightleftharpoons D(s) + E(g) + F(soln)$

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

$1A_{(g)} + 1B_{(g)} \rightleftharpoons 2C_{(g)} + 1D_{(g)}$

2 mol. 3 mol.

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

$$K_c = \frac{\left(P_C/RT\right)^2\left(P_D/RT\right)}{\left(P_A/RT\right)\left(P_B/RT\right)} = \frac{P_C^2 \cdot P_D}{P_A \cdot P_B} \cdot \left(\frac{1}{RT}\right)^1$$

$$K_p = K_c(RT) = \frac{P_C^2 \cdot P_D}{P_A \cdot P_B}$$

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

$$PV = nRT$$

$$\text{conc} = \frac{\text{mol}}{\text{vol}} = \frac{n}{V} = \frac{P}{RT}$$

$$2A_{(g)} + 1B_{(g)} \rightleftharpoons 1C_{(g)} \qquad \Delta n_g = 1 - 3 = -2$$

$$K_C = \frac{[C]}{[A]^2[B]} = \frac{\left(P_C/RT\right)}{\left(\frac{P_A}{RT}\right)^2\left(\frac{P_B}{RT}\right)} = \frac{P_C}{P_A^2 \cdot P_B}(RT)^2$$

$$\boxed{K_p = \frac{K_C}{(RT)^2} = \frac{P_C}{P_A^2 \cdot P_B}}$$

$$\boxed{K_p = K_C(RT)^{-2}}$$

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

Δn_g = gaseous moles of Products − gaseous moles of reactants

$$A_{(g)} + B_{(g)} \rightleftharpoons C_{(g)}$$

$$K_c = \frac{[C]}{[A][B]} \quad ; \quad K_p = \frac{P_C}{P_A \cdot P_B}$$

$$K_p = K_c (RT)^{-1}$$

Question For which of these eqbm $K_p = K_c(RT)^{-1}$?

$\Delta n_g = -1$

× i) $A_{(soln)} + 2B_{(g)} \rightleftharpoons C_{(soln)} + 2D_{(g)}$ $\Delta n_g = 0$

ii) $A_{(g)} + B_{(g)} + 1C_{(g)} \rightleftharpoons 2D_{(g)}$ $\Delta n_g = -1$

iii) $1A_{(g)} + B_{(s)} + 1C_{(g)} \rightleftharpoons D_{(s)} + 1E_{(g)}$ $\Delta n_g = -1$

× iv) $A_{(s)} + B_{(soln)} + 2C_{(g)} \rightleftharpoons 1D_{(g)} + E_{(soln)}$ $\Delta n_g = -1$

K_p is not defined.

iv) ~~A~~ $_{x\,(s)}$ + B $_{(soln)}$ + 2C $_{(g)}$ $\rightleftharpoons$ D $_{(g)}$ + E $_{(soln)}$

$$K_c = \frac{[D][E]}{[B][C]^2} = \frac{\left(\frac{P_D}{RT}\right)[E]}{[B]\left(\frac{P_C}{RT}\right)^2} = \frac{P_D \cdot [E]}{P_C^2\,[B]}(RT)$$

$$K_{pc} = \frac{K_c}{RT} = \frac{P_D \cdot [E]}{P_C^2\,[B]} \neq K_p$$

(Pmost, conc)

* We can not define the K_p for this eqbm.

K.Bo for the defined eqbm constant (K_p)

* There should not be any solution phase.

* There should be atleast one gaseous phase.

Q. [JEE-MAINS-14]

For the reaction $SO_{2(g)} + \frac{1}{2}O_{2(g)} \rightleftharpoons SO_{3(g)}$, if $K_p = K_c (RT)^x$ where the symbols have usual meaning then the value of x is : (assuming ideality)

Δn_g

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

A 1/2

B 1

C –1

D –1/2

Ans: D

Question

$\text{Log}\frac{K_p}{K_c} + \log RT = 0$ is true relationship for the following reaction :

A $PCl_5 \rightleftharpoons PCl_3 + Cl_2$

B $2SO_2 + O_2 \rightleftharpoons 2SO_3$

C $N_2 + 3H_2 \rightleftharpoons 2NH_3$

D (B) and (C) both

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

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

$$K_p = K_c(RT)^{-1}$$

Ans: B

Question For which of the reaction $\log K_p = \log K_c - 2\log RT$ is valid ?

(A) $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

(B) $PCl_{3(g)} + Cl_{2(g)} \rightleftharpoons PCl_{5(g)}$

(C) $2HI_{(g)} \rightleftharpoons H_{2(g)} + I_{2(g)}$

(D) $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$

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

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

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

$\Delta n_g = -2$

Unit of K_c and K_p

$\Delta n_g = -1$

$$1A_{(g)} + 1B_{(g)} \rightleftharpoons 1C_{(g)}$$

$$K_c = \frac{[C]}{[A][B]} = \frac{\left(\frac{mol}{L}\right)^1}{\left(\frac{mol}{L}\right)^1\left(\frac{mol}{L}\right)^1} = \left(\frac{mol}{L}\right)^{-1}$$

$$K_c = \left(\frac{mol}{L}\right)^{\Delta n_g}$$

$$K_c = [Conc_n]^{\Delta n_g}$$

Question

K.B.O

For which of these following equilibria unit of $K_c = \left(\frac{mol}{L}\right)^2$?

$\left(\frac{mol}{L}\right)^2 \Rightarrow \Delta n_g = 2$

(A) $1A_{(g)} + 1B_{(g)} \rightleftharpoons 1C_{(g)}$

(B) $1A_{(g)} \rightleftharpoons 1B_{(g)} + 2C_{(g)}$ ⟶ $\Delta n_g = 2$

(C) $A_{soln.} + B_{soln} \rightleftharpoons 4C_{(soln)}$ ⟶ $K_c = \frac{[C]^4}{[A][B]}$

$K_c = \frac{\left(\frac{mol}{L}\right)^4}{\left(\frac{mol}{L}\right)\left(\frac{mol}{L}\right)} = \left(\frac{mol}{L}\right)^2$

(D) $1A_{(g)} + B_{(s)} \rightleftharpoons 3C_{(g)} + D_{(s)}$ ⟶ $\Delta n_g = 2$

Q/ $\cancel{A_{(s)}} + 1B_{(g)} + 1C_{(g)} \rightleftharpoons \cancel{D_{(s)}} + 1E_{(g)}$

Unit of K_c ?

Unit of $K_c = (\text{conc})^{\Delta n} = \left(\frac{\text{mol}}{\text{L}}\right)^{1-2} = \left(\frac{\text{mol}}{\text{L}}\right)^{-1}$

Q/ $A_{(soln)} + 2B_{(g)} \rightleftharpoons 2C_{(soln)} + 2D_{(g)}$

Unit of K_c ?

Unit of $K_c = \left(\frac{mol}{L}\right)^{\Delta ng}$

$= \left(\frac{mol}{L}\right)^{0}$

~~X~~

Unit of $K_c = \left(\frac{mol}{L}\right)^{\Delta n}$

$= \left(\frac{mol}{L}\right)^{4-3} = \left(\frac{mol}{L}\right)^{1}$

Unit of $K_c = [\text{conc}]^{\Delta n_g} = \left(\frac{\text{mol}}{L}\right)^{\Delta n_g}$

Unit of $K_c = \left(\frac{\text{mol}}{L}\right)^{\Delta n}$

Unit of K_p

$$\text{unit of } K_p = (\text{bar})^{\Delta n_g} \text{ or } (\text{atm})^{\Delta n_g}$$

Question For which of these following equilibria the unit of $K_p = (\text{bar})^{-1}$?

$\Delta n_g = -1$

A) $1A_{(g)} + 1B_{(g)} \rightleftharpoons 1C_{(g)}$ $\quad \Delta n_g = -1$

B) $A_{(g)} \rightleftharpoons 2B_{(g)}$ $\quad \Delta n_g = 1$

C) $1A_{(soln)} + 1B_{(soln)} \rightleftharpoons 1C_{(soln)}$

D) $1A_{(g)} + 2B_{g} + C_{(s)} \rightleftharpoons D_{(s)} + 2E_{(g)}$ $\quad \Delta n_g = -1$

K.b.o

Unit of K_c = $(\text{conc})^{\Delta n}$

(Δn = difference of moles of products and reactants of those species which are present in the expression of K_c)

Unit of K_p = $(\text{bar})^{\Delta n_g}$ or $(\text{atm})^{\Delta n_g}$

Q. **JEE Main-31 Jan, 2023 (shift-I)**

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

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

$K_p = 2 \times 10^{12}$ at 27°C and 1 atm pressure. The K_C for the same reaction is _____ $\times 10^{13}$. (Nearest integer)

(Given R = 0.082 L atm K^{-1} mol^{-1})

$$K_C = \frac{K_p}{(RT)^{-1}} = \frac{2 \times 10^{12}}{(0.0821 \times 300)^{-1}}$$

factors affecting Equilibrium constant

i) Stoichiometry of the reaction

$$A \rightleftharpoons B \; ; \; K_1$$

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

$$2A \rightleftharpoons 2B \; ; \; K_2$$

$$K_2 = \left[\frac{[B]}{[A]}\right]^2 = K_1^{\,2}$$

$$K_{new} = (K_{old})^{\text{multiplying factor}}$$

Question

$$N_2 + 3H_2 \rightleftharpoons 2NH_3 \quad ; K_c = 25 \times 10^{-4}$$

$$\frac{1}{2}N_2 + \frac{3}{2}H_2 \rightleftharpoons NH_3 \quad ; K_c' = ?$$

multiplying factor $= \frac{1}{2}$

$$K_c' = (K_c)^{\frac{1}{2}} = (25 \times 10^{-4})^{\frac{1}{2}} = 5 \times 10^{-2}$$

K_{new} $(K_{old})^{1/2}$

ii) Mode of writing the chemical equilibrium

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

$B \rightleftharpoons A$; K_2 $\qquad K_2 = \frac{[A]}{[B]}$

$$K_2 = \frac{1}{K_1}$$

Question

The value of equilibrium constant of the reaction

$HI(g) \rightleftharpoons \frac{1}{2}H_2(g) + \frac{1}{2}I_2(g)$ is 8.0

The equilibrium constant of the reaction

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ will be

$(8.0)^2 \longrightarrow \frac{1}{(8.0)^2} = \frac{1}{64}$

A 1/16

B 1/64

C 16

D 1/8

Ans: B

Question

At 298 K the equilibrium constant is 2×10^{15} for the reaction:

$$Cu_{(s)} + 2Ag^{+}_{(aq)} \rightleftharpoons Cu^{2+}_{(aq)} + 2Ag_{(s)} \quad \rightarrow 2\times10^{15}$$

The equilibrium constant for the reaction

$$\frac{1}{2}Cu^{+2}_{(aq)} + Ag_{(s)} \rightleftharpoons \frac{1}{2}Cu_{(s)} + Ag^{+}_{(aq)}$$

is $X\times10^{-8}$

the value of 'X' is 2 (nearest integer) [July 2022]

(i) उल्टा करो

$$K = \frac{1}{2\times10^{15}} = 5\times10^{-16}$$

* now multiply it by $\frac{1}{2}$

$$K' = \left(5\times10^{-16}\right)^{1/2} = \sqrt{5}\times10^{-8}$$

$\sqrt{5}$

Q. [JEE-MAINS(online)-12]

K_1, K_2 and K_3 are the equilibrium constants of the following reactions (I), (II) and (III), respectively

(I) $N_2 + 2O_2 \rightleftharpoons 2NO_2$ (II) $2NO_2 \rightleftharpoons N_2 + 2O_2$

(III) $NO_2 \rightleftharpoons \frac{1}{2}N_2 + O_2$

The correct relation from the following is :

A $K_1 = \sqrt{K_2} = K_3$

B $K_1 = \frac{1}{K_2} = \frac{1}{K_3}$

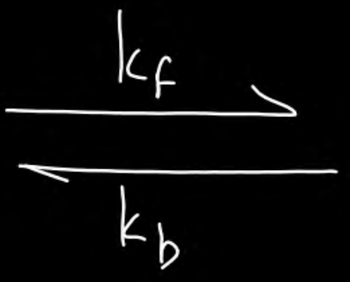
C $K_1 = \frac{1}{K_2} = K_3$

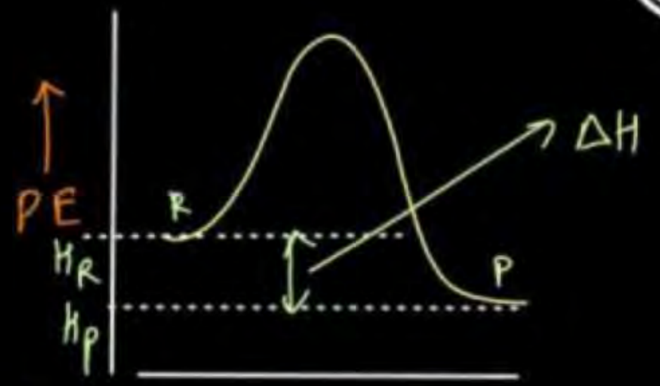
D $K_1 = \frac{1}{K_2} = \frac{1}{(K_3)^2}$

Ans: D

Temperature

$$K_{eq} = \frac{k_f}{k_b}$$





Since rate constant (k) depends on temperature that's why equilibrium constant (K) depends on temperature.

$$T_1 \longrightarrow K_{T_1} \; ; \; T_2 \longrightarrow K_{T_2} \quad (*)$$

$$\ln \frac{K_{T_2}}{K_{T_1}} = \frac{\Delta H}{R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

$$2.303 \log \frac{K_{T_2}}{K_{T_1}} = \frac{\Delta H}{R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

$$\log \frac{K_{T_2}}{K_{T_1}} = \frac{\Delta H}{2.303R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

$$\log \frac{K_{T_2}}{K_{T_1}} = \frac{\Delta H}{2.303R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

$$\log \frac{K_{T_2}}{K_{T_1}} = \frac{\Delta H}{2.303R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

i) Endothermic Rxn $\Delta H = (+)ve$; Temp increase $(T_2 > T_1)$.

$$\log \frac{K_{T_2}}{K_{T_1}} > 0$$

$$K_{T_2} > K_{T_1}$$

$(\log x > 0 \Rightarrow x > 1)$

ii) Endothermic Rxn $\Delta H > 0$; Temp decrease $(T_2 < T_1)$

$$\log \frac{K_{T_2}}{K_{T_1}} < 0$$

$$K_{T_2} < K_{T_1}$$

$$\log \frac{K_{T_2}}{K_{T_1}} = \frac{\Delta H}{2.303 R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

iii) Exothermic Rx^n $\Delta H < 0$; Temperature increase $T_2 > T_1$

$$\log \frac{K_{T_2}}{K_{T_1}} < 0$$

$$\boxed{K_{T_2} < K_{T_1}}$$

iv) Exothermic Rx^n $\Delta H < 0$ Temperature decrease $T_2 < T_1$

$$\log \frac{K_{T_2}}{K_{T_1}} > 0$$

$$\boxed{K_{T_2} > K_{T_1}}$$

endo T ↑ K ↑

endo T ↓ K ↓

exo T ↑ K ↓

exo T ↓ K ↑

K exponentially depends on temp.

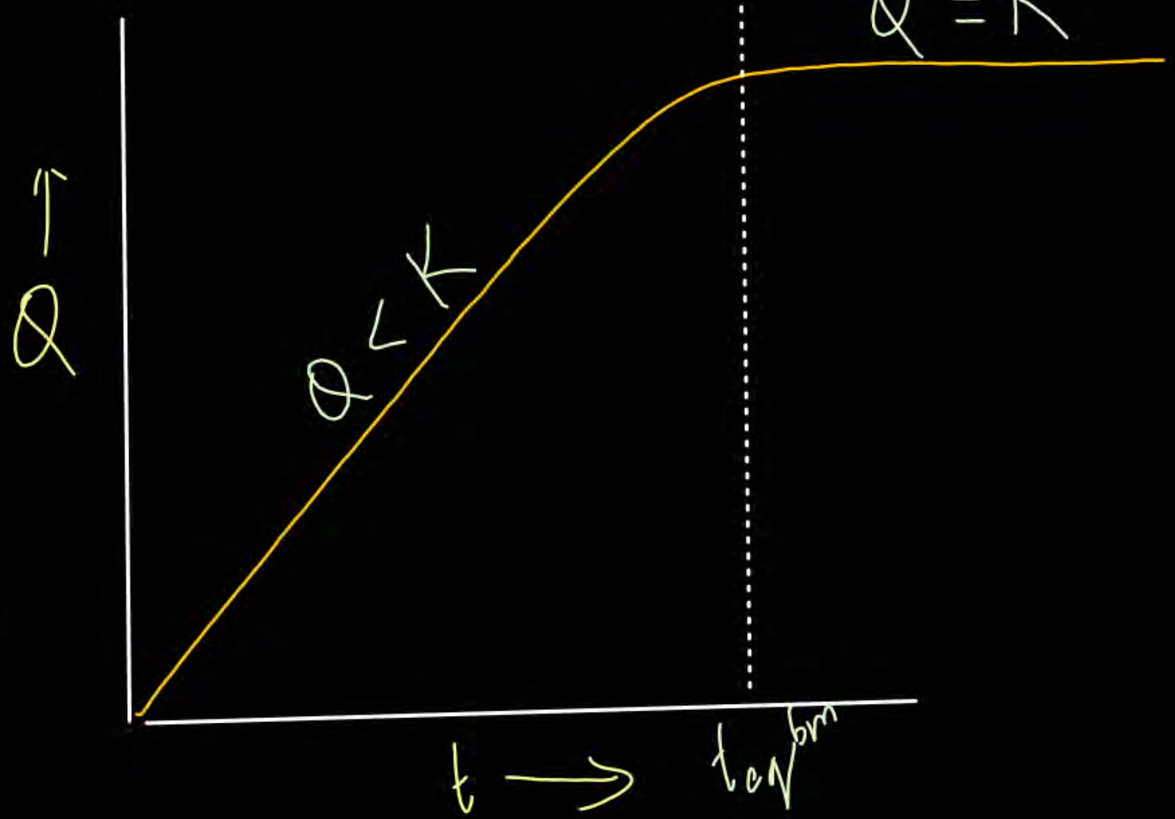
अगर K बढ़ा, बहुत बढ़ा !!

अगर K घटा, बहुत घटा !!

Reaction Quotient (Q)

$A_{(g)} + B_{(g)} \rightleftharpoons C_{(g)}$ (initially only A and B are present)

at $t = 0$ $\frac{[C]}{[A][B]} = 0$ → reaction quotient Q



Question

For the reaction $NOBr\,(g) \rightleftharpoons NO\,(g) + \frac{1}{2}Br_2\,(g)$, $K_p = 0.15\ atm^{1/2}$ at 90°C. If NOBr, NO and Br_2 are mixed at this temperature having partial pressure 0.5 atm, 0.4 atm & 2.0 respectively, will Br_2 be consumed or formed?

$P_{NOBr} = 0.5$ atm

$P_{NO} = 0.4$ atm

$P_{Br_2} = 2.0$ atm

$$Q = \frac{P_{NO} \cdot P_{Br_2}^{1/2}}{P_{NOBr}} = \frac{(0.4)\sqrt{2}}{0.5} > 0.15$$

Consumed

$Q > K$

reaction goes backward.

Question In a reaction $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$ concentration of SO_2, O_2 and SO_3 are 2 M, 2 M and 2 M respectively. find the direction of reaction if K_c of this reaction at this temperature is 4.

Homogeneous Equilibrium

all the species in the reaction are in same phase.

Case - 1 (Only reactants are present)

$$1A_{(g)} + 1B_{(g)} \rightleftharpoons C_{(g)} + D_{(g)} \quad ; K_c = 4$$

	$1A_{(g)}$	$1B_{(g)}$	$C_{(g)}$	$D_{(g)}$	
$t=0$	1 mol	1 mol	0	0	volume = 1 Lt
$t=t_{eq}$	$1-x$	$1-x$	x	x	

$$K_c = \frac{[C][D]}{[A][B]} = \frac{\left(\frac{x}{1}\right)\left(\frac{x}{1}\right)}{\left(\frac{1-x}{1}\right)\left(\frac{1-x}{1}\right)} = 4 \Rightarrow \frac{x}{1-x} = 2$$

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

Q. **JEE Main-27 June, 2022 (shift-I)**

$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$

In an experiment, 2.0 mole of NOCl was placed in a one-litre flask and the concentration of NO after equilibrium established, was found to be 0.4 mol/L. The equilibrium constant at 30°C is 125 $\times 10^{-4}$.

125

$2x = 0.4$

$x = 0.2$

$$K_c = \frac{[NO]^2[Cl_2]}{[NOCl]^2}$$

$$= \frac{(0.4)^2/0.2)}{(1.6)^2} = \frac{0.032}{(1.6)^2}$$

$2NOCl_{(g)} \rightleftharpoons 2NO_{(g)} + Cl_{2(g)}$

$t=0$	2	0	0
$t=t_{eq}$	$2-2x$	$2x$	x

$$[NO] = \frac{\text{moles of NO}}{\text{Vol.}} = \frac{2x}{1} = 2x \text{ mol/L}$$

Q. **JEE Main-11 April, 2023 (shift-II)**

4.5 moles each of hydrogen and iodine is heated in a sealed ten litre vessel. At equilibrium, 3 moles of HI were found. The equilibrium constant for

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$ is .....

4.5	4.5	0
4.5 - x	4.5 - x	2x = 3

$x = 1.5$

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

$$= \frac{\left(\frac{3}{10}\right)^2}{\left(\frac{3}{10}\right)\left(\frac{3}{10}\right)} = 1$$

Question

In a study of the gaseous reaction.

$$A(g) + 2B(g) \rightleftharpoons 2C(g) + D(g),$$

A and B are mixed in a reaction vessel kept at 25°C. The initial concentration of B is 1.5 times the initial concentration of A. After the equilibrium has been established, the equilibrium concentrations of A and D were equal. Calculate the equilibrium constant at 25°C.

Case-2 Reactants and Products both are present

$K_c = 4$

Vol = 1 lt

$A_g + B_g \rightleftharpoons C_g + D_g$

	A_g	B_g	C_g	D_g
$t=0$	1 mol	1 mol	1 mol	1 mol
	$1-x$	$1-x$	$1+x$	$1+x$

$$K_c = 4 = \frac{\left(\frac{1+x}{1}\right)\left(\frac{1+x}{1}\right)}{\left(\frac{1-x}{1}\right)\left(\frac{1-x}{1}\right)} \Rightarrow \frac{1+x}{1-x} = 2$$

$1+x = 2-2x$

$x = \frac{1}{3}$

$$Q = \frac{[C][D]}{[A][B]} = \frac{\left(\frac{1}{1}\right)\left(\frac{1}{1}\right)}{\left(\frac{1}{1}\right)\left(\frac{1}{1}\right)} = 1$$

$Q < K$

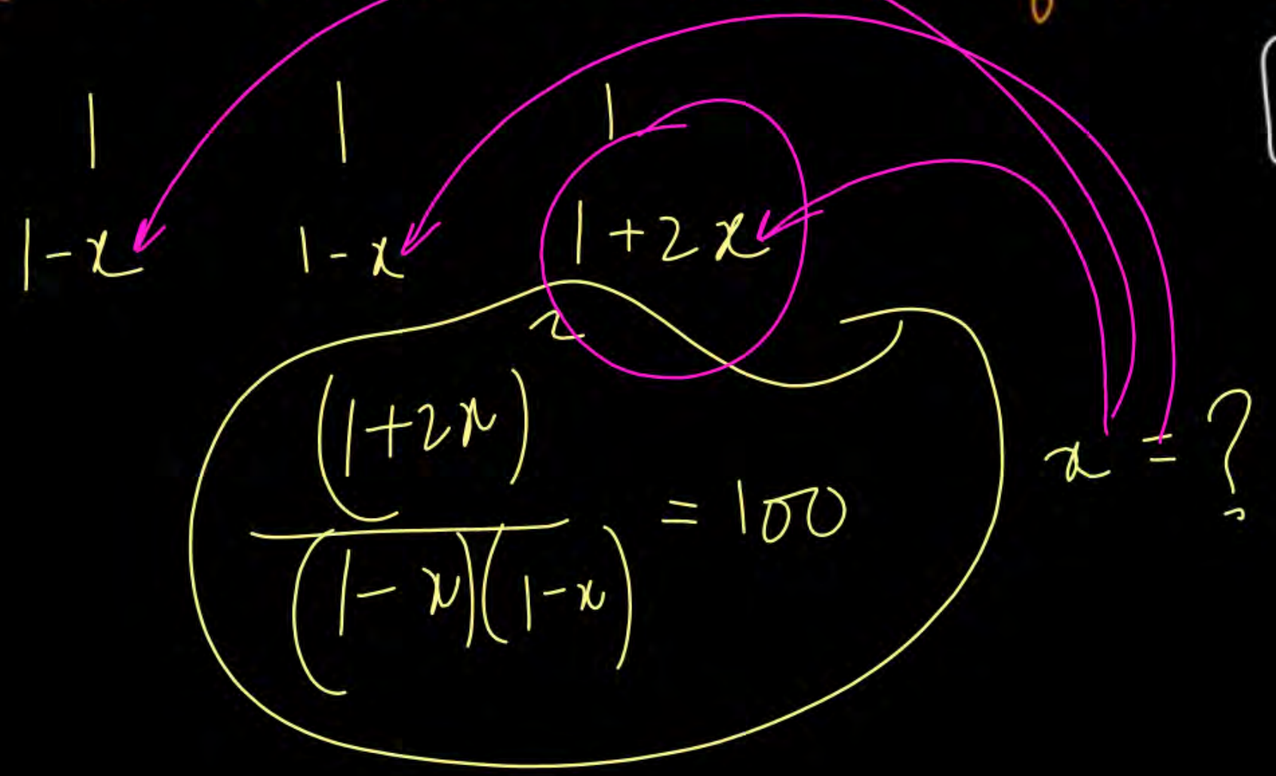
Q. **JEE Main-26 Aug, 2021 (shift-II)**

The equilibrium constant K_c at 298 K for the reaction $A + B \rightleftharpoons C + D$ is 100. Starting with an equimolar to 1 M, the equilibrium concentration of D is _____ $\times 10^{-2}$ M. (Nearest integer)

Question

$A + B \rightleftharpoons 2C$; $K_c = 100$ at 298 K. If Initial concentrations of all three species are 1M each then equilibrium concentration of C is $X \times 10^{-1}$ M. The value of 'X' is ___ .

[July 2021]



Case - 3 (when we disturbing the existing equilibrium)

Question

PCl_5 dissociates according to the following reaction

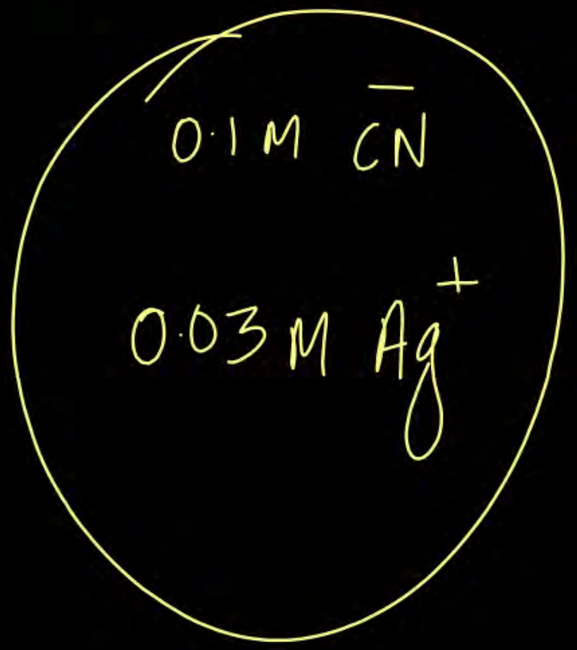
$$PCl_5 \rightleftharpoons PCl_3 + Cl_2$$

At equilibrium all the species have two moles each. Find the moles of Cl_2 added at the equilibrium so that at new equilibrium at constant temperature and pressure volume of the container is doubled.

Case-4 When there is a case of complex formation

for the reaction $Ag(CN)_2^-_{(aq)} \rightleftharpoons Ag^+_{(aq)} + 2CN^-_{(aq)}$

K_c is 4×10^{-19} at 25°C. Calculate $[Ag^+]$ in the solution which was 0.1 M in KCN and 0.03 M in $AgNO_3$ originally.



$$Ag^+ + 2CN^- \rightleftharpoons [Ag(CN)_2]^- \qquad K = \frac{1 \times 10^{19}}{4}$$

	0.03	0.1	0
	0.03 − x	0.1 − 2x	x

x

x

$$K_c = \frac{1}{4} \times 10^{19} = \frac{(0.03 - x)}{(0.1 - 2x)^2}$$

$$\frac{1}{4} \times 10^{19} = \frac{0.03}{y\,(0.1-0.06)^2}$$

$$\frac{1}{4} \times 10^{19} = \frac{0.03}{y\,(0.04)^2}$$

$$y = 7.5 \times 10^{-18}\ M = [Ag^+]$$

↓

Zero Jaisa not zero.

Q. **JEE Main-27 July, 2021 (shift-I)**

The number of moles of NH_3, that must be added to 2L of 0.80 M $AgNO_3$ in order to reduce the concentration of Ag^+ ions to 5.0×10^{-8} M ($K_{formation}$ for $[Ag(NH_3)_2]^+ = 1.0 \times 10^8$) is _____. (Nearest integer)
[Assume no volume change on adding NH_3]

$$Ag^+ + 2NH_3 \rightleftharpoons [Ag(NH_3)_2]^+$$

4 mol

DEGREE OF DISSOCIATION

$$PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$$

$$\text{degree of diss } (\alpha) = \frac{\text{moles dissociated at eq}^{bm}}{\text{Initial moles}} < 1$$

moles of reactant dissociated from its one mole is called dod (α).

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

	PCl_5	PCl_3	Cl_2
$t=0$	a	0	0
	$a-x$	x	x
$t=t_{eq}$	$a-a\alpha$	$a\alpha$	$a\alpha$

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

$$= \frac{\left(\frac{x}{V}\right)\left(\frac{x}{V}\right)}{\left(\frac{a-x}{V}\right)} = \frac{x^2}{a-x}\left(\frac{1}{V}\right)$$

$x = x_0$

Question If 5 moles of SO_3 is dissociated according to the reaction and 3 moles are left at eqbm

$$2SO_{3(g)} \rightleftharpoons 2SO_{2(g)} + O_{2(g)}$$

find the degree of dissociation

$$(dod)_{SO_3} = \frac{\text{moles diss at eq}^{bm}}{\text{initial moles}} = \frac{2}{5} = 0.4$$

Expected Relation b/w α, K_p and P_T

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

	$PCl_5(g)$	$PCl_3(g)$	$Cl_2(g)$
$t=0$	a	0	0
$t=t^{eq}$	$a(1-\alpha)$	$a\alpha$	$a\alpha$

$\Rightarrow a\alpha + a\alpha + a(1-\alpha) = a(1+\alpha)$

$$P \cdot P = \chi \cdot P_T$$

$$K_p = \frac{P_{PCl_3} \cdot P_{Cl_2}}{P_{PCl_5}} = \frac{(\chi_{PCl_3} \cdot P_T)(\chi_{Cl_2} \cdot P_T)}{(\chi_{PCl_5} \cdot P_T)} = \frac{\left[\frac{a\alpha}{a(1+\alpha)} \cdot P_T\right]\left[\frac{a\alpha}{a(1+\alpha)} \cdot P_T\right]}{\left[\frac{a(1-\alpha)}{a(1+\alpha)} \cdot P_T\right]}$$

$$K_p = \frac{\alpha^2}{1-\alpha^2} \cdot P_T$$

$$N_2O_4\,(g) \rightleftharpoons 2NO_2\,(g)$$

$$K_p = \frac{4\alpha^2}{1-\alpha^2} \cdot P_T$$

$1A_{(g)} \rightleftharpoons 1B_{(g)} + 1C_{(g)}$

$$K_p = \frac{\alpha^2 \cdot P_T}{1-\alpha^2}$$

$A_{(g)} \rightleftharpoons 2B_{(g)}$

$$K_p = \frac{4\alpha^2 \cdot P_T}{1-\alpha^2}$$

Question

At some temperature and under a pressure of 4 atm, PCl_5 is 10% dissociated. Calculate the pressure at which PCl_5 will be 20% dissociated, temperature remaining same.

Q. 06 April, 2023 (Shift-I)

For a solution of a weak electrolyte (Keq = equilibrium constant) A_2B_3 of concentration 'c', the degree of dissociation 'α' is

A

A $\left(\frac{K_{eq}}{108c^4}\right)^{\frac{1}{5}}$

B $\left(\frac{K_{eq}}{6c^5}\right)^{\frac{1}{5}}$

C $\left(\frac{K_{eq}}{5c^4}\right)^{\frac{1}{5}}$

D $\left(\frac{K_{eq}}{25c^2}\right)^{\frac{1}{5}}$

Weak electrolyte ($\alpha << 1$)

A_2B_3	$\rightleftharpoons$	$2A$	$+$	$3B$
C		0		0
$C(1-\alpha)$		$2C\alpha$		$3C\alpha$

$$K_{eq} = \frac{[A]^2[B]^3}{C(1-\alpha)} = \frac{(2C\alpha)^2(3C\alpha)^3}{C} \qquad (\alpha << 1)$$

$$K_{eq} = 2^2 3^3 C^4 \alpha^5$$

$$\alpha = \left[\frac{K_{eq}}{108C^4}\right]^{1/5}$$

Question

At temperature T, a compound $AB_2(g)$ dissociates according to the reaction $2AB_2(g) \rightleftharpoons 2AB(g) + B_2(g)$ with degree of dissociation α, which is small as compared to unity. The expression for K_p, in terms of α and the total pressure, P_T is

(A) $\frac{P_T\alpha^3}{2}$ (B) $\frac{P_T\alpha^2}{3}$ (C) $\frac{P_T\alpha^3}{3}$ (D) $\frac{P_T\alpha^2}{2}$

Q. **JEE Main-29 June, 2022 (shift-II)**

4.0 moles of argon and 5.0 moles of PCl_5 are introduced into an evacuated flask of 100 litre capacity at 610 K. The system is allowed to equilibrate. At equilibrium, the total pressure of mixture was found to be 6.0 atm. The K_P for the reaction is
[Given R = 0.082 L atm K^{-1} mol^{-1}]

A

A 2.25

B 6.24

C 12.13

D 15.24

Heterogeneous Equilibrium

All the species are not in same phase.

Generally dissociation of a solid is heterogeneous.

$$A_{(s)} \rightleftharpoons \text{gas} + \text{---}$$

Q. **JEE Main-27 July, 2021**

The equilibrium constant for the reaction

$A(x) \rightleftharpoons M(s) + \frac{1}{2} O_2(g)$

is $K_p = 4$. At equilibrium, the partial pressure of O_2 is 16 atm. (Round off to the nearest integer)

$$K_p = P_{O_2}^{\frac{1}{2}} = 4$$

$$P_{O_2} = 16 \text{ atm}$$

Question

A vessel at 1000K contains CO_2 with pressure of 0.5 atm. Some of the CO_2 is converted into CO on the addition of graphite. If the total pressure at equilibrium is 0.8 atm , the value of K_p is

A 1.8 atm

B 3 atm

C 0.18 atm

D 0.3 atm

$K_p = P_{CO}^2 / P_{CO_2} = \frac{(0.6)^2}{0.2} = \frac{0.36}{0.2} = 1.8$

A

$CO_2(g) + C(s) \rightleftharpoons 2CO(g)$

0.5	a	0
0.5 − x	a + x	2x

Total Press at Eq = 0.5 − x + 2x = 0.8

x = 0.3 atm

Question (expected)

Solid ammonium carbamate dissociates according to the reaction.

$$NH_2COONH_4(s) \rightleftharpoons \underset{2p}{2NH_3(g)} + \underset{p}{1CO_2(g)} \; ; K_p = 32$$

Find the total pressure at equilibrium.

$$K_p = P_{NH_3}^2 \cdot P_{CO_2} = 32$$

$$\Rightarrow (2p)^2 (p) = 32$$

$$p = 2 \text{ atm}$$

Total Eq^{bm} Pressure $= P_{NH_3} + P_{CO_2}$

$= 2p + p$

$= 3p$

$= 3(2)$

$= 6$ atm.

Question $CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$; $K_p = 1.2$ atm

Find out the minimum amount of $CaCO_3$ taken to form this eqbm at 500K and in 2 lt container.

Question

20.0 grams of $CaCO_3(s)$ were placed in a closed vessel, heated & maintained at 727°C under equilibrium $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$ and it is found that 75% of $CaCO_3$ was decomposed. What is the value of Kp ? The volume of the container was 15 litres.

Question For $NH_2COONH_{4(s)} \rightleftharpoons 2NH_{3(g)} + CO_{2(g)}$

total pressure at equilibrium = 12 atm. find K_p value.
Also calculate the total pressure at final equilibrium if NH_3 is added so that the new pressure of NH_3 becomes double its initial equilibrium pressure.

Question Find out the amount of $CaCO_{3(s)}$ (8gm) left after heating it in a closed 2 Lt container at 500 K.

$$CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)} \; ; K_p = 1.2 \text{ atm}$$

Question

Solid ammonium carbamate dissociates to give ammonia and carbon dioxide as follows

$$NH_2COONH_4(s) \rightleftharpoons 2NH_3(g) + CO_2(g)$$

At equilibrium, ammonia is added such that the partial pressure of NH_3 at the new equilibrium equals the original total pressure. Calculate the ratio of total pressure now to the original total pressure.

Multiple Equilibrium

$P \rightleftharpoons Q$; $K_1 = [Q]/[P]$

$Q \rightleftharpoons R$; $K_2 = [R]/[Q]$

$P \rightleftharpoons R$; $K_3 = [R]/[P]$

multiple Eqbm.

$$\frac{[R]}{[P]} = \frac{[Q]}{[P]} \times \frac{[R]}{[Q]}$$

$$K_3 = K_1 \times K_2$$

Q. **JEE 2008**

For the following three reactions (i), (ii) and (iii), equilibrium constants are given :

(i) $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$; K_1 —— (i)

(ii) $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$; K_2 —— (ii)

(iii) $CH_4(g) + 2H_2O(g) \rightleftharpoons CO_2(g) + 4H_2(g)$; K_3 — (iii)

Which of the following is correct?

(iii) = (i) + (ii)

$K_3 = K_1 \times K_2$

(A) $K_1\sqrt{K_2} = K_3$

(B) $K_2K_3 = K_1$

(C) $K_3 = K_1K_2$ ✓

(D) $K_3K_2^3 = K_1^2$

Q/ (Expected)

$A \rightleftharpoons B \;;\; 1 \longrightarrow A \rightleftharpoons B \;;\; 1 \longrightarrow A \rightleftharpoons B \;;\; 1$

$B \rightleftharpoons C \;;\; 2 \longrightarrow B \rightleftharpoons C \;;\; 2 \longrightarrow B \rightleftharpoons C \;;\; 2$

$2D \rightleftharpoons 2C \;;\; \frac{1}{4} \longrightarrow 2C \rightleftharpoons 2D \;;\; 4 \longrightarrow C \rightleftharpoons D \;;\; 2$

$A \rightleftharpoons D \quad 1 \times 2 \times 2 = 4$

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

$\downarrow$

4

Question

Sulphide ion in alkaline solution reacts with solid sulphur to form polysulphide ions having formula S_2^{2-}, S_3^{2-}, S_4^{2-} and so on. The equilibrium constant for the formation of S_2^{2-} is 12, and for the formation of S_3^{2-} is 130, both from S and S^{2-}. Find the equilibrium constant for the formation of S_3^{2-} from S_2^{2-} and S.

Simultaneous Equilibrium

$A \rightleftharpoons B$

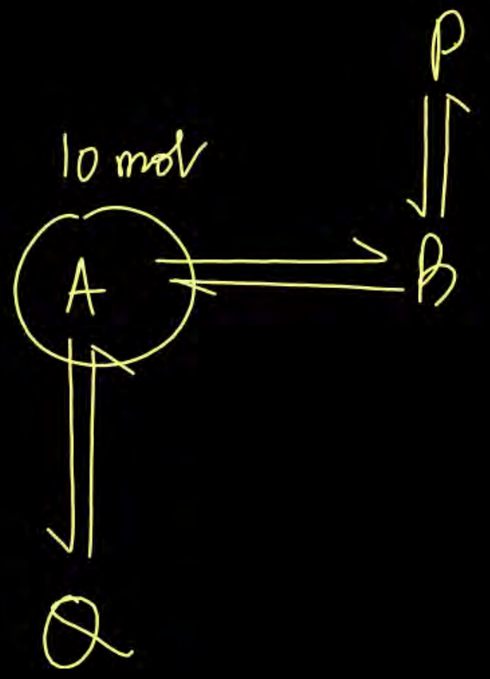
10 mol

$B \rightleftharpoons P$

$Q \rightleftharpoons A$

10 mol

असलियत



Question For these two simultaneous equilibria $K_{p_1} = 2$ atm and $K_{p_2} = 8$ atm. Find out the total pressure of the system when both equilibria are established.

$$CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + \boxed{CO_{2(g)}} \quad ; K_{p_1} = 2 \text{ atm}$$

$$C_{(s)} + \boxed{CO_{2(g)}} \rightleftharpoons 2CO_{(g)} \quad ; K_{p_2} = 8 \text{ atm}$$

$K_{p_1} = P_{CO_2} = 2$ atm

$K_{p_2} = \dfrac{P_{CO}^2}{P_{CO_2}} = 8$

$P_{CO}^2 = P_{CO_2} \times 8$

$= 2 \times 8 = 16$

$P_{CO} = 4$ atm

$P_T = P_{CO_2} + P_{CO_2} + P_{CO} = 2 + 4 = 6$ atm

Q. Two solids dissociate as follows

$A(s) \rightarrow B(g) + C(g)$; $K_{P1} = x\ atm^2$

$D(s) \rightarrow C(g) + E(g)$; $K_{P2} = y\ atm^2$

The total pressure when both the solids dissociate simultaneously is

(12th Jan 2019 (I))

A. $\sqrt{x+y}\ atm$

B. $2(\sqrt{x+y})\ atm$

C. $(x+y)\ atm$

D. $x^2+y^2\ atm$

$A_{(s)} \rightleftharpoons B_{(g)} + C_{(g)}$

$P_1 \quad P_1 + P_2$

$D_{(s)} \rightleftharpoons E_{(g)} + C_{(g)}$

$P_2 \quad P_1 + P_2$

$K_{P_1} = x = P_1(P_1+P_2)$ — (i)

$K_{P_2} = y = P_2(P_1+P_2)$ — (ii)

$P_{Total} = P_B + P_E + P_C = P_1 + P_2 + P_1 + P_2$

$= 2(P_1+P_2)$

$= 2\sqrt{x+y}$

Question

Three reactions are at simultaneous equilibrium . Moles of C, E and F are 3 , 2 and 4 respectively (at equilibrium).Calculate the Kc values of these equilibrium if initially A , B and D were 8 , 8 and 2 moles respectively taken in 1 lt container.

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

$$B + D \rightleftharpoons 2E$$

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

Le CHATELIER PRINCIPLE

If a system at equilibrium is subjected to a change of pressure, temperature, or the number of moles of a substance, there will be a tendency for a net reaction in the direction that tends to reduce the effect of this change.

any changes or disturbances except temperature only change reaction quotient Q_c or Q_p not K_p.

A. EFFECT OF CHANGE IN CONCENTRATION

Concept:

$Q > K$ backward

$Q < K$ Forward

$Q = K$ No change in the position of Equilibrium.

Change in the concentration of reactant :

- Reactant ↑ Q ↓ forward
- Reactant ↓ Q ↑ Backward

Change in the concentration of products :

- Product ↑ Q ↑ Backward
- Product ↓ Q ↓ Forward

Example

$$Q = \frac{[PCl_3][Cl_2]}{[PCl_5]}$$

$$PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$$

On adding PCl_5 — Forward

Example

$$PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$$

On adding Cl_2 — Backward

K.B.O

On increasing the amount of reactant reaction always goes forward (True / False)

$Q_c = [CO_2]$

$Q_p = P_{CO_2}$

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

Since reactant is not in the expression of Q so on changing its amount does not affect the equilibrium.

Change in both reactant and product:

$$Q = \frac{[PCl_3][Cl_2]}{[PCl_5]}$$

$$PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$$

$[PCl_3]$ → double

$[Cl_2]$ → 4 times

$[PCl_5]$ → 8 times

$$Q' = \frac{2[PCl_3]\,4[Cl_2]}{8[PCl_5]} = \frac{[PCl_3][Cl_2]}{[PCl_5]} = Q$$

$Q = Q'$

(No change)

B. EFFECT OF CHANGE IN PRESSURE

$$\underset{a}{PCl_5(g)} \rightleftharpoons \underset{b}{PCl_3(g)} + \underset{c}{Cl_2(g)}$$

Pressure ↑ volume ↓ Backward

Pressure ↓ volume ↑ Forward

$$Q = \frac{[PCl_3][Cl_2]}{[PCl_5]} = \frac{\left(\frac{b}{V}\right)\left(\frac{c}{V}\right)}{\left(\frac{a}{V}\right)}$$

$$\boxed{Q = \frac{bc}{a}\left(\frac{1}{V}\right)}$$

$A_{(g)} + B_{(g)} \rightleftharpoons 2C_{(g)}$

a b c

Pressure ↑ volume ↓

$$\text{conc} = \left(\frac{\text{moles}}{\text{volume}}\right)$$

$$Q = \frac{\left(\frac{c}{V}\right)^2}{\left(\frac{a}{V}\right)\left(\frac{b}{V}\right)} = \frac{c^2}{ab}$$

(No change)

Important : * moles of A, B, C remain same

*** conc of A, B, C increased.

Example $\overset{a}{2A}_{(g)} \rightleftharpoons \overset{b}{B}_{(g)}$

$$Q_p = \frac{\left(\frac{b}{V}\right)}{\left(\frac{a}{V}\right)^2} \frac{1}{RT} = \frac{b}{a^2}\left(\frac{V}{RT}\right)$$

On increasing the pressure —

Pressure ↑ vol ↓ Q ↓ Forward

Pressure ↓ vol ↑ Q ↑ Backward

Question

In which manner increase of pressure affect the following equilibrium?

$$C_{(s)} + H_2O_{(g)} \longrightarrow CO_{(g)} + H_{2(g)}$$

Addition of inert gas at constant pressure

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$
$$a \qquad\quad b \qquad\quad c$$

$$Q = \frac{bc}{a}\left(\frac{1}{V}\right)$$

On addition of inert gas at const press. moles of gas ↑

that's why volume ↑

(forward)

Addition of inert gas at constant volume

$$\underset{a}{PCl_5} \rightleftharpoons \underset{b}{PCl_3} + \underset{c}{Cl_2}$$

$$Q = \frac{bc}{a}\left(\frac{1}{V}\right)$$

moles ↑ Press ↑

Since there is no term of pressure in the expression of Q so no change.

D. EFFECT OF CATALYST

A catalyst has no effect on the position of the equilibrium since it increases not only the rate of forward reaction but also the rate of backward reaction. However it does help the system to reach the equilibrium faster.

Effect of temperature

endo T ↑ K ↑ दाएं पर forward.

exo T ↓ K ↑ दाएं पर forward.

endo T ↓ K ↓ बाएं पर Backward

exo T ↑ K ↓ बाएं पर Backward.

K.Bo

Since K_{eq} depends on temperature exponentially so if on changing temperature K increases, it increase with a large quantity and if decreases, it decreases with large quantity.

अगर बढ़ेंगे तो बहुत बढ़ेंगे !

अगर घटेंगे तो बहुत घटेंगे |

K.B.O

In case of more than one changes if one of the changes is temperature also then deciding Factor will be temperature only. Because other factors can change the reaction quotient value but temperature factor changes equilibrium const exponentially.

In case of physical Equilibrium:

$H_2O_{(s)} \rightleftharpoons H_2O_{(l)}$; ΔH = endo = (+)ve

$H_2O_{(l)} \rightleftharpoons H_2O_{(g)}$; ΔH = endo = (+)ve.

$C_{(graphite)} \rightleftharpoons C_{(diamond)}$; ΔH = endo = (+)ve.

Endothermic

T ↑ | K ↑ | Forward

Exothermic

T ↑ | K ↓ | Backward

K.Bo

On increasing the pressure of any physical equilibrium, equilibrium shifts toward the compound having more density.

Example

$H_2O_{(s)}$ $H_2O_{(l)}$

ice $\rightleftharpoons$ water ; ΔH = endo

learn

Temperature ↑ Forward = more ice melts.

Pressure ↑ forward = more ice melts.

$H_2O_{(l)}$ $H_2O_{(g)}$

Water $\rightleftharpoons$ vapour ; ΔH = endo

Temperature ↑ forward = more vapour formed.

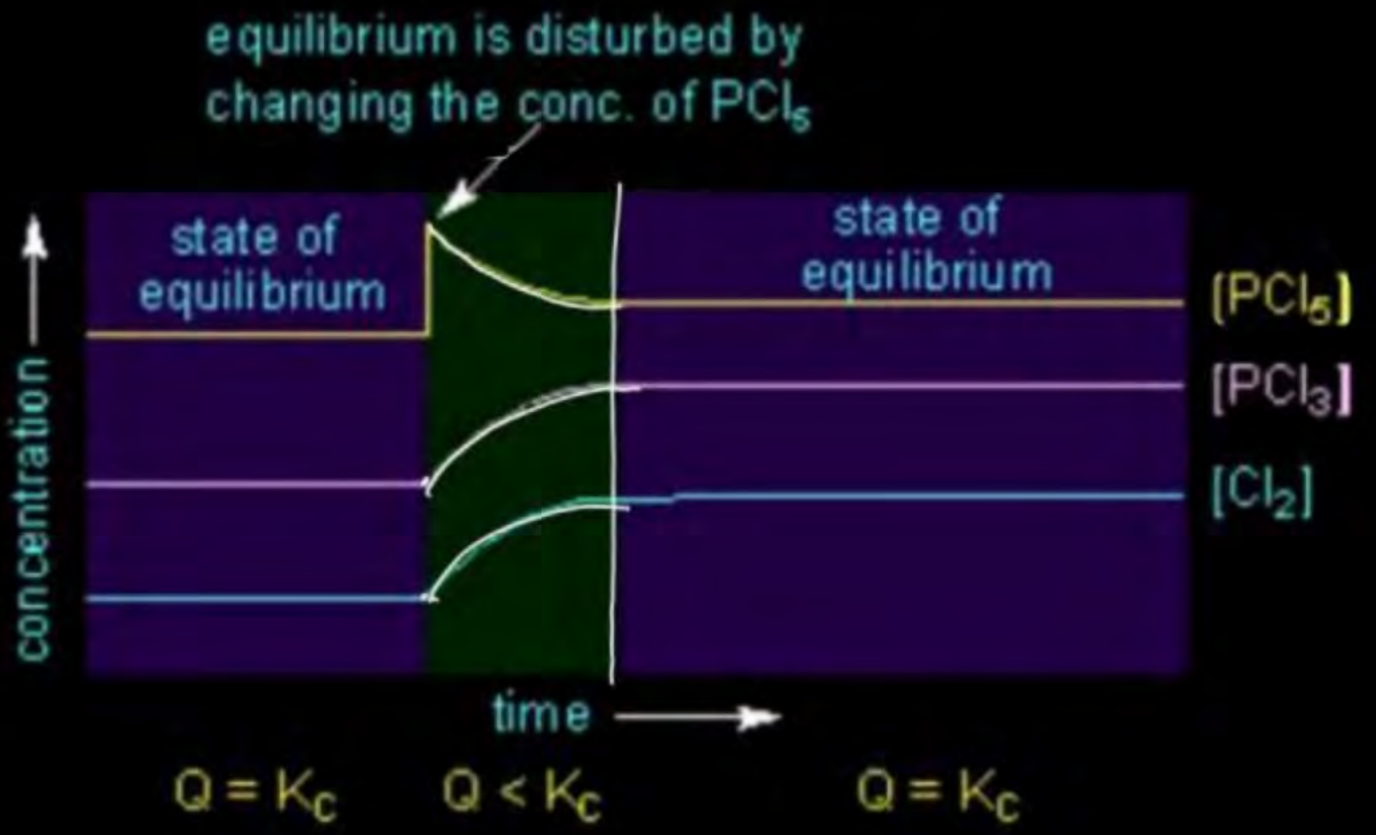
Pressure ↑ Backward = more vapour condensed into liquid.

$C_{(graphite)} \rightleftharpoons C_{(diamond)}$; ΔH = endo

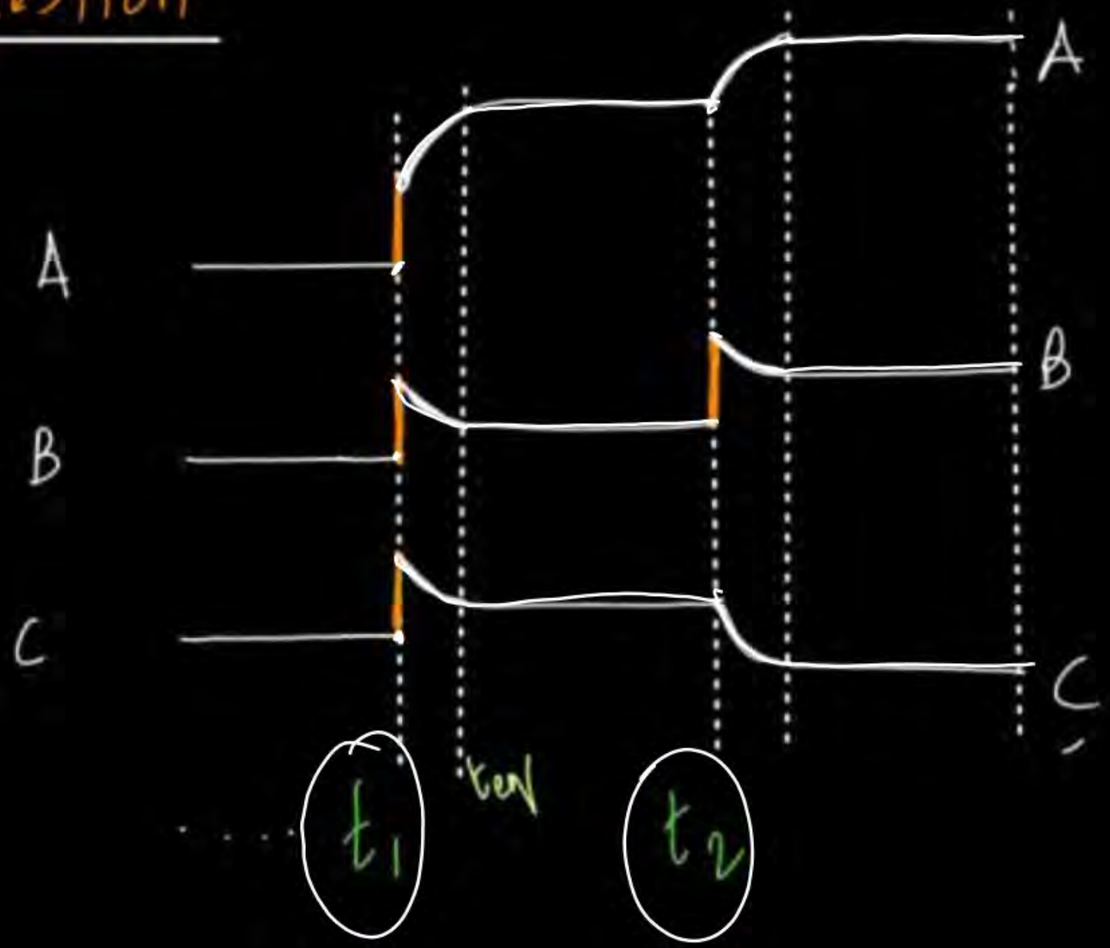
Temperature ↑ forward = more diamond formed

Pressure ↑ forward = more diamond formed.

$d_{diamond} > d_{graphite}$


equilibrium is disturbed by
changing the conc. of PCl_5
state of
equilibrium
state of
equilibrium
concentration
time
$[PCl_5]$
$[PCl_3]$
$[Cl_2]$
$Q = K_c$
$Q < K_c$
$Q = K_c$

Question



$A_{(g)} \rightleftharpoons B_{(g)} + C_{(g)}$; $\Delta H = (+)$

what are the changes applied on t_1 and t_2 time?

t_1 = Pressure ↑

$Q = \frac{b}{a}\left(\frac{1}{V}\right)$

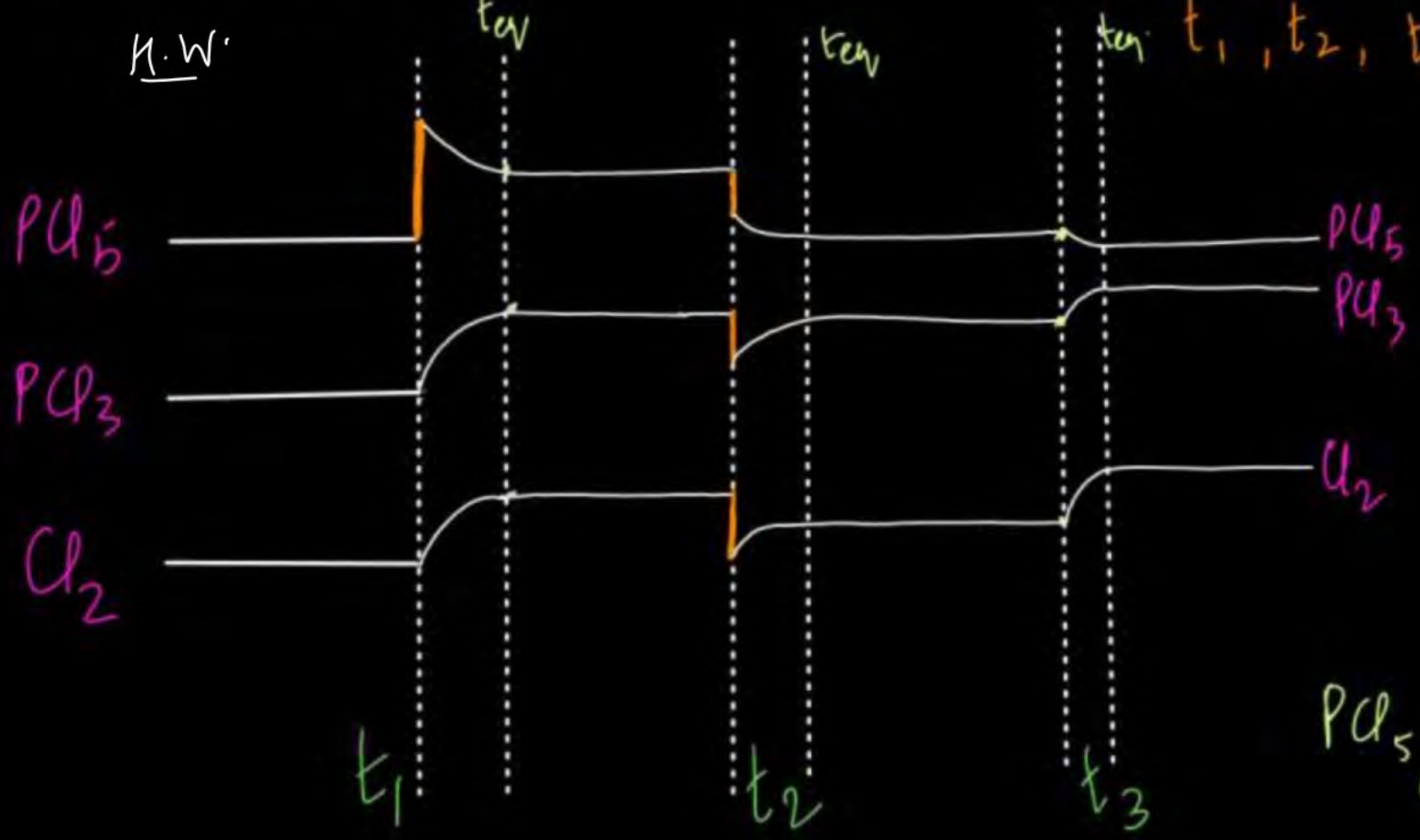
Backward

t_2 = addition of B

Question

H.W.

What are the changes applied at t_1, t_2, t_3 time?



t_1 = addition of PCl_5.

t_2 = Pressure reduced

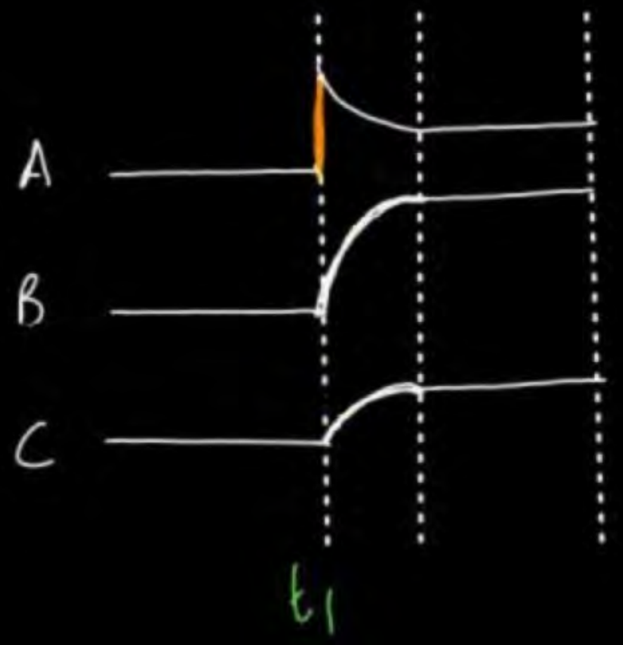
t_3 = temperature increased.

$$PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}; \text{(endo)}$$

Question -

Which of the following equilibria represents the given curves?

a) what change is applied at t_1 time?



b) i) $A_{(g)} \rightleftharpoons 2B_{(g)} + C_{(g)}$

ii) $A_{(g)} + B_{(g)} \rightleftharpoons C_{(g)}$

iii) $A_{(g)} \rightleftharpoons B_{(g)} + C_{(g)}$

iv) $A_{(g)} \rightleftharpoons B_{(g)} + 2C_{(g)}$


Thank
YOU
Keep Hustling!