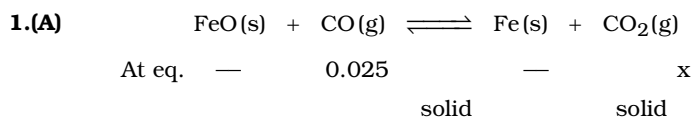


Miscellaneous Exercise Question Bank



$$K_c = \frac{[\text{CO}_2\text{(g)}]}{[\text{CO(g)}]} = \frac{x}{0.025} = 5 \text{ (given)}$$

$$\therefore x = 0.125 \text{ M} \Rightarrow [\text{CO}_2] = 0.125 \text{ M}$$

2.(A) $Q_c = \frac{\left(\frac{6}{2}\right)^2}{\left(\frac{2}{2}\right)\left(\frac{4}{2}\right)^3} = \frac{9}{8}$

3.(A) $K_p = \frac{P_{\text{S}_2\text{(g)}}^4}{P_{\text{S}_8\text{(g)}}} = \frac{(4 \times 0.3)^4}{0.70} = 2.96$

4.(C) $K_p = \frac{1}{P_{\text{H}_2\text{O(g)}}^4} \Rightarrow P_{\text{H}_2\text{O(g)}} = \left(\frac{1}{K_p}\right)^{1/4} \Rightarrow (10^{-12})^{1/4} = 10^{-3} \text{ atm}$

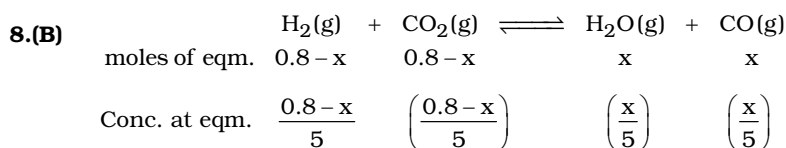
$$\therefore K_p = 10^{-3} \times 760 = 0.76 \text{ torr}$$

5.(B) $K_c = \frac{n_B n_C^3}{n_A^2} \times \frac{1}{V^2} \Rightarrow 16 = \frac{2 \times 2^3}{2^2 \times V^2} \Rightarrow V = \frac{1}{2}$

6.(A) $K_c = \frac{[\text{H}_2\text{S(g)}]}{[\text{H}_2\text{(g)}]} \Rightarrow 8 \times 10^{-2} = \frac{x}{0.3 - x} \Rightarrow x = 0.022$

$$[\text{H}_2\text{S(g)}] = \frac{0.022}{2} = 0.011 \text{ M}$$

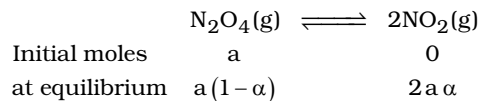
7.(C) $P_{\text{total}} = 3P \Rightarrow P = \frac{0.318}{3} = 0.106 \therefore K_p = 4P^3 = 4.76 \times 10^{-3}$



$$\therefore \Delta n_g = 0 \therefore K_c = \frac{\left(\frac{x}{5}\right)^2}{\left(\frac{0.8 - x}{5}\right)^2} \Rightarrow 2 = \frac{x}{0.8 - x} \Rightarrow x = 0.533$$

$$[\text{CO}_2\text{(g)}] = \frac{0.8 - 0.533}{5}$$

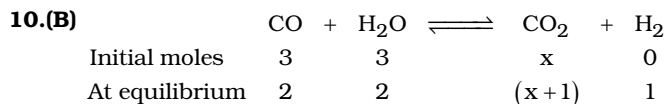
9.(B) For ideal gas mole % \equiv volume %



$$\text{As per given original volume} = \frac{75}{100} \times \text{Volume at equilibrium}$$

at constant T and P : $V \propto n$

$$\therefore a = 0.75 \times a(1+\alpha) \Rightarrow \alpha = 0.33$$

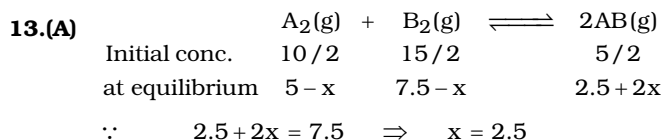


$$5 = \frac{(x+1)}{4} = 20 = x+1 \Rightarrow x = 19$$

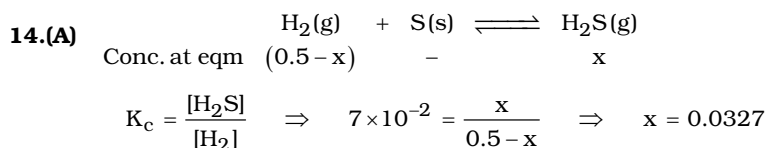
11.(A) $\alpha = \frac{M_T - M_O}{(n-1)M_O} \Rightarrow 0.2 = \frac{92 - M_O}{M_O} \Rightarrow M_O = 76.66$

$$d_{\text{mixture}} = \frac{PV_{\text{mixture}}}{RT} = \frac{1 \times 76.66}{0.821 \times 300} = 3.11 \text{ g/litre}$$

12.(C) $M_O = \frac{dRT}{P} = 57.47 \Rightarrow \alpha = \frac{99 - 57.47}{57.47} = 0.72$



$$K_c = \frac{(7.5)^2}{2.5 \times 5} = 4.5$$



$$P_{\text{H}_2\text{S}} = \left(\frac{n_{\text{H}_2\text{S}}}{V} \right) RT = 0.0327 \times 0.0821 \times 360 = 0.966$$

15.(C) The gaseous mixture contains 40% Cl_2 and 40% PCl_3 , since they are produced in 1 : 1 mole ratio. The PCl_5 % is 20.

For ideal gases mole % \equiv volume %

$$P_{\text{Cl}_2} = P_{\text{PCl}_3}$$

$$\Rightarrow 2 \times 0.40 = 0.80 \text{ atm}$$

$$P_{\text{Cl}_5} = 2 \times 0.2 = 0.40 \text{ atm}$$

$$\therefore K_p = \frac{P_{\text{PCl}_3} \cdot P_{\text{PCl}_2}}{P_{\text{PCl}_5}} = \frac{0.80 \times 0.80}{0.40} = 1.6 \text{ atm}$$

16.(A) For an ideal gas mole % \equiv volume %

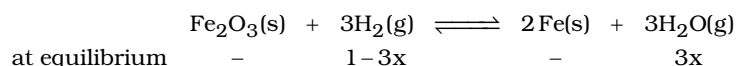
$$K_p = \frac{P_{\text{H}_2\text{O}}^2}{P_{\text{H}_2}^2} = \frac{(0.55)^2}{(0.45)^2} = 1.49$$

17.(D) Moles of CO_2 present at equilibrium = $\frac{1.642 \times 50}{0.0821 \times 1000} = 1$

$$\text{Mole \% of } \text{XCO}_3 \text{ decomposed} = \frac{1}{4} \times 100 = 25\%$$

Hence, 75 % remains undecomposed

18.(B) Let initial moles of $\text{H}_2(\text{g})$ is 1



$$K_c = \frac{\left(\frac{3x}{V}\right)^3}{\left(\frac{1-3x}{V}\right)^3} \Rightarrow 2 = \left(\frac{3x}{1-3x}\right) \Rightarrow x = 0.22$$

$$\% \text{ of } \text{H}_2 \text{ unreacted} = \frac{1-3 \times 0.22}{1} \times 100 = 34$$

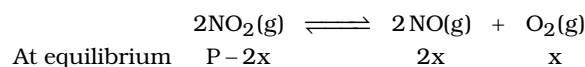
19.(C)
$$\text{AB}_3(\text{g}) \rightleftharpoons \text{AB}_2(\text{g}) + \frac{1}{2}\text{B}_2(\text{g})$$

At equilibrium $800 - x \quad \quad \quad x \quad \quad \quad x/2$

$$800 - x + x + \frac{x}{2} = 900 \Rightarrow x = 200$$

$$\% \text{ dissociated} = \frac{200}{800} \times 100 = 25$$

20.(B) Let P is initial pressure of NO_2



as per given $x = 0.25$

$$K_p = \frac{(2x)^2(x)}{(P-2x)^2} \Rightarrow 156.25 = \frac{(0.5)^2(0.25)}{P_{\text{NO}_2}^2} \Rightarrow P_{\text{NO}_2} = 0.02$$

21.(B)
$$2\text{NOCl}(\text{g}) \rightleftharpoons 2\text{NO}(\text{g}) + \text{Cl}_2(\text{g})$$

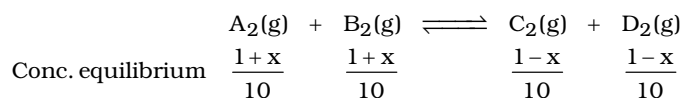
At equilibrium $P-2x \quad \quad \quad 2x \quad \quad \quad x$

$$P + x = 1; \quad P - 2x = 0.64; \quad x = 0.12$$

$$K_p = \frac{(0.24)^2(0.12)}{(0.64)^2} = 16.875 \times 10^{-3} \text{ atm}$$

22.(C) $Q_c = \frac{1 \times 1}{1 \times 1} = 1$

$\therefore Q_c > K_c$ so reaction will proceed in backward direction



$$0.25 = \frac{\left(\frac{1-x}{10}\right)^2}{\left(\frac{1+x}{10}\right)^2} \Rightarrow x = 0.333$$

$$[A_2(g)] = \frac{1+x}{10} = \frac{1.333}{10} = 0.133$$

23.(D) $K_c = [Hg(g)]; P = CRT$

$$C = \left(\frac{0.002}{760}\right) \times \frac{1}{(0.0821 \times 300)} = 1.068 \times 10^{-7} M$$

24.(B) $K_c = \frac{n_{AB_2}^2}{n_{A_2} \cdot n_{B_2}^2} \times V = \frac{n_{AB_2}^2}{n_{A_2} \cdot n_{B_2}^2} \times \left(\frac{n_{total}RT}{P}\right) = \frac{2^2}{5 \times 3^2} \times \left(\frac{10 \times 0.821 \times 300}{8.21}\right)$

25.(B) For exothermic reaction, on increasing temperature % yield of product decreases.

Therefore $T_3 < T_2 < T_1$



At t = 0	0.06	0	0
At t = eq	(0.06 - 0.018)	0.018	0.018
Molar conc.	1	$\frac{0.018}{2}$	$\frac{0.018}{2}$

$$\alpha = \frac{0.06 \times 30}{100} = 0.018$$

$$K_c = \frac{[NH_3][H_2S]}{[NH_4HS]} = \frac{(0.018/2)^2}{1} = 8.1 \times 10^{-5} \text{ mol/L}$$

27.(C) Variation of equilibrium constant with temperature $\ln k = \frac{\Delta S_r^\circ}{R} - \frac{\Delta H_r^\circ}{RT}$

Slope is $-\frac{\Delta H^\circ}{R}$ for exothermic, slope should be positive therefore graph C is correct.

28.(B) For endothermic value of $\ln k_p$ decreases with decrease in temperature.

29.(C) $\ln \frac{K_{P_2}}{K_{P_1}} = \frac{\Delta H^\circ}{R} \left[\frac{1}{T_1} - \frac{1}{T_2} \right] = \ln \left(\frac{10^{-4}}{10^{-6}} \right) = \frac{\Delta H^\circ}{8.314} \left(\frac{25}{298 \times 323} \right)$

$$\Delta_r H^\circ = 147.41 \text{ kJ/mol}$$

30.(B) $\Delta_r G^\circ = \Delta_r H^\circ - T \cdot \Delta_r S^\circ = -30 + 300 \times 0.1 = 0$

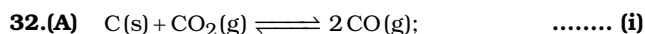
$$\Delta_r G^\circ = -2.303 RT \log K \Rightarrow K = 1$$

31.(D) $P_{total} = 0.2 \text{ bar}$

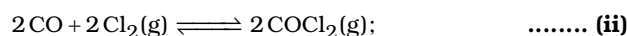
At equilibrium $P_{CO_2} = P_{H_2O} = 0.1 \text{ bar}$

$$K_p = (0.1)^2 = 0.01$$

$$\Delta_r G^\circ = -RT \ln K_p = -8.314 \times 420 \ln(0.01) = 16083.6 \text{ J/mol or } 16.083 \text{ kJ/mol}$$

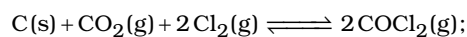


$$K_{p1} = 10^{14} \text{ atm}$$



$$K_{p2} = (6 \times 10^{-3})^2 \text{ atm}^{-2}$$

Add (i) and (ii)

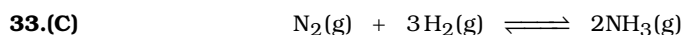


$$K_p = 10^{14} \times 36 \times 10^{-6} = 36 \times 10^8$$

For given reaction $\Delta n_g = -1$

$$\therefore K_c = K_p (RT) = 36 \times 10^8 \times 0.0821 \times 1120$$

$$K_c = 3.31 \times 10^{11} \text{ M}^{-1}$$

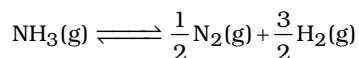


Initial moles	1	2	0
at eq	1 - x	2 - 3x	2x

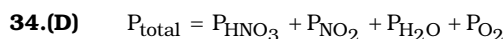
where $x = 0.5$

$$K_c = \frac{(1/4)^2}{\left(\frac{0.5}{4}\right)\left(\frac{0.5}{4}\right)^3} = 256$$

equilibrium constant for the reaction



$$K_c^1 = \frac{1}{\sqrt{K_c}} = \frac{1}{16}$$



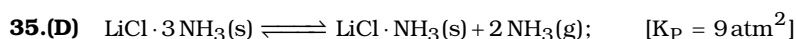
$$\therefore P_{NO_2} = 4P_{O_2} \text{ and } P_{H_2O} = 2P_{O_2}$$

$$\therefore P_{\text{total}} = P_{HNO_3} + 7P_{O_2}$$

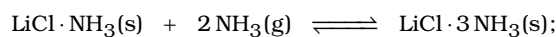
$$\Rightarrow 30 - 2 = P_{O_2} \times 7 \Rightarrow P_{O_2} = \frac{28}{7} = 4$$

$$K_p = \frac{P_{NO_2}^4 \cdot P_{H_2O}^2 \cdot P_{O_2}}{P_{HNO_3}^4} = \frac{(4 \times 4)^4 \times (2 \times 4)^2 \times 4}{2^4} = 2^{20}$$

$$K_p = K_c (RT)^{\Delta n_g} = K_c (0.08 \times 400)^3 \Rightarrow K_c = \frac{2^{20}}{(32)^3} = 32$$



Therefore,



Initial moles	0.1	a	0
Final moles at eqm.	0	(a - 0.2)	0.1

Let initial moles of NH_3 is a for completion of reaction.

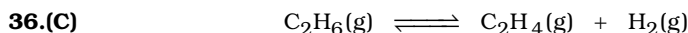
$$\text{At eqm. } K'_p = \frac{1}{(P'_{\text{NH}_3})^2} \text{ or } \frac{1}{9} = \frac{1}{(P'_{\text{NH}_3})^2}$$

$$\therefore P'_{\text{NH}_3} = 3 \text{ atm}$$

$$\therefore PV = nRT \Rightarrow 3 \times 5 = n \times 0.0820 \times 310$$

$$\therefore n = 0.59 \text{ i.e., } (a - 0.2) = 0.59$$

$$\therefore \text{initial moles of } \text{NH}_3 = 0.79$$



$$\text{At eqm.} \quad \begin{array}{ccc} 1-x & x & x \end{array}$$

$$K_P = \frac{P_{\text{C}_2\text{H}_4} \cdot P_{\text{H}_2}}{P_{\text{C}_2\text{H}_6}} \Rightarrow \frac{x^2}{1-x} = 5 \times 10^{-2}$$

$$x^2 + 0.05x - 0.05 = 0$$

$$x = \frac{-0.05 + \sqrt{(0.05)^2 + 4 \times 0.05}}{2} = 0.20 \text{ atm}$$

Partial pressure of C_2H_6 = mole fraction \times total pressure

$$\Rightarrow 0.80 = \text{mole fraction} \times 1.2$$

$$\therefore \text{mole \% of } \text{C}_2\text{H}_6 = \frac{0.8}{1.2} \times 100 = 66.66$$



$$\text{Initial pressure} \quad \begin{array}{ccc} P & 0 & 0 \end{array}$$

$$\text{at eqm} \quad \begin{array}{ccc} P-2x & 2x & x \end{array}$$

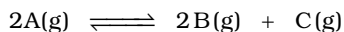
where $2x = 0.40P$

$$\Rightarrow x = 0.2P; \Rightarrow 1.20P = 0.30 \Rightarrow P = 0.25 \text{ atm}$$

$$K_P = \frac{P_{\text{NO}}^2 \cdot P_{\text{Br}_2}}{P_{\text{NOBr}}^2} = \frac{(0.4P)^2 (0.2P)}{(0.6P)^2} = 0.0222$$

$$\therefore K_P \text{ for the reaction } 2\text{NO}(\text{g}) + \text{Br}_2(\text{g}) \rightleftharpoons 2\text{NOBr}(\text{g}) \text{ is } \frac{1}{0.0222} = 45$$

38.(C) \therefore Initially only A is present so at eqm B and C should be present in 2 : 1.



$$\text{At eqm.} \quad \begin{array}{ccc} 400 \text{ mL} & 200 \text{ mL} & 100 \text{ mL} \end{array}$$

for ideal gases volume % = mole %

$$K_P = \frac{\left(\frac{200}{700} \times 10\right)^2 \left(\frac{100}{700} \times 10\right)}{\left(\frac{400}{700} \times 10\right)^2} = \frac{10}{28}$$



$$\text{Initial moles} \quad \begin{array}{cccc} 2 & 2 & 2 & 2 \end{array}$$

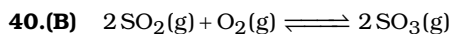
$$\text{at eqm} \quad \begin{array}{cccc} 2-x & 2-x & 2+x & 2+x \end{array}$$

Total number of moles of gases at equilibrium = 8 + 2 = 10

$$K_P = \frac{P_{\text{SO}_3} \cdot P_{\text{NO}}}{P_{\text{SO}_2} \cdot P_{\text{NO}_2}}$$

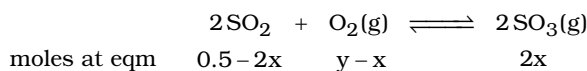
$$\Rightarrow 25 = \frac{\left(\frac{2+x}{10} \times P\right)^2}{\left(\frac{2-x}{10} \times P\right)^2} \Rightarrow 5 = \frac{2+x}{2-x} \Rightarrow x = 1.33$$

$$\text{Partial pressure of NO}_2 = \frac{2-x}{10} \times P_{\text{total}} = \frac{0.666}{10} \times 2 = 0.133 \text{ atm}$$



$$K_c = \frac{(0.12)^2}{(0.12)^2 \times 5} = 0.2$$

Another vessel



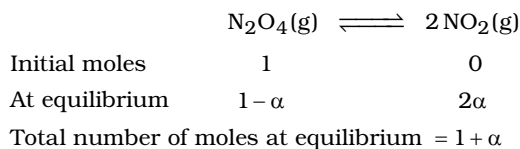
as per given $2x = \frac{20}{100} \times 0.5 = 0.1$

$$K_c = \frac{(0.1)^2}{(0.4)^2 (y - 0.05)} = 0.20$$

$$y = 0.3625 \text{ mole}$$

\therefore mass of O_2 added = 11.6 g

41.(B) Let initial mole of



Total number of moles at equilibrium = 1 + α

$$P_{\text{N}_2\text{O}_4} = \frac{1-\alpha}{1+\alpha} \times P$$

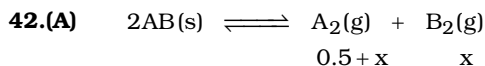
$$P_{\text{NO}_2} = \frac{2\alpha}{(1+\alpha)} \times P$$

Hence, $K_P = \frac{P_{\text{NO}_2}^2}{P_{\text{N}_2\text{O}_4}} = \frac{4\alpha^2}{(1-\alpha)^2} \times P$

$$\therefore 4.5 = \frac{4\alpha^2}{(1-\alpha)^2} \times 2 \Rightarrow \alpha = 0.6$$

Mole fraction of N_2O_4 : $X_{\text{N}_2\text{O}_4} = \frac{1-\alpha}{1+\alpha} = 0.25$ $\therefore X_{\text{NO}_2} = 0.75$

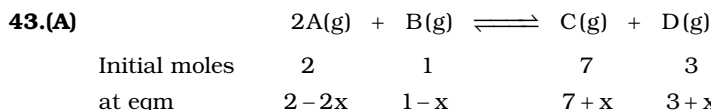
Average molar mass of mixture = $0.25 \times 92 + 0.75 \times 46 = 57.5$



$$K_P = P_{\text{A}_2} \cdot P_{\text{B}_2}$$

$$\Rightarrow 0.06 = (0.5+x)x = x^2 + 0.5x - 0.06 \Rightarrow x = 0.1$$

$$P_{\text{total}} = P_{\text{A}_2} + P_{\text{B}_2} = 0.6 + 0.1 = 0.70 \text{ atm}$$



Due to very high value of K_c we can assume that reactant almost converted into products so

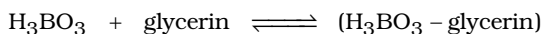
$$1-x = y; \quad 2-2x = 2y \Rightarrow x = 1$$

$$10^{12} = \frac{8 \times 4}{(2y)^2 y} \Rightarrow y^3 = 8 \times 10^{-12}$$

$$\therefore \text{Equilibrium concentration of A} = 2y = 4 \times 10^{-4}$$

44.(B) $K_c = \frac{[\text{complex}]}{[H_2BO_3][\text{glycerin}]} = 0.90 \Rightarrow \frac{[\text{complex}]}{[H_3BO_3]} = \frac{80}{20}$

$$\therefore [\text{glycerin}] = \frac{80}{20 \times 0.9} = 4.44 \text{ M}$$

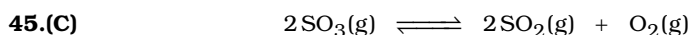


At eqm	$0.1-x$	$a-x$	x
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$$x = 0.1 \times \frac{80}{100} = 0.08;$$

$$a-x = 4.44 \Rightarrow a = 4.44 + 0.08 = 4.52 \text{ M}$$

or Initial moles = 4.52



Moles at eqm	$1-2x$	$2x$	x
--------------	--------	------	-----

Only SO_2 (O. No. = 4) will oxidized

So equivalent of SO_2 = equivalent of $KMnO_4$

$$2x \times 2 = 0.2 \times 5 \Rightarrow 2x = 0.5$$

$$K_c = \frac{\left(\frac{0.5}{2}\right)^2 \left(\frac{0.25}{2}\right)}{\left(\frac{0.5}{2}\right)^2} = 0.125$$

46.(B) $8 \times 10^{-6} = \frac{x^2}{0.5}$

$$\Rightarrow x = 2 \times 10^{-3} \therefore pOH = 2.7$$

So, $pH = 11.3$

47.(BCD) No effect of presence or absence of catalyst on value of equilibrium constant.

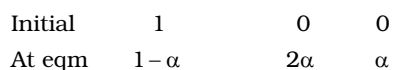
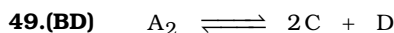
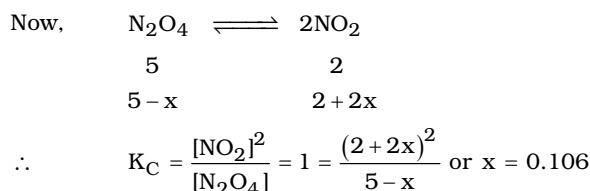
48.(ABCD) $\Delta G = \Delta G^\circ + 2.303 RT \log Q$

$$\Delta^\circ G = 2 \times \Delta^\circ G_{NO_2} - \Delta^\circ G_{N_2O_4} = 2 \times 50 - 100 = 0$$

$$\therefore \Delta G = 0 + 2.303 \times 8.314 \times 10^{-3} \times 298 \log \frac{2}{5} = 0 - 0.55 \text{ kJ}$$

$$\therefore \Delta G = -0.55 \text{ kJ, i.e., reaction proceed in forward direction}$$

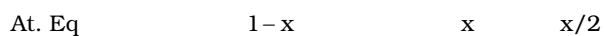
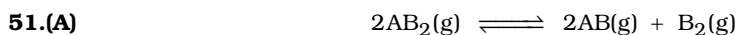
Also $\Delta G^\circ = 0 = 2.303 RT \log K_c \therefore K_c = 1$



$$K_P = (2\alpha)^2 \alpha \times \left[\frac{P}{\Delta n} \right]^2 = \frac{4\alpha^3 P^2}{(1+2\alpha)^2}$$

Use $2.303 \log \frac{K_2}{K_1} = \frac{\Delta H}{R} \left[\frac{T_2 - T_1}{T_1 T_2} \right]$ for effect of temperature

50.(B) Numerical value of K_p or K_c change with changes with temperature



$$\text{Total moles} = 1-x+x+\frac{x}{2} = \frac{2+x}{2}$$

$$p(\text{AB}_2) = \frac{2(1-x)}{2+x} p$$

$$p(\text{AB}) = \left(\frac{2x}{2+x} \right) \cdot p$$

$$p(\text{B}_2) = \left(\frac{x}{2+x} \right) p$$

$$K_P = \frac{(p\text{AB})^2 (p\text{B}_2)}{(p\text{AB}_2)^2}$$

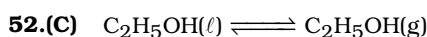
$$K_P = \frac{[(2x/(2+x) \cdot p)]^2 (x/2+x) \cdot p}{[2(1-x)/(2+x) \cdot p]^2} = \frac{x^3 p}{(2+x)(1-x)^2}$$

As x is very small

$$K_P = \frac{x^3 p}{2}$$

$$x^3 = \frac{2K_P}{p}$$

$$x = (2K_P / p)^{1/3}$$



$$\Delta G^\circ = \left[\Delta G_f^\circ(\text{C}_2\text{H}_5\text{OH})(\text{g}) - \Delta G_f^\circ(\text{C}_2\text{H}_5\text{OH})(\ell) \right]$$

$$\Delta G^\circ = (1)(-168.6) - (1)(-174.9) = +6.3 \text{ kJ}$$

$$\Delta G^\circ = -RT \ln k$$

$$\ln k = \frac{-\Delta G^\circ}{RT} = \frac{-(6.3 \text{ kJ/mol})}{8.314 \times 10^{-3} \times 298} = -2.54$$

$$k = e^{-2.54} = 0.079$$

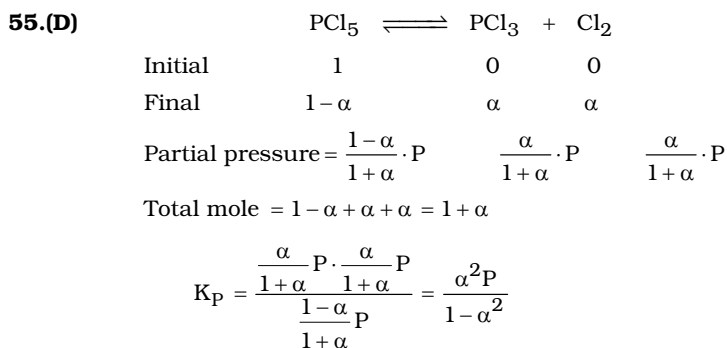
$$k = K_P = p(\text{C}_2\text{H}_5\text{OH}) = 0.079 \text{ atm}$$

53.(BC) Unit of $K_c = (\text{mol L}^{-1})^{\Delta n}$

$$\text{Unit of } K_p = (\text{atm})^{\Delta n}$$

$\Delta n = \text{mole of product (g)} - \text{moles of reactant (g)}$

54.(BCD) $K_1 = \frac{K_f}{K_b} = \frac{2 \times 10^{-2}}{4 \times 10^{-3}} = 5 \text{ at } 300 \text{ K}$



56.(D) Since the number of moles decreases. So reaction is favoured by increasing pressure,

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

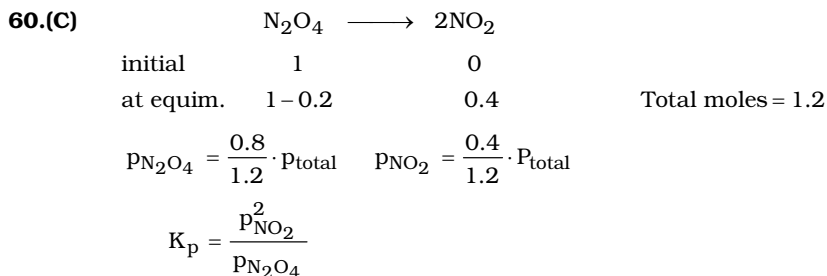
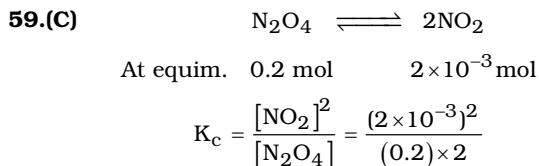
57.(B) Since K increases on increasing temperature, so the reaction will go forward by increasing temperature and hence is endothermic.

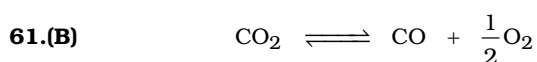
58.(B) $A + 2B \rightleftharpoons 2C$,(i) $K = 40$

and for $C \rightleftharpoons B + \frac{1}{2} A$,(ii) $K_1 = ?$

$$K_1 = \frac{1}{\sqrt{K}} = \frac{1}{(40)^{1/2}}$$

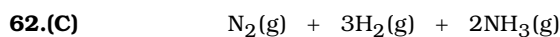
Since equation (ii) is obtained by reversing and dividing by 2, the equation (i).





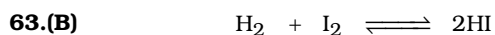
Initial	4	0	0
At equim.	3	1	$\frac{1}{2}$

Moles of CO at equilibrium = 1



Initial	1	3	0
At equim.	0.5	1.5	1

Total moles of gas at equilibrium = 3



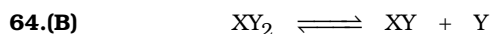
Initial	1	1	0
Final	$\frac{1-\alpha}{v}$	$\frac{1-\alpha}{v}$	$\frac{2\alpha}{v}$

Since $\Delta n = 0$ $[2 - (1+1)]$

\therefore K does not depend on volume.

So on reducing volume to half K does not change.

\therefore K = 50



Initial	P	0	0
Final	P - x	x	x

Initial P = 600 mm Hg, Final P = 800 mm Hg

Total moles \propto final P.

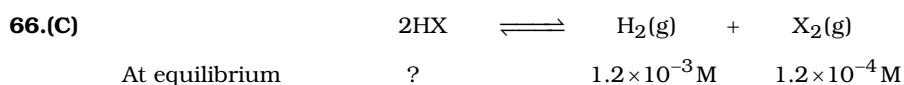
\therefore $P - x + x + x \propto 800$

$$600 - x + x + x \propto 800$$

$$x = 200 \text{ mm Hg}$$

$$K = \frac{x \times x}{P - x} = \frac{200 \times 200}{400} = 100 \text{ mm Hg}$$

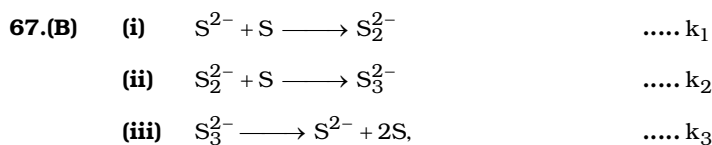
65.(C) $K = \frac{R_f}{R_b} = \frac{0.25}{5000} = 5 \times 10^{-5}$



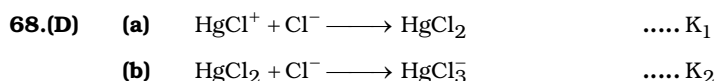
$$K = \frac{[\text{H}_2][\text{X}_2]}{[\text{HX}]^2}$$

$$10^{-5} = \frac{1.2 \times 10^{-3} \times 1.2 \times 10^{-4}}{[\text{HX}]^2}$$

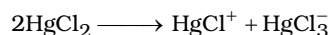
$$[\text{HX}] = \sqrt{\frac{1.2 \times 1.2 \times 10^{-7}}{10^{-5}}} = 1.2 \times 10^{-1} = 12 \times 10^{-2} \text{ M}$$



Since equation (iii) is obtained by reversing and adding equations (i) and (ii). The equation constant for the reaction is $k_3 = \frac{1}{k_1} \times \frac{1}{k_2} = \frac{1}{12 \times 11} = 7.58 \times 10^{-3}$



The eq. constant (k) for the reaction,

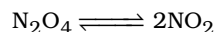


Can be obtained by reversing equation (a) and adding equation (b).

$$K = \frac{1}{K_1} \times K_2 = \frac{K_2}{K_1} = \frac{8.9}{3 \times 10^6} = 3 \times 10^{-6}$$

69.(B) $\alpha = \frac{D-d}{d}$

D = Vapour density before dissociation ; d = vapour density after dissociation

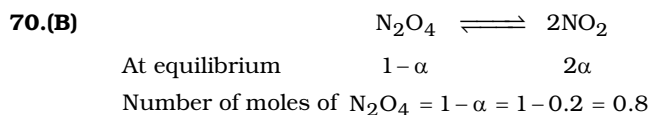
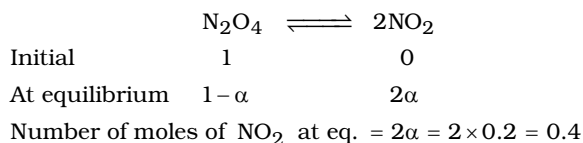


Vapour density of N_2O_4 before dissociation

$$(D) = \frac{14 \times 2 + 16 \times 4}{2} = \frac{92}{2} = 46$$

Vapour density after dissociation (d) = 38.3

$$\therefore \alpha = \frac{46 - 38.3}{38.3} = 0.2$$



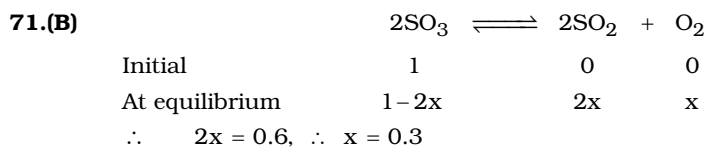
Weight of N_2O_4 in mixture = moles of $N_2O_4 \times$ Mw of $N_2O_4 = 0.8 \times 92 = 73.6$ g

Weight of NO_2 in mixture = moles of $NO_2 \times$ Mw of $NO_2 = 0.4 \times 46 = 18.4$

Total weight = $73.6 + 18.4 = 92.0$ g

In 92 g of mixture, number of moles of $N_2O_4 = 0.8$

In 100 g of mixture; number of moles of $N_2O_4 = \frac{0.8 \times 100}{92} = 0.86$

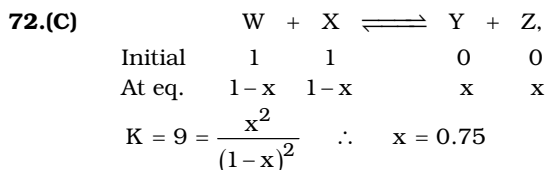


$$[\text{SO}_3] = 1 - 2x = 1 - 0.6 = 0.4$$

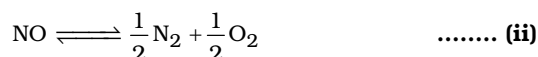
$$[\text{SO}_2] = 2x = 0.6$$

$$[\text{O}_2] = x = 0.3$$

$$K = \frac{x \times (2x)^2}{(1-2x)^2} = \frac{0.3 \times 0.6 \times 0.6}{0.4 \times 0.4} = 0.675$$



73.(C) With increase in temperature, K value decreases, which means that at high temperature the reaction proceeds in backward direction or proceeds forward at room temperature. In another words, at room temperature, HI dissociates or HI is less stable than H_2 and I_2 .



Equation (ii) is obtained by reversing equation (i) and dividing by 2.

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

75.(D) At equilibrium, amount of NH_3 formed is equal to the amount of NH_3 decomposed into H_2 and N_2 .

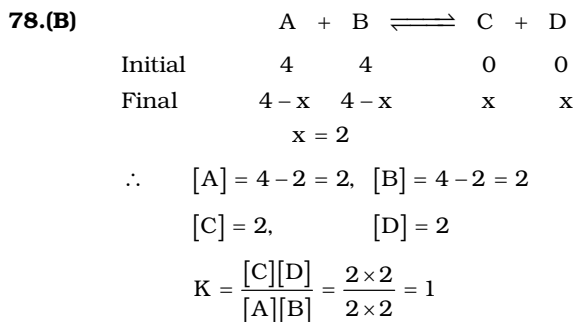
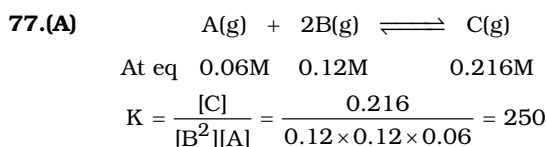
76.(B) I. $Q = \frac{[\text{NO}_2]^2}{[\text{N}_2\text{O}_4]}$

Since, $[\text{NO}_2]$ is maximum and $[\text{N}_2\text{O}_4]$ is minimum at point A, hence Q is minimum at this point. Thus, false.

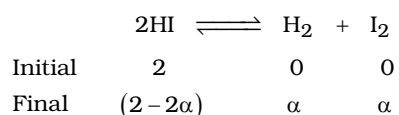
II. $Q = \frac{(0.1)^2}{(0.1)} = 0.1 < K_c$

Thus, reaction proceeds left to right. Thus, true

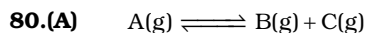
III. $K_c = Q$ when equilibrium is reached at point D or F Thus, true



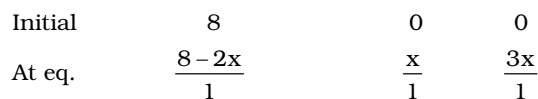
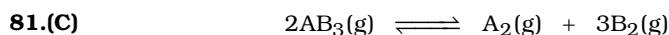
79.(D) $\alpha = 50\% = \frac{50}{100} = 0.5$



$$K = \frac{\alpha^2}{(2 - 2\alpha)^2} = \frac{0.5 \times 0.5}{(2 - 2 \times 0.5)^2} = 0.25$$



- (A)** With increase of temperature K_p increases, i.e., with increase of temperature, the reaction is favoured in forward direction and hence reaction is endothermic. Thus statement (A) is incorrect.
- (B)** Increase of temperature favours forward reaction and hence the formation of B increases. Correct statement.
- (C)** $\Delta n = 1 + 1 - 1 = 1$
 $\Delta n = +ve$, i.e., with the increase of pressure, reaction is favoured backward direction and hence the formation of A(g) increases. Correct statement.
- (D)** As from the above statement in (i) and (iii), the reaction is favoured backward with decrease of temperature and increase of pressure. Correct statement.



Since volume = $1 \text{ dm}^3 = 1 \text{ L}$

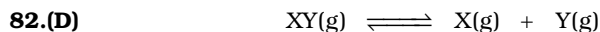
At eq. $[\text{A}_2] = 2 \text{ mol} = x$

$\therefore [\text{AB}_3] = 8 - 2 \times 2 = 4 \text{ M}$

$[\text{A}_2] = 2 \text{ M}$

$[\text{B}_2] = 3 \times 2 = 6 \text{ M}$

$$K = \frac{[\text{B}_2]^3 [\text{A}_2]}{[\text{AB}_3]^2} = \frac{6 \times 6 \times 6 \times 2}{4 \times 4} = 27 \text{ mol}^2 \text{ L}^{-2}$$



At Eq. $[\text{Y}] = 0.2 + x = 0.6$

$\therefore x = 0.4 \text{ mol} = \frac{0.4}{1} = 0.4 \text{ M}$

$[\text{XY}] = 1 - 0.4 \text{ mol} = 0.6 \text{ M}$

$[\text{X}] = x = 0.4 = \frac{0.4}{1} = 0.4 \text{ M}$

$$K = \frac{[\text{X}][\text{Y}]}{[\text{XY}]} = \frac{0.4 \times 0.6}{0.6} = 0.4 \text{ mol L}^{-1}$$

83.(A) $\Delta n = 2 - 1 = 1$

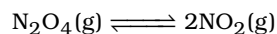
(A) That is, with the decrease of pressure, reaction shifts towards right, i.e., proportions of NO_2 increases. Statement (A) is correct.

(B) Value of K increases with increase of temperature and hence reaction is endothermic. i.e., $\Delta H = +ve$. Hence statement (B) is incorrect.

(C)
$$K_P = \frac{[\text{PNO}_2]^2}{[\text{PN}_2\text{O}_4]} = \frac{\text{atm}^2}{\text{atm}} = \text{atm}$$

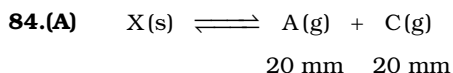
Hence statement (C) is incorrect.

(D) $K_P \text{ at } 600\text{K} = 1.78 \times 10^4$

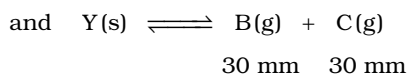


$$\Delta n = 2 - 1 = 1$$

Since by decrease of pressure reaction goes forward, i.e., more of N_2O_4 will dissociate. It means by decreasing pressure dissociation of N_2O_4 increases. Hence, the statement is wrong.

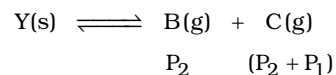
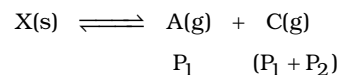


$$K_{P_1} = 20 \times 20 = 400 \text{ mm}^2$$



$$K_{P_2} = 30 \times 30 = 900 \text{ mm}^2 \quad \therefore \quad \frac{K_{P_1}}{K_{P_2}} = \frac{4}{9}$$

85.(C) In mixture, solid X and Y dissociate simultaneous,



$$\therefore \quad \frac{K_{P_1}}{K_{P_2}} = \frac{P_1}{P_2} = \frac{4}{9}$$

Hence, (C) is the correct answer

86.(B) $K_{P_1} = P_1(P_1 + P_2)$

$$K_{P_2} = P_2(P_1 + P_2)$$

On solving $P_1 = 23.09$, $P_2 = 51.75$

$$\therefore \quad P_1 + P_2 = 74.84 \text{ mm}$$

Hence, (B) is the correct answer



Partial pressure 0 P P
at equilibrium

$$\therefore \quad \text{Total pressure at equilibrium} = 2P = 0.298 \text{ atm}$$

$$\therefore P = 0.149 \text{ atm}$$

$$\text{Also, } K_P = P'_{\text{NH}_3} \times P'_{\text{HCN}} = 0.149 \times 0.149 = 0.0222 \text{ atm}^2$$

Now dissociation is made when, $P_{\text{NH}_3} = 0.25 \text{ atm}$

$$\begin{array}{lcl} \text{NH}_4\text{CN(s)} & \rightleftharpoons & \text{NH}_3 + \text{HCN} \\ \text{Initial pressure} & & 0.25 \quad 0 \\ \text{Pressure at eqm} & & 0.25 + P' \quad P' \\ \therefore K_P & = & P'(P' + 0.25) \\ \therefore 0.0222 & = & P'(P' + 0.25) \\ \therefore P' & = & 0.0694 \text{ atm} \end{array}$$



$$\begin{array}{lcl} \text{Initial moles} & 1 & 2 \quad 0 \\ \text{Moles at eqm} & (1-x) & (2-2x) \quad x \end{array}$$

$$\text{Total moles at equilibrium} = 1 - x + 2 - 2x + x = 3 - 2x$$

Let pressure at equilibrium be P ;

$$\text{Now, } P'_{AB_2} = \left[\frac{x}{3-2x} \right] P; P'_A = \left[\frac{1-x}{3-2x} \right] P; P'_B = \left[\frac{2-2x}{3-2x} \right] P$$

$$\therefore K_P = \frac{x \cdot P}{(3-2x) \cdot P \cdot \frac{(1-x)}{(3-2x)} \cdot P^2 \frac{(2-2x)^2}{(3-2x)^2}}$$

$$K_P = \frac{x \cdot (3-2x)^2}{P^2 (1-x)(2-2x)^2} \quad \text{..... (i)}$$

Alternate to derive K_P of equation (i)

$$\therefore K_P = \frac{n_{AB_2}}{n_A \times (n_B)^2} \times \left(\frac{P}{\sum n} \right)$$

$$\therefore K_P = \frac{x}{(1-x)(2-2x)^2} \times \left[\frac{P}{(3-2x)} \right]^{-2} = \frac{x(3-2x)^2}{(1-x)(2-2x)^2 \cdot P^2} \quad \text{..... (i)}$$

Given that, $x = 0.6$ and $\Delta n = -2$

$$\therefore K_P = K_C (RT)^{\Delta n} = 0.3475 \times (0.0821 \times 473)^{-2} \quad \text{..... (ii)}$$

By equation (i) and (ii),

$$\therefore 0.3475 \times (0.0821 \times 473)^{-2} = \frac{0.6(3-1.2)^2}{P^2 (1-0.6)(2-1.2)^2} = \frac{0.6 \times (1.8)^2}{P^2 (0.4)(0.8)^2}$$

$$\therefore P = 181.5 \text{ atm}$$

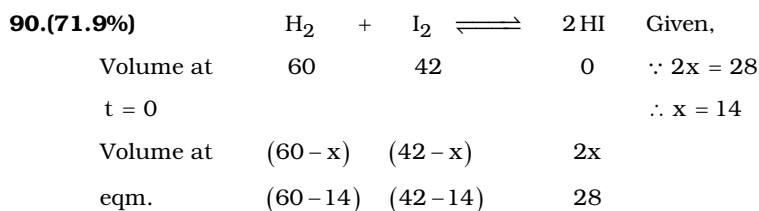


$$\begin{array}{lcl} \text{Moles at eqm} & \frac{1638.4}{128} & \frac{7.8}{2} \quad \frac{203.2}{254} \\ & = 12.8 & 3.9 \quad 0.8 \end{array}$$

Let volume of container be V L

$$[\text{H}_2] = \frac{3.9}{V}; [\text{HI}] = \frac{12.8}{V}; [\text{I}_2] = \frac{0.8}{V}$$

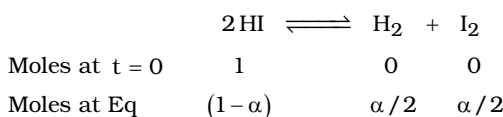
$$\therefore K_c = \frac{[H_2][I_2]}{[HI]^2} = \frac{3.9 \times 0.8}{V \times V \times \left(\frac{12.8}{V}\right)^2} = 0.019 \quad \therefore K_c = 0.019$$



Since at constant P and T, moles \propto Volume of gas (By $PV = nRT$). Thus, volume of gases given can be directly, used as concentration. Thus can be done only for reactions leaving $\Delta n = 0$.

$$\therefore K_c = \frac{28 \times 28}{46 \times 28} = \frac{28}{46}$$

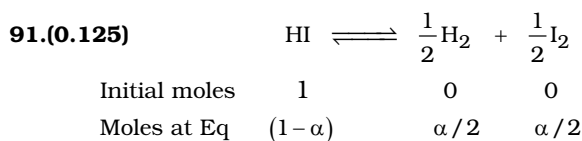
Now for dissociation of HI



Where α is degree of dissociation

$$K_{c1} = \frac{\alpha^2}{4(1 - \alpha)^2} = \frac{1}{K_c}$$

$$\therefore \frac{\alpha}{2(1 - \alpha)} = \sqrt{\left(\frac{46}{28}\right)} \quad \therefore \alpha = 0.719 \text{ or } 71.9\%$$



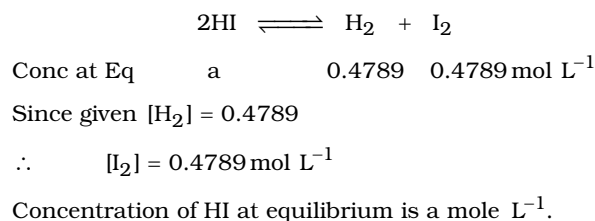
Where α is degree of dissociation and volume of container is VL.

$$K_P = K_c = \frac{\left(\frac{\alpha}{2V}\right)^{1/2} \left(\frac{\alpha}{2V}\right)^{1/2}}{\frac{(1 - \alpha)}{V}} \Rightarrow K_P = K_c = \frac{\alpha}{2(1 - \alpha)} \Rightarrow \alpha = 0.2$$

$$K_P = K_c = \frac{0.2}{2(1 - 0.2)} \Rightarrow K_P = K_c = 0.125$$



$$\therefore \Delta n = 0 \quad \therefore K_P = K_c = 1.84 \times 10^{-2}$$



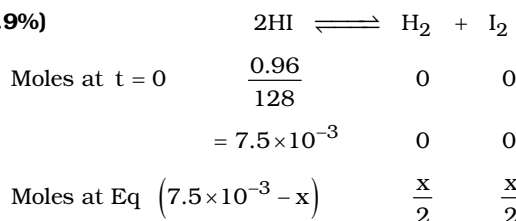
$$\therefore K_C = \frac{[H_2][I_2]}{[HI]^2} = \frac{0.4789 \times 0.4789}{a^2}$$

$$\therefore a^2 = \frac{0.4789 \times 0.4789}{1.84 \times 10^{-2}} \quad (\because K_C = 1.84 \times 10^{-2})$$

$$\therefore a = 3.53$$

$$\text{or } [HI] \text{ at equilibrium} = 3.53 \text{ mol L}^{-1}$$

93.(20.9%)



mEq of I_2 formed at equilibrium = mEq of hypo used for reaction mixture.

$$\frac{w_{I_2}}{E} \times 1000 = 15.7 \times \frac{1}{10}$$

$$\therefore \left(\frac{w}{E}\right) \text{ of } I_2 = 1.57 \times 10^{-3}$$

$$\therefore \text{Moles of } I_2 \text{ formed} = \frac{1.57 \times 10^{-3}}{2} = 0.785 \times 10^{-3}$$

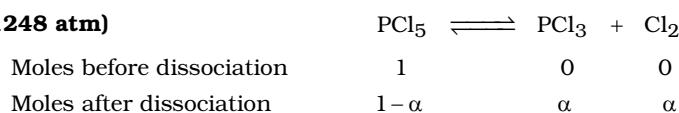
$$\frac{x}{2} = 0.785 \times 10^{-3} \Rightarrow x = 1.57 \times 10^{-3}$$

$$\therefore \text{Degree of dissociation of HI (or } \alpha_{HI}) = \frac{\text{Moles dissociated}}{\text{Moles taken}} = \frac{1.57 \times 10^{-3}}{7.5 \times 10^{-3}}$$

$$\alpha_{HI} = 0.209 \text{ or } 20.9\%$$

94.(D)

95.(0.1248 atm)



Given = 0.2 at 1 atm pressure

$$\therefore K_P = \frac{n_{PCl_3} \times n_{Cl_2}}{n_{PCl_5}} \times \left[\frac{P}{\sum n} \right]^{\Delta n} = \frac{\alpha \cdot \alpha}{(1 - \alpha)} \left[\frac{P}{1 + \alpha} \right] = \frac{P\alpha^2}{1 - \alpha^2} = \frac{1 \times (0.2)^2}{1 - (0.2)^2}$$

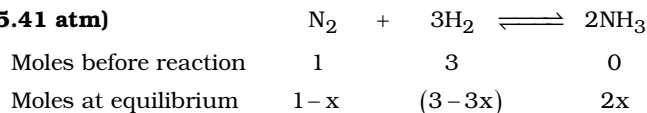
$$K_P = 0.0416 \text{ atm}$$

Again when α is desired at 0.5, K_P remains constant and thus,

$$K_P = \frac{P\alpha^2}{1 - \alpha^2}$$

$$0.0416 = \frac{P \times (0.5)^2}{1 - (0.5)^2}; \therefore P = 0.1248 \text{ atm}$$

96.(105.41 atm)



Given mole fraction of $NH_3 = 0.012$ at $P = 10 \text{ atm}$

$$\therefore \frac{2x}{(4-2x)} = 0.012 \Rightarrow x = 0.0237$$

$$\therefore K_P = \frac{(P'_{\text{NH}_3})}{P'_{\text{N}_2} \times (P'_{\text{H}_2})^3} = \frac{\left[\frac{2x \cdot P}{(4-2x)} \right]^2}{\frac{(1-x) \cdot P}{(4-2x)} \left[\frac{(3-3x)P}{(4-2x)} \right]^3}$$

$$K_P = \frac{4x^2(4-2x)^2}{(1-x)(3-3x)^3 P^2} = \frac{4(0.0237)^2 [4-2(0.0237)]^2}{(1-0.0237)[3-3(0.0237)]^3 \times 100}$$

$$K_P = 1.431 \times 10^{-5} \text{ atm}^{-2}$$

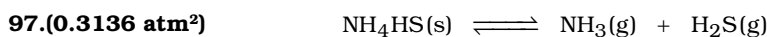
Let mole % of NH_3 in equilibrium mixture be increased to 10.4 at pressure P.

$$\therefore \frac{2x}{4-2x} = \frac{10.4}{100} \text{ or } x = 0.1884$$

Now again using equation (i)

$$K_P = \frac{4x^2(4-2x)^2}{(1-x)(3-3x)^3 \cdot P^2}$$

$$1.431 \times 10^{-5} = \frac{[4 \times (0.1884)^2][4-2(0.1884)]^2}{[1-0.1884][3-3(0.1884)]^3 \times P^2} \Rightarrow P = 105.41 \text{ atm}$$



Pressure at equil. P P

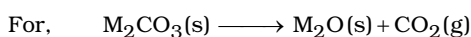
\therefore Total pressure at equilibrium = $2P = 1.12 \text{ atm}$

$\therefore P = 1.12 / 2 \text{ atm}$

$\therefore K_P = P'_{\text{NH}_3} \times P'_{\text{H}_2\text{S}}$

$\therefore K_P = \frac{1.12}{2} \times \frac{1.12}{2} = 0.3136 \text{ atm}^2$

98. ($P_{\text{CO}_2} < 0.0095 \text{ atm}$)



$\therefore \text{CO}_2$ is 1 % in air,

$$P'_{\text{CO}_2} = \frac{1}{100} \times P_{\text{air}} = \frac{1}{100} \times 1 \text{ atm}$$

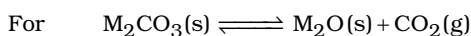
Also, for equilibrium $K_P = P'_{\text{CO}_2} = 0.0095 \text{ atm}$

\therefore Given, $P'_{\text{CO}_2} = 0.01 \text{ atm}$

Since decomposition is carried out in presence of P'_{CO_2} of 0.01 atm and $K_P = 0.0095 \text{ atm}$, thus, practically no decomposition of M_2CO_3 . Thus, 1 % CO_2 is sufficient to prevent any loss in weight.

If at all the reaction is desired, P'_{CO_2} must be lesser than 0.0095 atm as P'_{CO_2} at equilibrium cannot be more than 0.0095 atm.

Alternate method :



$$P_{\text{CO}_2} = \left(\frac{1}{100} + P \right)$$

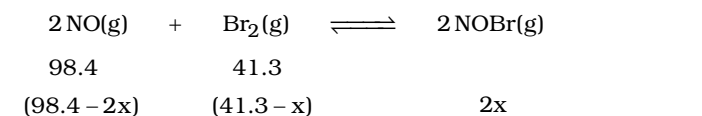
$\therefore K_P = P_{\text{CO}_2}$ and the pressure of CO_2 already present is $1/100$ atm. Let the decomposition of M_2CO_3 produces the CO_2 of pressure P , then

$$\therefore K_P = \frac{1}{100} + P \text{ or } 0.0095 = P + 0.01 \text{ or } P = -0.0005$$

The value of pressure comes negative and thus, it may be concluded that M_2CO_3 will not dissociate in pressure of CO_2 of pressure 0.01 atm.

99.(B) By Le-Chatelier's principle, due to increase in pressure equilibrium shifts in the direction of low pressure (in which number of mol decreases) i.e., forward side.

100.(-12.22 KJ mol⁻¹)



$$P_t \text{ (at equilibrium)} = (98.4 - 2x) + (41.3 - x) + 2x = 110.5 \text{ (given)}$$

$$\Rightarrow x = 29.2$$

$$\left[\begin{array}{l} P_{\text{NO}} = 98.4 - 2x = 40 \\ P_{\text{Br}_2} = 41.3 - x = 12.1 \\ P_{\text{NOBr}} = 2x = 58.4 \end{array} \right] \Rightarrow K_P = \frac{P_{\text{NOBr}}^2}{P_{\text{NO}}^2 P_{\text{Br}_2}} = 0.1762 \text{ torr}^{-1}$$

K_P = should be in atm units for calculation of $\Delta^\circ G$

$$K_P = 0.1762 \times 760 = 133.9 \text{ atm}^{-1}$$

$$\Delta^\circ G = -2.303RT \log K_P = -12216.26 \text{ J mol}^{-1} = -12.22 \text{ kJ mol}^{-1}$$