Miscellaneous Exercise Question Bank

1.(A)

$$\begin{array}{lcccc} & FeO(s) & + \; CO(g) & \rightleftharpoons \; Fe(s) & + \; CO_2(g) \\ \text{At eq.} & — & 0.025 & — & x \\ & \text{solid} & & \text{solid} & \end{array}$$

$$K_c = \left[\frac{CO_2(g)}{CO(g)}\right] = \frac{x}{0.025} = 5 \text{ (given)}$$

$$\therefore \quad x = 0.125\,M \quad \Rightarrow \quad [CO_2] = 0.125\,M$$

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) $$K_p = \frac{P^4_{S_2(g)}}{P_{S_8(g)}} = \frac{(4 \times 0.3)^4}{0.70} = 2.96$$

4.(C) $$K_p = \frac{1}{P^4_{H_2O(g)}} \quad \Rightarrow \quad P_{H_2O(g)} = \left(\frac{1}{K_p}\right)^{1/4} \quad \Rightarrow \quad (10^{-12})^{1/4} = 10^{-3}\text{ atm}$$

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

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

6.(A) $$K_c = \frac{[H_2S(g)]}{[H_2(g)]} \quad \Rightarrow \quad 8 \times 10^{-2} = \frac{x}{0.3 - x} \quad \Rightarrow \quad x = 0.022$$

$$[H_2S(g)] = \frac{0.022}{2} = 0.011\,M$$

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

8.(B)

$$\begin{array}{lcccc} & H_2(g) & + \; CO_2(g) & \rightleftharpoons \; H_2O(g) & + \; CO(g) \\ \text{moles of eqm.} & 0.8 - x & 0.8 - x & x & x \\ \text{Conc. at eqm.} & \frac{0.8 - x}{5} & \left(\frac{0.8 - x}{5}\right) & \left(\frac{x}{5}\right) & \left(\frac{x}{5}\right) \end{array}$$

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

$$[CO_2(g)] = \frac{0.8 - 0.533}{5}$$

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

$$\begin{array}{lcc} & N_2O_4(g) \rightleftharpoons & 2NO_2(g) \\ \text{Initial moles} & a & 0 \\ \text{at equilibrium} & a(1-\alpha) & 2a\alpha \end{array}$$

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

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

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

10.(B)

$$\begin{array}{lccccc} & CO & + & H_2O \rightleftharpoons & CO_2 & + \; H_2 \\ \text{Initial moles} & 3 & & 3 & x & 0 \\ \text{At equilibrium} & 2 & & 2 & (x+1) & 1 \end{array}$$

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

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

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

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

13.(A)

$$\begin{array}{lccc} & A_2(g) \; + & B_2(g) \rightleftharpoons & 2AB(g) \\ \text{Initial conc.} & 10/2 & 15/2 & 5/2 \\ \text{at equilibrium} & 5-x & 7.5-x & 2.5+2x \end{array}$$

$\because \quad 2.5 + 2x = 7.5 \quad \Rightarrow \quad x = 2.5$

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

14.(A)

$$\begin{array}{lccc} & H_2(g) \; + & S(s) \rightleftharpoons & H_2S(g) \\ \text{Conc. at eqm} & (0.5-x) & - & x \end{array}$$

$$K_c = \frac{[H_2S]}{[H_2]} \quad \Rightarrow \quad 7 \times 10^{-2} = \frac{x}{0.5-x} \quad \Rightarrow \quad x = 0.0327$$

$$P_{H_2S} = \left(\frac{n_{H_2S}}{V}\right)RT = 0.0327 \times 0.0821 \times 360 = 0.966$$

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 %

$P_{Cl_2} = P_{PCl_3}$

$\Rightarrow \quad 2 \times 0.40 = 0.80\,atm$

$PCl_5 = 2 \times 0.2 = 0.40\,atm$

$$\therefore \quad K_p = \frac{P_{PCl_3} \cdot P_{PCl_2}}{P_{PCl_5}} = \frac{0.80 \times 0.80}{0.40} = 1.6\,atm$$

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

$$K_p = \frac{P^2_{H_2O}}{P^2_{H_2}} = \frac{(0.55)^2}{(0.45)^2} = 1.49$$

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

Mole % of XCO_3 decomposed $= \frac{1}{4} \times 100 = 25\%$

Hence, 75 % remains undecomposed

18.(B) Let initial moles of $H_2(g)$ is 1

$$\begin{array}{lccccccc} & Fe_2O_3(s) & + & 3H_2(g) & \rightleftharpoons & 2Fe(s) & + & 3H_2O(g) \\ \text{at equilibrium} & - & & 1-3x & & - & & 3x \end{array}$$

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

% of H_2 unreacted $= \frac{1-3 \times 0.22}{1} \times 100 = 34$

19.(C)

$$\begin{array}{lccccc} & AB_3(g) & \rightleftharpoons & AB_2(g) & + & \frac{1}{2}B_2(g) \\ \text{At equilibrium} & 800-x & & x & & x/2 \end{array}$$

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

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

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

$$\begin{array}{lccccc} & 2NO_2(g) & \rightleftharpoons & 2NO(g) & + & O_2(g) \\ \text{At equilibrium} & P-2x & & 2x & & x \end{array}$$

as per given $x = 0.25$

$$K_p = \frac{(2x)^2(x)}{(P-2x)^2} \quad \Rightarrow \quad 156.25 = \frac{(0.5)^2(0.25)}{P^2_{NO_2}} \quad \Rightarrow \quad P_{NO_2} = 0.02$$

21.(B)

$$\begin{array}{lccccc} & 2NOCl(g) & \rightleftharpoons & 2NO(g) & + & Cl_2(g) \\ \text{At equilibrium} & P-2x & & 2x & & x \end{array}$$

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

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

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

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

$$\begin{array}{lccccccc} & A_2(g) & + & B_2(g) & \rightleftharpoons & C_2(g) & + & D_2(g) \\ \text{Conc. equilibrium} & \frac{1+x}{10} & & \frac{1+x}{10} & & \frac{1-x}{10} & & \frac{1-x}{10} \end{array}$$

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

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

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

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

Therefore $T_3 < T_2 < T_1$

26.(A)

$$\begin{array}{lcccc} & NH_4HS(s) & \rightleftharpoons & NH_3(g) & + & H_2S(g) \\ \text{At } t = 0 & 0.06 & & 0 & & 0 \\ \text{At } t = eq & (0.06 - 0.018) & & 0.018 & & 0.018 \\ \text{Melar conc.} & 1 & & \frac{0.018}{2} & & \frac{0.018}{2} \end{array}$$

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

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

27.(C) Variation of equilibrium constant with temperature $\ln k = \dfrac{\Delta S^\circ_r}{R} - \dfrac{\Delta H^\circ_r}{RT}$

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

$\Delta_r H^\circ = 147.41\,kJ/mol$

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

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

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

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

$K_p = (0.1)^2 = 0.01$

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

32.(A) $C(s) + CO_2(g) \rightleftharpoons 2CO(g);$ .... **(i)**

$$K_{p_1} = 10^{14}\ \text{atm}$$

$2CO + 2Cl_2(g) \rightleftharpoons 2COCl_2(g);$ .... **(ii)**

$$K_{p_2} = (6\times10^{-3})^2\,\text{atm}^{-2}$$

Add (i) and (ii)

$$C(s) + CO_2(g) + 2Cl_2(g) \rightleftharpoons 2COCl_2(g);$$

$$K_p = 10^{14}\times36\times10^{-6} = 36\times10^8$$

For given reaction $\Delta n_g = -1$

$$\therefore \quad K_c = K_p(RT) = 36\times10^8\times0.0821\times1120$$

$$K_c = 3.31\times10^{11}\ M^{-1}$$

33.(C)

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

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

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

34.(D) $P_{total} = P_{HNO_3} + P_{NO_2} + P_{H_2O} + P_{O_2}$

$\because \quad P_{NO_2} = 4P_{O_2}$ and $P_{H_2O} = 2P_{O_2}$

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

$\Rightarrow \quad 30 - 2 = P_{O_2}\times7 \quad \Rightarrow \quad P_{O_2} = \frac{28}{7} = 4$

$$K_p = \frac{P^4_{NO_2}\cdot P^2_{H_2O}\cdot P_{O_2}}{P^4_{HNO_3}} = \frac{(4\times4)^4\times(2\times4)^2\times4}{2^4} = 2^{20}$$

$$K_p = K_c(RT)^{\Delta n_g} = K_c(0.08\times400)^3 \quad \Rightarrow \quad K_c = \frac{2^{20}}{(32)^3} = 32$$

35.(D) $LiCl\cdot3NH_3(s) \rightleftharpoons LiCl\cdot NH_3(s) + 2NH_3(g);$ $[K_P = 9\,\text{atm}^2]$

Therefore,

	$LiCl\cdot NH_3(s)$	$+\ 2NH_3(g)$	$\rightleftharpoons\ LiCl\cdot3NH_3(s);$
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.

At eqm. $K'_P = \dfrac{1}{(P'_{NH_3})^2}$ or $\dfrac{1}{9} = \dfrac{1}{(P'_{NH_3})^2}$

$\therefore$ $P'_{NH_3} = 3\,\text{atm}$

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

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

$\therefore$ initial moles of $NH_3 = 0.79$

36.(C)

$$\begin{array}{lccc} & C_2H_6(g) & \rightleftharpoons C_2H_4(g) & + \; H_2(g) \\ \text{At eqm.} & 1-x & x & x \end{array}$$

$$K_P = \frac{P_{C_2H_4} \cdot P_{H_2}}{P_{C_2H_6}} \Rightarrow \frac{x^2}{1-x} = 5 \times 10^{-2}$$

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

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

Partial pressure of C_2H_6 = mole fraction × total pressure

$\Rightarrow$ 0.80 = mole fraction $\times 1.2$

$\therefore$ mole % of $C_2H_6 = \dfrac{0.8}{1.2} \times 100 = 66.66$

37.(A)

$$\begin{array}{lccc} & 2\,NOBr(g) & \rightleftharpoons 2\,NO(g) & + \; Br_2(g) \\ \text{Initial pressure} & P & 0 & 0 \\ \text{at eqm} & P-2x & 2x & x \end{array}$$

where $2x = 0.40\,P$

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

$$K_P = \frac{P_{NO}^2 \cdot P_{Br_2}}{P_{NOBr}^2} = \frac{(0.4P)^2\,(0.2P)}{(0.6P)^2} = 0.0222$$

$\therefore$ K_P for the reaction $2\,NO(g) + Br_2(g) \rightleftharpoons 2\,NOBr(g)$ is $\dfrac{1}{0.0222} = 45$

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

$$\begin{array}{lccc} & 2A(g) & \rightleftharpoons 2\,B(g) & + \; C(g) \\ \text{At eqm.} & 400\text{ mL} & 200\text{ mL} & 100\text{ mL} \end{array}$$

for ideal gases volume % = mole %

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

39.(C)

$$\begin{array}{lcccc} & SO_2(g) & + \; NO_2(g) & \rightleftharpoons SO_3(g) & + \; NO(g) \\ \text{Initial moles} & 2 & 2 & 2 & 2 \\ \text{at eqm} & 2-x & 2-x & 2+x & 2+x \end{array}$$

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

$$K_P = \frac{P_{SO_3} \cdot P_{NO}}{P_{SO_2} \cdot P_{NO_2}}$$

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

Partial pressure of $NO_2 = \frac{2-x}{10} \times P_{total} = \frac{0.666}{10} \times 2 = 0.133\,\text{atm}$

40.(B) $2\,SO_2(g) + O_2(g) \rightleftharpoons 2\,SO_3(g)$

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

Another vessel

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

moles at eqm $\quad 0.5 - 2x \qquad y - x \qquad 2x$

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

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

Initial moles $\quad 1 \qquad 0$

At equilibrium $\quad 1 - \alpha \qquad 2\alpha$

Total number of moles at equilibrium $= 1 + \alpha$

$$P_{N_2O_4} = \frac{1-\alpha}{1+\alpha} \times P$$

$$P_{NO_2} = \frac{2\alpha}{(1+\alpha)} \times P$$

Hence, $\quad K_P = \frac{P_{NO_2}^2}{P_{N_2O_4}} = \frac{4\alpha^2}{(1-\alpha)^2} \times P$

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

Mole fraction of N_2O_4 : $X_{N_2O_4} = \frac{1-\alpha}{1+\alpha} = 0.25 \qquad \therefore \qquad X_{NO_2} = 0.75$

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

42.(A) $2AB(s) \rightleftharpoons A_2(g) \; + \; B_2(g)$

$\qquad\qquad 0.5 + x \qquad x$

$K_P = P_{A_2} \cdot P_{B_2}$

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

$P_{total} = P_{A_2} + P_{B_2} = 0.6 + 0.1 = 0.70\,\text{atm}$

43.(A)

$$\begin{array}{lcccc} & 2A(g) + & B(g) \rightleftharpoons & C(g) + & D(g) \\ \text{Initial moles} & 2 & 1 & 7 & 3 \\ \text{at eqm} & 2-2x & 1-x & 7+x & 3+x \end{array}$$

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

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

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

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

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

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

$$\begin{array}{lccc} & H_3BO_3 \ + & \text{glycerin} \rightleftharpoons & (H_3BO_3 - \text{glycerin}) \\ \text{At eqm} & 0.1-x & a-x & x \end{array}$$

$$x = 0.1 \times \frac{80}{100} = 0.08;$$

$$a - x = 4.44 \quad \Rightarrow \quad a = 4.44 + 0.08 = 4.52\,M$$

or Initial moles $= 4.52$

45.(C)

$$\begin{array}{lccc} & 2SO_3(g) \rightleftharpoons & 2SO_2(g) + & O_2(g) \\ \text{Moles at eqm} & 1-2x & 2x & x \end{array}$$

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

So equivalent of SO_2 = equivalent of $KMnO_4$

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

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

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

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

So, pH = 11.3

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

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

$$\Delta^oG = 2 \times \Delta^oG_{NO_2} - \Delta^oG_{N_2O_4} = 2 \times 50 - 100 = 0$$

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

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

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

Now, $N_2O_4 \rightleftharpoons 2NO_2$

$$\begin{array}{cc} 5 & 2 \\ 5-x & 2+2x \end{array}$$

$\therefore$ $K_C = \frac{[NO_2]^2}{[N_2O_4]} = 1 = \frac{(2+2x)^2}{5-x}$ or $x = 0.106$

49.(BD) $A_2 \rightleftharpoons 2C + D$

$$\begin{array}{lccc} \text{Initial} & 1 & 0 & 0 \\ \text{At eqm} & 1-\alpha & 2\alpha & \alpha \end{array}$$

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

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

51.(A) $2AB_2(g) \rightleftharpoons 2AB(g) + B_2(g)$

$$\begin{array}{lccc} \text{At. Eq} & 1-x & x & x/2 \end{array}$$

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

$p(AB_2) = \frac{2(1-x)}{2+x}p$

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

$p(B_2) = \left(\frac{x}{2+x}\right)p$

$k_p = \frac{(pAB)^2\,(pB_2)}{(pAB_2)^2}$

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

As x is very small

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

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

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

52.(C) $C_2H_5OH(\ell) \rightleftharpoons C_2H_5OH(g)$

$\Delta G^\circ = \left[\Delta G_f^\circ(C_2H_5OH)(g) - \Delta G_f^\circ(C_2H_5OH)(l)\right]$

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

$\Delta G^\circ = -RT\ell nk$

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

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

$k = k_p = p(C_2H_5OH) = 0.079\,atm$

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

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

$\Delta n =$ mole of product (g) – moles of reactant (g)

54.(BCD) $K_1 = \frac{K_f}{K_b} = \frac{2\times10^{-2}}{4\times10^{-3}} = 5$ at 300 K

55.(D)

$$PCl_5 \rightleftharpoons PCl_3 + Cl_2$$

	PCl_5	PCl_3	Cl_2
Initial	1	0	0
Final	$1-\alpha$	α	α
Partial pressure	$=\frac{1-\alpha}{1+\alpha}\cdot P$	$\frac{\alpha}{1+\alpha}\cdot P$	$\frac{\alpha}{1+\alpha}\cdot P$

Total mole $= 1-\alpha+\alpha+\alpha = 1+\alpha$

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

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).

59.(C)

$$N_2O_4 \rightleftharpoons 2NO_2$$

At equim. 0.2 mol 2×10^{-3} mol

$$K_c = \frac{[NO_2]^2}{[N_2O_4]} = \frac{(2\times10^{-3})^2}{(0.2)\times2}$$

60.(C)

$$N_2O_4 \longrightarrow 2NO_2$$

	N_2O_4	$2NO_2$	
initial	1	0	
at equim.	$1-0.2$	0.4	Total moles = 1.2

$p_{N_2O_4} = \frac{0.8}{1.2}\cdot p_{total}$ $\quad p_{NO_2} = \frac{0.4}{1.2}\cdot P_{total}$

$$K_p = \frac{p_{NO_2}^2}{p_{N_2O_4}}$$

61.(B)

$$CO_2 \rightleftharpoons CO + \frac{1}{2}O_2$$

	CO_2	CO	$\frac{1}{2}O_2$
Initial	4	0	0
At equim.	3	1	$\frac{1}{2}$

Moles of CO at equilibrium $= 1$

62.(C)

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

	$N_2(g)$	$3H_2(g)$	$2NH_3(g)$
Initial	1	3	0
At equim.	0.5	1.5	1

Total moles of gas at equilibrium = 3

63.(B)

$$H_2 + I_2 \rightleftharpoons 2HI$$

	H_2	I_2	$2HI$
Initial	1	1	0
Final	$\frac{1-\alpha}{v}$	$\frac{1-\alpha}{v}$	$\frac{2\alpha}{v}$

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

$\therefore$ K does not depend on volume.

So on reducing volume to half K does not change.

$\therefore \quad K = 50$

64.(B)

$$XY_2 \rightleftharpoons XY + Y$$

	XY_2	XY	Y
Initial	P	0	0
Final	$P-x$	x	x

Initial $P = 600\,\text{mm Hg}$, Final $P = 800\,\text{mm Hg}$

Total moles $\propto$ final P.

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

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

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

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

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

66.(C)

$$2HX \rightleftharpoons H_2(g) + X_2(g)$$

	$2HX$	$H_2(g)$	$X_2(g)$
At equilibrium	?	$1.2 \times 10^{-3}M$	$1.2 \times 10^{-4}M$

$$K = \frac{[H_2][X_2]}{[HX]^2}$$

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

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

67.(B) **(i)** $S^{2-} + S \longrightarrow S_2^{2-}$ ..... k_1

(ii) $S_2^{2-} + S \longrightarrow S_3^{2-}$ ..... k_2

(iii) $S_3^{2-} \longrightarrow S^{2-} + 2S,$ ..... k_3

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

68.(D) **(a)** $HgCl^+ + Cl^- \longrightarrow HgCl_2$ ..... K_1

(b) $HgCl_2 + Cl^- \longrightarrow HgCl_3^-$ ..... K_2

The eq. constant (k) for the reaction,

$$2HgCl_2 \longrightarrow HgCl^+ + HgCl_3^-$$

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

$$N_2O_4 \rightleftharpoons 2NO_2$$

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

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

	N_2O_4	$\rightleftharpoons$	$2NO_2$
Initial	1		0
At equilibrium	$1 - \alpha$		2α

Number of moles of NO_2 at eq. $= 2\alpha = 2 \times 0.2 = 0.4$

70.(B)

	N_2O_4	$\rightleftharpoons$	$2NO_2$
At equilibrium	$1 - \alpha$		2α

Number of moles of $N_2O_4 = 1 - \alpha = 1 - 0.2 = 0.8$

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 $N_2O_4 = \frac{0.8 \times 100}{92} = 0.86$

71.(B)

	$2SO_3$	$\rightleftharpoons$	$2SO_2$	+	O_2
Initial	1		0		0
At equilibrium	$1 - 2x$		$2x$		x

$\therefore \quad 2x = 0.6, \; \therefore \; x = 0.3$

$[SO_3] = 1 - 2x = 1 - 06 = 0.4$

$[SO_2] = 2x = 0.6$

$[O_2] = x = 0.3$

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

72.(C)

$$\begin{array}{lcccccccc} & W & + & X & \rightleftharpoons & Y & + & Z, \\ \text{Initial} & 1 & & 1 & & 0 & & 0 \\ \text{At eq.} & 1-x & & 1-x & & x & & x \end{array}$$

$$K = 9 = \frac{x^2}{(1-x)^2} \qquad \therefore \quad x = 0.75$$

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.

74.(A) $N_2 + O_2 \rightleftharpoons 2NO$ .... **(i)**

$NO \rightleftharpoons \frac{1}{2}N_2 + \frac{1}{2}O_2$ .... **(ii)**

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

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

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.** $Q = \frac{[NO_2]^2}{[N_2O_4]}$

Since, $[NO]_2$ is maximum and $[N_2O_4]$ 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

77.(A)

$$\begin{array}{lcccccc} & A(g) & + & 2B(g) & \rightleftharpoons & C(g) \\ \text{At eq} & 0.06M & & 0.12M & & 0.216M \end{array}$$

$$K = \frac{[C]}{[B^2][A]} = \frac{0.216}{0.12 \times 0.12 \times 0.06} = 250$$

78.(B)

$$\begin{array}{lcccccccc} & A & + & B & \rightleftharpoons & C & + & D \\ \text{Initial} & 4 & & 4 & & 0 & & 0 \\ \text{Final} & 4-x & & 4-x & & x & & x \end{array}$$

$x = 2$

$\therefore \quad [A] = 4 - 2 = 2, \; [B] = 4 - 2 = 2$

$[C] = 2, \qquad [D] = 2$

$$K = \frac{[C][D]}{[A][B]} = \frac{2 \times 2}{2 \times 2} = 1$$

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

	$2HI \rightleftharpoons$	H_2	$+\ I_2$
Initial	2	0	0
Final	$(2-2\alpha)$	α	α

$$K = \frac{\alpha^2}{(2-2\alpha)^2} = \frac{0.5\times0.5}{(2-2\times0.5)} = 0.25$$

80.(A) $A(g) \rightleftharpoons B(g)+C(g)$

(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.

81.(C)

	$2AB_3(g) \rightleftharpoons$	$A_2(g)$	$+\ 3B_2(g)$
Initial	8	0	0
At eq.	$\frac{8-2x}{1}$	$\frac{x}{1}$	$\frac{3x}{1}$

Since volume $= 1\,dm^3 = 1\,L$

At eq. $[A_2] = 2\,mol = x$

$\therefore$ $[AB_3] = 8-2\times2 = 4\,M$

$[A_2] = 2\,M$

$[B_2] = 3\times2 = 6\,M$

$$K = \frac{[B_2]^3[A_2]}{[AB_3]^2} = \frac{6\times6\times6\times2}{4\times4} = 27\,mol^2\,L^{-2}$$

82.(D)

	$XY(g) \rightleftharpoons$	$X(g)$	$+\ Y(g)$
Initial	1	0	0.2
At Eq	$1-x$	x	$0.2+x$

At Eq. $[Y] = 0.2+x = 0.6$

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

$[XY] = 1-0.4\,mol = 0.6\,M$

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

$$K = \frac{[X][Y]}{[XY]} = \frac{0.4\times0.6}{0.6} = 0.4\,mol\,L^{-1}$$

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) $K_P = \frac{[P_{NO_2}]^2}{[P_{N_2O_4}]} = \frac{atm^2}{atm} = atm$

Hence statement (C) is incorrect.

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

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

$\Delta n = 2 - 1 = 1$

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.

84.(A) $X(s) \rightleftharpoons A(g) + C(g)$

20 mm 20 mm

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

and $Y(s) \rightleftharpoons B(g) + C(g)$

30 mm 30 mm

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

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

$X(s) \rightleftharpoons A(g) + C(g)$

$P_1 \quad (P_1 + P_2)$

$Y(s) \rightleftharpoons B(g) + C(g)$

$P_2 \quad (P_2 + P_1)$

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

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 $P_1 = 23.09$, $P_2 = 51.75$

$\therefore \quad P_1 + P_2 = 74.84\,mm$

Hence, (B) is the correct answer

87.(0.0694 atm) $NH_4CN(g) \rightleftharpoons NH_3(g) + HCN(g)$

	$NH_4CN(g)$	$NH_3(g)$	$HCN(g)$
Partial pressure at equilibrium	0	P	P

$\because$ Total pressure at equilibrium $= 2P = 0.298\,atm$

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

Also, $K_P = P'_{NH_3} \times P'_{HCN} = 0.149 \times 0.149 = 0.0222\,\text{atm}^2$

Now dissociation is made when, $P_{NH_3} = 0.25\,\text{atm}$

	$NH_4CN(s) \rightleftharpoons$	NH_3	+	HCN
Initial pressure		0.25		0
Pressure at eqm		$0.25 + P'$		P'

$\therefore \quad K_P = P'(P' + 0.25)$

$\therefore \quad 0.0222 = P'(P' + 0.25)$

$\therefore \quad P' = 0.0694\,\text{atm}$

88.(181.5 atm) $A + 2B \rightleftharpoons AB_2$

	A	2B	AB_2
Initial moles	1	2	0
Moles at eqm	$(1-x)$	$(2-2x)$	x

Total moles at equilibrium $= 1 - x + 2 - 2x + x = 3 - 2x$

Let pressure at equilibrium be P ;

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

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

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

Alternate to derive K_P of equation (i)

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

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

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

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

By equation (i) and (ii),

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

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

89.(0.019) $2HI \rightleftharpoons H_2 + I_2$

	$2HI$	H_2	I_2
Moles at eqm	$\frac{1638.4}{128}$	$\frac{7.8}{2}$	$\frac{203.2}{254}$
	$= 12.8$	3.9	0.8

Let volume of container be VL

$$[H_2] = \frac{3.9}{V};\ [HI] = \frac{12.8}{V};\ [I_2] = \frac{0.8}{V}$$

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

90.(71.9%)

	H_2	+	I_2	$\rightleftharpoons$	$2\,HI$	Given,
Volume at	60		42		0	$\because 2x = 28$
t = 0						$\therefore x = 14$
Volume at	$(60-x)$		$(42-x)$		$2x$	
eqm.	$(60-14)$		$(42-14)$		28	

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 $\Delta n = 0$.

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

Now for dissociation of HI

	$2\,HI$	$\rightleftharpoons$	H_2	+	I_2
Moles at $t = 0$	1		0		0
Moles at Eq	$(1-\alpha)$		$\alpha/2$		$\alpha/2$

Where α is degree of dissociation

$$K_{c_1} = \frac{\alpha^2}{4(1-\alpha)^2} = \frac{1}{K_c}$$

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

91.(0.125)

	HI	$\rightleftharpoons$	$\frac{1}{2}H_2$	+	$\frac{1}{2}I_2$
Initial moles	1		0		0
Moles at Eq	$(1-\alpha)$		$\alpha/2$		$\alpha/2$

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

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

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

92.(3.53) Given, $K_P = 1.84 \times 10^{-2}$

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

	$2HI$	$\rightleftharpoons$	H_2	+	I_2
Conc at Eq	a		0.4789		$0.4789\,\text{mol L}^{-1}$

Since given $[H_2] = 0.4789$

$\therefore \quad [I_2] = 0.4789\,\text{mol L}^{-1}$

Concentration of HI at equilibrium is a mole L^{-1}.

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

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

$$\therefore \quad a = 3.53$$

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

93.(20.9%)

	$2HI \rightleftharpoons$	H_2 +	I_2
Moles at $t = 0$	$\frac{0.96}{128}$	0	0
	$= 7.5 \times 10^{-3}$	0	0
Moles at Eq	$(7.5 \times 10^{-3} - x)$	$\frac{x}{2}$	$\frac{x}{2}$

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

$$\frac{w_{12}}{E} \times 1000 = 15.7 \times \frac{1}{10}$$

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

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

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

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

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

94.(D)

95.(0.1248 atm)

	$PCl_5 \rightleftharpoons$	PCl_3 +	Cl_2
Moles before dissociation	1	0	0
Moles after dissociation	$1 - \alpha$	α	α

Given = 0.2 at 1 atm pressure

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

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

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

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

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

96.(105.41 atm)

	N_2 +	$3H_2 \rightleftharpoons$	$2NH_3$
Moles before reaction	1	3	0
Moles at equilibrium	$1 - x$	$(3 - 3x)$	$2x$

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

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

$$\therefore \qquad K_P = \frac{\left(P'_{NH_3}\right)}{P'_{N_2} \times \left(P'_{H_2}\right)^3} = \frac{\left[\frac{2x \cdot P}{(4-2x)}\right]^2}{\frac{(1-x)\cdot P}{(4-2x)}\left[\frac{(3-3x)P}{(4-2x)}\right]^3}$$

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

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

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

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

Now again using equation (i)

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

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

97.(0.3136 atm^2) $\qquad NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g)$

Pressure at equil. $\qquad$ P $\qquad$ P

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

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

$\because$ $K_P = P'_{NH_3} \times P'_{H_2S}$

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

98.($P_{CO_2} < 0.0095\,\text{atm}$)

For, $\quad M_2CO_3(s) \longrightarrow M_2O(s) + CO_2(g)$

$\because$ CO_2 is 1 % in air,

$$P'_{CO_2} = \frac{1}{100} \times P_{air} = \frac{1}{100} \times 1\,\text{atm}$$

Also, for equilibrium $K_P = P'_{CO_2} = 0.0095\,\text{atm}$

$\because$ Given, $P'_{CO_2} = 0.01\,\text{atm}$

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 $0.0095\,\text{atm}$.

Alternate method :

For $\quad M_2CO_3(s) \rightleftharpoons M_2O(s) + CO_2(g)$

$$P_{CO_2} = \left(\frac{1}{100} + P\right)$$

$\because$ $K_P = P'_{CO_2}$ and the pressure of CO_2 already present in 1/100 atm. Let the decomposition of M_2CO_3 produces the CO_2 of pressure P, then

$\because$ $K_P = \frac{1}{100} + P$ or $0.0095 = P + 0.01$ 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-Chateller'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)

$$2NO(g) + Br_2(g) \rightleftharpoons 2NOBr(g)$$

$$\begin{array}{ccc} 98.4 & 41.3 & \\ (98.4-2x) & (41.3-x) & 2x \end{array}$$

P_t (at equilibrium) $= (98.4-2x)+(41.3-x)+2x = 110.5$(given)

$\Rightarrow$ $x = 29.2$

$$\left.\begin{array}{r} P_{NO} = 98.4-2x = 40 \\ P_{Br_2} = 41.3-x = 12.1 \\ P_{NOBr} = 2x = 58.4 \end{array}\right] \Rightarrow K_P = \frac{P^2_{NOBr}}{P^2_{NO}\,P_{Br_2}} = 0.1762\,\text{torr}^{-1}$$

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

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

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