

## EXERCISE - 1 [A]

1. (A)  
Irreversible reactions proceeds to completion while reversible reactions do not proceed to completion.
2. (C)  
Equilibrium is attained when rate of forward reaction becomes equal to rate of backward reaction.
3. (D)  
Equilibrium is attained when rate of forward reaction becomes equal to rate of backward reaction.
4. (D)  
 $r \propto [B]^2$
5. (A)  
According to law of active masses rate of reaction is directly proportional to product of active mass (molarity) raised to stoichiometric co-efficient.
6. (C)  
$$K = \frac{[MX_3]^2}{[MX_2]^2 [X_2]}$$
 $\Rightarrow$  (C)
7. (B)  
$$\left(\frac{dx}{dt}\right)_{\text{net}} = 2.6 \times 10^3 \times 10^{-6} - 4.1 \times 10^{-2}$$
$$= 2.6 \times 10^{-3} - 41 \times 10^{-3} = -ve$$
 $\Rightarrow$  (B)
8. (B)  
$$N_2O_4 \rightleftharpoons 2NO_2 \quad \Delta n_g = 1$$
$$K_p = K_c (RT)^{\Delta n_g}$$
$$\Rightarrow RT = 1 \quad (\because K_p = K_c \text{ \& } \Delta n_g = 1)$$
$$\Rightarrow T = 12.18 \text{ K}$$
9. (C)  
 $x \rightarrow \Delta n_g = -1$   
 $y \rightarrow \Delta n_g = 1$   
 $z \rightarrow \Delta n_g = 0$   
$$\frac{K_p}{K_c} = (RT)^{\Delta n_g} \quad \text{So } y > z > x$$
10. (B)  
$$K_p = (3.8 \times 10^{-3})(R \times 1000)^2$$
$$= 25.61$$

11. (B)  
 $K_P = K_C (RT)^{\Delta n_g} \Rightarrow K_C = K_P (RT)^{-\Delta n_g}$
12. (D)  
 $\frac{K_P}{K_C} = (RT)^{\Delta n_g} = (RT)^{-1/2}$   
 $\Rightarrow$  (D)
13. (B)  
 $(\because \Delta n_g < 0)$
14. (A)  
 $K_P = K_C (RT)^{\Delta n_g}$ , for  $K_P = K_C \Rightarrow (RT)^{\Delta n_g} = 1 \Rightarrow \Delta n_g = 0$
15. (B)  
 Reversing rxn II and adding when I with get rxn III  
 So  $K_3 = \frac{K_1}{K_2} = 10^{-14}$
16. (D)  
 For the rxn  $H_2 + I_2 \rightleftharpoons 2HI$   
 $r_f = 1.7 \times 10^{-18} [H_2][I_2] \Rightarrow k_f = 1.7 \times 10^{-18}$   
 $r_b = 2.4 \times 10^{-21} [HI]^2 \Rightarrow k_b = 2.4 \times 10^{-21}$   
 $\Rightarrow K_1 = \frac{1.7 \times 10^{-18}}{2.4 \times 10^{-21}}$   
 So for reaction  $\frac{1}{2}H_2 + \frac{1}{2}I_2 \rightleftharpoons HI$   
 $K = \sqrt{K_1} = \sqrt{\frac{1.7 \times 10^3}{2.4}} = 26.6$
17. (B)  
 Reversing Rxn 1 and adding with Rxn 2 we get the required reaction  
 $K_3 = \frac{K_2}{K_1} = 1.8 \times 10^{-5}$
18. (D)  
 For rxn  $HI \rightleftharpoons \frac{1}{2}H_2 + \frac{1}{2}I_2$   
 $K = \frac{1}{\sqrt{64}} = \frac{1}{8}$
19. (B)  
 Adding all reaction we get the required reaction  
 $K = K_1 K_2 K_3$   
 $\Rightarrow$  (B)
20. (A)

Reverse the second and multiply by  $\frac{1}{2}$  to get 1<sup>st</sup> reaction

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

$\Rightarrow$  (A)

21. (B)  
Add the reactions to get required reaction

$$K = K_1 K_2$$

$\Rightarrow$  (B)

22. (C)  
Add the reactions and multiply by  $\frac{1}{2}$  to get required reaction.

$$K = \sqrt{K_1 K_2}$$

$\Rightarrow$  (C)

23. (C)  
Adding the reaction will give overall reaction.

$$K = K_1 \times K_2 = 1$$

24. (A)

$$K_c = 27 = \frac{[\text{H}_2]^3}{[\text{H}_2\text{O}]^3}$$

$$\Rightarrow \frac{[\text{H}_2]}{[\text{H}_2\text{O}]} = 3$$

25. (A)  
 $\Delta n \neq 0$

26. (D)  
All have  $\Delta n = 0$

27. (D)  
 $\Delta n = 0$  So no units

28. (A)  
 $\Delta n = 1$   
So, units are mol/L

29. (D)  
 $K_p \Rightarrow \text{atm}^2 (\because \Delta n_g = 2)$

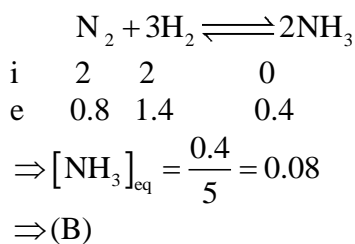
30. (C)  
K remains constant

31. (B)
- $$\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$$
- i    1        3                    0

$$e \quad 0.5 \quad 1.5 \quad 1$$

$$n_{\text{tot,eq}} = 3$$

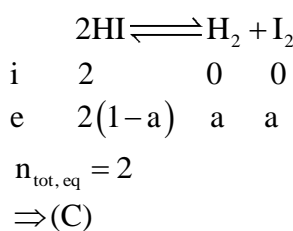
32. (B)



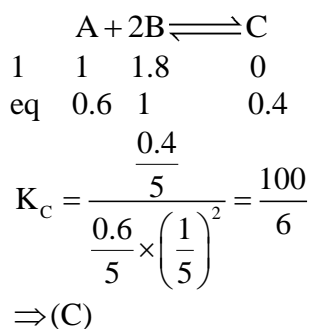
33. (B)

Small value of K indicates that at equilibrium products are much lesser than reactants so (B)

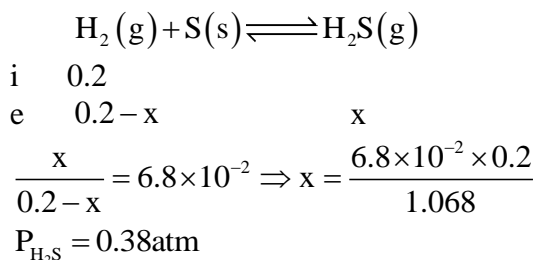
34. (C)



35. (C)



36. (B)



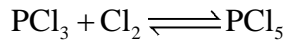
37. (C)

Higher value of K indicates more tendency to completion.

38. (A)

$$K_p = \frac{P_{SO_3}^2}{P_{SO_2}^2 P_{O_2}} \Rightarrow P_{O_2} = \frac{1}{3.5} = 0.29 \text{ atm}$$

39. (C)



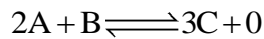
$$\begin{array}{l} \text{i} \quad 0 \quad 0 \quad \frac{x}{2.5} \\ \text{e} \quad 0.2 \quad 0.2 \quad \frac{x}{2.5} - 0.2 \end{array}$$

$$\Rightarrow \frac{\frac{x}{2.5} - 0.2}{0.2 \times 0.2} = 15$$

$$\frac{x}{2.5} = 0.6 + 0.2 = 0.8$$

$$\Rightarrow x = 2$$

40. (B)

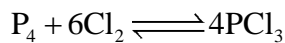


$$\begin{array}{l} \text{i} \quad 2 \quad 2 \quad 0 \quad 0 \\ \text{e} \quad 2 - 2x \quad 2 - x \quad 3x \quad x \end{array}$$

So  $[\text{B}] > [\text{A}]$

$\Rightarrow [\text{B}]$

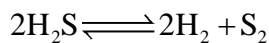
41. (C)



$$\begin{array}{l} \text{i} \quad x \quad x \quad 0 \\ \text{e} \quad x - y \quad x - 6y \quad 4y \end{array}$$

So  $[\text{Cl}_2] < [\text{P}_4]$

42. (B)



$$K = \frac{\left(\frac{0.2}{2}\right)^2 \left(\frac{0.8}{2}\right)}{\left(\frac{1}{2}\right)^2}$$

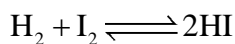
$$= 0.016$$

$\Rightarrow [\text{B}]$

43. (A)

Since K is very small reaction will proceed to negligible extent hence  $[\text{I}] < [\text{I}_2]$

44. (B)



$$Q = \frac{\left(\frac{2 \times 10^{-2}}{2}\right)^2}{\frac{1 \times 10^{-2}}{2} \times \frac{3 \times 10^{-2}}{2}} = \frac{4}{3} < K$$

So rxn proceeds in forward direction

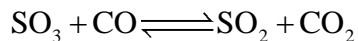
45. (D)

$$K_c = \frac{[\text{SO}_2]^2 [\text{O}_2]}{[\text{SO}_3]^2} = 10 \text{ mol/L}$$

$$\Rightarrow n_{\text{O}_2} = 10 \times 10 = 100$$

$$\Rightarrow \text{no. of O}_2 \text{ molecules} = 100N_A$$

46. (D)



$$\begin{array}{cccc} \text{i} & 2 & 2 & 2 & 2 \\ \text{e} & 2-x & 2-x & 2+x & 2+x \end{array}$$

$$\left( \frac{2+x}{2-x} \right)^2 = \frac{1}{9} \Rightarrow \frac{2+x}{2-x} = \frac{1}{3}$$

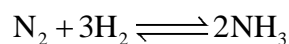
$$\Rightarrow 6+3x = 2-x$$

$$4 = -4x \Rightarrow x = -1$$

$$n_{\text{SO}_3} + n_{\text{CO}_2} = 2-x+2+x = 4$$

$$\frac{n_{\text{SO}_2}}{n_{\text{CO}}} = \frac{2+x}{2-x} = \frac{1}{3}$$

47. (D)



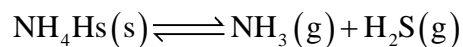
$$\begin{array}{ccc} \text{i.} & 3 & 10 & 0 \\ \text{e} & 3-x & 10-3x & 2x \end{array}$$

$$\frac{13-2x}{13} = \frac{2}{3} \Rightarrow 39-6x = 26$$

$$\Rightarrow x = \frac{13}{6}$$

$$K_C = \frac{\left( \frac{13/3}{4} \right)^2}{\frac{5}{4} \times \left( \frac{21}{4} \right)^3}$$

48. (C)



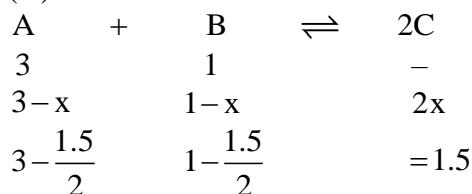
$$\begin{array}{ccc} \text{e} & & x & & x \end{array}$$

$$2x = p \Rightarrow x = \frac{p}{2}$$

$$K_P = x^2 = \frac{p^2}{4}$$

$\Rightarrow$ (C)

49. (D)



$$K = \frac{(1.5)^2}{0.5 \times 2.25} = 4$$

50. (C)

$$M_{w_{eq}} = \frac{122}{1-\alpha + \frac{\alpha}{2}} = \frac{122}{1-\frac{1}{4}} \Rightarrow 122 \times \frac{4}{3} = 163$$

51. (A)

$$d = \frac{D}{1-\alpha + 2\alpha} \Rightarrow \frac{D}{d} = 1 + \alpha$$

52. (B)

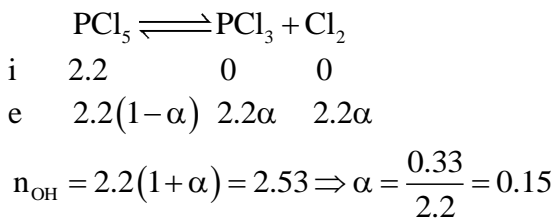
$$\frac{D}{d} = 1 + \alpha$$

$\Rightarrow$  (B)

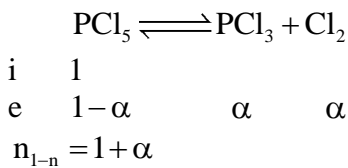
53. (A)

$K_p$  never changes with pressure

54. (C)



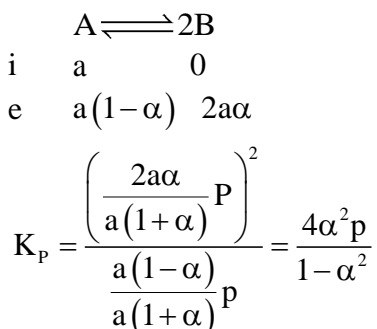
55. (B)



56. (D)

$K_p$  will not change with volume, but  $\alpha$  will

57. (A)



58. (C)  
Exothermic reaction is favored by low T  
 $\Delta n_g < 0$  is favored by high P
59. (B)  
Slope =  $\frac{-\Delta H}{2.303R} = 1$   
 $\Rightarrow \Delta H = -4.606 \text{ cal}$
60. (B)  
For I as  $T \uparrow K \downarrow \Rightarrow$  exothermic  
For II as  $T \uparrow K \uparrow \Rightarrow$  endothermic
61. (A)  
As  $T \uparrow K \downarrow \Rightarrow$  exothermic
62.  $T \geq \frac{50,000}{100} = 500$   
SO (D)
63. (D)  
At equilibrium  $\Delta G = 0$
64. (B)  
 $K = e^{\frac{16500}{8.314 \times 298}} = 780$
65. (A)  
 $\ln k = 4 - \frac{2000}{T} = \frac{\Delta S^\circ}{R} - \frac{\Delta H^\circ}{RT}$   
 $\Rightarrow \Delta S^\circ = 4R$
66. (D)  
For exothermic As  $T \uparrow K \downarrow$   
For endothermic As  $T \uparrow K \uparrow$
67. (B)  
Since reaction is exothermic increase in temp will favor decomposition of  $N_2O_4$
68. (D)  
Since reaction is exothermic increase in temp will favor backward rxn hence  $[NH_3]$  will decrease
69. (D)  
For endothermic reaction as  $T \uparrow, K \uparrow$
70. (D)



$K_p$  can change only with temperature

71. (C)  
Since the reaction is exothermic low temperature will favor forward rxn.
72. (A)  
Since the reaction is endothermic increasing temperature will increase  $P_{\text{CO}_2}$
73. (C)  
Endothermic reaction is favored by high T  
 $\Delta n_g < 0$  reaction is favored by high P
74. (D)  
Pressure does not effect K  
 $\Rightarrow$  (D)
75. Addition of  $\text{H}_2\text{O}$  will decrease  $\text{SO}_3$  as it will react with  $\text{H}_2\text{O}$  to form  $\text{H}_2\text{SO}_4$ , hence the rxn will proceed in forward direction.
76. (C)  
Only temperature can change K
77. (C)  
K remains unaffected if T is constant
78. (C)  
K remains unchanged on changing volume of container
79. (C)  
 $2\text{HI} \rightleftharpoons \text{H}_2 + \text{I}_2$ , dissociation reaction of HI has  $\Delta n_g = 0$  so change of volume of container will not have any effect.
80. (C)  
Increase in P favors backward rxn if  $\Delta n_g > 0$   
So (C)
81. (C)  
$$K = \frac{0.3}{0.15 \times P_B} = \frac{P_C}{0.3 \times 2P_B}$$
$$\Rightarrow P_C = 1.2 \text{ atm}$$
82. (A)  
Le Chatelier principle applies on disturbance on a system in equilibrium.
83. (B)  
Addition of product will shift reaction backwards so  $[\text{H}^+]$  will decrease
84. (C)

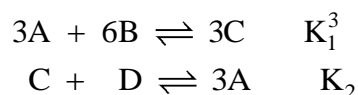
Since  $\Delta n_g > 0$  for reaction increasing volume will favor forward reaction.

85. (C)  
Increasing product concentration will favor backward reaction
86. (B)  
Adding  $\text{PCl}_5$  will favor forward reaction hence  $\text{Cl}_2$  will increase
87. (C)  
Since  $\Delta n_g = 0$  increasing pressure will have no effect.
88. (B)  
 $\Delta n_g > 0$  so increasing pressure will shift the reaction in backward direction
89. (C)  
Exothermic,  $\Delta n_g < 0$   
So low temperature & high pressure  
 $\Rightarrow$ (C)
90. (D)  
Exothermic,  $\Delta n_g < 0$   
So low temperature & high pressure  
 $\Rightarrow$  (D)
91. (A)  
Endothermic.  $\Delta n_g < 0$   
So high temperature & high pressure  
 $\Rightarrow$ (A)
92. (B)  
Adding  $\text{N}_2\text{O}_4$  shift the reaction in forward direction, so concentration  $\text{NO}_2$  will increase.
93. (A)  
Catalyst does not effects equilibrium.
94. (C)  
 $K = \frac{P_D^2}{P_B} \Rightarrow$  so  $P_B$  is doubled so  $P_D$  will increase by factor of  $\sqrt{2}$
95. (C)  
K does not changes on adding of inert
96. (B)  
Removal of  $\text{SO}_3$  will shift the reaction in forward direction
97. (D)  
Since  $\Delta n_g = 0$ , only temp. change will effect forward reaction

98. (D)  
 $\text{CaCO}_3$  is solid so adding  $\text{CaCO}_3$  will not change its active mass.
99. (A)  
 $\Delta n_g > 0$  So backwards reaction is favored
100. (C)  
 $\Delta n_g = 0$  will not be effected by P

## EXERCISE - 1 [B]

1. (D)



$$\text{Adding } 6B + D \rightleftharpoons 2C \quad K_3 = K_1^3 \times K_2$$

2. (C)

$$\begin{array}{l} C_{10}H_8(s) \rightleftharpoons C_{10}H_8(g) \\ e \qquad \qquad \qquad 0.1 \text{ mm Hg} \\ K_p = \frac{0.1}{760} = 1.32 \times 10^{-4} \text{ atm} \\ K_c = \frac{K_p}{RT} = \frac{1.32 \times 10^{-4}}{0.0821 \times 300} = 5.34 \times 10^{-6} \end{array}$$

3. (C)

Chemical equilibrium cannot be attained in open vessel.

4. (A)

K depends only on T

5. (D)

Since unit of  $K_p$  are atm so  $\Delta n_g = 1$

6. (A)

For endothermic reaction as  $T \uparrow K \uparrow$ .

7. (C)

Since T is same, so K remains constant.

8. (A)

For vapour density to decrease,  $\Delta n_g > 0$ .

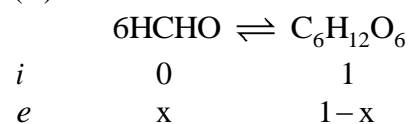
9. (D)

For oxide to be stable, K of its dissociation reaction should be least.

10. (A)

$$\begin{array}{l} 2SO_2 + O_2 \rightleftharpoons 2SO_3 \\ i \quad \quad 2 \quad \quad 1 \quad \quad 0 \\ e \quad \quad 2-2x \quad 1-x \quad 2x \\ K = \frac{(2x)^2}{(1-x)(2-2x)^2} V \end{array}$$

11. (B)



$$\frac{1-x}{x^6} = 6 \times 10^{22} \Rightarrow 1-x \approx 1$$

$$\text{So, } \frac{1}{x^6} = 6 \times 10^{22}$$

$$\Rightarrow x = 1.6 \times 10^{-4}$$

12. (C)

For vapour & liquid in equilibrium at boiling point, here KE is almost equal.

13. (D)

Initially only reactants are mixed so  $Q = 0$ , and it will increase with time.

14. (C)

$\Delta n_g > 0$  so increase in P will shift reaction in backward direction.

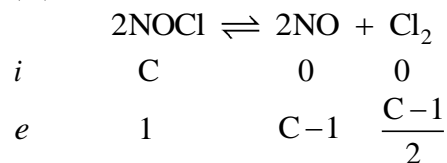
15. (C)

Addition of catalyst has no effect on K or equilibrium concentrations.

16. (B)

Lime kiln is a open vessel so  $\text{CO}_2(\text{g})$  escapes out.

17. (D)



$$\frac{(C-1)^2 \left( \frac{C-1}{2} \right)}{1} = 4$$

$$\Rightarrow C-1 = 2$$

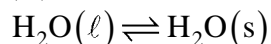
$$\Rightarrow C = 3$$

18. (A)

$$60 = \frac{92}{1+\alpha} \Rightarrow \alpha = \frac{92}{60} - 1$$

$$\Rightarrow \alpha = \frac{32}{60} = 0.5333$$

19. (D)



At  $-10^\circ\text{C}$  reaction is spontaneous so  $\Delta G^\circ < 0$

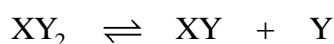
Reaction is exothermic so  $\Delta H < 0$

Liquid to solid so  $\Delta S < 0$ .

20. (D)

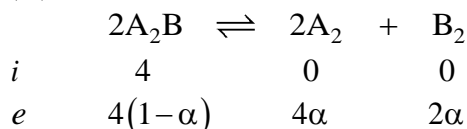
On halving the volume pressure will be doubled, and then to achieve new equilibrium reaction will decrease pressure, so at new equilibrium pressure will be less than  $2P$ .

21. (B)



$$\begin{array}{l}
 i \quad 600 \quad 0 \quad 0 \\
 e \quad 600 - P \quad P \quad P \\
 600 - P = 800 \\
 P = 200 \\
 K_P = \frac{200 \times 200}{400} = 100
 \end{array}$$

22. (A)



$$K_P = \frac{\frac{2\alpha}{4+2\alpha} \times \left(\frac{4\alpha}{4+2\alpha}\right)^2}{\left(\frac{4(1-\alpha)}{4+2\alpha}\right)^2} P$$

$$\text{So, } \frac{2\alpha}{4+2\alpha} \times \alpha^2 = (1-\alpha)^2 \quad (\because K_P = P)$$

$$2\alpha^3 = (1+\alpha^2-2\alpha)(4+2\alpha)$$

$$2\alpha^2 = 4 + 4\alpha^2 - 8\alpha + 2\alpha + 2\alpha^3 - 4\alpha^2$$

$$6\alpha = 4 \Rightarrow \alpha = \frac{2}{3}$$

23. (D)

Le Chatelier's principle can't be applied if all reactions & products are solids.

24. (B)

Adding HCl will increase  $H^+$  concentration  
So reaction will be shifted backward.

25. (C)

$\Delta n_g > 0$ , So (C).

26. (B)

For endothermic as  $T \uparrow K \uparrow$ , So (B)

27. (C)

For endothermic as  $T \uparrow K \uparrow$ , So (C)

28. (B)

Exothermic will be favoured by low T  
 $\Delta n_g < 0$  will be favoured by high P

29. (A)

$$\Delta n_g > 0$$

Adding inert at constant P will shift reaction in forward direction.

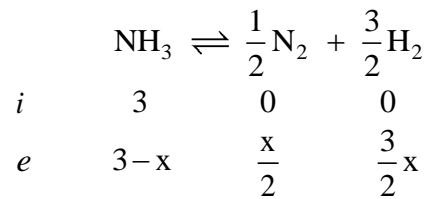
30. (D)

Addition of catalyst does not affect equilibrium concentrations.

31. (C)

$$2.9 \times 10^{-2} = \frac{\alpha^2}{1 - \alpha^2} \times 1$$
$$\Rightarrow \alpha = 0.17$$

32. (C)



$$\frac{\frac{3}{2}x}{4+x} = \frac{1}{2}$$

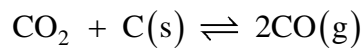
$$3x = 4 + x$$

$$x = 2$$

$$K_C = \frac{\left(\frac{3}{V}\right)^{3/2} \left(\frac{1}{V}\right)^{1/2}}{\frac{1}{V}}$$

$$K_C \times V = 3^{3/2}$$

33. (A)



|          |     |
|----------|-----|
| <i>i</i> | 0.5 |
|----------|-----|

|          |         |
|----------|---------|
| <i>e</i> | 0.5 - P |
|----------|---------|

$$0.5 + P = 0.8 \Rightarrow P = 0.3$$

$$K_P = \frac{(0.6)^2}{0.2} = 1.8$$

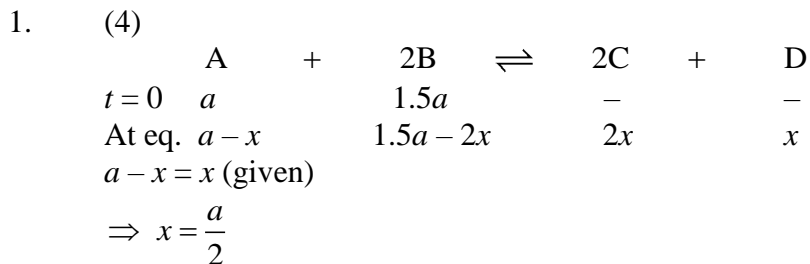
34. (D)

When ice and water are in equilibrium then  $G_{\text{ice}} = G_{\text{water}} \neq 0$

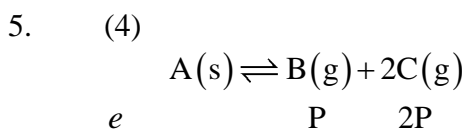
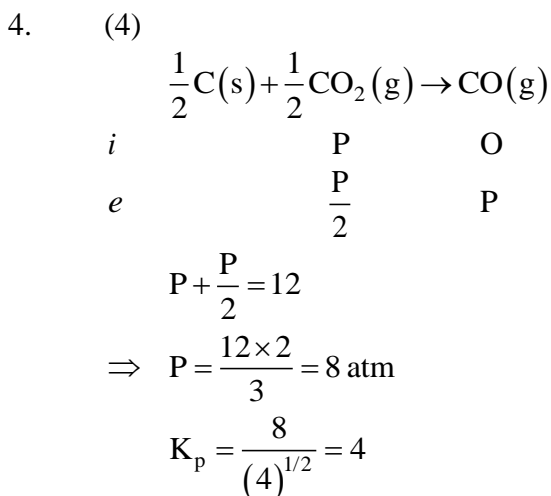
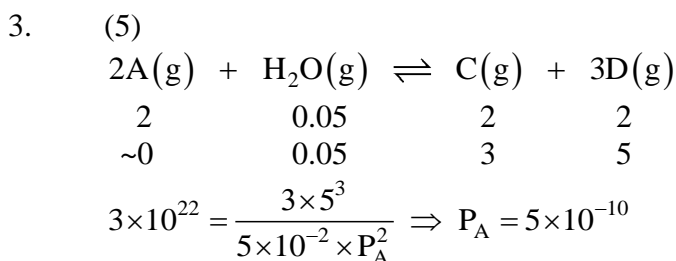
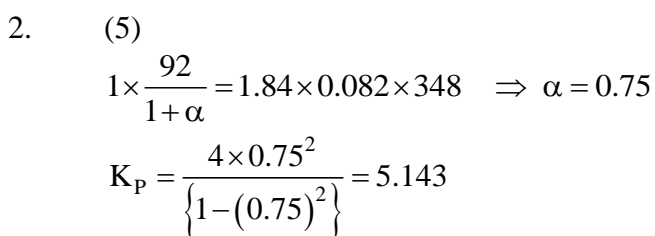
35. (C)

Since,  $\Delta n_g > 0$  increasing pressure will shift reaction in backwards direction.

## EXERCISE - 1 [C]



$$K_C = \frac{a^2 \times \frac{a}{2}}{\frac{a}{2} \times \left(\frac{a}{2}\right)^2} = 4$$





$$(P)(2P)^2 = 32$$

$$\Rightarrow P = 2$$

6. (1)

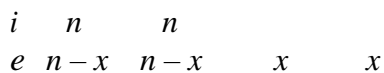
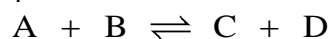
$$K_c = \frac{2/5}{2/5} = 1$$

7. (2)

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

$$\ln K = \frac{-830}{-2 \times 300} = \frac{83}{60}$$

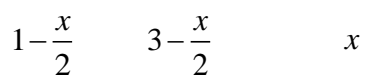
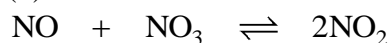
$$K = 4$$



$$\left( \frac{x}{n-x} \right)^2 = 4$$

$$\Rightarrow \frac{x}{n-x} = 2$$

8. (4)



$$K = \frac{x^2}{\left(1-\frac{x}{2}\right)\left(3-\frac{x}{2}\right)} \Rightarrow K = \frac{4x^2}{(3-x)^2}$$

Equating the two  $K$   $x = \frac{3}{2}$  and then  $K = 4$ .

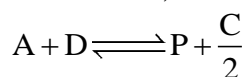
9. (2)

$$K_p = K_x (RT)^{\Delta n} = K_c (RT)^2$$

$$\Rightarrow \Delta n = 2$$

10. (3)

For the reactions,



$$K = \frac{6}{\sqrt{4}} = 3$$

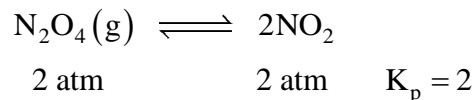
11. (9)

$$\log K = \frac{\Delta S^\circ}{2.3R} - \frac{\Delta H^\circ}{2.3RT}$$

$$\Rightarrow \frac{\Delta S^\circ}{2.3R} = 0.47$$

$$\text{Hence } \Delta S^\circ = 0.47 \times 2.3 \times 8.3 = 9$$

12. (2)



$$\frac{2}{x} - p = 0.85 \qquad \frac{2}{x} + 2p$$

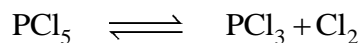
$$K_p = 2 = \frac{\left(\frac{2}{x} + 2p\right)^2}{0.85}$$

$$\Rightarrow \frac{2}{x} + 2p = 1.3 \qquad \dots(\text{i})$$

$$\text{and } \frac{2}{x} - p = 0.85 \qquad \dots(\text{ii})$$

Eliminating p from equation (i) and (ii) gives  $x = 2$ .

13. (2)



$$\text{Eqn-1 : } \quad n \qquad \qquad n \quad n$$

$$K_c = \frac{n}{V} \qquad \dots(\text{i})$$

$$\text{Eqn-2 : } \quad n + m \qquad \quad n - m \quad n + \frac{20}{3} - m$$

$$K_c = \frac{\left(n - m + \frac{20}{3}\right)(n - m)}{(n + m)2V} \qquad \dots(\text{iv})$$

Also since volume is doubled, moles will also be doubled

$$\Rightarrow 3n + \frac{20}{3} - m = 6n \text{ or } \frac{20}{3} - m = 3n \qquad \dots(\text{iii})$$

From (i) (ii) and (iii),  $n = 2$

14. (12)

$$K_c = \frac{x}{2(2)^2} = \frac{1}{2}$$

$$\Rightarrow x = 4 \text{ mol AB}_2 \text{ present.}$$

Now let y mol of  $\text{AB}_2$  is added.

$$K_c = \frac{1}{2} = \frac{4 + y}{2(2 + 2)^2}$$

$$\Rightarrow y = 12$$

15. (1)

$$\Delta G^\circ = -RT \ln K = 0$$

$$\Rightarrow K = 1$$

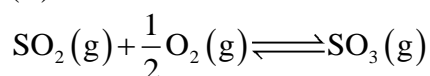
1. (D)

To calculate the value of  $K_4$  in the given equation we should apply:

$$\text{eq.}(2) + \text{eqn.}(3) \times 3 - \text{eqn.}(1)$$

$$\text{Hence, } K_4 = \frac{K_2 K_3^3}{K_1}$$

2. (B)



$$K_p = K_c (\text{RT})^x$$

Where  $x = \Delta n_g =$  number of gaseous moles in product – number of gaseous moles in reactants

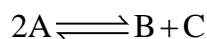
$$= 1 - \left(1 + \frac{1}{2}\right) = 1 - \frac{3}{2} = -\frac{1}{2}$$

3. (D)

On adding inert gas at constant volume, the total pressure of the system is increased, but the concentration of each reactant and product remains the same. Hence, there is no effect on the state of equilibrium.

4. (D)

$$\Delta G^\circ = 2494.2\text{J}$$



$$[\text{A}] = \frac{1}{2}, [\text{B}] = 2, [\text{C}] = \frac{1}{2}$$

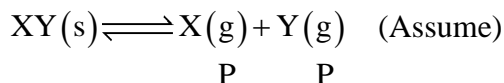
$$Q = \frac{[\text{B}][\text{C}]}{[\text{A}]^2} = \frac{2 \times 1/2}{\left(\frac{1}{2}\right)^2} = 4$$

$$\Delta G^\circ = -2.303\text{RT} \log K_c$$

$$2494.2\text{J} = -2.303 \times (8.314\text{J} / \text{K} / \text{mol}) \times (300\text{K}) \log K_c$$

$$\Rightarrow \log K_c = -0.4341 \Rightarrow K_c = 0.37; \therefore Q > K_c$$

5. (A)



$$P \quad P$$

At eqm, Total pressure =  $2p = 10\text{bar}$

$$\therefore p = 5; \text{ Now } K_p = (P_x)(P_y) = P^2 = 25$$

6. (C)

$$\text{Given, } \Delta H^\circ = -29.8\text{kJ mol}^{-1}$$

$$\Delta S^\circ = 0.1\text{kJ K}^{-1}$$

From the equation

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ = -29.8 - (298 \times (-0.100))$$

$$= -29.8 + 29.8 = 0$$

$$\text{Now, } \Delta G^\circ = -2.303RT \log K_{\text{eq}}$$

$$0 = -2.303RT \log K_{\text{eq}} \quad \therefore K = 1$$

7. (D)
- |  |                         |
|--|-------------------------|
| Perturbation                               | Shifts reaction towards |
| Removal of CO                              | Left                    |
| Removal of CO <sub>2</sub>                 | Right                   |
| Addition of CO <sub>2</sub>                | Left                    |
| Addition of Fe <sub>2</sub> O <sub>3</sub> | No change               |
- (This is a solid compound.  
Its concentration has no effect  
on the equilibrium)

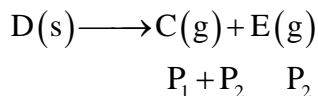
8. (B)
- As volume  $\uparrow$  pressure  $\downarrow$ , reaction proceeds in that direction where the number of moles of gases increases.

9. (A)
- We know that,  $K_p = K_c \cdot (RT)^{\Delta n_g}$
- $\therefore$  If  $\Delta n_g \neq 0$  then  $K_p \neq K_c$
- Now,  $2C(s) + O_2(g) \rightleftharpoons 2CO(g)$
- $$\Delta n_g = +1 \Rightarrow K_p = K_c (RT)^1$$
- Hence,  $K_p \neq K_c$

10. (C)
- Given,  $S + O_2 \rightleftharpoons SO_2$  .....(i);  $K_1 = 10^{52}$
- $2S + 3O_2 \rightleftharpoons 2SO_3$  .....(ii);  $K_2 = 10^{129}$
- $2SO_2 + O_2 \rightleftharpoons 2SO_3$  .....(iii);  $K = ?$
- To get equation (iii) follow (ii)  $-2(i)$ ,
- $$2S + 3O_2 \rightarrow 2SO_3 \quad K_2 = 10^{129}$$
- $$-(2S + 2O_2 \rightarrow 2SO_2 \quad K_1 = 10^{104})$$
- $$O_2 \rightarrow 2SO_3 - 2SO_2 \quad K = 10^{129-104}$$
- Or  $2SO_2 + O_2 \rightarrow 2SO_3 \quad K = 10^{25}$

11. (B)
- $$A(s) \longrightarrow B(g) + C(g)$$
- $$P_1 \quad P_1 + P_2$$
- $$K_{P_1} = P_B \times P_C$$

$$P_1(P_1 + P_2) = x \quad \dots\dots(i)$$



$$K_{P_1} = P_C \times P_E$$

$$(P_1 + P_2)P_2 = y \quad \dots\dots(ii)$$

Adding (i) and (ii)

$$\therefore P_1(P_1 + P_2) + P_2(P_1 + P_2) = x + y$$

$$\Rightarrow (P_1 + P_2)(P_1 + P_2) = (P_1 + P_2)^2 = x + y$$

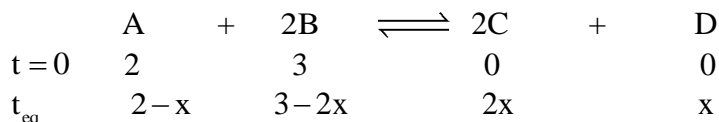
$$\Rightarrow P_1 + P_2 = \sqrt{x + y}$$

$$\therefore \text{Total pressure } (P_T) = P_C + P_B + P_E$$

$$(P_1 + P_2) + P_1 + P_2 = 2(P_1 + P_2)$$

$$P_T = 2(\sqrt{x + y})$$

12. (A)

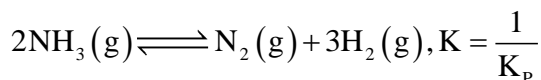


Given,  $3 - 2x = 2 - x$

$$\Rightarrow x = 1 \therefore [C] = 2, [D] = 1, [A] = 1, B = 1$$

$$\therefore K_c = \left\{ \frac{2^2 \times 1}{1^2 \times 1} \right\} = 4$$

13. (A)



$$P_{\text{NH}_3} \quad P_{\text{N}_2} \quad P_{\text{H}_2}$$

$$\therefore K = \frac{1}{K_p} = \frac{P_{\text{N}_2} (P_{\text{H}_2})^3}{(P_{\text{NH}_3})^2} \quad \dots\dots(i)$$

$$\Rightarrow P_{\text{total}}(P) = P_{\text{N}_2} + P_{\text{H}_2} + P_{\text{NH}_3}$$

$$\approx P_{\text{N}_2} + P_{\text{H}_2} \quad (\because P_{\text{NH}_3} \ll P_{\text{total}})$$

Now,

$$\text{Partial pressure of } \text{N}_2 = \text{mole fraction of } \text{N}_2 \times P = \frac{1}{4}P;$$

$$\text{Partial pressure of } \text{H}_2 = \frac{3}{4}P$$

$$\text{From eq(i), } \frac{1}{K_p} = \frac{\left(\frac{1}{4}P\right)\left(\frac{3}{4}P\right)^3}{(P_{\text{NH}_3})^2}$$

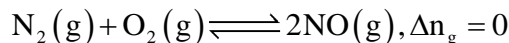
$$P_{\text{NH}_3} = \frac{3^{3/2} \cdot P^2 \cdot K_p^{1/2}}{16}$$

14. (B)

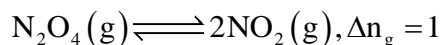
$$K_p = K_c (RT)^{\Delta n_g}$$

$\Delta n_g = \text{No. of gaseous moles of products} - \text{No. of gaseous moles of reactants}$

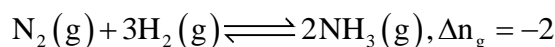
$$\frac{K_p}{K_c} = (RT)^{\Delta n_g}$$



$$\frac{K_p}{K_c} = (24.62 \text{ dm}^3 \text{ atm mol}^{-1})^0 = 1$$



$$\frac{K_p}{K_c} = 24.62 \text{ dm}^3 \text{ atm mol}^{-1}$$



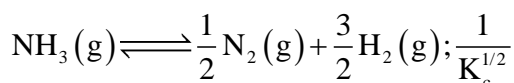
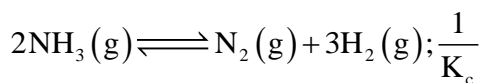
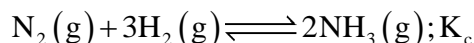
$$\frac{K_p}{K_c} = (24.62 \text{ dm}^3 \text{ atm mol}^{-1})^{-2} = 1.65 \times 10^{-3} \text{ dm}^{-6} \text{ atm}^{-2} \text{ mol}^2$$

15. (C)

$$K_p = K_c (RT)^{\Delta n_g} = K_c (RT)^{1-3/2} = K_c (RT)^{-1/2}$$

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

16. (D)

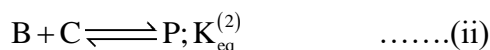
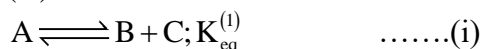


$$\frac{1}{K_c^{1/2}} = \frac{1}{(64)^{1/2}} = \frac{1}{8}$$

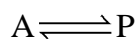
17. (B)

At equilibrium, rate of forward reaction = Rate of backward reaction.

18. (D)



On adding equations(i) and (ii), we get



$$K_{\text{eq}}(\text{overall}) = K_{\text{eq}}^{(1)} \cdot K_{\text{eq}}^{(2)}$$

19. (D)  
Equilibrium constant

$$K_c = \frac{[B]}{[A]} = \frac{11}{6} \approx 2$$

20. (C)  
 $\Delta G^\circ = -RT \ln K, T_1 = 25^\circ\text{C}, K_1 = 10$

$$\Delta G^\circ \text{ at } T_1 = -8.314 \times 298 \times 2.303 \times \log 10 = -5.71 \text{ kJ/mol}$$

$$\Delta G^\circ \text{ at } T_2 = -8.314 \times 373 \times 2.303 \times \log(100)$$

$$= -14.29 \text{ kJ/mol}$$

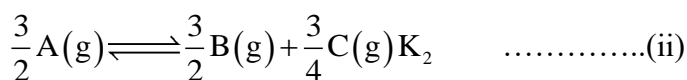
$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ \Rightarrow -5.71 = \Delta H^\circ - 298(\Delta S^\circ) \text{ and } -14.29 = \Delta H^\circ - 373(\Delta S^\circ)$$

$$\Delta H^\circ = 28.4 \text{ kJ/mol}$$

21. (A)  
Reaction at equilibrium,  $\text{N}_2\text{O}_4 \rightleftharpoons 2\text{NO}_2$ . According to Le chatelier's principle.

(A) addition of an inert gas at constant pressure will increase volume or decrease moles per unit volume. Thus equilibrium shifts towards more number of molecules.

22. (C)  
 $2\text{A}(\text{g}) \rightleftharpoons 2\text{B}(\text{g}) + \text{C}(\text{g}) K_1 \dots\dots\dots(\text{i})$



eq. (ii) is  $\frac{3}{4}$  times of equation (i), hence,  $K_2 = (K_1)^{\frac{3}{4}}$

23. (A)  
 $\text{PCl}_5 = 5$  moles;  $\text{Ar} = 4$  mole

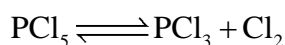
$$P_{\text{Total}} = \frac{9 \times 0.082 \times 610}{100} = 4.5 \text{ atm}$$

$$P_y = X_y P_T$$

$\swarrow$  Total pressure  
 $\searrow$  mole fraction of y

$$X_{\text{PCl}_5} = \frac{5}{9}; X_{\text{Ar}} = \frac{4}{9}$$

$$P_{\text{PCl}_5} = \frac{5 \times 4.5}{9} = 2.5 \text{ atm}; P_{\text{Ar}} = \frac{4 \times 4.5}{9} = 2 \text{ atm}$$



$$2.5 - P \qquad P \qquad P$$

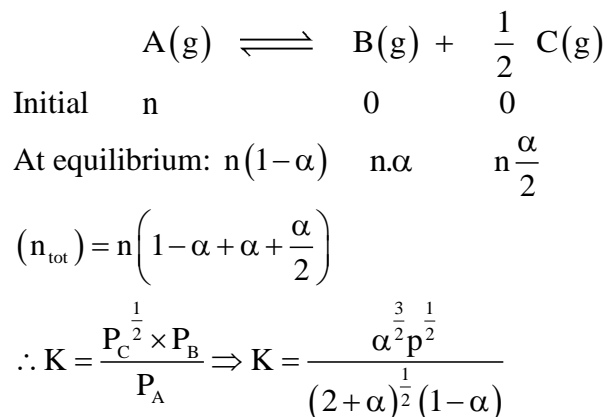
$$P_{\text{total}} = 2.5 - P + P + P + P_{\text{Ar}} = 6 \text{ atm}$$

$$P = 1.5 \text{ atm}$$

$$K_p = \frac{1.5 \times 1.5}{1} = 2.25$$



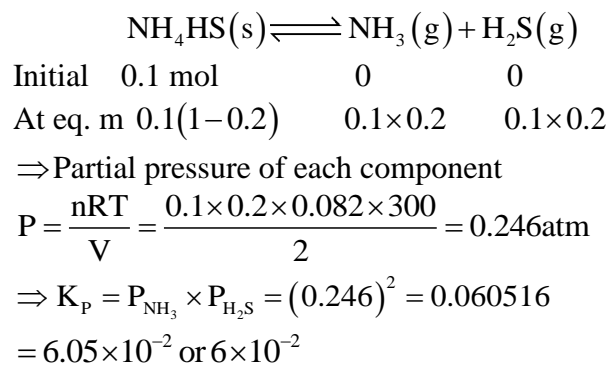
24. (B)



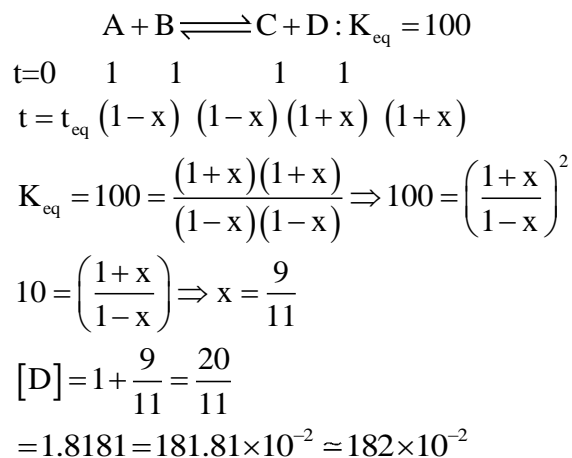
25. (6)

$$\text{Moles of NH}_4\text{HS initially taken} = \frac{5.1 \text{ g}}{51 \text{ g/mol}} = 0.1 \text{ mol}$$

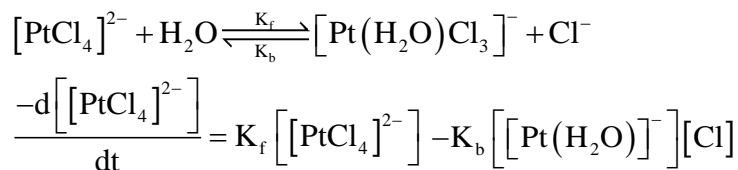
Volume of vessel = 2L



26. (182)



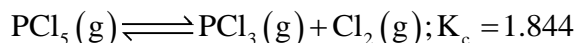
27. (0.02)



Comparing this equation with the given one:

$$\Rightarrow K_{eq} = \frac{K_f}{K_b} = \frac{4.8 \times 10^{-5}}{2.4 \times 10^{-3}} = 0.02$$

28. (1400)



$$t = 0 \quad 3 \text{ moles} \quad \quad 0 \quad \quad 0$$

$$t = \infty \quad (3-x) \quad \quad x \quad \quad x$$

$$\Rightarrow \frac{[\text{PCl}_3][\text{Cl}_2]}{[\text{PCl}_5]} = \frac{x^2}{3-x} = 1.844$$

$$\Rightarrow x^2 + 1.844x - 5.532 = 0$$

$$x = \frac{-b \pm \sqrt{D}}{2a} = \frac{-1.844 + \sqrt{(1.844)^2 + 4 \times 5.532}}{2} \cong 1.604$$

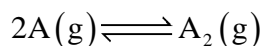
$$\Rightarrow \text{Moles of } \text{PCl}_5 = 3 - 1.604 \cong 1.396 \cong 1.4 \cong 1400 \times 10^{-3}$$

29. (16)

$$K_p = (P_{\text{O}_2})^{1/2}$$

$$4 = (P_{\text{O}_2})^{1/2} \Rightarrow P_{\text{O}_2} = 16$$

30. (166)



For homogenous gas phase reaction,  $K_{th} = K_p$

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

$$\Rightarrow 25.2 \times 10^3 = -8.3 \times 400 \times 2.3 \log K_p$$

$$\log K_p = \frac{-25.2 \times 10^3}{8.3 \times 400 \times 2.3} \Rightarrow \log K_p = -3.3$$

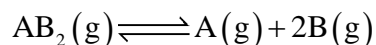
$$K_p = \text{antilog}(-3.3)$$

$$K_p = 10^{-3.3}; K_p = 10^{-3} \cdot 10^{-0.3}$$

$$K_p = 0.501 \times 10^{-3} = 5 \times 10^{-4} \therefore K_p = K_c (\text{RT})^{-1}$$

$$\therefore K_c = 5 \times 10^{-4} \times 8.3 \times 400 = 1.66 = 166 \times 10^{-2}$$

31. (72)



$$t = 0 \quad 1 \quad \quad - \quad \quad -$$

$$t = \text{eq}^m \quad 1-\alpha \quad \quad \alpha \quad \quad 2\alpha$$

$\therefore$  No. of moles at equilibrium

$$= 1 + 2\alpha = \frac{PV}{RT} = \frac{1.9 \times 25}{0.082 \times 300} \approx 1.93$$

$$\therefore \alpha = 0.465$$

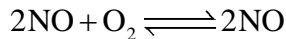
$$\therefore P_{AB_2} = \frac{1-\alpha}{1+2\alpha} \times P_T = \frac{1-0.465}{1+2 \times 0.465} \times 1.9 \approx 0.53 \text{ atm}$$

$$P_A = \frac{\alpha}{1+2\alpha} \times P_T = \frac{0.465}{1.93} \times 1.9 \approx 0.46 \text{ atm}$$

$$P_B = \frac{2\alpha}{1+2\alpha} \times P_T = \frac{2 \times 0.465}{1.93} \times 1.9 \approx 0.91 \text{ atm}$$

$$K_P = \frac{P_A \cdot (P_B)^2}{P_{AB_2}} = \frac{0.46 \times (0.91)^2}{0.53} \approx 0.72 \approx 72 \times 10^{-2}$$

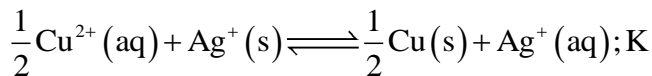
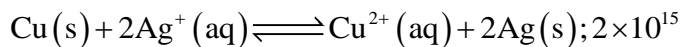
32. (2)



|              |        |       |      |
|--------------|--------|-------|------|
| Initial:     | 2      | 1     | -    |
| Change:      | $2-2x$ | $1-x$ | $2x$ |
| Equilibrium: | 1.2    | 0.6   | 0.8  |

$$K_P = \frac{\left(\frac{0.8}{2.6}\right)^2}{\left(\frac{1.2}{2.6}\right)^2 \left(\frac{0.6}{2.6}\right)} = 1.925$$

33. (2)



$$K = \frac{1}{\sqrt{2 \times 10^{15}}} = 2.23 \times 10^{-8}$$

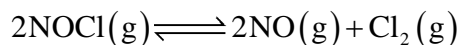
34. (29)

$$\text{moles of water} = \frac{0.90}{18}$$

By ideal gas equation  $PV = nRT$

$$V = \frac{nRT}{P} = \frac{0.90 \times 0.82 \times 300 \times 760}{18 \times 32} = 29.21 \approx 29$$

35. (125)



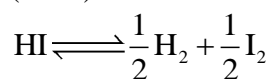
|            |          |      |                |
|------------|----------|------|----------------|
| $t=0$      | 2M       | -    | -              |
| $t=t_{eq}$ | $(2-x)M$ | $xM$ | $\frac{x}{2}M$ |

$$\therefore x = 0.4M$$

$$\therefore [NOCl]_{eq} = 2.0 - 0.4 = 1.6M; [Cl_2]_{eq} = 0.2M$$

$$\Rightarrow K_c = \frac{[NO]^2 [Cl_2]}{[NOCl]^2} = \frac{[0.4]^2 [0.2]}{[1.6]^2} = 125 \times 10^4$$

36. (2735)



$$t_i \quad 1$$

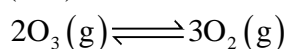
$$t_{\text{eq}} \quad 1 - 0.4 \quad \frac{0.4}{2} \quad \frac{0.4}{2}$$

$$K_p = \frac{(0.2)^{\frac{1}{2}} (0.2)^{\frac{1}{2}}}{1 - 0.4} = \frac{0.2}{0.6} = \frac{1}{3}$$

$$\Delta G = \Delta G^\circ + RT \ln K = 0 \quad [\because \text{at Equilibrium } \Delta G = 0]$$

$$\Delta G^\circ = -RT \ln K = -8.31 \times 300 \times 2.3 \times \log\left(\frac{1}{3}\right) = 2735 \text{ J/mol}$$

37. (747)



$$t = 0 \quad 2 \quad 0$$

$$t = \text{eq.} \quad 2 - 1 = 1 \quad 3/2$$

Total moles at equilibrium =  $1 + 3/2 = 5/2$

Total pressure = 1 atm (given)

Partial pressure = moles fraction  $\times$  total pressure

$$P_{\text{O}_3} = \frac{1}{5/2} \times 1 = \frac{2}{5}; P_{\text{O}_2} = \frac{3/2}{5/2} \times 1 = \frac{3}{5}$$

$$K_p = \frac{(P_{\text{O}_2})^3}{(P_{\text{O}_3})^2} = \frac{(3/5)^3}{(2/5)^2} = 1.35$$

Free energy change,

$$\Delta G = -RT \ln K_p = -8.3 \times 300 \times \ln 1.35 = -747 \text{ J mol}^{-1}$$

38. (1107)

Given: 2 mole of  $\text{N}_2$  gas was present as inert gas. Equilibrium pressure = 2.46 atm



$$t = 0 \quad 5 \quad 0 \quad 0$$

$$t = \text{Eq}^m \quad 5 - x \quad x \quad x$$

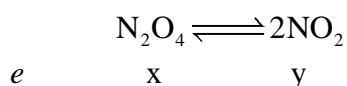
From ideal gas equation,  $PV = nRT$

$$2.46 \times 200 = (5 - x + x + x + 2) \times 0.082 \times 600 \Rightarrow x = 3$$

$$K_p = \frac{\left(\frac{3}{10} \times 2.46\right) \left(\frac{3}{10} \times 2.46\right)}{\left(\frac{2}{10} \times 2.46\right)} = 1.107 = 1107 \times 10^{-3}$$

## EXERCISE - 2 [A]

1. (B)

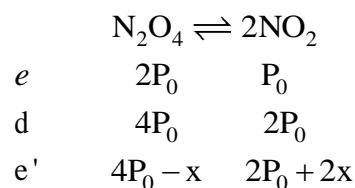


$$x + y = 3P_0$$

$$\frac{y^2}{x} = \frac{P_0}{2}$$

$$\text{Solving } x = 2P_0$$

$$y = P_0$$

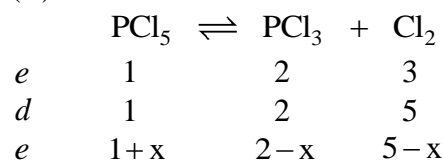


$$\frac{(2P_0 + 2x)^2}{4P_0 - x} = \frac{P_0}{2}$$

$$\text{Solving } x = \frac{-17 + \sqrt{161}}{16} P_0$$

$$P_{\text{tot}} = 6P_0 + x = \frac{79 + \sqrt{161}}{16} P_0$$

2. (B)



$$\frac{(5-x)(2-x)}{(1+x)} = 6$$

$$10 - 7x + x^2 = 6 + 6x$$

$$x^2 - 13x + 4 = 0$$

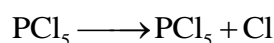
$$\text{Solving } x = \frac{13 - \sqrt{153}}{2}$$

$$X_{\text{PCl}_5} = \frac{1+x}{8-x+2} = \frac{1+x}{10-x} = \frac{15 - \sqrt{153}}{7 + \sqrt{153}}$$

3. (C)

Consider uses of 0% and 100% dissociation. If the given value lies in between, answer is possible. For C at 100% dissociation, molar mass will be 104.25 & at 0% dissociation, molar mass will be 208.5

4. (A)

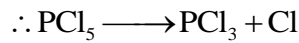


$$2(1-\alpha) \quad 2\alpha \quad 2\alpha \quad \frac{2\alpha}{2(1+\alpha)+1} = \frac{1}{7} \quad K = \frac{\left(\frac{1}{2}\right)\left(\frac{1}{2}\right)}{\left(\frac{3}{2}\right)(150)} = \frac{1}{900}$$

$$14\alpha = 3 + 2\alpha$$

$$12\alpha = 3$$

$$\alpha = \frac{1}{4}$$



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

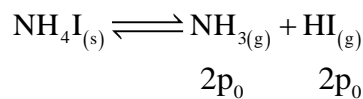
$$\frac{16\alpha^2}{4(1-\alpha)} = \frac{1}{900} \quad \alpha_2 = \frac{1}{60}$$

Ans. 1.67 %

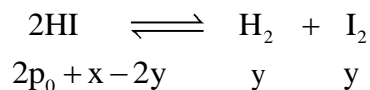
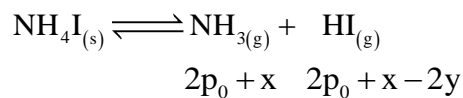
5. (B)

$$K_P = \left(\frac{0.6}{0.4}\right)^2 = \frac{9}{4} = 2.25$$

6. (B)



$$K_p = 4p_0^2$$



$$5p_0 = 2p_0 + x + 2p_0 + x - 2y + y + y$$

$$x = \frac{p_0}{2}$$

$$K_p = 4p_0^2 = \left(\frac{5p_0}{2}\right)\left(\frac{5p_0}{2} - 2y\right)$$

$$y = \frac{9p_0}{20}$$

$$\text{For reaction 2 } K_p = \frac{\frac{9p_0}{20} \times \frac{9p_0}{20}}{\left(\frac{8p_0}{5}\right)^2} = \frac{81}{1024}$$

7. (B)

$$K_p = (p_{\text{NH}_3})^2 (p_{\text{CO}_2})$$

$$(p_{\text{CO}_2}) = p$$

$$P_{\text{NH}_3} = 2P$$

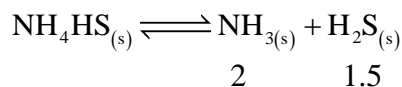
$$4P^3 = 2.9 \times 10^{-5}$$

$$P^3 = \frac{29}{4} \times 10^{-6}$$

$$P = \sqrt[3]{7.25 \times 10^{-2}} = 0.0194 \text{ atm}$$

$$\begin{aligned} \text{Total pressure} &= 3P \\ &= 0.0582 \text{ atm} \end{aligned}$$

8. (A)



$$K_p = 3 \text{ atm}^2$$

In  $V_2$

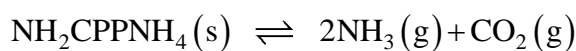
$$P_{\text{NH}_3} = \sqrt{3} \text{ atm}$$

$$P_{\text{H}_2\text{S}} = \sqrt{3} \text{ atm}$$

$$\text{Total pressure, } P_{\text{tot}} = 2\sqrt{3} \text{ atm}$$

$$\frac{W_{\text{NH}_3}}{W_{\text{H}_2\text{S}}} = \frac{2 \times 17}{1.5 \times 34} = \frac{2}{3}$$

9. (C)



$$e \quad \frac{2P_0}{3} \quad \frac{P_0}{3}$$

$$d \quad \frac{4P_0}{3} \quad \frac{2P_0}{3}$$

$$e' \quad \frac{4P_0}{3} - 2x \quad \frac{2P_0}{3} - x$$

$$\left(\frac{2P_0}{3}\right)^2 \left(\frac{P_0}{3}\right) = \left(\frac{4P_0}{3} - 2x\right)^2 \left(\frac{2P_0}{3} - x\right)$$

$$\Rightarrow \frac{2P_0}{3} - x = \frac{P_0}{3}$$

So at new equilibrium  $P_{\text{tot}} = P_0$

$$K_p = \left(\frac{2P_0}{3}\right)^2 \left(\frac{P_0}{3}\right) = \frac{4P_0^3}{27}$$

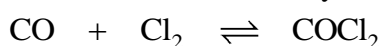
$$K_c = \frac{4P_0^3}{27(RT)^3}$$

10. (C)



$$i \quad 3x$$

$$e \quad 3x - x \quad x \quad x - y$$



$$i \quad 4y$$

$$e \quad 4y - y \quad x - y \quad y$$

$$K_C(I) = \frac{x(x-y)}{2x \times V} = \frac{x-y}{2V}$$

$$[PCl_5] + [CO] = \frac{2x+3y}{V}$$

11. (C)  
Endothermic so high T will favor  
Decrease in volume so high P will favor

12. (C)
- |          |     |   |     |                      |     |   |     |
|----------|-----|---|-----|----------------------|-----|---|-----|
|          | 2A  | + | B   | $\rightleftharpoons$ | C   | + | 3D  |
| <i>i</i> | 1.5 |   | 2.5 |                      | 0.5 |   | 0   |
| <i>e</i> | 0.5 |   | 2   |                      | 1   |   | 1.5 |

$$K = \frac{1 \times (1.5)^3}{(0.5)^2 \times 2} = 6.75 \text{ M}$$

13. (B)
- |           |                   |                      |            |   |                 |
|-----------|-------------------|----------------------|------------|---|-----------------|
|           | COCl <sub>2</sub> | $\rightleftharpoons$ | CO         | + | Cl <sub>2</sub> |
| <i>i</i>  | 0.2               |                      | 0          |   | 0               |
| <i>e</i>  | 0.1               |                      | 0.1        |   | 0.1             |
| <i>d</i>  | 0.05              |                      | 0.05 + C   |   | 0.05            |
| <i>e'</i> | 0.0625            |                      | 0.0375 + C |   | 0.0375          |

$$\frac{0.1 \times 0.1}{0.1} = \frac{(0.0375)(0.0375 + C)}{0.0625}$$

$$C = 0.129$$

$$x = 40C = 5.167$$

14. (B)
- $$\text{At } t = t_0 \quad \frac{W_{CO_2}}{W_{H_2O}} = \frac{W/44}{W/18} = \frac{9}{22}$$

So, At  $t = t_0$  equilibrium was established.

$$K = \frac{\frac{W}{44} \times \frac{W}{2}}{\frac{W}{18} \times \frac{W}{28}} = \frac{63}{11}$$

$$\frac{n_{H_2}}{n_{CO}} = \frac{W/2}{W/28} = \frac{14}{1}$$



## EXERCISE - 2 [B]

### One or More Than One Option Correct

- (A, B, C, D)  
Since, reaction is exothermic increasing temperature will favor backward reaction.  
Since,  $\Delta n_g < 0$ , so decreasing pressure will favor backward reaction.  
Since,  $H_2$  is reactant removing  $H_2$  will favor backward reaction.  
Since,  $C_2H_6$  is product adding  $C_2H_6$  will favor backward reaction.
- (C, D)  
 $NaNO_3$  &  $NaNO_2$  both are solid, so adding them will not disturb the reaction.
- (C)  
No change in the position of equilibrium an addition of He at constant volume
- (C, D)  
(A) Adding inert at constant volume is not a disturbance  
(B) Adding  $Cl_2$  will favor backward reaction  
(C) Adding inert at constant pressure will increase volume and forward reaction will be favored.  
(D) Increasing volume will favor forward reaction
- (D)  
On addition of reactant reaction will go in forward direction  
Since  $\Delta n_g$  is zero, adding inert or changing the volume will not effect equilibrium amount.
- (A, B, C)  
Chemical equilibrium is example of dynamic equation
- (C, D)  
$$AB_{(g)} \rightleftharpoons AB_{(g)} + B_{(g)}$$
$$K_p = \frac{\alpha^2}{1-\alpha^2} \times P$$
So,  $\alpha^2 \propto \frac{1}{P}$
- (A, C)  
On increasing pressure reaction will shift forwards if  $\Delta n_g < 0$ .
- (C, D)  
(A) Addition of  $O_2$  ( $\rightarrow$ ), decreasing volume ( $\rightarrow$ )  
(B) Addition of  $CO$  ( $\rightarrow$ ), removal of  $CO_2$  ( $\rightarrow$ )  
(C) Increasing temperature ( $\leftarrow$ ), decreasing volume ( $\rightarrow$ )  
(D) Addition of  $CO$  ( $\rightarrow$ ), increasing temperature ( $\leftarrow$ )
- (C, D)  
(A) introducing an inert gas at constant volume (no disturbance)  
(B) introducing chlorine gas at constant volume ( $\leftarrow$ )  
(C) introducing and inert gas at constant pressure ( $\rightarrow$ )  
(D) increasing the volume of the container ( $\rightarrow$ )

## Comprehension Type

### Passage [A]:

1. (C)

$$K_{\text{eq}} = \frac{k_f}{k_b} = 10$$

$$\frac{(P_{\text{H}_2})^4}{(P_{\text{H}_2\text{O}})^4} = 10$$

$$(P_{\text{H}_2\text{O}}) = (P_{\text{H}_2})(10)^{-1/4}$$

$$(P_{\text{H}_2\text{O}}) = (P_{\text{H}_2}) \times 10^{-0.25}$$

2. (A)

$$\begin{aligned}\Delta G^\circ &= -2.303 \log K \\ &= -2.303 \times 8.314 \times 400 \times \log 10 \\ &= -7657 \text{ J/k}\end{aligned}$$

3. (C)

As  $\Delta n_g$  is zero

4. (D)

$K_c$  is independence of volume

5. (B)

As given reaction is exothermic

### Passage [B]:

$$\log k_p = \frac{\Delta S^\circ}{2.303R} - \frac{\Delta H^\circ}{2.303R} \left( \frac{1}{T} \right)$$

1. (B)

$$\text{As slope} = -\frac{\Delta H^\circ}{2.303R}$$

For line (2)  $\Delta H^\circ$  is positive

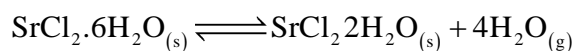
2. (B)

For exothermic reaction  $K_p$  decreases with increase in temperature

3. (C)

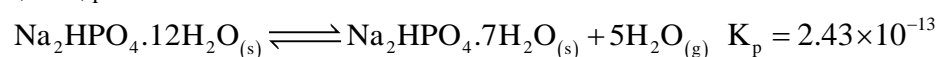
$$K_p = K_c (RT)^{\Delta n_g}$$

### Passage [C]:

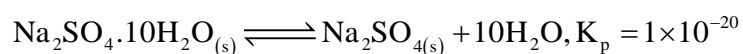


$$k_p = 1.6 \times 10^{-11}$$

$$(P_{\text{H}_2\text{O}})_1 = 2 \times 10^{-3} \text{ atm}$$



$$(P_{\text{H}_2\text{O}})_{\text{II}} = 3 \times 10^{-3} \text{ atm}$$



$$(P_{\text{H}_2\text{O}})_{\text{III}} = 1 \times 10^{-2} \text{ atm}$$

- (A)  
 $P_{\text{III}} > P_{\text{II}} > P_{\text{I}}$
- (C)  
Most effective drying agent  $\text{SrCl}_2 \cdot 2\text{H}_2\text{O}$  because  $P_{\text{I}}$  is least.
- (A)  
For efflorescent, Relative humidity  $< \frac{10^{-2}}{\frac{15.2}{760}} \times 100 = 50\%$
- (A)  
For deliquescent, Relative humidity  $> \frac{10^{-2}}{\frac{15.2}{760}} \times 100 = 50\%$
- (D)  
Molar ratio is same as partial pressure

Passage [D]:

$$K_c = \frac{\left(\frac{n_c}{v}\right)^c \left(\frac{n_d}{v}\right)^d}{\left(\frac{n_A}{v}\right)^a \left(\frac{n_B}{v}\right)^b}, K_p = \frac{\left(\frac{n_c RT}{v}\right)^c \left(\frac{n_D RT}{v}\right)^d}{\left(\frac{n_A RT}{v}\right)^a \left(\frac{n_B RT}{v}\right)^b} = K_c (RT)^{\Delta n_g}$$

$$K_x = \frac{(n_c)^c (n_D)^d}{(n_A)^a (n_B)^b} \times (\sum n)^{a+b-c-d}$$

- (B)  

$$K_c = \frac{\left(\frac{n_c}{v}\right)^c \left(\frac{n_d}{v}\right)^d}{\left(\frac{n_A}{v}\right)^a \left(\frac{n_B}{v}\right)^b}, K_p = \frac{\left(\frac{n_c RT}{v}\right)^c \left(\frac{n_D RT}{v}\right)^d}{\left(\frac{n_A RT}{v}\right)^a \left(\frac{n_B RT}{v}\right)^b} = K_c (RT)^{\Delta n_g}$$

$$K_x = \frac{(n_c)^c (n_D)^d}{(n_A)^a (n_B)^b} \times (\sum n)^{a+b-c-d}$$

$$K_p = K_c (RT)^{\Delta n_g} = K_x (p)^{\Delta n_g}$$
- (C)  
 $\Delta n_g = 1$   
 $K_p = K_x (p)$   
 If  $p > 1 \text{ atm}$ ,  $K_p > K_x$

3. (C)  
 $\Delta n_g = -1$

$$K_c = K_x \left( \frac{p}{RT} \right)^{-1}$$

$$K_c = K_x \left( \frac{RT}{p} \right)$$

Passage [E] :

$$\ln k = 2 - \frac{1000}{T} = \frac{\Delta S^\circ}{R} - \frac{\Delta H^\circ}{R} \left( \frac{1}{T} \right)$$

1. (A)

$$\ln k = 2 - \frac{1000}{T} = \frac{\Delta S^\circ}{R} - \frac{\Delta H^\circ}{R} \left( \frac{1}{T} \right)$$

$$\Delta S^\circ = 2R$$

2. (B)

For exothermic As  $T \uparrow$   $K \downarrow$

For endothermic As  $T \uparrow$   $K \uparrow$

3. (B)

$$\log k_{eq} = \frac{\Delta S^\circ}{2.303R} - \frac{\Delta H^\circ}{2.303R} \left( \frac{1}{T} \right)$$

$$\text{Slope} = -\frac{\Delta H^\circ}{2.303R} = 1$$

$$\Delta H^\circ = -2.303R$$

$$= -2.303 \times 8.314$$

$$= -19.147$$

4. (A)

$$\log \left( \frac{4}{T} \right) = \frac{\Delta H^\circ}{2.303R} \left( \frac{1}{300} - \frac{1}{320} \right)$$

$$\Delta H^\circ = 13.31 \text{ kcal / mole}$$

For reverse reaction  $\Delta H^\circ = -13.31 \text{ kcal / mole}$

### Matching Type

1. (A) – P; (B) – R; (C) – Q; (D) – S

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

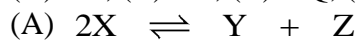
$$\text{If } \Delta n_g > 0 \text{ so, } \frac{K_p}{K_c} > 1$$

$$\Delta n_g < 0, \frac{K_p}{K_c} < 1$$

2. (A) – R; (B) – Q; (C) – P; (D) – S

$$\text{Unit of } k_p = (\text{atm})^{\Delta n_g}$$

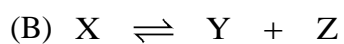
3. (A) – P; (B) – S; (C) – Q; (D) – R



$$\begin{array}{l} i \quad 1 \qquad 0 \quad 0 \\ e \quad (1-\alpha) \quad \frac{\alpha}{2} \quad \frac{\alpha}{2} \end{array}$$

$$K_C = \frac{\left(\frac{\alpha}{2}\right)^2}{(1-\alpha)^2} = \frac{\alpha^2}{4}$$

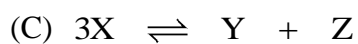
$$\alpha = 2 \times \sqrt{K_C}$$



$$\begin{array}{l} i \quad 1 \qquad 0 \quad 0 \\ e \quad (1-\alpha) \quad \alpha \quad \alpha \end{array}$$

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

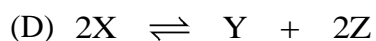
$$\alpha = \sqrt{K_C}$$



$$\begin{array}{l} i \quad 1 \qquad 0 \quad 0 \\ e \quad (1-\alpha) \quad \frac{\alpha}{3} \quad \frac{\alpha}{3} \end{array}$$

$$K_C = \frac{\left(\frac{\alpha}{3}\right)^2 \left(1-\frac{\alpha}{3}\right)}{(1-\alpha)^3} = \frac{\alpha^2}{9}$$

$$\alpha = 3 \times \sqrt{K_C}$$



$$\begin{array}{l} i \quad 1 \qquad 0 \quad 0 \\ e \quad (1-\alpha) \quad \frac{\alpha}{2} \quad \alpha \end{array}$$

$$K_C = \frac{\left(\frac{\alpha}{2}\right) \times \alpha^2}{(1-\alpha)^2 \left(1+\frac{\alpha}{2}\right)} = \frac{\alpha^3}{2}$$

$$\alpha = (2K_C)^{1/3}$$

4. (A) – P; (B) – R; (C) – S; (D) – Q

$$\log\left(\frac{k_2}{k_1}\right) = \frac{\Delta H^\circ}{2.303R} \left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

5. (A) – R; (B) – Q; (C) – P; (D) – S

(A)  $\Delta n_g = 0$ , so increasing pressure will not effect equilibrium

(B)  $\Delta n_g > 0$ , so increasing pressure shift reaction in backward direction

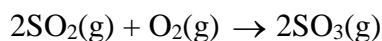
(C)  $\Delta n_g < 0$ , so increasing pressure shift reaction in forward direction & reaction in endothermic so increasing temperature shift the reaction in forward direction

(D)  $\Delta n_g < 0$ , so decreasing pressure shift reaction in backward direction & reaction in endothermic so increasing temperature shift the reaction in forward direction

## EXERCISE - 2 [C]



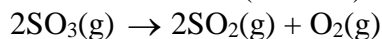
2. For forward direction :



$$K_c = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2[\text{O}_2]} = \frac{(5.0 \times 10^{-2})^2}{(3.0 \times 10^{-3})^2 (3.5 \times 10^{-3})}$$

$$= 7.936 \times 10^4 \text{ M}^{-1}$$

and for backward (reverse) direction :



$$K'_c = \frac{[\text{SO}_2]^2[\text{O}_2]}{[\text{SO}_3]^2} = \frac{1}{K_c} = 12.6 \times 10^{-6} \text{ M}$$

3. Let equilibrium moles of  $\text{SO}_2 = \text{SO}_3 = x$  and that of  $\text{O}_2 = y$

$$\therefore [\text{SO}_2] = [\text{SO}_3] = \frac{x}{5} \text{ mol L}^{-1}$$

$$[\text{O}_2] = \frac{y}{5} \text{ mol L}^{-1}$$

$$K_c = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2[\text{O}_2]} = \frac{\left(\frac{x}{5}\right)^2}{\left(\frac{x}{5}\right)^2 \left(\frac{y}{5}\right)} = 5 \quad (\text{given})$$

$$\therefore y = 1$$

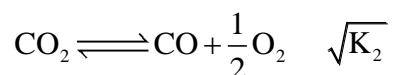
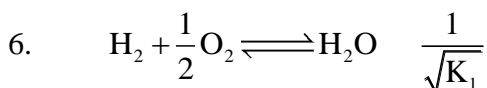
Hence,  $\text{O}_2$  at equilibrium = 1 mol

4. For the reaction,  $\Delta n = (2 + 1) - 2 = 1$

$$\begin{aligned} K_p &= K_c(RT)^{\Delta n} \\ &= 3.75 \times 10^{-6} (0.0821 \times 1069) \\ &= 3.3 \times 10^{-4} \end{aligned}$$

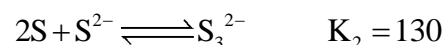
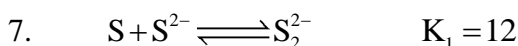
5. We first calculate value of  $K_p$

$$K_p = \frac{P_{\text{CO}_2} \cdot P_{\text{H}_2}}{P_{\text{CO}} P_{\text{H}_2\text{O}}} = \frac{0.2 \times 0.1}{2 \times 0.01} = 1 \quad \Delta n_g = (1 + 1) - (1 + 1) = 0 \quad \text{hence, } K_p = K_c = 1$$



---


$$\text{H}_2 + \text{CO}_2 \rightleftharpoons \text{CO} + \text{H}_2\text{O} \quad \sqrt{\frac{K_2}{K_1}} = \sqrt{\frac{1.4 \times 10^{-12}}{2.1 \times 10^{-13}}} = 2.58$$



$$\text{So } \text{S} + \text{S}_2^{2-} \rightleftharpoons \text{S}_3^{2-} \quad K = \frac{K_2}{K_1} = \frac{130}{12} = 10.83$$

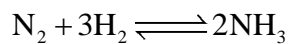
8.  $k_f = 2.6 \times 10^3$ ,  $k_b = 4.1$

$$\text{So } k = \frac{k_f}{k_b} = \frac{2600}{4.1} = 634.15$$

9.  $P_{\text{NH}_3} = 2.8 - 0.4 - 0.8 = 1.6$

$$k_p = \frac{(1.6)^2}{0.8 \times (0.4)^3} = 50$$

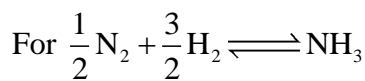
10.



|   |                   |                            |                 |
|---|-------------------|----------------------------|-----------------|
| i | 1                 | 3                          | 0               |
| e | $\frac{399}{400}$ | $\frac{3 \times 399}{400}$ | $\frac{2}{400}$ |

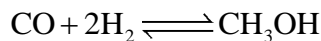
$$K_c = \frac{\left(\frac{2}{1600}\right)^2}{\left(\frac{399}{1600}\right)\left(\frac{3 \times 399}{1600}\right)^3}$$

$$= \frac{2^2 \times 1600^2}{3^3 \times 399^4} = 1.5 \times 10^{-5}$$



$$K = \sqrt{K_c} = 3.87 \times 10^{-3}$$

11.



|   |     |         |     |
|---|-----|---------|-----|
| I | 0.2 | x       | 0   |
| e | 0.1 | x - 0.2 | 0.1 |

$$n_{\text{H}} = x = \frac{4.92 \times 5}{0.082 \times 600} = 0.5$$

$$K_c = \frac{\frac{0.1}{5}}{\frac{0.1}{5} \times \left(\frac{0.3}{5}\right)^2} = 277.78$$

12. Reaction quotient,  $Q_c$  for the reaction will be written as

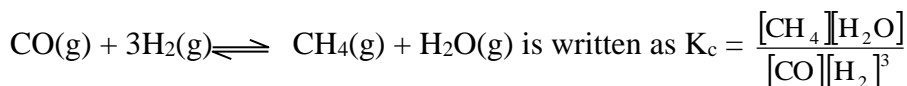
$$Q_c = \frac{[\text{NH}_3(\text{g})]^2}{[\text{N}_2(\text{g})][\text{H}_2(\text{g})]^3} = \frac{(2.0 \times 10^{-3})^2}{(1.0 \times 10^{-3})(3.0 \times 10^{-3})^3}$$

$$= \frac{4.0 \times 10^{-6}}{27.0 \times 10^{-12}} = 0.149 \times 10^6 \cong 1.5 \times 10^5$$

Since  $Q_c > K_c$ , reaction will go in the left direction and ammonia will decompose into hydrogen and nitrogen.

13. The equilibrium constant for the reaction



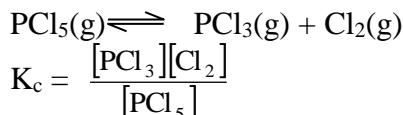


Now substituting the values of known concentration and  $K_c$ .

$$3.90 = \frac{[\text{CH}_4](0.020)}{(0.30)(0.10)^3} \text{ or } \frac{[\text{CH}_4]}{c_o} = \frac{(3.90)(0.30)(0.10)^3}{(0.020)} = 0.059$$

( $c_o = 1 \text{ M}$  is the standard state) and therefore,  $[\text{CH}_4] = 0.059 \text{ M}$

14. For the reaction



The initial molar concentration of

$$\text{PCl}_5 = \frac{1.50 \text{ mol}}{0.500 \text{ L}} = 3.00 \text{ mol L}^{-1}$$

Suppose change in molar concentration of  $\text{PCl}_5$  is  $(-x) \text{ mol L}^{-1}$

Then,

|                                 | $\text{PCl}_5$ | $\text{PCl}_3$ | $\text{Cl}_2$ |
|---------------------------------|----------------|----------------|---------------|
| Initial molar concentration     | 3.00           | 0              | 0             |
| Change in molar concentration   | - x            | +x             | +x            |
| Equilibrium molar concentration | $(3.00 - x)$   | x              | x             |

Now substituting the value of equilibrium concentrations in the expression for equilibrium constant, we get

$$K_c = \frac{[\text{PCl}_3][\text{Cl}_2]}{[\text{PCl}_5]} = \frac{x \times x}{(3.00 - x)} \text{ or } x^2 + 1.80x - 5.40 = 0$$

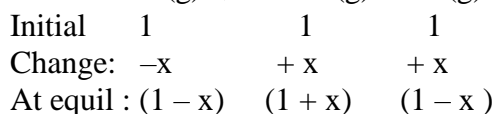
Therefore,

$$x = \frac{-1.80 \pm \sqrt{(1.80)^2 - 4(1)(-5.40)}}{2} = 1.59 \text{ and } -3.39$$

Since concentration must be positive, therefore,  $1.59 \text{ mol L}^{-1}$  is selected as appropriate solution.

Therefore, equilibrium concentration of  $[\text{PCl}_5] = (3.00 - 1.59) \text{ mol L}^{-1} = 1.41 \text{ mol L}^{-1}$  and  $[\text{PCl}_3] = 1.59 \text{ mol L}^{-1}$ ,  $[\text{Cl}_2] = 1.59 \text{ mol L}^{-1}$

15.  $\text{PCl}_5\text{(g)} \rightleftharpoons \text{PCl}_3\text{(g)} + \text{Cl}_2\text{(g)}$



$$[\text{Cl}_2] = \frac{(1-x) \text{ mol}}{1\text{L}} = 1 + x = 1.5\text{M}$$

$$\therefore x = 0.5$$

$$\therefore [\text{PCl}_5] = \frac{1-x}{1} = 0.5 \text{ M}$$

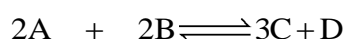
$$[\text{Cl}_2] = 1.5 \text{ M}$$

$$[\text{PCl}_3] = 1.5 \text{ M}$$

$$\therefore K_c = \frac{[\text{PCl}_3][\text{Cl}_2]}{[\text{PCl}_5]} = 4.5 \text{ M}$$

16. Since  $K$  for reaction of  $\text{mg}$  is higher, it will remove  $\text{Cu}^{2+}$  to a greater extent.

17.



$$\begin{array}{l}
 \text{i} \quad 2x \quad x \quad 0 \quad 0 \\
 \text{e} \quad 2x-2y \quad x-2y \quad 3y \quad y \\
 3y = (x-2y) \times 3 \Rightarrow x = 3y \\
 K = (x-2y) \times 3 \Rightarrow x = 3y
 \end{array}$$

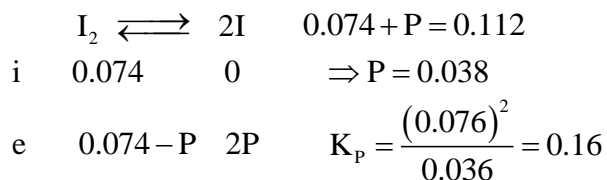
$$18. \quad \theta_c = \frac{\left(\frac{8}{10}\right)^2}{\left(\frac{1}{10}\right)^2 \times \frac{2}{10}} = \frac{64 \times 10}{2} = 320 > K_c$$

So backward

$$19. \quad \theta_c = \frac{\left(\frac{0.5}{50}\right)^2}{\left(\frac{1}{50}\right)\left(\frac{3}{50}\right)^3} = \frac{50^2 \times 0.5^2}{3^3} = 2.3.1 > K$$

$\Rightarrow$  So backward

20.



$$21. \quad \theta = \frac{0.4 \times (0.2)^{\frac{1}{2}}}{0.5} = 0.36 > K$$

$\Rightarrow$  So backward

22. K remain same

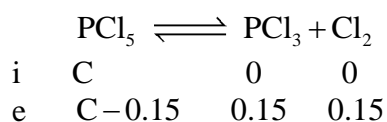
$$\left(\frac{0.6}{0.1}\right)^2 = \left(\frac{1.24 - 2x}{0.1 + x}\right)^2$$

$$7.4 = \frac{1.24 - 2x}{0.1 + x}$$

$$x = \frac{0.5}{9.4} = 0.053$$

$$[HI] = 0.1134$$

23.

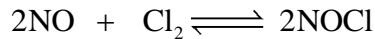


$$0.04 = \frac{0.15 \times 0.15}{C - 0.15}$$

$$C = 0.7125$$

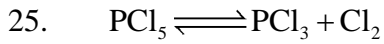
$$\text{Moles} = 0.7125 \times 3 = 2.1375$$

24.



$$\begin{array}{l} \text{i} \quad 0.373 \quad 0.31 \quad 0 \\ \text{e} \quad 0.373 - 2P \quad 0.31 - P \quad 2P \\ 0.683 - P = 0.544 \\ P = 0.139 \end{array}$$

$$K_p = \frac{(0.278)^2}{(0.095)^2 (0.171)} = 50.08$$



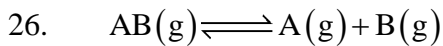
$$K_p = \frac{\alpha^2}{1 - \alpha^2} P$$

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

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

$$\frac{1}{\alpha^2} = \frac{P + K_p}{K_p}$$

$$\alpha = \sqrt{\frac{K_p}{P + K_p}}$$

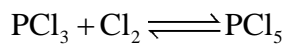


$$K_p = \frac{\alpha^2}{1 - \alpha^2} P$$

$$K_p = \frac{\left(\frac{1}{2}\right)^2}{1 - \left(\frac{1}{2}\right)^2} P = \frac{\frac{1}{4}}{\frac{3}{4}} P = \frac{1}{3} P$$

$$\Rightarrow P = 2K_p$$

27.



$$\begin{array}{l} \text{i} \quad n \quad n \quad 0 \\ \text{e} \quad n - y \quad n - y \quad y \end{array}$$

$$K_p = \frac{\frac{y}{2n - y} P}{\frac{n - y}{2n - y} P \times \frac{n - y}{2n - y} P}$$

$$K_p = \frac{y(2n - y)}{(n - y)^2} \times \frac{1}{P}$$

28.



$$\begin{array}{l} \text{i} \quad P_0 \quad 0 \quad 0 \quad 0 \\ \text{e} \quad P_0 - 4P' \quad 4P' \quad 2P' \quad P' \end{array}$$

$$P_0 + 3P' = P$$

$$P_0 = P - 3P'$$

$$K_p = \frac{(4P')^4 (2P')^2 (P')}{(P - 7P')^4}$$

29.  $K_p$  remains same

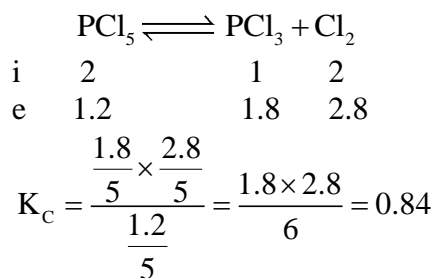
$$\frac{\left(\frac{1}{10}\right)^2}{1 - \left(\frac{1}{10}\right)^2} \times 1 = \frac{\alpha^2}{1 - \alpha^2} \times 4$$

$$\frac{1}{99} = \frac{\alpha^2}{1 - \alpha^2} \times 4$$

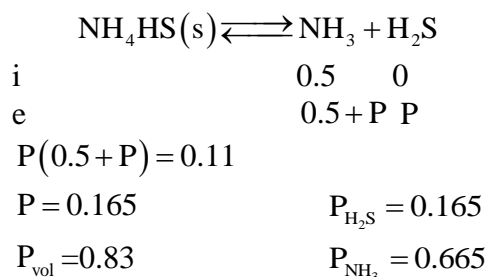
$$\frac{\alpha^2}{1 - \alpha^2} = \frac{1}{396}$$

$$\alpha = \frac{1}{\sqrt{397}} = 0.05 = 5\%$$

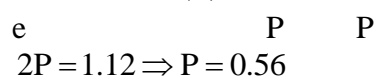
30.



31.



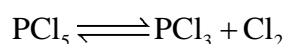
32.  $\text{NH}_4\text{HS}(s) \rightleftharpoons \text{NH}_3 + \text{H}_2\text{S}$



$$K_p = (0.56)^2 = 0.3136$$

$$5 = \frac{[\text{CO}_2]}{2.5 \times 10^{-2}} \Rightarrow [\text{CO}_2] = 1.25 \times 10^{-1}$$

34.  $n_{\text{vol}} = \frac{2.05 \times 100}{0.0621 \times 500} = 5$



$$\begin{array}{rcl}
 1 & 3 & 0 & 1 \\
 e & 3(1-\alpha) & 3\alpha & 1+3\alpha \\
 5 = 4 + 3\alpha & \Rightarrow & \alpha = \frac{1}{3}
 \end{array}$$

35.

$$(i) K_P = \frac{4 \times \left(\frac{1}{4}\right)^2}{1 - \left(\frac{1}{4}\right)^2} \times 1$$

$$= \frac{4 \times \frac{1}{16}}{\frac{15}{16}} \times 1 = \frac{4}{15}$$

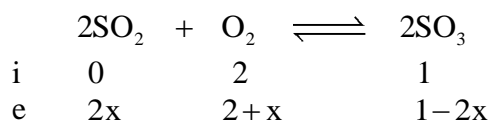
$$(ii) \frac{4}{15} = \frac{4\alpha^2}{1-\alpha^2} \times 0.1$$

$$\frac{\alpha^2}{1-\alpha^2} = \frac{10}{15} = \frac{2}{3}$$

$$3\alpha^2 = 2 - 2\alpha^2$$

$$\alpha = \sqrt{\frac{2}{5}} = 0.6325$$

36.



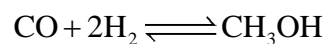
$$900 = \frac{1}{8 \times 900} \Rightarrow x = 0.0118$$

$$P_{\text{SO}_2} = 0.0236$$

$$P_{\text{O}_2} = 2.0118$$

$$P_{\text{SO}_3} = 0.9764$$

$$\begin{aligned}
 37. \quad n_{\text{OH}} \text{ at equation} &= \frac{8.5 \times 2.5}{0.082 \times 750} \\
 &= 0.345
 \end{aligned}$$



$$i. \quad 0.15 \quad x \quad 0$$

$$e. \quad 0.07 \quad x - 0.16 \quad 0.08$$

$$x - 0.01 = 0.345 \Rightarrow x = 0.355$$

$$(i) K_C = \frac{\frac{0.08}{2.5}}{\frac{0.07}{2.5} \times \frac{0.195}{2.5}} = 14.65$$

$$\begin{aligned}
 (ii) \quad P &= \frac{(0.355 + 0.15) \times 0.0821 \times 750}{2.5} \\
 &= 12.438 \text{ atm}
 \end{aligned}$$

38. Species in the solid state are not be considered.

| Equilibria | $\Delta n_g$ | Direction |           |           |
|------------|--------------|-----------|-----------|-----------|
|            |              | P ↓       | Moles of  |           |
|            |              |           | reactant  | product   |
| (A)        | - 1          | ←         | ↑         | ↓         |
| (B)        | + 1          | →         | ↓         | ↑         |
| (C)        | - 1          | ←         | ↑         | ↓         |
| (D)        | 0            | No effect | No effect | No effect |

In all of the above cases, you can also predict direction by using equation  $x \propto \left(\frac{1}{P}\right)^{\Delta n_g / 2}$

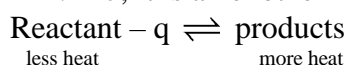
(A)  $x \propto \sqrt{P}$ , decrease in P, decreases x

(B)  $x \propto \sqrt{\frac{1}{P}}$ , decrease in P, increases x

(C)  $x \propto \sqrt{P}$ , as in (A)

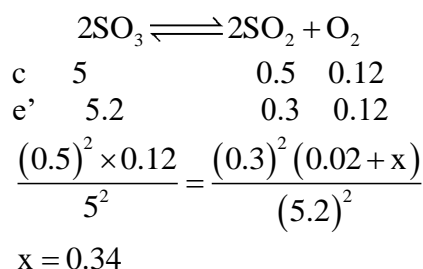
(D)  $x \propto P^0$ , no effect

39.  $\Delta H^\circ = -41.2$  kJ; it is an exothermic reaction with heat lost to the surrounding

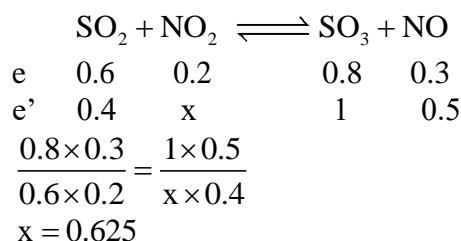


If temperature is increased, equilibrium displaces towards the direction of less heat to minimize the stress. This is backward direction, hence amount of  $H_2$  decreases. If temperature is decreased reaction displaces towards forward side, hence  $K_p$  increases.

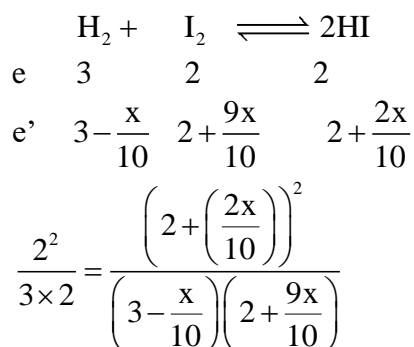
40.



41.



42.



$$x = 8.7$$

43. We know  $\Delta G^\circ = \Delta H^\circ - T \Delta S^\circ$   
 $= -29.8 - 298 \times 0.1 = 0$

Since  $\Delta G^\circ = -2.303 RT \log K$

Hence  $\log K = 0$  which gives  $K = 1$

44. (A) Above equation represent a straight line of

$$\text{Slope} = -\frac{\Delta H^\circ}{2.303R} = -\tan\theta = -0.5$$

$$\therefore \Delta H^\circ = 2.303 \times 8.314 \times 0.5 = 9.574 \text{ J mol}^{-1}$$

(B) Also intercept,  $\log A = OP = 10$

$$\therefore A = 10^{10}$$

(C)  $\log K = \log A - \frac{\Delta H^\circ}{2.303RT}$   
 $= 10 - \frac{9.574}{2.303 \times 8.314 \times 298}$

$$= 10 - 1.68 \times 10^{-3}$$

$$K = 9.96 \times 10^9$$

(D) Putting values calculated in (A) and (C) into equation

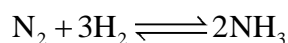
$$\Delta H^\circ = \frac{2.303RT_1T_2}{(T_2 - T_1)} \log \frac{K_2}{K_1}$$

We have

$$9.574 = \frac{2.303 \times 8.314 \times 298 \times 798}{(798 - 298)} \log \frac{K_2}{(9.96 \times 10^9)}$$

$$\therefore K_2 \text{ (Equilibrium constant at 798 K)} = 9.98 \times 10^9$$

45.



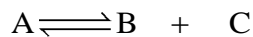
e 0.38 0.4 2

e' 0.45 p 1.86

$$\frac{2^2}{0.38 \times (0.4)^3} = \frac{1.86^2}{0.45 \times p^3}$$

$$P = 0.36$$

46.



c 4.6 2.3 2.3

d 2.6 2.3 2.3

e' 2.6 + n 2.3 - x 2.3 - x

$$\frac{2.3 \times 2.3}{4.6} = \frac{(2.3 - x)^2}{2.6 - x}$$

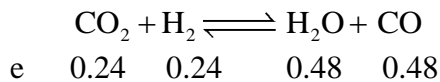
$$x = 0.44$$

$$[A] = 3.04$$

$$[B] = [C] = 1.86$$

Level-2

1.



$$(A) \frac{0.6 \times 0.6}{0.12 \times (0.12 + x)} = 4$$

$$x = 0.63$$

$$\text{Moles} = 0.62 \times 2 = 1.26$$

$$(B) \frac{0.6 \times 0.6}{0.12 \times (0.12 + x)} = 4$$

$$x = 0.63$$

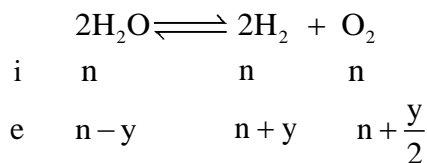
$$\text{Moles of CO}_2 = 0.63 \times 2 = 1.26$$

$$(C) \frac{0.6 \times (0.6 - x)}{0.12 \times 0.12} = 4$$

$$x = 0.504$$

$$\text{moles} = 0.504 \times 2 = 1.008$$

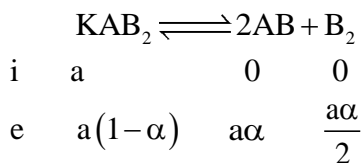
2.



$$K_p = \frac{\left( \frac{n + \frac{y}{2}}{3n + \frac{y}{2}} P \right) \left( \frac{n + y}{3n + \frac{y}{2}} P \right)^2}{\left( \frac{n - y}{3n + \frac{y}{2}} P \right)^2}$$

$$K_p = \frac{\left( n + \frac{y}{2} \right) (n + y)^2}{\left( 3n + \frac{y}{2} \right) (n - y)^2} P$$

3.

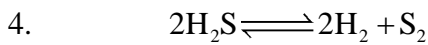


$$K_p = \frac{\left( \frac{\alpha}{1 + \frac{\alpha}{2}} P \right) \left( \frac{\alpha}{1 + \frac{\alpha}{2}} P \right)^2}{\left( \frac{1 - \alpha}{1 + \frac{\alpha}{2}} P \right)^2}$$



$$K_p = \frac{\alpha^3}{2} P \quad \left( 1 - \alpha \approx 1, 1 + \frac{\alpha}{2} \right)$$

$$\alpha = \left( \frac{2K_p}{P} \right)^{1/3}$$



$$10^{-6} = \frac{(0.25\alpha)^2 \left( \frac{0.25x}{2} \right)}{(0.25(1-\alpha))^2}$$

$$10^{-6} = \frac{1}{8} \alpha^3$$

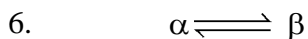
$$\alpha = 2 \times 10^{-2}$$

5.  $K_p = \frac{4 \times (0.9114)^2}{1 - (0.9114)^2} \times 1$

$$= 19.62$$

$$19.62 = \frac{4\alpha^2}{1-\alpha^2} \times 2$$

$$\alpha = \sqrt{\frac{2.45}{3.45}} = 0.8426$$



e.  $0.364c \quad 0.636c$

$$K = \frac{636}{364} = 1.747$$

7.  $K_p = \frac{4 \times (0.503)^2}{1 - (0.503)^2} \times 1$

$$= 1.355$$

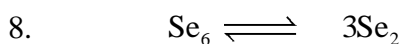
$$\frac{2\alpha}{1-\alpha} = 8 \Rightarrow 2\alpha = 8 - 8\alpha$$

$$\alpha = \frac{8}{10} - \frac{4}{5}$$

$$1.355 = \frac{4 \times \left( \frac{4}{5} \right)^2}{1 - \left( \frac{4}{5} \right)^2} \times P$$

$$1.355 = \frac{4 \times \frac{16}{25}}{\frac{9}{25}} \times P$$

$$P = 0.19$$



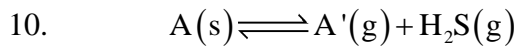
$$\begin{array}{l}
 \text{i} \quad \frac{0.755}{79 \times 6} \quad 0 \\
 \text{e} \quad \frac{0.0755}{79 \times 6}(1-\alpha) \quad \frac{0.0755}{29 \times 6} \times 3\alpha \\
 \frac{0.0755}{79 \times 6}(1+2\alpha) = \frac{185}{760} \times 0.1142 \\
 \frac{0.0755}{79 \times 6}(1+2\alpha) = \frac{185}{0.0821 \times 973}
 \end{array}$$

$$\alpha = 0.59$$

$$K_p = 264 \times 10^{-5}$$

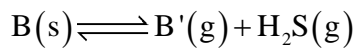


$$\begin{aligned}
 2 &= \frac{P_{\text{CO}}^2}{P_{\text{CO}_2}} \Rightarrow P_{\text{CO}} = \sqrt{8 \times 10^{-2}} \\
 &= 2.82 \times 10^{-1} \text{ atm}
 \end{aligned}$$



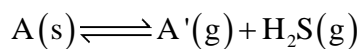
$$\text{e} \quad \quad \quad 25 \quad \quad 25$$

$$K_{b_1} = 25^2 = 625$$

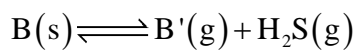


$$\text{e} \quad 34 \quad \quad 34$$

$$K_{P_2} = 34^2 = 1156$$



$$\text{e} \quad \quad \quad P_1 \quad \quad P_2 + P_1$$



$$\text{e} \quad \quad \quad P_2 \quad \quad P_2 + P_1$$

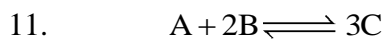
$$P_1(P_1 + P_2) = 625$$

$$P_2(P_1 + P_2) = 1156$$

$$(P_1 + P_2)^2 = 1781$$

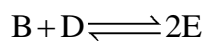
$$P_{\text{vol}} = 2(P_1 + P_2) = 2\sqrt{1781}$$

$$= 84.4$$



$$\text{i} \quad 8 \quad 8 \quad 0$$

$$\text{e} \quad 5 \quad 2 \quad 3$$



$$\text{i} \quad 8 \quad 2 \quad 0$$

$$\text{e} \quad 2 \quad 1 \quad 2$$



$$\text{i} \quad 8 \quad 8 \quad 0$$

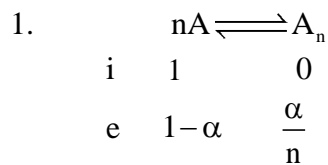
$$\text{e} \quad 2 \quad 5 \quad 4$$

$$K_1 = \frac{3^3}{5 \times 2^2} = \frac{27}{20}$$

$$K_2 = \frac{2^2}{2 \times 1} = 2$$

$$K_3 = \frac{4^4}{2^{y^3} \times 5^2} = \frac{32}{25}$$

### Level-3

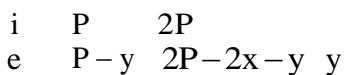
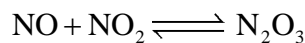
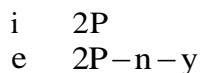


$$1-\alpha + \frac{\alpha}{n} = \frac{PV}{RT} \quad K_C = \frac{\frac{\alpha/n}{V}}{\left(\frac{1-\alpha}{V}\right)^n}$$

$$\frac{PV}{RT} = 1-\alpha \left(1 - \frac{1}{n}\right) \quad K_C = \frac{\alpha V^{n-1}}{n(1-\alpha)^n}$$

$$= 1 - \frac{n-1}{n} \frac{nK_C}{V^{n-1}} \quad K_C = \frac{\alpha V^{n-1}}{n}$$

$$= 1 - \frac{(n-1)K_C}{V^{n-1}} \quad \alpha = \frac{nK_C}{V^{n-1}}$$



$$x = 1.7$$

$$\frac{1.7}{(2P-2x-y)} = 6.8$$

$$\Rightarrow 2P-2x-y = 0.5$$

$$2P-2x-y+n+P-y+y = 5.05$$

$$0.5+1.7+P = 5.05$$

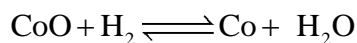
$$P = 2.65, y = 1.8$$

$$K_P = \frac{1.8}{1.05 \times 0.5} = 3.4286$$



$$K = \frac{9}{119}$$

$$e' 0.05-a-b \quad 0.17-a+c \quad 0.03+a+b \quad 0.03+a-c$$

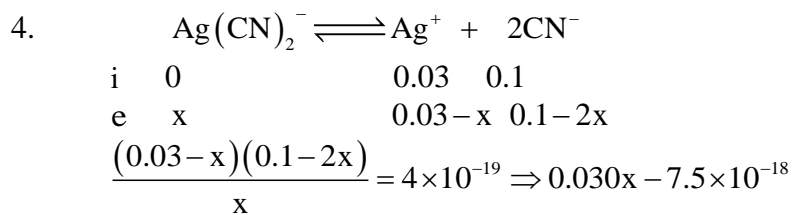


|    |            |            |
|----|------------|------------|
| e' | $0.03+a-c$ | $0.17-a+c$ |
|----|------------|------------|

$$0.03+a+b = 0.09 \Rightarrow a+b = 0.06$$

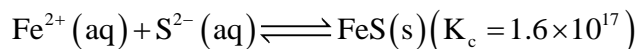
$$\text{So } K_2 = \frac{0.09}{0.01} = 9$$

$$\Rightarrow K_1 = \frac{K_2}{K_3} \Rightarrow K_3 = 119$$



1. (A, B, D)  
 (a)  $\Delta H = C_{p(\text{rxn})} \Delta T$   
 Hence, enthalpy depends on temperature.  
 (b)  $\text{CaCO}_3(\text{s}) \rightleftharpoons \text{CaO}(\text{s}) + \text{CO}_2(\text{g}) \quad K_p = P_{\text{CO}_2}$   
 (c)  $K_{\text{eq}}$  depends only on temperature and not on Pressure.  
 (d) Enthalpy of reaction is independent of the catalyst. Catalyst changes activation energy.

2. (8.93)



$$t = 0 \quad 0.03\text{M} \quad 0.1\text{M}$$

At equilibrium  $(0.03 - x) \quad (0.1 - x)$

Since,  $K_c \gg 10^3$ ;  $0.03 - x = 0 \therefore x = 0.03$  and  $0.1 - x = 0.07$

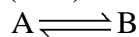
$$K_c = \frac{1}{(0.07) \times [\text{Fe}^{2+}]} = 1.6 \times 10^{17} \quad (\text{conc. of solid is taken as 1})$$

$$[\text{Fe}^{2+}] = \frac{1}{0.07 \times 1.6} \times 10^{-17} = \frac{250}{28} \times 10^{-17}$$

$$= 8.93 \times 10^{-17} \quad (\text{i})$$

Comparing (i) with given value in question we get,  $Y = 8.93$

3. (0.25)



$$K_{\text{eq}} = \frac{P_B}{P_A}$$

$$K_{1000\text{k}} = \frac{10}{1} = 10; K_{2000\text{k}} = \frac{100}{1} = 100$$

$$\text{Now, } \frac{\Delta G_{1000\text{k}}^\circ}{\Delta G_{2000\text{k}}^\circ} = \frac{(-RT \ln k_{\text{eq}})}{(-RT \ln k_{\text{eq}})_{2000\text{k}}} = \frac{1000 \times \ln 10}{2000 \times \ln 100} = 0.25$$