

## CHEMICAL EQUILIBRIUM -2

1. The gaseous reaction  $A + B \rightleftharpoons C + D + \text{heat}$ , has reached equilibrium. It is possible to make the reaction to proceed forward

- 1) by adding more of C
- 2) by adding more of D
- 3) by raising the temperature of the system
- 4) by lowering the temperature

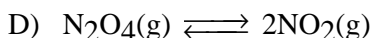
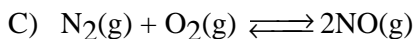
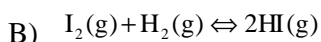
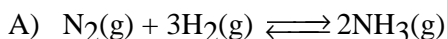
Hint:  $\because$  it is an exothermic reaction.

2. Given the reaction  $2X(g) + 2Y(g) \rightleftharpoons Z(g) + 80 \text{ k.cals}$ , which combination of pressure and temperature gives the highest yield of Z at equilibrium

- 1) 1000 atm and  $500^{\circ}\text{C}$
- 2) 500 atm and  $500^{\circ}\text{C}$
- 3) 1000 atm and  $100^{\circ}\text{C}$
- 4) 500 atm and  $100^{\circ}\text{C}$

Hint: Forward reaction is favoured by Low temperature  $\because$  it is an exothermic reaction and High 'P' as no. of moles decreases.

3. In which of the equilibria, the position of the equilibrium shifts towards products, if the total pressure is increased



- 1) B    2) C    3) A    4) D

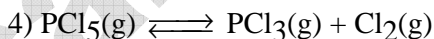
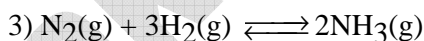
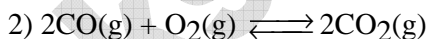
Hint: Increase of pressure shifts the reaction in the direction of decrease in moles.

4. The degree of dissociation of  $\text{PCl}_5$

- 1) increases with increasing pressure
- 2) decreases with increasing pressure
- 3) no effect on change in pressure
- 4) decreases with decreasing pressure

Hint; Dissociation of  $\text{PCl}_5$  involves increase of moles

5. In which of the following systems, doubling the volume of the container causes a shift to right ?



6. In the dissociation of  $\text{CaCO}_3$  in a closed vessel, the forward reaction is favoured by

- 1) Adding of more  $\text{CaCO}_3$
- 2) Removal of some  $\text{CaO}$
- 3) Increasing the pressure
- 4) Decreasing the pressure by removing some  $\text{CO}_2$  from the equilibrium mixture

Hint: Removal of product favours the forward reaction. Addition and removal of a solid has no effect.

7. In the reaction  $\text{NH}_4\text{HS(s)} \rightleftharpoons \text{NH}_3\text{(g)} + \text{H}_2\text{S(g)}$  on doubling the concentration of ammonia the equilibrium concentration of  $\text{H}_2\text{S}$
- 1) is reduced to half its initial value
  - 2) increases by two times
  - 3) remains unchanged
  - 4) increases by four times
- Hint: Increase of products concentration favours the backward reaction

8. In a gaseous reaction  $2\text{A} \rightleftharpoons 3\text{B}$  on doubling the volume of container, the equilibrium amount of the product
- 1) increases
  - 2) decreases
  - 3) remains same
  - 4) data insufficient
- Hint: Doubling the volume of container, Pressure decreases. decrease of pressure shifts the reaction in the direction of increase in moles.

9. Manufacture of ammonia by Haber's process involves the reaction  $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$  = -22.4 k cal. The effect of increase of temperature on the equilibrium is
- 1) equilibrium is shifted to the right
  - 2) equilibrium is unaffected
  - 3) equilibrium is shifted to the left
  - 4) equilibrium is shifted first to right then to left
- Hint: Increase of pressure shifts the reaction in the direction of decrease in moles.

10. Backward reaction is favoured by increase in the pressure of the equilibrium
- 1)  $2\text{SO}_2 + \text{O}_2 \rightleftharpoons 2\text{SO}_3$
  - 2)  $\text{N}_2 + \text{O}_2 \rightleftharpoons 2\text{NO}$
  - 3)  $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$
  - 4)  $\text{PCl}_5 \rightleftharpoons \text{PCl}_3 + \text{Cl}_2$

Hint: Increase of pressure shifts the reaction in the direction of decrease in moles.

11. In the manufacture of  $\text{NH}_3$ , which are favourable conditions
- 1) High pressure and low temperature
  - 2) High pressure and high temperature
  - 3) Low pressure and low temperature
  - 4) Low pressure and high temperature

Hint:  $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$   $\Delta H = -92\text{Kj/mole}$ . Forward reaction is exothermic and involve decrease of moles.

12. In which of the following equilibrium reaction the equilibrium would shift to the right, if pressure is increased
- 1)  $2\text{SO}_2 + \text{O}_2 \rightleftharpoons 2\text{SO}_3$
  - 2)  $\text{H}_2 + \text{I}_2 \rightleftharpoons 2\text{HI}$
  - 3)  $\text{H}_2 + \text{Cl}_2 \rightleftharpoons 2\text{HCl}$
  - 4)  $\text{N}_2\text{O}_4 \rightleftharpoons 2\text{NO}_2$

Hint: Ans; 1.  $\therefore$  No. of moles decreases in forward reactin.

13. The equilibrium concentration of  $\text{C}_2\text{H}_4$  in the following reaction can be increased by
- $$\text{C}_2\text{H}_4\text{(g)} + \text{H}_2\text{(g)} \rightleftharpoons \text{C}_2\text{H}_6\text{(g)}; \Delta H = -31.7 \text{ K.Cal}$$
- 1) removal of  $\text{C}_2\text{H}_6$
  - 2) addition of  $\text{H}_2$
  - 3) Increase in temperature
  - 4) Increase in pressure

14. Ammonium chloride dissolves in water with the absorption of heat. Which of the following is true?
1. The solubility of ammonium chloride decreases with increase in temperature
  2. The solubility of ammonium chloride increases with increase in temperature
  3. At higher temperature, ammonium chloride in solution exists as ammonia and hydrochloric acid
  4. At lower temperature ammonium chloride in solution is present in the molecular form
- Hint: As dissolution is endothermic, high temperature favours solubility.
15. For the reaction  $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$  at 721K, the value of equilibrium constant is 50. The value of  $K_p$  under the same conditions will be
- 1) 0.02
  - 2) 0.2
  - 3) 50
  - 4) 50/RT
- HINT;  $K_p = K_c$  as  $\Delta n = 0$ .
16. The effect of increasing the pressure on the following gaseous equilibrium  $2\text{A} + 3\text{B} \rightleftharpoons 3\text{C} + 2\text{D}$  is
- 1) favours forward reaction
  - 2) favours backward reaction
  - 3) no effect
  - 4) Favours for forward and backward reaction
17. Consider the reactions
- i)  $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$
  - ii)  $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$
- The addition of an inert gas at constant volume:
- 1). Will increase the dissociation of as well as
  - 2). will reduce the dissociation of as well as
  - 3). Will increase the dissociation of and step up the formation of
  - 4). Will not disturb the equilibrium of the reactions
- Hint: At constant volume addition of inert gas not disturb equilibrium state
18. In a reaction  $\text{A}_2(\text{g}) + 4\text{B}_2(\text{g}) \rightleftharpoons 2\text{AB}_4(\text{g})$ ;  $\Delta H < 0$ , the formation of  $\text{AB}_4(\text{g})$  will be favoured at
- 1) low temperature and high pressure
  - 2) high temperature and low pressure
  - 3) low temperature and low pressure
  - 4) high temperature and high pressure
19. In the equilibrium  $4\text{H}_2\text{O}(\text{g}) + 3\text{Fe}(\text{s}) \rightleftharpoons \text{Fe}_3\text{O}_4(\text{s}) + 4\text{H}_2(\text{g})$  the yield of  $\text{H}_2$  can be increased by
- 1) increasing the pressure
  - 2) passing more steam
  - 3) increasing the mass of iron
  - 4) decreasing the pressure
20. LeChatelier's principle is applicable to
- 1) chemical equilibria only
  - 2) physical equilibria only
  - 3) both 1 & 2
  - 4) neither 1 nor 2
21. The molar concentrations of A, B and C at equilibrium for the reaction  $\text{A} + 2\text{B} \rightleftharpoons 3\text{C}$  are 2, 3 and 4 moles/ lit respectively. Its  $K_c$  is
- 1) 2
  - 2) 3.56
  - 3) 0.2
  - 4) 0.026

Solution:

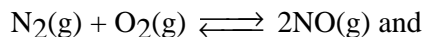
$$K_c = \frac{[\text{C}]^3}{[\text{A}][\text{B}]^2}$$

22. The equilibrium constant  $K_C$  of a reversible reaction is 10. The rate constant for the reverse reaction is 2.8. What is the rate constant for the forward reaction

- 1) 0.28    2) 28    3) 0.028    4) 280

Solution:  $K_C = K_f/K_b$

23. The equilibrium constants for the reactions



$NO(g) + 1/2 O_2(g) \rightleftharpoons NO_2(g)$  are  $K_1$  and  $K_2$  respectively. Then the equilibrium constant for the reaction  $N_2(g) + 2O_2(g) \rightleftharpoons 2NO_2(g)$  is

- 1)  $K_1/K_2$     2)  $K_1^2 - K_2^2$     3)  $K_1 K_2^2$     4)  $K_1/ K_2^2$

Solution; Multiply the second equation with (2) and then add both.

24. For the reaction  $C(s) + CO_2(g) \rightleftharpoons 2CO(g)$ , the partial pressures of  $CO_2$  and  $CO$  are 4.0 and 4.0 respectively at equilibrium, what is the value of  $K_p$  for this reaction

- 1) 0.5    2) 1.0    3) 4.0    4) 32

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

Solution:

25. The  $K_C$  for the reaction  $A + B \rightleftharpoons C$  is 4 and  $K_C$  for  $2A+D \rightleftharpoons C$  is 6 the value of

$K_C$  for  $C+D \rightleftharpoons 2B$  is

- 1) 0.67    2) 0.375    3) 2.7    4) 1.5

Solution; Equation 2 - 2X Equation 1. i.e  $K_C = K_2/K_1^2 = 6/4^2 = 6/16 = 0.375$

26. The equilibrium constant for the reaction

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$  is 81 at a certain temperature. If the concentrations of  $H_2$  and  $I_2$  are 3 mole / lit each at equilibrium, the equilibrium concentration of  $HI$  is

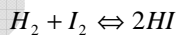
- 1) 3 mole / lit    2) 27 mole / lit  
3) 9 mole / lit    4) 13.5 mole / lit

Solution;  $K_C = [HI]^2/[H_2][I_2]$

27. 4.5 moles each of hydrogen and iodine are heated in a sealed 10 litre vessel. At equilibrium 3 moles of hydrogen iodide was found. The equilibrium constant for  $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$  is

- 1) 1    2) 10    3) 5    4) 0.33

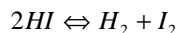
Solution;



Initial	4.5	4.5	0
Reacted & formed	1.5	1.5	3.0
At equilibrium	3/10	3/10	3/10
$K_C = [HI]^2/[H_2][I_2]$	$= (3/10) \times (3/10) / (3/10) = 1$		

28. 4 moles of HI is taken in a lit closed vessel and heated to equilibrium. At equilibrium, the concentration of H<sub>2</sub> is 1 mol lit<sup>-1</sup>. The equilibrium constant is  
 1) 4    2) 0.5    3) 2    4) 0.25

Solution:

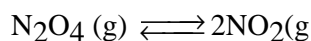


Intial:                    4            0            0

At equilibrium :    4-2x            x            x    But given at equilibrium concentration of H<sub>2</sub> is 1 mol lit<sup>-1</sup> i.e X=1  
 $K_C = \frac{[H_2][I_2]}{[HI]^2} = \frac{1 \times 1}{2^2} = 1/4 = 0.25$

29. 9.2 gm of N<sub>2</sub>O<sub>4</sub> (g) is taken in a closed one litre vessel and heated till the following equilibrium is reached N<sub>2</sub>O<sub>4</sub> (g)  $\rightleftharpoons$  2NO<sub>2</sub>(g). At equilibrium 50% of N<sub>2</sub>O<sub>4</sub> (g) is dissociated. What is the equilibrium constant (in mole lit<sup>-1</sup>) (M.wt. of N<sub>2</sub>O<sub>4</sub> is 92)  
 1) 0.1    2) 0.2    3) 0.4    4) 2

Solution; moles of N<sub>2</sub>O<sub>4</sub>=9.2/92= 0.1



initial            0.1            0

Reacted & Formed    0.05            0.1

At equilibrium :            0.05            0.1

$$K_C = \frac{[NO_2]^2}{[N_2O_4]} = \frac{[0.1]^2}{[0.05]} = 0.2$$

30. 1 mole of A (g) is heated to 300<sup>0</sup> C in closed one litre vessel till the following equilibrium is reached

A(g)  $\rightleftharpoons$  B(g) The equilibrium constant for the reaction at 300<sup>0</sup>C is 4. What is the concentration of B (in mol. lit<sup>-1</sup>) at equilibrium?

- 1) 0.2    2) 0.6    3) 0.8    4) 0.1

Solution:



initial            1            0

Reacted & Formed    x            x

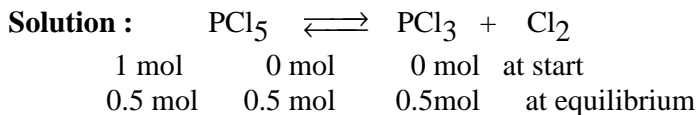
At equilibrium :            1-X            X

$$K_C = \frac{[B]}{[A]}, \quad 4 = \frac{x}{1-x}$$

$$4[1-x]=x, \quad 5x=4 \text{ and } x=4/5=0.8$$

31.  $\text{PCl}_5$  was taken at 2 atm in a closed vessel at  $154^\circ\text{C}$ . Keeping the temperature constant,  $\text{PCl}_5 \rightleftharpoons \text{PCl}_3 + \text{Cl}_2$  equilibrium is established when 50% of  $\text{PCl}_5$  decomposes. The  $K_p$  for the equilibrium is

- 1) 1atm    2) 3atm    3) 1.5atm    4) 0.5atm



The pressure at equilibrium  $= 2 \times \frac{1.5}{1} = 3 \text{ atm}$

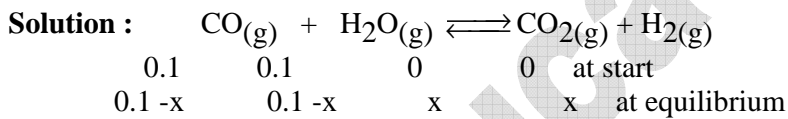
The partial pressures ;  $P_{\text{PCl}_3} = 3 \times \frac{0.5}{1.5} = 1 \text{ atm}$  ,  $P_{\text{Cl}_2} = 3 \times \frac{0.5}{1.5} = 1 \text{ atm}$

and  $P_{\text{PCl}_5} = 3 \times \frac{0.5}{1.5} = 1 \text{ atm}$

The equilibrium constant,  $K_p = \frac{P_{\text{PCl}_3} P_{\text{Cl}_2}}{P_{\text{PCl}_5}} = \frac{1 \times 1}{1} = 1 \text{ atm}$ .

32. The reaction was started with 0.1M each of  $\text{CO}$  and  $\text{H}_2\text{O}$  at 800K.  $K_c$  for the reaction,  $\text{CO(g)} + \text{H}_2\text{O(g)} \rightleftharpoons \text{CO}_2\text{(g)} + \text{H}_2\text{(g)}$ , at 800K is 4.24. What is the equilibrium concentration of the lightest gas ?

- 1) 0.933M    2) 0.067M    3) 1.067M    4) 0.1M



The equilibrium constant  $K_c$  is given as,  $K_c = \frac{[\text{CO}_2][\text{H}_2]}{[\text{CO}][\text{H}_2\text{O}]} = \frac{x^2}{(0.1-x)^2} = 4.24$

$3.24x^2 - 0.848x + 0.0424 = 0$  ,  $3.059x = 0.2059$ . Concentration of  $\text{H}_2 = x = 0.067\text{M}$ .

33.  $K_p$  for the reaction,  $\text{NH}_4\text{HS(s)} \rightleftharpoons \text{NH}_3\text{(g)} + \text{H}_2\text{S(g)}$ , at certain temperature is  $4 \text{ bar}^2$ .

The equilibrium pressure of mixture is

- 1) 16bar    2) 8bar    3) 2bar    4) 4bar

**Solution :** Equilibrium constant,  $K_p = P_{\text{NH}_3} \times P_{\text{H}_2\text{S}}$

Partial pressures are given as,  $P_{\text{NH}_3} = P_{\text{H}_2\text{S}} = \sqrt{4} = 2 \text{ bar}$

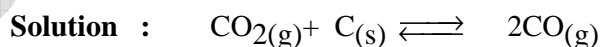
Total pressure at equilibrium is obtained using Dalton's law of partial pressures as,

$P_{\text{NH}_3} + P_{\text{H}_2\text{S}} = 2 + 2 = 4 \text{ bar}$ .

34. Calculate the ratio of pressures of  $\text{CO}_2$  gas and  $\text{CO}$  gas at equilibrium in the reaction,

$\text{CO}_2\text{(g)} + \text{C(s)} \rightleftharpoons 2\text{CO(g)}$ , if  $K_p$  is 3 bar at 900K and initial pressure of  $\text{CO}_2$  is 0.48 bar.

- 1) 1.2    2) 0.75    3) 0.557    4) 1.732



0.48 bar	0	0	at start
0.48 - x	0	2x	at equilibrium

$K_p = \frac{P_{\text{CO}}^2}{P_{\text{CO}_2}} = \frac{(2x)^2}{(0.48-x)} = 3 \Rightarrow \frac{2x}{0.48-x} = 1.732$  ,  $\frac{P_{\text{CO}_2}}{P_{\text{CO}}} = \frac{0.48-x}{2x} = \frac{1}{1.732} = 0.577$

35. For the cyclic trimerisation of acetylene to give one mole of benzene,  $K_c = 64 \text{ L}^2 \text{ mol}^{-2}$ . If the equilibrium concentration of benzene is  $1.0 \text{ mol L}^{-1}$ , The equilibrium concentration of acetylene is  
 1) 0.25M                      2) 0.5M                      3) 4M                      4) 0.05M

**Solution:** The equilibrium is,  $3\text{C}_2\text{H}_2 \text{ g} \rightleftharpoons \text{C}_6\text{H}_6(\text{l})$

$$K_c = [\text{C}_6\text{H}_6] / [\text{C}_2\text{H}_2]^3, \quad [\text{C}_2\text{H}_2]^3 = [\text{C}_6\text{H}_6] / K_c = 1/64$$

Equilibrium concentration of acetylene,  $[\text{C}_2\text{H}_2] = 0.25 \text{ mol L}^{-1}$ .

36. At 1000K,  $K_p = 1.0 \times 10^{-2} \text{ atm}$  for the reaction,  $2\text{NOCl}(\text{g}) \rightleftharpoons 2\text{NO}(\text{g}) + \text{Cl}_2(\text{g})$ . The value of  $K_c$  at the same temperature is

- 1)  $82.1 \times 10^{-2} \text{ mol L}^{-1}$     2)  $82.1 + 10^{-2} \text{ mol L}^{-1}$     3)  $10^{-2} / 82.1 \text{ mol L}^{-1}$     4)  $82.1 / 10^{-2} \text{ mol L}^{-1}$

**Solution:** Equilibrium constants are related as,

$$K_c = K_p / (RT)^{\Delta n}, \quad \Delta n = 2 + 1 - (2) = 1 \text{ and } R = 0.0821 \text{ L-atm K}^{-1} \text{ mol}^{-1}.$$

Equilibrium constant,  $K_c = 1.0 \times 10^{-2} / (0.0821 \times 1000) \text{ mol L}^{-1}$ .

37. For the equilibrium,  $2\text{SO}_3(\text{g}) \rightleftharpoons 2\text{SO}_2(\text{g}) + \text{O}_2(\text{g})$ , the partial pressures of  $\text{SO}_3$ ,  $\text{SO}_2$  and  $\text{O}_2$  gases, at 650K are respectively 0.3 bar, 0.6 bar and 0.4 bar. If the moles of both the oxides of sulphur are so adjusted as equal, the partial pressure of  $\text{O}_2$  will be

- 1) 0.6bar    2) 1.6bar    3) 0.4bar    4) 0.1bar

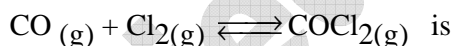
**Solution :** The equilibrium given as,  $2\text{SO}_3(\text{g}) \rightleftharpoons 2\text{SO}_2(\text{g}) + \text{O}_2(\text{g})$ ,

$$K_p = \frac{P_{\text{SO}_2}^2 P_{\text{O}_2}}{P_{\text{SO}_3}^2} = \frac{0.6 \times 0.6 \times 0.4}{0.3 \times 0.3} = 1.6 \text{ bar}$$

Equilibrium constant,

on adjustment,  $K_p$  does not change,  $1.6 \text{ bar} = x^2 \cdot P_{\text{O}_2} / x^2$ . Partial pressure of oxygen = 1.6 bar.

38. If 0.5 mol of  $\text{CO}$ , 0.2 mol of  $\text{Cl}_2$  and 0.2 mol of  $\text{COCl}_2$  are present at equilibrium in a 500ml of closed vessel at certain temperature. the  $K_c$  for the reaction,



- 1) 1 mole  $\text{L}^{-1}$     2) 1 L  $\text{mol}^{-1}$     3) 1 mole  $\text{L}^{-1}$     4) 2 L  $\text{mol}^{-1}$

**Solution:**  $[\text{CO}] = \text{moles/v.in.L} = 0.5/0.5 = 1 \text{ mol L}^{-1}$ ,  $[\text{Cl}_2] = 0.2/0.5 = 0.4 \text{ mol L}^{-1}$  and

$[\text{COCl}_2] = 0.2/0.5 = 0.4 \text{ mol L}^{-1}$ .

Equilibrium constant,  $K_c = [\text{COCl}_2] / [\text{CO}] [\text{Cl}_2] = 1 \text{ L mol}^{-1}$ .

39.  $K_c$  for the reaction  $2\text{X} \rightleftharpoons \text{Y} + \text{Z}$  is  $2 \times 10^{-3}$  at a given time the composition of reaction mixture

$[\text{X}] = [\text{Y}] = [\text{Z}] = 2.8 \times 10^{-4} \text{ M}$ . In what direction, the reaction will proceed ?

- 1) forward                      2) either forward or backward  
 3) backward                      4) neither forward nor backward

**Solution :** Reaction quotient Q is given as,

$$Q = \frac{[\text{Y}][\text{Z}]}{[\text{X}]^2}, \quad Q = \frac{2.8 \times 10^{-4} \times 2.8 \times 10^{-4}}{(2.8 \times 10^{-4})^2} = 1$$

Since  $Q > K$ , the reaction proceeds in backward direction.

40. What is the extent of dissociation if the equilibrium pressure  $p$  for the system

$\text{PCl}_5 \rightleftharpoons \text{PCl}_3 + \text{Cl}_2$  is numerically 3 times to its  $K_p$ .

- 1) 0.5    2) 0.866    3) 0.25    4) 1.0

**Solution:**  $\text{PCl}_5 \rightleftharpoons \text{PCl}_3 + \text{Cl}_2$

1            0            0            at start  
1-x        x            x            at equilibrium

Total moles at equilibrium (if  $x$  is extent of dissociation) =  $1 - x + x + x = 1 + x$

Partial pressure of  $\text{PCl}_5$ ,  $P_{\text{PCl}_5} = \frac{1-x}{1+x}p$

Similarly,  $\left( P_{\text{PCl}_3} = \frac{x}{1+x}p \right)$  and  $P_{\text{Cl}_2} = \frac{x}{1+x}p$

Equilibrium constant,

$$K_p = \frac{P_{\text{PCl}_3} P_{\text{Cl}_2}}{P_{\text{PCl}_5}}$$

Substituting the values,

$$K_p = \frac{\left( \frac{xp}{1+x} \right) \left( \frac{xp}{1+x} \right)}{\frac{(1-x)p}{1+x}} = \frac{x^2 p}{(1-x)^2}$$

$$\frac{p}{3} = \frac{x^2 p}{1-x^2} \rightarrow X=0.5 \text{ i.e Extent of dissociation of } \text{PCl}_5 = 0.5.$$

Assertion and Reason Type Questions

- 1) both A & R are true, R is the correct explanation of A
- 2) both A & R are true, R is not correct explanation of A
- 3) A is true, R is false
- 4) Both A and R are true

41. **A :** Introduction of catalyst does not affect position of equilibrium

**R :** For a reversible reaction, presence of a catalyst influences both forward & backward reactions to same extent

42. **A :** For  $\text{Zn(s)} + \text{Cu}^{+2}(\text{aq}) \rightleftharpoons \text{Zn}^{+2}(\text{aq}) + \text{Cu(s)}$ ,  $\Delta G = 0$ , but  $K_C = 10^{37}$

**R :** For a process under equilibrium Gibb energy change is zero, but as this process proceeds more towards right if  $K_C > 1$

43. **A :** For  $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$ ,  $\Delta H = -Q$  KJ, low pressure yields more Ammonia

**R :** According to Lechatlier's principle, increase of pressure shifts equilibrium in a direction that proceeds with increase in number of moles.

44. **A :** The degree of decomposition of  $\text{PCl}_5$  is less at high pressures.

**R :** In a reversible reaction, on increasing the pressure the equilibrium shifts in the direction in which decrease in volume takes place.

45. **A :**  $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$ . In this equilibrium system, the yield of  $\text{SO}_3$  is not altered in the presence of a catalyst.

**R :** A catalyst does not change the position of equilibrium.

46. **A :** The hydrolysis of an ester in acidic medium does not change with pressure.

**R :** Pressure does not show effect on equilibrium reactions taking place in solution.



47. If the degree of dissociation of  $\text{PCl}_5$  in the reaction  $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$  at equilibrium is 0.2 and if the initial number of moles of  $\text{PCl}_5$  is one, the total number of moles present in the gaseous mixture at equilibrium is

1) 2.8            2) 1.2            3) 1.4            4) 1.6

Solution:  $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$

1	0	0	at start
0.2	0.2	0.2	react or formed at equilibrium
0.8	0.2	0.2	present at equilibrium

The total moles at equilibrium =  $0.8 + 0.2 + 0.2 = 1.2$

48. The  $K_p$  value for  $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$  is  $5.0 \text{ atm}^{-1}$ . What is the equilibrium pressure of  $\text{O}_2$  if the equilibrium pressures of  $\text{SO}_2$  and  $\text{SO}_3$  are equal

1) 0.2 atm            2) 0.3 atm            3) 0.4 atm            4) 0.1 atm

Solution:  $K_p = 1/P_{\text{O}_2}$  as the equilibrium pressures of  $\text{SO}_2$  and  $\text{SO}_3$  are equal. Thus  $P_{\text{O}_2} = 1/K_p = 1/5 = 0.2$

49. One mole of ethyl alcohol and one mole of acetic acid are mixed. At equilibrium 0.666 moles of ester is present. The value of equilibrium constant is

1) 1/2            2) 1/4            3) 2            4) 4

Solution;  $\text{CH}_3\text{COOH}(\text{l}) + \text{C}_2\text{H}_5\text{OH}(\text{l}) \rightleftharpoons \text{CH}_3\text{COOC}_2\text{H}_5(\text{l}) + \text{H}_2\text{O}(\text{l})$

1.0	1.0	0	0	at start
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1-0.666	1-0.666	0.666	0.666	at equilibrium
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$K_c = (0.666 \times 0.666) / (0.334 \times 0.334) = 4$

50. In the equilibrium  $\text{NH}_4\text{HS}(\text{s}) \rightleftharpoons \text{NH}_3(\text{g}) + \text{H}_2\text{S}(\text{g})$  If the equilibrium pressure is 2 atm at  $80^\circ\text{C}$ .  $K_p$  for the reaction is

1) 1atm    2) 2atm    3) 11atm<sup>2</sup>    4) 4 atm<sup>2</sup>

Solution:  $\text{NH}_4\text{HS}(\text{s}) \rightleftharpoons \text{NH}_3(\text{g}) + \text{H}_2\text{S}(\text{g})$  , P of  $\text{NH}_3(\text{g}) + \text{P of H}_2\text{S}(\text{g}) = 2$ , P of  $\text{NH}_3(\text{g}) = \text{P of H}_2\text{S}(\text{g}) = 1$

$K_p = \text{P of NH}_3(\text{g}) \times \text{P of H}_2\text{S}(\text{g}) = 1 \times 1 = 1 \text{ atm}^2$

**KEY**

- |       |       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1) 4  | 2) 3  | 3) 3  | 4) 2  | 5) 4  | 6) 4  | 7) 1  | 8) 1  | 9) 3  | 10) 4 |
| 11) 1 | 12) 1 | 13) 3 | 14) 2 | 15) 3 | 16) 3 | 17) 4 | 18) 1 | 19) 2 | 20) 3 |
| 21) 2 | 22) 2 | 23) 3 | 24) 3 | 25) 2 | 26) 2 | 27) 1 | 28) 4 | 29) 2 | 30) 3 |
| 31) 1 | 32) 2 | 33) 4 | 34) 3 | 35) 1 | 36) 4 | 37) 2 | 38) 2 | 39) 3 | 40) 1 |
| 41) 1 | 42) 1 | 43) 4 | 44) 1 | 45) 1 | 46) 1 | 47) 2 | 48) 1 | 49) 4 | 50) 3 |