

Chemical Equilibrium

LEVEL - I

- Ammonium chloride dissolves in water with the absorption of heat. Which of the following is true?
 - The solubility of ammonium chloride decreases with increase in temperature.
 - The solubility of ammonium chloride increases with increase in temperature.
 - At higher temperature, ammonium chloride in solution exists as ammonia and hydrochloric acid.
 - At lower temperature ammonium chloride in solution is present in the molecular form.
- For the reaction

$$\text{C}_2\text{H}_{6(g)} \rightleftharpoons \text{C}_2\text{H}_{4(g)} + \text{H}_{2(g)}$$
 the $K_p = 0.05$ atm. The value of ΔG^0 of the reaction at 627°C would be
 - $11.19 \text{ kJ mol}^{-1}$
 - $22.40 \text{ kJ mol}^{-1}$
 - $33.57 \text{ kJ mol}^{-1}$
 - $27.98 \text{ kJ mol}^{-1}$
- The concentration of a pure condensed (solid or liquid) phase is not included in the expression of equilibrium constant because
 - solid and liquid concentrations are independent of their quantities.
 - solids and liquids react slowly
 - solids and liquids at equilibrium have no interactions with the gaseous phase
 - the molecules in solids and liquids cannot migrate to the gaseous phase.
- For the reaction

$$\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightleftharpoons 2\text{NH}_{3(g)} + 93.6\text{kJ}$$
 the concentration of H_2 at equilibrium will increase if
 - the temperature is lowered
 - the volume is decreased
 - N_2 is added at constant volume
 - NH_3 is removed.
- At 90°C , pure water has $[\text{H}_3\text{O}^+] = 10^{-6} \text{ mol dm}^{-3}$. The value of pK_w at 90°C
 - 6
 - 12
 - 6
 - 12
- The pH of a solution obtained by mixing 20 mL of 0.02 M sodium acetate and 10 mL of 0.01 M acetic acid ($K_a = 1.8 \times 10^{-5}\text{M}$) is
 - 4.75
 - 5.05
 - 4.45
 - 5.34
- Given: $K_{sp}(\text{AgI}) = 8.5 \times 10^{-17} \text{ M}^2$. The solubility of AgI in 0.1M KI solution is
 - $8.5 \times 10^{-15}\text{M}$
 - $8.5 \times 10^{-16}\text{M}$
 - $8.5 \times 10^{-17}\text{M}$
 - $8.5 \times 10^{-18}\text{M}$

QUESTION BANK-CH-2

8. Van't Hoff equation giving the effect of temperature on chemical equilibrium is represented as

(a) $\frac{d \ln F}{dT} = \frac{\Delta H}{RT^2}$

(b) $\frac{d \ln K_p}{dT} = \frac{\Delta H T^2}{R}$

(c) $\frac{d \ln K_p}{dT} = \frac{\Delta H}{RT^2}$

(d) $\frac{d \ln K_p}{dT} = \frac{RT^2}{\Delta H}$

9. For the reaction $A + B \rightleftharpoons C + D$; ΔH for forward reaction is +20 kcal and has activation energy 40 kcal, the activation energy and ΔH for backward reaction are respectively.

(a) 20, 40

(b) 40, 20

(c) 20, -20

(d) -20, 40

10. Which of the following is correct about reversible reaction?

(a) $E_a(f) - E_a(b) = \Delta H(f)$

(b) $E_a(b) - E_a(f) = \Delta H(f)$

(c) $E_a(b) + E_a(f) = \Delta H(f)$

(d) $E_a(b) + E_a(f) = \Delta H(b)$

11. For the reaction $N_2 + 3H_2 \rightleftharpoons 2NH_3$ at $500^\circ C$ the value of K_p is 1.44×10^{-5} . What will be the value of K_p at low pressure where the gases are behaving almost ideally

(a) 1.44×10^{-5}

(b) $(0.082 \times 773)^2 \times 1.44 \times 10^{-5}$

(c) $1.44 \times 10^{-5} \times (0.082 \times 500)^2$

(d) $1.44 \times 10^{-5} \times (0.082 \times 773)^3$

12. When chemical equilibrium is attained

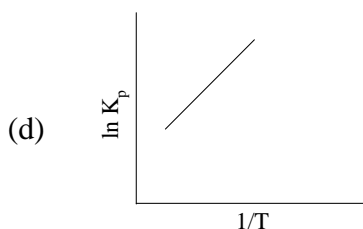
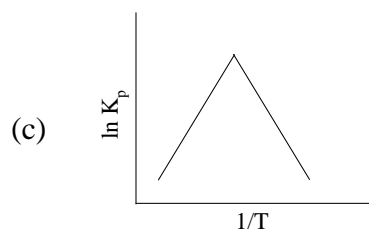
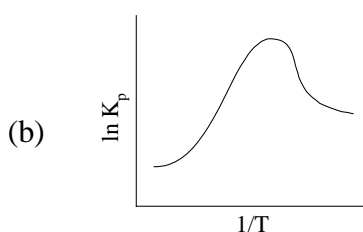
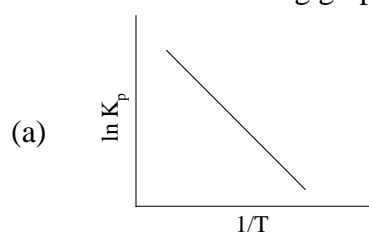
(a) $\Delta G = 0$ and reaction quotient (Q) attains the maximum value called equilibrium constant (K) of the reaction.

(b) $\Delta G^0 = 0$ and $Q = K$

(c) $\Delta G = 0$ and Q assumes minimum value

(d) $\Delta G = RT \ln K$

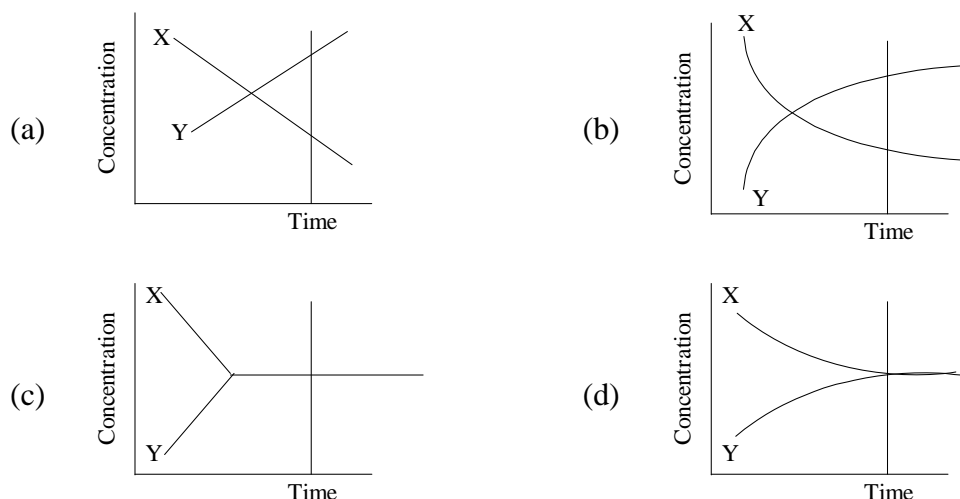
13. Which of the following graphs represents an exothermic reaction?



14. In a flask colourless N_2O_4 is in equilibrium with brown coloured NO_2 . At equilibrium when the flask is heated at 100°C , the brown colour deepens and on cooling it becomes less coloured, the change in enthalpy, ΔH for this system is
 (a) Negative (b) Positive
 (c) Zero (d) Undefined
15. The following two reactions
 i) $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$ and
 ii) $\text{COCl}_2(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + \text{Cl}_2(\text{g})$ are
 Simultaneously in equilibrium in an equilibrium box at constant volume. A few moles of $\text{CO}(\text{g})$ are later introduced into the vessel. After some time, the new equilibrium concentration of
 (a) PCl_5 will remain unchanged (b) Cl_2 will be greater
 (c) PCl_5 will become less (d) PCl_5 will become greater
16. Consider the reactions
 i) $\text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + \text{H}_2(\text{g}); K_1$
 ii) $\text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + 3\text{H}_2(\text{g}); K_2$
 iii) $\text{CH}_4(\text{g}) + 2\text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + 4\text{H}_2(\text{g}); K_3$
 (a) $K_3 = \frac{K_1}{K_2}$ (b) $K_3 = \frac{K_1^2}{K_2^3}$
 (c) $K_3 = K_1 K_2$ (d) $K_3 = K_1 \sqrt{K_2}$
17. Which of the following statement is correct?
 (a) In the limit $T \rightarrow 0$, ΔG^0 approaches ΔH^0 .
 (b) S of a closed system is always maximum at equilibrium
 (c) In any closed system, G is always minimum at equilibrium
 (d) Addition of a reactant gas to an ideal gas reaction mixture shifts the equilibrium such that some of the added gas is used up
18. The condition for spontaneity in a chemical reaction is
 (a) $(\Delta G)_T, p \leq 0$ (b) $(\Delta U)_{S, v} \leq 0$
 (c) $(\Delta H)_{S, p} \leq 0$ (d) $(\Delta S)_{U, v} \geq 0$
19. Of the following which is the characteristics that is applicable to systems at equilibrium?
 (a) equilibrium stands for a stable and static condition.
 (b) no measurable property of the system remains constant at equilibrium
 (c) the equilibrium expression involving concentration of reacting substances has nothing to do with temperature.
 (d) the magnitude of the value of the concentration related expression is an indication of the extent to which the reaction proceeds before reaching equilibrium.
20. For the reaction $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$, the units of K_c is
 (a) $\text{mol}^{-1} \text{L}^{-2}$ (b) $(\text{mol L}^{-1})^2$
 (c) mol L^{-1} (d) has no units

QUESTION BANK-CH-4

21. A small value of K , the equilibrium constant, indicates that
- the concentration of the un-ionized molecules must be relatively small compared to the ion concentrations.
 - the concentration of the ionized molecules must be larger than the ion concentration
 - the substance ionizes to a large degree
 - the concentration of the un-ionized molecules must be relatively large compared to the ion concentration.
22. When pressure is applied to the equilibrium system $\text{ice} \rightleftharpoons \text{water}$ which of the following phenomenon will happen?
- more ice will be formed
 - more water will be formed
 - water will evaporate
 - equilibrium will not be established
23. Which of the following is correct from the point of view of Le-Chatelier's principle?
- if a system is at equilibrium and the partial pressure of one of the reactant in the gas phase is increased then the system will readjust to decrease the partial pressure of that reactant.
 - for a system involving gases, when the total pressure is increased in a homogeneous case the system will react in such a way as to decrease the total number of molecules.
 - if a system at equilibrium is subjected to a change which displaces it from the equilibrium, a net reaction will occur in a direction that counteracts the change.
 - all statements a, b and c are correct
24. The balanced chemical equation $2\text{CO}_{(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{CO}_{2(g)}$ signifies which one of the following?
- one can add to a vessel only 2 mol of CO for each mol of O_2 added.
 - no matter how much of these two reagents are added to a vessel, only 1 mol of O_2 will react, and it will react with 2 mol of CO.
 - when they react, then CO reacts with O_2 in a 2:1 mole ratio.
 - when 2 mol of CO and 1 mol of O_2 are placed in a vessel, they will react to give 2 mol of CO_2 .
25. Which of the following statements about the reaction quotient, Q is FALSE?
- the reaction quotient, Q and the equilibrium constant, K_{eq} always have the same numerical value.
 - the reaction quotient may some times be zero
 - the reaction quotient may be larger then the equilibrium constant
 - the reaction quotient may be smaller than the equilibrium constant.
26. The decomposition of phosgene, $\text{COCl}_{2(g)} \rightleftharpoons \text{CO}_{(g)} + \text{Cl}_{2(g)}$ is an endothermic process. Which of the following factors will cause the value of the equilibrium constant to increase?
- adding Cl_2
 - adding He (g)
 - decreasing the total pressure
 - none of the above
27. Which diagrams could represent the variation in the concentration of X and Y with time in the reversible reaction $\text{X} \rightleftharpoons \text{Y}$ which come to equilibrium after a time t ?



28. Which of the following condition will give the maximum yield of SO_3 in the reaction
- $$2\text{SO}_{2(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{SO}_{3(g)} + \text{heat}$$
- (a) temperature is increased keeping the pressure constant
 (b) temperature is reduced and pressure is increased
 (c) both temperature and pressure are lowered.
 (d) both temperature and pressure are increased
29. Rate of disappearance of the reactant A at two different temperatures is given by
- $$\text{A} \rightleftharpoons \text{B}$$
- $$-\frac{d[\text{A}]}{dt} = 2 \times 10^{-2} \text{ s}^{-1} [\text{A}] - 4 \times 10^{-3} \text{ s}^{-1} [\text{B}] \text{ at } 300\text{K}$$
- $$-\frac{d[\text{A}]}{dt} = 4 \times 10^{-2} \text{ s}^{-1} [\text{A}] - 16 \times 10^{-4} \text{ s}^{-1} [\text{B}] \text{ at } 400\text{K}$$
- heat of reaction in the given temperature range, when equilibrium is set up is
- (a) $\frac{2.303 \times 2 \times 300 \times 400}{100} \log 50 \text{ cal}$ (b) $\frac{2.303 \times 2 \times 300 \times 400}{100} \log 250 \text{ cal}$
 (c) $\frac{2.303 \times 2 \times 300 \times 400}{100} \log 5 \text{ cal}$ (d) None
30. Favourable conditions for the formation of $\text{NH}_3(g)$ in good yield are using
- $$\text{N}_{2(g)} + 3\text{H}_{2(g)} - 22 \text{ kcal} \rightleftharpoons 2\text{NH}_{3(g)}$$
- (a) high T, P and vaporization of $\text{NH}_3(l)$
 (b) high T, low P and vaporization of $\text{NH}_3(l)$
 (c) low T, high P and liquefaction of $\text{NH}_3(g)$
 (d) low T, high P, liquefaction of $\text{NH}_3(g)$ and presence of a catalyst.

LEVEL - II

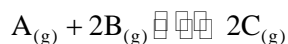
1. The equilibrium constant (K_c) for the reaction



is 16. If 1 mol of each of all the four gases is taken in 1 dm³ vessel, the equilibrium concentration of NO would be

- (a) 0.4M (b) 1.6M
(c) 1.4M (d) 0.6M

2. For the reaction



one mole of A and 1.5 mol of B are taken in a 2.0 litre vessel. At equilibrium, the concentration of C was found to be 0.35 mol L⁻¹. The equilibrium constant K_c of the reaction would be

- (a) 0.295 M⁻¹ (b) 0.673 M⁻¹
(c) 2.36 M⁻¹ (d) 1.178 M⁻¹

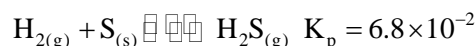
3. For the decomposition reaction



the K_p = 2.9 × 10⁻⁵ atm³. The total pressure of gases at equilibrium when 1.0 mol of NH₂COONH_{4(s)} was taken to start with would be

- (a) 0.0194 atm (b) 0.0388 atm
(c) 0.0582 atm (d) 0.0776 atm

4. If 0.2 mol of H_{2(g)} and 2.0 mol of S_(s) are mixed in a 1.0 litre vessel at 90°C, the partial pressure of H₂S_(g) formed according to the reaction



would be

- (a) 0.38 atm (b) 0.19 atm
(c) 0.6 atm (d) 6.8 × 10⁻² atm / (0.2 × 2)

5. For a fairly concentrated solution of a weak electrolyte A_xB_y, the degree of dissociation is given as

- (a) $\alpha = \sqrt{K_{eq} / c(x+y)}$ (b) $\alpha = (K_{eq} / c^{x+y-1} x^x y^y)^{1/(x+y)}$
(c) $\alpha = \sqrt{K_{eq} c / xy}$ (d) $\alpha = \sqrt{K_{eq} xy / c}$

6. If s₀, s₁, s₂ and s₃ are the solubilities of AgCl in water, 0.01 M CaCl₂, 0.01M NaCl and 0.05M AgNO₃ solutions, respectively, then

- (a) s₀ > s₁ > s₂ > s₃ (b) s₀ > s₂ > s₁ > s₃
(c) s₀ > s₂ > s₃ > s₁ (d) s₀ > s₁ = s₂ > s₃

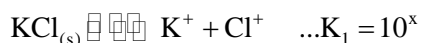
7. At a certain temperature the following equilibrium is established



one mole of each of the four gases is mixed in one litre container and the reaction is allowed to react equilibrium state. When excess of baryta water is added to the equilibrium mixture, the weight of white precipitate obtained is 236.4g. The equilibrium constant K_c of the reaction is

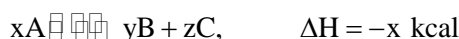
- (a) 1.2 (b) 2.25
(c) 2.1 (d) 3.6

8. In dilute solution there are two equilibria



The equilibrium constant for the reaction $\text{Ag}^+ + \text{KCl}^- \rightleftharpoons \text{K}^+ + \text{AgCl}_{(s)}$ in dilute solution is

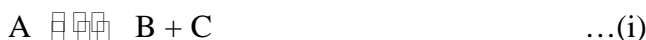
- (a) 10^{x+y} (b) 10^{x-y}
 (c) 10^y (d) $(10^x)^y$
9. High pressure and low temperature are the favourable conditions for the formation of product for the reaction



Hence:

- (a) $x > y + z$ (b) $x < y + z$
 (c) $x = y + z$ (d) None of these
10. $\text{X} \rightleftharpoons n\text{Y}$ X decomposes to give Y (in one litre vessel):
 If degree of dissociation is α then K_c and its unit is
- (a) $\frac{n\alpha}{1-\alpha} \text{ mol}^{n-1} \text{ lit}^{n-1}$ (b) $\frac{(n\alpha)^n}{1-\alpha} \text{ mol}^n \text{ lit}^n$
 (c) $\frac{n\alpha}{1-\alpha}$, K_c is unit less (d) $\frac{(n\alpha)^n}{1-\alpha}$, K_c is unit less

11. For the reaction (1) and (2)



Given $K_{P1} : K_{P2} :: 9 : 1$

If the degree of dissociation of A and D be same then the total pressure at equilibria (1) and (2) are in the ratio

- (a) 3 : 1 (b) 36 : 1
 (c) 1 : 1 (d) 0.5 : 1
12. Which of the following is wrong?
- | Reaction | Degree of dissociation |
|--|---------------------------------|
| (a) $\text{PCl}_5 \rightleftharpoons \text{PCl}_3 + \text{Cl}_2$ | $\frac{D-d}{d}$ |
| (b) $\text{N}_2\text{O}_4 \rightleftharpoons 2\text{NO}_2$ | $\frac{M_t - M_0}{2d}$ |
| (c) $\text{N}_2 + \text{I}_2 \rightleftharpoons 2\text{HI}$ | $\frac{\sqrt{K}}{\sqrt{K} + 2}$ |
| (d) $\text{A} + \text{B} \rightleftharpoons \text{C} + \text{D}$ | $\frac{\sqrt{K}}{2 + \sqrt{K}}$ |
13. The reaction $\text{A} + \text{B} \rightleftharpoons \text{C} + \text{D}$ is studied in a one litre vessel at 250°C. The initial concentration of A was 3n and the initial concentration of B was n. After equilibrium was

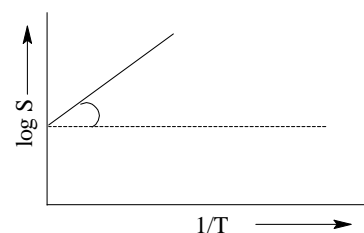
- attained then equilibrium concentration of C was found to be equal to equilibrium concentration of B. What is the concentration of D at equilibrium
- (a) $n/2$ (b) $(3n - n/2)$
 (c) $(n - n/2)$ (d) n
14. If in the reaction $\text{PCl}_{5(g)} \rightleftharpoons \text{PCl}_{3(g)} + \text{Cl}_{2(g)}$, α is the degree of dissociation of PCl_5 , then the number of molecules at equilibrium will be
- (a) 3 (b) $1 + \alpha$
 (c) $1 - \alpha^2$ (d) $1 + 2\alpha$
15. The decomposition of N_2O_4 to NO_2 is carried out at 553K is carbon tetrachloride. When equilibrium is reached, 0.2 mole of N_2O_4 and 2.0×10^{-3} mole of NO_2 are present in a 2.0 L container. The equilibrium constant for the reaction $\text{N}_2\text{O}_{4(g)} \rightleftharpoons 2\text{NO}_{2(g)}$ at 553K is
- (a) 1.0×10^{-2} (b) 2.0×10^{-3}
 (c) 1.0×10^{-5} (d) 2.0×10^{-5}
16. At 90°C , the following equilibrium is established
- $$\text{H}_{2(g)} + \text{S}_{(s)} \rightleftharpoons \text{H}_2\text{S}_{(g)} \quad K = 6.8 \times 10^{-2}$$
- If 0.20 mole of hydrogen and 1.0 mole of sulphur are heated to 90°C in a 1.0 L vessel. What will the concentration of H_2S at equilibrium
- (a) $2.8 \times 10^{-2} \text{ mol L}^{-1}$ (b) $1.4 \times 10^{-2} \text{ mol L}^{-1}$
 (c) $3.6 \times 10^{-2} \text{ mol L}^{-1}$ (d) $1.05 \times 10^{-2} \text{ mol L}^{-1}$
17. For the reaction $\text{H}_{2(g)} + \text{I}_{2(g)} \rightleftharpoons 2\text{HI}_{(g)}$ the equilibrium pressures are p_{H_2} , p_{I_2} and p_{HI} . The volume of the reaction vessel is reduced so as to reestablish equilibrium, the partial pressure of H_2 and I_2 were doubled. The partial pressure of HI would be
- (a) p_{HI} (b) $\frac{p_{\text{HI}}}{2}$
 (c) $2p_{\text{HI}}$ (d) $4p_{\text{HI}}$
18. For the reaction $\text{A} \longrightarrow \text{B} + \text{C}$, the following data were obtained at 300°C
- | Experiment | $[\text{A}]$, mol L^{-1} | Rate $\text{mol L}^{-1} \text{ h}^{-1}$ |
|------------|------------------------------------|---|
| 1 | 0.170 | 0.05 |
| 2 | 0.340 | 0.10 |
| 3. | 0.680 | 0.20 |
- The equilibrium constant for the reaction is 0.50 mol L^{-1} . Assuming that the reaction proceeds by a one step mechanism, calculate the rate constant for the reverse reaction:
- (a) $0.294 \text{ L mol}^{-1} \text{ hr}^{-1}$ (b) $0.588 \text{ L mol}^{-1} \text{ hr}^{-1}$
 (c) $0.50 \text{ L mol}^{-1} \text{ hr}^{-1}$ (d) $0.125 \text{ L mol}^{-1} \text{ hr}^{-1}$
19. Sulphide ion reacts with solid sulphur forming S_2^{2-} and S_3^{2-} with formation constant 12 and 132. Formation constant S_3^{2-} from sulphur and S_2^{2-} is
- (a) 12 (b) 132
 (c) 132×12 (d) 11

20. Solubility of a solute in a solvent (say H_2O) is dependent on temperature as given by $S = Ae^{-\Delta H/RT}$ where ΔH is heat of reaction:

Solute + H_2O \rightleftharpoons solution, $\Delta H = \pm x$

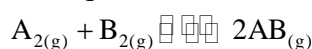
For a given solution variation of $\log S$ with temperature is shown graphically. Hence solute is

- (a) $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ (b) NaCl
(c) Sucrose (d) CaO



LEVEL - III

1. The equilibrium constant (K_c) of the reaction



is 50. If 1 mol of A_2 and 2 mol of B_2 are mixed, the amount of AB at equilibrium would be

- (a) 0.934 mol (b) 0.467 mol
(c) 1.866 mol (d) 1.401 mol

2. For the reaction



the relation connecting the degree of dissociation (α) of $\text{N}_2\text{O}_{4(g)}$ with the equilibrium constant K_p is

- (a) $\alpha = \frac{K_p/P}{4 + K_p/P}$ (b) $\alpha = \frac{K_p}{4 + K_p}$
(c) $\alpha = \left(\frac{K_p/P}{4 + K_p/P} \right)^{1/2}$ (d) $\alpha = \left(\frac{K_p}{4 + K_p} \right)^{1/2}$

3. Which of the following expressions is not true?

- (a) For a neutral solution $[\text{H}^+] = [\text{OH}^-] = \sqrt{K_w}$
(b) For an acidic solution $[\text{H}^+] > \sqrt{K_w}$ and $[\text{OH}^-] < \sqrt{K_w}$
(c) For an alkaline solution $[\text{H}^+] < \sqrt{K_w}$ and $[\text{OH}^-] > \sqrt{K_w}$
(d) For a neutral solution $[\text{H}^+] = [\text{OH}^-] = 10^{-7} \text{ M}$ at all temperatures

4. Given: $K_{sp}(\text{AgCl}) = 1.7 \times 10^{-10} \text{ M}^2$, $K_{sp}(\text{Ag}_2\text{CrO}_4) = 1.9 \times 10^{-12} \text{ M}^3$
Which ion is precipitated first when solid AgNO_3 is added to a solution containing 0.1M each of NaCl and Na_2CrO_4 ?

- (a) chloride ion (b) chromate ion
(c) Both Cl^- and CrO_4^{2-} precipitate together (d) cannot be predicted

5. The molarity of Mg^{2+} ions in a saturated solution of $\text{Mg}_3(\text{PO}_4)_2$ whose solubility product is $1.08 \times 10^{-13} \text{M}^5$ is
 (a) $1.0 \times 10^{-3} \text{M}$ (b) $2.0 \times 10^{-3} \text{M}$
 (c) $3.0 \times 10^{-3} \text{M}$ (d) $4.0 \times 10^{-3} \text{M}$
6. The maximum pH of a solution which is 0.10 M in Mg^{2+} from which $\text{Mg}(\text{OH})_2$ is not precipitated is
 (a) 4.96 (b) 6.96
 (c) 7.04 (d) 9.04
7. The expression to compute pH of NH_4Cl solution is
 (a) $\text{pH} = \frac{1}{2} \text{pK}_w - \frac{1}{2} \text{pK}_b(\text{NH}_4\text{OH}) - \frac{1}{2} \log[\text{salt}]$
 (b) $\text{pH} = \frac{1}{2} \text{pK}_w + \frac{1}{2} \text{pK}_b(\text{NH}_4\text{OH}) - \frac{1}{2} \log[\text{salt}]$
 (c) $\text{pH} = \frac{1}{2} \text{pK}_w + \frac{1}{2} \text{pK}_b(\text{NH}_4\text{OH}) + \frac{1}{2} \log[\text{salt}]$
 (d) $\text{pH} = \frac{1}{2} \text{pK}_b(\text{NH}_4\text{OH}) - \frac{1}{2} \text{pK}_w + \frac{1}{2} \log[\text{salt}]$
8. $\text{X}_2 + \text{X}^- \rightleftharpoons \text{X}_3^-$ ($\text{X} = \text{Iodine}$)
 This reaction is set up in aqueous medium. We start with 1 mol of X_2 and 0.5 mol of X^- in 1L flask. After equilibrium is reached, excess of AgNO_3 gave 0.25 mol of yellow ppt. Equilibrium constant is
 (a) 1.33 (b) 2.66
 (c) 2.00 (d) 3.00
9. A vessel contains $\text{H}_2(\text{g})$ at 2 atm pressure. When $\text{H}_2\text{S}(\text{g})$ at a pressure of 4 atm is introduced into the vessel. Where in reaction

$$8\text{H}_2\text{S}(\text{g}) \rightleftharpoons 8\text{H}_2(\text{g}) + \text{S}_8(\text{s})$$
 occurs at a temperature of 2000K. It is found that

$$\left[\frac{n[\text{H}_2]}{n(\text{H}_2\text{S})} \right]_{\text{at equilibrium}} = \left[\frac{n(\text{H}_2\text{S})}{n(\text{H}_2)} \right]_{\text{at } t=0}$$
 (a) Maximum weight of solid formed is 32 gm
 (b) Maximum weight of solid formed is 0.32gm
 (c) $K_p = K_c RT$
 (d) $K_c = 256$
10. K_c for the reaction $[\text{Ag}(\text{CN})_2]^- \longrightarrow \text{Ag}^+ + 2\text{CN}^-$, the equilibrium constant at 25°C is 4.0×10^{-19} , then the silver ion concentration in a solution which was originally 0.1 molar in KCN and 0.03 molar in AgNO_3 is
 (a) 7.5×10^{18} (b) 7.5×10^{-18}
 (c) 7.5×10^{19} (d) 7.5×10^{-19}

11. Given: $A \rightarrow B + C$, $\Delta H = -10$ kcal, the energy of activation of backward reaction is 15 kcal mol^{-1} . If the energy of activation of forward reaction in the presence of a catalyst is 3 kcal mole^{-1} the catalyst will increase the rate of reaction at 300 K by the number of times equal to
- (a) $e^{3.33}$ (b) $e^{4.21}$
 (c) $e^{-2.7}$ (d) $e^{2.303}$
12. In a 2 litre flask, the reaction takes place as
- $$\text{COCl}_2(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + \text{Cl}_2(\text{g})$$
- The equilibrium conc. of $[\text{COCl}_2]$ was found to be 0.4. If the excess of COCl_2 is added to the system, the equilibrium re-establishes and $[\text{COCl}_2]$ becomes 1./6. What is the equilibrium conc. of $[\text{CO}]$
- (a) Half of the former value (b) Thrice of the former value
 (c) Remains unaltered (d) Twice of the former value
13. The complexation of Fe^{2+} with the chelating agent dipyrldyl (abbreviated dipy) has been studied kinetically in both the forward and reverse direction. For the complexation reaction.
- $$\text{Fe}^{2+} + 3\text{dipy} \longrightarrow \text{Fe}(\text{dipy})_3^{2+}$$
- the rate of the formation of the complex at 25°C is given by
- $$\text{Rate} = (1.45 \times 10^{13} \text{ L}^3 \text{ mol}^{-3} \text{ s}^{-1}) [\text{Fe}^{2+}] [\text{dipy}]^3$$
- and for the reverse reaction the rate of disappearance of the complex is
- $$\text{Rate} = (1.22 \times 10^{-4} \text{ s}^{-1}) [\text{Fe}(\text{dipy})_3^{2+}]$$
- What is stability constant of the complex?
- (a) 1.188×10^{17} (b) 0.84×10^{-17}
 (c) 1.188×10^{-17} (d) 0.84×10^{17}
14. The equilibrium constants for the reaction $\text{H}_3\text{BO}_3 + \text{glycerine} \rightleftharpoons \text{H}_3\text{BO}_3 \cdot \text{glycerine}$ is 0.90. Glycerine present per litre of 0.1M H_3BO_3 to convert 60% of H_3BO_3 into $\text{H}_3\text{BO}_3 \cdot \text{Glycerine}$ product is:
- (a) 0.167M (b) 1.73M
 (c) 0.0167 M (d) 10.67 M
15. For the reaction $A + B \rightleftharpoons C + D$, equilibrium concentration of $[C] = [D] = 0.5\text{M}$ if we start with 1 mole each of A and B. Percentage of A converted into C if we start with 2 mole of A and 1 mole of B is:
- (a) 25% (b) 40%
 (c) 66.66% (d) 33.33%
16. $\text{I}_2 + \text{I}^- \rightleftharpoons \text{I}_3^-$
- This reaction is set up in aqueous medium. We start with 1 mol of I_2 and 0.5 mol of I^- in 1 L flask. After equilibrium is reached, excess of AgNO_3 gave 0.25 mol of yellow ppt. Equilibrium constant is:
- (a) 1.33 (b) 2.66
 (c) 2.00 (d) 3.00

17. One mole each of A and B and 3 mole each of C and D are placed in 1 L flask, if equilibrium constant is 2.25 for $A + B \rightleftharpoons C + D$, equilibrium conc. of A and C will be in the ratio
 (a) 2 : 3 (b) 3 : 2
 (c) 1 : 2 (d) 2 : 1
18. The approach to the following equilibrium was observed kinetically from both directions:
 $\text{PtCl}_4^{2-} + \text{H}_2\text{O} \rightleftharpoons \text{Pt}(\text{H}_2\text{O})\text{Cl}_3^- + \text{Cl}^-$
 At 25°C, it was found that

$$-\frac{d[\text{PtCl}_4^{2-}]}{dt} = (3.90 \times 10^{-5} \text{ s}^{-1})[\text{PtCl}_4^{2-}] - (2.1 \times 10^{-3} \text{ L mol}^{-1} \text{ s}^{-1})(\text{Pt}(\text{H}_2\text{O})\text{Cl}_3^-)[\text{Cl}^-]$$
 What is the value of equilibrium constant when fourth Cl^- is complexed?
 (a) $1.86 \times 10^{-2} \text{ mol L}^{-1}$ (b) $0.54 \times 10^2 \text{ L mol}^{-1}$
 (c) 3.90×10^{-5} (d) 2.1×10^{-3}
19. For the reaction
 $2\text{HI}(\text{g}) \rightleftharpoons \text{H}_2(\text{g}) + \text{I}_2(\text{g})$
 The degree of dissociation (α) of $\text{HI}(\text{g})$ is related to equilibrium constant, K_p by the expression
 (a) $\frac{1 + 2\sqrt{K_p}}{2}$ (b) $\sqrt{\frac{1 + 2K_p}{2}}$
 (c) $\sqrt{\frac{2K_p}{1 + 2K_p}}$ (d) $\frac{2\sqrt{2K_p}}{1 + 2\sqrt{K_p}}$
20. At temperature T, a compound $\text{AB}_2(\text{g})$ dissociates according to the reaction
 $2\text{AB}_2(\text{g}) \rightleftharpoons 2\text{AB}(\text{g}) + \text{B}_2(\text{g})$ with degree of dissociation α , which is small compared with unity. The expression for K_p , in terms of α and the total pressure, P_T is
 (a) $\frac{P_T \alpha^3}{2}$ (b) $\frac{P_T \alpha^2}{3}$
 (c) $\frac{P_T \alpha^3}{3}$ (d) $\frac{P_T \alpha^2}{2}$.

Answers

Chemical Equilibrium

LEVEL - I

- | | | | | | |
|-----|-----|-----|--------------------|-----|-----|
| 1. | (b) | 11. | (a) | 21. | (d) |
| 2. | (b) | 12. | (a) | 22. | (b) |
| 3. | (a) | 13. | (d) | 23. | (d) |
| 4. | (b) | 14. | (b) | 24. | (d) |
| 5. | (b) | 15. | (c) | 25. | (a) |
| 6. | (d) | 16. | (c) | 26. | (d) |
| 7. | (b) | 17. | (a) | 27. | (b) |
| 8. | (c) | 18. | (a), (b), (c), (d) | 28. | (b) |
| 9. | (c) | 19. | (d) | 29. | (c) |
| 10. | (a) | 20. | (b) | 30. | (c) |

LEVEL - II

- | | | | | | |
|----|-----|-----|-----|-----|-----|
| 1. | (b) | 8. | (c) | 15. | (c) |
| 2. | (c) | 9. | (a) | 16. | (b) |
| 3. | (c) | 10. | (d) | 17. | (c) |
| 4. | (a) | 11. | (b) | 18. | (b) |
| 5. | (b) | 12. | (d) | 19. | (d) |
| 6. | (b) | 13. | (a) | 20. | (d) |
| 7. | (b) | 14. | (b) | | |

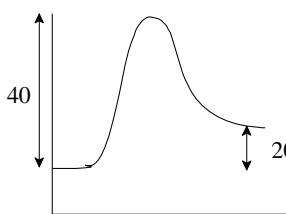
LEVEL - III

- | | | | | | |
|----|-----|-----|-----|-----|-----|
| 1. | (c) | 8. | (a) | 15. | (d) |
| 2. | (c) | 9. | (d) | 16. | (a) |
| 3. | (d) | 10. | (b) | 17. | (a) |
| 4. | (a) | 11. | (a) | 18. | (b) |
| 5. | (c) | 12. | (d) | 19. | (a) |
| 6. | (d) | 13. | (a) | 20. | (d) |
| 7. | (a) | 14. | (b) | | |

Hints & Solutions

Chemical Equilibrium

LEVEL – I

2. $\Delta G^{\circ} = RT \ln K_p$
 $= - (8.314 \text{ J K}^{-1} \text{ mol}^{-1}) (900 \text{ K}) (2.303) \log (0.05)$
 $= 22400 \text{ J mol}^{-1}$
5. For pure water, $[\text{H}_3\text{O}^+] = [\text{OH}^-]$
 $K_w = [\text{H}_3\text{O}^+] [\text{OH}^-] = 10^{-12} (\text{mol dm}^{-3})^2$
 $\text{p}K_w = -\log K_w = 12$
6. $\text{pH} = \text{p}K_a + \log \frac{[\text{salt}]}{[\text{acid}]}$
 $= -\log(1.8 \times 10^{-5}) + \log \frac{(0.02 \times 2/3)\text{M}}{(0.01 \times 1/3)\text{M}}$
 $= 4.74 + 0.60 = 5.34$
7. $[\text{Ag}^+] = \frac{K_{sp}}{[\text{I}^-]} = \frac{8.5 \times 10^{-17} \text{ M}^2}{0.1\text{M}} = 8.5 \times 10^{-16} \text{ M}$
8. The variation of equilibrium constant with temperature is given by Van't Hoff isochore as
 $\frac{d}{dT} \ln K_p = \frac{\Delta H}{R T^2}$
9. 
11. K_p is independent of pressure
14. On heating $\text{N}_2\text{O}_4 \rightleftharpoons 2\text{NO}_2$ if NO_2 is formed more, it means $\Delta H = +\text{ve}$ because endothermic reactions are favoured with increase in temperature.
19. An equilibrium constant is the ratio of multiplication of the concentration of products and reactants raised to the power of coefficient of each species.
20. $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$
 $K_c = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$
 $= \frac{(\text{mol L}^{-1})}{(\text{mol L}^{-1})(\text{mol L}^{-1})^3} = \frac{(\text{mol L}^{-2})}{(\text{mol L}^{-1})^4} = (\text{mol L}^{-1})^{-2}$

21. Small values of K (smaller than 10^{-3}) favours the reactants strongly. Therefore, the concentration of the un-ionised molecules will be relatively large compared to the ion concentration.
22. When pressure is applied to the equilibrium $\text{ice} \rightleftharpoons \text{water}$ then volume decrease and the density increases. Water is denser than ice, therefore the forward reaction would be favoured. More water will be formed.
23. Equilibria are unaffected by the presence of a catalyst. They respond to concentration, pressure and temperature changes in accordance with Le-Chatelier's principle. All the three statements (a), (b) and (c) are correct statement of Le-Chatelier's principle.
24. The stoichiometry states that 2 moles of CO on reaction with 1 mole of O_2 will produce 2 moles of CO_2 .
25. The Q may be zero when there is no produce formed in the reaction. When $Q > K$, then the reaction tends to proceed left, towards reactants and when $Q < K$, the reaction tends to proceed right, toward product. And $Q = K$ only at equilibrium.
26. According to Le-Chatelier's principle, when a stress is applied to a system in dynamic equilibrium, the equilibrium adjust to minimize the effect of the stress. The value of the equilibrium constant does not change by any one of the factors given.
27. The concentrations of reactants and products would be expected to approach constant values which would be reached after time t . This is only the case in (b).
28. The reaction is exothermic, therefore SO_3 formation will be favoured at low temperature. Also the increase in pressure will shift the equilibrium towards product side.
29. At 300K, $K_c = \frac{k_f}{k_b} = \frac{2 \times 10^{-2}}{4 \times 10^{-3}} = 5$
 At 400K, $K_c = \frac{4 \times 10^{-2}}{16 \times 10^{-4}} = 25$

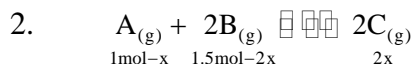
$$\Delta H = \frac{2.303RT_1T_2}{(T_2 - T_1)} \log \frac{K_{400}}{K_{300}}$$

LEVEL – II

1. $\text{SO}_{2(g)} + \text{NO}_{2(g)} \rightleftharpoons \text{SO}_{3(g)} + \text{NO}_{(g)}$
 $\begin{matrix} 1 \text{ mol} - x & 1 \text{ mol} - x & 1 \text{ mol} + x & 1 \text{ mol} + x \end{matrix}$
- $$K_c = \frac{(1 \text{ mol} + x)^2}{(1 \text{ mol} - x)^2}$$
- i.e. $16 = \left(\frac{1 \text{ mol} + x}{1 \text{ mol} - x} \right)^2$
 or $(1 \text{ mol} + x) = 4 (1 \text{ mol} - x)$
 or $x = 0.6 \text{ mol}$

Amount of NO = 1 mol + x = 1.6 mol

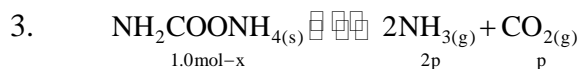
Concentration of NO = 1.6 M



Hence $\frac{2x}{2L} = 0.35\text{molL}^{-1} \Rightarrow x = 0.35\text{mol}$

$$K_c = \frac{[C]^2}{[A][B]^2} = \frac{(0.70\text{mol}/2L)^2}{(0.65\text{mol}/2L)(0.8\text{mol}/2L)^2}$$

$$= 2.36 \text{ mol}^{-1}\text{L}$$

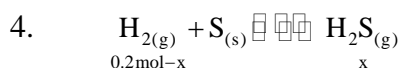


$$K_p = p_{NH_3}^2 p_{CO_2}$$

$$2.9 \times 10^{-5} \text{ atm}^3 = (2p)^2 p$$

$$p = \left(\frac{2.9 \times 10^{-5} \text{ atm}^3}{4} \right)^{1/3} = 0.0194 \text{ atm}$$

$$p_{\text{total}} = 2p + p = 3p \times 0.0194 \text{ atm} = 0.0582 \text{ atm}$$



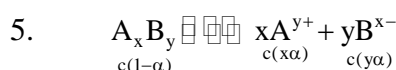
Since $\Delta v_{(g)} = 0$, $K_p = K_n = \frac{n_{H_2S}}{n_{H_2}}$

$$\frac{x}{0.2\text{mol}-x} = 0.068$$

Solving for x, we get

$$x = 0.072 \text{ mol}$$

$$p = \left(\frac{0.072 \times 0.082 \times 363}{1} \right) \text{ atm} = 0.38 \text{ atm}$$



$$K_{eq} = \frac{(cx\alpha)^x (cy\alpha)^y}{c(1-\alpha)} = c^{x+y-1} x^x y^y \alpha^{x+y}$$

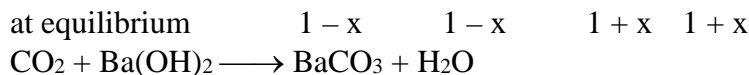
$$\text{or } \alpha = \left(\frac{K_{eq}}{c^{x+y-1} x^x y^y} \right)^{1/(x+y)}$$

6. $s_0 = \sqrt{K_{sp}}$; $s_1 = K_{sp}/0.02M$; $s_2 = K_{sp}/0.01M$; $s_3 = K_{sp}/0.05M$

Obviously $s_0 > s_2 > s_1 > s_3$



$$t = 0 \qquad \qquad \qquad 1 \qquad \qquad 1 \qquad \qquad 1 \qquad \qquad 1$$



$$\text{Moles of BaCO}_3 = \frac{236.4}{197} = 1.2$$

\therefore Mole of CO_2 at equilibrium = 1.2

$$\text{or } 1 + x = 1.2$$

$$x = 0.2$$

$$\therefore K_c = \left(\frac{1+x}{1-x} \right)^2 = \left(\frac{1.2}{0.8} \right)^2 = 2.25$$

8. The value of x is very much larger and KCl is 100% ionized

$$\therefore [\text{NaCl}] = [\text{Cl}^-]$$

10. As K_c is the expression in terms of activity (which itself is unit less) it is unitless quantity

$$1 \quad 0$$



$$1 - \alpha \quad n\alpha$$

$$K_c = \frac{(n\alpha)^n}{1 - \alpha}$$

11. For these reaction

$$\therefore K_{P_1} = \frac{x^2 P_1}{(1-x)^2}$$

$$\text{and } K_{P_2} = \frac{4x^2 P_2}{(1-x)^2}$$

$$\frac{K_{P_1}}{K_{P_2}} = \frac{P_1}{4P_2}$$

$$\text{or } \frac{36}{1} = \frac{P_1}{P_2}$$

14.	$\text{PCl}_5(\text{g})$	\rightleftharpoons	$\text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$	Total mole
Initial moles	1		1 0	1
Moles at equilibrium	$1 - \alpha$		α α	$1 - \alpha + \alpha + \alpha$ $= 1 + \alpha$

15.	$\text{N}_2\text{O}_4(\text{g})$	\rightleftharpoons	$2\text{NO}_2(\text{g})$
Moles at equilibrium	0.2		0.002
Conc. at equilibrium	$\left(\frac{0.2}{2} \right)$		$\left(\frac{0.002}{2} \right)$

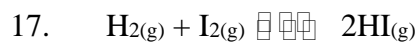
$$K = \frac{[\text{NO}_2]^2}{[\text{N}_2\text{O}_4]} = \frac{(0.001)^2}{(0.1)} = 0.00001 = 1.0 \times 10^{-5}$$

16.	$\text{H}_2(\text{g})$	+	$\text{S}(\text{s})$	\rightleftharpoons	$\text{H}_2\text{S}(\text{g})$
Conc. at equilibrium	$(0.2 - x)$				x

$$K = 6.8 \times 10^{-2} = \frac{[\text{H}_2\text{S}]}{[\text{H}_2]} = \frac{x}{(0.2-x)}$$

$$(0.2) \times 6.8 \times 10^{-2} - (0.2) \times 6.8 \times 10^{-2} x = x$$

$$x = \frac{0.0136}{1.0136} = 1.34 \times 10^{-2}$$



$$K_p = \frac{P_{\text{HI}}^2}{P_{\text{H}_2} P_{\text{I}_2}}$$

Let the new partial pressure of HI = p' , then change in volume will not change the k_p .
Therefore,

$$\frac{P_{\text{HI}}^2}{P_{\text{H}_2} P_{\text{I}_2}} = \frac{P_{\text{HI}}'^2}{2P_{\text{HI}}'^2 P_{\text{I}_2}}$$

$$P_{\text{HI}}' = 4P_{\text{HI}}$$

$$P_{\text{HI}}' = 2P_{\text{HI}}$$

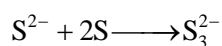
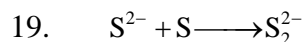
18. Since rate is doubled on doubling conc. of A hence first order hence

$$\left(\frac{dx}{dt} \right) = k_f [A]$$

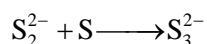
$$0.05 = k_f (0.17)$$

$$\text{also } K_c = \frac{k_f}{k_b}, \quad k_b = \frac{k_f}{K_c}$$

$$= \frac{0.05}{0.17 \times 0.5} = 0.5888$$



$$K_2 = 132$$



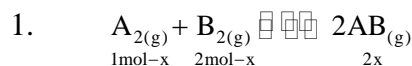
$$K_3 = ?$$

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

20. Solubility decreases with decrease in T hence

$$\Delta H = -ve$$

LEVEL - III



Since $\Delta v_g = 0$, we will have $K_c = K_p = K_n$

$$K_n = \frac{(2x)^2}{(1\text{mol} - x)(1\text{mol} + x)}$$

$$\text{that is } \frac{2x}{(1\text{mol} - x)(1\text{mol} - x)} = 50$$

solving for x, we get

$$x = 0.933 \text{ mol}$$

$$\text{Amount of AB} = 2x = 1.866 \text{ mol}$$



$$p_{\text{N}_2\text{O}_4} = \frac{1 - \alpha}{1 + \alpha} p$$

$$p_{\text{NO}_2} = \frac{2\alpha}{1 + \alpha} p$$

$$K_p = \frac{p_{\text{NO}_2}^2}{p_{\text{N}_2\text{O}_4}} = \left(\frac{2\alpha}{1 + \alpha} p \right)^2 \left(\frac{1 + \alpha}{1 - \alpha} \right) = \frac{4\alpha^2}{1 - \alpha^2} p$$

Rearranging, we get

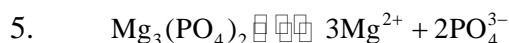
$$\alpha = \left(\frac{K_p / p}{4 + K_p / p} \right)^{1/2}$$

3. The state (d) is applicable only at 25°C and is not independent of temperature.

4. $[\text{Ag}^+]$ needed to start precipitation of $\text{Cl}^- = \frac{1.7 \times 10^{-10}}{0.1} \text{M}$

$$[\text{Ag}^+]$$
 needed to start precipitation of $\text{CrO}_4^{2-} = \sqrt{\frac{1.9 \times 10^{-12}}{0.1}} \text{M}$

Obviously, the former is smaller and thus will be reached first causing Cl^- to precipitate.



$$K_{\text{sp}} = [\text{Mg}^{2+}]^3 [\text{PO}_4^{3-}]^2$$

If x is the solubility of $\text{Mg}_3(\text{PO}_4)_2$, then

$$(3x)^3 (2x)^2 = 1.08 \times 10^{-13} \text{M}^5$$

$$x = \left(\frac{1.018 \times 10^{-13}}{108} \text{M}^5 \right)^{1/5} = 9.88 \times 10^{-4} \text{M}$$

$$[\text{Mg}^{2+}] = 3x = 2.97 \times 10^{-3} \text{M}$$

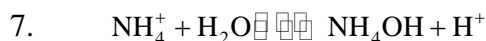
6. For $\text{Mg}(\text{OH})_2$ not to be precipitated

$$[\text{OH}^-] < \left[\frac{K_{\text{sp}}(\text{Mg}(\text{OH})_2)}{[\text{Mg}^{2+}]} \right]^{1/2}$$

$$[\text{OH}^-] < \left(\frac{1.2 \times 10^{-11} \text{M}^3}{0.10 \text{M}} \right)^{1/2} < 1.035 \times 10^{-5} \text{M}$$

$$\text{pOH} < 4.36$$

$$\text{pH} > 14 - 4.36 = 9.04$$



$$K_h = \frac{K_w}{K_b} = \frac{[\text{NH}_4\text{OH}][\text{H}^+]}{[\text{NH}_4^+]} = \frac{[\text{H}^+]^2}{[\text{NH}_4^+]_0}$$

$$\text{or } [\text{H}^+]^2 = \frac{K_w}{K_b} [\text{NH}_4^+]_0$$

$$2 \log [\text{H}^+] = \log K_w - \log K_b + \log [\text{NH}_4^+]$$

$$\text{or } -\log [\text{H}^+] = -\frac{1}{2} \log K_w + \frac{1}{2} \log K_b - \frac{1}{2} \log [\text{NH}_4^+]$$

$$\text{pH} = \frac{1}{2} \text{p}K_w - \frac{1}{2} \text{p}K_b - \frac{1}{2} \log [\text{salt}]$$



$$1 \quad \quad \quad 0.5 \quad \quad \quad 0$$

$$(1-x) \quad (0.5-x) \quad x$$

$$(0.5-x) = \text{unreacted } \text{X}^-$$

$$x = \text{Ag} + 0.25$$

$$x = 0.25$$

$$K_c = \frac{[\text{X}_3^-]}{[\text{X}_2][\text{X}^-]} = \frac{0.25}{0.75 \times 0.25} = 1.33$$

9. Under identical condition of volume and temperature

$$P \propto n$$

$$\text{So initially, } \frac{n_{\text{H}_2}}{n_{\text{H}_2\text{S}}} = \frac{1}{2}$$



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

$$\text{at equilibrium} \quad 2-x \quad \quad \quad 1+x$$

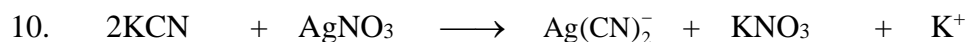
but at equilibrium,

$$\frac{n_{\text{H}_2}}{n_{\text{H}_2\text{S}}} = 2, \frac{1+x}{8-x} = 2, x = 1$$

$$\therefore K_p = \frac{P_{\text{H}_2}}{(P_{\text{H}_2\text{S}})^8} = \frac{(2)^8}{(1)^8} = 256$$

$$\text{Since } \Delta n_{(\text{g})} = 8 - 8 = 0$$

$$\therefore K_p = K_c = 256$$

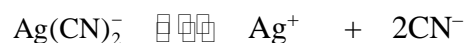


$$0.1 \quad \quad \quad 0.03 \quad \quad \quad 0 \quad \quad \quad 0 \quad \quad \quad 0$$

$$(0.1 - 0.06) \quad 0 \quad \quad \quad 0.03 \quad \quad \quad 0.03 \quad \quad \quad 0.03$$

$$\therefore [\text{Ag}(\text{CN})_2^-] = 0.03$$

$$\text{Now } [\text{Ag}(\text{CN})_2^-] = 0.03$$



$$0.03 \quad \quad \quad 0 \quad \quad \quad 0.04$$

$$\begin{array}{l}
 \text{(left from KCN)} \\
 (0.03 - a) \quad a \quad (0.04 + a) \\
 K_c \text{ is small} \\
 \therefore 0.03 - a = 0.03 \\
 \text{and } 0.04 + a = 0.04 \\
 \therefore K_c = 4 \times 10^{-19} = \frac{(0.04)^2 \times 9}{0.03} \\
 \therefore a = 7.5 \times 10^{-18}
 \end{array}$$

11. $\Delta H = E_a$ for FR – E_a of Br
 $-10 = E_a$ of FR – 15
 $\therefore E_a$ of FR = 5 kcal mol⁻¹
 the catalyst decreases the E_a by 2 kcal mol⁻¹
 $\frac{K_c}{K} = e^{\Delta E/RT} = e^{2 \times 10^{-3} \times 300} = e^{3.33}$

12. $\text{COCl}_2(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + \text{Cl}_2(\text{g})$
 $\frac{[\text{CO}][\text{Cl}_2]}{[\text{COCl}_2]} = K_c$
 Let $[\text{CO}] = x$, then $[\text{Cl}_2] = x$
 $\therefore \frac{x^2}{[\text{COCl}_2]} = K_c \times x$
 or $\frac{x^2}{0.4} = K_c$
 Again $K_c = \frac{x^2}{0.4} = \frac{[\text{CO}][\text{Cl}_2]}{[\text{CoCl}_2]}$
 $\frac{x^2}{0.4} = \frac{[\text{CO}]^2}{16}$
 $\{[\text{CO}] = [\text{Cl}_2]\}$
 $x^2 \times 4 = [\text{CO}]^2$
 $2x = [\text{CO}]$
 $x = [\text{CO}]$

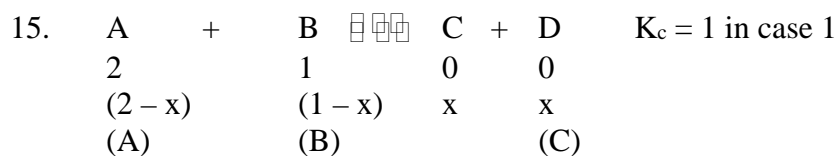
13. At equilibrium rate of formation = rate of disappearance
 $1.45 \times 10^{13} [\text{Fe}^{2+}] [\text{dipy}]^3$
 $= 1.22 \times 10^{-4} [\text{Fe}(\text{dipy})_3^{2+}]$
 Stability constant = $\frac{[\text{Fe}(\text{dipy})_3^{2+}]}{[\text{Fe}^{2+}][\text{dipy}]^3} = \frac{1.45 \times 10^{13}}{1.22 \times 10^{-4}}$

14. $\text{H}_3\text{BO}_3 + \text{glycerine} \rightleftharpoons (\text{H}_3\text{BO}_3 \cdot \text{glycerine})$
 (A) (B) (C)
 0.1 x (0)
 (0.1 – 0.06) (x – 0.06) 0.06

$$0.90 = \frac{[C]}{[A][B]}$$

$$= \frac{0.06}{0.04(x - 0.06)}$$

$$x = 1.73M$$

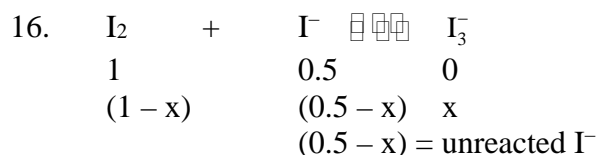


$$K_c = \frac{x^2}{(2-x)(1-x)} = 1$$

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

Hence % of A converted into product

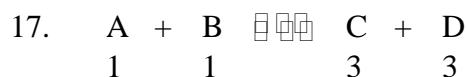
$$= \frac{2}{3} \times \frac{1}{2} \times 100 = 33.33\%$$



$$I^- \equiv Ag^+ = 0.25$$

$$x = 0.25$$

$$K_c = \frac{[I_3^-]}{[I_2][I^-]} = \frac{0.25}{0.75 \times 0.25} = 1.33$$

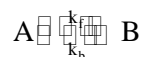


This equilibrium shifts in backward side

$$K_c = 2.25 = \frac{[C][D]}{[A][B]} = \frac{[C]^2}{[A]^2}$$

$$\frac{[C]}{[A]} = 1.5, \frac{[A]}{[C]} = 2 : 3$$

18. For reversible reaction



$$\frac{dx}{dt} = k_f[A] = k_b[B]$$

and $K_c = \frac{k_f}{k_b}$ but question requires k_c of reversible reaction hence on comparison

$$K_c = \frac{2.1 \times 10^{-3}}{3.9 \times 10^{-5}} = 0.54 \times 10^2$$



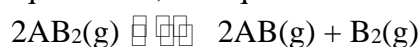
$$1 - \alpha \qquad \frac{\alpha}{2} \qquad \frac{\alpha}{2}$$

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

$$\frac{\alpha}{1 - \alpha} = 2\sqrt{K_p}$$

$$\alpha = \frac{2\sqrt{K_p}}{1 + 2\sqrt{K_p}}$$

20. For the given equilibrium, the equilibrium concentration are



$$\text{Equilib. conc. } c(1 - \alpha) \qquad c\alpha \qquad \frac{c\alpha}{2}$$

$$\therefore K_p = \frac{(P_{\text{B}_2})(P_{\text{AB}})^2}{(P_{\text{AB}_2})^2} = \frac{\frac{c\alpha}{2} \times (c\alpha)^2 \times P_T}{[c(1 - \alpha)]^2 [c(1 + \frac{\alpha}{2})]}; K_p = \frac{\alpha^3 \times P_T}{2(1 - \alpha)^2 \left(1 + \frac{\alpha}{2}\right)}$$

Since, α is small compared to unity, so $1 - \alpha \approx 1$ and $1 + \frac{\alpha}{2} \approx 1$.

$$\therefore K_p = \frac{\alpha^3 \times P_T}{2}$$