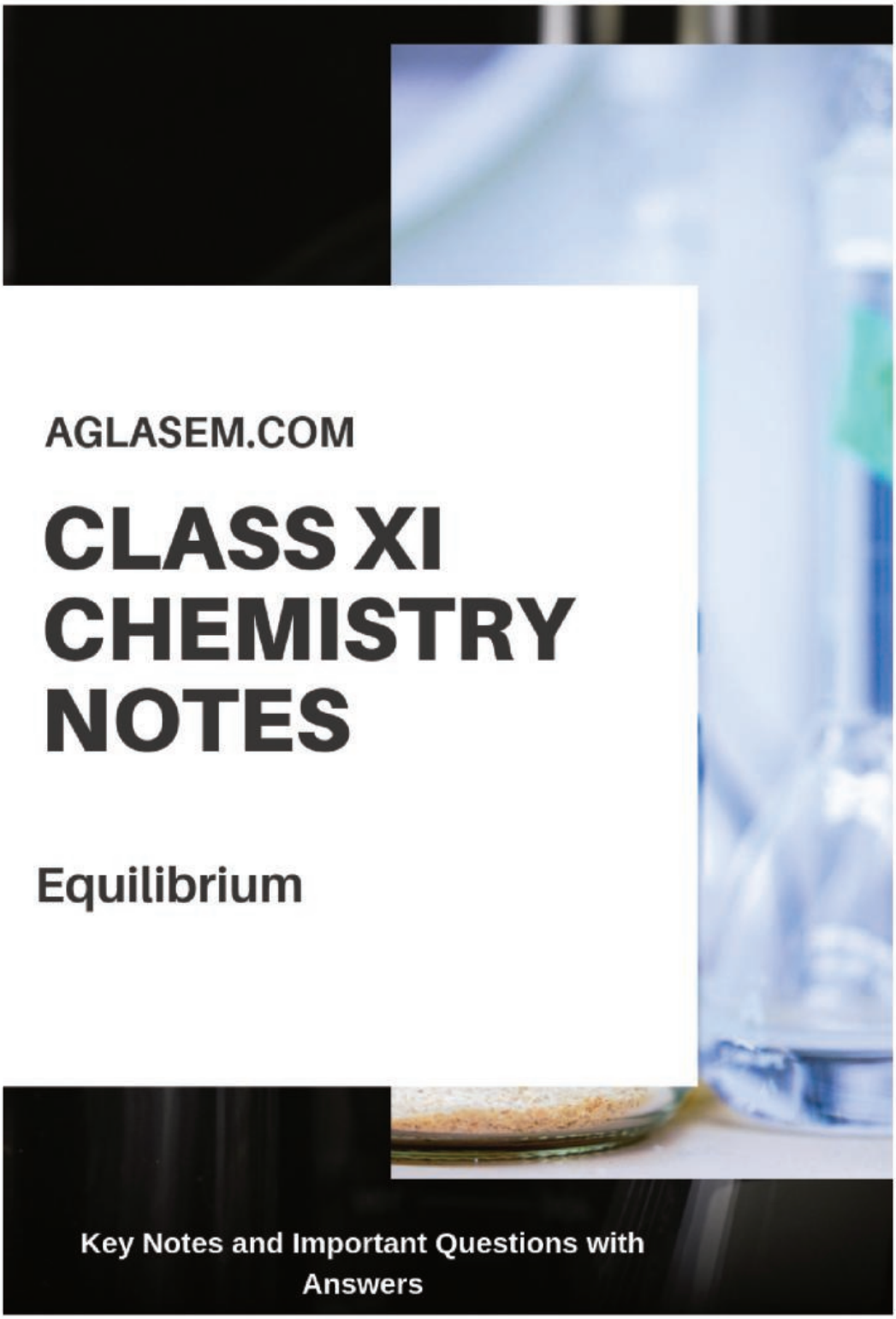
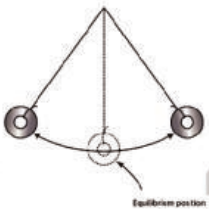


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CLASS XI CHEMISTRY NOTES

Equilibrium

Key Notes and Important Questions with Answers



Chapter - 7

Equilibrium

- **Equilibrium :** It is a state in a process when two opposing processes (forward and reverse) occur simultaneously at the same rate. The free energy change at equilibrium state is zero *i.e.*, $\Delta G = 0$.
- **Equilibrium constant :** For a general reaction :

$$aA + bB \rightleftharpoons cC + dD$$

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b} \text{ and } K_p = \frac{P_C^c \times P_D^d}{P_A^a \times P_B^b}$$

- **Relationship between K_p and K_c :**

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

$$\Delta n_g = n_p(g) - n_r(g)$$

- Magnitude of equilibrium constant depends upon the way in which a reaction is written :

Chemical equation	Equilibrium constant
$aA + bB \rightleftharpoons cC + dD$	K
$cC + dD \rightleftharpoons aA + bB$	$K_1 = \frac{1}{K}$
$naA + nbB \rightleftharpoons ncC + ndD$	$K_2 = K^n$
$\frac{1}{n}aA + \frac{1}{n}bB \rightleftharpoons \frac{1}{n}cC + \frac{1}{n}dD$	$K_3 = K^{1/n}$

- **Predicting the direction of reaction :**

If $Q_c = K_c \Rightarrow$ the reaction is in a state of equilibrium.

$Q_c > K_c \Rightarrow$ the reaction proceeds in reverse direction.

$Q_c < K_c \Rightarrow$ the reaction proceeds in forward direction.

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- **Ostwald's dilution law :** Degree of dissociation of weak electrolyte, $\alpha = \sqrt{\frac{K}{C}}$
- **Ionic Product of water (K_w) = $[H_3O^+]$ $[OH^-]$ = 10^{-14} at 298K**
- **Le-Chatelier's Principle :** When a system of equilibrium is subjected to a change in temperature, pressure or concentration, the equilibrium shifts itself in such a way so as to undo or nullify the effect of change.
- **Outcomes of Le-Chatelier's Principle**

Change at equilibrium	Shift in equilibrium
Increase in temperature	Endothermic direction
Decrease in temperature	Exothermic direction
Increase in pressure	Towards lesser gaseous moles
Decrease in pressure	Towards greater gaseous moles
Increase in Conc. of reactants	Forward direction
Increase in Conc. of products	Reverse direction

- **Conjugate Acid or Base : Acid-base pair which differ by H^+ ion.**
  Species – H^+ = Conjugate base
  Species + H^+ = Conjugate acid
- **pH of solution :**
  pH = –log $[H_3O^+]$ or $[H^+] = 10^{-pH}$, pOH = –log $[OH^-]$
  pH + pOH = pK_w = 14 at 298K
- **Common ion effect** : The depression of ionisation of weak electrolyte by the presence of common ion from a strong electrolyte is called common ion effect. For example degree of dissociation of NH_4OH decreases in the presence of strong electrolyte NH_4Cl.
- **Hydrolysis of salts and pH of their solutions :** Hydrolysis of salt is defined as the reaction of cation or anion with water as a result of which the pH of water changes.

  1. Salts of strong and strong bases (*e.g.*, NaCl) do not hydrolyse. The solution pH will be 7.

  2. Salts of weak acids and strong bases (*e.g.*, CH_3COONa) hydrolyse, pH >7 (The anion acts as a base).

$$X^- + H_2O \rightleftharpoons \underset{\text{(Weak acid)}}{HX} + \underset{\text{(Weak base)}}{OH^-}$$

$$pH = 7 + \frac{1}{2}(pK_a + \log C)$$

3. Salt of strong acids and weak bases (*e.g.*, NH_4Cl) hydrolyse, pH < 7. (The cation acts as an acid).

$$M^+ + H_2O \rightleftharpoons MOH + H^+$$

$$pH = 7 - \frac{1}{2}(pK_b + \log C)$$

4. Salt of weak acids and weak base (*e.g.*, CH_3COONH_4) hydrolyse. The cation acts as an acid and anion as a base but whether the solution is acidic or basic depends upon the relative values of K_a and K_b for these **ions.**

$$M^+ + X^- + H_2O \rightleftharpoons MOH + HX$$

$$pH = 7 + \frac{1}{2}(pK_a - pK_b)$$

- **Buffer solutions :** The solutions, which resist the change in pH on dilution or addition of small amounts of acid or base, are called buffer solutions.
- **Basic buffer :** Solution of weak base and its salt with strong acid, For *e.g.*, $NH_4OH + NH_4Cl$
- **Acidic buffer :** Solution of weak acid and its salt with strong base, For *e.g.*, $CH_3COOH + CH_3COONa$.
- **Henderson Hasselbalch Equation for the pH of Buffer solution—**

$$pH = pK_a + \log\frac{[Salt]}{[Acid]} \quad \text{(for acidic buffer)}$$

$$pOH = pK_a + \log\frac{[Salt]}{[Base]} \quad \text{(for basic buffer)}$$

- **Solubility Product (K_{sp}) :** The equilibrium constant that represent the equilibrium between undissolved salt (solute) and its ions in a saturated solution is called solubility product constant (K_{sp}).

For $A_xB_y \underset{}{\overset{aq}{\rightleftharpoons}} xA^{y+} + yB^{x-}$

$$K_{sp} = [A^{y+}]^x [B^{x-}]^y = (xs)^x (ys)^y = x^x . y^x . s^{(x+y)}$$

where s = Molar solubility

If ionic product < K_{sp} ; salt remain dissolve.

If ionic product > K_{sp} ; salt will be precipitated.

- **Relationship between solubility (s) and solubility product (K_{sp}).**

$K_{sp} = x^x . y^y . s^{x+y}$

For binary salts (*e.g.*, AgCl, AgBr, AgI) $K_{sp} = s^2$

For Ternary salts (*e.g.*, PbI_2) $K_{sp} = 4s^3$

1 - Mark Questions

1. Define physical equilibrium. Give an example also.
2. Fizz is observed when soda water bottle is opened. Why ?
3. Justify the statement : 'Both physical and chemical equilibria are dynamic in nature'
4. State Henry's law.
5. In a reversible reaction, the two substances are in equilibrium. If the concentration of each one is reduced to half, then what is the effect on the equilibrium constant ?
6. K_1 and K_2 are equilibrium constant for reactions (1) and (2)

   (1) $N_2(g) + O_2(g) \rightleftharpoons 2\,NO(g)$

   (2) $NO(g) \rightleftharpoons 1/2\,N_2(g) + 1/2\,O_2(g)$

   calculate the relation between K_1 and K_2
7. Write the equilibrium constant expression for the following reaction :

   $3\,Fe(s) + 4\,H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4\,H_2(g)$
8. Classify the equilibrium as homogenous or heterogenous :

   $CH_3COOC_2H_5(aq) + H_2O(1) \rightleftharpoons CH_3COOH(aq) + C_2H_5OH\,(aq)$
9. $K_p = \dfrac{(P_{NH_3})}{(P_{H_2})^{3/2}(P_{N_2})^{1/2}}$

   Write the balanced chemical equation corresponding to the above expression.
10. Give the direction in which the reaction would proceed if $Q_c > K_c$.
11. $Hb(s) + O_2(g) \rightleftharpoons HbO_2(s)$

    Predict the direction in which equilibrium gets shifted if partial pressure of $O_2(g)$ is lowered.
12. Discuss the position of equilibrium if the following reaction is carried out in the presence of catalyst.

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

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13. In which case the yield of the product will be more.

$A \rightleftharpoons B \quad K_1 = 10^{10}$

$X \rightleftharpoons Y \quad K_2 = 10^6$

14. Value of K_c at 500 K for $A + 2B \rightleftharpoons C$ is 10.6

Determine the value of K_c at the same temperature for $C \rightleftharpoons A + 2B$

15. Why do we sweat more on a humid day ?

16. Why does a catalyst not affect the magnitude of equilibrium constant ?

17. Write the relation between K_p and K_c for the given reaction.

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

18. Write the expression of Kc for the following reaction

$CH_3COOC_2H_5(l) + H_2O(l) \rightleftharpoons CH_3COOH(aq) + C_2H_5OH(aq)$

19. Write the expression of Kp for the following reaction

$Cu(NO_3)_2(s) \rightleftharpoons 2\,CuO(s) + 4NO_2(g) + O_2(g)$

20. For an exothermic reaction, what happens to the equilibrium constant if temperature is increase ?

21. K_a for HA_1 is 10 and K_a for HA_2 is 12

Which acid is stronger.

22. For tribasic acid $Ka_1 > Ka_2 > Ka_3$

What will happen to the acid strength of polyprotic acid if protons are lost ?

23. C(s) Diamond (Density = 3.5 g/cm^3) $\rightleftharpoons$ C(s) Graphite (Density = 2.3 g/cm^3)

What will be the effect of increasing the pressure in this equilibrium.

24. Under what condition does the active mass becomes equal to the molarity ?

25. Which expression of K_c or K_{eq}, involved solutions and gases only?

26. What will be the change in the direction of equilibrium if Ne gas is added in a reaction at constant volume?

27. What will be the effect on the boiling point of liquid if pressure is increased ?

2 - Mark Questions

1. What is Kc for the following equilibrium when the equilibrium concentration of each substance is :

   $[SO_2] = 0.60M$, $[O_2] = 0.82$ M and $[SO_3] = 1.90$ M ?

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

2. At a certain temperature and total pressure of 10^5 Pa, iodine vapour contains 40% by volume of I atoms

   $I_2(g) \rightleftharpoons 2I(g)$

   Calculate Kp for the equilibrium. [**Ans.** 2.67 × 104 Pa]

3. Explain why pure liquids and solids can be ignored while writing the equilibrium constant expression ?

4. A sample of HI(g) is placed in flask at a pressure of 0.2 atm. At equilibrium the partial pressure of HI(g) is 0.04 atm.

   What is Kp for the given equilibrium ?

   $2\ HI(g) \longrightarrow H_2(g) + I_2(g)$ [**Ans.** 4]

5. One mole of H_2O and one mole of CO are taken in 10 L vessel and heated to 725 K. At equilibrium 40% of water (by mass) reacts with CO according to the equation,

   $H_2O(g) + CO(g) \rightleftharpoons H_2(g) + CO_2(g)$

   Calculate the equilibrium constant for the reaction. [**Ans.** 0.444]

6. At 1127 K and 1 atm pressure, a gaseous mixture of CO and CO_2 in equilibrium with soild carbon has 90.55% CO by mass

   $C(s) + CO_2(g) \rightleftharpoons 2CO(g)$

   Calculate Kc for this reaction at the above temperature. [**Ans.** 0.153]

7. Describe the effect of :

   (a) addition of H_2

   (b) addition of CH_3OH
   (c) removal of CO

   (d) removal of CH_3OH

   on the equilibrium of the reaction :

   $2H_2(g) + CO(g) \rightleftharpoons CH_3OH(g)$

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8. $A + 3B \rightleftharpoons 2X$; $K = x$

What will be the equilibrium constant for the decomposition of 1 mol of x ?

9. $N_2(g) + 3H_2(g) \rightleftharpoons 2\,NH_3(g)$; ——— K_1

$N_2(g) + O_2(g) \rightleftharpoons 2\,NO(g)$; ——— K_2

$H_2(g) + 1/2O_2(g) \rightleftharpoons H_2O(g)$; ——— K_3

Determine the equilibrium constant for

$2\,NH_3(g) + 5/2O_2(g) \rightleftharpoons 2NO(g) + 3H_2O)(g)$.

10. K_c for $PCl_5\,(g) \rightleftharpoons PCl_3\,(g) + Cl\,(g)$ is 0.04 at 25°C

How much mole of PCl_5 must be added to 3 L flask to obtain a chlorine concentration of 0.15 M ? **[Ans.** 2.1]

3 - Mark Questions

1. Four moles of PCl_5 are heated in a closed 4 dm^3 container to reach equilibrium at 400 K. At equilibrium 50% of PCl_5 is dissociated. What is the value of K_c for the dissociation of PCl_5 into PCl_3 and Cl_2 at 400 K **[Ans.** 0.50]

2. (a) How does the value of equilibrium constant predict the extent of a reaction ?

   (b) Equilibrium constant for a reaction is 10. What will be the equilibrium constant for the reverse reaction ?

3. (a) Define the equilibrium constant.

   (b) For the general reaction :

   $a\,A(g) + b\,B(g) \rightleftharpoons c\,C\,(g) + d\,D(g)$.

   Derive the relationship between Kp and Kc

4. (a) What is meant by dynamic nature of equilibrium ?

   (b) Consider the following transformation.

   $A \rightleftharpoons B$ $\qquad K_1 = 1$

   $B \rightleftharpoons C$ $\qquad K_2 = 2$

   $C \rightleftharpoons D$ $\qquad K_3 = 3$

   Calculate the value of K for $A \rightleftharpoons D$

5. K_c for $SO_2(g) + 1/2\,O_2(g) \rightleftharpoons SO_3(g)$ at 600°C is 61.7

   Calculate K_p. What is the unit K_p for the above equilibrium. [R = 0.0821 L atm K^{-1} mol^{-1}]

6. 3.2 mole of HI were heated in a sealed bulb at 444°C till the equilibrium state was reached. Its degree of dissociation was found to be 20%. Calculate the number of moles hydrogen iodide, hydrogen and iodine present at the equilibrium point and also determine the equilibrium constant.

   $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$.

7. At 25°C and 1 atm, the partial pressure in an equilibrium mixture of N_2O_4 NO_2 are 0.7 and 0.3 atm, respectively. Calculate the partial pressure when they are in equilibriums at 25°C and at a total pressure of 10 atm.

8. 13.8 g of N_2O_4 was placed in a 1L reaction vessel at 400 K and allowed to attain equilibrium: $N_2O_4(g) \rightleftharpoons 2NO_2(g)$

   The total pressure at equilbrium was found to be 9.15 bar. Calculate K_c, K_p and partial pressure at equilibrium. $[K_c = 2.6]$

9. The equilibrium constant for the following reaction is 1.6×10^5 at 1024 K

   $H_2(g) + Br(g) \rightleftharpoons 2HBr(g)$

   Find the equilibrium pressure of all gases if 10.0 bar a HBr is introduced into a sealed container at 1024 K.

   $[P_{H_2}\ eq. = P_{Br_2}\ eq. = 2.5 \times 10^{-2}$ bar; $P_{HBr} = 10.0$ bar$]$

10. In a reaction: $CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(l)$ $\Delta_r H^\theta = -92$ kJ/mol

    Indicate the direction in which equilibrium will shift when:-

    (i) Temperature is decreased.

    (ii) Pressure is decreased.

    (iii) Ne gas is added at constant pressure.

5 – Mark Questions

1. Dihydrogen gas is obtained from natural gas by partial oxidation with steam as per following endothermic reaction :

   $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$

   (a) Write as expression for Kp for the above reaction.

   (b) How will the values of Kp and composition of equilibrium mixture be affected by :

   (i) increasing the pressure
   (ii) increasing the temperature
   (iii) using a catalyst ?

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2. At 473 K, equilibrium constant Kc for decomposition of phosphorus pentachloride, PCl_5 is 8.3×10^{-3}. If decomposition is depicted as,

$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ $\Delta H^\theta = 124.0$ kJ mol^{-1}

(a) Write an expression for Kc for the reaction.

(b) What is the value of Kc for the reverse reaction at the same temperature?

(c) What would be the effect on Kc if (i) PCl_5 is added (ii) pressure is increased (iii) the temperature is increased ? [(b) $K_C = 120.48$ (c) (i) No effect (ii) No effect (iii) Kc increase]

3. Ammonia is prepared by Haber's process is which the following reaction occurs

$N_2(g) + 3H_2(g) \rightleftharpoons 2\,NH_3(g)$ $\Delta H^\theta = -93.6$ kJ

Mention the effect of following on the equilibrium concentration of ammonia:-

(a) Increasing pressure
(b) Increasing temperature
(c) Use of catalyst at an optimum temperature.
(d) Addition of inert gas at constant volume.
(e) Addition of inert gas at constant pressure.

4. Ethyl acetate is formed by the reaction between ethanol and acetic acid and the equilibrium is represented as :

$CH_3COOH(l) + C_2H_5OH(l) \rightleftharpoons CH_3COOC_2H_5(l) + H_2O(l)$

(i) Write the concentration ratio (reaction quotient), Qc, for this reaction (note : water is not in excess and is not a solvent in this reaction)

(ii) At 293 K, if one starts with 1.00 mol of acetic acid and 0.18 mol of ethanol, there is 0.171 mol of ethyl acetate in the final equilibrium mixture. Calculate the equilibrium constant.

(iii) Starting with 0.5 mol of ethanol and 1.0 mol of acetic acid and maintaining it at 293 K, 0.214 mol of ethyl acetate is found after sometime. Has equilibrium been reached ?

[(ii) 3.92 (iii) Qc = 0.204, Equilibrium has not been attained.]

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Ionic Equilibrium

1 – Mark Questions

1. Which of the following are Lewis acids ?

   H_2O, BF_3, H^+, NH_4^+

2. Write the conjugate acids for the following Bronsted bases.

   C_6H_5OH, H_2O

3. Write the conjugate bases for the following Bronsted acids.

   H_2O, CH_3COOH.

4. Which of the following are Lewis acids ?

   (a) H_2O, (b) $AlCl_3$ (c) NH_4^+

5. Define the Ostwald's dilution law.

6. SO_3^{2-} is Bronsted base or acid and why ?

7. Why pH of our blood remains almost constant at 7.4 though we quite often eat spicy food ?

8. pH of black coffee is 5.0 at 25°C. Is black coffee acidic or basic ?

   [**Ans.** Acidic]

9. What will be the value of (pKa + pKb) at 25°C.

10. What will be the pH of 1 M KNO_3 solutions at 25°C?

11. $CaCl_2(s) + H_2O(l) \rightleftharpoons CaCl_2(aq) + \text{Heat}$

    Discuss the solubility of $CaCl_2$ if temperature is increased.

12. Why does the solubility of CO_2 decrease with rise in temperature ?

13. The solubility of A_2X_3 is y mol dm^{-3}. Calculate its solubility product.

14. Write the Ksp expression for $Al(OH)_3$

15. What is the condition for precipitation of a salt ?

16. Pridict whether the solution is acidic, basic or natural when NH_4NO_3 undergo hydrolysis.

17. Explain why pure NaCl precipitates out when HCl gas is passed through the solution of NaCl ?

18. Give the Henderson's -Hasselbalch equation for an acidic buffer solution.

19. On which of the factors the equilibrium depend : Temperature, nature of reactant and product, initial concentration and pressure of the reactants.

20. What are amphoteric substances ? Give one example.

21. What could be the temperature 15°C or 100°C for Kw = 7.5×10^{-14} ?

22. What happens to ionic product of water if some acid is added to it ?

23. What is the conjugate base of HCO_3^- ?

2 – Mark Questions

1. Explain ionic product of water. What is the effect of temperature on ionic product of water ?

2. What is pOH ? What is its value for neutral water at 25°C ?

3. (a) Define buffer solution.

   (b) Give one example each of acidic and basic buffer.

4. The solubility of $Ca_3(PO_4)_2$ in water is x moles / litre. Calculate its solubility product. [**Ans.** $108x^5$]

5. Calculate the pH of a 0.01 M solution of acetic acid. K_a for CH_3COOH is 1.8×10^{-5} at 25°C. [**Ans.** 3.37]

6. Calculate pH when 9.8 g H_2SO_4 is dissolved in 2 litre of solution. [1]

7. Calculate the pH of 10^{-9} M HCl. [**Ans.** pH = 6.9957]

8. An acid having pH = 6 is diluted 100 times. What will be the pH of the final solution ? [**Ans.** pH = 6.98]

9. Calculate the pH of 10^{-10} M NaOH solution. [**Ans.** pH = 7.0004]

10. Solid $Ba(NO_3)_2$ is gradually dissolved in a 1.0×10^{-4} M Na_2CO_3 solution. At what concentration of Ba^{2+} will a precipitation took place ?
    (K_{sp} for $BaCO_3 = 5.1 \times 10^{-9}$) [**Ans.** 5.1×10^{-5} M]

11. The pKa of acetic acid and pKb of ammonium hydroxide are 4.76 and 4.75 respectively. Calculate the pH of ammonium acetate solution.
    [**Ans.** 7.005]

3–Mark Questions

1. What is meant by the conjugate acid-base pair ? Find the conjugate acid/base for the following species :

   HNO_2, CN^-, $HClO_4$, F^-, OH^-, OH_3^-, and S^{2-}.

2. Define solubility product. Calculate the solubility product of $Ca(OH)_2$ if its solubility is 3 moles L^{-1}. [**Ans.** $K_{sp} = 108$]

3. Calculate the pH of the following mixture.

   200 mL of M/10 H_2SO_4 + 400 mL of M/10 H_3PO_4 + 400 mL of M/10 HCl. [0.69]

4. The solubility product of AgCl in water is 1.5×10^{-10}. Calculate its solubility in 0.01 M NaCl aqueous solution. [1.5 × 10–8 M]

5. Predict whether a precipitate will be formed or not on mixing 20 ml of 0.001 M NaCl solution with 80 mL of 0.01 M $AgNO_3$ solution, Ksp for AgCl is 1.5×10^{-10}. [Yes, ppt. will be formed]

6. Equal volumes of three acids solution with pH 3, 4 and 5 are mixed in a vessel. What will be the H^+ ion concentration in the mixture ?

7. Calculate the pH of a solution obtained by mixing 50 mL of 0.2 M HCl and 50 mL of 0.1 M NaOH. [**Ans.** 1.3010]

8. The pH of 0.1 M hydrocyanic acid solution is 5.2. What is the value of K_a for hydrocyanic acid ? [**Ans.** Ka = 3.69×10^{-10}]

9. A buffer solution is prepared by mixing equal concentration of weak base and its salt with strong acid. For the base K_b is given as 10^{-9}. Calculate the pH of the buffer solution. [5]

10. Calculate the pH of the resultant mixtures :

    (a) 10 mL of 0.2 M $Ca(OH)_2$ + 25 mL of 0.1 M HCl

    (b) 10 mL of 0.01 M H_2SO_4 + 10 mL of 0.01 M $Ca(OH)_2$

    (c) 10mL of 0.1 M H_2SO_4 + 10mL of 0.1 M KOH.

    [(a) 12.632 (b) 7 (c) 1.3]

11. Equal volumes of 0.002 M solutions of sodium iodate and cupric chlorate are mixed together. Will it lead to precipitation of copper iodate ? (For cupric iodate $K_{sp} = 7.4 \times 10^{-8}$). [NO ppt. will ocurr]

12. What is the maximum concentration of equimolar solutions of ferrous sulphate and sodium sulphide so that when mixed in equal volumes, there is no precipitation of iron sulphide ? (For iron sulphide, $K_{sp} = 6.3 \times 10^{-18}$) [$5.02 \times 10^{-9}$ mol L^{-1}]

13. The ionization constant of aniline is 3.69×10^{-10} :

    (i) Calculate pH of 0.01 M solution of aniline.

    (ii) Calculate the degree of dissociation of aniline in the solution.

    (iii) Calculate the ionization constant of conjugate acid of the aniline.

14. The K_{sp} for $Al(OH)_3$ is 2.7×10^{-11}. Calculate its solubility in g/L and pH of this solution.

15. Calculate the volume of water required to dissolve 0.3 gm of $Zn(OH)_2$ to get a saturated solution. $K_{sp}\ [Zn(OH)_2] = 1 \times 10^{-15}$
[Given Atomic mass of Zn = 65.3, O = 16, H = 1 g mol^{-1} respectively]

16. The pH of an aqueous solution of ammonia is 11.5. Find the molarity of the solution. $K_b\ (NH_4OH) = 1.8 \times 10^{-5}$ [0.57]

17. What is the pH of the solution when 0.2 mole of HCl is added to 1 L of the solution containing 0.1 M each of CH_3COOH & acetate ion. Assume that volume is 1 L.

$K_{a(CH_3COOH)} = 1.8 \times 10^{-5}$. [1]

5 – Mark Questions

1. Calculate the pH value of the following solutions.

(a) 10^{-2} M HCl.

(b) 10^{-3} M H_2SO_4.

(c) 10^{-4} M NaOH

(d) 0.04 M NaOH.

(e) 0.03 M HCl. [**Ans.** (a) 2 (b) 2.6990 (c) 10 (d) 12.60 (e) 1.5229]

2. (i) Calculate the pH of a buffer solution containing 2.0 mol/L CH_3COOH in 1.0 mol/L of CH_3COONa . [Given K_a for CH_3COOH is 1.8×10^{-5} at 25°C.]

(ii) Calculate the change in pH of the buffer after the addition of 0.01 mol NaOH.

(iii) Calculate the pH of the buffer after the addition of 0.01 M HCl ?

[**Ans.** (i) 4.4337, (ii) 0.0065, (iii) 4,4372]

3. (a) What is solubility product ? How is it different from ionic product ?

(b) Calculate the solubility of $PbCl_2$ if its solubility product is 1.0×10^{-6} at 298 K. [**Ans.** 6.3×10^{-3} M]

4. (a) Write short notes on the following :

(i) Common ion effect

(ii) Buffer solution

(b) Calculate the pH of a buffer solution containing 0.2 mole of NH_4Cl and 0.1 mole of NH_4OH per litre. K_b for $NH_4OH = 1.8 \times 10^{-5}$

[**Ans.** 8.966]

5. 500 mL saturated solution of $Ca(OH)_2$ is mixed with equal volume of 0.4 M NaOH. How much $Ca(OH)_2$ in mg is precipitated ?

[K_a ($Ca(OH)_2$) = 4.42×10^{-5} at 25°C]

6. Calculate the pH of 0.1 M ammonia solution. Calculate the pH after 50 mL of this solution is treated with 25 mL of 0.1 M HCl.

(Given K_b (NH_3) = 1.77×10^{-5}.]