2. IONIC EQUILIBRIUM- SQ

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Acid-Base Concepts

1. Arrhenius Concept

2. Bronsted–Lowry Concept (Proton Transfer Theory)

1. Explain Bronsted and Lewis's concepts of acids and bases with suitable examples. 4
   Define the Bronsted-Lowry concept of acid and base with an example of each.
   Define the term Bronsted-Lowry acid. 1
   Give a suitable example of a Bronsted-Lowry acid. 0.5
2. Write examples to show water acts as a Bronsted-Lowry acid and base. 2
3. Write the formulae of the conjugate acid and conjugate base of NH_3. 2
4. Give the formula of the conjugate base of H_3PO_3. 1
5. Hydrogen sulfide gas, $H_2S(g)$, is slightly soluble in water. It acts as a weak acid in aqueous solution.
   Give the formula of the conjugate base of H_2S. [1]
6. Hypophosphorous acid is an inorganic acid.
   The conjugate base of hypophosphorous acid is $H_2PO_2^-$.
   Write the formula of hypophosphorous acid. 1
7. Give proper reasons why NH_3 acts as a Bronsted base but not an Arrhenius base. 1

3. Lewis Concept (Electronic Concept)

8. Write a short note on Lewis's concept of acids and bases. 4
   Define Lewis acid and Lewis base, giving an example of each. 2
   Define the term Lewis base. 2
   Give an example of a Lewis acid. 0.5
   Give an example of a Lewis base. 0.5
9. What are the limitations of Lewis's concept of acid and base? 2
   Define Lewis's concept of base and point out its limitations. 2
10. Water is a Lewis base as well as a Brønsted acid; explain. 2
11. Differentiate between Brønsted-Lowry acid and Lewis acid. [2]
12. Differentiate between the Brønsted-Lowry and Lewis concepts of bases.

Ionisation of Electrolytes and Ostwald's Law

13. What is meant by a weak electrolyte? [1]
14. Define the dynamic equilibrium state in a reversible reaction? 2
15. Define Ostwald's dilution law. What is its limitation? 2
    Define Ostwald's dilution law. 1
    State Ostwald's dilution law. 1
16. Why is Ostwald's dilution law not applicable to strong electrolytes? 1
    Give a proper reason. Ostwald's dilution law does not apply to strong electrolytes
17. ★ i) Derive Ostwald's dilution equation. [2]
    ii) Point out any two limitations of Ostwald's dilution law. [2]
18. Define the ionisation constant and degree of ionisation of weak electrolytes. State how each varies with temperature. 2
    Define the term degree of ionisation. 1
    State the term degree of dissociation. 1
19. Calculate the degree of ionisation of HCN having concentration 0.01 N ($K_a = 4.8 \times 10^{-10}$). (ans $=2.19 \times 10^{-4}$) 3
20. A weak monobasic acid is 2.0% ionised in a 0.10 mol L^{-1} solution. Determine its ionisation constant. 2

pH

21. State the term ionic product of water. 1
22. Define the ionic product of water. Why does the K_w of water increase with temperature?
23. State the term pH value of a solution. 1
    Define the term pH of a solution. 1
24. Write the relation between pH and pOH of the solution. 1
    Derive the relation between pH and pOH. 2

25. Write a short note on pH and the pH scale. 4
26. The ionic product of water at 25^0 C is 1 x 10^{-14}, making water a very weak electrolyte.
    - **i)** Define the ionic product of water.
    - **ii)** Deduce the relation: $K_w = [H^+]\,[OH^-]$
    - **iii)** What is the effect of temperature on the ionic product of water?
27. The acidic strength of a solution is expressed as pH.
    What are the applications of pH in our daily life?
28. A solution has a pH of 3 while another has a pH of 5. Compare their hydrogen ion concentrations.
29. Is an aqueous solution containing a hydrogen ion concentration 3 x 10^{-5} $molL^{-1}$ acidic, basic, or neutral? (ans = acidic) 2
30. What will be the H^+ ion concentration of a solution having a pH of 5.5? (ans = 3.16×10^{-6} M) **2**
31. Calculate the pH value of the 0.04 N HNO_3 solution, assuming HNO_3 is completely ionised. *(ans =1.398)* 2
32. A solution contains 0.63 g of nitric acid per 100 mL of solution. What is the pH of the solution if it is completely dissociated? (ans = 1)
33. Calculate the pH of 0.1 M H_2SO_4. (ans = 0.698) 2
34. Calculate the pH of 0.1N H_2SO_4. (ans = 1) 2
35. 49g of H_2SO_4 is present in 1000ml of its solution. What is the pH of the solution? (ans = 0) 2
36. The pH of an HCl solution is 3. Calculate the strength of the HCl solution in terms of molarity. *(ans =0.001)*
37. Is the solution acidic, basic, or neutral in which the concentration of hydroxyl ion is 3.33 x 10^{-10} mol L^{-1}? (ans = acidic) 2
38. Calculate the pH of 10^{-3} M KOH. (ans = 11) 2
39. Calculate the hydrogen ion concentration of a solution whose pH is 9.5. (ans = 3.16×10^{-10} M) 2
40. What is the pH of a solution of NaOH whose concentration is 0.4 g/litre? *(12)* 2
    Calculate the pH of 1 g/ L of NaOH solution. (12.398) 2
41. 10^{-2} moles of KOH are dissolved in 10 litres of water. What will be the pH of the solution? 2
    10^{-2} moles of NaOH are dissolved in 10 litres of water. What will be the pH of the solution? (11) 2
42. Calculate the hydroxide ion concentration of a solution having a pH of 10.5. (3.162 x 10^{-4}) 2
43. Calculate the strength in gm/litre of NaOH, whose pH value is 11. (0.04g/L) 2
44. The pH of a solution of KOH is 10. Calculate the hydroxyl ion concentration. (1x10^{-4}) 2

45. ★ What is the pH of 10^{-9} M HCl? (Ans = 6.995) 2
46. ★ Calculate the pH of the solution containing 10^{-7} moles of NaOH per litre. (7.301) 2

47. What mass of KOH should be dissolved in one litre of a solution to prepare a solution having a pH of 12 at 25 ^oC? *(0.56g)* 2
48. How many moles of $Ca(OH)_2$ must be dissolved to produce 250 mL of an aqueous solution of pH 10.65? (ans = 5.58×10^{-5} mol) 3
49. Calculate the $[OH^-]$ concentration of 0.01 M HCl at 25 ^{0}C. (ans = 10^{-12} M) 2
50. Calculate the hydroxyl ion concentration in mol/litre of a solution whose pH is 4.7. Also, determine the weight of NaOH required to produce these ions in one litre of the solution. 4

51. Calculate the degree of ionisation of HCN having a concentration of 0.01 N ($K_a = 4.8 \times 10^{-10}$). Also, calculate the H^+ ion concentration and pH. (ans: $\alpha = 2.19 \times 10^{-4}$, $[H^+] = 2.19 \times 10^{-6}$ M, pH = 5.66) 5
52. ★ Calculate the pH of a 1.0 M solution of acetic acid. [K_a=1.8 x 10^{-5}] (ans = 2.37) 2
    Calculate the pH of 0.1 M acetic acid having K_a = 1.8 x 10^{-5}. (ans = 2.87) 2
53. Find the pH of 0.1 M NH_4OH solution. K_b = 1.8 x 10^{-5}. **3**

54. 200 ml of an aqueous solution of HCl (pH = 2) is mixed with 300 ml of an aqueous solution of NaOH (pH = 12). What will be the pH of the resulting mixture solution? *(ans = 11.3)* 5
55. If equal volumes of two solutions having pH = 1 and pH = 12 are mixed, what will be the pH of the resulting solution? (ans = 1.347) 3
56. Two litres of 1 M HCl are mixed with one litre of 1 M NaOH solution. Calculate the strength of the salt formed and the pH of the resulting solution. (ans = 0.33M, 0.48) 2
57. Calculate the pH of the solution obtained by mixing equal volumes of two solutions having pH = 3 and pH = 5. (ans = 3.3) 3
58. ★ 10 cc N/2 HCl, 30 cc N/10 HNO_3 and 60 cc N/5 H_2SO_4 are mixed together. Find the pH of the mixture. *(ans = 0.698)* 3

59. Arrange the following acids in decreasing order of strength and justify your answer.
Ka values: Acid A = 1.8×10^{-5} Acid B = 4.7×10^{-4} Acid C = 7.1×10^{-8} 2

60. Acids A, B, C, and D have the following pKa values:
A = 4.744, B = 3.698, C = 3.346 and D = 4.214. Arrange these acids in the increasing order of their strength. 2

Solubility Product and Solubility Product Principle

61. Define the solubility product. 1
What is meant by the solubility product of sparingly soluble electrolytes?
State the solubility product constant. 1

62. Define the ionic product. 1

63. State proper conditions for the precipitation of salt from a solution. 1

64. Write a concise account of the solubility product principle. 5
Define the solubility product principle. 1
Write a short note on the solubility product principle. 5
Write a short note on the solubility product and its application in analytical chemistry. 5

65. **State what each of the following indicates:**
(i) Ionic product > Ksp
(ii) Ionic product = Ksp
(iii) Ionic product < Ksp

66. A. Write equilibrium expressions for the solubility products of the following:
a. $Fe(OH)_2$ c. Fe_2S_3 c. $Al(OH)_3$
B. State the units of solubility product for each of the compounds in part **A**.

67. The solubility of calcium phosphate, $Ca_3(PO_4)_2$, is 1.14×10^{-7} mol dm^{-3} at 25 °C.
The expression for the solubility product, Ksp, of $Ca_3(PO_4)_2$is shown.
$Ksp = [Ca^{2+}]^3[PO_4^{3-}]^2$
Calculate the value of Ksp for $Ca_3(PO_4)_2$. 2

68. The solubility of aluminium hydroxide, $Al(OH)_3$, in water is 2.47×10^{-9} mol dm^{-3}.
(i) Give the expression for the solubility product, Ksp, of aluminium hydroxide.
(ii) Calculate the numerical value of the Ksp of aluminium hydroxide. Include the units of Ksp in your answer. 1+1

69. Nickel(II) iodate(V), $Ni(IO_3)_2$, is sparingly soluble in water. The concentration of its saturated solution is 2.30×10^{-2} mol dm^{-3} at 298 K.
(i) Complete the expression for the solubility product, Ksp, of $Ni(IO_3)_2$.
(ii) Calculate the numerical value for K_{sp} of $Ni(IO_3)_2$ at 298 K. [1]

70. Calcium hydroxide is slightly soluble in water.
(i) Write an equation to show the dissociation of calcium hydroxide, $Ca(OH)_2(s)$, in aqueous solution. Include state symbols. [1]
(ii) Calculate the solubility, in mol dm^{-3}, of $Ca(OH)_2$.
[Ksp: $Ca(OH)_2$, 5.02×10^{-6} mol^3 dm^{-9}] 2

71. 0.00143 g of AgCl dissolves in one litre of water at 25 °C to form a saturated solution. What is the solubility product of the salt? (Ag = 108, Cl = 35.5) *(Ans = 9.93×10^{-11})* 3

72. The solubility of CaF_2 in water at 18°C is 2.05×10^{-4} mole per litre. Calculate its solubility product. *(ans = 3.45×10^{-11} mol/litre)* 3

73. The solubility product of chalk is 9.3×10^{-8}. Calculate its solubility in gm per litre. (ans = 3.049×10^{-2})4

74. The solubility product of CuS is 8.0×10^{-45} at a certain temperature. Find its solubility at this temperature. (ans = 8.94×10^{-23} $molL^{-1}$) 4

75. The solubility product of $BaSO_4$ in water at 25°C is 1×10^{-10} $mole^2L^{-2}$. Calculate the solubility of $BaSO_4$ in g/L. [Ba= 137] (ans= 2.33×10^{-3} g/L) 2

76. ★What is the minimum volume of water required to dissolve 1 g of calcium sulphate at 298 K. (Given solubility product (Ksp) for $CaSO_4$= 9.1×10^{-6}) (ans = 2.44 litres) 4

77. ★Calculate the pH of a saturated $Mg(OH)_2$ solution; K_{sp} for $Mg(OH)_2$ is 8.9×10^{-12}. (ans =10.42) 3

78. Explain why the Ksp values of two different sparingly soluble salts cannot always be used to compare their solubilities. Illustrate your answer with a suitable example. 2

Common Ion Effect

79. What is the common ion effect? Explain its main applications. 1+4
Define the common ion effect. 2

Write a short note on the common ion effect. 5

80. Describe the solubility product principle. Explain any two factors affecting the solubility of a sparingly soluble salt. 3
81. Write a short note on the applications of the solubility product principle and the common ion effect in salt analysis. 5
    Write the applications of the solubility product principle and the common ion effect in the qualitative salt analysis. 4
82. Define the solubility product principle. How are the solubility product principle and the common ion effect applied for the analysis of group II metal ions in qualitative salt analysis? [1+2]
83. What will happen when HCl gas is passed through a saturated solution of NaCl? Also, explain the principle involved. 2
    Explain why sodium chloride precipitates from a saturated solution when hydrogen chloride is passed into the solution. 2
84. The solubility of calcium phosphate, $Ca_3(PO_4)_2$, is 1.14×10^{-7} mol dm^{-3} at 25 °C.
    Some solid sodium phosphate is added to a saturated solution of $Ca_3(PO_4)_2$.
    Predict the effect, if any, on the solubility of $Ca_3(PO_4)_2$.
    Explain your answer. 1
85. (i) Write an equation to show the equilibrium for the solubility product of MgCO3. Include state symbols. [1]
    (ii) With reference to your equation in (i), suggest what is observed when a few cm^3 of concentrated $Na_2CO_3(aq)$ are added to a saturated solution of MgCO3. Explain your answer.[2]
86. Predict what happens to the solubility of AgCl when $NaNO_3$ solution is added. Explain your answer.
87. Explain the application of the solubility product principle and the common ion effect. 4
88. ★ The solubility product principle and the common ion effect are simultaneously applied in the qualitative salt analysis.
    i) Distinguish between the solubility product principle and the common ion effect.
    ii) Apply the solubility product principle and the common ion effect in the salt analysis of group III A metal ions.
    Give a proper reason: Group II metal ions get precipitated as their sulfides when H_2S is passed through their acidified salts. 2
89. Apply the solubility product principle and the common ion effect in the salt analysis of group III A metal ions. 3
90. Detection of basic radicals by wet tests is common in laboratory experiments of Class 12 students. How would you apply the common ion effect and solubility product principle in this experiment?
91. Give a proper reason for group II metal ions precipitating as their sulfides when H_2S is passed through their acidified salts.
92. Calcium hydroxide is slightly soluble in water
    Suggest how the solubility of $Ca(OH)_2$ in aqueous NaOH compares to its solubility in water.
    Explain your reasoning. 1
93. Predict whether precipitation will occur or not on mixing 20 mL of 1×10^{-3} N NaCl solution with 80 mL of 1×10^{-2} N $AgNO_3$ solution if Ksp for AgCl = 1.5×10^{-10}. [at. Wt of Ag = 108 amu.] [3]
94. The solubility product of $BaSO_4$ is 2×10^{-10}. Will the precipitation occur if equal volumes of 2×10^{-8} M $BaCl_2$ and 2×10^{-3} M Na_2SO_4 are mixed? (ans = No) 3
95. The solubility product of $BaSO_4$ is 1×10^{-11}. Will the precipitation occur if equal volumes of 2×10^{-3} M $BaCl_2$ and 2×10^{-4} M Na_2SO_4 are mixed? (ans = yes) 3
96. The solubility of AgCl in water at 298K is 1.43×10^{-3} g L^{-1}; calculate its solubility in a 0.1 M KCl solution. *(ans = 9.93×10^{-10} M)* 3
97. If 25 cm^3 of 0.05 M $Ba(NO_3)_2$ is mixed with 25 cm^3 of 0.02 M NaF, will any precipitation take place? [K_{sp} for BaF_2 is 1.7×10^{-6} at 298 K].
98. 40 cm^3 of 0.2 M $CaCl_2$ solution is mixed with 40 cm^3 of 0.1 M Na_3PO_4 solution. Will any $Ca_3(PO_4)_2$ precipitate out? K_{sp} of $Ca_3(PO_4)_2 = 2.3 \times 10^{-6}$ 3

99. ★★ Calculate the solubility of $PbCl_2$ in terms of mol L^{-1} in:
    [K_{sp} for $PbCl_2$ is 1.7×10^{-5}]
    i) Pure water ii) Solution containing 0.15 M $MgCl_2$
100. ★The solubility product of $BaSO_4$ is 1.5×10^{-9}. Find its solubility in (i) pure water, (ii) 0.1 M $BaCl_2$. (ans = 3.87×10^{-5}, 1.5×10^{-8}) 4
101. ★The solubility product of AgCl is 1.8×10^{-10}. What mass of AgCl (molecular mass = 143.5) is precipitated if 0.2 moles of HCl is added to 500 ml of saturated solution of AgCl? (ans=

Buffer solution and its application

102. Define the term basic buffer. 1
103. Define a buffer solution with an example. Explain the buffer action of a buffer solution qualitatively.

Selection of Indicators in Acid-Base Titration and pH Curve

104. Define indicators. Explain how indicators are selected in acid-base titration. 5
Write a short note on the selection of indicators in acid-base titrations. 5
105. Explain the nature of the pH titration curve and also the basis of the selection of indicators in the titration of strong acid, strong base reactions. 2
106. Why is titration between ammonium hydroxide and carbonic acid uncommon? 1
107. A student has performed two acid-base titrations as follows;

	Acid	Base
Titration 1	HCl	NH_4OH
Titration 2	CH_3COOH	NaOH

$(NH_4OH) = 1.8 \times 10^{-5}$ $(CH_3COOH) = 1.8 \times 10^{-6}$

Provide a suitable indicator as well as an endpoint range for both titrations. 2

Types of salts

Hydrolysis of Salts

108. Predict whether the aqueous solution of $CuSO_4$ is acidic, basic, or neutral.
109. Is the aqueous solution of $CaCl_2$ acidic, basic, or neutral? Give a reason.
110. Explain why an aqueous sodium carbonate solution is basic, while the aqueous sodium chloride solution is neutral.
Why is aqueous Na_2CO_3 basic? 2
111. Why is the aqueous solution of $FeCl_3$ acidic? 2
112. Give a suitable example of an acidic salt. 1
113. Give a suitable reason why NaCl cannot undergo hydrolysis. 1
114. Consider two salts, ammonium chloride and sodium acetate. Provide the reactions to show whether these salts are acidic or basic.

Higher Ability Questions

115. 6 grams of CH_3COOH are present in a 100 mL solution. Find out the pOH for the solution. [K_a for acetic acid is 1.8×10^{-5}] 3
116. A solution is prepared by dissolving 0.175 g NH_4OH and making the volume up to 50 mL. Find its pH. $K_b = 1.8 \times 10^{-5}$
117. Calculate the pH of the solution obtained by mixing equal volumes of solutions, one having a pH of 5 and another having a pH of 10. (ans= 9.65) 3
118. There are two weak acids, **A** and **B**. The pH of a 0.2 M acid **A** solution is 2.9, and the pH of a 0.5 M acid **B** solution is 3.2. Find K_a for the acids **A** and **B,** and compare their acidic strength.
119. The solubility product of $PbSO_4$ is 1.6×10^{-8} at 25 °C. If 10^{-3} M Na_2SO_4 is added to 1 L of a saturated solution of $PbSO_4$, what amount of $PbSO_4$ will be precipitated? 3
120. If 80 mL of 0.01 $AgNO_3$ is mixed with 20 mL of 0.001 M NaCl solution. Will any AgCl precipitate or not? [K_{sp} for AgCl = 1.5×10^{-10}] 4
121. A sample of AgCl is treated with 5 mL of 2 M Na_2CO_3 solution to produce Ag_2CO_3. The remaining solution contained 0.003 g of Cl^- per litre. Calculate the solubility product of AgCl. (K_{sp} of Ag_2CO_3= 8.2×10^{-12}) (ans = 1.71×10^{-10}) 4
122. The solubility product of $Ca(OH)_2$ at 25 °C is 4.42×10^{-5}. A 500 mL saturated $Ca(OH)_2$ solution is mixed with an equal volume of 0.4 M NaOH. How much $Ca(OH)_2$ precipitates? (ans = 0.758g) 4
123. Calculate the pH of 1.0 M acetic acid. To what volume should one litre of this solution be diluted so that the pH of the solution formed is twice the original value? [K_a=1.8×10^{-5}] *(ans; pH=2.37, 234 litres)* 4
124. What amount of $Zn(OH)_2$ will be precipitated out at 20 °C if 0.22 g NaOH is added to 1 litre of a saturated solution of $Zn(OH)_2$? The precipitate is obtained in this reaction; why? [solubility product of $Zn(OH)_2$ at 20^0C is 1.8×10^{-14}] (ans= 1.65×10^{-3} or 0.00164 g) 4+1

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