ADVANCED LEVEL PHYSICAL CHEMISTRY PROBLEMS

CHAPTER 12: IONIC EQUILIBRIA

1. (a). Write the equation for the ionisation of aqueous hydrogen fluoride in a
   (i). Dilute solution
   (ii). Concentrated solution
   (b). In which of the two solutions in (a) above would you expect hydrogen fluoride to be more acidic? Explain.
   (c). Calculate the ionisation constant, K_a, for ethanoic acid at 25°C given the degree of ionisation of the acid in a 0.1M aqueous solution is 0.00133

2. (a). What is meant by the term pH
   (b). A solution of magnesium hydroxide contains 0.0002 moles per litre of magnesium ions. Calculate the
   (i). Number of moles of hydroxide ions present in the solution
   (ii). The pH of the solution. ($K_w = 1.0 \times 10^{-14}\text{mol}^2\text{dm}^{-6}$)

3. (a). Silver chromate is a sparingly soluble salt in water.
   (i). Write the equation for the dissolution of silver chromate in water
   (ii). Write the expression for the solubility product of silver chromate.
   (b). Calculate the mass of silver chromate required to saturate 0.5 litre of water given the solubility product constant, K_{sp}, of silver chromate is 1.15×10^{-12} at 25°C

4. Sodium sulphide is salt that undergoes hydrolysis when dissolved in water
   (a). Explain what is meant by the term salt hydrolysis
   (b). Write the equation for the hydrolysis of sodium sulphide in water
   (c). State whether the pH of and aqueous solution of sodium sulphide will be greater, less than or equal to 7. Explain your answer.

5. Sodium benzoate undergoes hydrolysis when dissolved in water.
   (a). Write an equation for the hydrolysis of sodium benzoate in water
   (b). Write an expression for the hydrolysis constant, K_h, for sodium benzoate
   (c). The hydrolysis constant of sodium benzoate is $1.6 \times 10^{-10}\text{moll}^{-1}$.
   (i). Calculate the concentration of hydroxide ions in a 0.1M solution of sodium benzoate ($K_w = 1.0 \times 10^{-14}\text{mol}^2\text{dm}^{-6}$)
   (ii). State the assumptions made in the calculation in (c) (i)
   (iii). From your result in c (i), calculate the hydrogen ion concentration of the solution

6. (a). 20cm^3 of 0.1M sodium hydroxide solution was added to 100cm^3 of 0.1M solution of ethanoic acid. Calculate the pH of the resulting solution. ($K_a = 1.75 \times 10^{-5}\ moldm^{-3}$)
   (b). Barium sulphate is sparingly soluble in water.
   (i). Write equation for solubility of barium sulphate in water
   (ii). Write the expression for the solubility product of barium sulphate

(iii). A saturated solution of barium sulphate contains 1.1×10^{-5} moles per litre pf the salt. Calculate the solubility of barium sulphate in gl^{-1}

(iv). Calculate the solubility of barium sulphate in a litre of 0.1M barium chloride solution

7. (a). Phenylamine hydrochloride undergoes hydrolysis when dissolved in water. Write an equation for the reaction.

(b). A 0,2M solution of phenylamine hydrochloride has a pH of 3.5. Calculate

(i). The molar concentration of hydrogen ions in the solution

(ii). The hydrolysis constant, K_h, of phenylamine hydrochloride

8. (a). Explain what is meant by

(i). Salt hydrolysis

(ii). Common ion effect

(iii). Solubility product

(b). When sodium hydroxide solution is added to aqueous calcium hydroxide, a white precipitate is formed, but when ammonia solution is used instead, no precipitation occurs. Explain

(c). Mercury(I) iodide was dissolved in 0.3M sodium iodide solution. Calculate the concentration of mercury(I) iodide in solution in gdm^{-3}. The solubility of mercury(I) iodide in water is $3.0 \times 10^{-7} gdm^{-3}$. Mercury(I) iodide dissolves in water according to the following equation

$$Hg_2I_2(s) \quad \leftrightharpoons \quad Hg_2^{2+}(aq) \quad + \quad 2I^-(aq)$$

9. (a). A solution contains 0.05 moles of nitric acid in 1 litre. Calculate the pH of the solution

(b). A 0.1M ethanoic acid solution was titrated with 0.1M sodium hydroxide solution until the acid was exactly half neutralised. Calculate the pH of the resultant solution. $K_a = 1.8 \times 10^{-5}\ moldm^{-3}$.

(c). Two drops of aqueous sodium hydroxide solution were added to the resultant solution in (b). State and explain what happened to the pH of the solution.

10. (a). Phenylamine hydrochloride undergoes hydrolysis in water. Write

(i). Equation for the reaction.

(ii). An expression for the hydrolysis constant, K_h.

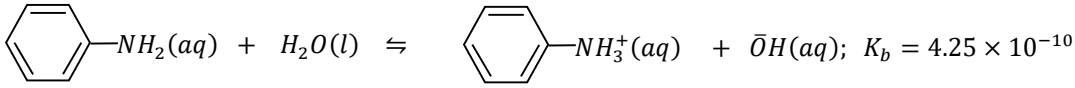
(b). A solution containing 15.0g of phenylamine hydrochloride in 100 cm^3 of water was shaken with 100cm^3 of benzene. At equilibrium, the benzene layer contained 0.12g of phenylamine. Calculate the

(i). Molar concentration of phenylamine in the benzene layer

(ii). Hydrolysis constant, K_h, of phenylamine hydrochloride.

11. Iron(III) hydroxide and phenylamine react with water according to the following equations

$$Fe(OH)_3(s) \quad \leftrightharpoons \quad Fe^{3+}(aq) \quad + \quad 3\bar{O}H(aq);\ K_{sp} = 1.0 \times 10^{-38}$$



(a). Write the expression for the solubility product. K_{sp}, for iron(III) hydroxide and the base dissociation constant, K_b, for phenylamine. In each case, state the assumptions made

(b). The equation for the reaction between phenylamine and iron(III) ions is given below

$$Fe^{3+}(aq) + 3C_6H_5NH_2(aq) + 3H_2O(l) \leftrightharpoons 3C_6H_5NH_3^+(aq) + Fe(OH)_3(s)$$

(i). Write the expression for the equilibrium constant, K_c, for the reaction

(ii). Express the equilibrium constant in terms of K_{sp} and K_b

(iii). Calculate the value of equilibrium constant, K_c.

12. (a). Describe how the solubility product of magnesium hydroxide in water can be determined

(b). (i). A saturated solution of magnesium hydroxide in water contains 1.44×10^{-4} mol of magnesium hydroxide per litre of solution. Calculate the value of solubility product, K_{sp}, of magnesium hydroxide

(ii). Solid magnesium hydroxide was shaken with a 0.1M solution of magnesium nitrates until equilibrium was attained. Calculate the amount of magnesium hydroxide in grams per litre that dissolved.

(c). Equations of some reactions are given below

$$AgCl(s) \leftrightharpoons Ag^+(aq) + Cl^-(aq)\ ;\ K_1 = 1.7 \times 10^{-10}$$

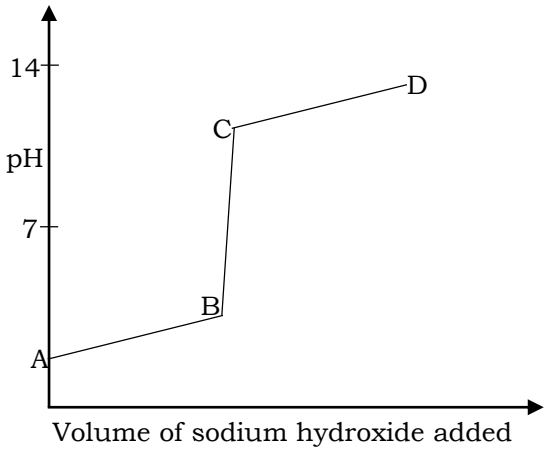
$$Ag^+(aq) + 2NH_3(aq) \leftrightharpoons Ag(NH_3)_2^+(aq)\ ;\ K_2 = 1.7 \times 10^{-7}$$

(i). Derive an expression for the equilibrium constant for the following reaction.

$$AgCl(s) + 2NH_3(aq) \leftrightharpoons Ag(NH_3)_2^+(aq) + Cl^-(aq)$$

(ii). Calculate the value of the equilibrium constant in (i)

13. The curve below was obtained for when hydrochloric acid was titrated with sodium hydroxide



(a). Explain what happens to the pH in the region

(i). AB

(ii). BC
(iii). CD

(b). Name one indicator that can be used in the titration in (a)

(c). (i). Sketch a graph that would be obtained if hydrochloric acid is titrated with ammonia solution

(ii). Explain the shape of the graph in c (i) above

14. A 0.01M solution of ammonia is 4.0% ionised.

(a). Calculate the pH of the solution $K_w = 1.0 \times 10^{-14}\ mol^2dm^{-6}$

(b). Determine the base dissociation constant, K_b, for ammonia

15. (a). Write an expression to show the relationship between acid dissociation constant, K_a, and the degree of dissociation, $\propto$, for a weak acid

(b). Calculate the value of the acid dissociation constant, K_a, for a 0.1M ethanoic acid and state its units. (the molar conductivity of a 0.1M ethanoic acid is $5.2 \times 10^{-4}\Omega^{-1}cm^2mol^{-1}$ while the molar conductivity of ethanoic acid at infinite dilution is $3.9 \times 10^{-2}\Omega^{-1}cm^2mol^{-1}$)

16. (a). Ethanoic acid is a weak acid.

(i). Explain what is meant by the term a weak acid

(ii). Calculate the pH of a 0.05M ethanoic acid solution
(K_a for ethanoic acid is $1.8 \times 10^{-5}\ moldm^{-3}$)

(b). (i). Explain what is meant by the term "buffer solution".

(ii). Discuss the action of the buffer solution.

(c). a solution was made by dissolving 7.2g of ethanoic acid and 12.0g of sodium ethanoate to make 1 litre of solution. Calculate the pH of the solution. State any assumption made

17. Ammonium chloride undergoes hydrolysis when dissolved in water

(a). Write the equation for the hydrolysis of ammonium chloride in water

(b). Calculate the

(i). pH of a 0.1M solution of ammonium chloride, $K_h = 5.6 \times 10^{-10}$

(ii). Percentage hydrolysis of a 0.1M ammonium chloride solution.

18. (a). A solution contains a mixture of sodium hydroxide and sodium carbonate in 1 litre. Briefly describe how the percentage of sodium hydroxide in the mixture can be determined using standard hydrochloric acid

(b). Sketch a graph to show the variation of pH during the titration of hydrochloric acid with

(i). Sodium hydroxide

(ii). Ammonia solution

(c). Explain the shape of each graph in (b) above

(d). Calculate the pH of the resultant solution when $10cm^3$ of 0.1M sodium hydroxide solution is added to $25cm^3$ of 0.1M ethanoic acid
(K_a for ethanoic acid is $1.8 \times 10^{-5}\ moldm^{-3}$)

19. (a). The pH of a 0.1M solution of a weak acid HX is 3.65. calculate the acid dissociation constant, K_a.

(b). When 50cm^3 of 0.1M solution of aqueous ammonia was added to 50cm^3 of 0.1M hydrochloric acid solution, the pH of the resultant solution was less than 7. Explain this observation

20. (a). At 25°C, ammonia has a base dissociation constant, K_b, of $1.8 \times 10^{-5}\ moldm^{-3}$
    (b). Write an expression for the K_b, of ammonia
    (c). Calculate the concentration of hydroxide ion concentration which occurs when 0.01M ammonium chloride is added to 1 dm^3 of the solution in (b). State the assumptions made.
    (d). Explain the change in the hydroxide ion concentration in (c).

21. (a). Write an equation for the hydrolysis of sodium ethanoate in water
    (b). Write an expression for the hydrolysis constant, K_h, of sodium ethanoate.
    (c). Calculate
        (i). The value of hydrolysis constant, K_h,for sodium ethanoate and indicate its units. (K_a for ethanoic acid is $1.8 \times 10^{-5}\ moldm^{-3}$, $K_w = 10 \times 10^{-14}\ moldm^{-3}$)
        (ii). The pH of a 0.1M sodium ethanoate solution
    (d). State what would be the effect on the pH of the solution in c (ii) if 1 cm^3 of 0.1M ethanoic acid was added to it.

22. Lead(II) sulphate is sparingly soluble in water
    (a). Write an expression for the solubility product of lead(II) sulphate
    (b). 5g of lead(II) sulphate was shaken with 1dm^3 of water. Determine the percentage of lead(II) sulphate that dissolved in water. (the solubility product K_{sp}, of lead(II) sulphate is 1.6×10^{-8}; $Pb = 207; S = 32; O = 16$)
    (c). If 0.05M sulphuric acid was used instead of water in (b), calculate the percentage of lead(II) sulphate that dissolved and state assumption made.

23. (a). Explain
        (i). What is meant by a buffer solution
        (ii). How a buffer solution works
    (b). Calculate the pH of a buffer solution made by mixing 15cm^3 with 25cm^3 of 0.1M sodium ethanoate solution.
    (c). (i). Draw a graph to show pH changes when a strong acid is titrated with a weak base
        (ii). Explain the shape of the graph in c(i)

24. The solubility of lead(II) sulphate is $1.5 \times 10^{-4} moll^{-1}$ at 25°C
    (a). (i). Write the equation for the solubility of lead(II) sulphate in water
        (ii). Write an expression for the solubility product constant, K_{sp}, of lead(II) sulphate
    (b). Calculate the solubility product constant, K_{sp}, for lead(II) sulphate at 25°C.
    (c). When a solution of sodium sulphate was added to a saturated solution of lead(II) sulphate, a precipitate was formed. Explain this observation
    (d). The solubility product of calcium sulphate is $2.0 \times 10^{-5} mol^2 l^{-2}$. A solution Q contains calcium ions and lead(II) ions. Using your results from part (b), which ion will be precipitated first on addition of sulphate ions to Q. Explain your answer.

25. The solubility product of zinc hydroxide is $1.5 \times 10^{-4}\ mol^3dm^{-9}$.
    (a). Write the
        (i). Equation for the solubility of zinc hydroxide in water
        (ii). Expression for the solubility product constant, K_{sp} of zinc hydroxide
    (b). Determine the concentration in moles per litre of zinc and hydroxide ions in a saturated solution of zinc hydroxide
    (c). State how the solubility of zinc hydroxide would change if its saturated solution is treated separately treated with
        (i). Aqueous zinc sulphate
        (ii). Ammonia solution
    (d). Briefly explain your answer in (c) above.

26. (a). Write an expression for the
        (i). Acid dissociation constant, K_a, for ethanoic acid
        (ii). Relationship between acid dissociation constant, K_a, and the degree of dissociation.
    (b). The electrolytic conductivity of ethanoic acid at 20°C of a $1.6 \times 10^{-2}M$ ethanoic acid is $1.9 \times 10^{-2}\ Sm^2mol^{-1}$. Calculate the
        (i). Degree of ionisation of the acid at 20°C.
        (ii). pH of the acid
    (c). state any other factor that can affect the pH of an acid

27. (a). Write the equation for the solubility of silver bromide in water.
    (b). The solubility product of silver bromide is $5.1 \times 10^{-13}\ mol^2l^{-2}$. Calculate the solubility of silver bromide in gdm-3 in
        (i). Water
        (ii). 0.1M potassium bromide solution. State any assumptions made.
    (c). State two methods that can be used to determine the solubility product of a sparingly soluble salt.

28. (a). Define the term **buffer solution**.
    (b). Calculate the mass of sodium ethanoate that should be added to 1 litre of 0.1M ethanoic acid solution in order to produce a solution of pH 4.0
    ($K_a\ for\ ethanoic\ acid\ is\ 1.8 \times 10^{-5}\ moldm^{-3}$)
    (c). State what would happen to the pH of the solution in (b) id a small amount of the following are added
        (i). Sodium hydroxide solution
        (ii). Hydrochloric acid solution
    (d). State one biological use of buffer solutions

29. (a). Write
        (i). The equation for the solubility of silver sulphate in water
        (ii). The expression for the solubility product, , K_{sp}, of silver sulphate
    (b). Determine the molar concentration of silver and sulphate ions in a saturated solution of silver sulphate (, K_{sp} of silver sulphate is $1.7 \times 10^{-5}mol^3dm^{-9}$)
    (c). State how the solubility of silver sulphate would be affected if the following substances were added

(i). Sodium sulphate
(ii). Ammonia solution

(d). Explain your answer in (c) above.

30. (a). Draw diagrams to show the change in pH when a 0.1M sodium hydroxide solution is added in portions to
(i). $20cm^3$ of a 0.1M hydrochloric acid
(ii). $20cm^3$ of a 0.1M ethanoic acid

(b). Explain the shape if the curves in (a)

(c). $20cm^3$ of 0.1M sodium hydroxide was added to $100cm^3$ of a 0.1M ethanoic acid. Calculate the pH of the resulting solution ($K_a\ for\ ethanoic\ acid\ is\ 1.8 \times 10^{-5}\ moldm^{-3}$)

(d). The solubility of calcium phosphate is 0.0011g per 100g of water at 25°C. calculate the solubility product of calcium sulphate.

31. (a). Write the equation for the
(i). Solubility of silver chromate in water
(ii). Solubility constant, K_{sp}, for silver chromate.

(b). The solubility of silver chromate at 25°C is $3.207 \times 10^{-2}\ gdm^{-3}$. Calculate the solubility constant for silver chromate.

(c). Determine the molar concentration of silver ions required to precipitate silver chromate from an aqueous solution containing 0.005M chromate ions

(d). A solution containing silver ions was added to a solution containing 0.005M chromate ions and 0.005M chloride ions. State which of the salts, silver chromate or silver chloride was precipitated first. Give a reason for your answer. (K_{sp} of silver chloride is $1.96 \times 10^{-10}\ mol^2dm^{-6}$).

32. (a). Write the
(i). Equation for the ionisation of methylamine in water
(ii). Expression for the base dissociation constant, K_b, for methylamine

(b). The hydrogen ion concentration of a 1M methylamine solution is $2.5 \times 10^{-13}\ M$. Calculate the base dissociation constant, K_b, for methylamine.

33. The solubility product of lead(II) chloride is $1.6 \times 10^{-6}\ mol^3l^{-3}$.

(a). Write the
(i). Equation for the solubility of lead(II) chloride in water
(ii). Expression for the solubility product, K_{sp}, of lead(II) chloride

(b). Calculate the
(i). Concentration of the chloride ions in $moll^{-1}$ in a saturated solution of lead(II) chloride
(ii). The solubility of lead(II) chloride in gl^{-1}

(c). State what would be observed if a saturated solution of lead(II) ethanoate was added to a solution of lead(II) chloride. Give a reason for your answer.

34. (a). State how
(i). The solubility product of a sparingly soluble salt may be determined
(ii). The solubility product of a sparingly soluble salt can be affected by addition of a common ion.

(b). Calcium fluoride is sparingly soluble in water. Write
  (i). An equation for the solubility of calcium fluoride in water
  (ii). An expression for the solubility product, K_{sp}, fir calcium fluoride
(c). Calculate the solubility of calcium fluoride in a solution containing 0.35M of sodium fluoride
(d). State one application of solubility product

35. (a). A solution containing 0.001M of methanoic acid is 1% ionised. Calculate the
  (i). pH of methanoic acid solution
  (ii). Acid dissociation constant, K_a, for methanoic acid

36. (a). What is meant by the term common ion effect
(b). Calcium iodate is sparingly soluble in water. Write the
  (i). Equation for the solubility of calcium iodate in water
  (ii). Expression for the solubility product, K_{sp}, of calcium iodate
(c). The solubility product of calcium iodate is $1.72 \times 10^{-9} mol^3 dm^{-9}$. Calculate the solubility of calcium iodate in gl^{-1} in
  (i). Water
  (ii). 0.1M sodium iodate solution
(d). Comment on your answers in (c) above.

37. (a). $25cm^3$ of 0.3M sodium hydroxide was added to $225cm^3$ of water. Calculate the pH of the resultant solution.
(b). Calculate the mass of sodium ethanoate that should be added to $1dm^3$ of 0.1M ethanoic acid at 25°C to give a solution whose pH is 5.5. state any assumptions made. (K_a for ethanoic acid is $1.8 \times 10^{-5} mol dm^{-3}$)
(c). A few drops of dilute hydrochloric acid were added to the solution in (b) above.
  (i). State what was happen to the pH of the solution
  (ii). Give a reason for your answer.

38. (a). Describe an experiment to determine the solubility product of calcium iodate
(b). The solubility product of calcium iodate is $1.70 \times 10^{-9} mol^3 dm^{-9}$. Calculate the concentration of iodate ions in a saturated solution of calcium iodate
(c). State three factors that can affect the value of solubility product.
(d). 0.1M of calcium nitrate was added to a litre of saturated solution of calcium iodate and the mixture stirred. Calculate the mass of calcium iodate which was precipitated. State any assumptions made.
(e). Triphosphate ions form a soluble complex with calcium ions. State what would happen when triphosphate ions are added to a saturated solution of calcium iodate. Give a reason for your answer.
(f). State two applications of solubility product.

39. (a). Write the equation for the hydrolysis of sodium ethanoate in water
(b). Write an expression for the hydrolysis constant, K_h, of sodium ethanoate
(c). The pH of 0.1M aqueous sodium ethanoate solution is 8.9. calculate the

40. (a). Write

(i). Equation for the hydrolysis of sodium benzoate in water

(ii). The expression for the hydrolysis constant, K_h, of sodium benzoate

(b). A solution of 0.2M sodium benzoate was made

(i). Calculate the pH of the solution ($K_h = 1.6 \times 10^{-10}\ moldm^{-3}$; $K_w = 1.0 \times 10^{-14}\ moldm^{-3}$)

(ii). State any assumptions made in (b)

41. (a). Strontium hydroxide is sparingly soluble in water.

(i). Write the equation for the solubility of strontium hydroxide in water

(ii). Write the expression for solubility product, K_{sp}, for strontium hydroxide

(b). The solubility product of strontium hydroxide is 0.524g per 100cm^3 of water at 20°C. calculate the

(i). Solubility product of strontium hydroxide and state its units

(ii). Volume of 0.01M potassium chromate(VI) solution that must be added to 1dm^3 of a saturated solution of strontium hydroxide to precipitate strontium chromate(VI). (K_{sp} of strontium chromate(VI) is $3.6 \times 10^{-5}\ mol^2dm^{-6}$ ($Sr = 87.6$)

(c). Sodium hydroxide was added to a saturated solution of strontium hydroxide

(i). State what happened to the solubility of strontium hydroxide

(ii). Give a reason for your answer in c (i) above

42. Dimethylammonium chloride undergoes hydrolysis in water according to the equation

$$(CH_3)_2NH_2^+(aq) \quad + \quad H_2O(l) \quad \leftrightharpoons \quad (CH_3)_2NH(aq) \quad + \quad H_3O^+(aq)$$

(a). Write the expression for the hydrolysis constant, K_h, for dimethylammonium chloride

(b). When 4.0M of dimethylammonium chloride was hydrolysed. 25.0cm^3 of the resulting solution required 7.5cm^3 of 0.01M sodium hydroxide for complete neutralisation. Calculate the

(i). pH of the solution

(ii). Hydrolysis constant, K_h, and state any assumptions made

43. (a). Silver ethanedioate is sparingly soluble in water. Write the

(i). Equation for the solubility of silver ethanedioate in water.

(ii). The expression for the solubility constant, K_{sp}, for silver ethanedioate.

(b). The solubility product, K_{sp}, of silver ethanedioate is $5.3 \times 10^{-2}\ mol^3dm^{-9}$ at 25°C. calculate the concentration of the following ions in a saturated solution of silver ethanedioate

(i). Silver ions

(ii). Ethanedioate

(c). Calculate the mass of silver nitrate that should be added to the saturated solution in (b) in order to reduce the concentration of the ethanedioate ions to a fifth of its original concentration.

(d). Sodium ethanedioate solution was added to the solution in (b). state how the concentration of the silver ions was affected and give a reason for your answer.

44. (a). Write the equation for the ionisation of phenol in water

(b). If the pH of a 0.01M solution of a phenol is 5.95. calculate the dissociation constant, K_a, of phenol

(c). 10 litres of aqueous solution of trichloroethanoic acid were completely neutralised by 10cm^3 of 0.01M sodium hydroxide. Calculate the pH of the solution of trichloroethanoic acid.

(d). The solution of trichloroethanoic acid in (b) was added to a 0.1M sodium trichloroethanoate. Calculate the pH of the mixtures

45. (a). Define the following terms

(i). Solubility product

(ii). Common ion effect

(b). The solubility product expression of silver oxalate, $Ag_2C_2O_4$, is given by $K_{sp} = [Ag^+]^2[C_2O_4]$ describe an experiment that can be carried out to determine the solubility product of silver oxalate

(c). A saturated solution of silver oxalate contains 1.1×10^{-4} moles of silver oxalate per litre. Calculate the solubility product of silver oxalate and indicate its units

(d). Determine the solubility of silver oxalate in 0.01M silver nitrate solution. State any assumption made.

(e). Explain how the solubility of silver oxalate would be affected if few drops of the following were added

(i). Concentrated ammonia solution

(ii). Sodium oxalate solution.

46. (a). Ammonium chloride solution gives effervescence with magnesium ribbon while sodium ethanoate gives a blue precipitate with aqueous copper(II) chloride. Explain these observations.

(b). The hydrolysis constant of sodium methanoate is $6.25 \times 10^{-11}\ moldm^3$ at 25°C.

(i). Calculate the pH of a 0.1M aqueous solution of sodium methanoate at 25°C ($K_w = 1 \times 10^{-14} mol^2 dm^{-6}$)

(ii). To 1 dm^3 of 0.1M sodium methanoate solution was added to 10cm^3 of 1M hydrochloric acid. Calculate the pH of the resultant solution (K_a for methanoic acid is $1.6 \times 10^{-4}\ moldm^3$)

(c). Explain what would happen to the pH of a solution containing sodium methanoate and methanoic acid, if to it was added a small amount of s

(i). Hydrochloric acid

(ii). Sodium hydroxides

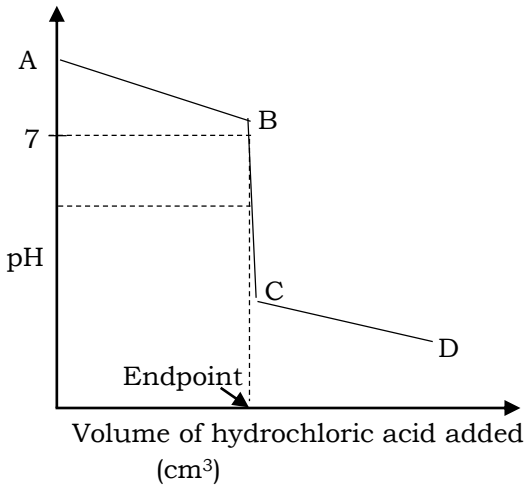
47. (a). Explain why the pH of a solution containing ammonia and ammonium chloride would remain almost constant when mixed with a small amount of

(i). Sodium hydroxide

(ii). Dilute hydrochloric acid

(b). 1.07g of ammonium chloride was dissolved in 1dm^3 of 0.01M ammonia solution. Calculate the pH of the solution and state the assumptions made in the calculations. (K_b for ammonium is $1.75 \times 10^{-5}\ moldm^3$; $K_w = 1 \times 10^{-14} mol^2 dm^{-6}$)

(c). The graph below shows the variation in pH of ammonia solution when it was titrated with dilute hydrochloric acid



Explain the shape of the graph

48. (a). Hydrochloric acid was added to 25cm^3 of 0.1M ammonia solution and the pH of the solution was measured at intervals. The data below was obtained

Volume of hydrochloric acid (cm^3)	10.0	15.0	16.5	17.0	20.0	25.0
pH of the mixture	9.08	8.30	6.70	2.97	1.96	1.60

(i). Plot a graph of pH against volume of hydrochloric acid
(ii). Explain the shape of the graph
(iii). Calculate the molarity of the hydrochloric acid

(b). The pH ranges of some indicators are given below

Indicator	pH range
Thymol blue	1.2 – 2.8
Methyl red	4.8 – 6.0
Phenolphthalein	6.6 – 8.0

Which one of the above indicators is most suitable for use in the above titration? Give a reason for your answer.

(c). Calculate
(i). The molarity of ammonium chloride at end point
(ii). The hydrolysis constant for ammonium chloride

49. Methanoic acid is a weak acid
(a). Explain what is meant by the term weak acid
(b). Write an equation for the ionisation of methanoic acid in water
(c). Calculate the pH of a 0.04M methanoic acid whose acid dissociation constant, K_a, is $1.5 \times 10^{-5}\ moldm^3$. State any assumptions made.

50. (a). Aminoethane is a weak base. What is meant by a weak base.
(b). The pH of a 0.0024M solution of aminoethane is 9.6. Calculate
(i). The base dissociation constant, K_b.
(ii). Degree of ionisation of aminoethane

(c). 25cm^3 of a 0.01M aminoethane required 25cm^3 of 0.01M hydrochloric acid for neutralisation. Calculate the
  (i). pH of the resultant solution
  (ii). Degree of hydrolysis of the salt formed
(d). Explain why the pH of water decreases with increase in temperature.

51. (a). A solution of 0.01M methanoic acid is 4% ionised. Calculate the
  (i). Dissociation constant of the acid
  (ii). pH of the solution
(b). the hydrolysis constant for sodium benzoate is $1.6 \times 10^{-10}\ moldm^3$.
  (i). Calculate the pH of a solution of sodium benzoate
  (ii). State any assumptions made
(c). Explain the following observations
  (i). A solution of sodium methanoate has a pH greater than 7
  (ii). A solution of ammonium chloride has a pH less than 7

52. Ammonium chloride undergoes hydrolysis in water
(a). Write the
  (i). Equation for hydrolysis of ammonium chloride in water
  (ii). Expression for the hydrolysis constant, K_h, for ammonium chloride
  (iii). Expression for the hydrolysis constant, K_h, fo ammonium chloride in terms of K_w and K_b.
(b). Calculate the
  (i). Hydrolysis constant K_h for ammonium chloride
  (ii). The hydrogen ion concentration in solution
  (iii). The pH of 0.01M ammonium chloride.
  ($K_b = 1.8 \times 10^{-5}\ moldm^3$; $K_w = 1 \times 10^{-14} mol^2 dm^{-6}$

53. (a). What is meant by a **buffer solution**.
(b). Describe how the following act as buffers
  (i). A solution of ethanoic acid and sodium ethanoate
  (ii). A solution of ammonium chloride and ammonia solution
(c). A solution is made by dissolving 7.2g of ethanoic acid and 12.0g of sodium ethanoate to make 1 dm^3. To this solution was added 14cm^3 of 1M hydrochloric acid calculate the pH of the solution. Stating any assumptions made. ($K_a = 1.8 \times 10^{-5}\ moldm^3$)
(d). Calculate the pH
  (i). Of a solution made by mixing 40cm^3 of 0.1M aminoethane and 16cm^3 of 0.1M hydrochloric acid
  (ii). Change if 6cm^3 of 0.1M potassium hydroxide is added to the solution in (d) (i) above ($K_b = 1.8 \times 10^{-5}\ moldm^3$)

54. (a). Silver chloride is a sparingly soluble salt in water
  (i). Write an equation for the solubility of silver chloride in water
  (ii). Write an expression for the solubility product, K_{sp}, for silver chloride
(b). Explain how the solubility of silver chloride is affected by addition of
  (i). Ammonia solution
  (ii). Sodium chloride solution

(c). The solubility of anhydrous calcium iodate in water is 3.07gdm-^{3}. Calculate its
  (i). Solubility product
  (ii). Solubility in gdm^{-3} in a solution of 0.1M sodium iodate solution
  (iii). Mass grams precipitated in a 0,1M sodium iodate solution

(d). 25.0cm^{3} of a saturated solution of lead(II) chloride required 17.8cm^{3} of 0.1M silver nitrate solution for complete removal of chloride ions from the solution. Calculate the
  (i). The molar concentration of lead(II) ions in the solution
  (ii). Solubility product of lead(II) chloride at 25°C.

55. (a). Briefly describe an experiment by which the solubility of lead(II) hydroxide in water can be determined

(b). A saturated solution of lead(II) hydroxide in water contains 2.38×10^{-5} mol per litre of solution.
  (i). Calculate the value of solubility product, K_{sp}, of lead(II) hydroxide
  (ii). Solid lead(II) hydroxide was shaken with 0.1M solution of lead(II) nitrate unitl equilibrium was attained. Calculate the amount of lead(II) hydroxide in grams per litre that dissolved

(c). Explain the following observations
  (i). Addition of aqueous ammonia to a solution of aluminium hydroxide is precipitated but in the presence of ammonium chloride, no precipitate is formed
  (ii). Silver chloride is more soluble in aqueous ammonia than in sodium chloride solution
  (iii). Copper(II) sulphide is precipitated in the presence of an acid, while nickel(II) sulphide in an alkaline medium using hydrogen sulphide.

56. (a). What is an acid – base indicator

(b). Give an example of an acid – base indicator and describe how it functions

(c). Sketch a graph each to show the variation of the pH of the resultant solution when
  (i). Dilute hydrochloric acid is added to sodium hydroxide solution
  (ii). Aqueous ammonia is added to dilute hydrochloric acid
  (iii). Sodium hydroxide solution is added to ethanoic acid
  (iv). Ethanoic acid is added to sodium hydroxide solution
  (v). Dilute hydrochloric acid is added to aqueous ammonia solution
  (vi). Sodium hydroxide solution is added to dilute hydrochloric acid

(d). Explain the shape of each graph above and suggest the suitable indicator to be used in the titration, giving a reason for your answer.

57. (a). Explain the meaning of
  (i). Salt hydrolysis
  (ii). Buffer solution

(b). Give three applications of buffer solutions

(c). Calculate the pH of the solution obtained by adding
  (i). 20 cm^{3} of 0.1M sodium hydroxide to 40cm^{3} of 0,1M hydrochloric acid
  (ii). 55cm^{3} of 0,2M sodium hydroxide to 35cm^{3} of 0.2M hydrochloric acid

58. (a). Sodium hydroxide was added in portions to 25cm^3 of 0.1M ethanoic acid and the pH of the resultant solution was measured at intervals and the results are as shown in the table below

Volume of sodium hydroxide (cm^3)	0.0	8.0	16.0	20.0	22.0	23.0	28
pH of the solution	2.8	4.0	5.1	5.8	7.0	10.5	12.5

Plot a graph for the pH against volume of sodium hydroxide added

(b). Use your graph above to determine the

(i). pH at end point and account for this value

(ii). Molarity of sodium hydroxide solution

(iii). Dissociation constant, K_a, of ethanoic acid.

(c). To 20cm^3 of 0.02M aqueous ammonia was added an equal volume of 0.02M hydrochloric acid. Calculate the pH of the resultant solution and explain your answer. ($K_b = 1.8 \times 10^{-5}\ moldm^3$, $K_w = 1 \times 10^{-14} mol^2 dm^{-6}$)

59. (a). (i). Define the term **buffer solution**

(ii). Describe how an acidic buffer of pH 3.5 can be prepared using methanoic acid of pKa value of 3.75

(iii). Explain how an acidic buffer solution works

(b). State two applications of buffer solutions

(c). Benzoic acid ionises in water according to the following equation

$$C_6H_5CO_2H(aq) \quad + \quad H_2O(l) \quad \leftrightharpoons \quad C_6H_5CO_2^-(aq) \quad + \quad H_3O^+(aq)$$

(i). Write an expression for the ionisation constant, K_a, for benzoic acid

(ii). Using the expression in c(i) above, calculate the ration of the concentration of benzoate ions to the concentration of benzoic acid in a solution of pH 4 and that in a solution of pH 6 (K_a for benzoic acid is $6.3 \times 10^{-5}\ moldm^{-3}$)

(iii). At which of the two pH values would better buffering occur. Give a reason for your answer.

60. (a). Describe how the solubility product of silver chromate(VI) can be determined by titrimetric method.

(b). The solubility of silver chromate at 25°C is $2.0 \times 10^{-5} mol^3 dm^{-9}$. Calculate the

(i). Solubility product for silver chromate

(ii). Solubility of silver chromate(VI) in 0.1M silver nitrate solution

(c). (i). Explain the term buffer solution

(ii). Calculate the pH when 1.0cm^3 of 1M hydrochloric acid is added to a solution on 1.07gl^{-1} ammonium chloride in 0.01M ammonia solution

61. (a). What is meant by the following terms

(i). Solubility product

(ii). Saturated solution

(iii). Solubility of a salt

(b). The solubility product of silver phosphate at 25°C is $1{,}4 \times 10^{-21} mol^4 l^{-4}$. Calculate the

(i). Solubility of silver phosphate in gdm^{-3} at 25°C.

(ii). Molar concentration of silver ions in a saturated solution of silver phosphate at 25°C. ($Ag = 108; P = 31; O = 16$)

(c). Describe how the solubility product of silver phosphate can be determined

(d). Calculate the

(i). The volume of 0.1M sodium phosphate solution required to precipitate half of the silver ions in a saturated solution of silver phosphate at 25°C.

(ii). The concentration of silver nitrate solution in gl^{-1} required to precipitate a fifth of the phosphate ions in a saturated solution of silver phosphate at 25°C.

62. (a). What is meant by the terms

(i). Solubility product

(ii). Common ion effect

(b). Describe an experiment that can be used to determine the solubility product of silver sulphate

(c). The solubility of silver sulphate in 0.1M sodium sulphate at 25°C is $2.034\ gdm^{-3}$. Calculate the solubility product of silver sulphate at this temperature. ($Ag = 108; S = 32; O = 16$)

(d). State and explain the effect on the solubility of silver sulphate when the following were added to its saturated solution

(i). Silver nitrate solution

(ii). Ammonia solution

(e). State two application of solubility product.

63. (a). Define the tem **buffer solution**

(b). Explain the action of an acid buffer

(c). $50cm^3$ of a 0.05M ethanoic acid was added to $50cm^3$ of 0.02M sodium hydroxide solution

(i). Write an equation for the reaction that took place

(ii). Calculate the pH of the resultant solution at 25°C (K_a for ethanoic acid is $1.8 \times 10^{-5}\ moldm^{-3}$

(d). To $50cm^3$ of a 0.02M ethanoic acid was added an equal volume of 0.02M potassium hydroxide solution

(i). Calculate the pH of the resultant solution

(ii). Explain your answer in d (i)($K_w = 1 \times 10^{-14} mol^2 dm^{-6}$)

64. (a). What do you understand by the term **weak base?**

(b). Write the

(i). Equation for the ionisation of methylamine in water

(ii). An expression for the base dissociation constant, K_b, for methylamine

(c). The pK_b of 0.02M methylamine is 3.45 at 25°C

(i). Calculate the pH of the solution ($K_w of\ water = 1.0 \times 10^{-14} mol^2 dm^{-6}$)

(ii). $650cm^3$ of 0.02M methylamine was mixed with $350cm^3$ of 0.02M hydrochloric acid at 25°C. Calculate the pH of the resultant solution.

(d). State and explain how the pH of the resultant solution in c(ii) above would be affected if portions of sodium hydroxide and hydrochloric acid were added.

(e). Explain the following observations

(i). Ethanoic acid is a weaker acid than benzoic acid

(ii). An aqueous solution of methylammonium chloride has a pH less than 7.

65. Lead(II) chloride is a sparingly soluble salt

(a). Write an

(i). Equation for the solubility of lead(II) chloride in water

(ii). Expression for the solubility product of lead(II) chloride

(b). Describe an experiment that can be carried out to determine the solubility product of lead(II) chloride at 25°C

(c). The solubility of lead(II) chloride in water at 25°C is 0.623g per 100g of water. Calculate the

(i). The solubility product of lead(II) chloride at 25°C

(ii). The solubility of lead(II) chloride in a 0.5M potassium chloride solution

(d). State and explain the effect of adding the following solutions to the above solution in (c)

(i). Dilute hydrochloric acid

(ii). Concentrated hydrochloric acid

(e). Calculate the mass of lead(II) chloride that would precipitate when $1dm^3$ of 0.1M sodium chloride at 25°C.

(f). Calculate the mass of lead(II) nitrate that should be added to the saturated solution in (c) in order to reduce the concentration of chloride ions by a quarter of its original value

(g). Calculate the volume of 0.5M hydrochloric acid that should be added to $1dm^3$ of 0.02M lead(II) nitrate to cause precipitation

(h). Calculate the volume of 0.03M sodium chloride that should be added to $30cm^3$ of 0.05M lead(II) nitrate solution to precipitate lead(II) chloride at 25°C.
($Pb = 207; Cl = 35.5; N = 14; O = 16$)

END