CHEMISTRY 3.7 Paper 1

Describe aqueous systems using equilibrium principles

Credits: Five

INSTRUCTIONS

Answer **ALL** questions

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You are advised to spend about 50 minutes answering these questions.

Question One: (Bursary 2003 Question 6: modified)

Hydrogen cyanide is a weak acid.

a Write an equation for the reaction of HCN with water. A

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b The p*K*a of HCN is 9.21 and the p*K*a of CH_3COOH (ethanoic acid) is 4.76.

Circle the acid that is the stronger of the two. A

CH_3COOH HCN

c Calculate the pH of a 0.0100 mol L^{-1} solution of HCN (Ka = 6.17×10^{-10}). A M

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Question Two (Bursary 2003 Question 8: modified)

The following table shows the pH of some 0.1 mol L^{-1} aqueous solutions.

Compound	pH
HCl	1
CH_3COOH	3
$AlCl_3$	3
NH_4Cl	5
NH_3	11

a **i** Estimate the pH of an aqueous solution of CH_3CH_2OH. pH = _____ A

ii Explain why the pH of HCl is lower than the pH of CH_3COOH. A M

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iii Write an equation to account for the pH of the $AlCl_3$ solution. A M

iv Show the relative concentrations of the species (other than water) in a 0.1 mol L^{-1} solution of NH_4Cl by completing the sequence below. A M

v Compare the conductivity of the NH_4Cl solution with that of the NH_3 solution. Discuss the reasoning for your answer. A M E

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The concentration of an ethanoic acid solution ($CH_3COOH(aq)$) can be determined by titration with sodium hydroxide solution of known concentration. 20.0 mL of an aqueous solution of ethanoic acid is pipetted into a conical flask and 0.100 mol L^{-1} sodium hydroxide solution is run in from the burette.

The equation for the reaction is:

$$NaOH(aq) + CH_3COOH(aq) \rightleftharpoons CH_3COONa(aq) + H_2O(l)$$

b **i** Give ONE further instruction that would be necessary to experimentally determine the volume of sodium hydroxide needed to reach equivalence point. A

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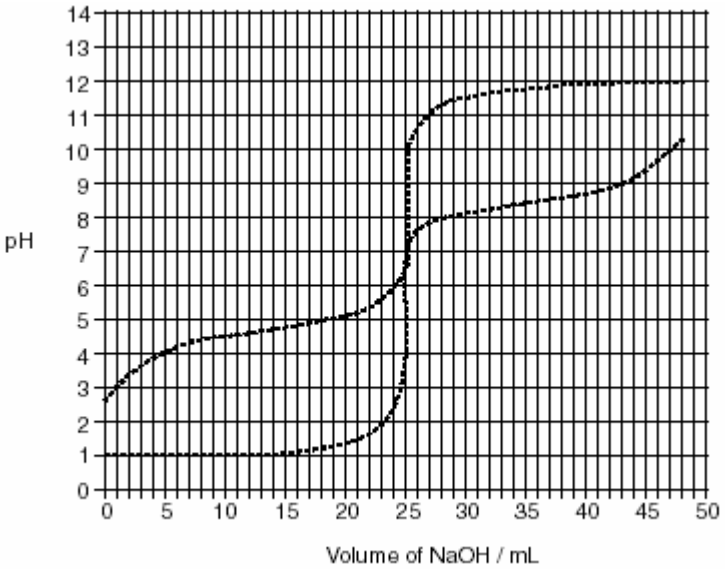
ii Draw a line through the dots on the graph below to show the curve that best represents the titration of ethanoic acid solution with sodium hydroxide. A



iii Explain why the line you have drawn represents the titration between ethanoic acid and sodium hydroxide. A M

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iv Calculate the concentration of the ethanoic acid solution used in the titration. A

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v Mark and label a buffer region on the graph. A

vi Explain why the solution represented by this region of the graph has buffering properties. A M

vii At the equivalence point, the sodium ethanoate (CH_3COONa) concentration is 0.0556 mol L^{-1}.
Calculate the pH at the equivalence point. A M E
$K_a(CH_3COOH) = 1.74 \times 10^{-5}$ $K_w = 1.00 \times 10^{-14}$

viii Explain how the titration curve could be used to select a suitable indicator to determine the equivalence point of this titration. A M

Question Three

Silver salts are used extensively in the photographic industry. Silver bromide has a solubility of 1.33×10^{-4} g L^{-1}.

a What is the solubility of silver bromide in mol L^{-1}? A

b Write the equilibrium equation for the formation of saturated silver bromide solution. A

c Write the expression for K_s for silver bromide. A

d Calculate the value of K_s. A M

Question Four (Bursary 2003 Question 11: modified)

Barium salts are poisonous. A solution of 1.0×10^{-3} mol L^{-1} Ba^{2+} ions will cause stomach upsets. Yet a 'barium meal', which contains a saturated solution of barium sulfate, can safely be given to patients before a stomach X-ray is taken.

a **i** Calculate the concentration of barium ions in a saturated solution of barium sulfate. A M
K_s ($BaSO_4$) = 1.1×10^{-10}

Magnesium sulfate is also present in a barium meal.

ii Explain how this helps reduce the concentration of aqueous barium ions. A M

iii 200 mL of 0.001 mol L^{-1} sodium sulfate is mixed with 200 mL of 0.001 mol L^{-1} barium chloride solution. Determine whether a precipitate will form. A M E

Benzoic acid, C_6H_5COOH, is a white solid that is used as a preservative in fruit juices. It inhibits growth of micro-organisms, and is found to work best at pH values below 5. The reaction of benzoic acid with water can be represented by the following equation:

$$C_6H_5COOH + H_2O \rightleftharpoons C_6H_5COO^- + H_3O^+ \qquad K_a = 6.3 \times 10^{-5}$$

b i Write the K_a expression for benzoic acid. A

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ii Deduce whether the benzoic acid molecule or the benzoate ion will be present in the higher concentration in a fruit juice that has a pH of 4. A M E

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