HL Paper 2

Chloroethene, C_2H_3Cl, is an important organic compound used to manufacture the polymer poly(chloroethene).

d.i. State an equation for the reaction of ethanoic acid with water. [1]

d.ii. Calculate the pH of $0.200\ \text{mol dm}^{-3}$ ethanoic acid $(\text{p}K_\text{a} = 4.76)$. [3]

e. Determine the pH of a solution formed from adding $50.0\ \text{cm}^3$ of $1.00\ \text{mol dm}^{-3}$ ethanoic acid, $CH_3COOH(aq)$, to $50.0\ \text{cm}^3$ of $0.600\ \text{mol dm}^{-3}$ sodium hydroxide, NaOH(aq). [4]

f. (if acid added) $CH_3COO^- + H^+ \rightarrow CH_3COOH$; [2]

(if alkali added) $CH_3COOH + OH^- \rightarrow CH_3COO^- + H_2O$;

Explanation marks cannot be awarded without equations.

An equilibrium exists between nitrosyl chloride, NOCl, nitrogen oxide, NO, and chlorine, Cl_2.

$$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$$

$20.0\ \text{cm}^3$ of hexane, C_6H_{14}, and $20.0\ \text{cm}^3$ of pentan-1-ol, $C_5H_{11}OH$, were placed separately into two closed containers at 298 K and allowed to reach equilibrium.

Ammonia is a weak base.

a. (i) Deduce the equilibrium constant expression for this reaction. [7]

(ii) Explain the effect on the position of equilibrium and the value of K_c when pressure is decreased and temperature is kept constant.

(iii) 2.00 mol of NOCl was placed in a $1.00\ \text{dm}^3$ container and allowed to reach equilibrium at 298 K. At equilibrium, 0.200 mol of NO was present. Determine the equilibrium concentrations of NOCl and Cl_2, and hence calculate the value of K_c at this temperature.

(iv) The value of K_c is 1.60×10^{-5} at 318 K. State and explain whether the forward reaction is exothermic or endothermic.

b. (i) Compare the two liquids in terms of their boiling points, enthalpies of vaporization and vapour pressures. [4]

(ii) Explain your answer given for part (b)(i).

c.i. Calculate the pH of a $1.50\ \mathrm{mol\,dm^{-3}}$ solution of ammonia at 298 K to two decimal places, using Table 15 of the Data Booklet. [2]

c.ii. A buffer solution is made using $25.0\ \mathrm{cm^3}$ of $0.500\ \mathrm{mol\,dm^{-3}}$ hydrochloric acid, HCl (aq), and $20.0\ \mathrm{cm^3}$ of $1.50\ \mathrm{mol\,dm^{-3}}$ ammonia solution, $NH_3(aq)$. [2]

Describe the meaning of the term *buffer solution*.

c.iii. Determine the pH of the buffer solution at 298 K. [4]

c.iv. A $1.50\ \mathrm{mol\,dm^{-3}}$ solution of ammonia is added to $25.0\ \mathrm{cm^3}$ of a $0.500\ \mathrm{mol\,dm^{-3}}$ hydrochloric acid solution in a titration experiment. [1]

Calculate the total volume of the solution at the equivalence point.

c.v. Calculate the pH of the solution at the equivalence point, using Table 15 of the Data Booklet. [4]

c.vi. Identify a suitable indicator for this titration, using Table 16 of the Data Booklet. [1]

A buffer solution with a pH of 3.87 contains $7.41\ \mathrm{g\,dm^{-3}}$ of propanoic acid, CH_3CH_2COOH, together with an unknown quantity of sodium propanoate, CH_3CH_2COONa.

a. Define the term *buffer solution*. [2]

b. Explain, using appropriate equations, how this solution acts as a buffer solution. [2]

c. Calculate the concentration, in $\mathrm{mol\,dm^{-3}}$, of sodium propanoate in this buffer solution. [4]

The pK_a of propanoic acid is 4.87 at 298 K.

Buffer solutions are widely used in both chemical and biochemical systems.

a. Describe the composition of an acidic buffer solution. [1]

b. Determine the pH of a buffer solution, correct to **two** decimal places, showing your working, consisting of 10.0 g of CH_3COOH and 10.0 g of CH_3COONa in $0.250\ dm^3$ of solution. K_a for $CH_3COOH = 1.8 \times 10^{-5}$ at 298 K. [5]

Water is an important substance that is abundant on the Earth's surface.

Buffer solutions resist small changes in pH. A phosphate buffer can be made by dissolving NaH_2PO_4 and Na_2HPO_4 in water, in which NaH_2PO_4 produces the acidic ion and Na_2HPO_4 produces the conjugate base ion.

A $0.10\ mol\,dm^{-3}$ ammonia solution is placed in a flask and titrated with a $0.10\ mol\,dm^{-3}$ hydrochloric acid solution.

a. (i) State the expression for the ionic product constant of water, K_w. [7]

(ii) Explain why even a very acidic aqueous solution still has some OH^- ions present in it.

(iii) State and explain the effect of increasing temperature on the value of K_w given that the ionization of water is an endothermic process.

(iv) State and explain the effect of increasing temperature on the pH of water.

b. (i) Deduce the acid and conjugate base ions that make up the phosphate buffer and state the ionic equation that represents the phosphate buffer. [7]

(ii) Describe how the phosphate buffer minimizes the effect of the addition of a strong base, $OH^-(aq)$, to the buffer. Illustrate your answer with an ionic equation.

(iii) Describe how the phosphate buffer minimizes the effect of the addition of a strong acid, $H^+(aq)$, to the buffer. Illustrate your answer with an ionic equation.

c. (i) Explain why the pH of the ammonia solution is less than 13. [11]

(ii) Estimate the pH at the equivalence point for the titration of hydrochloric acid with ammonia and explain your reasoning.

(iii) State the equation for the reaction of ammonia with water and write the K_b expression for $NH_3(aq)$.

(iv) When half the ammonia has been neutralized (the half-equivalence point), the pH of the solution is 9.25. Deduce the relationship between $[NH_3]$ and $[NH_4^+]$ at the half-equivalence point.

(v) Determine pK_b and K_b for ammonia based on the pH at the half-equivalence point.

(vi) Describe the significance of the half-equivalence point in terms of its effectiveness as a buffer.

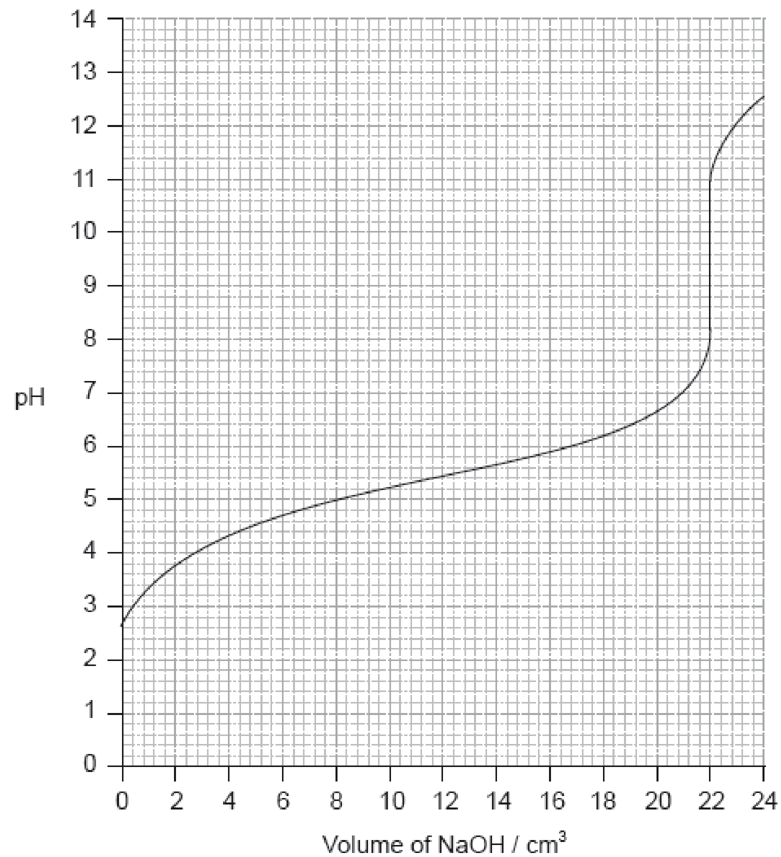
Acids can be described as strong or weak.

a. (i) Outline the difference in dissociation between strong and weak acids of the same concentration. [4]

(ii) Describe **three** tests that can be carried out in the laboratory, and the expected results, to distinguish between $0.10\ \text{mol dm}^{-3}$ $HCl(aq)$ and $0.10\ \text{mol dm}^{-3}$ $CH_3COOH(aq)$.

b. Calculate the pH, using table 15 of the data booklet, of a solution of ethanoic acid made by dissolving 1.40 g of the acid in distilled water to make a $500\ \text{cm}^3$ solution. [4]

c.i. Determine the pH at the equivalence point of the titration and the pK_a of an unknown acid using the acid-base titration curve below. [3]



c.ii. Identify, using table 16 of the data booklet, a suitable indicator to show the end-point of this titration. [1]

c.iii. Describe how an indicator, that is a weak acid, works. Use Le Chatelier's principle in your answer. [2]

d.i. State the formula of the conjugate base of chloroethanoic acid, $CH_2ClCOOH$. [1]

d.ii. Identify, with a reason, whether chloroethanoic acid is weaker or stronger than ethanoic acid using table 15 of the data booklet. [1]

d.iii. Determine the pH of the solution resulting when $100\ \text{cm}^3$ of $0.50\ \text{mol dm}^{-3}$ $CH_2ClCOOH$ is mixed with $200\ \text{cm}^3$ of $0.10\ \text{mol dm}^{-3}$ NaOH. [4]

e. Describe how chlorine's position in the periodic table is related to its electron arrangement. [2]

f. SCl_2 and $SClF_5$ are two sulfur chloride type compounds with sulfur having different oxidation states. Predict the name of the shape, the bond angle and polarity of these molecules. [[N/A