Candidate Name	Centre Number	Candidate Number

WELSH JOINT EDUCATION COMMITTEE
General Certificate of Education
Advanced

WJEC CBAC

CYD-BWYLLGOR ADDYSG CYMRU
Tystysgrif Addysg Gyffredinol
Uwch

335/01

CHEMISTRY CH5

A.M. MONDAY, 26 June 2006

(1 hour 40 minutes)

ADDITIONAL MATERIALS

In addition to this examination paper, you will need:
• a calculator;
• an 8 page answer book;
• a copy of the **Periodic Table** supplied by WJEC. Refer to it for any **relative atomic masses** you require.

INSTRUCTIONS TO CANDIDATES

Write your name, centre number and candidate number in the spaces at the top of this page.

Section A   Answer **all** the questions in the spaces provided.
Section B   Answer **both** questions in **Section B** in a separate answer book which should then be placed inside this question-and-answer book.

Candidates are advised to allocate their time appropriately between **Section A (35 marks)** and **Section B (40 marks)**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 75.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

You are reminded that marking will take into account the Quality of Written Communication used in all your written answers

No certificate will be awarded to a candidate detected in any unfair practice during the examination.

SECTION A

*Answer **all** the questions in the spaces provided.*

1. *(a)* Each of the following sets of compounds, (i) and (ii), contains **three** salts, which are to be distinguished by means of chemical tests.
Two tests are given for **each set** of three compounds. Complete both tables to show the expected observation(s) for the first two compounds and the identity of the third compound.

(i) Test 1 Flame test

Test 2 Warm each solid with a few drops of concentrated sulphuric acid

Compound	Observation(s) for Test 1. Flame test.	Observation(s) for Test 2. Warm with concentrated sulphuric acid.
Sodium bromide		
Potassium iodide		
	Orange-red colour in flame	Misty fumes, but no colour change

[4]

(ii) Test 1 Addition of **excess** aqueous sodium hydroxide solution to a solution of the compound.

Test 2 Addition of dilute nitric acid followed by aqueous barium nitrate solution to an aqueous solution of the compound.

Compound	Observation(s) for Test 1. Excess aqueous sodium hydroxide.	Observation(s) for Test 2. Aqueous barium nitrate.
Magnesium nitrate		
Zinc sulphate		
	Grey-green precipitate which redissolves to give a dark green solution	White precipitate

[4]

(b) Write balanced equations for the following:

(i) **one** reaction in which lead(IV) oxide is an oxidising agent; [1]

....

(ii) **two** reactions which show the amphoteric behaviour of lead or one of its compounds; [2]

....

....

(iii) **one** reaction in which carbon monoxide is a reducing agent. [1]

....

Total [12]

Turn over.

2. The ester methyl ethanoate, CH_3COOCH_3, hydrolyses slowly when dissolved in dilute hydrochloric acid.

$$CH_3COOCH_3 \ + \ H_2O \ \longrightarrow \ CH_3COOH \ + \ CH_3OH$$

It has been shown by experiments that, at constant room temperature, the rate of the reaction is given by the rate equation

$$Rate \ = \ k \ [CH_3COOCH_3]^x[HCl]^y$$

(a) The rate of reaction at constant temperature was measured for different concentrations of methyl ethanoate in hydrochloric acid. The results are shown in the following table.

Methyl Ethanoate concentration / mol dm^{-3}	*Hydrochloric Acid concentration* / mol dm^{-3}	*Rate of Reaction* / mol dm^{-3} s^{-1}
0·0100	0·0500	$0·560 \times 10^{-6}$
0·0200	0·0500	$1·12 \times 10^{-6}$
0·0300	0·0500	$1·68 \times 10^{-6}$
0·0100	0·100	$1·12 \times 10^{-6}$
0·0200	0·100	$2·24 \times 10^{-6}$
0·0300	0·100	$3·36 \times 10^{-6}$

(i) Explain the term ***rate of reaction*** for a chemical reaction. [1]

....

....

(ii) From the results in the table, determine x, the order of reaction with respect to methyl ethanoate, and y, the order of reaction with respect to hydrochloric acid. [2]

Determination of x ....

....

Determination of y ....

....

(iii) Giving your reasons, explain the role of hydrochloric acid in the hydrolysis of methyl ethanoate. [2]

....

....

....

(b) (i) Write out the rate equation for the reaction, calculate the value of the rate constant, k, to **three** significant figures and give its units. [3]

Rate equation ....

Rate constant k ....

....

Units of k ....
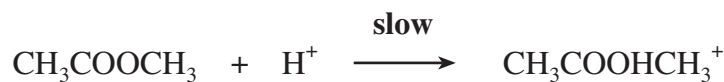
(ii) Giving your reasons, state which **one** of the following three mechanisms is compatible with the rate equation. [2]
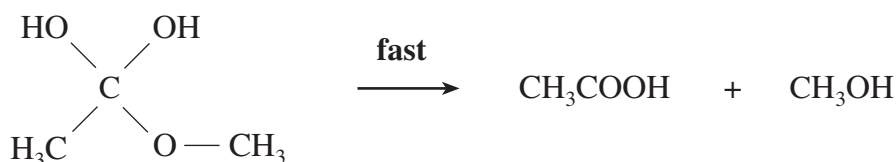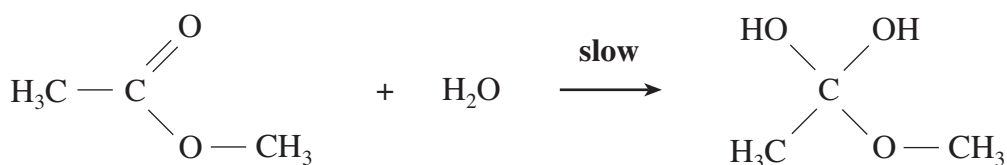
Mechanism 1

$$CH_3COOCH_3 \xrightarrow{\text{slow}} CH_3COO^- + CH_3^+$$

$$CH_3COO^- + CH_3^+ + H^+ + OH^- \xrightarrow{\text{fast}} CH_3COOH + CH_3OH$$

Mechanism 2

$$CH_3COOCH_3 + H^+ \xrightarrow{\text{slow}} CH_3COOHCH_3^+$$

$$CH_3COOHCH_3^+ + H_2O \xrightarrow{\text{fast}} CH_3COOH + CH_3OH + H^+$$

Mechanism 3

....

....

....

....

Turn over.

(c) (i) Although the reaction produces ethanoic acid, explain why the measurement of pH would not be a suitable technique for studying the progress of this reaction.   [1]

....

....

(ii) State **one** technique, other than pH measurement, which could be used to study the progress of a chemical reaction.   [1]

....

Total [12]

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Turn over.

3. A 25·0 cm^3 sample of aqueous chloroethanoic acid, $CH_2ClCOOH$, of concentration 0·100 mol dm^{-3}, was titrated against aqueous sodium hydroxide solution from a burette.

$$CH_2ClCOOH \quad + \quad NaOH \quad \longrightarrow \quad CH_2ClCOONa \quad + \quad H_2O$$

(a) Chloroethanoic acid is a weak acid with acid dissociation constant, K_a, having a value $1·30 \times 10^{-3}$ mol dm^{-3}.

   (i) Write an expression for K_a for chloroethanoic acid, $CH_2ClCOOH$. [1]

$$K_a \;=$$

   (ii) Define the term pH. [1]

....

....

   (iii) Calculate the pH of aqueous chloroethanoic acid solution of concentration 0·100 mol dm^{-3}. [2]

....

....

....

(b) The diagram on page 9 shows the change in pH for part of the titration.

   (i) Enter a cross on the diagram to show the pH at the start of the titration. [1]

   (ii) From the graph, determine the pH at the end-point of the titration. [1]

....

   (iii) From the graph, determine, to **three** significant figures, the volume of sodium hydroxide solution added at the end-point. [1]

....

   (iv) Using the concentration of the aqueous chloroethanoic acid given, calculate, to **three** significant figures, the concentration of the sodium hydroxide solution in mol dm^{-3}. [2]

....

....

Titration of Chloroethanoic acid v Sodium hydroxide

pH
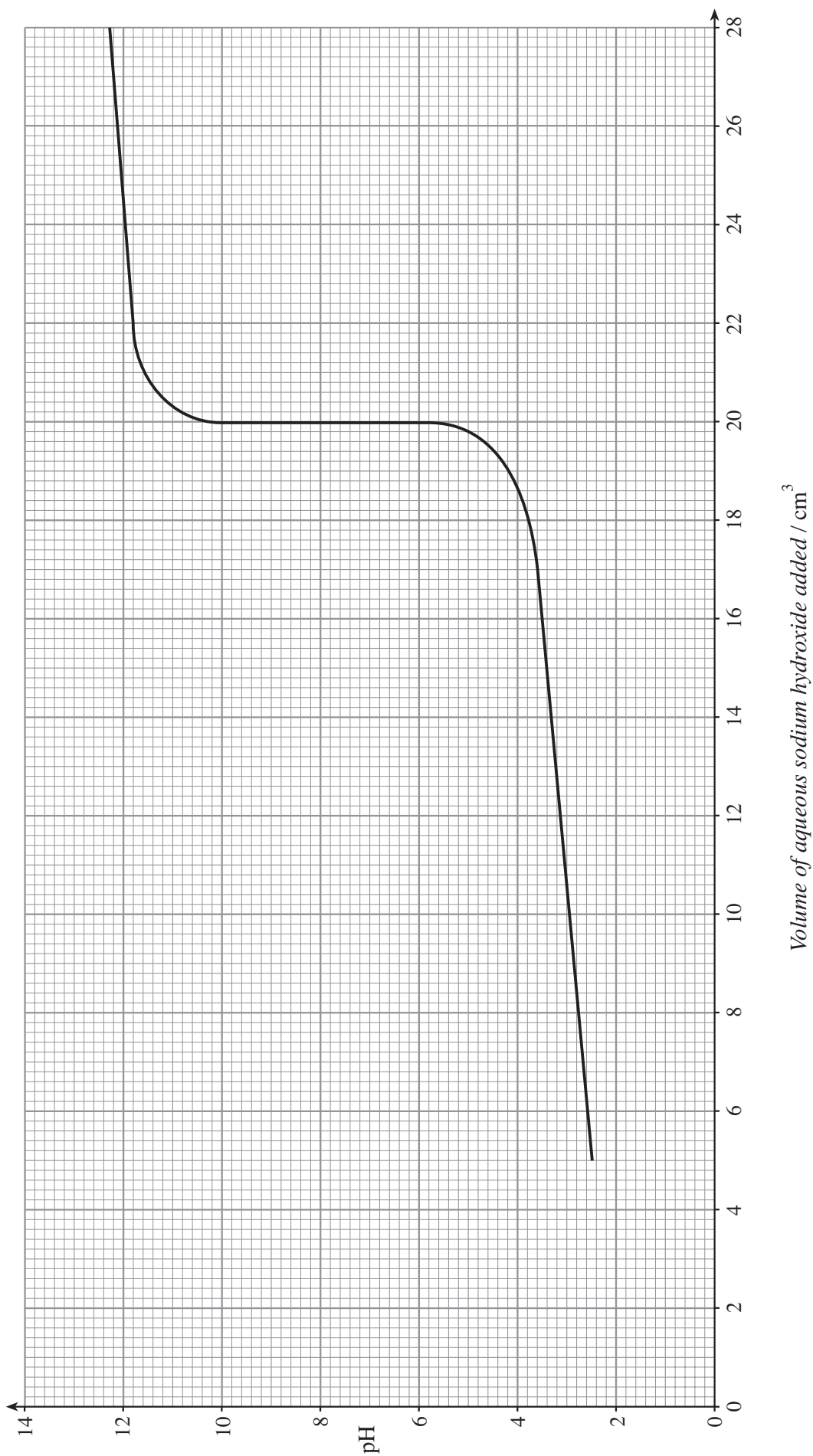
Volume of aqueous sodium hydroxide added / cm^3

Turn over.

(v)   Giving a reason, state which of the following indicators would be suitable for this titration.   [2]

| Indicator	pH range
Methyl orange	3·2 to 4·4
Bromothymol blue	6·0 to 7·6
Phenolphthalein	8·2 to 10·0

....

....

....

Total [11]

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Turn over.

SECTION B

*Answer **both** questions in the separate answer book provided.*

4. *(a)* Give the **full** electron configuration of

    (i)   an iron atom, Fe,

    (ii) an iron(II) cation, Fe^{2+}.   [2]

(b) Iron forms Fe^{3+} as well as Fe^{2+} ions. Explain why transition metals such as iron form compounds with more than one oxidation state.   [2]

(c) Iron forms a green octahedral complex ion $[Fe(H_2O)_6]^{2+}$.

    (i)   Describe the bonding between a water molecule, H_2O, and the Fe^{2+} cation in the complex ion.   [2]

    (ii) Explain the origin of colour in octahedral transition metal complexes, such as $[Fe(H_2O)_6]^{2+}$.   [4]

(d) Iron metal can corrode in aerated water by a redox reaction.

$$2Fe(s) + O_2(g) + 2H_2O(l) \longrightarrow 2Fe^{2+}(aq) + 4OH^-(aq)$$

    (i)   Use the changes in oxidation numbers (states) to determine which reactant is being oxidised and which reduced in the above equation.   [2]

    (ii) An equivalent corrosion reaction could be written for silver, Ag:

$$4Ag(s) + O_2(g) + 2H_2O(l) \longrightarrow 4Ag^+(aq) + 4OH^-(aq)$$
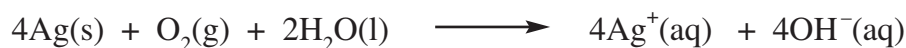
        Given the standard electrode potentials below, explain why the corrosion reaction for iron occurs but silver does not corrode.

$$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s) \qquad E^{\ominus}\ -0{\cdot}44\ V$$

$$O_2(g) + 2H_2O(l) + 4e^- \rightleftharpoons 4OH^-(aq) \qquad E^{\ominus}\ +0{\cdot}40\ V$$

$$Ag^+(aq) + e^- \rightleftharpoons Ag(s) \qquad E^{\ominus}\ +0{\cdot}80\ V$$
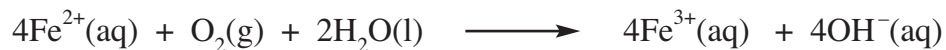
        [2]

    (iii) Explain the term ***standard electrode potential***.   [2]

(e) (i) Given the standard enthalpy changes of formation, $\Delta H_f^{\ominus}$, shown in the table below, calculate the standard enthalpy change, $\Delta H^{\ominus}$, for the following reaction.

[2]

$$4Fe^{2+}(aq) + O_2(g) + 2H_2O(l) \longrightarrow 4Fe^{3+}(aq) + 4OH^-(aq)$$

Species	Standard Enthalpy Change of Formation $\Delta H_f^{\ominus}$, / $kJ\,mol^{-1}$
$Fe^{2+}(aq)$	$- 89 \cdot 1$
$Fe^{3+}(aq)$	$- 48 \cdot 5$
$2H_2O(l)$	$- 285 \cdot 8$
$OH^-(aq)$	$- 230 \cdot 0$

(ii) Using the calculated enthalpy change and the information in *(d)*(ii), state the final oxidation state of Fe when iron metal corrodes in aerated water. Give a reason for your answer. [2]

Total [20]

Turn over.

5. *(a)* The name "aluminium chloride" is applied to a number of species which differ in their bonding.

   (i) Monomeric aluminium chloride is an example of an electron-deficient molecule. Give the formula of a monomeric aluminium chloride molecule and explain why it is electron-deficient. [2]

   (ii) Aluminium chloride readily forms a dimer. Draw the structure of a dimeric aluminium chloride molecule, clearly showing the bonding present. [2]

   (iii) In aqueous solution, aluminium chloride is ionic. State the formulae of the ions present in aqueous aluminium chloride. [1]

(b) State what is observed in **each** of the following:

   (i) tetrachloromethane, CCl_4, is added to water;

   (ii) silicon(IV) chloride, $SiCl_4$, is added to water.

   Explain the difference in behaviour. [3]

(c) Phosphorus(V) chloride vapour dissociates according to the equation

$$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

   (i) Use the Valence Shell Electron Pair Repulsion Theory to determine the shapes of PCl_5 and PCl_3 molecules. [2]

   (ii) Giving your reasons, state whether the dissociation of $PCl_5(g)$ will be greater at high pressure or at low pressure. [2]

   (iii) Write the expression for the equilibrium constant, K_p, for the reaction. [1]

   (iv) At 150 °C, K_p has the value $2 \cdot 88 \times 10^{-2}$ atm. If the equilibrium pressures due to $PCl_3(g)$ and $Cl_2(g)$ are each $5 \cdot 00 \times 10^{-2}$ atm, calculate the equilibrium pressure due to $PCl_5(g)$. [2]

(d) There are some important differences in behaviour between Group I (Alkali metal) elements and Group II (Alkaline Earth metal) elements.
Using sodium and magnesium as examples, discuss the differences between Group I and Group II in the following cases:

(equations are not required)

   • the products on heating solid nitrate(V) salts
   • the reaction of the elements with cold water
   • the solubility of the carbonates in water
   • the stability of the hydrogencarbonates. [5]

Total [20]

Total Section B [40]