Candidate Name	Centre Number	Candidate Number

WELSH JOINT EDUCATION COMMITTEE
General Certificate of Education
Advanced

CYD-BWYLLGOR ADDYSG CYMRU
Tystysgrif Addysg Gyffredinol
Uwch

335/01

CHEMISTRY CH5

A.M. MONDAY, 25 June 2007

(1 hour 40 minutes)

FOR EXAMINER'S USE ONLY		
Section	Question	Mark
A	1	
	2	
	3	
B	4	
	5	
TOTAL MARK		

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

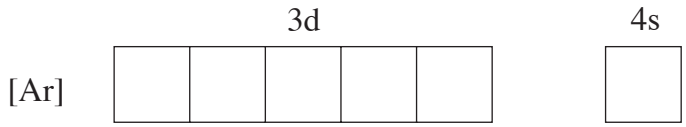
No certificate will be awarded to a candidate detected in any unfair practice during the examination.

SECTION A

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

1. Many hazardous materials are carried by road, usually without incident. However, police recently closed a road in Derbyshire, owing to a spillage of concentrated aqueous iron(III) chloride.

(i) Using the convention of representing electrons by arrows in boxes, give the electronic configuration of an iron(III) ion, Fe^{3+}. [1]



(ii) Hydrated crystals of iron(III) chloride contain the purple $[Fe(H_2O)_6]^{3+}$ ion, which has the same shape as the $[Cu(H_2O)_6]^{2+}$ ion.
Sketch the shape of the $[Fe(H_2O)_6]^{3+}$ ion. [1]

(iii) Explain why aqueous ions such as $[Fe(H_2O)_6]^{3+}$ and $[Cu(H_2O)_6]^{2+}$ are coloured. [3]

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(iv) Describe what is **seen** when an aqueous solution of sodium hydroxide is added, dropwise, to a solution containing $Fe^{3+}(aq)$ ions until an **excess** of sodium hydroxide is present.
You should give an equation for any reaction that occurs. [3]

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(v) Describe a test, giving reagent(s) and observations(s), for the presence of chloride ions in aqueous iron(III) chloride. [2]

Reagent(s) .....

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Observation(s) .....

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Total [10]

2. At present, there is much debate about the excessive use of carbon-based energy sources. This has increased interest in the chemistry of hydrogen and its possible use as a fuel.

(a) (i) Hydrogen and an aqueous solution of lithium hydroxide are produced when lithium metal is added to water. Give the equation for this reaction. [1]

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(ii) The pH of an aqueous lithium hydroxide solution at 298 K is 11·5. Calculate the concentration, in mol dm^{-3}, of hydroxide ions in this solution. [3]

[The ionic product of water, K_w, is $1{\cdot}00 \times 10^{-14}$ mol^2 dm^{-6} at 298 K]

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(b) One stage in the production of hydrogen for use in the Haber process is the reaction of carbon monoxide with steam.

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

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

(ii) Equal numbers of moles of carbon monoxide and steam were allowed to reach equilibrium at a total pressure of 2500 kPa.
At equilibrium, the partial pressure of hydrogen was 1150 kPa.

Calculate the value of the equilibrium constant, K_p, for this reaction, **stating its units**, if any. [4]

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(iii) Any increase or decrease in pressure in this reaction does not affect the equilibrium yield of products.
Explain why a pressure of 2500 kPa is used rather than atmospheric pressure, which is 101 kPa. [1]

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(c) Hydrogen reacts with iodine monochloride, ICl, to produce iodine and hydrogen chloride.

$$H_2(g) + 2ICl(g) \longrightarrow I_2(g) + 2HCl(g)$$

In an experiment, the following value for the initial rate was obtained.

Iodine monochloride concentration / mol dm^{-3}	*Hydrogen concentration* / mol dm^{-3}	*Initial rate of reaction* / mol dm^{-3} s^{-1}
$1{\cdot}60 \times 10^{-3}$	$1{\cdot}60 \times 10^{-3}$	$6{\cdot}40 \times 10^{-7}$

(i) The reaction is first order for both hydrogen and iodine monochloride.
Calculate the value of the rate constant, k, and state its units. [3]

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(ii) Write a chemical equation showing a possible rate-determining step for this reaction. [1]

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(iii) Write a further equation to show how the products shown in the overall equation are obtained from (ii). [1]

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Total [15]

3. *(a)* Hydrogen iodide is one of the products obtained when potassium iodide is warmed with concentrated sulphuric acid.
However, some of the hydrogen iodide then reacts further, giving rise to additional products.

Using the information above, describe and explain what is seen during this reaction. [4]

Observations .....

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Explanation .....

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(b) In 1900, around 6000 people died from consuming sugar contaminated by arsenic(III) oxide, As_4O_6. The impure sugar was analysed for arsenic in the following way.
A sample of contaminated sugar of mass 40·0 g was dissolved in water. After removal of the sugar, the solution containing the impurities was made up to 250 cm^3 and portions titrated against a standard iodine solution.
Arsenic(III) oxide reacts with iodine according to the following equation, giving an acidic solution.

$$As_4O_6(aq) + 4I_2(aq) + 4H_2O(l) \rightleftharpoons 2As_2O_5(aq) + 8HI(aq)$$

(i) 20·0 cm^3 of a standard iodine solution of concentration 0·050 mol dm^{-3} reacted with 25·0 cm^3 of the arsenic containing solution.

Calculate the number of moles of iodine used and hence the number of moles of arsenic(III) oxide, As_4O_6, present in 25·0 cm^3 of the solution. [2]

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(ii) Use the answer to part (i) to calculate the total number of moles of arsenic(III) oxide, As_4O_6 present and hence the percentage, by mass, of arsenic(III) oxide in the sugar sample of mass 40·0 g. Give your answer to **three** significant figures. [2]

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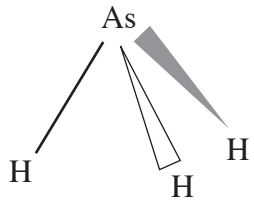
(c) A qualitative test for the Group V element, arsenic, in a compound is to reduce any arsenic present to gaseous arsine, AsH_3. On gentle heating, arsine decomposes giving a shiny black mirror of arsenic.
Gaseous arsine has the shape shown below.



Use the valence shell electron pair repulsion (VSEPR) principle to explain the shape of gaseous arsine. [2]

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Total [10]

SECTION B

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

4. *(a)* Bauxite is a mineral that is largely aluminium oxide contaminated with iron(III) oxide. Aluminium oxide is an amphoteric oxide but iron(III) oxide is a basic oxide.

(i) State what is meant by an ***amphoteric oxide***. [1]

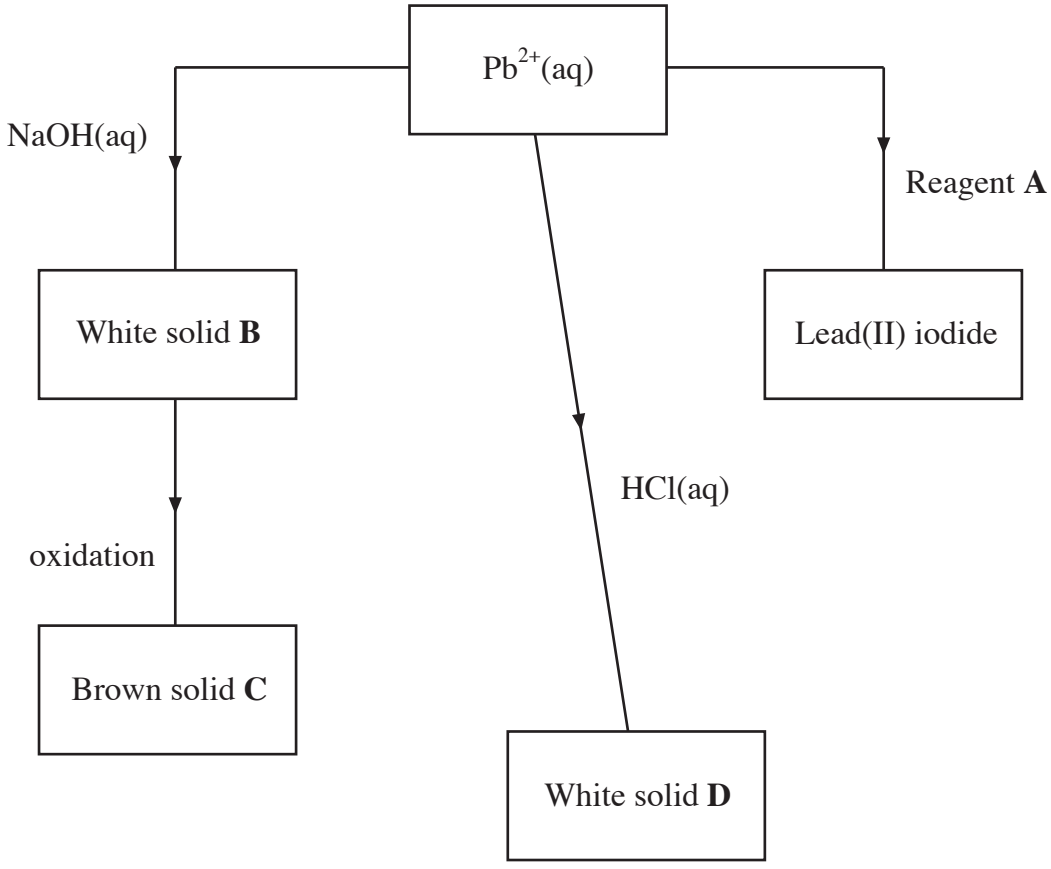
(ii) Suggest how iron(III) oxide can be chemically separated from aluminium oxide. [2]

(b) Aluminium oxide can be made by burning aluminium in oxygen.

(i) Give the equation for this reaction. [1]

(ii) Explain, in terms of electronegativities, why oxygen acts as an oxidising agent in this reaction. [2]

(c) The diagram shows some of the reactions of aqueous lead(II) ions.



(i) State the name of reagent **A**. [1]

(ii) State the name of the white solid **D**. [1]

(iii) Give the ionic equation for the formation of white solid **B** and state what would be seen (if anything) when an excess of aqueous sodium hydroxide was then added. [2]

(iv) Brown solid **C** contains approximately 86·6% of lead by mass and the rest is oxygen. Deduce the molecular formula of solid **C**, which contains one lead atom per molecule. [2]

(v) The brown solid **C** reacts with hot concentrated hydrochloric acid, giving white solid **D** as one of the products. Give the equation for this reaction. [2]

(d) The concentration of carbon monoxide in air can be found by reacting it with iodine oxide and titrating the iodine produced with sodium thiosulphate.

$$5CO + I_2O_5 \longrightarrow 5CO_2 + I_2$$

$$I_2 + 2Na_2S_2O_3 \longrightarrow Na_2S_4O_6 + 2NaI$$

(i) 20 dm^3 of air containing carbon monoxide was reacted with iodine oxide so that all the carbon monoxide present reacted to produce iodine.
$5{\cdot}0 \times 10^{-3}$ moles of sodium thiosulphate were needed to react with all the iodine produced.

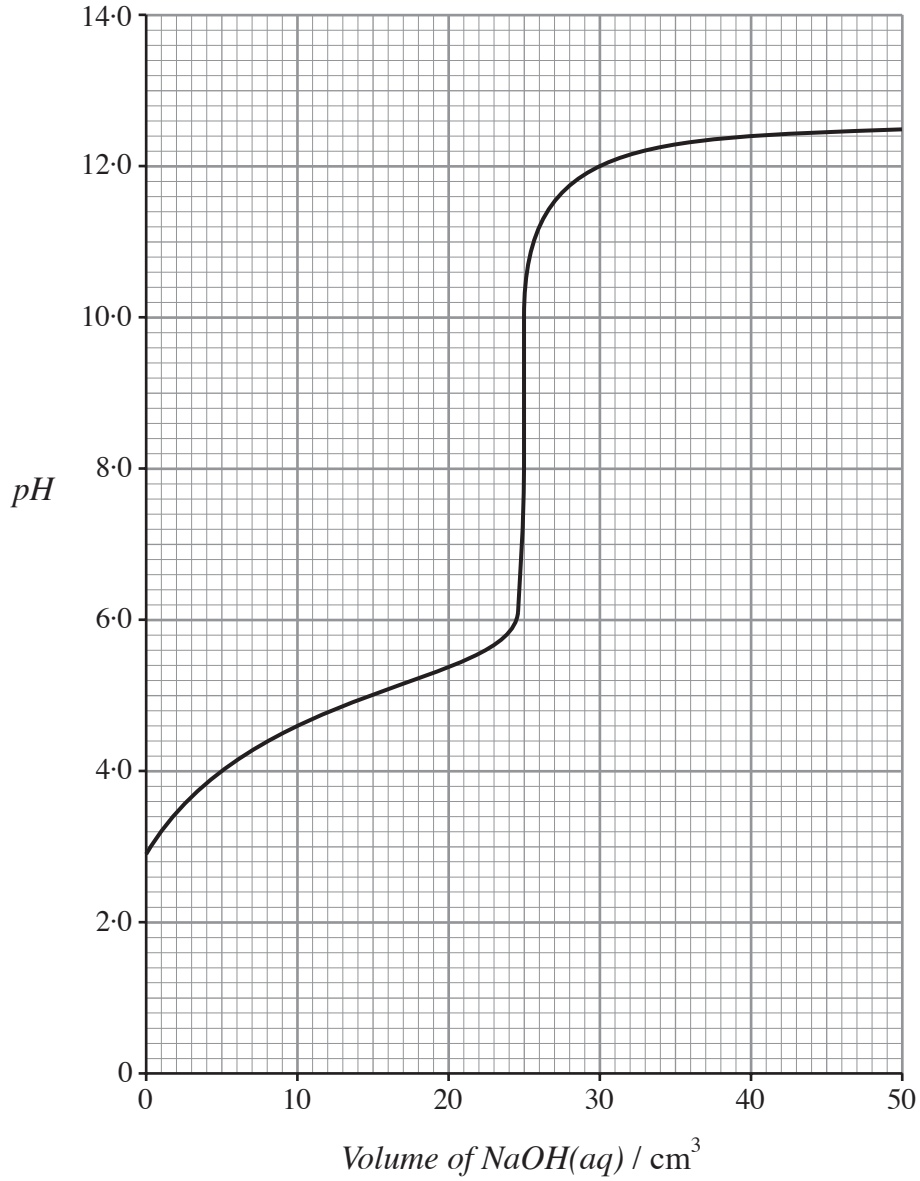
Calculate the number of moles of carbon monoxide present and use your answer to calculate the percentage by volume of carbon monoxide in the air.
[1 mole of a gas has a volume of 24·0 dm^3 at the temperature of the experiment.] [3]

(ii) Assign oxidation states (numbers) to the carbon and iodine species in the first equation and hence deduce the reducing agent in the reaction.
You should assume that the oxidation state of oxygen is unchanged. [2]

(e) Give an equation for a reaction where carbon monoxide is used to produce a metal from its oxide. [1]

Total [20]

5. *(a)* The graph shows the change in pH that occurred when aqueous sodium hydroxide of concentration 0·1 mol dm^{-3} was added to 25 cm^3 of aqueous ethanoic acid of concentration 0·1 mol dm^{-3}.



(i) Select, from the table below, the name of an acid-base indicator which is suitable for this titration, giving a reason for your choice. [2]

Indicator	*pH range*
Tropaeolin OO	1·3 – 3·0
Bromocresol green	3·8 – 5·4
Thymolphthalein	8·3 – 10·5
Tropaeolin O	11·1 – 12·7

(ii) State, giving a reason, the pH of aqueous sodium ethanoate. [2]

(iii) The sodium hydroxide solution used for this experiment was prepared by dissolving solid sodium hydroxide in water, to make 150 cm^3 of solution of concentration 0·1 mol dm^{-3}.

I. Explain how the enthalpy of solution of sodium hydroxide is related to the lattice breaking enthalpy and the hydration enthalpies of the ions. [1]

II. The enthalpy of solution of sodium hydroxide is –45 kJ mol^{-1}.
Calculate the heat produced when this solution is made. [2]

(iv) Explain briefly, why the value of the lattice breaking enthalphy for sodium hydroxide is greater than the corresponding value for sodium ethanoate. [1]

(b) There are differences in the chemistry of the compounds of some Group I and Group II elements.

Compare the thermal decomposition of sodium nitrate with that of calcium nitrate.
In each case, you should describe what is seen and comment on the relative thermal stability of the two nitrates.
You may include relevant chemical equations if you wish. [5]

(c) Some standard electrode potentials, $E^{\ominus}$, are given in the table.

System	$E^{\ominus}$ / volts
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	–0·76
$Cd^{2+}(aq) + 2e^- \rightleftharpoons Cd(s)$	–0·40
$V^{3+}(aq) + e^- \rightleftharpoons V^{2+}(aq)$	–0·26
$2H^{+}(aq) + 2e^- \rightleftharpoons H_2(g)$	
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	+0·34

Answer the following questions by reference to the table or otherwise.

(i) State the standard electrode potential for the $2H^{+}(aq) + 2e^- \rightleftharpoons H_2(g)$ system, and explain why this value is used. [2]

(ii) Give the equation for the reaction between metallic zinc and aqueous cadmium ions, $Cd^{2+}(aq)$. [1]

(iii) Calculate the standard cell potential represented by the equation in (ii) above. [1]

(iv) Predict whether aqueous vanadium(II) ions, $V^{2+}(aq)$, are able to reduce copper(II) ions, $Cu^{2+}(aq)$, to copper, giving a reason for your answer. [2]

(d) Phosphorus(III) chloride, PCl_3, is a covalently bonded chloride which reacts violently with water giving phosphonic acid, H_3PO_3, as one of the products.

Give the equation for this reaction, during which oxidation and reduction do **not** occur. [1]

Total [20]

Total Section B [40]