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**CHEMISTRY**
**STANDARD LEVEL**
**PAPER 2**

Wednesday 12 May 2010 (afternoon)

1 hour 15 minutes

Candidate session number

| 0 | 0 | | | | | | | |
|---|---|---|---|---|---|---|---|---|

INSTRUCTIONS TO CANDIDATES

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all of Section A in the spaces provided.
- Section B: answer one question from Section B. Write your answers on answer sheets. Write your session number on each answer sheet, and attach them to this examination paper and your cover sheet using the tag provided.
- At the end of the examination, indicate the numbers of the questions answered in the candidate box on your cover sheet and indicate the number of sheets used in the appropriate box on your cover sheet.



0111

## SECTION A

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

**1.** Brass is a copper containing alloy with many uses. An analysis is carried out to determine the percentage of copper present in three identical samples of brass. The reactions involved in this analysis are shown below.

Step 1: $Cu(s) + 2HNO_3(aq) + 2H^+(aq) \rightarrow Cu^{2+}(aq) + 2NO_2(g) + 2H_2O(l)$

Step 2: $4I^-(aq) + 2Cu^{2+}(aq) \rightarrow 2CuI(s) + I_2(aq)$

Step 3: $I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$

(a) (i) Deduce the change in the oxidation numbers of copper and nitrogen in step 1. *[2]*

Copper:

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Nitrogen:

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(ii) Identify the oxidizing agent in step 1. *[1]*

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(b) A student carried out this experiment three times, with three identical small brass nails, and obtained the following results.

Mass of brass = 0.456 g ± 0.001 g

| **Titre** | **1** | **2** | **3** |
|---|---|---|---|
| **Initial volume of 0.100 mol dm$^{-3}$ $S_2O_3^{2-}$ (±0.05 cm$^3$)** | 0.00 | 0.00 | 0.00 |
| **Final volume of 0.100 mol dm$^{-3}$ $S_2O_3^{2-}$ (±0.05 cm$^3$)** | 28.50 | 28.60 | 28.40 |
| **Volume added of 0.100 mol dm$^{-3}$ $S_2O_3^{2-}$ (±0.10 cm$^3$)** | 28.50 | 28.60 | 28.40 |
| **Average volume added of 0.100 mol dm$^{-3}$ $S_2O_3^{2-}$ (±0.10 cm$^3$)** | 28.50 | | |

*(This question continues on the following page)*

*(Question 1 continued)*

(i) Calculate the average amount, in mol, of $S_2O_3^{2-}$ added in step 3. *[2]*

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(ii) Calculate the amount, in mol, of copper present in the brass. *[1]*

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(iii) Calculate the mass of copper in the brass. *[1]*

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(iv) Calculate the percentage by mass of copper in the brass. *[1]*

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(v) The manufacturers claim that the sample of brass contains 44.2 % copper by mass. Determine the percentage error in the result. *[1]*

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(c) With reference to its metallic structure, describe how brass conducts electricity. *[1]*

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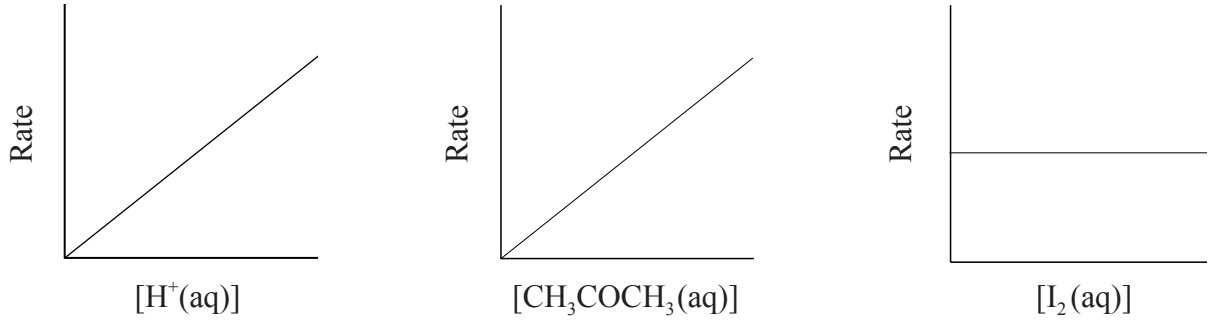
**2.** Alex and Hannah were asked to investigate the kinetics involved in the iodination of propanone. They were given the following equation by their teacher.

$$CH_3COCH_3(aq) + I_2(aq) \xrightarrow{H^+(aq)} CH_2ICOCH_3(aq) + HI(aq)$$

Alex's hypothesis was that the rate will be affected by changing the concentrations of the propanone and the iodine, as the reaction can happen without a catalyst. Hannah's hypothesis was that as the catalyst is involved in the reaction, the concentrations of the propanone, iodine and the hydrogen ions will all affect the rate.

They carried out several experiments varying the concentration of one of the reactants or the catalyst whilst keeping other concentrations and conditions the same. Their results are shown graphically below.




(a) Discuss whether either Alex's or Hannah's hypothesis is correct. *[2]*

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(b) Explain why the reaction rate will increase with increasing temperature. *[2]*

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*(This question continues on the following page)*

*(Question 2 continued)*

(c) (i) This reaction uses a catalyst. Sketch and annotate the Maxwell-Boltzmann energy distribution curve for a reaction with and without a catalyst on labelled axes below. *[3]*

(ii) Describe how a catalyst works. *[1]*

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

(i) Draw the Lewis structure for chloroethene and predict the H–C–Cl bond angle. *[2]*

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(ii) Draw a section of poly(chloroethene) containing six carbon atoms. *[1]*

(iii) Outline why the polymerization of alkenes is of economic importance and why the disposal of plastics is a problem. *[2]*

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(b) (i) Chloroethene can be converted to ethanol in two steps. For each step deduce an overall equation for the reaction taking place. *[2]*

Step 1:

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Step 2:

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*(This question continues on the following page)*

*(Question 3 continued)*

(ii) State the reagents and conditions necessary to prepare ethanoic acid from ethanol in the laboratory. *[2]*

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(iii) State an equation, including state symbols, for the reaction of ethanoic acid with water. Identify a Brønsted-Lowry acid in the equation and its conjugate base. *[3]*

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## SECTION B

*Answer **one** question. Write your answers on the answer sheets provided. Write your session number on each answer sheet, and attach them to this examination paper and your cover sheet using the tag provided.*

**4.** (a) Define the term *relative atomic mass* ($A_r$). *[1]*

(b) Relative atomic masses are obtained using a mass spectrometer. Draw a simple annotated diagram of the mass spectrometer. *[5]*

(c) The relative atomic mass of naturally occurring copper is 63.55. Calculate the abundances of $^{63}Cu$ and $^{65}Cu$ in naturally occurring copper. *[2]*

(d) The isotopes of some elements are radioactive. State a radioisotope used in medicine. *[1]*

(e) State a balanced equation for the reaction of sodium with water. Include state symbols. *[2]*

(f) With reference to electronic arrangements, suggest why the reaction between rubidium and water is more vigorous than that between sodium and water. *[2]*

(g) Describe and explain what you will see if chlorine gas is bubbled through a solution of

(i) potassium iodide. *[2]*

(ii) potassium fluoride. *[1]*

(h) Explain why the melting points of the elements decrease down group 1 and increase down group 7. *[4]*

**5.** (a) (i) Draw an annotated diagram of a voltaic cell composed of a magnesium electrode in 1.0 mol $dm^{-3}$ magnesium nitrate solution and a silver electrode in 1.0 mol $dm^{-3}$ silver nitrate solution. State the direction of electron flow on your diagram. *[4]*

(ii) Deduce half-equations for the oxidation and reduction reactions. *[2]*

(b) Consider the following three redox reactions.

$$Cd(s) + Ni^{2+}(aq) \rightarrow Cd^{2+}(aq) + Ni(s)$$

$$Ni(s) + 2Ag^{+}(aq) \rightarrow Ni^{2+}(aq) + 2Ag(s)$$

$$Zn(s) + Cd^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cd(s)$$

(i) Deduce the order of reactivity of the four metals, cadmium, nickel, silver and zinc and list in order of **decreasing** reactivity. *[2]*

(ii) Identify the best oxidizing agent and the best reducing agent. *[2]*

(c) (i) Solid sodium chloride does not conduct electricity but molten sodium chloride does. Explain this difference. *[2]*

(ii) Outline what happens in an electrolytic cell during the electrolysis of molten sodium chloride using inert electrodes. Deduce equations for the reactions occurring at each electrode. *[4]*

(d) (i) A state of equilibrium can exist when a piece of copper metal is placed in a solution of copper(II) sulfate. Outline the characteristics of a chemical system in dynamic equilibrium. *[2]*

(ii) For an exothermic reaction state how an increase in temperature would affect both $K_c$ and the position of equilibrium. *[2]*

**6.** (a) In an experiment to measure the enthalpy change of combustion of ethanol, a student heated a copper calorimeter containing 100 $cm^3$ of water with a spirit lamp and collected the following data.

| | |
|---|---|
| Initial temperature of water: | 20.0 °C |
| Final temperature of water: | 55.0 °C |
| Mass of ethanol burned: | 1.78 g |
| Density of water: | 1.00 g $cm^{-3}$ |

(i) Use the data to calculate the heat evolved when the ethanol was combusted. *[2]*

(ii) Calculate the enthalpy change of combustion per mole of ethanol. *[2]*

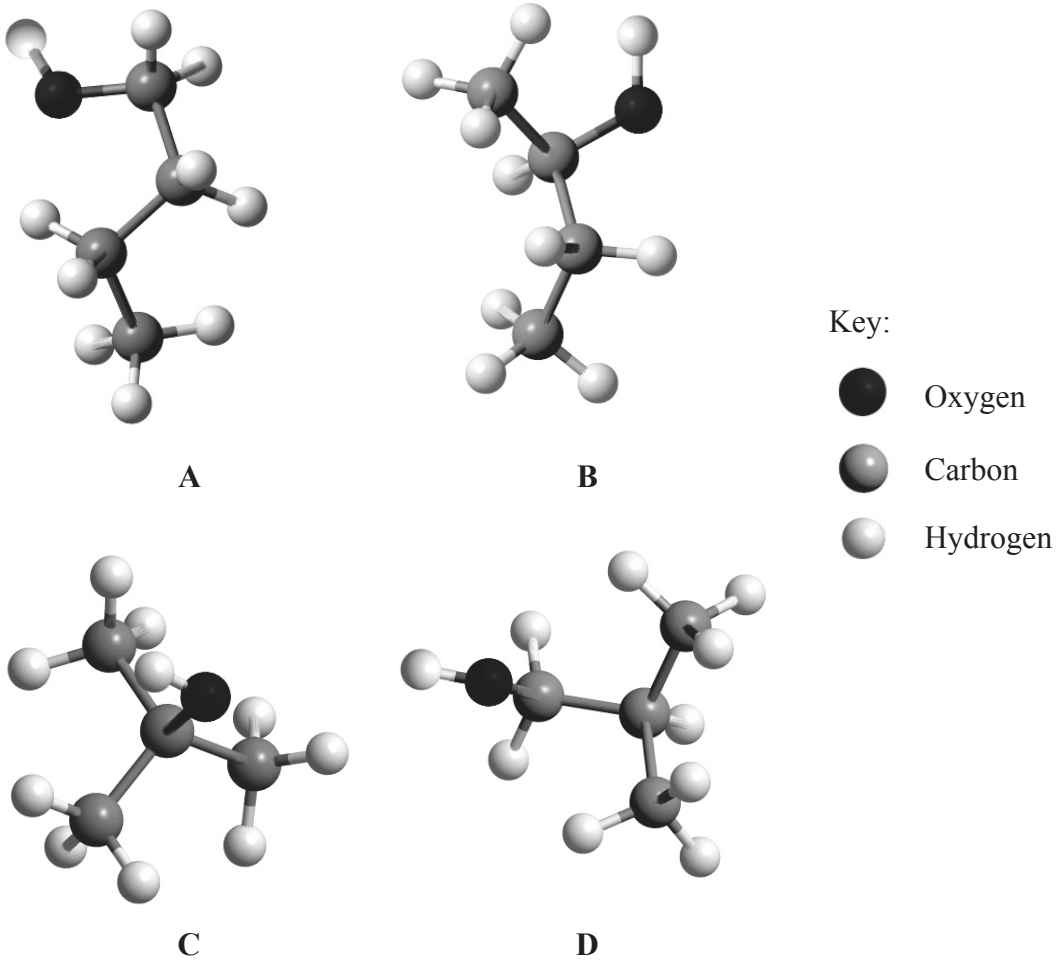
(iii) Suggest two reasons why the result is not the same as the value in the Data Booklet. *[2]*

(b) Ethanol is part of the homologous series of alcohols. Describe **two** features of a homologous series. *[2]*

*(This question continues on the following page)*

*(Question 6 continued)*

(c) (i) Below are **four structural** isomers of alcohols with molecular formula $C_4H_{10}O$. State the name of each of the isomers **A**, **B**, **C** and **D**. *[4]*




**A** **B**

**C** **D**

(ii) Determine the isomer that cannot be oxidized by acidified potassium dichromate(VI), $K_2Cr_2O_7$. *[1]*

(iii) Determine the isomer which can be oxidized to butanal. *[1]*

(iv) Determine the isomer which can be oxidized to butanone. *[1]*

(v) Suggest the structural formula of another isomer of $C_4H_{10}O$. *[1]*

(d) (i) Isomer **A** is formed by reacting 1-bromobutane with aqueous sodium hydroxide. State whether the reaction would proceed via an $S_N1$ or $S_N2$ mechanism. *[1]*

(ii) Explain the mechanism named in part (d) (i) using curly arrows to represent the movement of electron pairs. *[3]*