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

Thursday 11 November 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.



0113

## SECTION A

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

**1.** The data below are from an experiment to measure the enthalpy change for the reaction of aqueous copper(II) sulfate, $CuSO_4(aq)$ and zinc, $Zn(s)$.

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

50.0 $cm^3$ of 1.00 $mol\,dm^{-3}$ copper(II) sulfate solution was placed in a polystyrene cup and zinc powder was added after 100 seconds. The temperature-time data was taken from a data-logging software program. The table shows the initial 23 readings.

| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| 1 | **time / s** | **Temperature / °C** | | | | | | |
| 2 | 0.0 | 24.8 | | | | | | |
| 3 | 1.0 | 24.8 | | | | | | |
| 4 | 2.0 | 24.8 | | | | | | |
| 5 | 3.0 | 24.8 | | | | | | |
| 6 | 4.0 | 24.8 | | | | | | |
| 7 | 5.0 | 24.8 | | | | | | |
| 8 | 6.0 | 24.8 | | | | | | |
| 9 | 7.0 | 24.8 | | | | | | |
| 10 | 8.0 | 24.8 | | | | | | |
| 11 | 9.0 | 24.8 | | | | | | |
| 12 | 10.0 | 24.8 | | | | | | |
| 13 | 11.0 | 24.8 | | | | | | |
| 14 | 12.0 | 24.8 | | | | | | |
| 15 | 13.0 | 24.8 | | | | | | |
| 16 | 14.0 | 24.8 | | | | | | |
| 17 | 15.0 | 24.8 | | | | | | |
| 18 | 16.0 | 24.8 | | | | | | |
| 19 | 17.0 | 24.8 | | | | | | |
| 20 | 18.0 | 24.8 | | | | | | |
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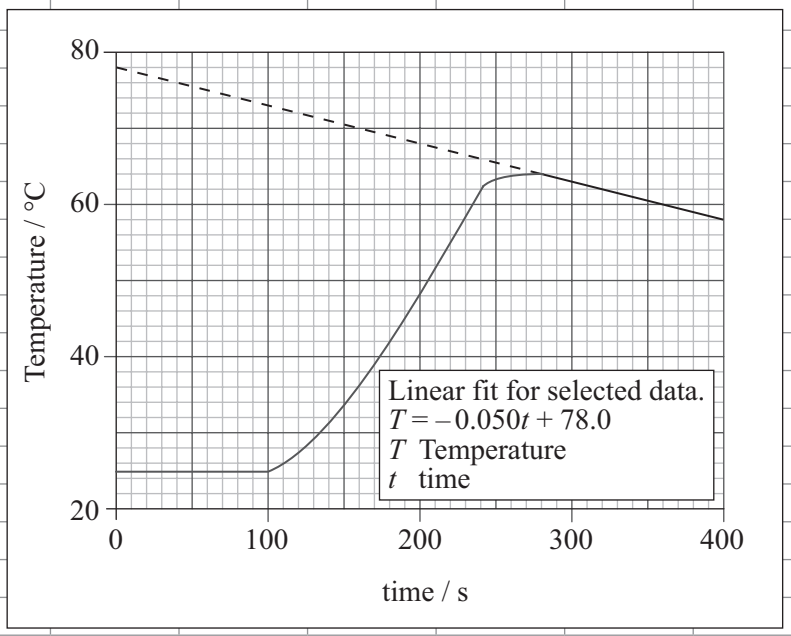


A straight line has been drawn through some of the data points. The equation for this line is given by the data logging software as

$$T = -0.050t + 78.0$$

where $T$ is the Temperature at time $t$.

*(This question continues on the following page)*

*(Question 1 continued)*

(a) The heat produced by the reaction can be calculated from the temperature change, $\Delta T$, using the expression below.

$$\text{Heat change} = \text{Volume of } CuSO_4(aq) \times \text{Specific heat capacity of } H_2O \times \Delta T$$

Describe **two** assumptions made in using this expression to calculate heat changes. *[2]*

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(b) (i) Use the data presented by the data logging software to deduce the temperature change, $\Delta T$, which would have occurred if the reaction had taken place instantaneously with no heat loss. *[2]*

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(ii) State the assumption made in part (b) (i). *[1]*

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(iii) Calculate the heat, in kJ, produced during the reaction using the expression given in part (a). *[1]*

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(c) The colour of the solution changed from blue to colourless. Deduce the amount, in moles, of zinc which reacted in the polystyrene cup. *[1]*

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(d) Calculate the enthalpy change, in $kJ\,mol^{-1}$, for this reaction. *[1]*

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*(This question continues on the following page)*

*(Question 1 continued)*

(e) An experiment was designed to investigate how the enthalpy change for a displacement reaction relates to the reactivities of the metals involved. The following metals in order of decreasing reactivity were available.

Magnesium *most reactive*
Uranium
Zinc
Iron
Copper
Silver *least reactive*

Excess amounts of each metal were added to 1.00 mol dm$^{-3}$ copper(II) sulfate solution. The temperature change was measured and the enthalpy change calculated.

(i) Suggest a possible hypothesis for the relationship between the enthalpy change of the reaction and the reactivity of the metal. *[1]*

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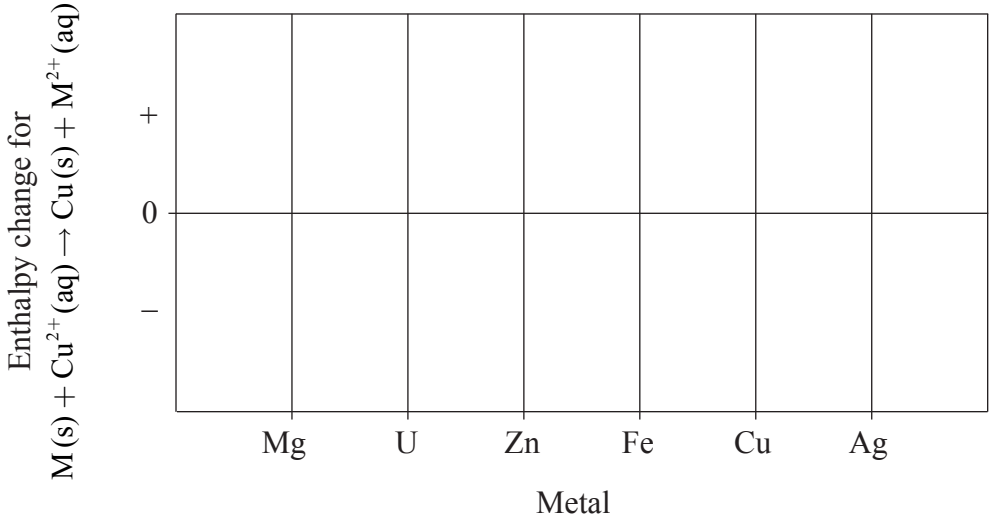
(ii) Sketch a graph on the diagram below to illustrate your hypothesis. *[1]*



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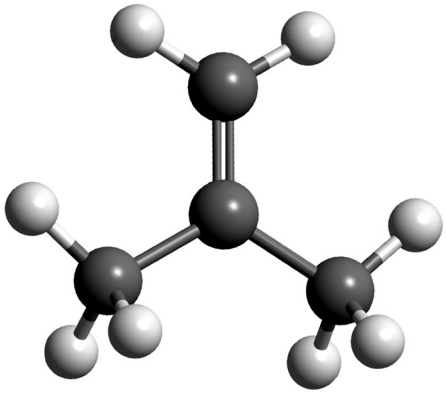
**2.** The alkenes are an example of a homologous series.

(a) State the name of the alkene shown. *[1]*

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(b) Bromine water, $Br_2(aq)$, can be used to distinguish between the alkanes and the alkenes.

(i) Describe the colour change observed when the alkene shown in part (a) is added to bromine water. *[1]*

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(ii) Draw the structural formula and state the name of the product formed. *[2]*

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*(This question continues on the following page)*

*(Question 2 continued)*

(c) The polymerization of the alkenes is one of the most significant reactions of the twentieth century.

(i) Outline **two** reasons why the polymers of the alkenes are of economic importance. *[2]*

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(ii) State the type of polymerization reaction shown by the alkene in part (a). *[1]*

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(iii) Deduce the structure of the resulting polymer showing **three** repeating units. *[1]*

(iv) Explain why monomers are often gases or volatile liquids, but polymers are solids. *[2]*

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**3.** Iron has three main naturally occurring isotopes which can be investigated using a mass spectrometer.

(a) The first stage in the operation of the mass spectrometer is vaporization. The iron is then ionized.

(i) Explain why the iron is ionized. *[2]*

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(ii) Explain why a very low pressure is maintained inside the mass spectrometer. *[1]*

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(b) A sample of iron has the following isotopic composition by mass.

| **Isotope** | $^{54}Fe$ | $^{56}Fe$ | $^{57}Fe$ |
|---|---|---|---|
| **Relative abundance / %** | 5.95 | 91.88 | 2.17 |

Calculate the relative atomic mass of iron based on this data, giving your answer to **two decimal places.** *[2]*

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(c) Calculate the number of electrons in the ion $^{56}Fe^{2+}$. *[1]*

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*(Question 3 continued)*

(d) Describe the bonding in iron and explain the electrical conductivity and malleability of the metal. *[4]*

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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.** Ethene, $C_2H_4$, and hydrazine, $N_2H_4$, are hydrides of adjacent elements in the periodic table.

(a) (i) Draw Lewis (electron dot) structures for $C_2H_4$ and $N_2H_4$ showing all valence electrons. *[2]*

(ii) State and explain the H–C–H bond angle in ethene and the H–N–H bond angle in hydrazine. *[5]*

(b) The polarity of a molecule can be explained in terms of electronegativity.

(i) Define the term *electronegativity*. *[2]*

(ii) Compare the relative polarities of the C–H bond in ethene and the N–H bond in hydrazine. *[1]*

(iii) Hydrazine is a polar molecule and ethene is non-polar. Explain why ethene is non-polar. *[1]*

(c) The boiling point of hydrazine is much higher than that of ethene. Explain this difference in terms of the intermolecular forces in each compound. *[2]*

(d) Hydrazine is a valuable rocket fuel.

The equation for the reaction between hydrazine and oxygen is given below.

$$N_2H_4(g) + O_2(g) \rightarrow N_2(g) + 2H_2O(g)$$

Use the bond enthalpy values from Table 10 of the Data Booklet to determine the enthalpy change for this reaction. *[3]*

(e) State the name of the product and identify the type of reaction which occurs between ethene and hydrogen chloride. *[2]*

(f) The reaction between $N_2H_4(aq)$ and $HCl(aq)$ can be represented by the following equation.

$$N_2H_4(aq) + 2HCl(aq) \rightarrow N_2H_6^{2+}(aq) + 2Cl^-(aq)$$

(i) Identify the type of reaction that occurs. *[1]*

(ii) Predict the value of the H–N–H bond angle in $N_2H_6^{2+}$. *[1]*

**5.** Consider the following sequence of reactions.

$$RCH_3 \xrightarrow{\textit{reaction 1}} RCH_2Br \xrightarrow{\textit{reaction 2}} RCH_2OH \xrightarrow{\textit{reaction 3}} RCOOH$$

$RCH_3$ is an unknown alkane in which R represents an alkyl group.

(a) The alkane contains 81.7 % by mass of carbon. Determine its empirical formula, showing your working. *[3]*

(b) Equal volumes of carbon dioxide and the unknown alkane are found to have the same mass, measured to an accuracy of two significant figures, at the same temperature and pressure. Deduce the molecular formula of the alkane. *[1]*

(c) (i) State the reagent and conditions needed for *reaction 1*. *[2]*

(ii) State the reagent(s) and conditions needed for *reaction 3*. *[2]*

(d) *Reaction 1* involves a free-radical mechanism. Describe the stepwise mechanism, by giving equations to represent the initiation, propagation and termination steps. *[4]*

(e) The mechanism in *reaction 2* is described as $S_N2$.

(i) State the meaning of each of the symbols in $S_N2$. *[1]*

(ii) Explain the mechanism of this reaction using curly arrows to show the movement of electron pairs, and draw the structure of the transition state. *[3]*

(f) Propan-1-ol has two structural isomers.

(i) Deduce the structural formula of each isomer. *[2]*

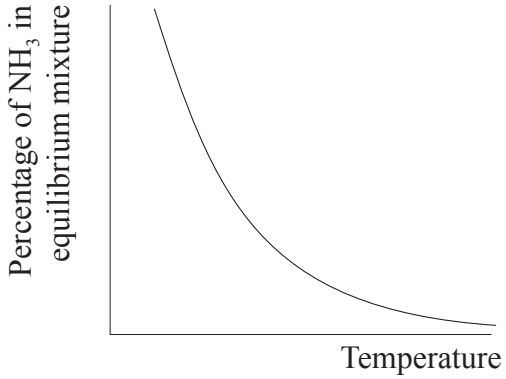
(ii) Identify the isomer from part (f) (i) which has the higher boiling point and explain your choice. Refer to both isomers in your explanation. *[2]*

**6.** The Haber process enables the large-scale production of ammonia needed to make fertilizers.

(a) The equation for the Haber process is given below.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The percentage of ammonia in the equilibrium mixture varies with temperature.




(i) Use the graph to deduce whether the forward reaction is exothermic or endothermic and explain your choice. *[2]*

(ii) State and explain the effect of increasing the pressure on the yield of ammonia. *[2]*

(iii) Explain the effect of increasing the temperature on the rate of reaction. *[2]*

(b) Fertilizers may cause health problems for babies because nitrates can change into nitrites in water used for drinking.

(i) Define *oxidation* in terms of oxidation numbers. *[1]*

(ii) Deduce the oxidation states of nitrogen in the nitrate, $NO_3^-$, and nitrite, $NO_2^-$, ions. *[1]*

(c) The nitrite ion is present in nitrous acid, $HNO_2$, which is a weak acid. The nitrate ion is present in nitric acid, $HNO_3$, which is a strong acid. Distinguish between the terms *strong* and *weak acid* and state the equations used to show the dissociation of each acid in aqueous solution. *[3]*

(d) A small piece of magnesium ribbon is added to solutions of nitric and nitrous acid of the same concentration at the same temperature. Describe **two** observations that would allow you to distinguish between the two acids. *[2]*

*(This question continues on the following page)*

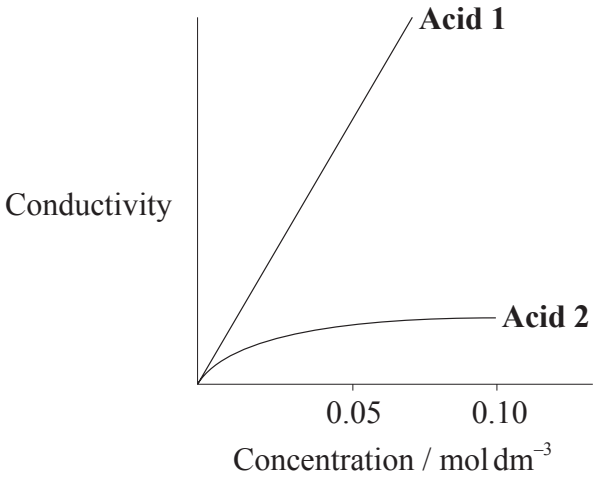
*(Question 6 continued)*

(e) A student decided to investigate the reactions of the two acids with separate samples of 0.20 mol $dm^{-3}$ sodium hydroxide solution.

(i) Calculate the volume of the sodium hydroxide solution required to react exactly with a 15.0 $cm^3$ solution of 0.10 mol $dm^{-3}$ nitric acid. *[1]*

(ii) The following hypothesis was suggested by the student: "Since nitrous acid is a weak acid it will react with a smaller volume of the 0.20 mol $dm^{-3}$ sodium hydroxide solution." Comment on whether or not this is a valid hypothesis. *[1]*

(f) The graph below shows how the conductivity of the two acids changes with concentration.




Identify **Acid 1** and explain your choice. *[2]*

(g) Nitric acid reacts with silver in a redox reaction.

$$\_\_\ Ag(s) + \_\_\ NO_3^-(aq) + \_\_\_\_ \rightarrow \_\_\ Ag^+(aq) + \_\_\ NO(g) + \_\_\_\_$$

Using oxidation numbers, deduce the complete balanced equation for the reaction showing all the reactants and products. *[3]*