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CHEMISTRY
STANDARD LEVEL
PAPER 2

Candidate session number

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Monday 9 May 2011 (afternoon)

1 hour 15 minutes

Examination code

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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 questions.
- Section B: answer one question.
- Write your answers in the boxes provided.

0120

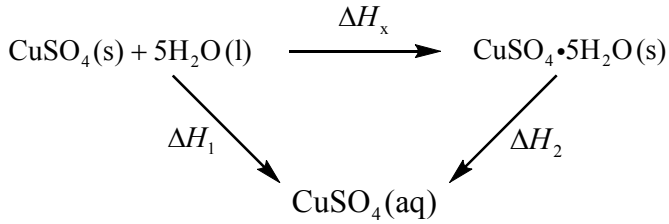
SECTION A

*Answer **all** questions. Write your answers in the boxes provided.*

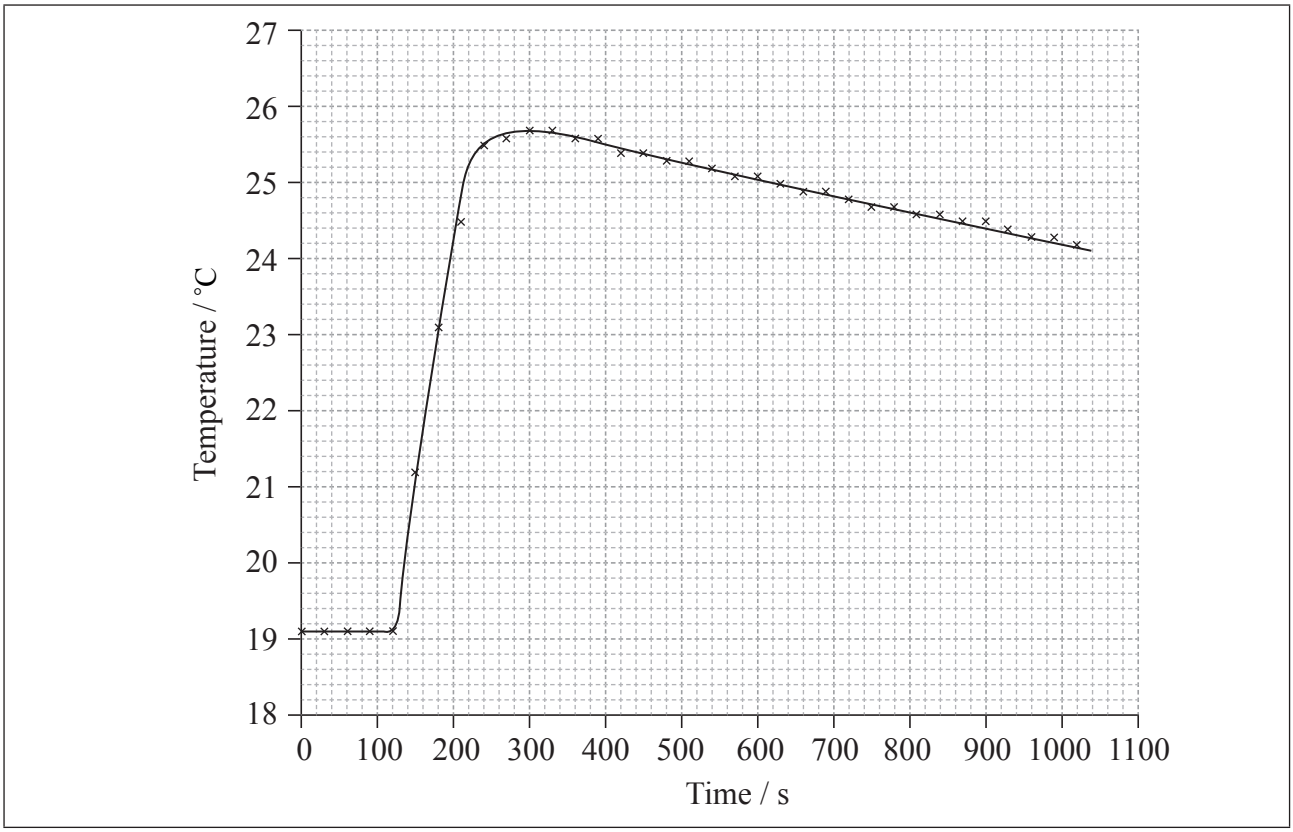
1. If white anhydrous copper(II) sulfate powder is left in the atmosphere it slowly absorbs water vapour giving the blue pentahydrated solid.

$$\underset{\text{(anhydrous)}}{CuSO_4(s)} + 5H_2O(l) \rightarrow \underset{\text{(pentahydrated)}}{CuSO_4 \bullet 5H_2O(s)}$$

It is difficult to measure the enthalpy change for this reaction directly. However, it is possible to measure the heat changes directly when both anhydrous and pentahydrated copper(II) sulfate are separately dissolved in water, and then use an energy cycle to determine the required enthalpy change value, ΔH_x, indirectly.



(a) To determine ΔH_1 a student placed 50.0 g of water in a cup made of expanded polystyrene and used a data logger to measure the temperature. After two minutes she dissolved 3.99 g of anhydrous copper(II) sulfate in the water and continued to record the temperature while continuously stirring. She obtained the following results.



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(Question 1 continued)

(i) Calculate the amount, in mol, of anhydrous copper(II) sulfate dissolved in the 50.0 g of water. *[1]*

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(ii) Determine what the temperature rise would have been, in °C, if no heat had been lost to the surroundings. *[2]*

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(iii) Calculate the heat change, in kJ, when 3.99 g of anhydrous copper(II) sulfate is dissolved in the water. *[2]*

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(iv) Determine the value of ΔH_1 in kJ mol^{-1}. *[1]*

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(Question 1 continued)

(b) To determine ΔH_2, 6.24 g of pentahydrated copper(II) sulfate was dissolved in 47.75 g of water. It was observed that the temperature of the solution decreased by 1.10 °C.

(i) Calculate the amount, in mol, of water in 6.24 g of pentahydrated copper(II) sulfate. *[2]*

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(ii) Determine the value of ΔH_2 in kJ mol^{-1}. *[2]*

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(iii) Using the values obtained for ΔH_1 in (a) (iv) and ΔH_2 in (b) (ii), determine the value for ΔH_x in kJ mol^{-1}. *[1]*

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(Question 1 continued)

(c) The magnitude (the value without the + or – sign) found in a data book for ΔH_x is 78.0 kJ mol^{-1}.

(i) Calculate the percentage error obtained in this experiment. (If you did not obtain an answer for the experimental value of ΔH_x then use the value 70.0 kJ mol^{-1}, but this is **not** the true value.) *[1]*

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(ii) The student recorded in her qualitative data that the anhydrous copper(II) sulfate she used was pale blue rather than completely white. Suggest a reason why it might have had this pale blue colour and deduce how this would have affected the value she obtained for ΔH_x. *[2]*

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2. The element antimony, Sb, is usually found in nature as its sulfide ore, stibnite, Sb_2S_3. This ore was used two thousand years ago by ancient Egyptian women as a cosmetic to darken their eyes and eyelashes.

(a) (i) Deduce the oxidation number of antimony in stibnite. *[1]*

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(ii) Deduce **one** other common oxidation number exhibited by antimony in some of its compounds. *[1]*

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(b) One method of extracting antimony from its sulfide ore is to roast the stibnite in air. This forms antimony oxide and sulfur dioxide. The antimony oxide is then reduced by carbon to form the free element.

(i) Deduce the chemical equations for these **two** reactions. *[2]*

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(ii) Identify **two** different environmental concerns associated with this method of extraction. *[2]*

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3. Rubidium contains two stable isotopes, ^{85}Rb and ^{87}Rb. The relative atomic mass of rubidium is given in Table 5 of the Data Booklet.

(a) Calculate the percentage of each isotope in pure rubidium. State your answers to **three** significant figures. *[2]*

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(b) The percentage of each isotope can be checked experimentally using a mass spectrometer. A vaporized sample of pure rubidium is ionized and then accelerated in a mass spectrometer. Outline how the use of a magnetic field and a detector in the mass spectrometer enables the percentages of the two isotopes to be determined. *[3]*

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(c) State the number of electrons and the number of neutrons present in an atom of ^{87}Rb. *[2]*

Number of electrons:

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Number of neutrons:

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4. Methoxymethane, CH_3OCH_3, and ethanol, C_2H_5OH, have the same relative molecular mass. Explain why methoxymethane has a much lower boiling point than ethanol. *[3]*

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SECTION B

*Answer **one** question. Write your answers in the boxes provided.*

5. (a) Ammonia, NH_3, is a weak base.

(i) Draw the Lewis structure of ammonia and state the shape of the molecule and its bond angles. *[3]*

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(ii) The conjugate acid of ammonia is the ammonium ion, NH_4^+. Draw the Lewis structure of the ammonium ion and deduce its shape and bond angles. *[3]*

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(Question 5 continued)

(iii) Define an acid in terms of the Lewis theory. Deduce, giving a reason, whether NF_3 is able to function as a Lewis acid or as a Lewis base. *[2]*

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(iv) Describe **two** different properties that could be used to distinguish between a 1.00 mol dm^{-3} solution of a strong monoprotic acid and a 1.00 mol dm^{-3} solution of a weak monoprotic acid. *[2]*

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(v) Explain, using the Brønsted-Lowry theory, how water can act either as an acid or a base. In **each** case identify the conjugate acid or base formed. *[2]*

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(Question 5 continued)

(b) Iron is more reactive than copper.

(i) Draw a labelled diagram of a voltaic cell made from an $Fe(s) / Fe^{2+}(aq)$ half-cell connected to a $Cu(s) / Cu^{2+}(aq)$ half-cell. In your diagram identify the positive electrode (cathode), the negative electrode (anode) and the direction of electron flow in the external circuit. *[4]*

(ii) Deduce the half-equations for the reactions taking place at the positive electrode (cathode) and negative electrode (anode) of this voltaic cell. *[2]*

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(iii) Deduce the overall equation for the reaction taking place in the voltaic cell and determine which species acts as the oxidizing agent and which species has been reduced. *[2]*

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6. (a) An example of a homogeneous reversible reaction is the reaction between hydrogen and iodine.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

(i) Outline the characteristics of a homogeneous chemical system that is in a state of equilibrium. *[2]*

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(ii) Deduce the expression for the equilibrium constant, K_c. *[1]*

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(iii) Predict what would happen to the position of equilibrium and the value of K_c if the pressure is increased from 1 atm to 2 atm. *[2]*

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(Question 6 continued)

(iv) The value of K_c at 500 K is 160 and the value of K_c at 700 K is 54. Deduce what this information tells us about the enthalpy change of the forward reaction. *[1]*

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(v) The reaction can be catalysed by adding platinum metal. State and explain what effect the addition of platinum would have on the value of the equilibrium constant. *[2]*

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(b) Propane can be formed by the hydrogenation of propene.

$$CH_3CH{=}CH_2(g) + H_2(g) \rightarrow CH_3CH_2CH_3(g)$$

(i) State the conditions necessary for the hydrogenation reaction to occur. *[2]*

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(Question 6 continued)

(ii) Enthalpy changes can be determined using average bond enthalpies. Define the term *average bond enthalpy*. *[2]*

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(iii) Determine a value for the hydrogenation of propene using information from Table 10 of the Data Booklet. *[2]*

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(iv) Explain why the enthalpy of hydrogenation of propene is an exothermic process. *[1]*

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(Question 6 continued)

(c) (i) Describe a chemical test that could be used to distinguish between propane and propene. In **each** case state the result of the test. *[2]*

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(ii) Under certain conditions propene can polymerize to form poly(propene). State the type of polymerization taking place and draw a section of the polymer to represent the repeating unit. *[2]*

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(iii) Other than polymerization, state **one** reaction of alkenes which is of economic importance. *[1]*

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7. (a) Factors that affect the rate of a chemical reaction include particle size, concentration of reactants and the temperature of the reaction.

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

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(ii) List the **three** characteristic properties of reactant particles which affect the rate of reaction as described by the collision theory. *[3]*

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(Question 7 continued)

(iii) On the axes below sketch **two** Maxwell-Boltzmann energy distribution curves for the same sample of gas, one at a temperature T and another at a higher temperature T'. Label both axes. Explain why raising the temperature increases the rate of a chemical reaction. *[5]*

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(iv) Explain why coal dust burns much faster than a large piece of coal with the same mass. *[1]*

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(Question 7 continued)

(b) Propan-1-ol and propan-2-ol are two structural isomers of C_3H_8O.

(i) State the equation for the complete combustion of C_3H_8O. *[2]*

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(ii) Both propan-1-ol and propan-2-ol can be oxidized in aqueous solution by potassium dichromate(VI). State any necessary conditions for the oxidation to occur and describe the colour change during the oxidation process. *[3]*

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(This question continues on the following page)

(Question 7 continued)

(iii) State the name(s) and structure(s) of the organic product(s) that can be formed when each of the alcohols is oxidized and suggest why one of the alcohols gives two organic products and the other only gives one organic product. *[5]*

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Please **do not** write on this page.

Answers written on this page
will not be marked.