IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
PROGRAMA DEL DIPLOMA DEL BI

N03/420/S(2)

CHEMISTRY
STANDARD LEVEL
PAPER 2

Candidate number

Friday 7 November 2003 (afternoon)

1 hour 15 minutes

INSTRUCTIONS TO CANDIDATES

- Write your candidate number in the box 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 candidate 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.

SECTION A

*Candidates must answer **all** questions in the spaces provided.*

1. (a) Given the following data:

$$C(s) + 2F_2(g) \rightarrow CF_4(g); \Delta H_1 = -680 \text{ kJ mol}^{-1}$$
$$F_2(g) \rightarrow 2F(g); \Delta H_2 = +158 \text{ kJ mol}^{-1}$$
$$C(s) \rightarrow C(g); \Delta H_3 = +715 \text{ kJ mol}^{-1}$$

calculate the average bond enthalpy (in kJ mol^{-1}) for the C—F bond. *[4]*

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(b) For the process:

$$C_6H_6(l) \rightarrow C_6H_6(s)$$

the standard entropy and enthalpy changes are:

$$\Delta H^{\ominus} = -9.83 \text{ kJ mol}^{-1} \text{ and } \Delta S^{\ominus} = -35.2 \text{ J K}^{-1} \text{ mol}^{-1}.$$

Predict and explain the effect of an increase in temperature on the spontaneity of the process. *[3]*

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2. (a) Aqueous XO_4^{3-} ions form a precipitate with aqueous silver ions, Ag^+. Write a balanced equation for the reaction, including state symbols. *[2]*

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(b) When $41.18\ cm^3$ of a solution of aqueous silver ions with a concentration of $0.2040\ mol\ dm^{-3}$ is added to a solution of XO_4^{3-} ions, 1.172 g of the precipitate is formed.

(i) Calculate the amount (in moles) of Ag^+ ions used in the reaction. *[1]*

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(ii) Calculate the amount (in moles) of the precipitate formed. *[1]*

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(iii) Calculate the molar mass of the precipitate. *[2]*

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(iv) Determine the relative atomic mass of X and identify the element. *[2]*

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3. (a) State a physical property that is different for isotopes of an element. *[1]*

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(b) Chlorine exists as two isotopes, ^{35}Cl and ^{37}Cl. The relative atomic mass of chlorine is 35.45. Calculate the percentage abundance of each isotope. *[2]*

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4. (a) Draw the Lewis structure of methanoic acid, HCOOH. *[1]*

(b) In methanoic acid, predict the bond angle around the *[2]*

(i) carbon atom. . . . . .

(ii) oxygen atom bonded to the hydrogen atom. . . . . .

(c) State and explain the relationship between the length and strength of the bonds between the carbon atom and the two oxygen atoms in methanoic acid. *[3]*

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5. (a) State what is meant by the term *buffer solution*. *[2]*

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(b) State and explain whether each of the following solutions will form a buffer solution.

(i) A 1.0 dm^3 solution containing 0.10 mol NH_3 and 0.20 mol HCl *[2]*

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(ii) A 1.0 dm^3 solution containing 0.20 mol NH_3 and 0.10 mol HCl *[2]*

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SECTION B

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

6. (a) Describe the acid-base character of the oxides of the period 3 elements Na to Ar. For sodium oxide and sulfur trioxide, write balanced equations to illustrate their acid-base character. *[4]*

(b) Table 6 of the Data Booklet lists melting points of the elements. Explain the trend in the melting points of the alkali metals, halogens and period 3 elements. *[8]*

(c) (i) Explain how the first ionization energy of K compares with that of Na and Ar. *[3]*

(ii) Explain the difference between the first ionization energies of Na and Mg. *[4]*

(iii) Suggest why much more energy is needed to remove an electron from Na^+ than from Mg^+. *[1]*

7. (a) (i) List **three** characteristics of an homologous series, and explain the term *functional group.* *[3]*

(ii) Ethanol and ethanoic acid can be distinguished by their melting points. State and explain which of the two compounds will have a higher melting point. *[2]*

(iii) Draw the **four** different structures of alcohols of formula C_4H_9OH. Identify the structure that exists as optical isomers and give a reason for your answer. *[4]*

(b) (i) Ethanoic acid reacts with ethanol in the presence of concentrated sulfuric acid and heat. Identify the type of reaction that takes place. Write an equation for the reaction, name the organic product formed and draw its structure. *[4]*

(ii) State and explain the role of sulfuric acid in this reaction. *[2]*

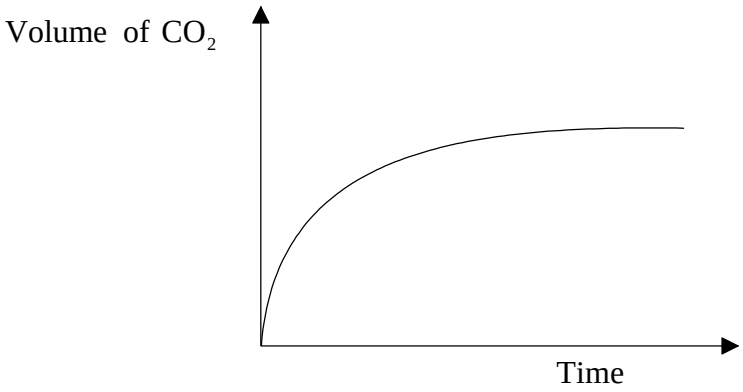
(iii) State **one** major commercial use of the organic product from this type of reaction. *[1]*

(c) For the two compounds $HCOOCH_2CH_3$ and $HCOOCHCH_2$:
I II

(i) State and explain which of the two compounds can react readily with bromine. *[2]*

(ii) Compound II can form polymers. State the type of polymerization compound II undergoes, and draw the structure of the repeating unit of the polymer. *[2]*

8. (a) The graph below shows the volume of carbon dioxide gas produced against time when excess calcium carbonate is added to x cm^3 of 2.0 mol dm^{-3} hydrochloric acid.



(i) Write a balanced equation for the reaction. *[1]*

(ii) State and explain the change in the rate of reaction with time. Outline how you would determine the rate of the reaction at a particular time. *[4]*

(iii) Sketch the above graph on an answer sheet. On the same graph, draw the curves you would expect if:

I. the same volume (x cm^3) of 1.0 mol dm^{-3} HCl is used.

II. double the volume (2x cm^3) of 1.0 mol dm^{-3} HCl is used.

Label the curves and explain your answer in each case. *[5]*

(b) The following equilibrium is established at 1700 °C.

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

If only carbon dioxide gas and hydrogen gas are present initially, sketch on a graph a line representing rate against time for (i) the forward reaction **and** (ii) the reverse reaction until shortly after equilibrium is established. Explain the shape of each line. *[7]*

(c) K_c for the equilibrium reaction is determined at two different temperatures. At 850 °C, $K_c = 1.1$ whereas at 1700 °C, $K_c = 4.9$.

On the basis of these K_c values explain whether the reaction is exothermic or endothermic. *[3]*