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

M04/420/S(2)

CHEMISTRY
STANDARD LEVEL
PAPER 2

Candidate number

Tuesday 18 May 2004 (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.

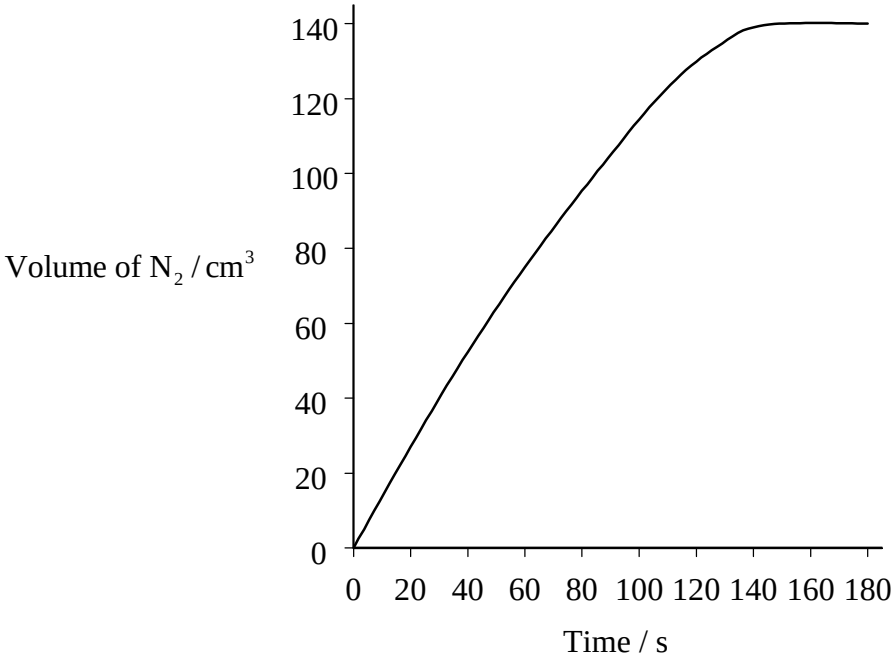
SECTION A

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

1. The reaction between ammonium chloride and sodium nitrite in aqueous solution can be represented by the following equation.

$$NH_4Cl(aq) + NaNO_2(aq) \rightarrow N_2(g) + 2H_2O(l) + NaCl(aq)$$

The graph below shows the volume of nitrogen gas produced at 30 second intervals from a mixture of ammonium chloride and sodium nitrite in aqueous solution at $20\,^{\circ}C$.



(a) (i) State how the rate of formation of nitrogen changes with time. Explain your answer in terms of collision theory. *[2]*

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(ii) Explain why the volume eventually remains constant. *[1]*

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(This question continues on the following page)

(Question 1 continued)

(b) (i) State how the rate of formation of nitrogen would change if the temperature were increased from $20\,^{\circ}C$ to $40\,^{\circ}C$. *[1]*

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(ii) State **two** reasons for the change described in (b)(i) and explain which of the two is more important in causing the change. *[3]*

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(iii) The reaction between **solid** ammonium chloride and aqueous sodium nitrite can be represented by the following equation.

$$NH_4Cl(s) + NaNO_2(aq) \rightarrow N_2(g) + 2H_2O(l) + NaCl(aq)$$

State and explain how the rate of formation of nitrogen would change if the same amount of ammonium chloride were used as large lumps instead of as a fine powder. *[2]*

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2. (a) Define the term *isotope*. *[2]*

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(b) A sample of argon exists as a mixture of three isotopes.

mass number 36, relative abundance 0.337 %
mass number 38, relative abundance 0.0630 %
mass number 40, relative abundance 99.6 %

Calculate the relative atomic mass of argon. *[2]*

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(c) State the number of electrons, protons and neutrons in the ion $^{56}Fe^{3+}$. *[2]*

electrons: . . . . . protons: . . . . . neutrons: . . . . . .

3. (a) (i) Draw Lewis (electron dot) structures for CO_2 and H_2S showing all valence electrons. *[2]*

(ii) State the shape of each molecule and explain your answer in terms of VSEPR theory. *[4]*

CO_2 . . . . . .

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H_2S . . . . . .

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(iii) State and explain whether each molecule is polar or non-polar. *[2]*

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(b) Identify the strongest type of intermolecular force in each of the following compounds. *[3]*

CH_3Cl . . . . . .

CH_4 . . . . . .

CH_3OH . . . . . .

4. Consider the following equilibrium reaction.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -198\,kJ$$

Using Le Chatelier's Principle, state and explain what will happen to the position of equilibrium if

(a) the temperature increases. *[2]*

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(b) the pressure increases. *[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.*

5. (a) The standard enthalpy change of formation of $Al_2O_3(s)$ is $-1669\ kJ\ mol^{-1}$ and the standard enthalpy change of formation of $Fe_2O_3(s)$ is $-822\ kJ\ mol^{-1}$.

(i) Use these values to calculate $\Delta H^{\ominus}$ for the following reaction.

$$Fe_2O_3(s) + 2Al(s) \rightarrow 2Fe(s) + Al_2O_3(s)$$

State whether the reaction is exothermic or endothermic. *[3]*

(ii) Draw an enthalpy level diagram to represent this reaction. State the conditions under which standard enthalpy changes are measured. *[2]*

(iii) Estimate, without doing a calculation, the magnitude of the entropy change for this reaction. Explain your answer. *[3]*

(b) Explain in terms of $\Delta G^{\ominus}$, why a reaction for which both $\Delta H^{\ominus}$ and $\Delta S^{\ominus}$ values are positive can sometimes be spontaneous and sometimes not. *[4]*

(c) Consider the following reaction.

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

(i) Use values from Table 10 in the Data Booklet to calculate the enthalpy change, $\Delta H^{\ominus}$, for this reaction. *[3]*

(ii) The magnitude of the entropy change, ΔS, at $27\ ^{\circ}C$ for the reaction is $62.7\ J\ K^{-1}\ mol^{-1}$. State, with a reason, the sign of ΔS. *[2]*

(iii) Calculate ΔG for the reaction at $27\ ^{\circ}C$ and determine whether this reaction is spontaneous at this temperature. *[3]*

6. Consider the following redox equation.

$$5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)$$

(a) (i) Determine the oxidation numbers for Fe and Mn in the reactants and in the products. *[2]*

(ii) Based on your answer to (i), deduce which substance is oxidized. *[1]*

(iii) The compounds CH_3OH and CH_2O contain carbon atoms in different oxidation states. Deduce the oxidation states and state the kind of chemical change needed to make CH_2O from CH_3OH. *[3]*

(b) A part of the reactivity series of metals, in order of decreasing reactivity, is shown below.

magnesium
zinc
iron
lead
copper
silver

If a piece of copper metal were placed in separate solutions of silver nitrate and zinc nitrate

(i) determine which solution would undergo reaction. *[1]*

(ii) identify the type of chemical change taking place in the copper and write the half-equation for this change. *[2]*

(iii) state, giving a reason, what visible change would take place in the solutions. *[2]*

(c) (i) Solid sodium chloride does not conduct electricity but molten sodium chloride does. Explain this difference, and outline what happens in an electrolytic cell during the electrolysis of molten sodium chloride using carbon electrodes. *[4]*

(ii) State the products formed and give equations showing the reactions at each electrode. *[4]*

(iii) State what practical use is made of this process. *[1]*

7. The compound C_2H_4 can be used as a starting material for the preparation of many substances.

(a) Name the compound C_2H_4 and draw its structural formula. *[2]*

(b) In the scheme below, state the type of reaction and identify the reagent needed for each reaction.

$$C_2H_4 \xrightarrow{\textbf{A}} CH_3CH_2OH \xrightarrow{\textbf{B}} CH_3COOH$$ *[4]*

(c) C_2H_4 can be converted into one of the compounds below in a single step reaction.

C_2H_3Cl $C_2H_4Cl_2$

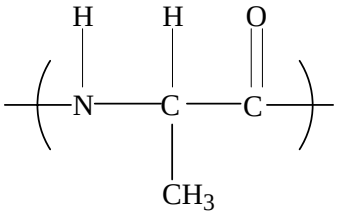
Draw the structural formula for each of these compounds and identify the compound which can be formed directly from C_2H_4. *[3]*

(d) One of the two compounds in (c) has an isomer. Draw the structural formula of the isomer and explain why it can not be formed directly from C_2H_4. *[2]*

(e) C_2H_4 can also react to form a polymer. Name this **type** of polymer and draw the structural formula of a section of this polymer consisting of three repeating units. *[2]*

(f) Polymers can also be formed in a different type of reaction. Identify this type of reaction and name **two** different types of such polymers. *[3]*

(g) The polymer with the repeating unit



exists as optical isomers.

(i) State a test for optical isomers.

(ii) Identify the chiral centre in the repeating unit.

(iii) Draw the two enantiomeric forms of the repeating unit. *[4]*