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

N05/4/CHEMI/SP2/ENG/TZ0/XX+

88056105

CHEMISTRY
STANDARD LEVEL
PAPER 2

Monday 7 November 2005 (afternoon)

1 hour 15 minutes

Candidate session number

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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 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 number of the question 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. An organic compound, **A**, containing only the elements carbon, hydrogen and oxygen was analysed.

(a) **A** was found to contain 54.5 % C and 9.1 % H by mass, the remainder being oxygen. Determine the empirical formula of the compound. *[3]*

(b) A 0.230 g sample of **A**, when vaporized, had a volume of $0.0785\ dm^3$ at 95 °C and 102 kPa. Determine the relative molecular mass of **A**. *[3]*

(c) Determine the molecular formula of **A** using your answers from parts (a) and (b). *[1]*

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(d) Another organic compound, **B**, has the formula $CH_3CH_2CH(CH_3)COOH$.

(i) State the name of the compound. *[1]*

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(ii) Deduce, giving a reason, whether or not **B** can exist as optical isomers. *[1]*

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

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(b) The reaction between gases **C** and **D** is slow at room temperature.

(i) Suggest **two** reasons why the reaction is slow at room temperature. *[2]*

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(ii) A relatively small increase in temperature causes a relatively large increase in the rate of this reaction. State **two** reasons for this. *[2]*

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(iii) Suggest **two** ways of increasing the rate of reaction between **C** and **D** other than increasing temperature. *[2]*

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3. The element bromine exists as the isotopes ^{79}Br and ^{81}Br , and has a relative atomic mass of 79.90.

(a) Complete the following table to show the numbers of sub-atomic particles in the species shown. *[3]*

	an atom of ^{79}Br	an ion of $^{81}Br^-$
protons		
neutrons		
electrons		

(b) State and explain which of the two isotopes ^{79}Br and ^{81}Br is more common in the element bromine. *[1]*

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(c) The element calcium is in the same period of the Periodic Table as bromine.

(i) Write the electron arrangement for an atom of calcium. *[1]*

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(ii) Deduce the formula of the compound calcium bromide. *[1]*

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4. (a) (i) Define the term *ionization energy*. *[2]*

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(ii) Write an equation, including state symbols, for the process occurring when measuring the first ionization energy of aluminium. *[1]*

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(b) The first ionization energies of the elements are shown in Table 7 of the Data Booklet. Explain why the first ionization energy of magnesium is greater than that of sodium. *[2]*

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(c) Lithium reacts with water. Write an equation for the reaction and state **two** observations that could be made during the reaction. *[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.*

5. (a) Two reactions occurring in the manufacture of sulfuric acid are shown below:

reaction I	$S(s) + O_2(g) \rightarrow SO_2(g)$	$\Delta H^{\ominus} = -297$ kJ
reaction II	$SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g)$	$\Delta H^{\ominus} = -92$ kJ

(i) State the name of the term $\Delta H^{\ominus}$. State, with a reason, whether reaction I would be accompanied by a decrease or increase in temperature. *[3]*

(ii) At room temperature sulfur trioxide, SO_3, is a solid. Deduce, with a reason, whether the $\Delta H^{\ominus}$ value would be more negative or less negative if $SO_3(s)$ instead of $SO_3(g)$ were formed in reaction II. *[2]*

(iii) Deduce the $\Delta H^{\ominus}$ value of this reaction:

$$S(s) + 1\tfrac{1}{2}O_2(g) \rightarrow SO_3(g)$$ *[1]*

(iv) Predict the sign of $\Delta S^{\ominus}$ for reaction II, and explain your choice. *[3]*

(b) (i) Define the term *average bond enthalpy.* *[3]*

(ii) Explain why Br_2 is not suitable as an example to illustrate the term *average bond enthalpy.* *[1]*

(iii) Using values from Table 10 of the Data Booklet, calculate the enthalpy change for the following reaction:

$$CH_4(g) + Br_2(g) \rightarrow CH_3Br(g) + HBr(g)$$ *[3]*

(iv) Sketch an enthalpy level diagram for the reaction in part (b) (iii). *[2]*

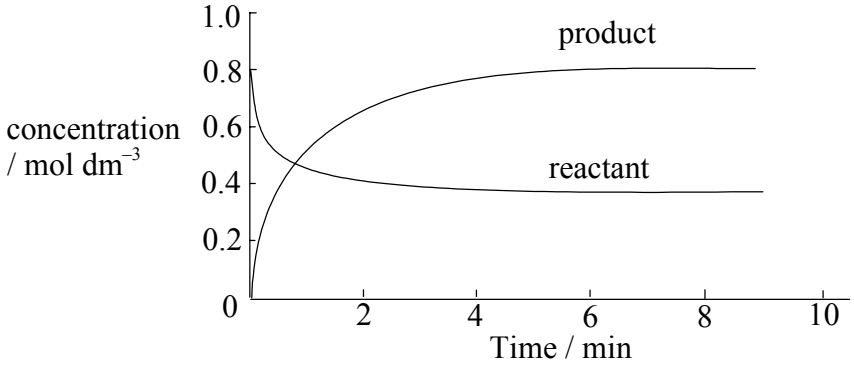
(v) Without carrying out a calculation, suggest, with a reason, how the enthalpy change for the following reaction compares with that of the reaction in part (b) (iii):

$$CH_3Br(g) + Br_2(g) \rightarrow CH_2Br_2(g) + HBr(g)$$ *[2]*

6. (a) The equation for one reversible reaction involving oxides of nitrogen is shown below:

$$N_2O_4\,(g) \rightleftharpoons 2NO_2\,(g) \qquad \Delta H^{\ominus} = +58\ \text{kJ}$$

Experimental data for this reaction can be represented on the following graph:



(i) Write an expression for the equilibrium constant, K_c, for the reaction. Explain the significance of the horizontal parts of the lines on the graph. State what can be deduced about the magnitude of K_c for the reaction, giving a reason. *[4]*

(ii) Use Le Chatelier's principle to predict and explain the effect of increasing the temperature on the position of equilibrium. *[2]*

(iii) Use Le Chatelier's principle to predict and explain the effect of increasing the pressure on the position of equilibrium. *[2]*

(iv) State and explain the effects of a catalyst on the forward and reverse reactions, on the position of equilibrium and on the value of K_c. *[6]*

(b) The pH values of solutions of three organic acids of the same concentration were measured.

acid X	pH = 5
acid Y	pH = 2
acid Z	pH = 3

(i) Identify which solution is the least acidic. *[1]*

(ii) Deduce how the $[H^+]$ values compare in solutions of acids Y and Z. *[2]*

(iii) Arrange the solutions of the three acids in decreasing order of electrical conductivity, starting with the greatest conductivity, giving a reason for your choice. *[2]*

(iv) Identify **one** substance that could be added to a solution of acid X to form a buffer solution. *[1]*

7. Ethene, propene and but-2-ene are members of the alkene homologous series.

(a) Describe **three** features of members of a homologous series. *[3]*

(b) State and explain which compound has the highest boiling point. *[3]*

(c) Draw the structural formula and give the name of an alkene containing five carbon atoms. *[2]*

(d) Write an equation for the reaction between but-2-ene and hydrogen bromide, showing the structure of the organic product. State the type of reaction occurring. *[3]*

(e) Propene can be converted to propanoic acid in three steps:

$$\text{propene} \xrightarrow{\text{step 1}} \text{propan-1-ol} \xrightarrow{\text{step 2}} \text{propanal} \xrightarrow{\text{step 3}} \text{propanoic acid}$$

State the type of reaction occurring in steps 2 and 3 and the reagents needed. Describe how the conditions of the reaction can be altered to obtain the maximum amount of propanal, and in a separate experiment, to obtain the maximum amount of propanoic acid. *[5]*

(f) Identify the strongest type of intermolecular force present in each of the compounds propan-1-ol, propanal and propanoic acid. List these compounds in decreasing order of boiling point. *[4]*