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

N06/4/CHEMI/SP2/ENG/TZ0/XX

88066105

CHEMISTRY
STANDARD LEVEL
PAPER 2

Wednesday 8 November 2006 (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 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.

0109

SECTION A

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

1. (a) An organic compound **A** contains 62.0 % by mass of carbon, 24.1 % by mass of nitrogen, the remainder being hydrogen.

(i) Determine the percentage by mass of hydrogen and the empirical formula of **A**. *[3]*

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(ii) Define the term *relative molecular mass.* *[2]*

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(iii) The relative molecular mass of **A** is 116. Determine the molecular formula of **A**. *[1]*

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(b) A molecule of **A** contains an NH_2 group at each end of a hydrocarbon chain.

(i) Draw a structural formula to represent a molecule of **A**. Include any lone pairs of electrons in your structure. *[1]*

(This question continues on the following page)

(Question 1(b) continued)

(ii) Use the VSEPR theory to predict the C–C–N bond angle in **A** and identify the shape of the distribution of electron pairs around the carbon atoms. *[2]*

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(c) Identify the strongest type of intermolecular force in **A** and explain how it arises. *[3]*

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2. Methylamine can be manufactured by the following reaction.

$$CH_3OH(g) + NH_3(g) \rightarrow CH_3NH_2(g) + H_2O(g)$$

(a) Define the term *average bond enthalpy.* *[2]*

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(b) Use information from Table 10 of the Data Booklet to calculate the enthalpy change for this reaction. *[4]*

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(c) In the manufacturing process 2000 kg of each reactant are mixed together.

(i) Identify the limiting reactant, showing your working. *[2]*

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(ii) Calculate the maximum mass, in kg, of methylamine that can be obtained from this mixture of reactants. *[2]*

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3. The elements sodium, aluminium, silicon, phosphorus and sulfur are in period 3 of the periodic table.

(a) Describe the metallic bonding present in aluminium and explain why aluminium has a higher melting point than sodium. *[3]*

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(b) State the electron arrangements of the following species: *[2]*

Si . . . . . .

P^{3-} . . . . . .

(c) Identify the numbers of protons, neutrons and electrons in the species $^{33}S^{2-}$. *[1]*

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(d) Explain, by reference to the intermolecular forces, why sulfur has a higher melting point than phosphorus. *[2]*

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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. Information about the halogens appears in the Data Booklet.

(a) (i) Explain why the ionic radius of chlorine is less than that of sulfur. *[2]*

(ii) Explain what is meant by the term *electronegativity* and explain why the electronegativity of chlorine is greater than that of bromine. *[3]*

(b) For each of the following reactions in aqueous solution, state **one** observation that would be made, and deduce the equation.

(i) The reaction between chlorine and sodium iodide. *[2]*

(ii) The reaction between silver ions and chloride ions. *[2]*

(c) Deduce whether or not each of the reactions in (b) is a redox reaction, giving a reason in each case. *[4]*

(d) (i) Draw a diagram of apparatus that could be used to electrolyse molten potassium bromide. Label the diagram to show the polarity of each electrode and the product formed. *[3]*

(ii) Describe the **two** different ways in which electricity is conducted in the apparatus. *[2]*

(iii) Write an equation to show the formation of the product at each electrode. *[2]*

5. (a) Butane, C_4H_{10}, and but-2-ene, C_4H_8, are both colourless gases at $70\,°C$.

(i) Write an equation for the complete combustion of but-2-ene. *[1]*

(ii) Describe a chemical test, and its result, to distinguish but-2-ene from butane. *[2]*

(iii) Calculate the volume that 0.0200 mol of butane would occupy at $70\,°C$ and 1.10×10^5 Pa. *[3]*

(b) CH_3COCH_3 is the first member of the ketone homologous series. Draw the full structural formula of the next member of this homologous series and predict how its melting point compares with that of CH_3COCH_3. *[2]*

(c) Explain why butan-2-ol, $CH_3CH(OH)CH_2CH_3$, exists as *enantiomers*, and describe how pure samples of the enantiomers can be distinguished experimentally. *[3]*

(d) Ethanal can be used as the starting material for the preparation of an ester. The steps can be summarised as follows:

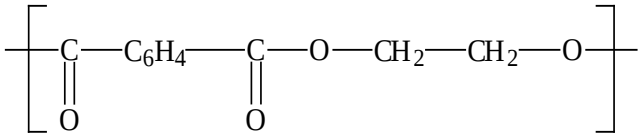
$$CH_3CHO \xrightarrow{\text{Step 1}} CH_3COOH \xrightarrow{\text{Step 2}} CH_3COOCH_2CH_3$$

(i) State the reagents and conditions needed for Step 1 and identify the type of reaction occurring. *[4]*

(ii) State the name of the other organic compound needed for Step 2. *[1]*

(iii) State the name of the ester formed. *[1]*

(e) Polyesters are formed in a condensation reaction. The structure of the repeat unit of a polyester is



(i) Draw the structures of the two monomers that react to form this polyester. *[2]*

(ii) Identify the essential feature of the monomers in (e)(i) that enable them to form a condensation polymer. *[1]*

6. Information about some reactions used in industry is shown in the following table:

Reaction	Equation	$\Delta H^{\ominus}$ / kJ
A	$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$	–184
B	$CH_4(g) + H_2O(g) \rightleftharpoons 3H_2(g) + CO(g)$	+210
C	$CO(g) + H_2O(g) \rightleftharpoons H_2(g) + CO_2(g)$	–42
D	$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$	+180
E	$nC_2H_4(g) \rightarrow (-CH_2-CH_2-)_n(s)$	–92

(a) Identify, with a reason, which of the reactions A to E is/are

(i) the **two** in which an increase in temperature shifts the position of equilibrium to the right. *[2]*

(ii) the **two** in which an increase in pressure shifts the position of equilibrium to the left. *[2]*

(iii) the **one** with the largest decrease in the value of $\Delta S^{\ominus}$. *[2]*

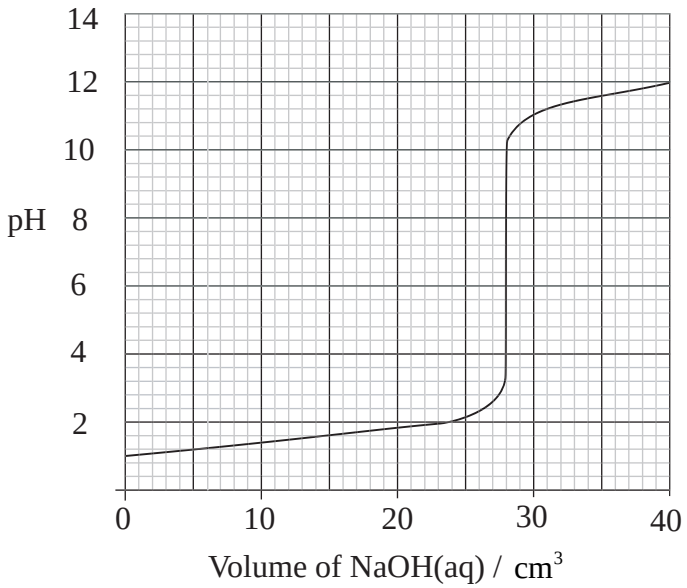
(iv) the **one** with the most negative value of $\Delta G^{\ominus}$ at room temperature. *[2]*

(b) Many reversible reactions in industry use a catalyst. State and explain the effect of a catalyst on the position of equilibrium and on the value of K_c. *[4]*

(This question continues on the following page)

(Question 6 continued)

(c) A titration was carried out to determine the concentration of 25.0 cm^3 of an aqueous solution of nitric acid. The pH value of the liquid in the flask was measured as 0.100 mol dm^{-3}, aqueous sodium hydroxide was added. The results are shown on the graph below.



(i) Use the graph to determine the value of $[H^+]$ of the nitric acid solution. *[1]*

(ii) Determine the pH value when the value of $[H^+]$ has decreased to 1×10^{-3} mol dm^{-3}. *[1]*

(iii) Use the graph to determine the volume of 0.100 mol dm^{-3} aqueous sodium hydroxide solution needed to exactly neutralize the nitric acid. *[1]*

(iv) Calculate the concentration, in mol dm^{-3}, of the nitric acid. *[2]*

(d) The pH values of three acidic solutions, X, Y and Z, are shown in the following table:

Solution	Acid	pH
X	HCl(aq)	2
Y	HCl(aq)	4
Z	CH_3COOH(aq)	4

(i) Solutions X and Z have the same acid concentration. Explain, by reference to both acids, why they have different pH values. *[2]*

(ii) Deduce by what factor the values of $[H^+]$ in solutions X and Y differ. *[1]*