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

M02/420/S(2)

CHEMISTRY
STANDARD LEVEL
PAPER 2

Monday 20 May 2002 (afternoon)

1 hour

Name

Number

INSTRUCTIONS TO CANDIDATES

- Write your candidate name and 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 in a continuation answer booklet, and indicate the number of booklets used in the box below. Write your name and candidate number on the front cover of the continuation answer booklets, and attach them to this question paper using the tag provided.
- At the end of the examination, indicate the number of the Section B question answered in the box below.

QUESTIONS ANSWERED		EXAMINER	TEAM LEADER	IBCA
SECTION A	ALL	/20	/20	/20
SECTION B QUESTION	. . . . .	/20	/20	/20
NUMBER OF CONTINUATION BOOKLETS USED	. . . . .	TOTAL /40	TOTAL /40	TOTAL /40

SECTION A

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

1. The values of atomic radius and ionic radius for the period 3 elements are given below.

Symbol of element	Na	Mg	Al	Si	P	S	Cl
Atomic radius / 10^{-12} m	186	160	143	117	110	104	99
Ionic radius / 10^{-12} m	98	65	45	42	212	190	181

(a) Complete the following table to show the number of protons and electrons in **each** of the following species: *[3]*

	Number of protons	**Number of electrons**
Na	. . . . .	. . . . .
Al^{3+}	. . . . .	. . . . .
P^{3-}	. . . . .	. . . . .

(b) Explain why the **atomic** radius decreases from sodium to chlorine. *[2]*

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(c) The ionic radius of aluminium is smaller than its atomic radius. The ionic radius of phosphorus is greater than its atomic radius. Explain the large difference in ionic radius between aluminium and phosphorus. *[2]*

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(This question continues on the following page)

(Question 1 continued)

(d) Sodium and chlorine both react with water.

(i) Write an equation for the reaction between sodium and water and state whether the resulting solution is acidic, neutral or alkaline. *[2]*

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(ii) Write an equation for the reaction between chlorine and water and state whether the resulting solution is acidic, neutral or alkaline. *[2]*

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2. In aqueous solution, sodium hydroxide is a strong base and ammonia is a weak base.

(a) Use the Brønsted–Lowry theory to state why both substances are classified as bases. *[1]*

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(b) Solutions of 0.1 $\mathrm{mol\,dm^{-3}}$ sodium hydroxide and 0.1 $\mathrm{mol\,dm^{-3}}$ ammonia have different electrical conductivities.

(i) State and explain which solution has the greater conductivity. *[1]*

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(ii) The pH value of 0.1 $\mathrm{mol\,dm^{-3}}$ ammonia solution is approximately 11. State and explain how the pH value of the 0.1 $\mathrm{mol\,dm^{-3}}$ sodium hydroxide solution would compare. *[2]*

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(This question continues on the following page)

(Question 2 continued)

(c) Write an equation to show the reaction of ammonia with water and classify **each** product as a Brønsted–Lowry acid or base. *[2]*

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3. A student was asked to make some copper(II) sulfate-5-water ($CuSO_4 \cdot 5H_2O$) by reacting copper(II) oxide (CuO) with sulfuric acid.

(a) Calculate the molar mass of copper(II) sulfate-5-water. *[1]*

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(b) Calculate the amount (in mol) of copper(II) sulfate-5-water in a 10.0 g sample. *[1]*

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(c) Calculate the mass of copper(II) oxide needed to make this 10.0 g sample. *[1]*

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SECTION B

*Answer **one** question. Write your answers in a continuation answer booklet. Write your name and candidate number on the front cover of the continuation answer booklets, and attach them to this question paper using the tag provided.*

4. This question is about four compounds **A**, **B**, **C** and **D**, which can be made from ethene by the following reactions. All four compounds are liquid at room temperature, and each compound's molecular formula is shown. Two of the reagents needed for the reactions are shown on the arrows.

$$C_2H_4 \xrightarrow{H_2O} \underset{\mathbf{A}}{C_2H_6O} \longrightarrow \underset{\mathbf{B}}{C_2H_4O} \longrightarrow \underset{\mathbf{C}}{C_2H_4O_2} \xrightarrow{C_2H_6O} \underset{\mathbf{D}}{C_4H_8O_2}$$

Magnesium was added to each compound and the only compound that produced a gas was **C**.

(a) Use the information above to identify **each** of the compounds **A**, **B**, **C** and **D**, giving the name of each one. *[4]*

(b) (i) State the type of reaction occurring when **C** is converted to **D**, and state a catalyst that is used. What other product is formed? *[3]*

(ii) Write the structural formulas of **A** and **C**. *[2]*

(iii) State a use of compounds of the same type as **D** in the food industry. *[1]*

(c) Identify the gas formed when **C** reacts with magnesium and write an equation for the reaction occurring. Name the other product of the reaction. *[3]*

(d) Arrange the compounds **A**, **B** and **C** in order of **increasing** boiling point (lowest boiling point first). Explain your choice by referring to the intermolecular forces in **each** case. *[4]*

(e) Compound **C** has another isomer. Name and give the structural formula of this isomer. *[2]*

(f) None of the compounds **A**, **B**, **C** and **D** exist as optical isomers. State the structural feature which is present in a compound that exists as optical isomers. *[1]*

5. Ammonia is made on a large scale by the Haber process. The main reaction occurring is

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ mol}^{-1}.$$

(a) State **two** characteristics of a reversible reaction at equilibrium. *[2]*

(b) This reaction is described as *homogeneous*. State what is meant by the term *homogeneous*. *[1]*

(c) Write the equilibrium constant expression for the reaction. *[2]*

(d) When nitrogen and hydrogen are mixed together at room temperature and atmospheric pressure the reaction is very slow. In industry, typical values of pressure and temperature used are 250 atmospheres and 450 °C.

(i) State the effects on both the rate of reaction and the value of the equilibrium constant of increasing the temperature. *[2]*

(ii) State the effects on both the rate of reaction and the value of the equilibrium constant of increasing the pressure. *[2]*

(iii) Suggest why a pressure of 1000 atmospheres is not used. *[1]*

(e) Name the catalyst used in the Haber process. State and explain its effect on the value of the equilibrium constant. *[3]*

(f) Use the collision theory to explain the effect of increasing the temperature on the rate of reaction between nitrogen and hydrogen. *[3]*

(g) A mixture of nitrogen and hydrogen is left at 450 °C and 250 atmospheres until equilibrium is reached. Use Le Chatelier's principle to state and explain what will happen to the position of equilibrium when

(i) some of the ammonia is removed; *[2]*

(ii) the pressure is increased. *[2]*

6. (a) The elements sodium and fluorine and the compound sodium fluoride can be used to show the connection between bonding, structure and physical properties.

(i) Describe the type of bonding in sodium metal and explain why sodium is a good conductor of electricity. *[4]*

(ii) Draw a Lewis structure for fluorine. Name and describe the bonding within and between the molecules in liquid fluorine. *[5]*

(iii) Write the electronic structures of both sodium and fluorine and describe how the atoms combine to form sodium fluoride. *[4]*

(iv) Explain why sodium fluoride does not conduct electricity until it is heated above its melting point. *[1]*

(b) Sketch and name the shape of each of the following molecules:

(i) SiH_4 *[2]*

(ii) PH_3 *[2]*

(c) State the bond angle in SiH_4 and explain why the bond angle in PH_3 is less than in SiH_4. *[2]*