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

M03/420/S(2)

CHEMISTRY
STANDARD LEVEL
PAPER 2

Candidate number

Wednesday 14 May 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

Answer all questions in the spaces provided.

1. The table below gives information about the percentage yield of ammonia obtained in the Haber process under different conditions.

Pressure/ atmosphere	**Temperature/ °C**			
	200	**300**	**400**	**500**
10	50.7	14.7	3.9	1.2
100	81.7	52.5	25.2	10.6
200	89.1	66.7	38.8	18.3
300	89.9	71.1	47.1	24.4
400	94.6	79.7	55.4	31.9
600	95.4	84.2	65.2	42.3

(a) From the table, identify which combination of temperature and pressure gives the highest yield of ammonia. *[1]*

. . . . . .

(b) The equation for the main reaction in the Haber process is

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H \text{ is negative}$$

Use this information to state and explain the effect on the yield of ammonia of increasing the

(i) pressure: . . . . . *[2]*

. . . . . .

. . . . . .

. . . . . .

(ii) temperature: . . . . . *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(c) In practice, typical conditions used in the Haber process are a temperature of 500 °C and a pressure of 200 atmospheres. Explain why these conditions are used rather than those that give the highest yield. *[2]*

. . . . . .

. . . . . .

. . . . . .

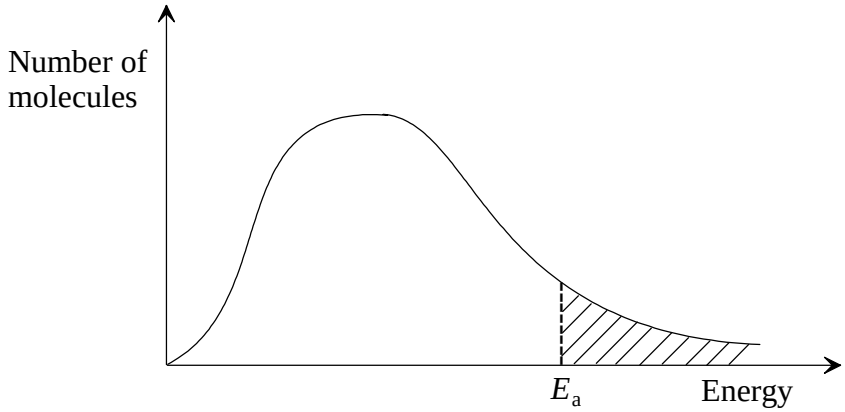
. . . . . .

(d) Write the equilibrium constant expression, K_c, for the production of ammonia. *[1]*

. . . . . .

. . . . . .

2.



The diagram shows the distribution of energy for the molecules in a sample of gas at a given temperature, T_1.

(a) In the diagram E_a represents the *activation energy* for a reaction. Define this term. *[1]*

. . . . . .

. . . . . .

(b) On the diagram above draw another curve to show the energy distribution for the same gas at a higher temperature. Label the curve T_2. *[2]*

(c) With reference to your diagram, state and explain what happens to the rate of a reaction when the temperature is increased. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

3. (a) The relative molecular mass of aluminium chloride is 267 and its composition by mass is 20.3 % Al and 79.7 % chlorine. Determine the empirical and molecular formulas of aluminium chloride. *[4]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Sodium reacts with water as follows.

$$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$$

1.15 g of sodium is allowed to react completely with water. The resulting solution is diluted to 250 cm^3. Calculate the concentration, in mol dm^{-3}, of the resulting sodium hydroxide solution. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

4. Explain the following statements.

(a) The first ionization energy of sodium is

(i) less than that of magnesium. *[2]*

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(ii) greater than that of potassium. *[1]*

. . . . . .
. . . . . .

(b) The electronegativity of chlorine is higher than that of sulfur. *[2]*

. . . . . .
. . . . . .
. . . . . .
. . . . . .

5. The element vanadium has two isotopes, $^{50}_{23}V$ and $^{51}_{23}V$, and a relative atomic mass of 50.94.

(a) Define the term *isotope*. *[1]*

. . . . . .

. . . . . .

(b) State the number of protons, electrons and neutrons in $^{50}_{23}V$. *[2]*

. . . . . .

. . . . . .

(c) State and explain which is the more abundant isotope. *[1]*

. . . . . .

. . . . . .

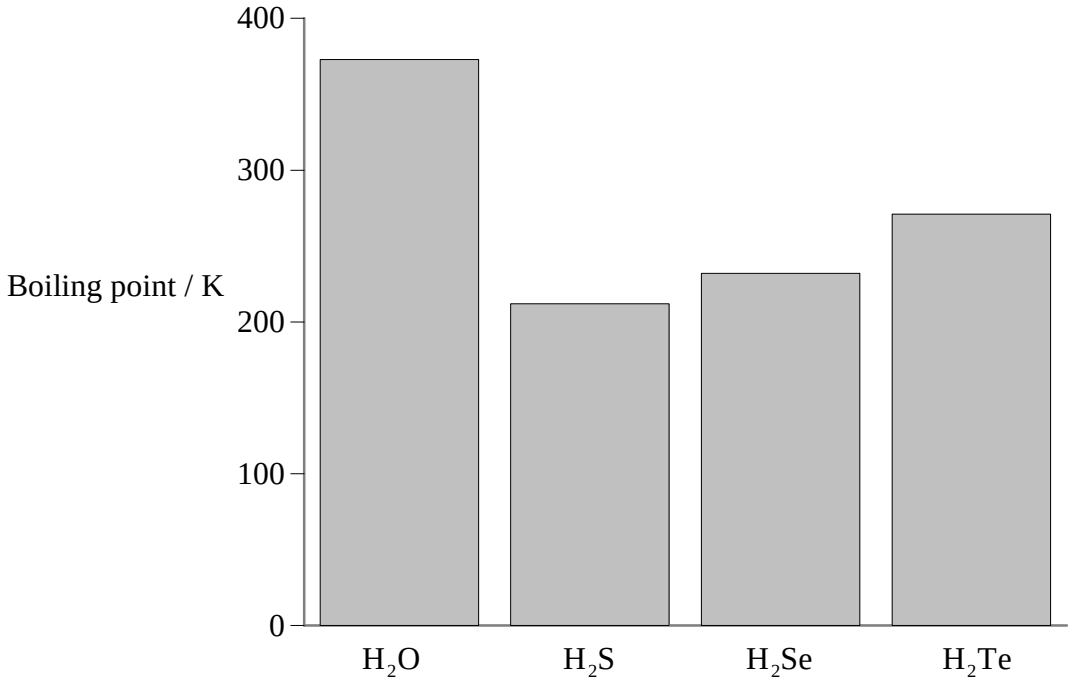
(d) State the name and the mass number of the isotope relative to which **all** atomic masses are measured. *[1]*

. . . . . .

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) The boiling points of the hydrides of the group 6 elements are shown below.



(i) Explain the trend in boiling points from H_2S to H_2Te. *[2]*

(ii) Explain why the boiling point of water is higher than would be expected from the group trend. *[2]*

(b) (i) State the shape of the electron distribution around the oxygen atom in the water molecule and state the shape of the molecule. *[2]*

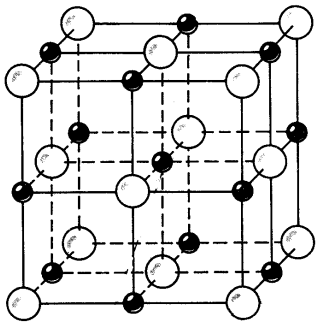
(ii) State and explain the value of the HOH bond angle. *[2]*

(c) Explain why the bonds in silicon tetrachloride, $SiCl_4$, are polar, but the molecule is not. *[2]*

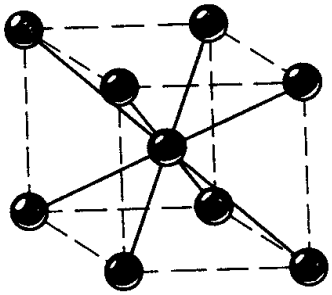
(This question continues on the following page)

(Question 6 continued)

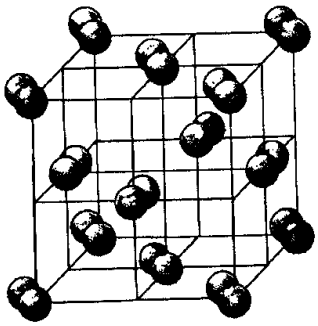
The diagrams below represent the structures of iodine, sodium and sodium iodide.



A



B



C

(d) (i) Identify which of the structures (**A**, **B** and **C**) correspond to iodine, sodium and sodium iodide. *[1]*

(ii) State the type of bonding in each structure. *[3]*

(e) (i) Sodium and sodium iodide can both conduct electricity when molten, but only sodium can conduct electricity when solid. Explain this difference in conductivity in terms of the structures of sodium and sodium iodide. *[4]*

(ii) Explain the high volatility of iodine compared to sodium and sodium iodide. *[2]*

7. (a) Define the terms *strong acid* and *weak acid*. Using hydrochloric and ethanoic acid as examples, write equations to show the dissociation of each acid in aqueous solution. *[4]*

(b) (i) Calcium carbonate is added to separate solutions of hydrochloric acid and ethanoic acid of the same concentration. State **one** similarity and **one** difference in the observations you could make. *[2]*

(ii) Write an equation for the reaction between hydrochloric acid and calcium carbonate. *[2]*

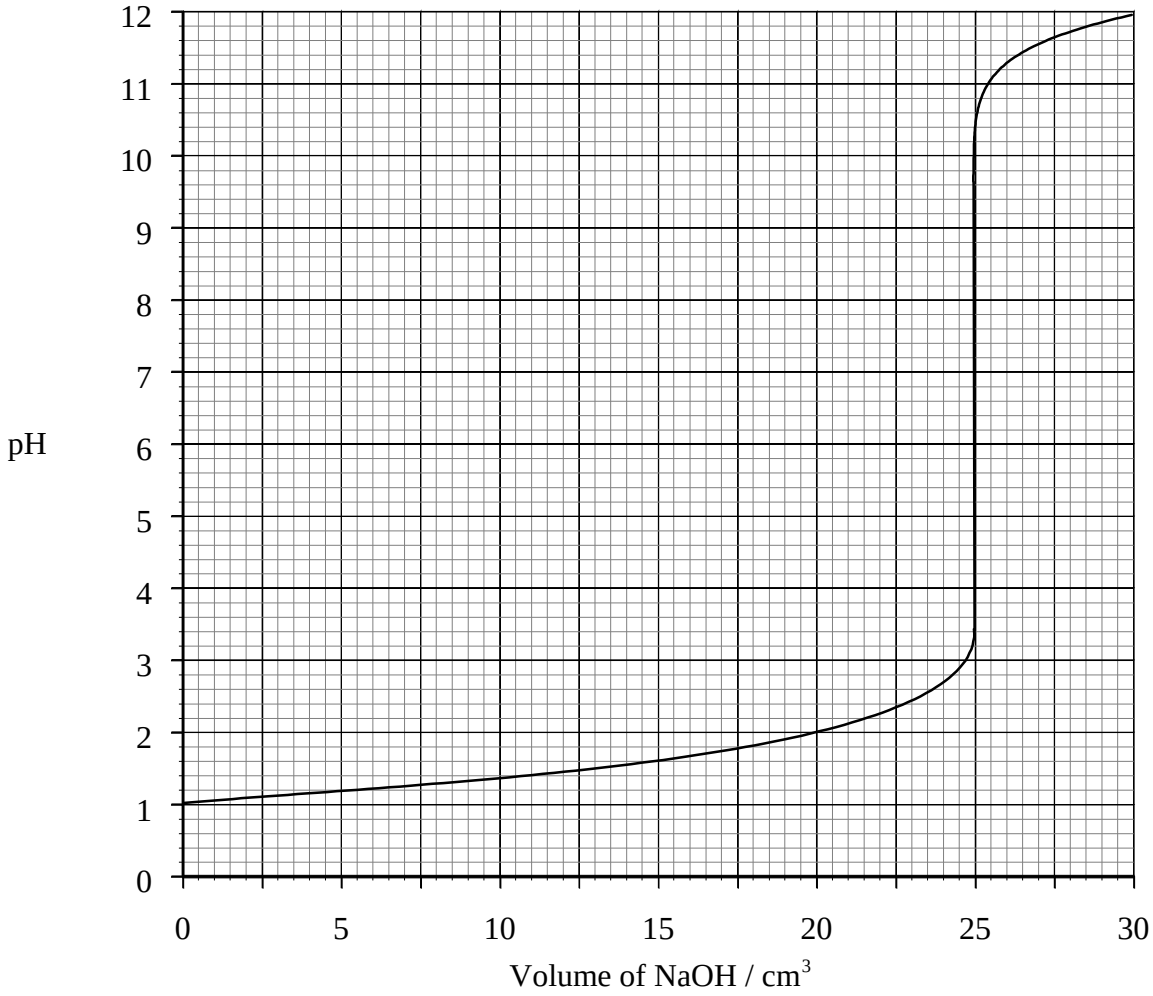
(iii) Determine the volume of 1.50 mol dm^{-3} hydrochloric acid that would react with exactly 1.25 g of calcium carbonate. *[3]*

(iv) Calculate the volume of carbon dioxide, measured at 273 K and 1.01×10^{5} Pa , which would be produced when 1.25 g of calcium carbonate reacts completely with the hydrochloric acid. *[2]*

(This question continues on the following page)

(Question 7 continued)

(c) The graph below shows the change in pH when aqueous sodium hydroxide is added to 20 cm^3 of aqueous hydrochloric acid.



By reference to the graph

(i) state the $[H^+]$ before any alkali is added. *[1]*

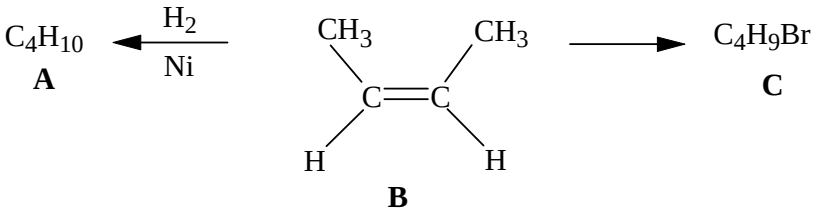
(ii) state by how much the $[H^+]$ changes after the addition of 20 cm^3 of aqueous sodium hydroxide. *[1]*

(iii) determine the volume of the same sodium hydroxide solution needed to neutralize 20 cm^3 of aqueous ethanoic acid of the same concentration as the hydrochloric acid. *[1]*

(d) (i) Define the term *buffer solution*. *[2]*

(ii) State a suitable mixture that can act as a buffer solution. *[2]*

8. Two reactions of an alkene, **B**, are shown below.



(a) (i) State the name of **A** and write an equation for its complete combustion. Explain why the incomplete combustion of **A** is dangerous. *[5]*

(ii) Outline a test to distinguish between **A** and **B**, stating the result in each case. *[3]*

(iii) Write an equation for the conversion of **B** to **C**. State the type of reaction taking place and draw the structure of **C**. *[3]*

(b) (i) A compound **D** has the molecular formula $C_2H_4O_2$ and is obtained from a reaction between methanoic acid and methanol. Write an equation for this reaction and state the name of **D**. *[3]*

(ii) A second compound, **E**, has the same molecular formula as **D** and has acidic properties. State the name of compound **E**. *[1]*

(c) The first synthetic thread was made from a polyester. A section of the polyester is drawn below:

——CH_2COO——CH_2COO——CH_2COO——

(i) Give the structural formula of the monomer (containing two functional groups) that could be used to make this polyester and state the names of the two functional groups. *[3]*

(ii) State, giving a reason, whether this polyester is made by a condensation reaction or an addition reaction. *[2]*