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

N04/4/CHEMI/SP2/ENG/TZ0/XX

88046105

CHEMISTRY
STANDARD LEVEL
PAPER 2

School code

Candidate code

Wednesday 17 November 2004 (afternoon)

1 hour 15 minutes

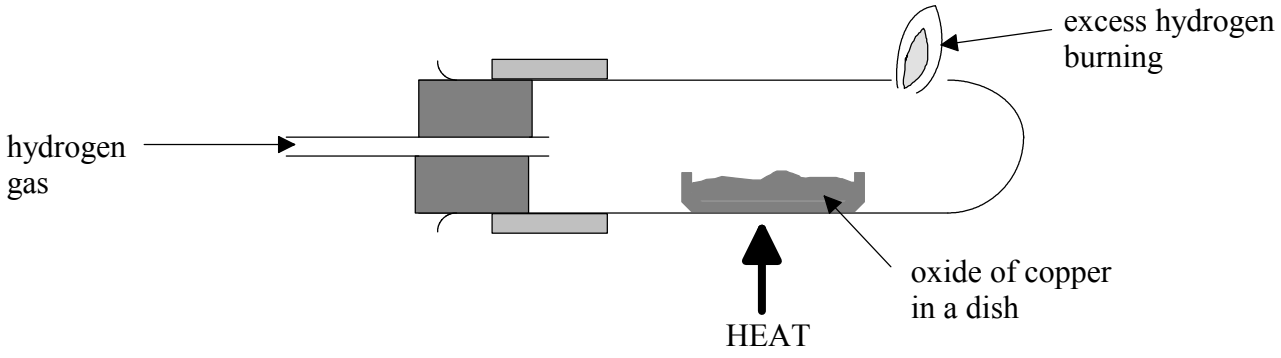
INSTRUCTIONS TO CANDIDATES

- Write your school code and candidate code 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 school code and candidate code 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. An oxide of copper was reduced in a stream of hydrogen as shown below.



After heating, the stream of hydrogen gas was maintained until the apparatus had cooled.

The following results were obtained.

Mass of empty dish = 13.80 g
Mass of dish and contents before heating = 21.75 g
Mass of dish and contents after heating and leaving to cool = 20.15 g

(a) Explain why the stream of hydrogen gas was maintained until the apparatus cooled. *[1]*

. . . . . .

. . . . . .

(b) Calculate the empirical formula of the oxide of copper using the data above, assuming complete reduction of the oxide. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(c) Write an equation for the reaction that occurred. *[1]*

. . . . . .

(d) State **two** changes that would be observed inside the tube as it was heated. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

2. The alkanes are a *homologous series* of *saturated hydrocarbons*.

(a) State the meaning of each of the following terms.

(i) *homologous series* *[2]*

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

(ii) *hydrocarbon* *[1]*

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

(iii) *saturated* *[1]*

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

(b) (i) State and explain the trend in the boiling points of the first five alkanes. *[2]*

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

(ii) Explain why the enthalpies of combustion of alkanes are negative values. *[1]*

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

(c) State the products of the complete combustion of alkanes. *[2]*

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

3. (a) Define the term *average bond enthalpy*, illustrating your answer with an equation for methane, CH_4. *[3]*

. . . . . .

. . . . . .

. . . . . .

(b) The equation for the reaction between methane and chlorine is

$$CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$$

Use the values from Table 10 of the Data Booklet to calculate the enthalpy change for this reaction. *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) Explain why no reaction takes place between methane and chlorine at room temperature unless the reactants are sparked, exposed to UV light or heated. *[2]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(d) Draw an enthalpy level diagram for this reaction. *[2]*

4. A 0.01 mol dm^{-3} solution of hydrochloric acid has a pH value of 2. Suggest, with a reason, the pH values of

(a) 0.10 mol dm^{-3} hydrochloric acid. *[2]*

. . . . . .

. . . . . .

. . . . . .

(b) 0.10 mol dm^{-3} ethanoic acid. *[2]*

. . . . . .

. . . . . .

. . . . . .

SECTION B

*Answer **one** question. Write your answers on the answer sheets provided. Write your school code and candidate code on each answer sheet, and attach them to this examination paper and your cover sheet using the tag provided.*

5. (a) The plastic PVC, poly(chloroethene), is made from the monomer chloroethene, C_2H_3Cl, by a polymerization reaction.

(i) Draw the structural formula of chloroethene. *[1]*

(ii) State the type of polymerization reaction that occurs to make poly(chloroethene) and identify the structural feature needed in the monomer. *[2]*

(iii) Draw the structure of the repeating unit of poly(chloroethene). *[1]*

(iv) Explain why monomers are often gases or volatile liquids, whereas polymers are solids. *[2]*

(b) Hexanedioic acid and 1,6-diaminohexane react together to form a synthetic polymer. There are many natural polymers, some of the most familiar being proteins formed from 2-amino acids.

(i) Give the structural formula of each monomer in the synthetic polymer. *[2]*

(ii) State the type of polymerization reaction that occurs between these two monomers and identify the structural feature needed in the monomers. *[2]*

(iii) Draw the structure of and state the type of linkage formed in this polymer, and identify the other product of this polymerization reaction. *[3]*

(iv) The structures of some 2-amino acids are shown in Table 20 of the Data Booklet. Using alanine as an example, explain what is meant by the term *optical activity*, identify the structural feature that needs to be present and illustrate your answer with suitable diagrams of both isomers. *[3]*

(v) Identify a 2-amino acid from Table 20 which does **not** show optical activity. *[1]*

(vi) Polyesters are formed in a similar polymerization reaction to proteins. Their monomers are esters. State **one** use of esters and identify the **two** compounds that react together to form the ester ethyl methanoate. *[3]*

6. (a) Nitrogen is found in period 2 and group 5 of the periodic table.

(i) Distinguish between the terms *period* and *group*. *[1]*

(ii) State the electron arrangement of nitrogen and explain why it is found in period 2 and group 5 of the periodic table. *[3]*

(b) Table 8 of the Data Booklet gives the atomic and ionic radii of elements. State and explain the difference between

(i) the atomic radius of nitrogen and oxygen. *[2]*

(ii) the atomic radius of nitrogen and phosphorus. *[1]*

(iii) the atomic and ionic radius of nitrogen. *[2]*

(c) An important compound of nitrogen is ammonia, NH_3. The chemistry of ammonia is influenced by its polarity and its ability to form hydrogen bonds. Polarity can be explained in terms of electronegativity.

(i) Explain the term *electronegativity*. *[2]*

(ii) Draw a diagram to show hydrogen bonding between two molecules of NH_3. The diagram should include any dipoles and/or lone pairs of electrons *[3]*

(iii) State the H—N—H bond angle in an ammonia molecule. *[1]*

(iv) Explain why the ammonia molecule is polar. *[1]*

(d) Ammonia reacts with hydrogen ions forming ammonium ions, NH_4^+.

(i) State the H—N—H bond angle in an ammonium ion. *[1]*

(ii) Explain why the H—N—H bond angle of NH_3 is different from the H—N—H bond angle of NH_4^+; referring to both species in your answer. *[3]*

7. When excess lumps of magnesium carbonate are added to dilute hydrochloric acid the following reaction takes place.

$$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + CO_2(g) + H_2O(l)$$

(a) Outline **two** ways in which the rate of this reaction could be studied. In each case sketch a graph to show how the value of the chosen variable would change with time. *[4]*

(b) State and explain **three** ways in which the rate of **this** reaction could be increased. *[6]*

(c) State and explain whether the total volume of carbon dioxide gas produced would increase, decrease or stay the same if

(i) more lumps of magnesium carbonate were used. *[2]*

(ii) the experiments were carried out at a higher temperature. *[2]*

(d) Carbon dioxide gas in the atmosphere reacts slightly with rainwater as shown below.

$$CO_2(g) + H_2O(l) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

(i) State the meaning of the $\rightleftharpoons$ sign. *[1]*

(ii) Predict the effect, if any, of the presence of a catalyst on the acidity of rainwater. Give a reason for your answer. *[2]*

(iii) Use Le Chatelier's principle to predict the effect of the addition of a small quantity of an alkali on the acidity of rainwater. Explain what effect, if any, this would have on the equilibrium constant, K_c. *[3]*