INTERNATIONAL BACCALAUREATE
BACCALAURÉAT INTERNATIONAL
BACHILLERATO INTERNACIONAL

M01/420/H(2)

CHEMISTRY
HIGHER LEVEL
PAPER 2

Thursday 10 May 2001 (afternoon)

2 hours 15 minutes

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 two questions 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 numbers of the Section B questions answered in the boxes below.

QUESTIONS ANSWERED		EXAMINER	TEAM LEADER	IBCA
SECTION A	ALL	/40	/40	/40
SECTION B				
QUESTION	. . . . .	/25	/25	/25
QUESTION	. . . . .	/25	/25	/25
NUMBER OF CONTINUATION BOOKLETS USED	. . . . .	TOTAL /90	TOTAL /90	TOTAL /90

SECTION A

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

In order to receive full credit in Section A, the method used and the steps involved in arriving at your answer must be shown clearly. It is possible to receive partial credit but, without your supporting work, you may receive little credit. For numerical calculations, you are expected to pay proper attention to significant figures.

1. (a) Using the Periodic Table (Table 5) in the Data Booklet, give the symbol(s) of:

(i) an element with a ground state electronic configuration of [Xe] $6s^2\,4f^{14}\,5d^{10}\,6p^1$. *[1]*

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(ii) an ion with a double positive charge (2+) with an electronic configuration of [Ar] $3d^5$. *[1]*

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(iii) **two** elements with a ground state configuration of ns^2np^3. *[1]*

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(b) Describe the emission spectrum of hydrogen. Explain how this spectrum is related to the energy levels in hydrogen. *[3]*

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(c) Give **two** reasons why the lithium ion, Li^+, has a smaller radius than the lithium atom. *[2]*

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(This question continues on the following page)

(Question 1 continued)

(d) Give **two** reasons why noble gases are not assigned electronegativity values. *[2]*

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2. (a) An anti-cancer drug called Cisplatin has the following percentage composition by mass:

$$\text{Pt} = 65.01\ \%,\ \text{Cl} = 23.63\ \%,\ \text{N} = 9.340\ \%,\ \text{H} = 2.020\ \%.$$

Calculate the empirical formula of Cisplatin.
(Relative Atomic Masses are $\text{Pt} = 195.09$, $\text{Cl} = 35.45$, $\text{N} = 14.01$, $\text{H} = 1.01$.) *[3]*

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(b) The molecular and empirical formulas of Cisplatin are the same. Analysis of the molecule shows platinum to be the central atom, being bonded to four separate atoms; the hydrogen is bonded to nitrogen. Draw a representation of the molecule. *[1]*

(c) 16.20×10^{-3} dm^3 of 0.1020 mol dm^{-3} aqueous AgNO_3 is added to 14.80×10^{-3} dm^3 of 0.1250 mol dm^{-3} aqueous NaCl. Calculate the maximum mass (g) of AgCl which could be obtained from this reaction. (Relative Atomic Masses are $\text{Ag} = 107.87$, $\text{Cl} = 35.45$.) *[4]*

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3. (a) (i) Define the term *standard enthalpy of formation*. *[2]*

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(ii) Write an equation, including state symbols, to show the formation of propane. *[1]*

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(b) (i) State what is meant by the term *average bond enthalpy*. Use the average bond enthalpies, provided in the Data Booklet (Table 10), to calculate the enthalpy change ($\Delta H^{\ominus}$) for the following reaction:

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$$ *[5]*

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(ii) Suggest, with a reason, whether the entropy change ($\Delta S^{\ominus}$) for the reaction would be positive or negative. *[2]*

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4. When 1.0 mole of ethanoic acid is mixed with 1.0 mole ethanol, and the mixture allowed to reach equilibrium, the following reaction occurs:

$$CH_3COOH(l) + C_2H_5OH(l) \rightleftharpoons CH_3COOC_2H_5(l) + H_2O(l)$$

The amounts of ethyl ethanoate and water at equilibrium are both 0.67 moles.

(a) (i) What is meant by the term *equilibrium*? *[2]*

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(ii) Write an expression for K_c for this reaction. *[1]*

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(iii) Calculate the value of K_c for this reaction. *[2]*

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(b) For the dissociation $H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$, the ionic product is given by $K_w = [H^+(aq)][OH^-(aq)]$. The value of K_w is 1.0×10^{-14} $mol^2\,dm^{-6}$ at 298 K and 2.4×10^{-14} $mol^2\,dm^{-6}$ at 310 K. Using Le Chatelier's principle, deduce whether the dissociation of water is exothermic or endothermic. *[3]*

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(Question 4 continued)

(c) For the system $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ state and explain the effect on the position of equilibrium of

(i) adding a catalyst. *[2]*

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(ii) adding some helium gas but keeping the total gas volume constant. *[2]*

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SECTION B

*Answer **two** questions. 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.*

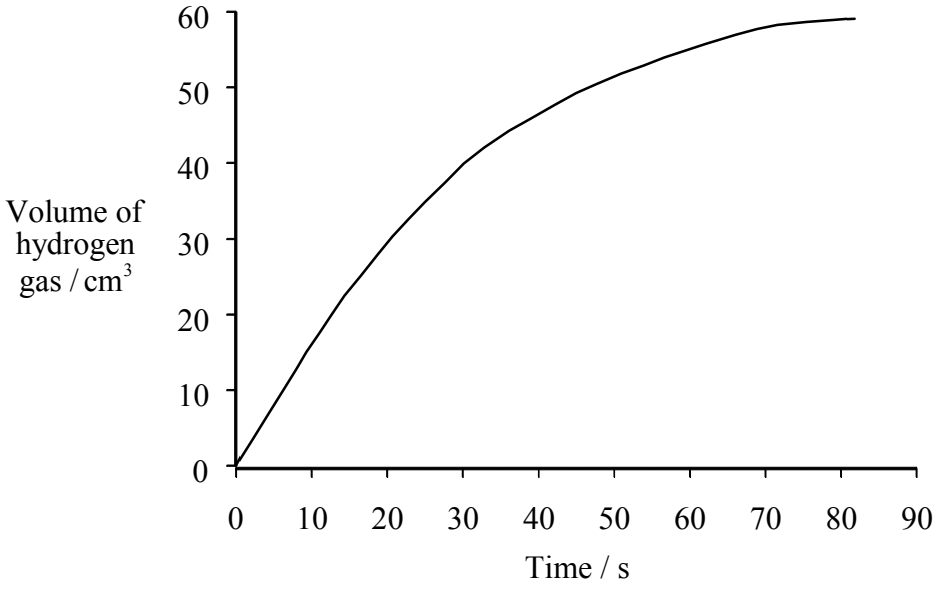
5. Magnesium reacts exothermically with dilute sulfuric acid according to the following equation:

$$Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$$

(a) Outline an experimental procedure by which you could obtain a value for the rate of this reaction. *[6]*

(b) From the results of such an experiment using excess magnesium ribbon and sulfuric acid of concentration **0.6 mol dm^{-3}**, the graph shown in Figure 1 was obtained. Describe how and explain why the slope of the curve changes with time. *[2]*

Figure 1



(c) Sketch the graph shown in Figure 1 and label the curve A.

(i) The experiment is repeated using the same mass of magnesium ribbon and the same volume of acid of concentration **0.3 mol dm^{-3}**. Show on the same sketch the curve you would expect to obtain and label it B. Explain your choice at a molecular level. *[3]*

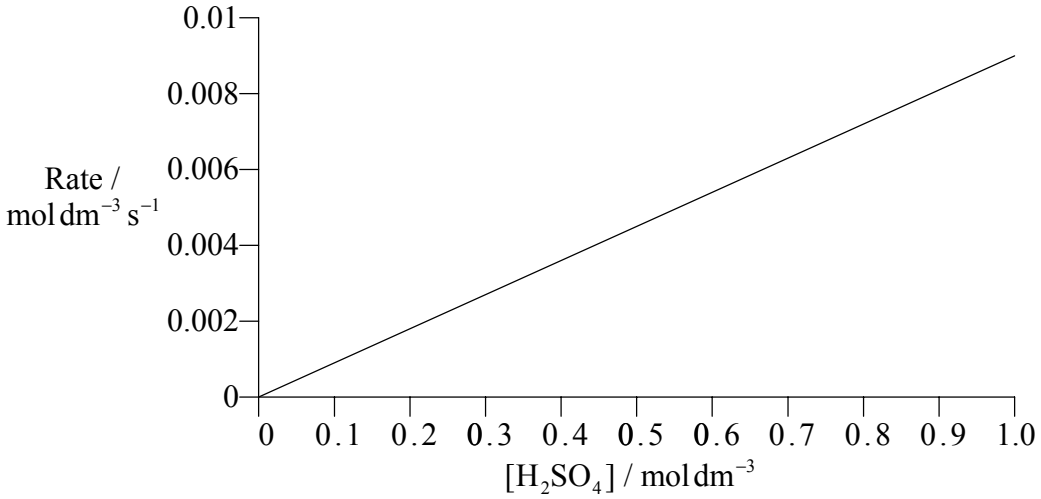
(ii) The experiment is repeated using the same mass of magnesium **powder** and the same volume of acid of concentration **0.6 mol dm^{-3}**. Show on the same sketch the curve you would expect to obtain and label it C. Explain your choice at a molecular level. *[3]*

(This question continues on the following page)

(Question 5 continued)

(d) From the results of a series of experiments involving magnesium and sulfuric acid, a graph of rate against acid concentration was plotted (Figure 2). Use Figure 2 to deduce the order of reaction with respect to sulfuric acid. *[2]*

Figure 2



(e) Under the conditions used, the order of reaction with respect to magnesium is zero. Give the rate expression for this reaction. Calculate the value of the rate constant and give its units. State how the value of the rate constant would change if the experiment were repeated at a higher temperature. *[4]*

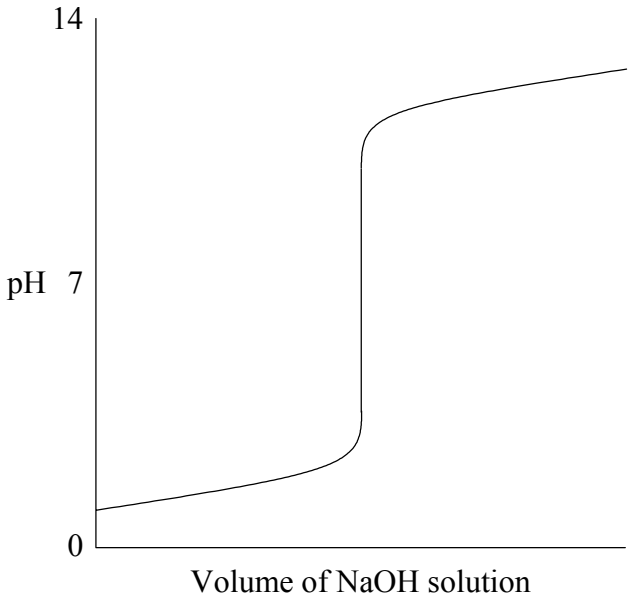
(f) Sketch an enthalpy level diagram for an exothermic reaction, showing the enthalpy change, (ΔH), the activation energy, (E_a), and the activation energy for the catalysed reaction, (E_{cat}). *[5]*

6. (a) State the definitions of an acid and a base according to the Brønsted–Lowry **and** Lewis theories. Give a different equation to illustrate an acid–base reaction for **each** theory, identifying clearly the acid and the base. State the type of bond formed in a Lewis acid-base reaction. *[7]*

(b) State the difference between a strong acid and a weak acid and give **one** example of **each**. *[2]*

(c) Explain qualitatively how an acid-base indicator works. *[4]*

(d) Sodium hydroxide solution is added to aqueous hydrochloric acid. The graph of pH against volume of sodium hydroxide solution added is shown below:



Sketch clearly labelled corresponding graphs for each of the following and suggest a suitable indicator in each case:

(i) The addition of sodium hydroxide solution to aqueous ethanoic acid. *[3]*

(ii) The addition of ammonia solution to aqueous hydrochloric acid. *[3]*

(e) $30\,\text{cm}^3$ of $0.100\ \text{mol dm}^{-3}\ CH_3COOH$ is placed in a beaker and mixed with $10\,\text{cm}^3$ of $0.100\ \text{mol dm}^{-3}\ NaOH$.

(i) Explain, with the help of an equation, how the solution formed acts as a buffer solution when a small quantity of acid is added to it. *[2]*

(ii) Calculate the pH of the buffer solution. (K_a of $CH_3COOH = 1.74\times10^{-5}\ \text{mol dm}^{-3}$) *[4]*

7. (a) Redox equations may be balanced using changes in oxidation number. For the following redox equation calculate the oxidation number of manganese and carbon. Use these values to balance the equation.

$$MnO_4^-(aq) + C_2O_4^{2-}(aq) + H^+(aq) \rightarrow Mn^{2+}(aq) + CO_2(g) + H_2O(l)$$ *[5]*

(b) (i) Draw a cell diagram for the cell formed by connecting the following **standard** half-cells:

$$Ni(s) / Ni^{2+}(aq) \| Cd^{2+}(aq) / Cd(s)$$ *[3]*

(ii) Describe the key features of the standard hydrogen electrode. *[3]*

(c) Given:

$$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s) \qquad E^\ominus = -0.2 \text{ V}$$
$$Cd^{2+}(aq) + 2e^- \rightarrow Cd(s) \qquad E^\ominus = -0.4 \text{ V}$$

(i) Write an equation for the reaction in **each** half-cell, identify the species which is oxidised **and** the oxidising agent. *[4]*

(ii) On the diagram of this cell drawn in (b) (i), label the anode (**A**), and show, with an arrow, the direction of electron flow in the external circuit. *[2]*

(iii) For the overall cell, calculate its voltage and state the sign of ΔG. *[2]*

(d) An aqueous solution of silver nitrate is electrolysed. Predict the product formed at each electrode. *[2]*

(e) A membrane cell is used to electrolyse aqueous sodium chloride. Hydrogen and sodium hydroxide are produced according to the following equation:

$$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$$

A current of 20 A is passed through the solution for 5 hours. Calculate the number of moles of OH^- produced, and the mass of sodium hydroxide formed. *[4]*

8. (a) For **each** of the molecules C_2H_2, C_2Cl_4 and SF_4, draw their Lewis (electron dot) structure, and use the Valence Shell Electron Pair Repulsion (VSEPR) Theory to predict their shape **and** bond angles. *[10]*

(b) State the type of hybridisation in C_2H_2 and C_2Cl_4. *[2]*

(c) Draw **two** resonance structures for **each** of the ethanoate ion ($CH_3CO_2^-$) and the benzene molecule. *[4]*

(d) Comment on

(i) the carbon to oxygen bond length in the ethanoic acid molecule and the ethanoate ion. *[4]*

(ii) the fact that benzene tends not to undergo addition reactions; *[2]*

(iii) the relative acidities of ethanoic acid and ethanol ($pK_a = 4.76$ and approximately 16 respectively). *[3]*
