INTERNATIONAL BACCALAUREATE
BACCALAURÉAT INTERNATIONAL
BACHILLERATO INTERNACIONAL

N99/420/H(2)

CHEMISTRY

Higher Level

Tuesday 16 November 1999 (afternoon)

Paper 2 — 2 hours 15 minutes

A

Candidate name:	Candidate category & number:

This examination paper consists of 2 sections, Section A and Section B.
The maximum mark for Section A is 40.
The maximum mark for Section B is 50.
The maximum mark for this paper is 90.

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. You may use the lined pages at the end of this paper or attach extra sheets of paper with your candidate number clearly marked at the top.

At the end of the examination, complete box B below with the numbers of the questions answered in Section B.

B

QUESTIONS ANSWERED	
A/ ALL	
B/	
B/	
Number of extra sheets attached	

C

EXAMINER	TEAM LEADER
/40	/40
/25	/25
/25	/25
TOTAL /90	TOTAL /90

D

IBCA
/40
/25
/25
TOTAL /90

EXAMINATION MATERIALS

Required:
Calculator
Chemistry Data Booklet
Millimetre square graph paper

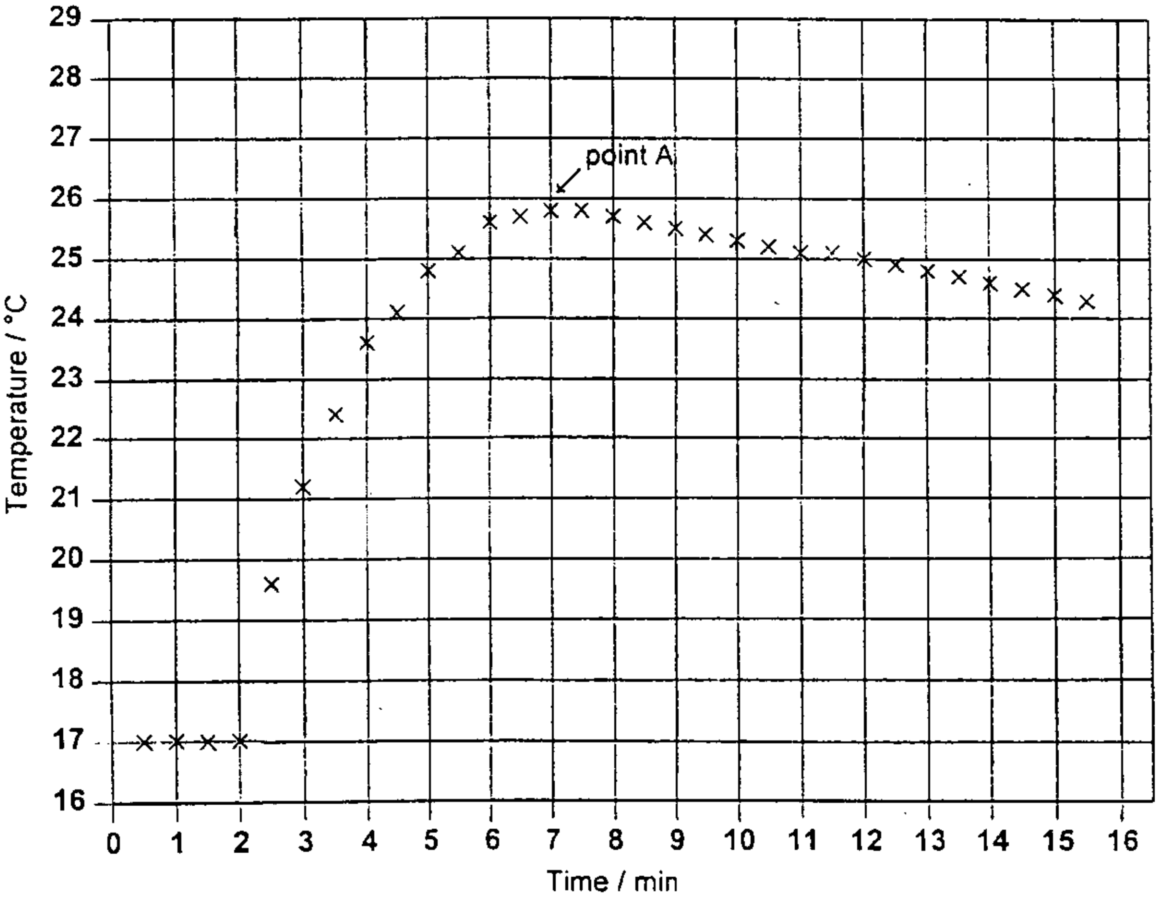
Allowed:
A simple translating dictionary for candidates not working in their own language

SECTION A

Answer ALL questions.

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. In order to determine the enthalpy change of reaction between zinc and copper(II) sulfate, a student placed 50.0 cm^3 of 0.200 $mol\,dm^{-3}$ copper(II) sulfate solution in a polystyrene beaker. The temperature was recorded every 30 seconds. After two minutes 1.20 g of powdered zinc was added. The solution was stirred and the temperature recorded every half minute for the next 14 minutes. The results obtained were then plotted to give the following graph:



(a) Write the equation for the reaction taking place. *[1]*

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(This question continues on the following page)

(Question 1 continued)

(b) Determine which of the two reagents was present in excess. *[2]*

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(c) The highest temperature is reached at point **A**. Explain what is happening in the system at this point. *[1]*

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(d) By drawing a suitable line on the graph estimate what the rise in temperature would have been if the reaction had taken place instantaneously. *[2]*

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(e) Calculate how much heat was evolved during the reaction. Give your answer to **three** significant figures. *[2]*

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(f) What is the enthalpy change of reaction in $kJ\ mol^{-1}$? *[1]*

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(g) The accepted value for the enthalpy change of reaction is $-218\ kJ\ mol^{-1}$. What is the percentage error for the value obtained in this experiment? *[1]*

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(h) Suggest **two** reasons why there is disagreement between the experimental value and the accepted value. *[2]*

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2. (a) Write an equation to show the ionisation of propanoic acid in water. *[1]*

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(b) Give the equilibrium expression for this reaction. *[1]*

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(c) Using information from Table 16 in the Data Booklet, determine the pH of a 0.200 $mol\,dm^{-3}$ aqueous solution of propanoic acid. State the approximation that you have made in arriving at your answer. *[3]*

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(d) What mass of sodium propanoate, $Na^+CH_3CH_2COO^-$, is required in 500 cm^3 of a solution of 0.200 $mol\,dm^{-3}$ propanoic acid to give a pH of 4.87? *[2]*

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(e) Explain, with equations, why the pH of the above solution in (d) will remain relatively constant even if small amounts of acid or alkali are added. *[2]*

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3. Iron shows the characteristic properties of a transition metal.

(a) Why does zinc not show the characteristic properties of a transition metal? *[1]*

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(b) Give the electronic configuration of the Fe^{3+} ion. *[1]*

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(c) Iron can form Fe^{2+} ions as well as Fe^{3+} ions. Give an example of another transition element that can show variable oxidation states, showing clearly **two** of its oxidation states. *[1]*

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(d) Give the formula and describe the shape of the complex ion formed between Fe^{3+} and water. *[2]*

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(e) Explain why complexes of Sc^{3+} are colourless whereas complexes containing Fe^{3+} are coloured. *[2]*

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(f) Explain why iron is used in the Haber process to manufacture ammonia and why is it added in finely divided form rather than in large pieces. *[2]*

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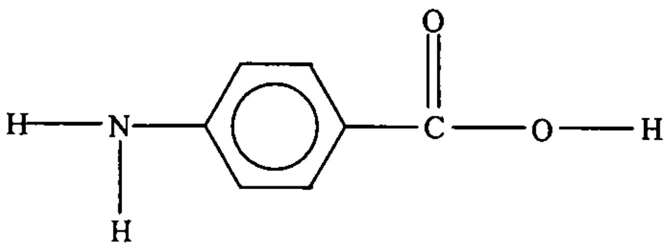
4. (a) Name the **two** functional groups attached to the benzene ring in the following compound: *[2]*



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(b) (i) The above compound undergoes polymerisation. Write the structural formula of the organic product formed when **two** molecules of this compound react with one another. *[1]*

(ii) What name is given to the links between the rings in the polymer formed from this compound? *[1]*

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(iii) Give the name **or** formula of the other substance that is formed in the polymerisation reaction. *[1]*

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(iv) What type of polymerisation reaction is this? *[1]*

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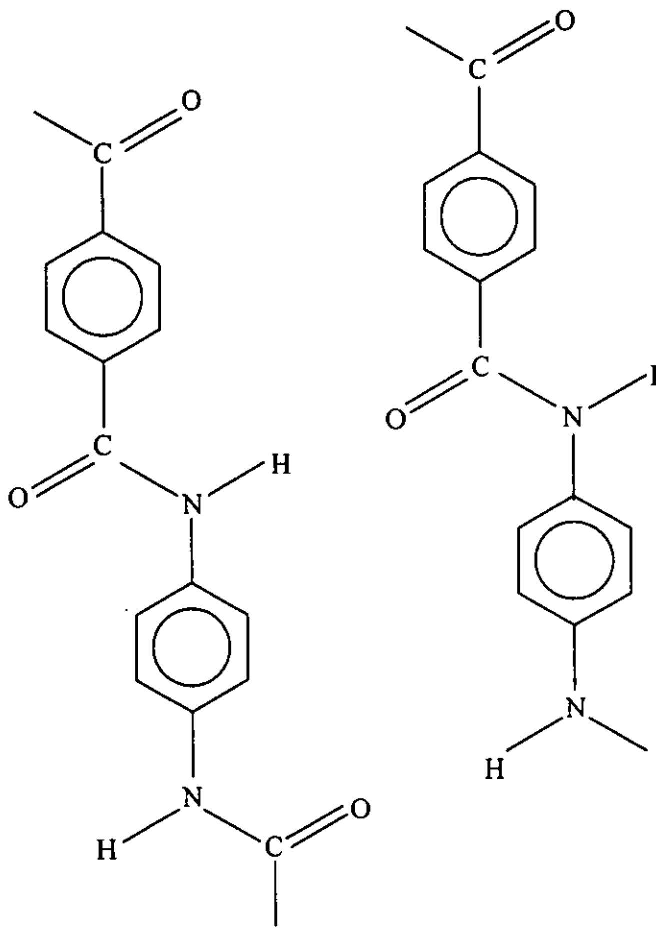
(Question 4 continued)

(c) Kevlar is a very strong material used to make bullet-proof vests. Two strands of the Kevlar polymer are shown below.



(i) Kevlar is particularly strong because hydrogen bonding can occur between the strands. On the above diagram draw in a hydrogen bond showing how it links the strands. *[1]*

(ii) Give the structural formulas of **two** different monomer molecules that can be used to make Kevlar. *[2]*

(iii) Kevlar forms flat sheets which have to be coiled to make a fibre. Explain why sheets of Kevlar are flat. *[1]*

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SECTION B

Answer TWO of the questions in this section. You may use the lined pages at the end of this paper or attach extra sheets of paper with your candidate number clearly marked at the top.

5. (a) Explain what is meant by the terms

(i) dynamic equilibrium. *[2]*

(ii) homogeneous equilibrium. *[2]*

(iii) closed (isolated) system. *[2]*

(b) Two important examples of chemical equilibrium are the formation of hydrogen iodide from hydrogen and iodine and the manufacture of ammonia from hydrogen and nitrogen. The equations for these two reactions are:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H = +52 \text{ kJ mol}^{-1}$$
$$3H_2(g) + N_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92 \text{ kJ mol}^{-1}$$

Write the expression of K_c for the formation of ammonia and give its units if concentrations are expressed as mol dm^{-3}. *[2]*

(c) For **each** of the two reactions above state and explain the effect of the following changes both on the position of equilibrium and on the value of the equilibrium constant, K_c.

(i) Increasing the volume of the reaction vessel. *[6]*

(ii) Lowering the temperature. *[6]*

(iii) Adding a catalyst. *[3]*

(d) At 600 K the numerical value of K_c for the reaction between H_2 and I_2 shown in (b) is 54.7. Calculate K_c for the following reaction at 600 K:

$$HI(g) \rightleftharpoons \tfrac{1}{2}H_2(g) + \tfrac{1}{2}I_2(g)$$ *[2]*

6. (a) The rate constant, k, for any reaction is related to the activation energy, E_a, by the Arrhenius equation.

(i) Explain the meaning of the terms: *rate constant* and *activation energy*. *[4]*

(ii) A particular reaction is found to be second order overall. Specify the units for both the rate of reaction and the rate constant. *[2]*

(b) Rates of reactions depend on temperature.

(i) Using the same sets of axes, draw **two** clearly labelled curves to show the distribution of energies of the molecules of a fixed mass of gas at different temperatures, T_1 and T_2 where T_2 is the higher temperature. *[4]*

(ii) With reference to the curves in (i) explain why an increase in temperature increases the rate of a gaseous reaction. *[2]*

(iii) Explain briefly how a catalyst can increase the rate of a chemical reaction. *[2]*

(c) The rate constant, k, was determined for the decomposition of hydrogen iodide at various temperatures. The results giving $\ln k$ for a range of temperatures are given below.

Temperature T/K	$\ln k$	T^{-1} / K^{-1}
550	−15.6	1.82×10^{-3}
600	−12.2	1.67×10^{-3}
650	−9.4	1.54×10^{-3}
700	−7	1.43×10^{-3}
750	−4.9	1.33×10^{-3}

(i) Plot a graph of $\ln k$ against T^{-1}.
(Take the $\ln k$ axis from −20 to 0 and the T^{-1} axis from 1.2×10^{-3} to 1.9×10^{-3} K^{-1}) *[4]*

(ii) Calculate the gradient (slope) of your graph and use it to determine a value for the activation energy, E_a, stating its units. *[5]*

(iii) Without obtaining the actual value, state **two** different ways in which the value of A in the Arrhenius equation could be determined. *[2]*

7. (a) The properties of an unknown metal **M** and its ions are being investigated.

(i) Assuming that there is a supply of the metal and its soluble sulfate, describe how the standard electrode potential, $M^{2+}(aq) / M(s)$, could be determined.
(You may answer by drawing a fully-labelled diagram if you wish.) *[8]*

(ii) M also forms an oxyanion, MO_3^-, that is readily converted to M^{2+} in acid solution. Calculate the oxidation number of M in the MO_3^- ion. State and explain whether $MO_3^- \rightarrow M^{2+}$ is an oxidation or a reduction process. Write a balanced half-equation for this reaction. *[3]*

(iii) The standard electrode potential for the reaction in (a) (ii) is found to be +1.2 V. Using Table 15 in the Data Booklet explain how this value could be used to predict whether MO_3^- would oxidise Br^- ions to Br_2 or whether Br_2 would oxidise colourless M^{2+} to MO_3^-. Write a balanced equation for the reaction that would be expected to occur. How could this prediction be tested experimentally? (Give the observations you would expect for both a positive and negative result.) Suggest a reason why this prediction might not be realised in practice. *[8]*

(b) Electrolysis of molten potassium bromide and aqueous potassium bromide produces some products which are the same, and others which are different. Write balanced equations for the electrolysis in each case and account for the different products formed. *[6]*

8. (a) (i) Butane, C_4H_{10}, propanal, C_3H_6O, and propan-1-ol, C_3H_8O have very similar molar masses (59 ± 1). Draw the Lewis structure of each of these molecules. *[3]*

(ii) For **each** of the three molecules state how many carbon atoms are sp, sp^2 and sp^3 hybridised. *[3]*

(b) What are the values for:

(i) $H\hat{O}C$ bond angle in propan-1-ol? *[1]*

(ii) $H\hat{C}O$ bond angle in propanal? *[1]*

(c) Explain:

(i) why butane has the lowest boiling point of the three compounds. *[2]*

(ii) why propan-1-ol has the highest boiling point of the three compounds. *[2]*

(iii) what type of intermolecular bonding occurs in propanal. *[2]*

(d) Propan-1-ol and propanioc acid both contain an –OH group. Explain why the –OH group is acidic in propanoic acid but not in propan-1-ol. *[3]*

(e) Give **three** different pieces of evidence to support the fact that the six carbon atoms in the benzene ring are not joined by alternate double and single carbon to carbon bonds. Describe the bonding in benzene in terms of the delocalisation of electrons and show how this description accounts for each of the three pieces of evidence you have chosen. *[8]*
