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CHEMISTRY
STANDARD LEVEL
PAPER 2

Thursday 8 May 2008 (afternoon)

1 hour 15 minutes

Candidate session number

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INSTRUCTIONS TO CANDIDATES

- Write your session 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 on answer sheets. Write your session 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.

0110

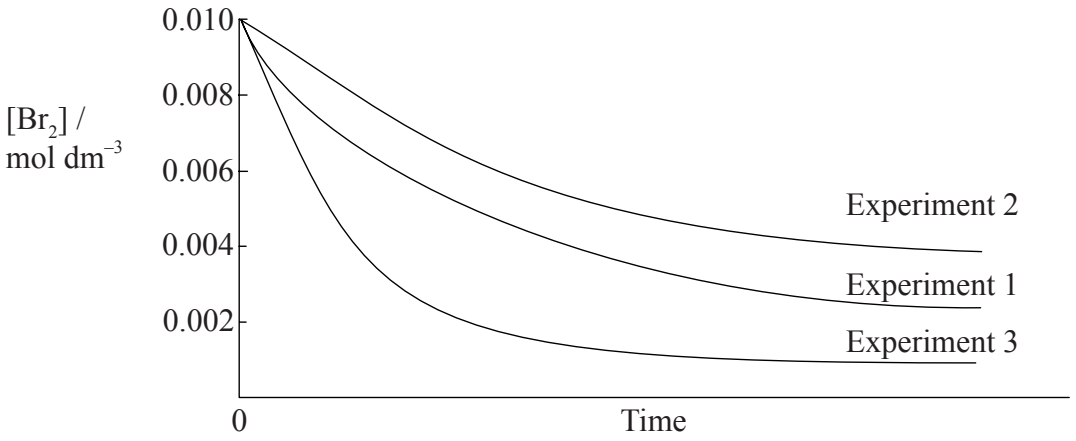
SECTION A

*Answer **all** the questions in the spaces provided.*

1. Bromine and methanoic acid react together in aqueous solution as shown below.

$$Br_2(aq) + HCOOH(aq) \rightarrow 2HBr(aq) + CO_2(g)$$

The rate of this reaction was investigated by measuring the change in colour as the bromine was used up. The following graph shows the results of a series of experiments in which 0.010 mol dm^{-3} $Br_2(aq)$ reacted with a large excess of HCOOH(aq).



Experiments 1 and 2 were carried out at different temperatures. Experiment 3 was carried out at the same temperature as Experiment 1 but in the presence of a catalyst.

(a) The term *rate of reaction* can be defined as the decrease in the concentration of reactants per unit time. State the alternative definition of rate of reaction. *[1]*

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(b) Suggest a different measurement that could be made during this reaction that would also allow the rate of reaction to be investigated. *[1]*

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(Question 1 continued)

(c) The collision theory can be used to explain the effects of changing conditions on the rate of this reaction.

(i) State **two** reasons why reactant particles may not react together when they collide. *[2]*

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(ii) Identify the experiment (1, 2 or 3) in which the rate of reaction was fastest. *[1]*

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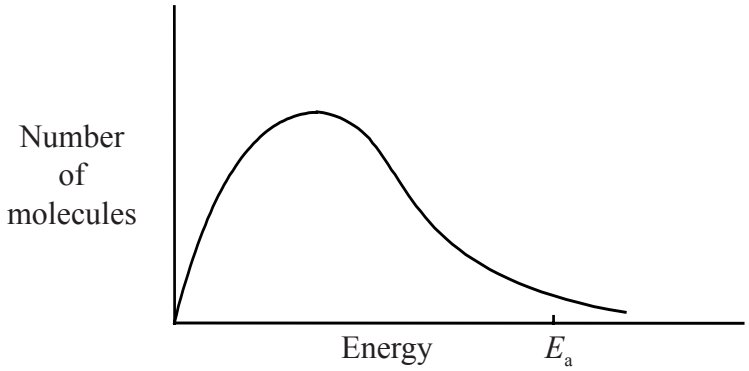
(iii) The following Maxwell-Boltzmann graph refers to Experiment 1. Draw another line on the graph that refers to Experiment 2. *[2]*



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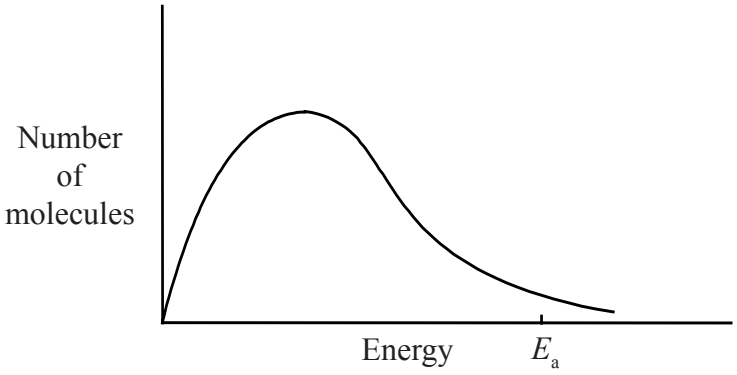
(Question 1 continued)

(iv) The following Maxwell-Boltzmann graph refers to Experiment 1. Annotate the graph to show the effect of using the catalyst in Experiment 3. *[1]*



(v) By referring to the graph in part (c)(iv), explain how the catalyst caused the rate to differ in Experiment 3. *[2]*

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2. (a) A chromium compound contains 28.4 % by mass of sodium, 32.1 % by mass of chromium, the rest being oxygen. Determine the empirical formula of the compound. *[3]*

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(b) A sample of the element chromium contains four isotopes, as shown in the table below.

Isotope	Relative abundance / %
^{50}Cr	4.30
^{52}Cr	83.8
^{53}Cr	9.50
^{54}Cr	2.40

Calculate the relative atomic mass of chromium in the sample, giving your answer to two decimal places. *[2]*

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3. Ethanol is manufactured by the hydration of ethene according to the equation below.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g)$$

(a) State the expression for the equilibrium constant, K_c, for this reaction. *[1]*

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(b) Under certain conditions, the value of K_c for this reaction is 3.7×10^{-3} $mol^{-1}\,dm^3$. When the temperature is increased the value is 4.9×10^{-4} $mol^{-1}\,dm^3$.

(i) State what can be deduced about the position of equilibrium at the higher temperature from these values of K_c. *[1]*

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(ii) State what can be deduced about the sign of ΔH for the reaction, explaining your choice. *[3]*

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(c) The process used to manufacture ethanol is carried out at high pressure. State and explain two advantages of using high pressure. *[4]*

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4. (a) The approximate pH values of six aqueous solutions are shown in the following table.

Solution	A	B	C	D	E	F
pH value	0	1	3	10	13	14

The solutions are listed below. Match each of the solutions with the letter (A, B, C, D, E or F) by writing the letter next to the appropriate solution. *[3]*

1.0 mol dm^{-3} HCl. . . . . .

1.0 mol dm^{-3} NaOH. . . . . .

0.1 mol dm^{-3} HNO_3 . . . . . .

0.1 mol dm^{-3} KOH. . . . . .

0.1 mol dm^{-3} CH_3COOH . . . . . .

0.1 mol dm^{-3} NH_3 . . . . . .

(b) The electrical conductivities of the following solutions were measured.

G 0.1 mol dm^{-3} HCl

H 0.1 mol dm^{-3} H_2SO_4

I 0.1 mol dm^{-3} CH_3COOH

Using the letters G, H and I, list these solutions in decreasing order of electrical conductivity (starting with the best conductor), giving reasons for your choice. *[3]*

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SECTION B

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

5. (a) (i) But-2-ene, $CH_3–CH=CH–CH_3$, reacts with hydrogen bromide to form a halogenoalkane. Deduce the structural formula of the halogenoalkane and state the type of reaction occurring. *[2]*

(ii) This halogenoalkane can exist as *optical isomers*. Explain what is meant by this term and identify the structural feature responsible for this type of isomerism. Outline how these isomers can be distinguished from each other. *[4]*

(iii) Using information from Table 10 of the Data Booklet, calculate the enthalpy change for the following reaction. *[3]*

$$CH_2=CH_2 + HBr \rightarrow CH_3CH_2Br$$

(b) Butan-1-ol can be converted by acidified potassium dichromate(VI) to either butanal or butanoic acid. Identify the type of reaction occurring and describe the colour change seen during the reaction. Outline the experimental technique needed to produce the maximum amount of butanal and the technique needed to produce the maximum amount of butanoic acid. Explain why these techniques work. *[6]*

(c) In an esterification reaction butanoic acid, $CH_3CH_2CH_2COOH$, reacts with methanol, in the presence of a few drops of sulfuric acid, to form two products. Deduce the equation for this reaction, showing the structure of the organic product. *[2]*

(d) Benzene-1,4-dicarboxylic acid and ethane-1,2-diol react to form a polyester. Explain why these reactants form a polymer, while the reactants in (c) do not. Deduce the structure of the polyester formed. *[3]*

6. (a) Using the reaction between lithium and fluorine as an example, describe the formation of an ionic bond. In your answer, refer to the electron arrangements of the species involved, and explain why the product of the reaction has a high melting point. *[5]*

(b) The product of the reaction between gaseous hydrogen and bromine contains a covalent bond. Draw a Lewis structure for a bromine molecule, and for the product of the reaction. Explain why the product of the reaction has a lower boiling point than bromine. *[3]*

(c) Table 7 of the Data Booklet contains electronegativity values of elements. Use these values to predict the type of bonding in lithium nitride and chlorine(I) oxide. Write the formula of each compound. *[2]*

(d) The compound ammonium nitrite (NH_4NO_2) contains both ionic and covalent bonding. Show how the VSEPR theory can be used to predict the shape of, and bond angle in each of the ions NH_4^+ and NO_2^-. *[8]*

(e) State and explain which of the two ions in ammonium nitrite is polar. *[2]*

7. (a) By referring to electron arrangements and using information from Table 8 of the Data Booklet, explain the difference in radius for each of the following pairs.

(i) Na and Na^+ *[2]*

(ii) Na^+ and F^- *[2]*

(b) By referring to atomic structure and using information from Table 6 of the Data Booklet, explain the difference in melting point for each of the following pairs.

(i) Na and Mg *[2]*

(ii) F_2 and Cl_2 *[2]*

(c) The conversion of iron(II) chloride to iron(III) chloride using chlorine gas can be used to illustrate the definitions of the terms *oxidation* and *reduction*. Write an equation for this reaction and deduce what is oxidized and reduced, by reference to **both** electron transfer and oxidation numbers. *[5]*

(d) Draw a diagram of a cell suitable for the electrolysis of molten lead(II) bromide, $PbBr_2$, and describe the two different ways in which current flows during the electrolysis. Write an equation showing the formation of each of the products. *[7]*