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Centre Number			Candidate Number									
Candidate Signature												

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General Certificate of Education
June 2001
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

CHEMISTRY CHM2
Unit 2 Foundation Physical and Inorganic Chemistry

Monday 4 June 2001 Afternoon Session

In addition to this paper you will require:
a Periodic Table;
a calculator.

Time allowed: 1 hour 30 minutes

Instructions

- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions in **Section A** and **Section B** in the spaces provided. All working must be shown.
- Do all rough work in this book. Cross through any work you do not want marked.

Information

- The maximum mark for this paper is 90.
- Mark allocations are shown in brackets.
- This paper carries 30 per cent of the total marks for AS. For Advanced Level this paper carries 15 per cent of the total marks.
- You are expected to use a calculator where appropriate.
- The following data may be required.
  Gas constant $R = 8.31$ J mol^{-1} K^{-1}
- Your answers to questions in Section B should be written in continuous prose, where appropriate. You will be assessed on your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary, where appropriate.

Advice

- You are advised to spend about 1 hour on **Section A** and about 30 minutes on **Section B**.

For Examiner's Use			
Number	Mark	Number	Mark
1			
2			
3			
4			
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7			
8			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

SECTION A

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

1 (a) Define the term s*tandard enthalpy of combustion*.

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(3 marks)

(b) Using the data given below, calculate the standard enthalpy change for the following reaction.

$$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(l)$$

$$\Delta H_f^{\ominus}\ CO_2(g) = -394\ kJ\ mol^{-1}$$
$$\Delta H_f^{\ominus}\ H_2O(l) = -286\ kJ\ mol^{-1}$$
$$\Delta H_f^{\ominus}\ CH_4(g) = -75\ kJ\ mol^{-1}$$

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(3 marks)

(c) (i) State what is meant by the term *mean bond enthalpy*.

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(ii) Using the standard enthalpy of formation of methane given in part (b) and the data given below, calculate the mean bond enthalpy of the C–H bond in methane.

$C(s) \longrightarrow C(g) \qquad \Delta H^{\ominus} = +715 \text{ kJ mol}^{-1}$

$H_2(g) \longrightarrow 2H(g) \qquad \Delta H^{\ominus} = +436 \text{ kJ mol}^{-1}$

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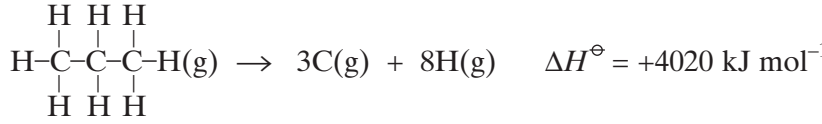
(iii) Using the C–H bond enthalpy calculated in part (c)(ii) and the standard enthalpy change for the reaction given below, calculate the mean bond enthalpy of the C–C bond in propane.

N.B. If you failed to complete part (c)(ii), you may assume that the mean bond enthalpy of the C–H bond is +390 kJ mol^{-1}. (This is not the correct value.)



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(7 marks)

13

2 A student added 50.0 cm^3 of hydrochloric acid to 50.0 cm^3 of sodium hydroxide solution in a polystyrene cup. The temperature rose by 6.5 °C. The initial concentration of each solution was 1.00 mol dm^{-3}.

(a) Write an ionic equation for the reaction occurring.

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(1 mark)

(b) Calculate the number of moles of acid used in the reaction.

.....

(1 mark)

(c) Calculate the heat energy evolved in the reaction. (Assume that the final solution has a specific heat capacity of 4.18 J g^{-1} K^{-1} and a density of 1.00 g cm^{-3}.)

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(2 marks)

(d) Calculate the molar enthalpy change for the reaction.

.....

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(2 marks)

6

3 (a) State what is meant by the terms *rate of reaction* and *activation energy*.

Rate of reaction .....

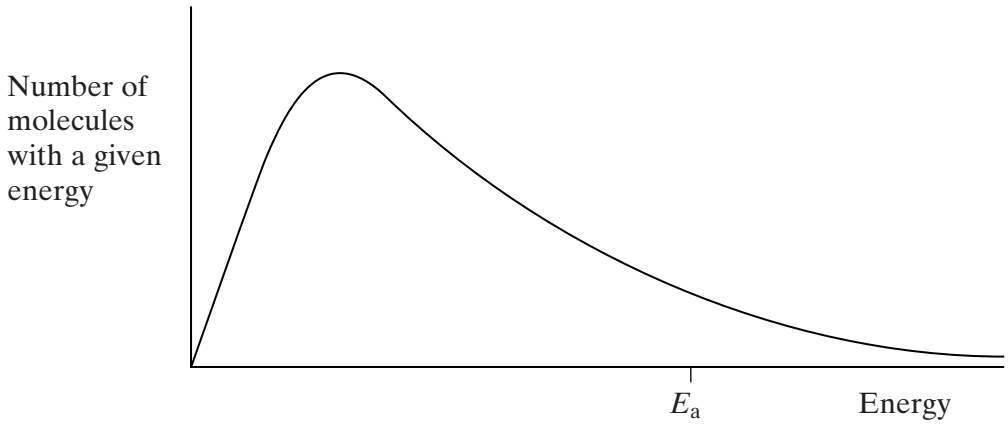
.....

Activation energy .....

.....

(4 marks)

(b) The diagram below shows the Maxwell–Boltzmann energy distribution curve for a sample of gas at a fixed temperature. E_a is the activation energy for the decomposition of this gas.



(i) On this diagram sketch the distribution curve for the same sample of gas at a higher temperature.

(ii) What is the effect of an increase in temperature on the rate of a chemical reaction? Explain your answer with reference to the Maxwell–Boltzmann distribution.

Effect .....

Explanation .....

.....

.....

(iii) What is the effect of the addition of a catalyst on the rate of a chemical reaction? Explain your answer with reference to the Maxwell–Boltzmann distribution.

Effect .....

Explanation .....

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(9 marks)

4 When carbon monoxide reacts with steam at 670 K, the following homogeneous dynamic equilibrium is established.

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g) \quad \Delta H^{\ominus} = -42 \text{ kJ mol}^{-1}$$

(a) (i) Explain why this reaction is described as a *homogeneous* reaction.

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(ii) State what is meant by the term *dynamic equilibrium*.

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(3 marks)

(b) State the effect, if any, of the following changes on the concentration of hydrogen in the equilibrium mixture. In each case, explain your answer.

(i) An increase in the concentration of steam

Effect .....

Explanation .....

.....

(ii) A decrease in the temperature

Effect .....

Explanation .....

.....

(6 marks)

(c) State and explain the effect, if any, of a catalyst on the position of this equilibrium.

Effect .....

Explanation .....

.....

(3 marks)

12

5 (a) Define *reduction* in terms of electrons.

.....

(1 mark)

(b) The oxide of nitrogen formed when copper reacts with nitric acid depends upon the concentration and the temperature of the acid. The reaction of copper with cold, dilute acid produces NO as indicated by the following equation.

$$3Cu + 8H^+ + 2NO_3^- \longrightarrow 3Cu^{2+} + 4H_2O + 2NO$$

In warm, concentrated acid, NO_2 is formed.

(i) Give the oxidation states of nitrogen in NO_3^-, NO_2 and NO

Oxidation state in NO_3^- .....

Oxidation state in NO_2 .....

Oxidation state in NO .....

(ii) Identify, as oxidation or reduction, the formation of NO from NO_3^- in the presence of H^+ and deduce the half-equation for the reaction.

NO from NO_3^- .....

Half-equation .....

(iii) Deduce the half-equation for the formation of NO_2 from NO_3^- in the presence of H^+.

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(iv) Deduce the overall equation for the reaction of copper with NO_3^- and H^+ to produce Cu^{2+} ions, NO_2 and water.

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(8 marks)

9

6 (a) State and explain the trend in electronegativity of the halogens down Group VII.

Trend .....

Explanation .....

.....

.....

.....

(4 marks)

(b) State and explain the trend in boiling points of the halogens down Group VII.

Trend .....

Explanation .....

.....

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(3 marks)

7

SECTION B

Answer **both** questions below in the space provided on pages 9 to 12 of this booklet.

7 (a) State what you would observe on adding aqueous chlorine to separate aqueous solutions of sodium bromide and sodium iodide. Write equations for the reactions occurring. *(4 marks)*

(b) State what you would observe on adding concentrated sulphuric acid to separate solid samples of sodium bromide and sodium iodide. In each case, identify all the reduction products. Using half-equations, construct an overall ionic equation for the oxidation of bromide ions by concentrated sulphuric acid. *(9 marks)*

8 Aluminium and titanium are extracted from their purified oxides by different methods.

(a) Discuss, with the aid of chemical equations, the method used for each metal. *(10 marks)*

(b) Explain why each method is chosen. *(4 marks)*

(c) Explain why aluminium is recycled although aluminium oxide is in plentiful supply. *(3 marks)*

END OF QUESTIONS

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