Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

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General Certificate of Education
January 2002
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

CHEMISTRY CHM2
Unit 2 Foundation Physical and Inorganic Chemistry

Friday 11 January 2002 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.
- The 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 $R = 8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$
- 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			
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Examiner's Initials			

NO QUESTIONS APPEAR ON THIS PAGE

SECTION A

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

1 (a) Define the term *standard molar enthalpy of formation*, $\Delta H_f^{\ominus}$

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....

....

(3 marks)

(b) State Hess's law.

....

....

(1 mark)

(c) Propanone, CH_3COCH_3, burns in oxygen as shown by the equation

$$CH_3COCH_3(l) + 4O_2(g) \longrightarrow 3H_2O(l) + 3CO_2(g)$$

Use the data given below to calculate the standard enthalpy of combustion of propanone.

	$CO_2(g)$	$H_2O(l)$	$CH_3COCH_3(l)$
$\Delta H_f^{\ominus}$/kJ mol^{-1}	–394	–286	–248

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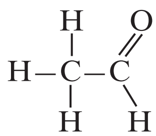
(3 marks)

7

Turn over ▶

2 (a) State what is meant by the term *mean bond enthalpy*.

(2 marks)

(b) Ethanal has the structure 

Gaseous ethanal burns as shown by the equation

$$CH_3CHO(g) \ + \ 2\tfrac{1}{2}O_2(g) \longrightarrow 2H_2O(g) \ + \ 2CO_2(g)$$

Use the mean bond enthalpy data given below to answer the following questions.

Bond	Mean bond enthalpy/kJ mol^{-1}
C–H	+413
C–C	+347
C=O	+736
O=O	+498
O–H	+464

(i) Calculate the enthalpy change which occurs when all the bonds in the reactants shown in the above equation are broken.

(ii) Calculate the enthalpy change which occurs when all the bonds in the products shown in the above equation are formed.

....

....

....

(iii) Hence, calculate the enthalpy change for the complete combustion of ethanal as shown in the equation above.

....

....

(5 marks)

7

TURN OVER FOR THE NEXT QUESTION

3 (a) Hydrogen used in the Haber Process is produced in the following dynamic equilibrium reaction.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

(i) In terms of rates and of concentrations, what does the term *dynamic equilibrium* mean?

Rates ....

Concentrations ....

(ii) State how an increase in pressure will affect the equilibrium yield of hydrogen. Explain your answer.

Equilibrium yield ....

Explanation ....

....

(iii) The equilibrium yield of hydrogen is reduced when the reaction is carried out at a lower temperature. What can be deduced about the enthalpy change in this reaction?

....

(iv) Explain why the equilibrium yield is unchanged when a catalyst is introduced.

....

....

(8 marks)

(b) Ammonia is produced in the Haber Process according to the following equation.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H_f^\ominus = -92\,\text{kJ mol}^{-1}$$

Typical operating conditions are 450 °C and 20 MPa (200 bar).

(i) Explain why 450 °C is a compromise temperature.

....

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(ii) Explain why 20 MPa is a compromise pressure.

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(6 marks)

14

TURN OVER FOR THE NEXT QUESTION

Turn over ▶

4 (a) The following is an equation for a redox reaction.

$$2NO + 12H^{+} + 10I^{-} \longrightarrow 2NH_4^{+} + 2H_2O + 5I_2$$

(i) Define *oxidation* in terms of electrons.

....

(ii) Deduce the oxidation state of nitrogen in NO and of nitrogen in NH_4^+

Oxidation state of nitrogen in NO ....

Oxidation state of nitrogen in NH_4^+ ....

(iii) Identify the species formed by oxidation in this reaction..

(4 marks)

(b) When chlorine gas is bubbled into an aqueous solution of sulphur dioxide, hydrogen ions, sulphate ions and chloride ions are formed.

(i) Write a half-equation for the formation of chloride ions from chlorine.

....

(ii) Write a half-equation for the formation of hydrogen ions and sulphate ions from sulphur dioxide and water.

....

(iii) Hence, deduce an overall equation for the reaction which occurs when chlorine is bubbled into aqueous sulphur dioxide.

....

(3 marks)

7

5 An excess of potassium iodide was added to an aqueous solution of chlorine. In a titration the liberated iodine required 28.2 cm^3 of a 0.360 mol dm^{-3} solution of sodium thiosulphate for complete reaction.

(a) Calculate the number of moles of sodium thiosulphate used in the titration.

....

....

(2 marks)

(b) Write an equation for the reaction between thiosulphate ions and iodine.

....

(1 mark)

(c) Calculate the number of moles of iodine which reacted with the sodium thiosulphate used in the titration.

....

(1 mark)

(d) Write an equation for the reaction between potassium iodide and chlorine.

....

(1 mark)

(e) Calculate the mass of chlorine in the original solution which reacted with potassium iodide.

....

....

....

....

(3 marks)

(f) Name an indicator which could be used when a solution of iodine is titrated with sodium thiosulphate solution from a burette. State the colour change at the end-point.

Indicator ....

Colour change ....

(2 marks)

10

Turn over ▶

6 (a) (i) Write an equation for the reaction which is mainly responsible for the high temperature in the Blast Furnace.

....

(ii) Write an equation for a reaction in which iron is formed from its oxide in the Blast Furnace.

....

(iii) Iron from the Blast Furnace can contain sulphur. Write an equation to show how this impurity is removed.

....

(iv) Iron from the Blast Furnace contains carbon. State how most of this carbon is removed. Give one reason why this removal is necessary.

Removal of carbon ....

....

Reason ....

....

(6 marks)

(b) (i) State why carbon cannot be used to reduce titanium(IV) oxide directly to titanium.

....

(ii) Carbon is used in one of the steps in the batch process for titanium extraction. Write an equation for the reaction which occurs in this step and state a condition under which this reaction is carried out.

Equation ....

Condition ....

(4 marks)

(c) Aluminium is not usually extracted by heating aluminium oxide with carbon, but carbon does have a use in the extraction of aluminium from aluminium oxide. State how carbon is used during the extraction process and write a half-equation showing how aluminium is produced.

Use of carbon ....

Half-equation ....

(2 marks)

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(d) State **three** factors which determine the choice of reduction method used for the extraction of metals from their ores.

Factor 1 ....

Factor 2 ....

Factor 3 ....

(3 marks)

15

TURN OVER FOR THE NEXT QUESTION

Turn over ▶

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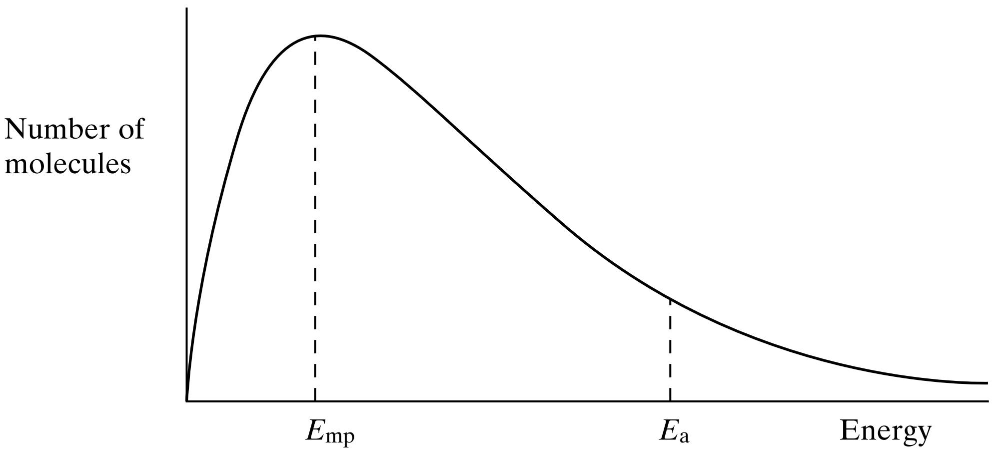
SECTION B

Answer **both** questions in the space provided on pages 13 to 16 of this booklet.

7 (a) State what is meant by the term *activation energy* of a reaction. *(1 mark)*

(b) State in general terms how a catalyst increases the rate of a chemical reaction. *(2 marks)*

(c) The curve below shows the Maxwell–Boltzmann distribution of molecular energies, at a constant temperature, in a gas at the start of a reaction. On this diagram the most probable molecular energy at this temperature is indicated by the symbol E_{mp} and the activation energy by the symbol E_a.



Consider the following changes.

(i) The number of molecules is increased at constant temperature.

(ii) The temperature is decreased without changing the number of molecules.

(iii) A catalyst is introduced without changing the temperature or the number of molecules.

For **each** of these changes state how, if at all, the following would vary:

- the value of the most probable energy, E_{mp}
- the number of molecules with the most probable energy, E_{mp}
- the area under the molecular energy distribution curve
- the number of molecules with energy greater than the activation energy, E_a

(12 marks)

8 (a) Samples of solid sodium fluoride, sodium chloride, sodium bromide and sodium iodide are each warmed separately with concentrated sulphuric acid. All four compounds react with concentrated sulphuric acid but only two can reduce it.

(i) Identify the **two** halides which do **not** reduce concentrated sulphuric acid. Write an equation for the reaction which does occur with **one** of these two halides.

(ii) Identify the **two** halides which reduce concentrated sulphuric acid to sulphur dioxide. Using half-equations for the oxidation and reduction processes, deduce an overall equation for the formation of sulphur dioxide when concentrated sulphuric acid reacts with **one** of these halides.

(iii) In addition to sulphur dioxide, two further reduction products are formed when one of these two halides reacts with concentrated sulphuric acid. Identify the two reduction products and write a half-equation to show the formation of **one** of them from concentrated sulphuric acid. *(9 marks)*

(b) How would you distinguish between separate solutions of sodium chloride, sodium bromide and sodium iodide using solutions of silver nitrate and ammonia? *(6 marks)*

END OF QUESTIONS

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