OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced Subsidiary GCE

CHEMISTRY

How Far, How Fast?

2813/01

Wednesday **11 JANUARY 2006** Morning 45 minutes

Candidates answer on the question paper.
Additional materials:
Data Sheet for Chemistry
Scientific calculator

Candidate Name

Centre Number

Candidate Number

TIME 45 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers, in blue or black ink, in the spaces provided on the question paper.
- Pencil may be used for diagrams and graphs **only**.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do not write in the bar code. Do not write in the grey area between the pages.
- **DO NOT** WRITE IN THE AREA **OUTSIDE** THE BOX BORDERING EACH PAGE. ANY WRITING IN THIS AREA WILL NOT BE MARKED.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- You may use a scientific calculator.
- You may use the *Data Sheet for Chemistry*.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	13	
2	8	
3	11	
4	13	
TOTAL	45	

This question paper consists of 10 printed pages and 2 blank pages.

Answer **all** the questions.

1 Methane reacts with oxygen to produce carbon dioxide and water. The equation for this reaction is given below.

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

Gas cookers use methane as a fuel because this reaction is exothermic and takes place at a fairly fast rate.

Activation energy is important in considering the conditions needed to change the rate of a reaction.

(a) What is meant by the term *exothermic*?

.....[1]

(b) Fig. 1.1 is an incomplete enthalpy profile diagram for the reaction between methane and oxygen.

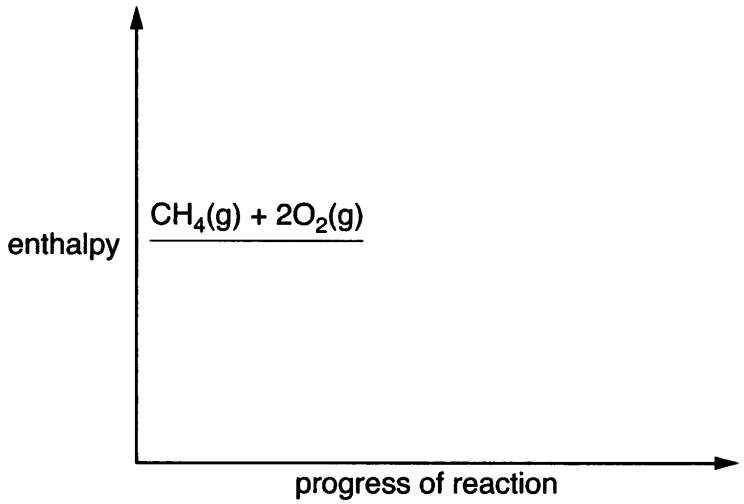

Fig. 1.1

(i) Complete Fig. 1.1 to show the complete enthalpy profile for the reaction. [2]

(ii) Label the activation energy, E_a, on Fig. 1.1. [1]

(c) The Boltzmann distribution can be used to show the effect of a change in temperature on the rate of a reaction.

- Draw a labelled Boltzmann distribution diagram.
- Explain the essential features of your diagram.
- Using your diagram, explain how an increase in temperature affects the rate of a reaction.

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.....[9]

[Total: 13]

2 Methane can be reacted with steam to produce carbon monoxide and hydrogen. The equation for this process is given below.

$$CH_4(g) + H_2O(g) \longrightarrow CO(g) + 3H_2(g) \qquad \textbf{equation 2.1}$$

Table 2.1 below shows the enthalpy changes of formation for methane, steam and carbon monoxide.

compound	ΔH_f / kJ mol^{-1}
CH_4	–75
H_2O	–242
CO	–110

Table 2.1

(a) Define the term *enthalpy change of formation*.

.....

.....

.....[2]

(b) Write the equation, including state symbols, representing the enthalpy change of formation for methane, CH_4.

.....[2]

(c) Use the ΔH_f values in Table 2.1 to calculate the enthalpy change for the reaction shown in **equation 2.1**.

..... kJ mol^{-1} [3]

(d) State one important manufacturing process in which hydrogen is used.

.....

.....[1]

[Total: 8]

3 Limestone contains calcium carbonate, $CaCO_3$.

Limestone is an important source of commercially important chemicals such as lime, calcium oxide, CaO.

(a) If calcium carbonate is heated strongly in an open container, it decomposes according to the equation below.

$$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g) \qquad \Delta H = +180\ kJ\,mol^{-1}$$

Suggest **two** reasons why it is necessary to heat the calcium carbonate strongly to achieve decomposition.

1 .....

2 .....[2]

(b) Another sample of calcium carbonate was placed in a closed container before being heated strongly. This allows an equilibrium to be set up. This equilibrium is shown below.

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$$

(i) What can you say about the rates of the forward and reverse reactions when the calcium carbonate starts to decompose?

.....

.....[1]

(ii) What can you say about the rates of the forward and reverse reactions when the equilibrium has been established?

.....

.....[1]

(iii) A valve allowed some of the carbon dioxide to escape.

State and explain what happens to the composition of the mixture in the container.

.....

.....

.....

.....[3]

(c) Both calcium carbonate, $CaCO_3$, and calcium oxide, CaO, are white solids.

Dilute hydrochloric acid, HC*l*, can be used to identify whether a sample of white solid is $CaCO_3$ or CaO.

(i) Write equations, including state symbols, for the reaction of HC*l* with $CaCO_3$ and the reaction of HC*l* with CaO.

.....

.....[3]

(ii) How would observation of the reactions with hydrochloric acid allow the identification of the white solid?

$CaCO_3$ .....

.....

CaO .....

.....[1]

[Total: 11]

4 A chemical **C** is made by reacting chemical **A** with chemical **B** in a reversible reaction. **A**, **B** and **C** are all gases under the reaction conditions.

Research chemists wanted to know the optimum conditions to use in the manufacture of **C**. They carried out a series of reactions under different conditions of temperature and pressure. The percentage conversion of **A** at equilibrium is shown in Table 4.1.

pressure / MPa	temperature / °C	% **A** converted
10	350	8
	450	12
	550	16
20	350	11
	450	21
	550	29
40	350	18
	450	
	550	49

Table 4.1

(a) Suggest the percentage of **A** that is converted at 450 °C and 40 MPa.

.....

[1]

(b) **(i)** Use the data in Table 4.1 to state the effect of increasing pressure on the percentage of **A** converted.

.....

[1]

(ii) What can be deduced, from this change, about the total number of moles of reactants **A** and **B** compared with the number of moles of product **C** in the equation for the reaction? Explain how you reached your conclusion.

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.....[2]

(c) Use the data in Table 4.1 to deduce whether the reaction between **A** and **B** is exothermic or endothermic. Explain how you reached your conclusion.

.....

.....

.....[2]

(d) It was found necessary to use a catalyst in the production of **C**.

(i) What is meant by a *catalyst*?

.....

.....

.....[2]

(ii) Suggest and explain **two** reasons why catalysts are used in industrial processes.

1 .....

.....

2 .....

.....[2]

(e) Conditions were used that should have given a conversion of **A** of 39%. In the manufacture, using these conditions, it was found that only 20% conversion was achieved.

Suggest why the conversion was much less than theory suggested.

.....

.....[1]

(f) Give **two** economically important processes that use catalysts.

process 1 .....

catalyst used in process 1 .....

process 2 .....

catalyst used in process 2 .....[2]

[Total: 13]

END OF QUESTION PAPER