OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

CHEMISTRY 2813/1

How Far, How Fast?

Monday **4 JUNE 2001** Afternoon 1 hour

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

Candidate Name	Centre Number	Candidate Number

TIME 1 hour

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 the spaces on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

INFORMATION FOR CANDIDATES

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

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	11	
2	12	
3	10	
4	6	
5	11	
6	10	
TOTAL	60	

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

Registered Charity Number: 1066969
[Turn over

Answer **all** questions.

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

.....

.....

.....[2]

(ii) Write an equation, including state symbols, to represent the standard enthalpy change of formation of water.

.....[2]

(b) Hydrogen is obtained industrially from methane and water.

The overall process can be represented by the equation below.

$$CH_4(g) + 2H_2O(l) \longrightarrow CO_2(g) + 4H_2(g)$$

Use the following standard enthalpy changes of formation to calculate the enthalpy change of this reaction.

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

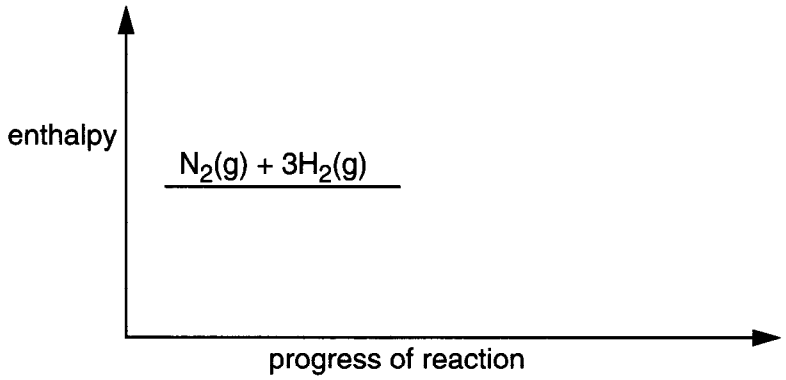
Answer ..... kJ mol^{-1} [3]

(c) Hydrogen can be reacted with nitrogen in the presence of a catalyst to make ammonia in the Haber process.

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

The activation energy for the **forward** reaction is $+68\,kJ\,mol^{-1}$.

(i) Complete the enthalpy profile diagram below. Label clearly the enthalpy change of reaction and the activation energy.



[3]

(ii) Calculate the activation energy for the **reverse** reaction.

[1]

[Total : 11]

2 Benzene, C_6H_6, can be manufactured by passing the gaseous hydrocarbon ethyne, C_2H_2, over finely divided nickel.

The equation is shown below.

$$3C_2H_2(g) \xrightarrow{\text{nickel}} C_6H_6(l) \qquad \textbf{reaction 2.1}$$

(a) Write a chemical equation, including state symbols, to represent the standard enthalpy change of combustion of benzene, $C_6H_6(l)$.

.....[2]

(b) Use the following standard enthalpy changes of combustion to calculate the standard enthalpy change for **reaction 2.1**.

compound	$\Delta H_c^{\ominus}$/kJ mol^{-1}
C_2H_2	–1301
C_6H_6	–3267

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

(c) Suggest, with explanations, how the **rate** of **reaction 2.1** might be affected by

(i) an increase in temperature,

.....

.....

.....

.....[3]

(ii) an increase in pressure.

.....

.....

.....[2]

(d) Describe and explain the purpose of the nickel in **reaction 2.1**.

.....

.....

.....[2]

[Total : 12]

3 When the indicator bromothymol blue (which can be represented by the formula HIn) dissolves in water the following dynamic equilibrium is set up.

$$\underset{\text{yellow}}{HIn(aq)} \rightleftharpoons \underset{\text{blue}}{In^-(aq)} + H^+(aq)$$

The indicator solution appears green because it contains both the yellow HIn and the blue In^- forms.

(a) State **two** features of a *dynamic equilibrium.*

.....

.....

.....[2]

(b) State le Chatelier's principle.

.....

.....

.....[2]

(c) Hydrochloric acid is added to the indicator solution above until no further colour change takes place.

Using le Chatelier's principle, suggest and explain what colour change you might see.

.....

.....

.....[2]

(d) Aqueous sodium hydroxide is gradually added to the resulting solution in **(c)** until no further colour changes take place.
Suggest **all** the colour changes you might see.
Explain your answer.

.....

.....

.....

.....

.....[4]

[Total : 10]

4 One of the disadvantages of hard water is the limescale that accumulates inside kettles when water is boiled. This can be removed by a de-scaler. Commercial de-scalers contain a weak organic acid (which can be represented by the formula HA).

(a) Explain the difference between a *weak* acid and a *strong* acid.

.....

.....

.....[2]

(b) The instructions for the use of a de-scaler are as follows.

Dissolve 10 g of the powder in enough water to cover the element of the kettle. Switch on the kettle until the water boils, then turn it off and leave to stand for 10 minutes. Empty out the contents and rinse thoroughly before use.

Limescale is calcium carbonate, $CaCO_3$.

(i) Write a balanced equation for the reaction between the organic acid, HA, and limescale.

.....[1]

(ii) Explain why heating the solution of the de-scaler increases its rate of reaction with limescale. Use collision theory and the concept of activation energy in your answer.

.....

.....

.....

.....[3]

[Total : 6]

5 The question refers to the enthalpy changes of some reactions of hydrocarbons. Table 5.1 below lists some average bond enthalpies.

Table 5.1

bond	bond enthalpy /kJ mol^{-1}
C–H	+413
C–C	+347
O–H	+464
C=O	+805
O=O	+498

(a) (i) Explain the term *average bond enthalpy*.

.....

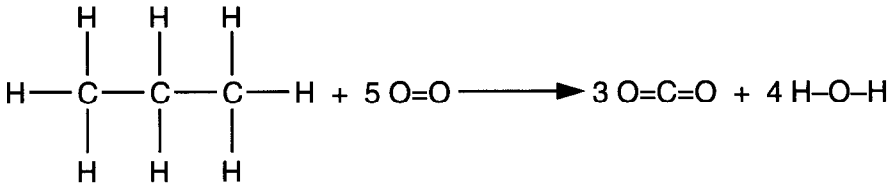
.....

.....[2]

(ii) Write an equation, including state symbols, to represent the average C–H bond enthalpy in methane, CH_4.

.....[2]

(b) Using the information in Table 5.1, calculate the enthalpy change of combustion of propane.



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

(c) Table 5.2 shows the **actual** standard enthalpy changes of combustion of some alkanes.

Table 5.2

compound	molecular formula	$\Delta H_c^{\ominus}$/kJ mol^{-1}
propane	C_3H_8	–2220
butane	C_4H_{10}	–2870
pentane	C_5H_{12}	
hexane	C_6H_{14}	–4160

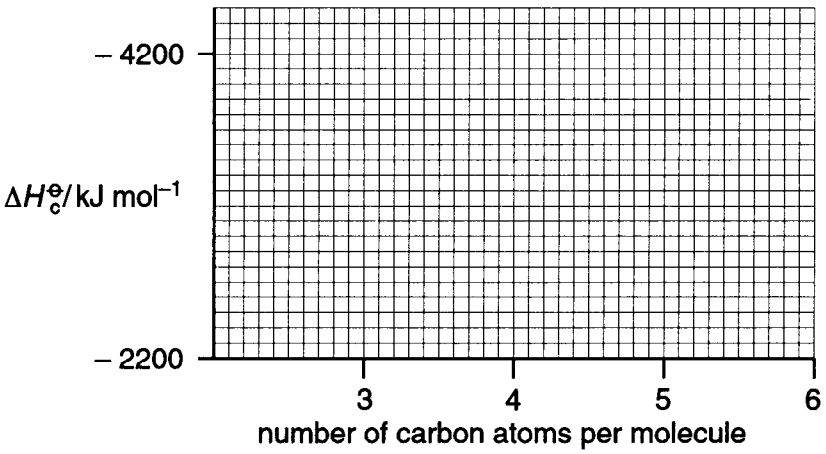
(i) Using average bond energies, the enthalpy change of combustion of butane was calculated as –2672 kJ mol^{-1}. The **actual** value for butane is shown in Table 5.2.

Suggest a reason for the difference.

.....

.....[1]

(ii) Plot a graph below using the data in Table 5.2.



[1]

(iii) Use your graph to determine a value for the standard enthalpy change of combustion of pentane.

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

(iv) Suggest why there is a regular trend in $\Delta H_c^{\ominus}$ for the alkanes.

.....

.....[1]

[Total : 11]

For Examiner's Use

In this question, 1 mark is available for the quality of written communication.

6 **(a)** Explain how a car's catalytic converter works, describing what type of catalysis is shown here.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[6]

(b) Why is the Haber process so important for mankind?

.....

.....

.....

.....

.....

.....[4]

[Total : 10]