OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced Subsidiary GCE

CHEMISTRY 2813/01

How Far, How Fast?

Wednesday **4 JUNE 2003** 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 the spaces provided 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 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	8	
2	7	
3	9	
4	12	
5	9	
TOTAL	45	

This question paper consists of 8 printed pages.

Registered Charity Number: 1066969
[Turn over

Answer **all** the questions.

1 Ammonia is manufactured by the Haber process according to the following equation.

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

(a) State the temperature used in this industrial process.

.....[1]

(b) The temperature used is often described as a 'compromise' or an 'optimum' temperature.

What would be the main **disadvantage** of using

(i) a lower temperature

.....

.....[1]

(ii) a higher temperature?

.....

.....[1]

(c) A few years ago some Haber process plants were designed to run at extremely high pressures, but now these have mostly been closed down.

(i) Suggest one **advantage** of running a plant at a very high pressure.

.....

.....[1]

(ii) Suggest one **disadvantage** of running a plant at a very high pressure.

.....

.....[1]

(d) Under the conditions usually employed, the yield of ammonia is between 10% and 15%.

Suggest what happens to the unreacted nitrogen and hydrogen in the Haber plant.

.....[1]

(e) State two **large scale** uses of ammonia.

.....

.....[2]

[Total: 8]

2 In the vapour state, sulphur dichloride, SCl_2, undergoes the following equilibrium reaction.

$$2\,Cl\text{—}S\text{—}Cl(g) \rightleftharpoons Cl\text{—}S\text{—}S\text{—}Cl(g) + Cl\text{—}Cl(g) \qquad \textbf{reaction 2.1}$$

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

1 .....

.....

2 .....

.....[2]

(b) Use the following average bond enthalpies to calculate the standard enthalpy change, $\Delta H_r^{\ominus}$, for the forward reaction 2.1.

bond	average bond enthalpy / kJ mol^{-1}
Cl—Cl	242
S—Cl	255
S—S	266

$\Delta H_r^{\ominus}$ = ...kJ mol^{-1} [3]

(c) Describe how the position of equilibrium might be affected by an increase in temperature. Explain your answer.

.....

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.....[2]

[Total: 7]

3 The standard enthalpy changes of formation of hydrocarbons are difficult to measure directly by experiment, but they can be calculated from standard enthalpy changes of combustion by using Hess's Law.

Table 3.1 lists some standard enthalpy changes of combustion of some relevant substances.

Table 3.1

substance	$\Delta H_c^{\ominus}$ / kJ mol^{-1}
$C_3H_8(g)$	–2220
C(s)	–394
$H_2(g)$	–286

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

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.....

.....

.....[3]

(ii) Write a balanced equation, including state symbols, to represent the standard enthalpy change of combustion of propane, C_3H_8.

.....[2]

(b) The equation that represents the standard enthalpy change of formation, $\Delta H_f^{\ominus}$, of propane is shown below.

$$3C(s) + 4H_2(g) \longrightarrow C_3H_8(g)$$

(i) Suggest a reason why $\Delta H_f^{\ominus}$ of propane is difficult to determine directly.

.....

.....[1]

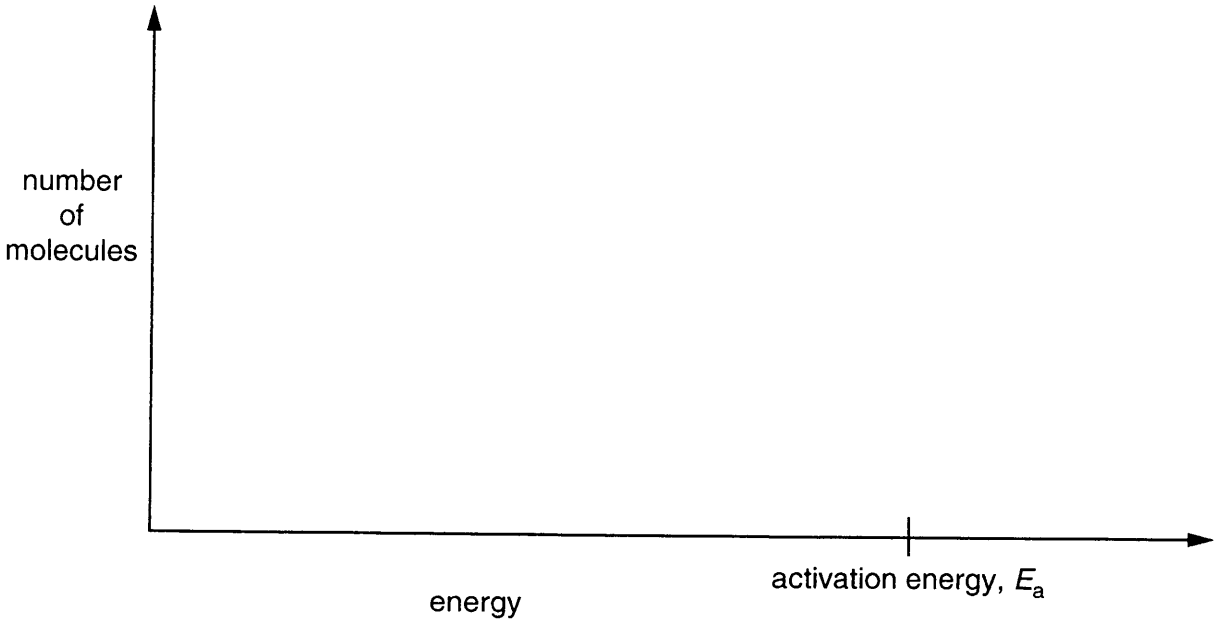
(ii) Use Hess's law and the data in Table 3.1 to calculate a value of $\Delta H_f^{\ominus}$ for propane.

$\Delta H_f^{\ominus}$ = ...kJ mol^{-1} [3]

[Total: 9]

[Turn over

4 **(a)** **(i)** On the following axes, sketch the Boltzmann distribution of molecular energies for a fixed amount of gas at a particular temperature.



[2]

Fig. 4.1

(ii) What is meant by the term *activation energy*?

.....

.....[1]

(iii) Mark on Fig. 4.1 a possible activation energy in the presence of a catalyst. Label this E_a(cat). [1]

For Examiner's Use

(b) In this question, one mark is available for the quality of written communication.

Explain how a catalyst speeds up a reaction. Use ideas from part **(a)** in your explanation.

Catalysts are of two types, *homogeneous* and *heterogeneous*. Explain the two terms in italics. Give an example of each type of catalyst and write an equation for the reaction it catalyses.

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[7]

Quality of Written Communication [1]

[Total: 12]

[Turn over

5 When dissolved in water, methanoic acid is a weak acid, whereas hydrochloric acid is a strong acid.

Methanoic acid reacts with an excess of sodium hydroxide as follows.

$$\underset{\text{methanoic acid}}{HCOOH} + NaOH \longrightarrow \underset{\text{sodium methanoate}}{HCOONa} + H_2O$$

(a) What ion is common to all acidic solutions?

.....[1]

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

.....

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.....[2]

(c) Write an ionic equation, including state symbols, for the reaction between hydrochloric acid and magnesium.

.....[2]

(d) $100\,cm^3$ of $1.0\,mol\,dm^{-3}$ HCl reacts with excess powdered $CaCO_3$. The volume of CO_2 evolved is $1.2\,dm^3$.

$100\,cm^3$ of $1.0\,mol\,dm^{-3}$ HCOOH reacts with excess powdered $CaCO_3$. The volume of CO_2 evolved is also $1.2\,dm^3$, but the reaction occurs at a much slower rate.

Use your knowledge of the theory of reaction rates and dynamic equilibrium to explain why

(i) HCOOH(aq) reacts with $CaCO_3$ at a much slower rate than does HCl(aq)

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.....[2]

(ii) the final volumes of CO_2(g) are the same in the two cases.

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.....[2]

[Total: 9]