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RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE **2813/01**

CHEMISTRY

How Far, How Fast?

WEDNESDAY 4 JUNE 2008

Morning
Time: 45 minutes

Candidates answer on the question paper
Additional materials (enclosed): *Data Sheet for Chemistry* (Inserted)

Additional materials (required):
Scientific calculator

CUP/T41132

Candidate Forename		Candidate Surname	
Centre Number		Candidate Number	

INSTRUCTIONS TO CANDIDATES

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is **45**.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry* is provided as an insert with this question paper.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	**Max**	**Mark**
1	**9**	
2	**11**	
3	**12**	
4	**13**	
TOTAL	**45**	

This document consists of **11** printed pages, **1** blank page and a *Data Sheet for Chemistry*.

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Answer **all** the questions.

1 Reactions that release energy are essential to maintain many aspects of everyday life.

(a) Enthalpy changes can be calculated using average bond enthalpies. **Table 1.1** shows some average bond enthalpies.

Table 1.1

bond	average bond enthalpy/ kJ mol^{-1}
C—C	+347
C—H	+413
O—H	+464
O═O	+498
C═O	+805
C—O	+358

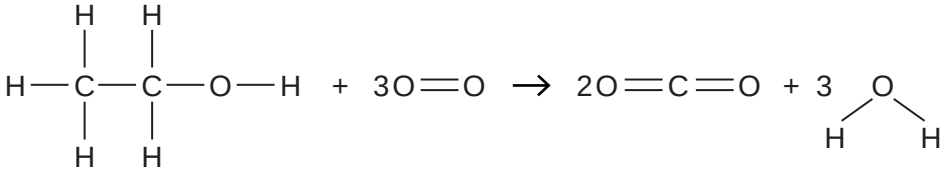
(i) Define the term *bond enthalpy*.

.....

.....

.....[2]

(ii) Ethanol, C_2H_5OH, can be burnt to release energy. The equation below shows the combustion of ethanol.



Use the data in **Table 1.1** to calculate a value for the enthalpy change of combustion of gaseous ethanol, ΔH_c.

ΔH_c = ... kJ mol^{-1} [3]

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(b) Glucose, $C_6H_{12}O_6$, can also be oxidised.

The table below shows some enthalpy changes of formation, ΔH_f.

compound	ΔH_f/ kJ mol^{-1}
$C_6H_{12}O_6(s)$	–1273
$CO_2(g)$	–394
$H_2O(l)$	–286

(i) Use the data to calculate the enthalpy change of combustion, ΔH_c, for glucose.

$$C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$$

ΔH_c = ... kJ mol^{-1} [3]

(ii) What name is given to this process of energy release when it occurs in a living species?

.....[1]

[Total: 9]

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2 Many chemical reactions are reversible and are able to form equilibrium mixtures.

Hydrogen and iodine react together to form hydrogen iodide in a reversible reaction.

$$\underset{\text{colourless}}{H_2(g)} + \underset{\text{purple}}{I_2(g)} \rightleftharpoons \underset{\text{colourless}}{2HI(g)} \qquad \Delta H = +53 \text{ kJ mol}^{-1}$$

(a) Explain the following observations when changes are made to an equilibrium mixture of $H_2(g)$, $I_2(g)$ and HI(g).

Include reference to the equilibrium position and any other factors.

(i) When the temperature is increased the purple colour becomes paler.

.....

.....

.....[2]

(ii) When the pressure is increased the purple colour becomes deeper.

.....

.....

.....

.....[3]

(b) The **rate** at which equilibrium is reached could be increased by increasing the temperature or pressure.

In each case explain why the rate increases:

(i) on increasing the temperature,

.....

.....

.....[2]

(ii) on increasing the pressure.

.....

.....[1]

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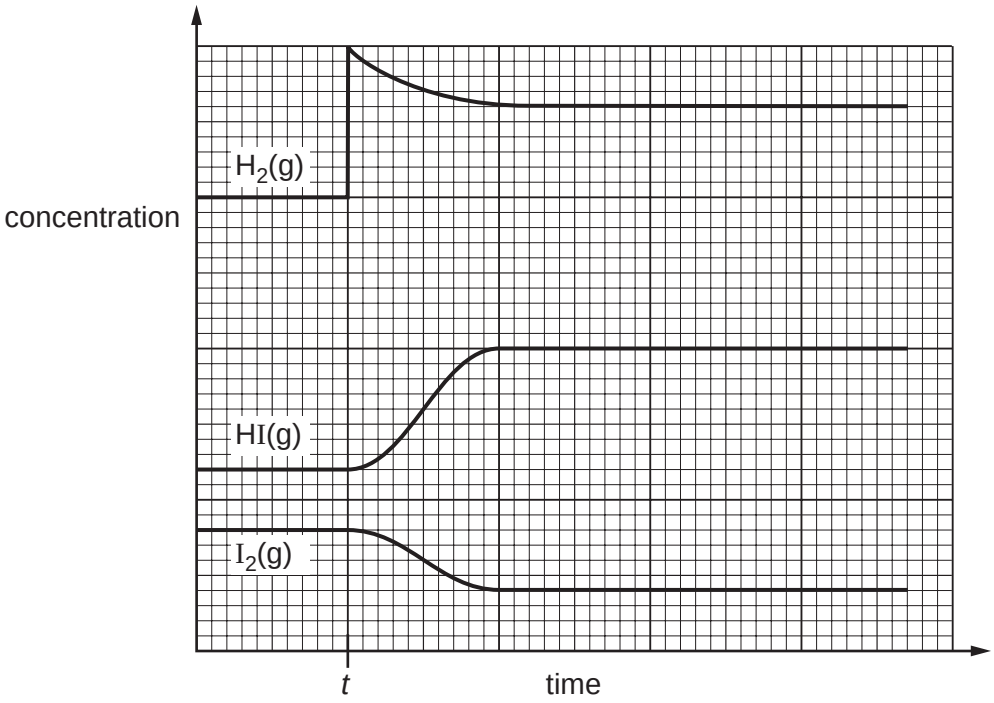
(c) $H_2(g)$, $I_2(g)$ and HI(g) were mixed together and allowed to reach equilibrium. The concentrations of the gases were then measured at various times and the results plotted. At time *t*, a change was made to the composition of the mixture.



(i) What change was made to the mixture at time *t*?

.....[1]

(ii) Explain the changes that happen to the equilibrium mixture after time *t*.

.....

.....

.....

.....[2]

[Total: 11]

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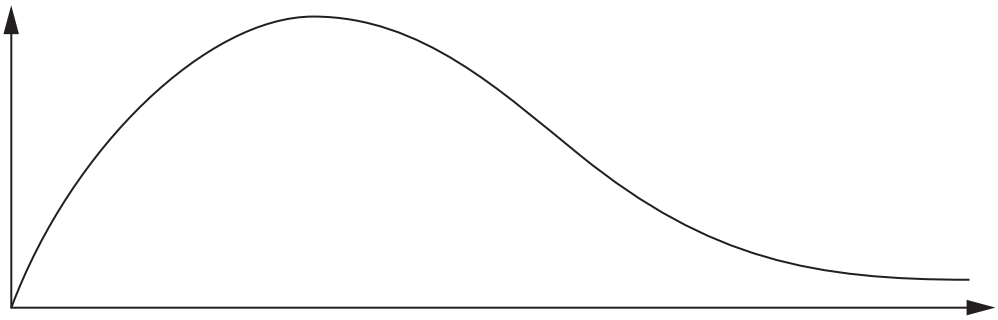
3 This question is concerned with some of the graphs you may have seen in your studies.

(a) **Graph A** shows a Boltzmann distribution.

Graph A



(i) Label the axes on **graph A**. [2]

(ii) Explain, using **graph A**, the effect of adding a catalyst on the reaction rate.

Include labelled lines of the energies involved on **graph A**.

.....

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.....[2]

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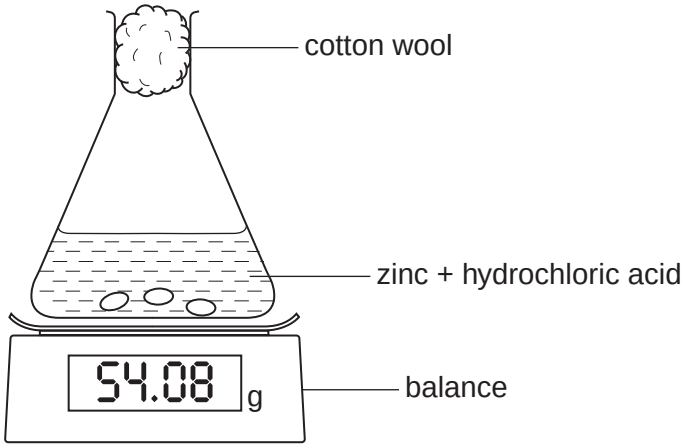
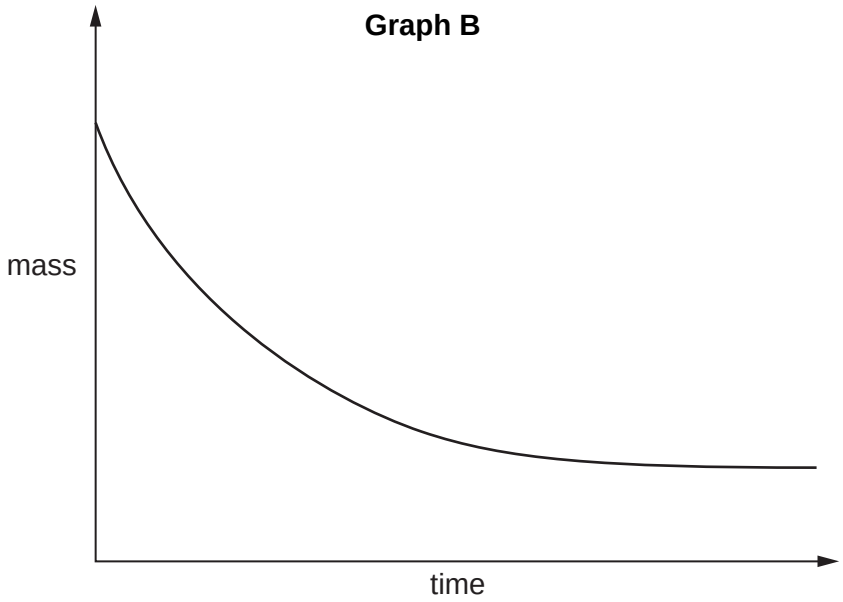
(b) **Graph B** shows the change in mass observed in an experiment used to investigate the rate of a reaction.



Graph B



(i) Suggest what is happening in this experiment to produce the loss of mass with time.

.....[1]

(ii) Exactly the same experiment was repeated but with a catalyst added.

On **graph B** sketch the line that would be produced in the presence of the catalyst. [2]

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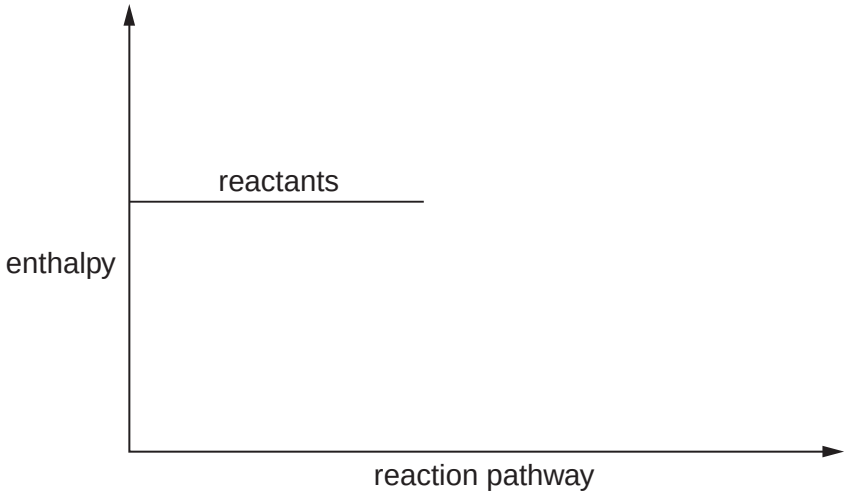
(c) The forward direction of a reversible reaction has an enthalpy change of reaction, ΔH, of –120 kJ mol^{-1} and an activation energy, E_a, of 250 kJ mol^{-1}.

(i) On the axes below, complete the enthalpy profile diagram for this reaction. [2]



(ii) On your diagram label ΔH and E_a. [2]

(iii) Use your diagram to calculate E_a for the reverse reaction. [1]

E_a = ... kJ mol^{-1}

[Total: 12]

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TURN OVER FOR QUESTION 4

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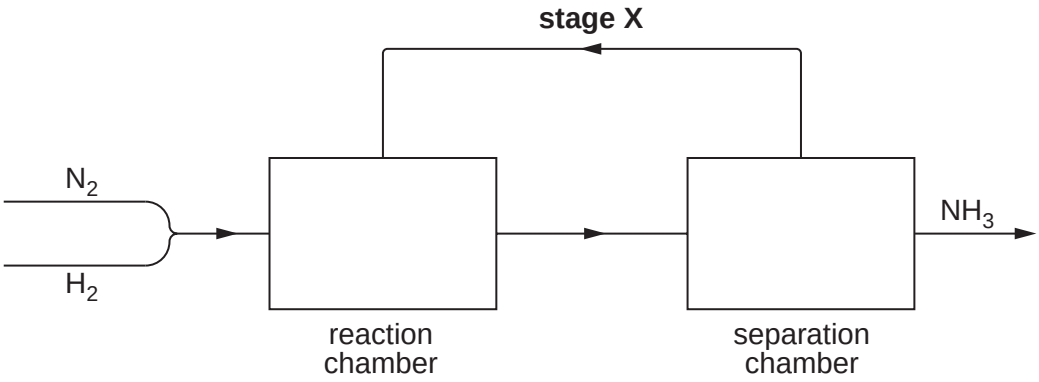
4 Ammonia is manufactured in large quantities to make fertilisers and other commercially important chemicals.

(a) In the Haber process, nitrogen reacts with hydrogen to make ammonia.

The diagram below shows the stages involved in this method of ammonia production.



Ammonia is formed in the reaction chamber.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -93 \text{ kJ mol}^{-1}$$

(i) Describe the conditions that are used in the reaction chamber and explain why these conditions are chosen.

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.....[7]

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(ii) The table below gives the boiling points of nitrogen, hydrogen and ammonia.

substance	boiling point/ °C
nitrogen	−196
hydrogen	−253
ammonia	−33

Suggest how ammonia could be separated in the separation chamber.

.....

.....

.....[2]

(iii) Suggest what is happening in **stage X** in the diagram.

.....

.....[1]

(b) Ammonia can be described as a base since it reacts with acids. When ammonia reacts with phosphoric acid, H_3PO_4, ammonium phosphate is formed. Compounds similar to this containing nitrogen and phosphorus are used as fertilisers.

(i) Write the **ionic** equation for the reaction that occurs when ammonia reacts with an acid to form an ammonium ion, NH_4^+.

.....[1]

(ii) Write the equation for the reaction between ammonia and phosphoric acid to form ammonium phosphate.

.....[2]

[Total: 13]

END OF QUESTION PAPER

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