UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

3126331034

CHEMISTRY **9701/42**

Paper 4 Structured Questions **May/June 2013**

2 hours

Candidates answer on the Question Paper.

Additional Materials: Data Booklet

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.

Section B
Answer **all** questions.

You may lose marks if you do not show your working or if you do not use appropriate units.
A Data Booklet is provided.
Electronic calculators may be used.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

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1	
2	
3	
4	
5	
6	
7	
8	
Total	

This document consists of **16** printed pages and **4** blank pages.

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For Examiner's Use

Section A

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

1 A bromoalkane, R–Br, is hydrolysed by aqueous sodium hydroxide.

(a) (i) Write a balanced equation for this reaction.

.....

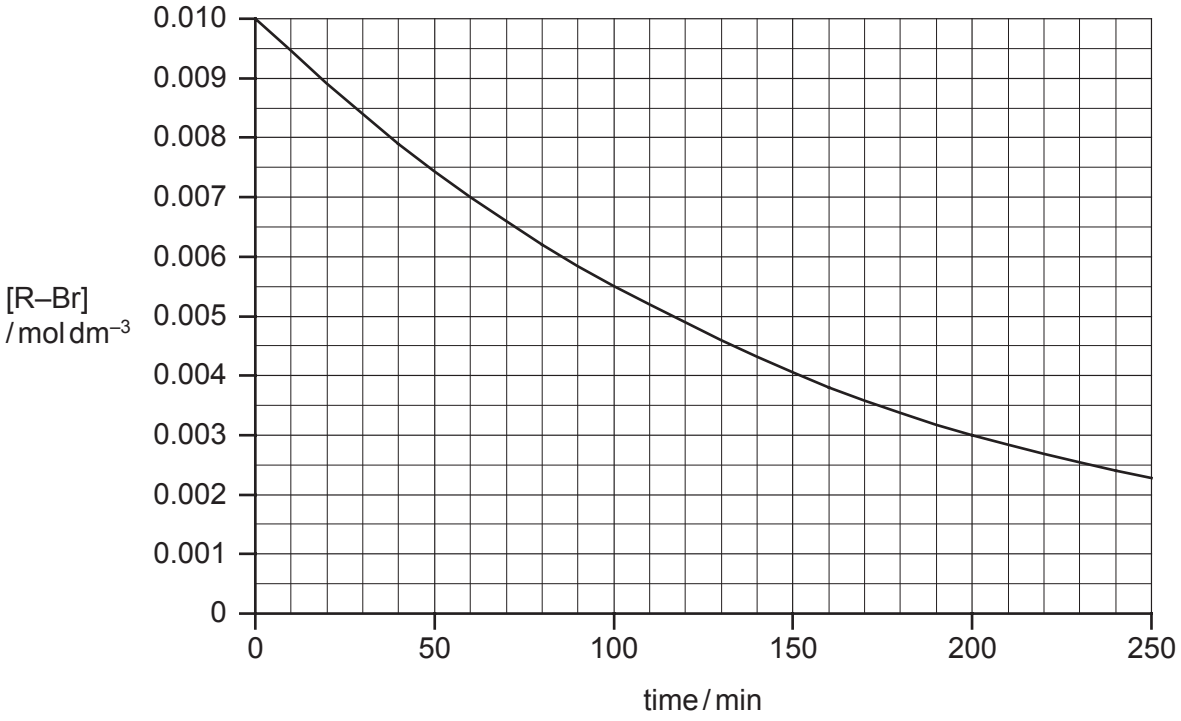
(ii) What *type of reaction* is this?

.....

[2]

(b) The concentration of bromoalkane was determined at regular time intervals as the reaction progressed.

Two separate experiments were carried out, with different NaOH concentrations.
The graph below shows the results of an experiment using [NaOH] = 0.10 mol dm^{-3}.



When the experiment was repeated using [NaOH] = 0.15 mol dm^{-3}, the following results were obtained.

time / min	[R–Br] / mol dm^{-3}
0	0.0100
40	0.0070
80	0.0049
120	0.0034
160	0.0024
200	0.0017
240	0.0012

(i) Plot these data on the axes above, and draw a line of best fit.

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(ii) Use one of the graphs to confirm that the reaction is first order with respect to R–Br. Show all your working, and show clearly any construction lines you draw.

(iii) Use the graphs to calculate the order of reaction with respect to NaOH. Show all your working, and show clearly any construction lines you draw on the graphs.

(iv) Write the rate equation for this reaction, and calculate the value of the rate constant.

rate =

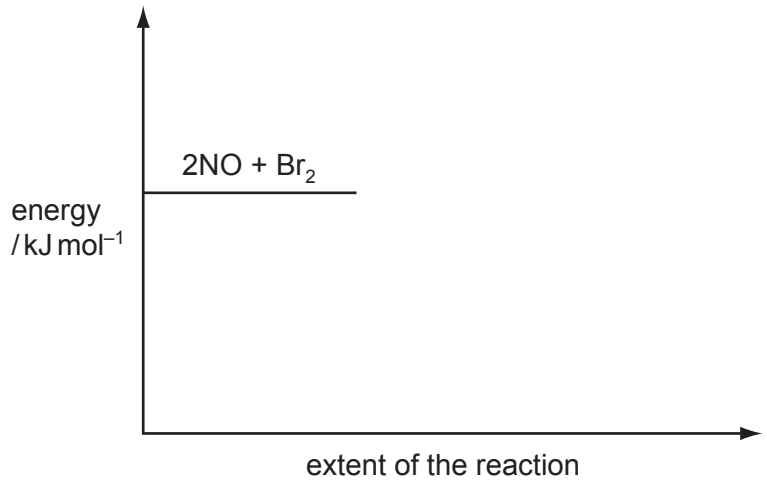
[7]

(c) Nitric oxide, NO, and bromine vapour react together according to the following equation.

$$2NO(g) + Br_2(g) \rightarrow 2NOBr(g) \qquad \Delta H = -23\,kJ\,mol^{-1}$$

The reaction has an activation energy of $+5.4\,kJ\,mol^{-1}$.

Use the following axes to sketch a fully-labelled reaction pathway diagram for this reaction.
Include all numerical data on your diagram.



[2]

[Total: 11]

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2 (a) (i) With the aid of a fully-labelled diagram, describe the standard hydrogen electrode.

(ii) Use the *Data Booklet* to calculate the standard cell potential for the reaction between Cr^{2+} ions and $Cr_2O_7^{2-}$ ions in acid solution, and construct a balanced equation for the reaction.

$E^{\ominus}_{cell}$ = ... V

equation .....

(iii) Describe what you would see if a blue solution of Cr^{2+} ions was added to an acidified solution of $Cr_2O_7^{2-}$ ions until reaction was complete.

.....

.....

[8]

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(b) A buffer solution is to be made using 1.00 mol dm^{-3} ethanoic acid, CH_3CO_2H, and 1.00 mol dm^{-3} sodium ethanoate, CH_3CO_2Na.
Calculate to the nearest 1 cm^3 the volumes of each solution that would be required to make 100 cm^3 of a buffer solution with pH 5.50.
Clearly show all steps in your working.
K_a (CH_3CO_2H) = 1.79×10^{-5} mol dm^{-3}

volume of 1.00 mol dm^{-3} CH_3CO_2H = ... cm^3

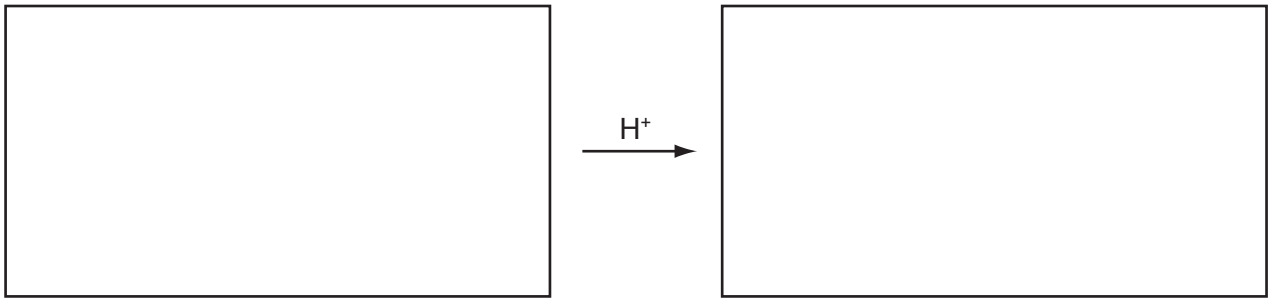
volume of 1.00 mol dm^{-3} CH_3CO_2Na = ... cm^3
[4]

(c) Write an equation to show the reaction of this buffer solution with each of the following.

(i) added HC*l* .....

(ii) added NaOH .....
[2]

(d) Choose **one** reaction in organic chemistry that is catalysed by an acid, and write the structural formulae of the reactants and products in the boxes below.



[3]

[Total: 17]

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[Turn over

For Examiner's Use

3 **(a)** Describe the reagents and conditions required to form a nitro compound from the following.

(i) methylbenzene 

.....

(ii) phenol 

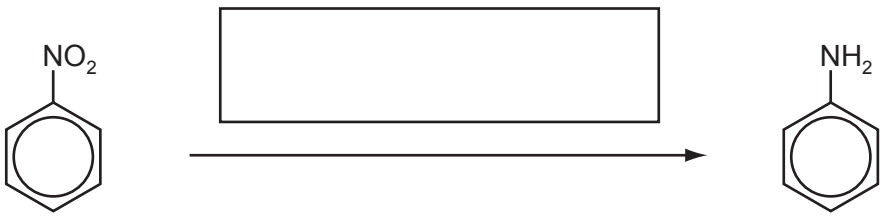
.....

[3]

(b) Draw the structure of the intermediate organic ion formed during the nitration of benzene.

[1]

(c) In the box over the arrow below, write the reagents needed to convert nitrobenzene into phenylamine.



[1]

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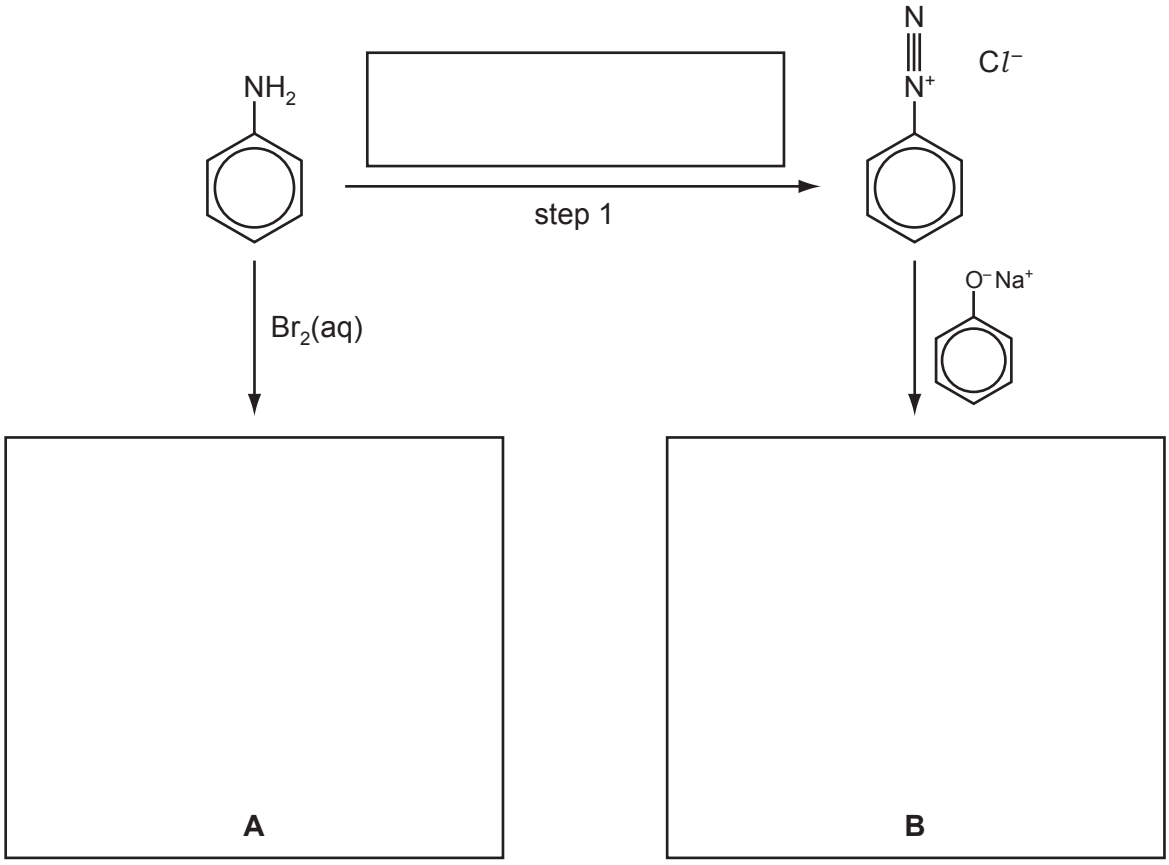
(d) Phenylamine can be converted into the organic compounds **A** and **B**.

(i) Suggest the structural formulae of **A** and **B** in the boxes below.

(ii) Suggest suitable reagents and conditions for step 1, and write them in the box over the arrow.



[3]

(e) When phenylamine is treated with propanoyl chloride a white crystalline compound, **C**, $C_9H_{11}NO$, is formed.

(i) Name the functional group formed in this reaction. .....

(ii) Calculate the percentage by mass of nitrogen in **C**.

percentage = ... %

(iii) Draw the structural formula of **C**.

[3]

[Total: 11]

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[Turn over

For Examiner's Use

4 **(a)** **(i)** Suggest why transition elements show variable oxidation states in their compounds whereas s-block elements like calcium do not.

.....

.....

(ii) Calculate the oxidation number of the metal in each of the following ions.

VO_2^+ .....

CrF_6^{2-} .....

MnO_4^{2-} .....

[4]

(b) Explain why transition element complexes are often coloured whereas compounds of s-block elements such as calcium and sodium are not.

.....

.....

.....

.....

.....

.....

[4]

(c) SO_2 and MnO_4^- react together in acidic solution.

(i) Use the *Data Booklet* to construct a balanced equation for this reaction.

.....

(ii) Describe the colour change you would see when SO_2(aq) is added to a sample of acidified $KMnO_4$ until the SO_2 is in excess.

from ..... to .....

[3]

(d) Describe the observations you would make when NH_3(aq) is added gradually to a solution containing Cu^{2+} ions, until the NH_3 is in an excess.

.....

.....

.....

.....

[3]

[Total: 14]

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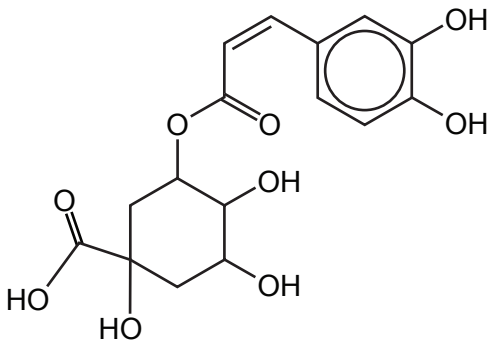
5 Coffee beans contain chlorogenic acid.



chlorogenic acid

(a) (i) Draw circles around any chiral centres in the above structure.

(ii) Write down the molecular formula of chlorogenic acid.

.....

(iii) How many moles of $H_2(g)$ will be evolved when 1 mol of chlorogenic acid reacts with an excess of sodium metal?

.....

(iv) How many moles of NaOH(aq) will react with 1 mol of chlorogenic acid under each of the following conditions?

in the cold .....

on heating .....

[6]

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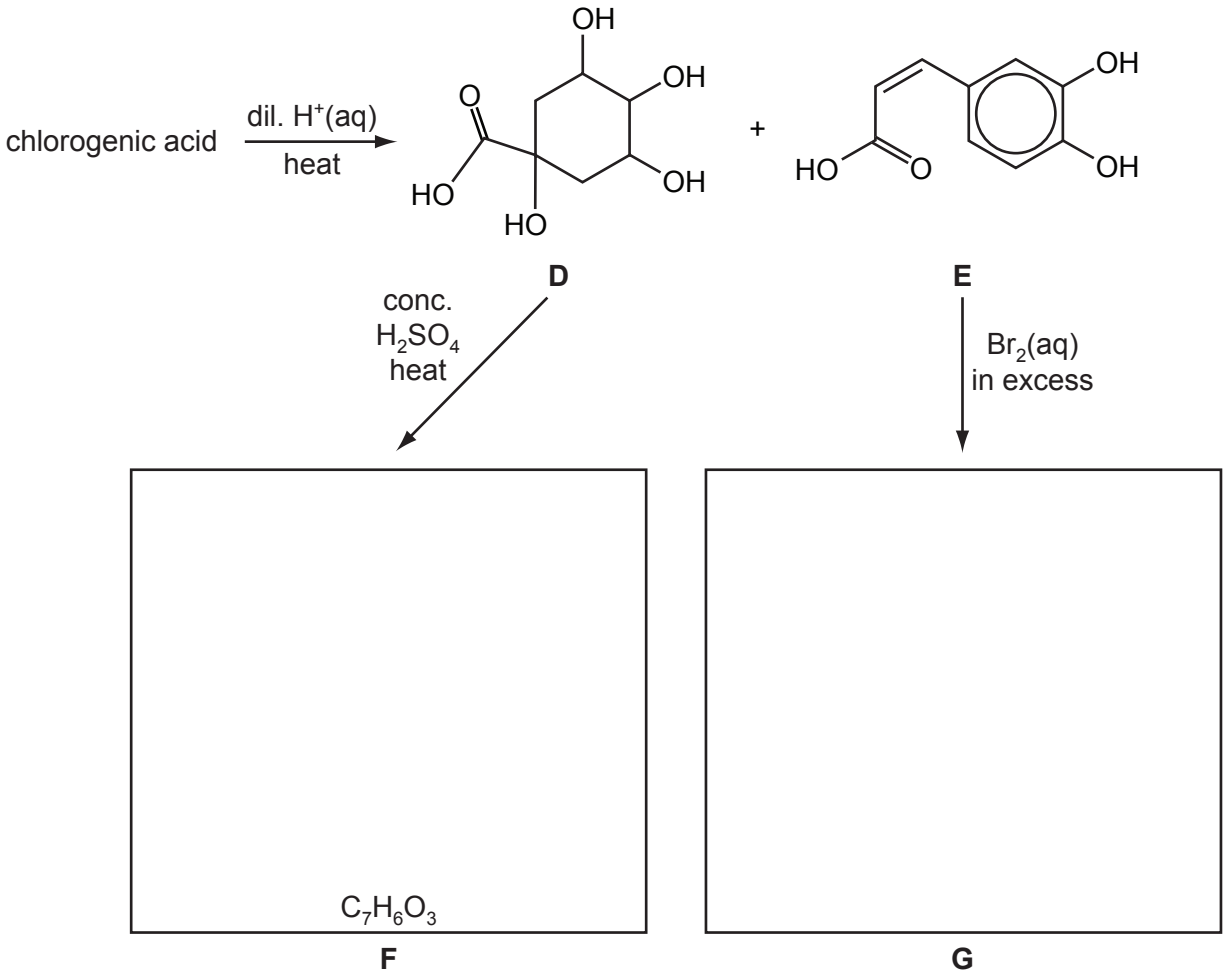
(b) On heating with dilute aqueous acid, chlorogenic acid produces two compounds, **D** and **E**.



(i) What *type of reaction* is chlorogenic acid undergoing when **D** and **E** are formed?

.....

When compound **D** is heated with concentrated H_2SO_4, compound **F**, $C_7H_6O_3$, is formed.

Compound **F** evolves $CO_2(g)$ when treated with $Na_2CO_3(aq)$, and decolourises $Br_2(aq)$, giving a white precipitate. It does not, however, decolourise cold dilute acidified $KMnO_4$.

When compound **E** is treated with an excess of $Br_2(aq)$, compound **G** is produced.

(ii) If the test with cold dilute acidified $KMnO_4$ had been positive, which functional group would this have shown to be present in **F**?

.....

(iii) **Name** the functional groups in compound **F** that would react with the following.

$Na_2CO_3(aq)$ ..... $Br_2(aq)$ .....

(iv) Suggest structures for compounds **F** and **G** and draw them in the relevant boxes above.

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(v) Compound **E** is one of a pair of stereoisomers.

What type of stereoisomerism is shown by compound **E**?

.....

(vi) Draw the structure of the other stereoisomer in the box below.

[8]

(c) Calculate the volume of 0.1 mol dm^{-3} NaOH that is needed to react completely with 0.1 g of compound **E**.

volume = ... cm^3

[3]

[Total: 17]

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Section B

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

6 There are two important polymerisations that occur within living organisms – protein synthesis and the formation of DNA.

(a) Complete the table by placing a tick (✓) in the correct column to indicate in which process each substance could be used.

substance	protein synthesis	formation of DNA
cysteine		
cytosine		
glutamine		
guanine		

[3]

(b) DNA consists of a double helical structure.

(i) Describe the bonding between the two strands in DNA and state which part of each strand is joined by it.

.....

.....

(ii) How does the strength of this bonding relate to the mechanism of the replication of DNA?

.....

.....

[4]

(c) Some diseases are caused by changes in the structure of proteins. Explain the genetic basis of these changes.

.....

.....

.....

.....

[3]

[Total: 10]

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7 The techniques of mass spectrometry and NMR spectroscopy are useful in determining the structures of organic compounds.

(a) The three peaks of highest mass in the mass spectrum of organic compound **L** correspond to masses of 142, 143 and 144.
The ratio of the heights of the M : M+1 peaks is 43.3 : 3.35, and the ratio of heights of the M : M+2 peaks is 43.3 : 14.1.

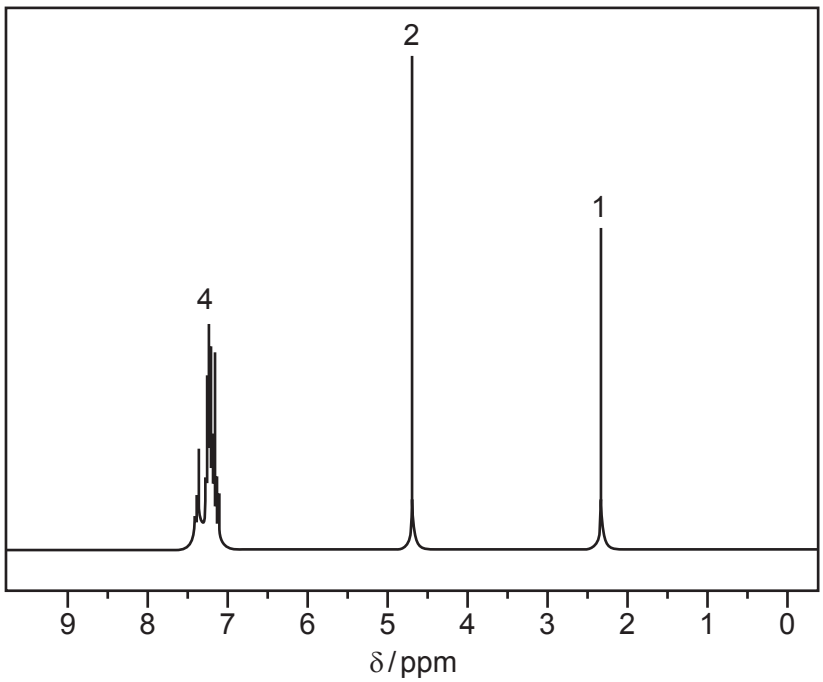
(i) Use the data to calculate the number of carbon atoms present in **L**.

(ii) Explain what element is indicated by the M+2 peak.

.....

.....

Compound **L** reacts with sodium metal. The NMR spectrum of compound **L** is given below.



(iii) What does the NMR spectrum tell you about the number of protons in **L** and their chemical environments?

.....

.....

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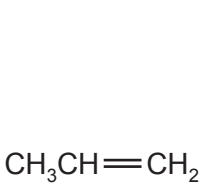
(iv) Use the information given and your answers to **(i)**, **(ii)** and **(iii)** to deduce a structure for **L**.
Explain how you arrive at your answer.

structure of **L**

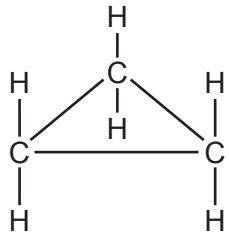


[7]

(b) The molecular formula C_3H_6 represents the compounds propene and cyclopropane.



propene



cyclopropane

(i) Suggest **one** difference in the fragmentation patterns of the mass spectra of these compounds.

.....

.....

(ii) Suggest **two** differences in the NMR spectra of these compounds.

.....

.....

.....

[3]

[Total: 10]

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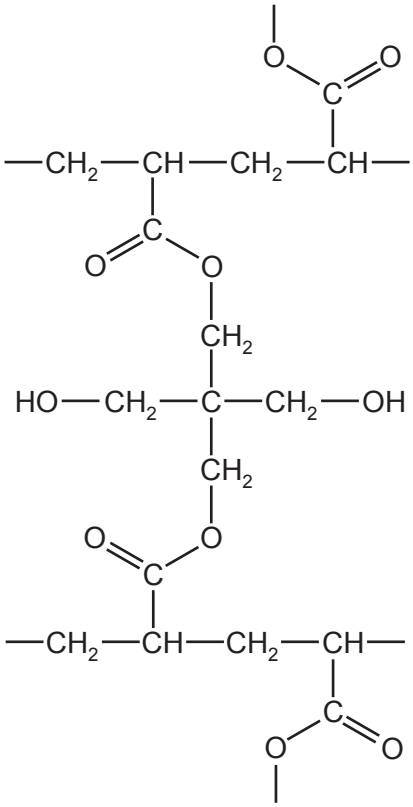
8 In recent years there has been considerable interest in a range of polymers known as 'hydrogels'. These polymers are hydrophilic and can absorb large quantities of water.

(a) The diagram shows part of the structure of a hydrogel.



The hydrogel is formed from chains of one polymer which are cross-linked using another molecule.

(i) Draw the structure of the monomer used in the polymer chains.

(ii) State the type of polymerisation used to form these chains.

.....

.....

(iii) Draw the structure of the molecule used to cross-link the polymer chains.

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(iv) During the cross-linking, a small molecule is formed as a by-product. Identify this molecule.

.....

[5]

(b) Once a hydrogel has absorbed water, it can be dried and re-used many times. Explain why this is possible, referring to the structure on the opposite page.

.....

.....

.....

[2]

(c) Not every available side chain in the polymer is cross-linked, and the amount of cross-linking affects the properties of the hydrogel.

(i) The amount of cross-linking has little effect on the ability of the gel to absorb water. Suggest why this is the case.

.....

.....

.....

(ii) Suggest **one** property of the hydrogel that will change if more cross-linking takes place. Explain how the increased cross-linking brings about this change.

.....

.....

.....

[3]

[Total: 10]

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