Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **9701/42**

Paper 4 Structured Questions **May/June 2015**

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 an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section A
Answer **all** questions.

Section B
Answer **all** questions.

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

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.

For Examiner's Use	
1	
2	
3	
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5	
6	
7	
8	
9	
Total	

This document consists of **17** printed pages and **3** blank pages.

CAMBRIDGE International Examinations

Section A

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

1 **(a)** Complete the electronic configurations of the following atoms.

fluorine: $1s^2$.....

sulfur: $1s^2$.....

[1]

(b) **(i)** Write an equation to show the thermal decomposition of HC*l*.

..... [1]

(ii) Using all relevant bond energy values from the *Data Booklet*, explain why the thermal stability of HF is **much** more than that of HC*l*.

.....

.....

..... [1]

(c) Explain what is meant by the term *electronegativity*, and how it relates to the concept of *bond polarity*.

.....

.....

.....

..... [2]

(d) Sulfur and fluorine react together to give the covalent compound SF_4.

(i) Draw a 'dot-and-cross' diagram to show the bonding in SF_4. Include **all** outer shell electrons in your diagram.

[2]

(ii) State whether a molecule of SF_4 has a dipole moment. Explain your answer.

.....

..... [1]

(e) Suggest a reason why sulfur can form both SF_4 and SF_6 whereas oxygen can only form OF_2.

.....

..... [1]

(f) **(i)** State a major source of atmospheric sulfur dioxide.

..... [1]

(ii) State **one** environmental consequence of atmospheric sulfur dioxide.

..... [1]

[Total: 11]

2 **(a)** A sample of lead consists of the following isotopes in the percentage abundances stated.

isotope	% abundance
^{204}Pb	1.9
^{206}Pb	24.8
^{207}Pb	21.4
^{208}Pb	51.9

Use these data to calculate the relative atomic mass of the sample of lead to **two** decimal places.

A_r (Pb) = ... [2]

(b) Tin and lead both form oxides in oxidation states (II) and (IV).

(i) How does the acid-base nature of tin(II) oxide compare to that of tin(IV) oxide?

..... [1]

(ii) Illustrate your answer to **(i)** with equations, showing the reaction of each oxide with a suitable acid or base, as appropriate.

SnO .....

SnO_2 .....
[2]

(iii) Describe the reactions, if any, that occur when separate samples of tin(IV) oxide and lead(IV) oxide are heated in air.
Include any relevant observations and write equations for any reactions that occur.

.....

.....

.....

.....

..... [3]

[Total: 8]

3 **(a)** Complete the table with the symbol of the ion that contains the number of protons, electrons and neutrons stated in the following table. The first line has been completed as an example.

protons	electrons	neutrons	*symbol*
3	2	4	$^{7}Li^{+}$
15	16	18	

[2]

(b) Describe and explain the trend in the solubilities of the sulfates of the Group II elements down the group.

.....

.....

.....

..... [4]

(c) Calcium sulfate is sparingly soluble in water.

Describe and explain what you would see when a few cm^3 of concentrated $Na_2SO_4(aq)$ were added to a saturated solution of $CaSO_4(aq)$.

.....

.....

.....

..... [2]

(d) When a solution of a chromium salt **X** is electrolysed, chromium metal is deposited on the cathode, according to the following equation.

$$Cr^{n+}(aq) + ne^{-} \rightarrow Cr(s)$$

When a current of 1.8 A was passed for 40 minutes through a solution of salt **X**, it was found that 0.776 g of chromium had been deposited.

Calculate the value of *n* in the above equation. Show your working.

n = ... [4]

[Total: 12]

4 **(a)** **(i)** What is meant by the term *buffer solution*?

.....

.....

..... [2]

(ii) Write equations to show how the hydrogencarbonate ion, HCO_3^-, controls the pH of blood.

.....

..... [2]

(iii) A solution containing both Na_2HPO_4 and NaH_2PO_4 is commonly used as a buffer solution. The following equilibrium is present in the solution.

$$H_2PO_4^-(aq) \rightleftharpoons HPO_4^{2-}(aq) + H^+(aq) \qquad K_a = 6.2 \times 10^{-8}\,\text{mol}\,\text{dm}^{-3}$$

Calculate the pH of a buffer solution made by mixing 100 cm^3 of 0.5 mol dm^{-3} Na_2HPO_4 and 100 cm^3 of 0.3 mol dm^{-3} NaH_2PO_4.

pH = ... [2]

(b) Silver phosphate, Ag_3PO_4, is sparingly soluble in water.

(i) Write an expression for the solubility product, K_{sp}, of Ag_3PO_4, and state its units.

K_{sp} = units: ..... [1]

(ii) The numerical value of K_{sp} is 1.25×10^{-20} at 298 K. Use this value to calculate $[Ag^+(aq)]$ in a saturated solution of Ag_3PO_4.

$[Ag^+(aq)]$ = ... mol dm^{-3} [3]

(c) The half-equation for the redox reaction between phosphoric(III) acid and phosphoric(V) acid is shown.

$$H_3PO_4(aq) + 2H^+(aq) + 2e^- \rightleftharpoons H_3PO_3(aq) + H_2O(l) \qquad E^\ominus = -0.28\,V$$

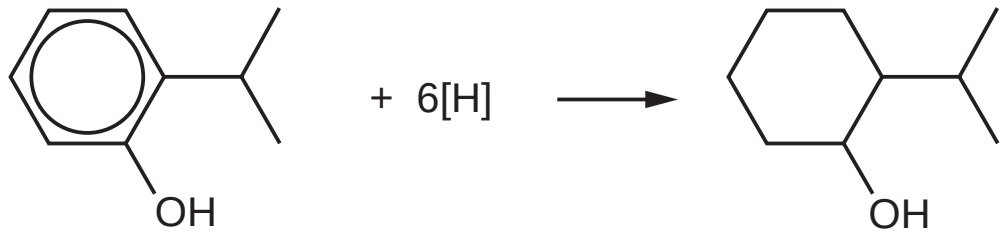
Find suitable data from the *Data Booklet* to write an equation for the reaction between H_3PO_3 and $Fe^{3+}(aq)$ ions, and calculate the $E^\ominus_{cell}$ for the reaction.

equation: .....

$E^\ominus_{cell}$ = ... V [2]

[Total: 12]

5 **(a)** Compound **B** is a component of several perfumes and flavourings. It can be obtained by the hydrogenation of compound **A**.
During the reaction, the hydrogen atoms all add onto the same side of the benzene ring.



A **B**

(i) Suggest reagents and conditions for this reaction.

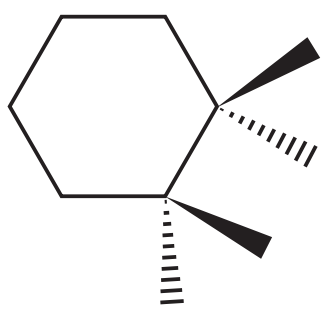
..... [1]

(ii) Circle all the chiral atoms on the structure of **B** above. [1]

(iii) How many possible optical isomers are there with the same structural formula as **B**?

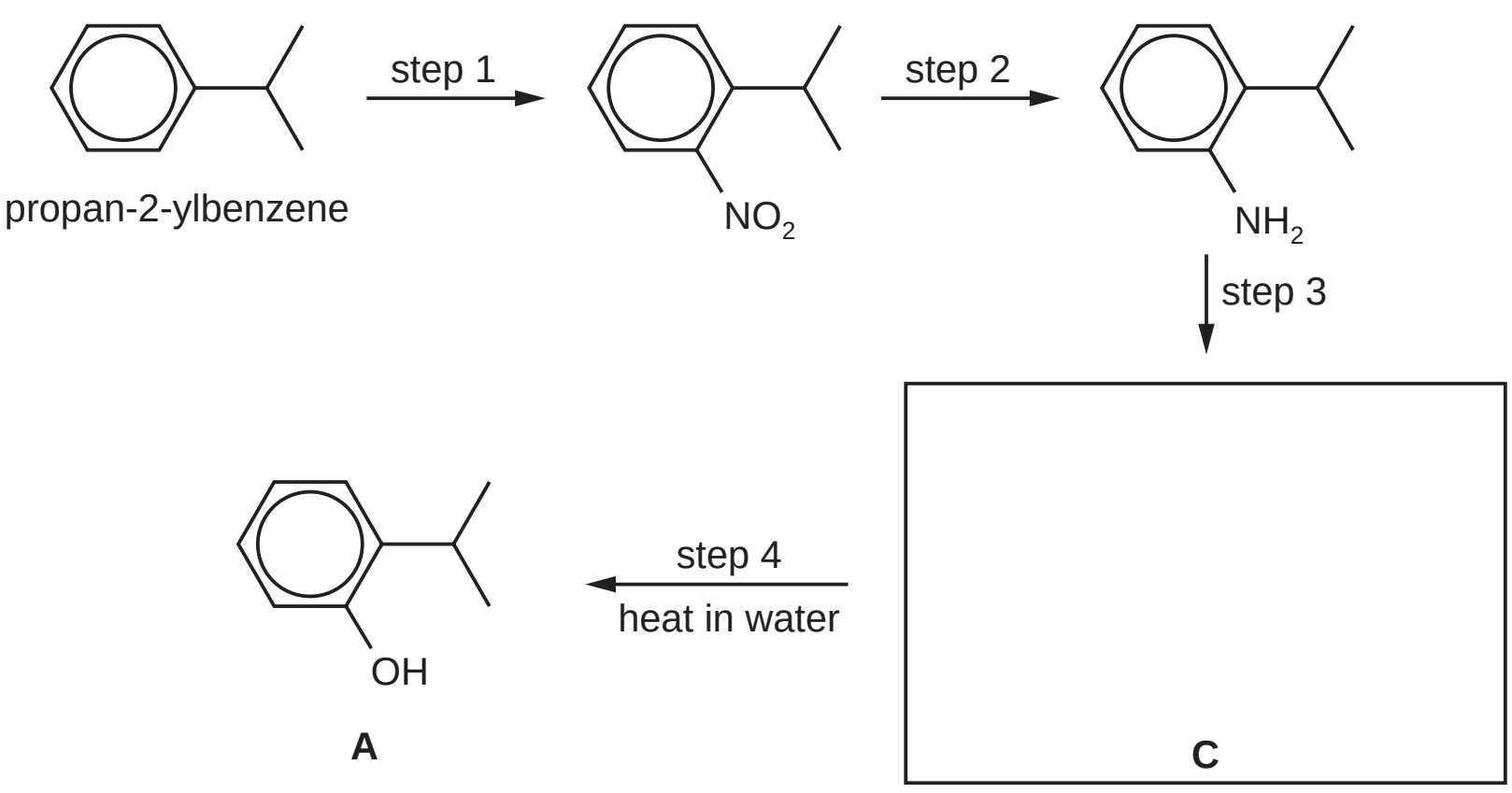
..... [1]

(iv) Complete the following part-structure to show the structure of one of the isomers of **B** that would be formed during the above reaction.



[1]

(b) Compound **A** can be obtained from propan-2-ylbenzene by the following route.



(i) Suggest the structure of the intermediate cation **C** and draw it in the box above. [1]

(ii) Suggest reagents and conditions for the following steps.

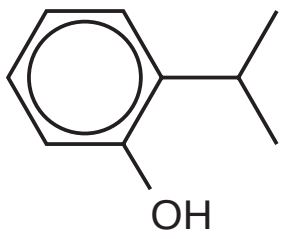
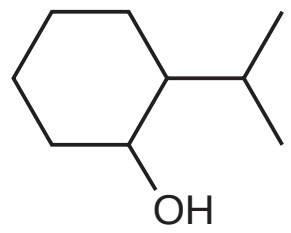
step 1 .....

step 2 .....

step 3 .....

[4]

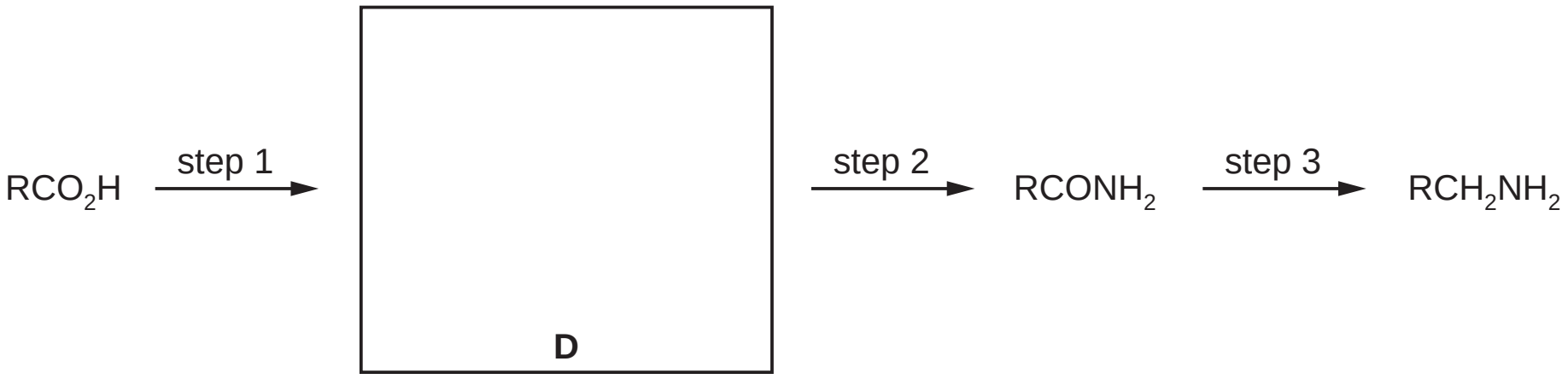
(c) Suggest the structures of the organic products of the reactions between each of the compounds **A** and **B** and the following reagents. If no reaction occurs write 'no reaction' in the relevant box.

	product with **A**, 	product with **B**, 
reagent		
HBr		
Na		
NaOH(aq)		

[5]

[Total: 14]

6 **(a)** Carboxylic acids can be converted into primary amines by the following sequence of reactions.



(i) Suggest the identity of intermediate **D** and write its structure in the box above. [1]

(ii) Suggest the reagents for

step 1 .....

step 2 .....

step 3 .....
[2]

(b) Four compounds, **E**, **F**, **G** and **H**, are isomers of each other.
Each compound contains an aromatic ring and **two** functional groups from the following list.

- alcohol
- amide
- amine
- carboxylic acid
- ester
- phenol

(i) Which of these functional groups react readily with cold HC*l*(aq)?

..... [1]

(ii) Which of these functional groups react readily with cold NaOH(aq)?

..... [1]

The molecular formula of the four isomers, **E**, **F**, **G** and **H**, is $C_8H_9NO_2$. All four compounds are insoluble in water. **Table 1** shows their solubilities in acid or alkali.

compound	solubility in HC*l*(aq)	solubility in NaOH(aq)
E	insoluble	insoluble
F	soluble	soluble
G	soluble	insoluble
H	insoluble	soluble

Table 1

(iii) Use this information to suggest the **two** functional groups, taken from the list on page 10, that each compound contains.

compound	first functional group	second functional group
E		
F		
G		
H		

[4]

(iv) Suggest a structure for each compound.

E

F

G

H

[4]

[Total: 13]

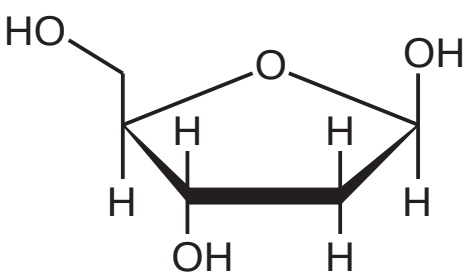
Section B

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

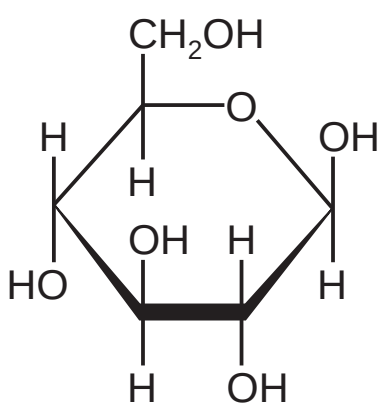
7 This question is about the structures and roles of DNA and RNA in protein synthesis.

(a) Study the structures of the three molecules below.
One of the molecules could be a building block for a protein while the other two could be building blocks for other biological polymers.

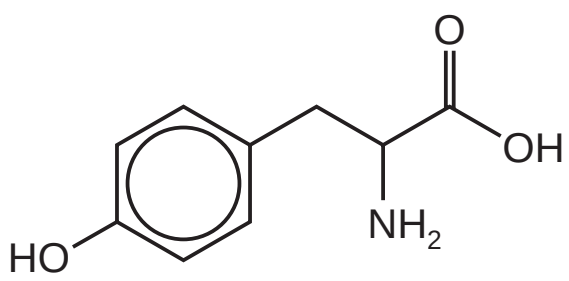
J



K



L



Which of the three could be a building block for a protein? Explain your answer.

.....

..... [1]

(b) Outline the **different** roles played by mRNA and tRNA in producing a protein with a specific primary structure.

mRNA .....

.....

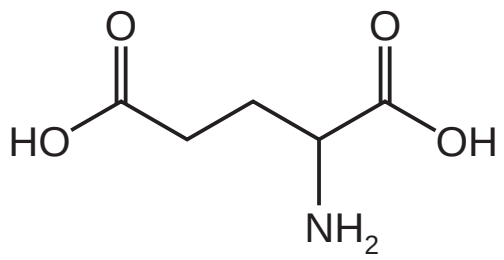
.....

tRNA .....

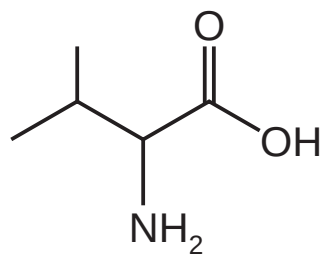
.....

.....
[4]

(c) Sickle cell anaemia is a genetic-based disease in which one of the glutamic acid residues is replaced by a valine residue.



glutamic acid



valine

Suggest and explain how this change in the primary structure of the protein would affect the overall structure and function of the protein.

.....

.....

.....

.....

..... [3]

[Total: 8]

8 **(a)** NMR spectroscopy and X-ray crystallography can both be used to examine the structure of organic compounds.

NMR is very useful at examining hydrogen atoms in compounds, but hydrogen atoms are invisible to X-rays.

(i) Explain why NMR spectroscopy can detect hydrogen atoms in molecules.

.....

..... [1]

(ii) Explain why hydrogen atoms are invisible to X-rays.

.....

..... [1]

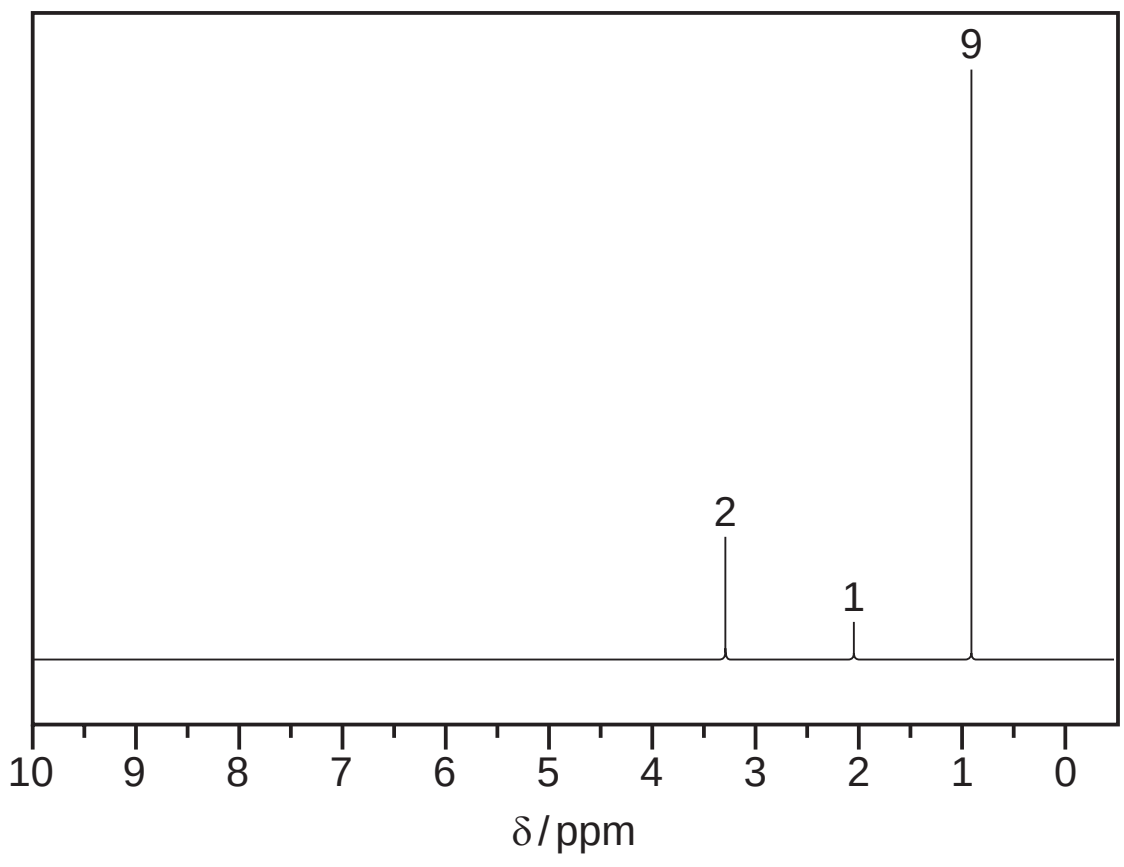
(iii) The molecular formula of the amino acid cysteine is $C_3H_7O_2NS$.

Explain which of the atoms present would show the greatest absorption on exposure to X-rays.

.....

..... [1]

(b) The NMR spectrum below was obtained from an organic liquid, **P**, which contains five carbon atoms per molecule.



(i) How many protons are present in one molecule of **P**? Explain your answer.

number of protons .....

.....

..... [1]

(ii) When a little D_2O is added to **P**, the absorption at δ2.0 disappears.

Explain what this tells you about the group responsible for this absorption and why.

.....

.....

..... [2]

(iii) What does the absorption at δ0.9 tell you about the adjacent carbon atom?

.....

..... [1]

(iv) What group(s) is/are responsible for the absorption at δ0.9?

..... [1]

(v) Suggest a structure for **P**.

[1]

(c) When an isomer of **P** is heated with concentrated H_2SO_4 it forms a new compound, **Q**. This new compound **Q** reacts with bromine to give a dibromide, **R**.

(i) A mass spectrum was obtained of **R**. The ratio of the heights of the M : M+1 peaks was 9.3 : 0.5.

Show that there are five carbon atoms present in one molecule of **R**.

[1]

(ii) Predict the ratio of the heights of the M : M+2 : M+4 peaks as a result of the two bromine atoms in the dibromide **R**. Show your working.

ratio ..... [1]

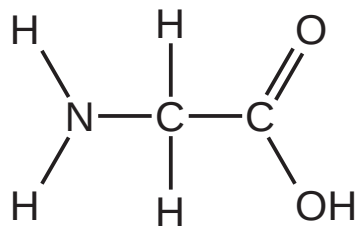
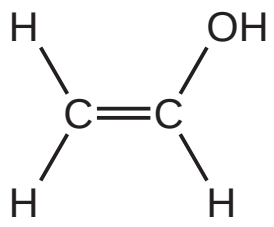
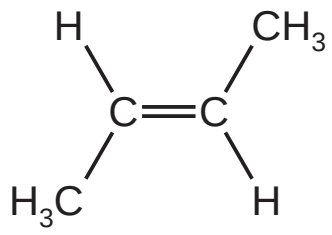
(iii) What is the molecular formula of **R**?

..... [1]

[Total: 12]

9 Polymers consist of monomers joined either by addition or condensation reactions.

(a) Complete the table by placing a tick (✓) in the correct column to indicate the type of reaction that would polymerise each of the monomers.

monomer	addition	condensation	both
			
			
			

[3]

(b) Poly(ethene) bags pollute the environment for a long time because they are non-biodegradable.

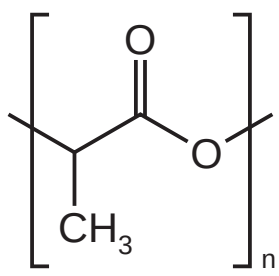
Suggest why.

.....

.....

..... [2]

(c) There has been considerable research into making biodegradable plastic bags. The repeat unit for one of the polymers used, polylactic acid (PLA), is shown.



(i) Draw the structure of the monomer for PLA.

[1]

(ii) Suggest why PLA breaks down **more** easily in the environment than poly(ethene).

.....

.....

..... [1]

(d) The table shows the melting points of three polymers.

polymer	melting point / °C
polyethene	137
polychloroethene (PVC)	212
nylon 6,6	265

Explain the differences in melting point of these three polymers in terms of the intermolecular forces between the chains.

.....

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 10]

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