Oxford Cambridge and RSA

Monday 16 June 2025 – Morning

A Level Chemistry A

H432/02 Synthesis and analytical techniques

Time allowed: 2 hours 15 minutes

You must have:
- the Data Sheet for Chemistry A

You can use:
- a ruler (cm/mm)
- a scientific or graphical calculator
- an HB pencil

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **100**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*****).
- This document has **36** pages.

ADVICE
- Read each question carefully before you start your answer.

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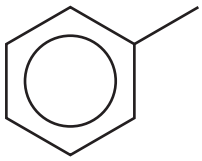
Section A

You should spend a **maximum** of **20 minutes** on this section.

Write your answer to each question in the box provided.

1 Which compound is alicyclic **and** unsaturated?

A



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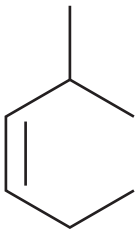

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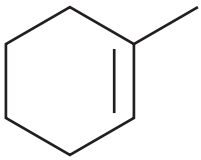

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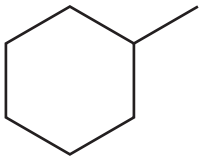

Your answer ☐

[1]

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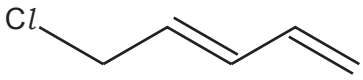
2 0.0200 mol of the compound below reacts with Br_2(aq) to make a saturated compound.

How many grams of Br_2 are needed for this reaction?



A 3.20

B 6.39

C 7.99

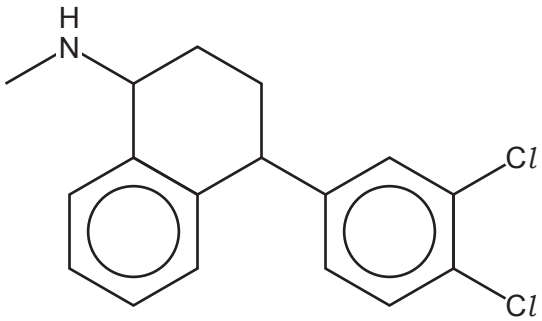
D 12.80

Your answer ☐

[1]

3 The skeletal structure of a medicinal drug is shown below.

How many hydrogen atoms are in its molecular formula?



A 14

B 15

C 17

D 19

Your answer ☐

[1]

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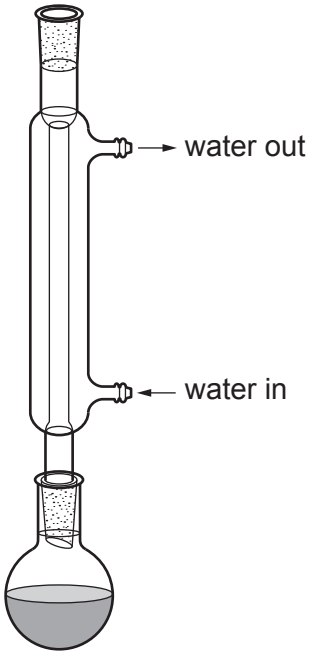
4 Which diagram shows the correct way to set up apparatus for converting ethanol to ethanoic acid?

A



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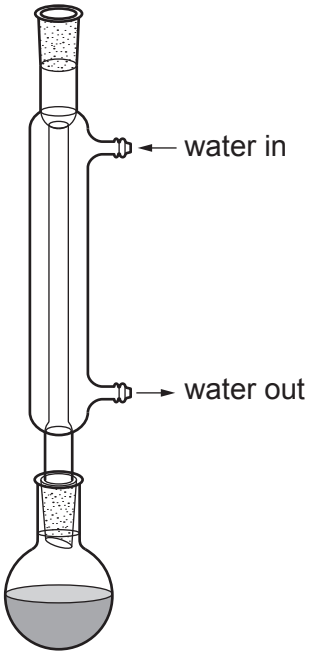

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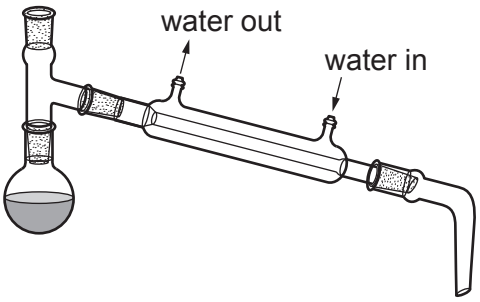

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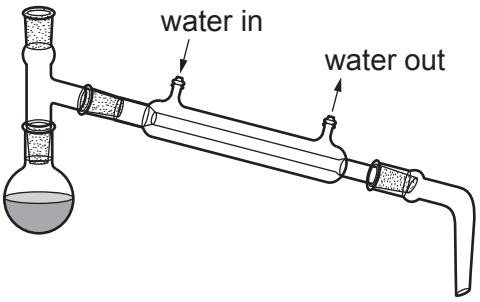

Your answer ☐

[1]

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5 0.200 mol of $HOOCCH_2CH_2COOH$ is reacted with 0.300 mol NaOH.

How many water molecules are formed?

A 1.204×10^{23}

B 1.806×10^{23}

C 2.408×10^{23}

D 3.612×10^{23}

Your answer ☐

[1]

6 Propene can be prepared using the reactions shown.

Which reaction has the **lowest** atom economy?

A $C_3H_7Br \rightarrow C_3H_6 + HBr$

B $C_{12}H_{26} \rightarrow 2C_3H_6 + C_6H_{14}$

C $C_8H_{18} \rightarrow C_3H_6 + C_5H_{12}$

D $C_3H_7OH \rightarrow C_3H_6 + H_2O$

Your answer ☐

[1]

7 What are the **organic** products of the **acid** hydrolysis of $CH_3CH_2CONHCH_3$?

A $CH_3CH_2COO^- + CH_3NH_3^+$

B $CH_3CH_2COOH + CH_3NH_3^+$

C $CH_3CH_2COOH + CH_3NH_2$

D $CH_3CH_2COO^- + CH_3NH_2$

Your answer ☐

[1]

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8 Ethene can be reacted with hydrogen bromide.

Which statement about this reaction is correct?

A H^- acts as a nucleophile.

B Br^+ acts as an electrophile.

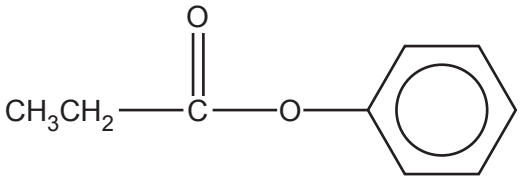
C $H^{\delta+}$—$Br^{\delta-}$ acts as an electrophile.

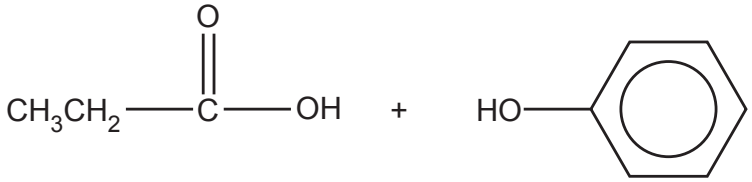
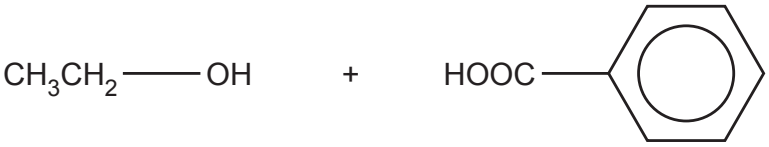
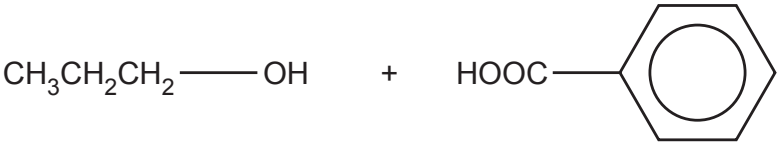
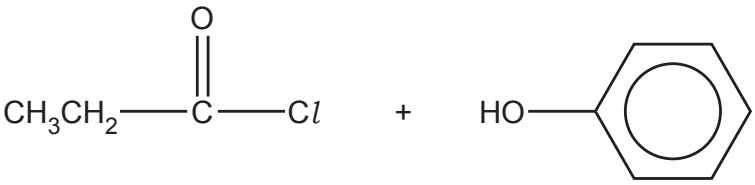
D $H^{\delta+}$—$Br^{\delta-}$ acts as a nucleophile.

Your answer ☐

[1]

9 Which reagents could a student use to prepare the ester shown?



A	
B	
C	
D	

Your answer ☐

[1]

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10 How many stereoisomers does the compound $CH_3CH(Br)CH{=}CHCH(Cl)CH_3$ have?

A 2

B 4

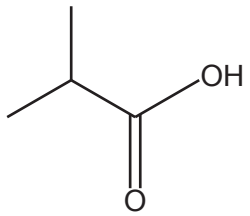
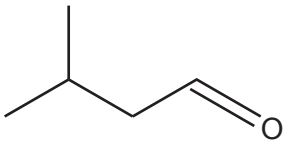
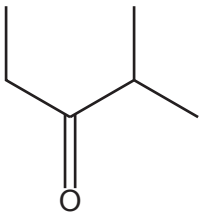
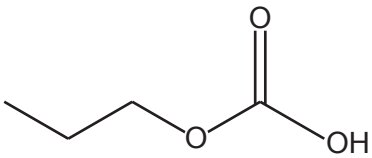
C 6

D 8

Your answer ☐

[1]

11 Which molecule does **not** produce a mass spectrum containing a peak at *m*/*z* = 29?

A	
B	
C	
D	

Your answer ☐

[1]

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12 Which process does **not** involve infrared radiation?

A Catalytic ozone depletion

B Monitoring toxic gases in the air

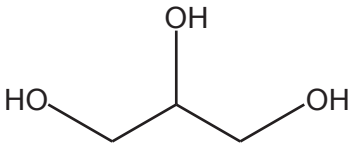
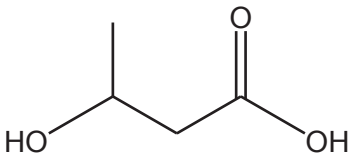
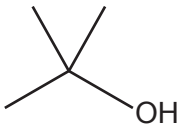
C Measuring ethanol in breathalyser tests

D Global warming

Your answer ☐

[1]

13 Which molecule(s) would form a ketone group when oxidised?

1	
2	
3	

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐

[1]

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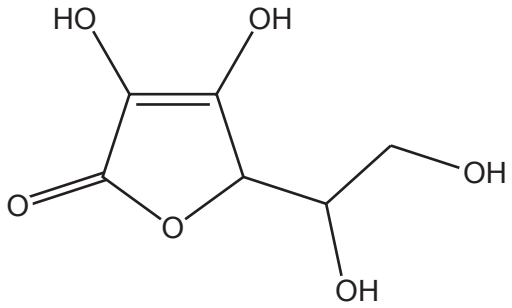
14 The structure of vitamin C is shown.



Which reagent(s) will react with vitamin C?

1 Aqueous bromine water

2 Acidified potassium dichromate(VI)

3 Aqueous silver nitrate in ethanol

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐

[1]

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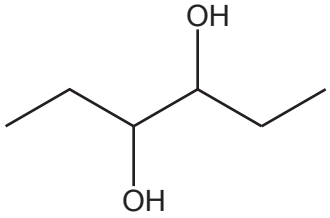
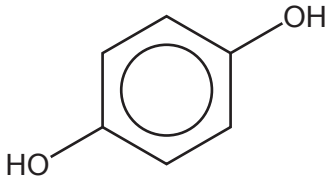
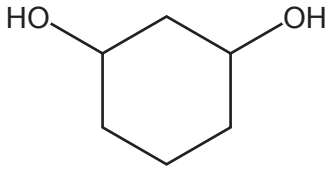
15 Which compound(s) has/have **three** peaks in their ^{13}C NMR spectrum?

1	
2	
3	

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐

[1]

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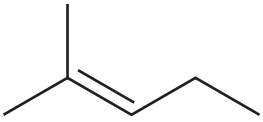
Section B

16 This question is about hydrocarbons with six carbon atoms.

(a) Compound **A** is a hydrocarbon:



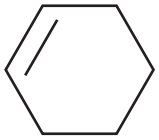
Compound A

What is the systematic name of compound **A**?

..... **[1]**

(b) The table below shows incomplete information about two hydrocarbons.

Complete the table.

Skeletal formula		
Molecular formula		
Number of σ bonds		
Number of π bonds		

[3]

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(c) Compound **B**, $CH_3CH{=}C(CH_3)CH_2CH_3$, exists as *E* and *Z* stereoisomers.

(i) Draw the structures of the *E* and *Z* stereoisomers of compound **B**.

E	***Z***

[2]

(ii) Explain why compound **B** can form *E* and *Z* stereoisomers.

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..... **[2]**

(d) Hexane, C_6H_{14}, is used as a fuel.

1.0 mol of hexane is mixed with 6.0 mol of oxygen and combusted.

Construct an equation for the **incomplete** combustion of 1.0 mol of hexane with 6.0 mol of oxygen.

..... **[1]**

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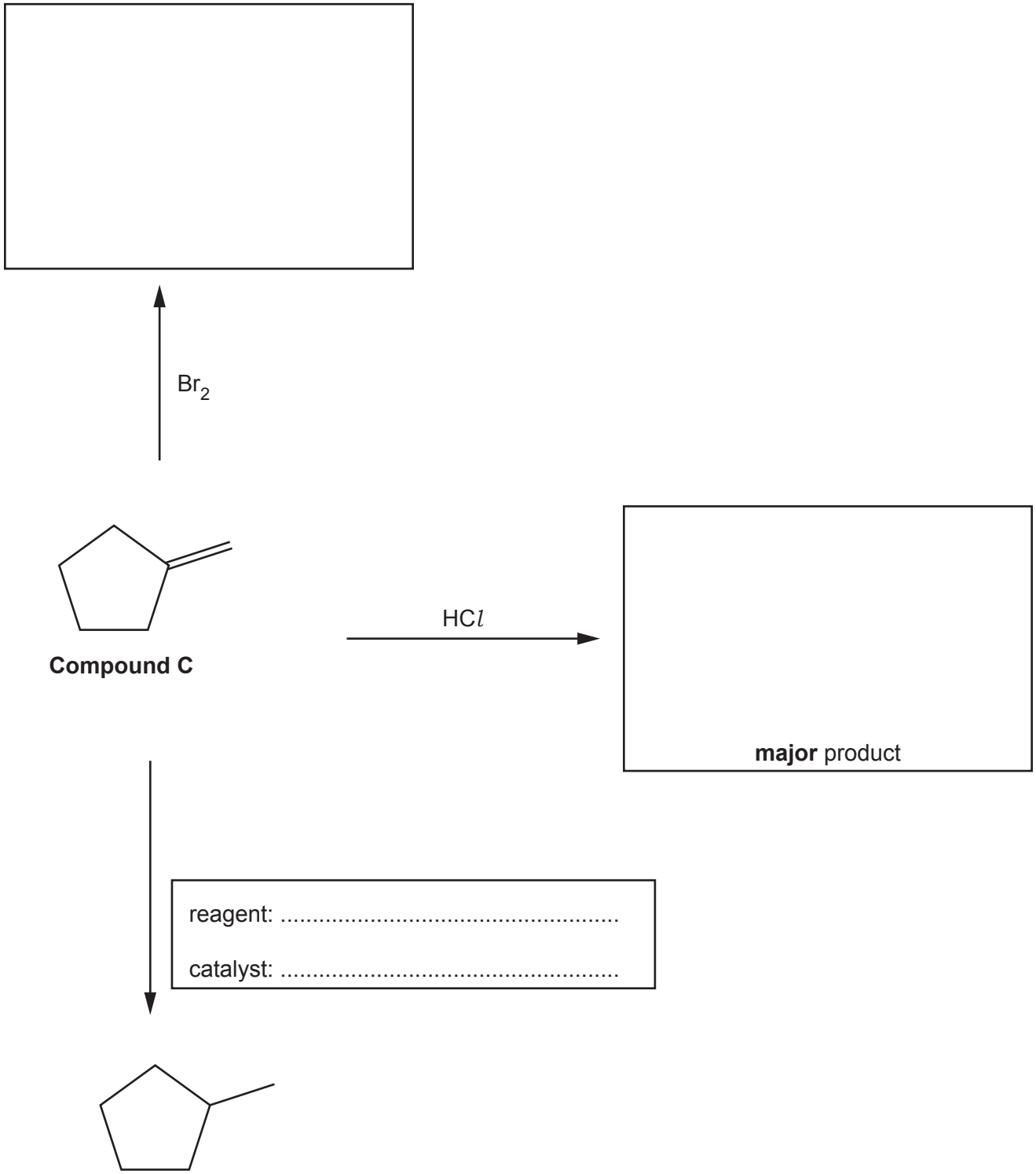
(e) The flowchart below shows some reactions of compound **C**.

Complete the flowchart to show the missing reagent, catalyst and the structures of the organic products.



[3]

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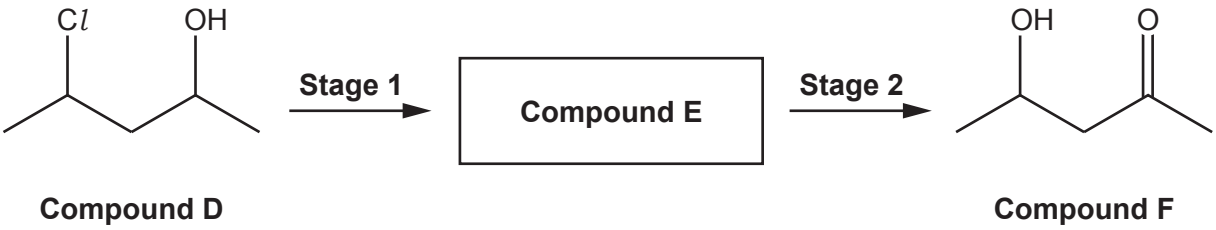
17* This question is about an organic synthesis.

A student plans a two-stage synthesis of compound **F** from compound **D**, as shown below.



Plan a two-stage synthesis for the preparation of 2.50 g of compound **F** from compound **D**.

The overall percentage yield of compound **F** from compound **D** is 31.5%.

In your answer include the mass of compound **D** required, reagents and equations for each step.

[6]

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Extra answer space if required.

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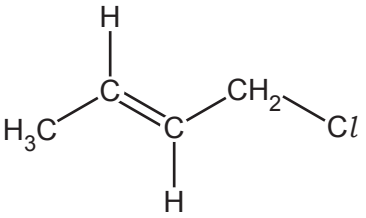
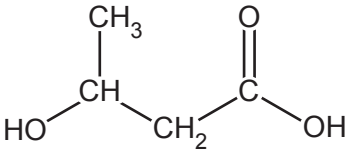
18 This question is about polymers.

The structures of 1-chlorobut-2-ene and 3-hydroxybutanoic acid are shown.



1-Chlorobut-2-ene



3-Hydroxybutanoic acid

(a) 1-Chlorobut-2-ene and 3-hydroxybutanoic acid can both form polymers.

Draw **two** repeat units of each of the polymers formed.

State the type of polymerisation reaction that takes place for each compound.

Two repeat units of polymer of 1-chlorobut-2-ene
Type of polymerisation .....

Two repeat units of polymer of 3-hydroxybutanoic acid
Type of polymerisation .....

[4]

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(b) The disposal of polymers containing chlorine is a major challenge.

(i) Suggest why a polymer made from monomers containing chlorine, such as 1-chlorobut-2-ene, is difficult to dispose of by incineration.

.....

..... **[1]**

(ii) The polymer formed from 3-hydroxybutanoic acid can be hydrolysed. This makes the polymer biodegradable.

Suggest what feature in the structure of this polymer allows this hydrolysis.

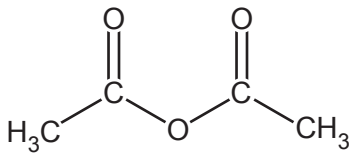
.....

..... **[1]**

(c) 3-Hydroxybutanoic acid reacts with ethanoic anhydride, $(CH_3CO)_2O$.

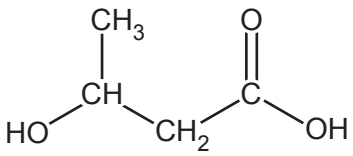
Complete the equation for this reaction.

Show the structures of the organic compounds.



Ethanoic anhydride

+



3-Hydroxybutanoic acid

+

[2]

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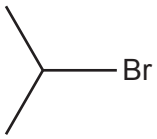
19 This question is about reactions of haloalkanes.

(a) Haloalkanes can react with potassium cyanide to form new carbon–carbon bonds.

(i) Outline the mechanism for the reaction of 2-bromopropane with cyanide ions.

Show curly arrows, relevant dipoles and products.



[3]

(ii) Name this type of mechanism.

..... **[1]**

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(b) The table below shows the boiling points of propan-1-ol and 1-bromopropane.

	Propan-1-ol	**1-Bromopropane**
Boiling point / °C	97	71

Propan-1-ol can be reacted to form 1-bromopropane.

(i) Suggest suitable reagents for this reaction.

..... **[1]**

(ii) The reaction to form 1-bromopropane from propan-1-ol is carried out in a flask.

After the reaction, the flask contains a mixture of an organic layer (density = 1.35 g cm^{-3}) and an aqueous layer (1.04 g cm^{-3}).

Describe how to obtain pure **1-bromopropane** from the mixture.

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..... **[4]**

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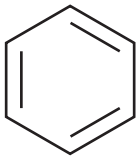
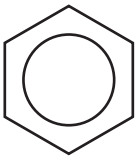
20 This question is about aromatic compounds.

(a) The diagrams show the Kekulé and delocalised models of benzene.



Kekulé



Delocalised

One piece of evidence for the delocalised model is that benzene does **not** decolourise aqueous bromine.

Suggest **two other** pieces of evidence which support the delocalised model of benzene.

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.....

..... **[2]**

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(b) A student investigates the reactions of benzene and phenol with excess bromine.

The student's observations are given in **Table 20.1**.

Table 20.1

Compound	Benzene	Phenol
Observation with excess bromine	no change	decolourises and forms a white precipitate

(i) Explain the difference in the relative reactivities of benzene and phenol with bromine.

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..... **[3]**

(ii) The white precipitate has a relative molecular mass of 330.7.

Construct an equation for the reaction of phenol with excess bromine shown in **Table 20.1**.

Show the structure of the organic species.

[2]

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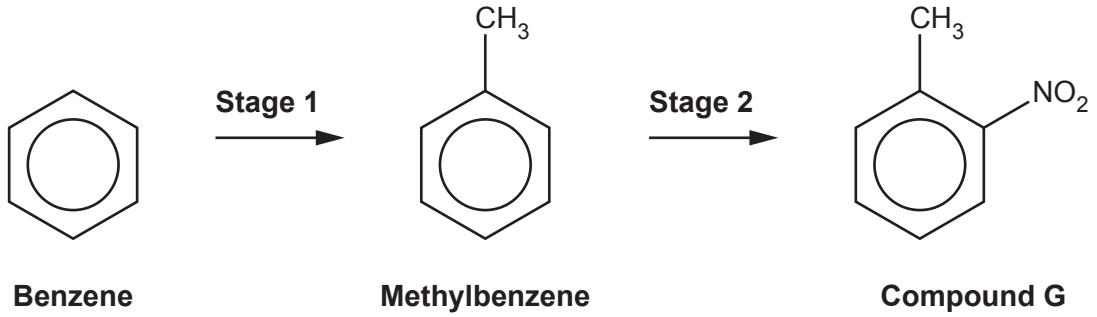
(c) Compound **G** is an organic compound used in the production of pesticides.

Compound **G** can be synthesised from benzene in the two-stage process shown.

Synthesis 1



(i) Suggest a reagent and halogen carrier that could be used in **Stage 1** of **Synthesis 1**.

..... **[1]**

(ii) **Stage 2** of **Synthesis 1** is the conversion of methylbenzene to compound **G**.

Outline the mechanism for the reaction in **Stage 2**.

Show the role of H_2SO_4 as a catalyst.

[5]

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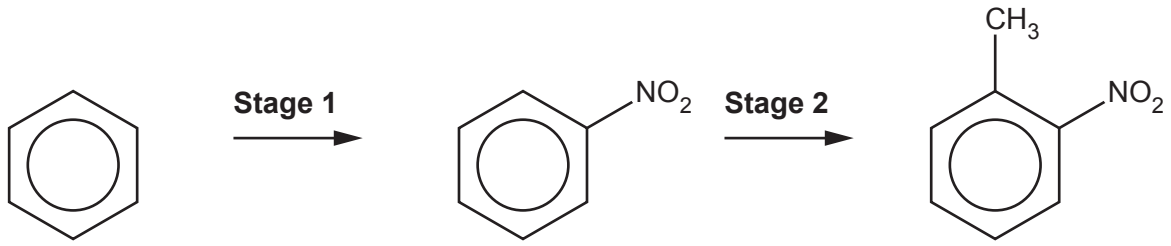
(iii) A student suggested an alternative two-stage synthesis of compound **G** from benzene.

Synthesis 2



Benzene **Nitrobenzene** **Compound G**

When **Synthesis 2** is attempted, the synthesis is **not** successful and a different organic compound from compound **G** is produced.

- Suggest why **Synthesis 1** is successful but **Synthesis 2** is **not** successful.
- Suggest the structure of the different organic compound that is formed in **Synthesis 2**.

.....

.....

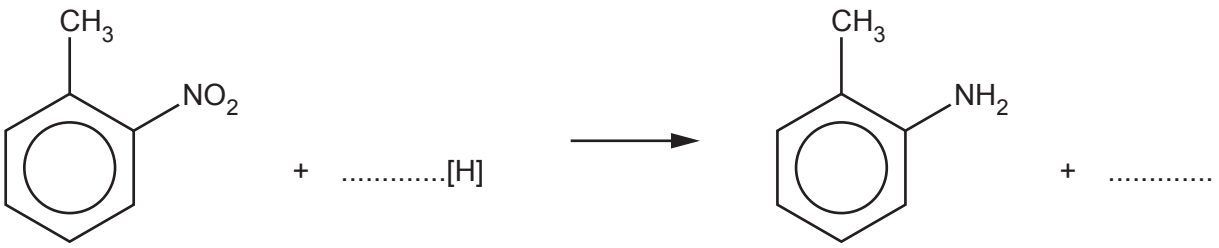
[2]

(iv) In the production of a pesticide, compound **G** is reduced to amine **H**.

Suggest suitable reagents and complete the equation for this reduction.

Reagents .....

Equation:



Compound G **Amine H**

[2]

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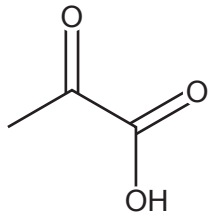
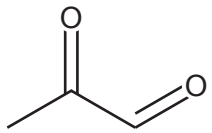
21 This question is about carbonyl compounds.

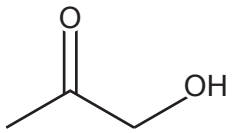
The three compounds below each contain a ketone and one other functional group.



Pyruvic acid



Methylglyoxal



Acetol

(a) What is a **functional group**?

.....

..... **[1]**

(b) A chemical test is carried out which gives a positive result for **all three** compounds.

Suggest the reagent and observation of this chemical test.

Reagent .....

Observation .....

[2]

(c) A student is provided with three unlabelled sample tubes, containing either pyruvic acid, methylglyoxal or acetol.

The student carries out three chemical tests on each sample.

Complete the table with the expected observations, including 'no change' where appropriate.

Chemical test	**Expected observations**		
	Pyruvic acid	**Methylglyoxal**	**Acetol**
Tollens' reagent	....	....	....
$Na_2CO_3(aq)$	....	....	....
$Cr_2O_7^{2-}(aq)/H^+(aq)$	....	....	....

[3]

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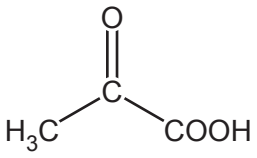
(d) Pyruvic acid reacts with $NaBH_4$.

Outline the mechanism for the reaction of pyruvic acid with $NaBH_4$.

Include curly arrows and relevant dipoles.



[4]

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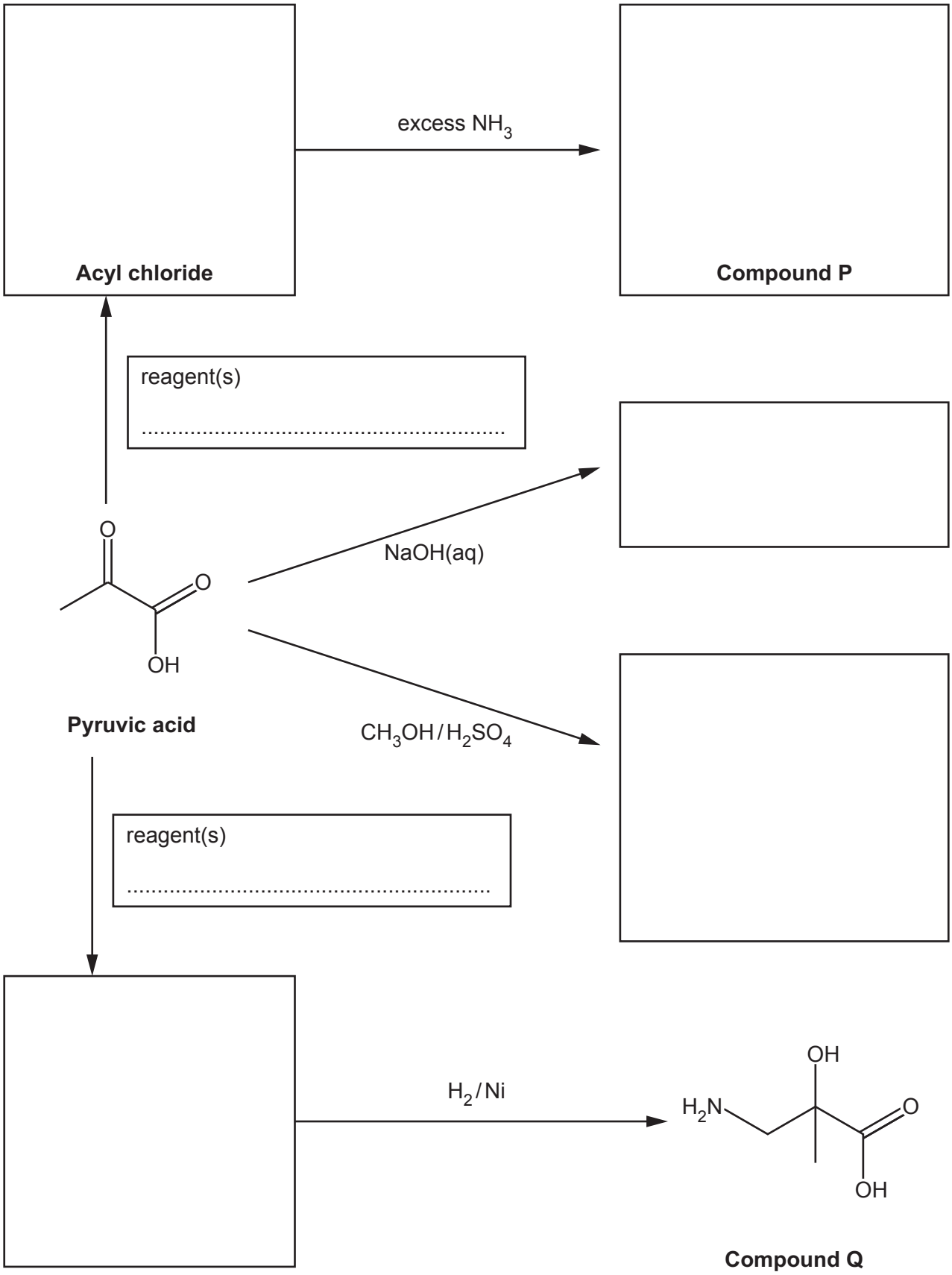
(e) Complete the flowchart for the reactions of pyruvic acid.



[7]

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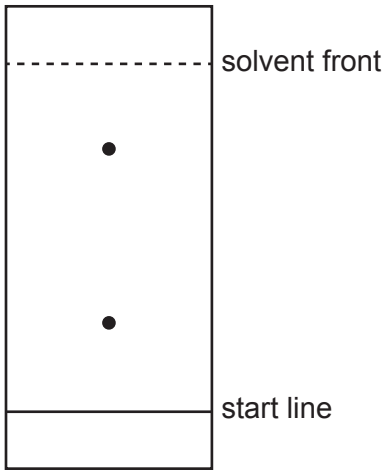
22 This question is about organic acids.

α-Amino acids have the general formula $RCH(NH_2)COOH$.

(a) Compound **S** is made of two α-amino acids bonded together.

Compound **S** is hydrolysed into its component α-amino acids.

The resulting mixture is analysed using TLC to produce a chromatogram:



The R group and the R_f value is shown for some α-amino acids.

R group	R_f value
–H	0.18
$–CH_3$	0.25
$–CH_2CH(CH_3)_2$	0.64
$–CH(CH_3)_2$	0.77

(i) Determine the R_f values of the **two** α-amino acids in the chromatogram.

[1]

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(ii) Compound **S** has **two** possible structures.

Draw both of these structures.

[2]

Question 22(b) starts on Page 30

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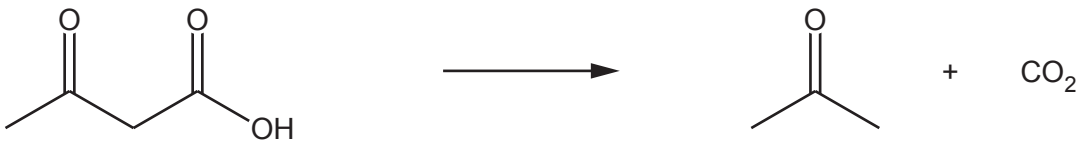
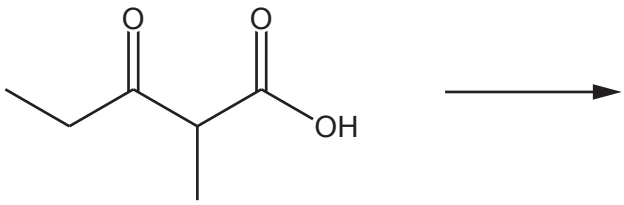
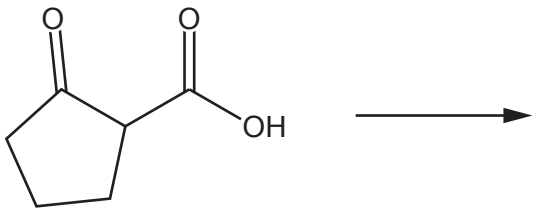
(b) This part is about compounds called β-keto acids.

The equation shows the decomposition of a β-keto acid.



(i) Draw the structures of the organic products you would expect from the decomposition of the **two** other β-keto acids below.





[2]

(ii) α-Amino acids have the NH_2 group bonded to the carbon atom adjacent to the carboxylic acid group.

Suggest the difference between an α-keto acid and a β-keto acid.

.....

.....

..... **[1]**

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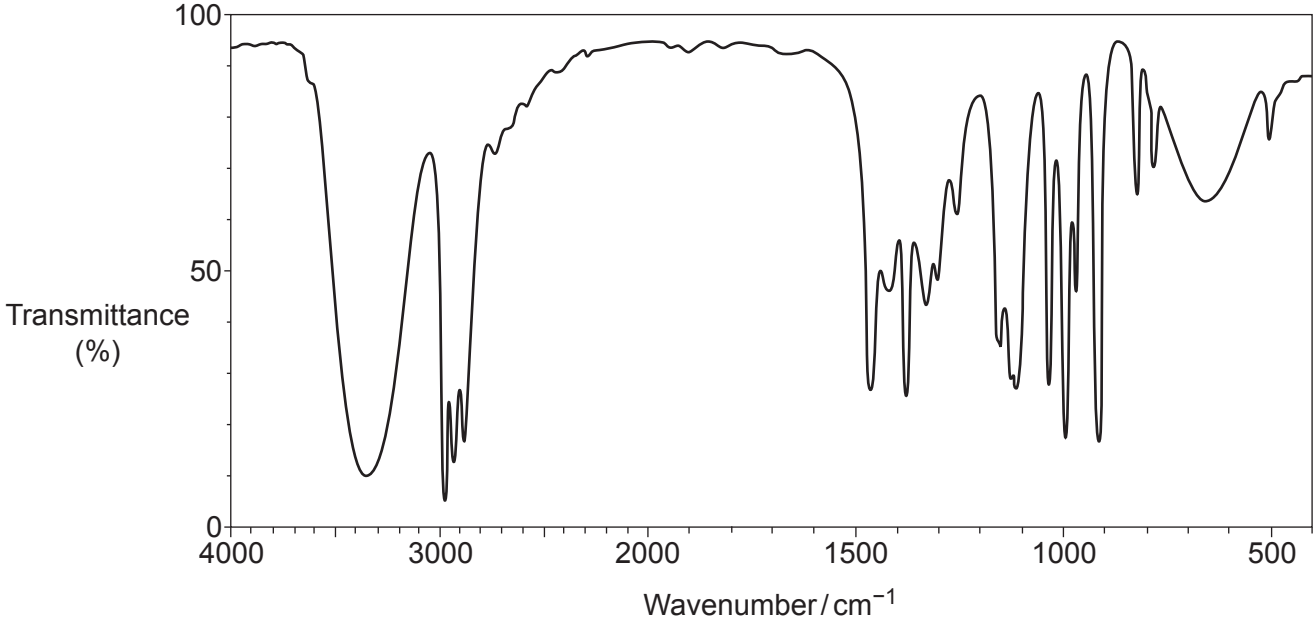
23 This question is about spectral analysis.

(a) Compound **K**, $C_4H_{10}O$, is refluxed with H_2SO_4 to form a mixture of compound **L** and compound **M**.

The infrared spectrum of compound **K** is shown.



Compound **L** and compound **M** are analysed using ^{13}C NMR spectroscopy.

- The ^{13}C NMR spectrum of compound **L** has 4 peaks.
- The ^{13}C NMR spectrum of compound **M** has 2 peaks.

Suggest the functional group in compound **K**, showing your reasoning, and suggest possible structures for compound **K**, compound **L** and compound **M**.

Functional group .....

Reasoning .....

	Possible structure
K	
L	
M	

[4]

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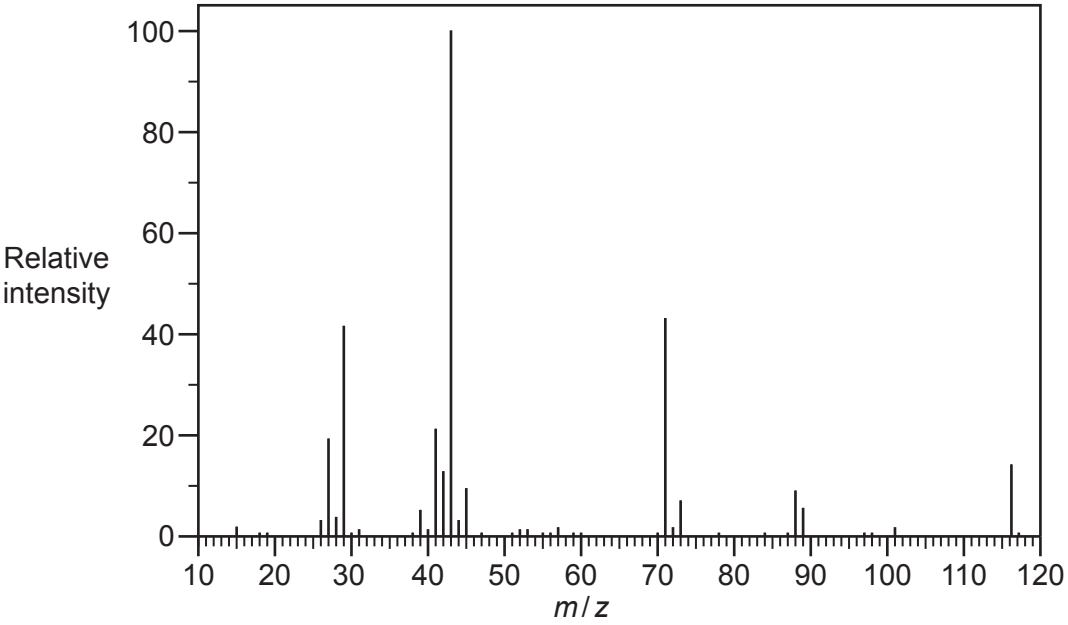
(b)* An unknown organic compound **N** is analysed and produces the following results.

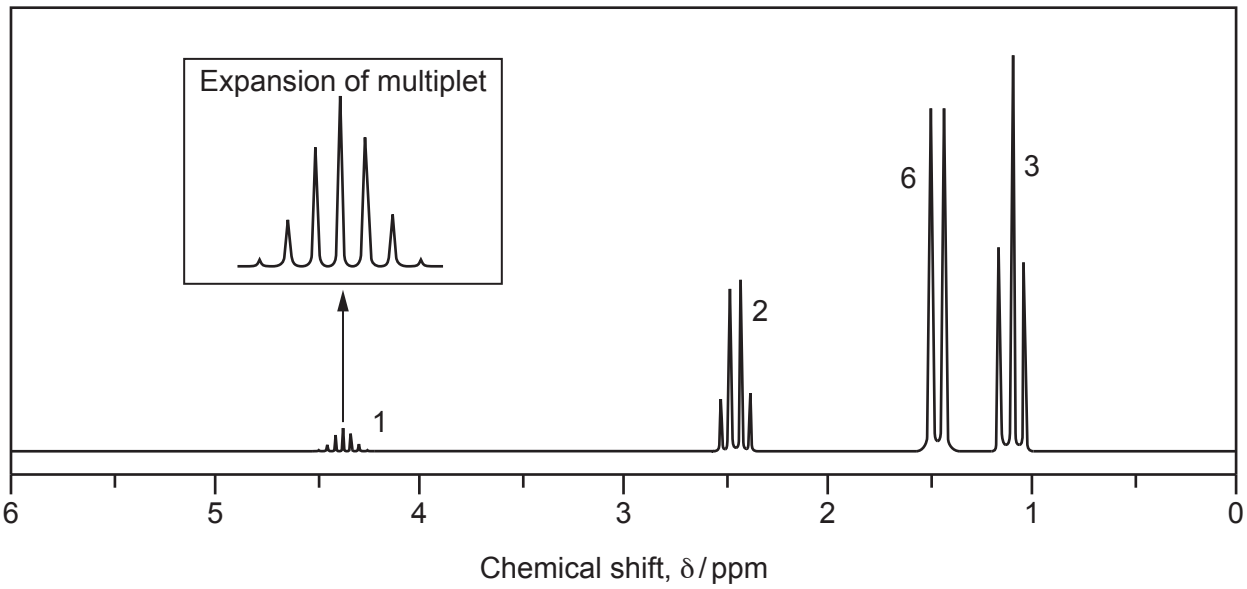
Elemental analysis by mass

C, 62.07%; H, 10.34%; O, 27.59%

Mass spectrum



Proton NMR spectrum



The numbers by the peaks are the relative peak areas.

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Determine the structure of the compound **N**, showing **all** your reasoning.

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..... **[6]**

Extra answer space if required.

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END OF QUESTION PAPER

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EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.

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