



Rewarding Learning

ADVANCED

General Certificate of Education  
2025

Centre Number

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Candidate Number

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## Life and Health Sciences

Assessment Unit A2 2

*assessing*

Organic Chemistry

<b>MV18</b>
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[AZ021]

FRIDAY 6 JUNE, AFTERNOON

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### Time

1 hour 45 minutes, plus your additional time allowance.

### Instructions to Candidates

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

**You must answer the questions in the spaces provided.**

**Do not write on blank pages.**

Complete questions in black ink and use a dark HB pencil for drawings and graphs.

**Do not write with a gel pen.**

Answer **all six** questions.

## Information for Candidates

The total mark for this paper is **100**.

Figures in brackets printed at the end of each question indicate the marks awarded to each question or part question.

You may use a scientific calculator.

Quality of written communication will be assessed in question **5(a)(i)**.

A Data Leaflet, which includes a Periodic Table of the Elements, is included in this question paper.

**1** This question is about hydrocarbons and their reactions.

**(a)** The IUPAC names of seven hydrocarbons are listed below.

Circle **all** the hydrocarbons that are unsaturated.  
[1 mark]

**butane**

**but-1-ene**

**ethane**

**ethene**

**methane**

**propane**

**propene**

**(b)** Draw the structural formula of propane.  
[1 mark]

**(c)** State the molecular formula of propene. [1 mark]

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**(d)** Draw the structural formula of a branched chain isomer of but-1-ene. [1 mark]

**(e) (i)** Methane reacts with chlorine in the presence of UV light to form trichloromethane.

Name this type of reaction. [1 mark]

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**(ii)** Write a balanced symbol equation for the formation of trichloromethane from methane and chlorine. [2 marks]

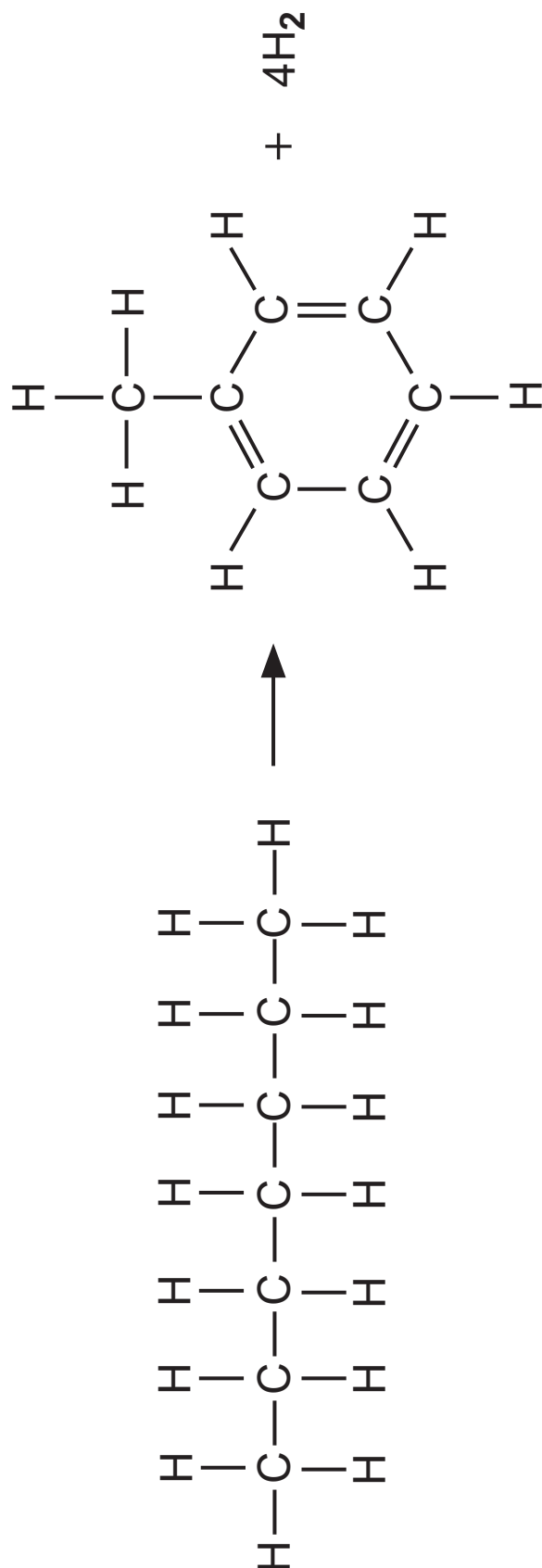
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**(Questions continue overleaf)**

(f) Heptane (C<sub>7</sub>H<sub>16</sub>) can be reformed to produce toluene (C<sub>7</sub>H<sub>8</sub>).

The structural equation for this process is shown below.



Explain how this equation shows that heptane is being reformed. [2 marks]

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- (g) (i)** Hexadecane ( $C_{16}H_{34}$ ) undergoes cracking to form octane ( $C_8H_{18}$ ) and one other organic product in a 1:2 ratio respectively.

Determine the molecular formula for the other organic product formed from the cracking of hexadecane. [1 mark]

Molecular formula \_\_\_\_\_

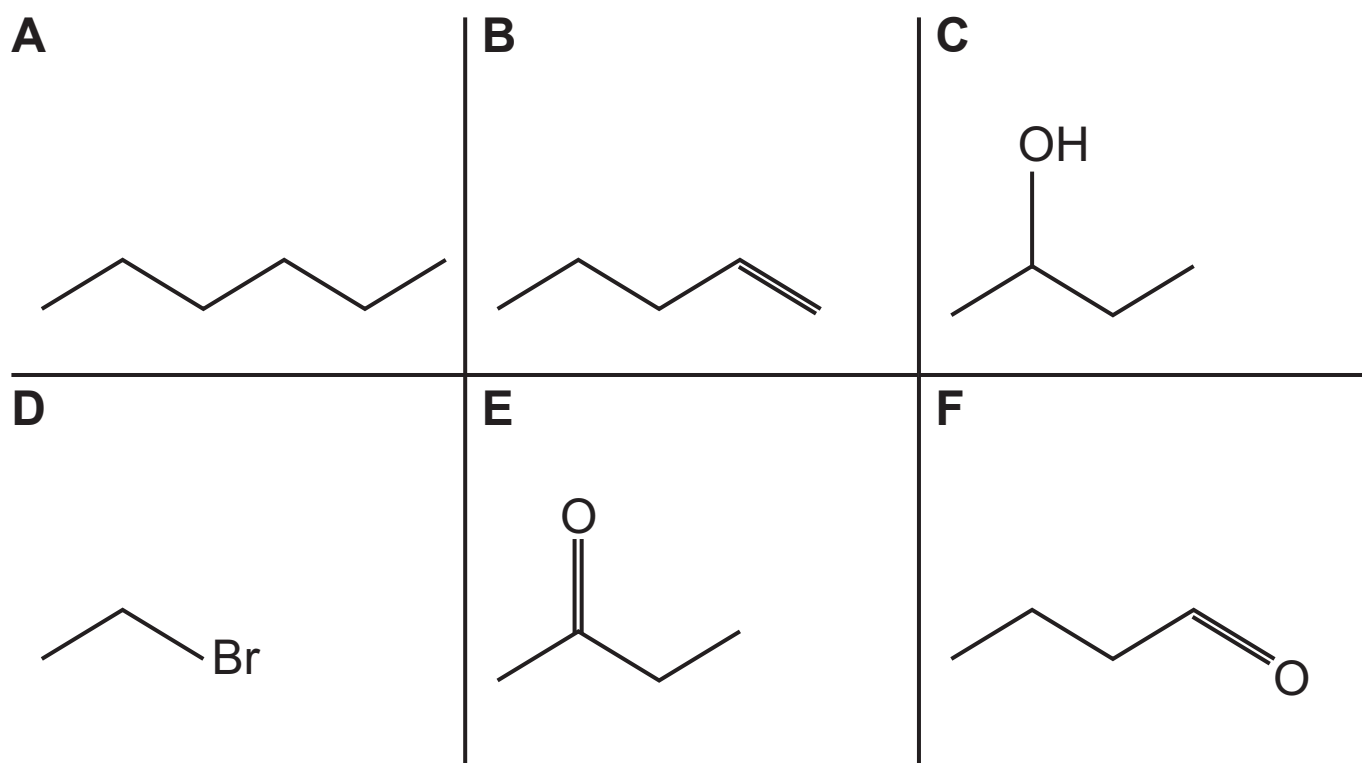
- (ii)** Name the homologous series to which octane ( $C_8H_{18}$ ) belongs. [2 marks]  
Explain your reasoning.

Homologous series \_\_\_\_\_

Reasoning \_\_\_\_\_

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2 The skeletal formulae of six different organic compounds, **A** to **F**, are given below.



(a) Compound **A** is a colourless liquid that reacts with oxygen in combustion reactions.

(i) State the empirical formula of compound **A**.  
[1 mark]

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(ii) Write a balanced symbol equation for the combustion of compound **A** in a plentiful supply of oxygen. [2 marks]

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- (iii) What change to the reaction conditions would result in the formation of carbon monoxide or soot?  
[1 mark]

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(b) Compound **B** contains a C=C.

It is a reactive hydrocarbon.

- (i) Describe a chemical test that could be carried out in a laboratory to show that compound **B** contains a C=C.

State the expected observations for a positive test.  
[4 marks]

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- (ii) Explain in terms of sigma or pi bonds why compound **B** is a reactive hydrocarbon. [2 marks]

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(c) Compound **B** reacts with hydrogen in the presence of a catalyst.

(i) State the name of this type of reaction and suggest the name of a suitable catalyst. [2 marks]

Type of reaction \_\_\_\_\_

Catalyst \_\_\_\_\_

(ii) Write a balanced symbol equation for the reaction of compound **B** with hydrogen and state the IUPAC name of the organic product formed. [2 marks]

\_\_\_\_\_  
IUPAC name \_\_\_\_\_

(d) Compound **C** can be dehydrated to form two different organic compounds, **X** and **Y**.

Compound **X** does not have a geometric isomer.

Compound **Y** exists as a pair of E–Z geometric isomers.

(i) Name the reagent that could be used to dehydrate compound **C**. [1 mark]

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(ii) Write a balanced structural equation for the dehydration of compound **C** to form compound **X** and state the IUPAC name of the organic product formed. [2 marks]

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IUPAC name \_\_\_\_\_

(iii) Complete the table below to show the structural formula of the E and Z geometric isomers of compound Y. [2 marks]

Geometric isomer of compound Y	Structural formula
E	
Z	

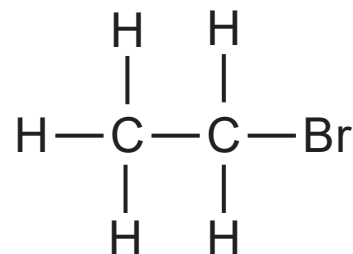
(e) Compound D can be prepared in a reaction using hydrogen bromide.

Complete the mechanism for this reaction.  
[5 marks]

Reactants

Intermediates

Product



- (f) Compound **E** is a ketone and compound **F** is an aldehyde.

They are structural isomers.

- (i) Explain why compounds **E** and **F** are structural isomers. [2 marks]

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- (ii) State the IUPAC name of compound **E**. [1 mark]

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- (iii) Describe a chemical test that could be carried out in a laboratory to show that compound **F** is an aldehyde.

State the expected observations for a positive test.  
[4 marks]

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3 Nylon and polythene are polymers that have many important uses.

(a) There are various forms of nylon.

Nylon-6,6 is made from the monomer  
1,6-diaminohexane.

Nylon-4,6 is made from the monomer  
1,4-diaminobutane.

(i) Define the term **monomers**. [1 mark]

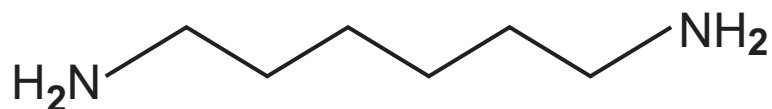
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(ii) Name the type of polymerisation reaction used to prepare nylon-6,6. [1 mark]

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(iii) The skeletal formula of 1,6-diaminohexane is given below.



Suggest the **structural formula** of  
1,4-diaminobutane. [1 mark]

**(b)** Polythene is made from an alkene monomer.

Write a balanced structural equation to represent the polymerisation reaction used to produce polythene.  
[2 marks]

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**(c)** Polythene is chemically inert.

One of the waste management strategies used to deal with polythene waste is incineration.  
This can lead to air pollution.

**(i)** State two other waste management strategies used to deal with polythene waste. [2 marks]

1. \_\_\_\_\_

2. \_\_\_\_\_

- (ii) The development of biodegradable polymers has helped to improve sustainability and to reduce the air pollution caused by the incineration of polythene and other polymer waste.

Define the term **biodegradable polymer**.

[1 mark]

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- (iii) State one other way in which chemists are attempting to reduce the air pollution caused by the incineration of polythene and other polymer waste.

[1 mark]

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4 Four alcohols, **K**, **L**, **M** and **N**, all have the molecular formula,  $C_4H_9OH$ .

(a) Alcohol **K** is a primary alcohol with a straight chain.

Draw the skeletal formula of alcohol **K** and state its IUPAC name. [2 marks]

Skeletal formula

IUPAC name \_\_\_\_\_

(b) Alcohol **L** is butan-2-ol.

It is a secondary alcohol.

(i) Define the term **secondary alcohol**. [1 mark]

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(ii) Name a suitable reagent that can be used to oxidise alcohol **L**. [2 marks]

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(iii) Write a balanced structural equation, using [O] to represent a suitable oxidising agent, for the oxidation of alcohol **L**. [2 marks]

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(c) Alcohol **M** is 2-methylpropan-1-ol.

It can be oxidised in separate reactions to form organic compounds **T** and **U**.

Compound **T** is obtained when the oxidation is carried out under reflux with excess oxidising agent. Compound **U** is obtained by distilling it off as soon as it forms.

(i) Draw the structural formula of alcohol **M**. [1 mark]

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(ii) Classify alcohol **M** as primary, secondary or tertiary.  
[1 mark]

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(iii) Identify the homologous series to which  
compound **T** belongs. [1 mark]

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(iv) Draw the skeletal formula of compound **T**.  
[1 mark]

(v) State the molecular formula and IUPAC name of  
compound **U**. [2 marks]

Molecular formula \_\_\_\_\_

IUPAC name \_\_\_\_\_

**(d)** Alcohol **N** is 2-methylpropan-2-ol.

It cannot be oxidised.

**(i)** State why alcohol **N** cannot be oxidised. [1 mark]

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**(ii)** Name the reagent and state the IUPAC name of a suitable halogenoalkane that could be used to prepare alcohol **N**. [2 marks]

Reagent \_\_\_\_\_

Halogenoalkane \_\_\_\_\_

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**(Questions continue overleaf)**



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**(ii)** Name a technique that could be used to purify laboratory prepared aspirin. [1 mark]

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**(iii)** At the end of the purification process the crystals of pure aspirin are separated from the remaining liquid by vacuum filtration.

Draw a labelled diagram of the assembled apparatus used for vacuum filtration. [4 marks]

**(b)** A student hypothesised that the aspirin they had prepared was pure.

To test this hypothesis, they placed a small sample of their aspirin in a test tube and dissolved it using distilled water.

They then added a few drops of a pale yellow solution.

The mixture turned violet.

**(i)** Suggest the name of the pale yellow solution.  
[1 mark]

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**(ii)** State what the student should conclude about the purity of the aspirin they prepared. [1 mark]

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**(iii)** State the name of another laboratory technique that could be used to test their hypothesis. [1 mark]

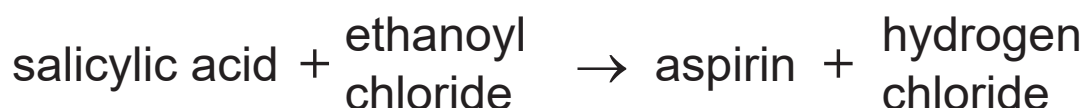
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**(Questions continue overleaf)**

- (c) An alternative method used to prepare aspirin in the laboratory uses salicylic acid and ethanoyl chloride.

The equation for this reaction and the relative molecular mass of each of the reactants and products are given below.



**Relative  
molecular  
mass**



A sample of aspirin was prepared using 3.05 g of salicylic acid and 2.50 g of ethanoyl chloride.

The yield of aspirin was 3.10 g.

- (i) The molar ratio of the reactants in the equation is 1:1.  
Show that the ethanoyl chloride was in excess.  
[2 marks]

- (ii) Calculate the percentage yield of aspirin.  
[3 marks]  
**Show your working out.**

\_\_\_\_\_ %

6 This question is about the analysis of two organic compounds, **Q** and **R**.

(a) Elemental analysis was carried out on compound **Q**, a straight chain organic compound.

The following percentage composition by mass was recorded.

Element	Percentage composition by mass /%
C	62.069
H	10.345
O	27.586

(i) Show that the empirical formula of compound **Q** is  $C_3H_6O$ . [4 marks]

**(ii)** The relative molecular mass of compound **Q** is 116.

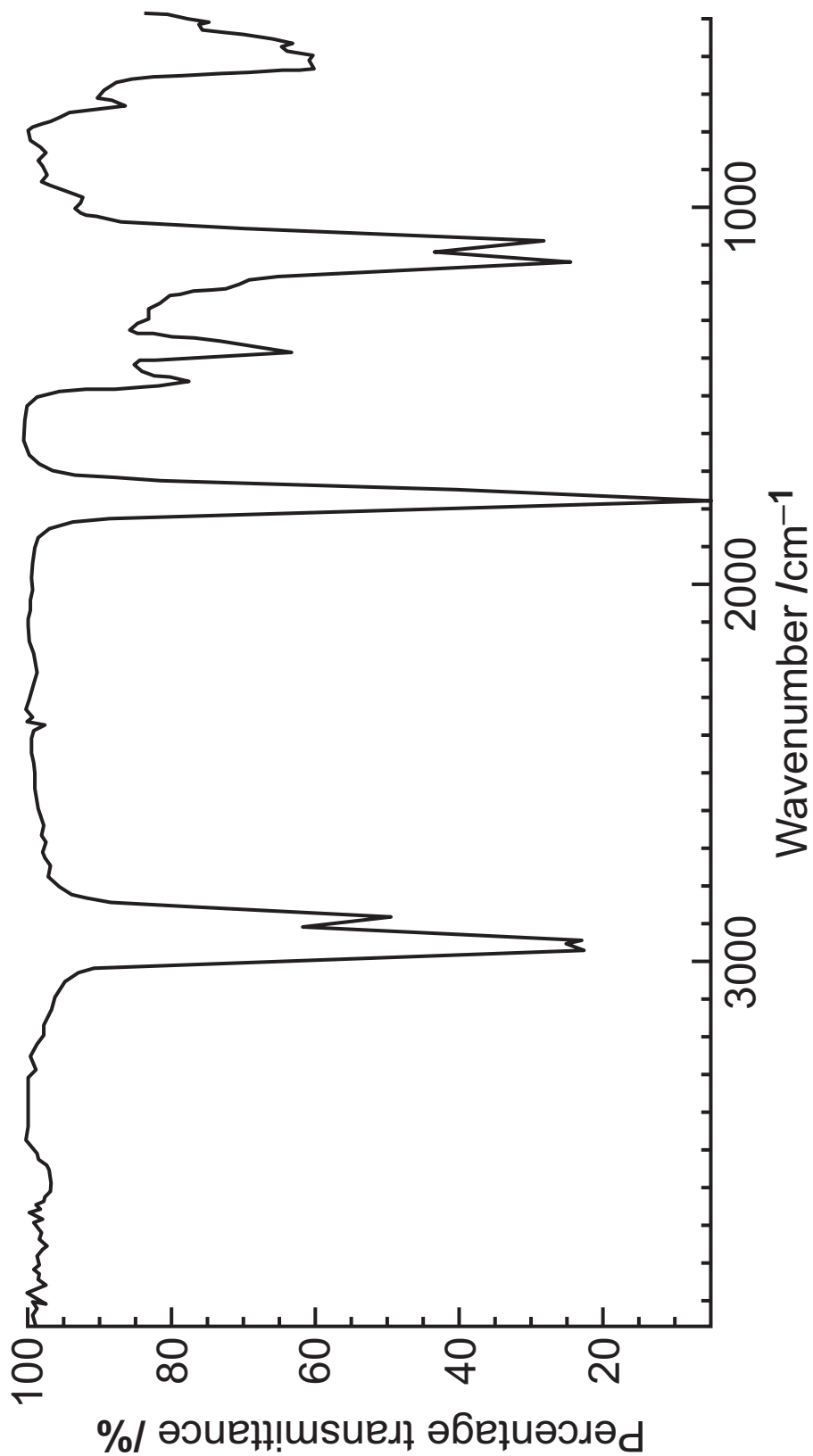
Determine the molecular formula of compound **Q**.

[2 marks]

**Show your working out.**

Molecular formula \_\_\_\_\_

(iii) The infrared spectrum of compound **Q** and infrared bond absorbance data are shown below and opposite.



Wavenumber /cm <sup>-1</sup>	Bond	Compound
750 – 1100	C—C	Alkanes, alkyl groups
1000 – 1300	C—O	Alcohols, carboxylic acids
1600 – 1700	C=C	Alkenes
1650 – 1800	C=O	Carboxylic acids, aldehydes, ketones
2500 – 3200	O—H	Carboxylic acid
2750 – 2850	C—H	Aldehydes
2850 – 3000	C—H	Alkanes, alkyl groups, alkenes
3200 – 3600	O—H	Alcohols

Identify the homologous series to which compound **Q** belongs. [3 marks]

Explain your reasoning.

Homologous series \_\_\_\_\_

Reasoning \_\_\_\_\_

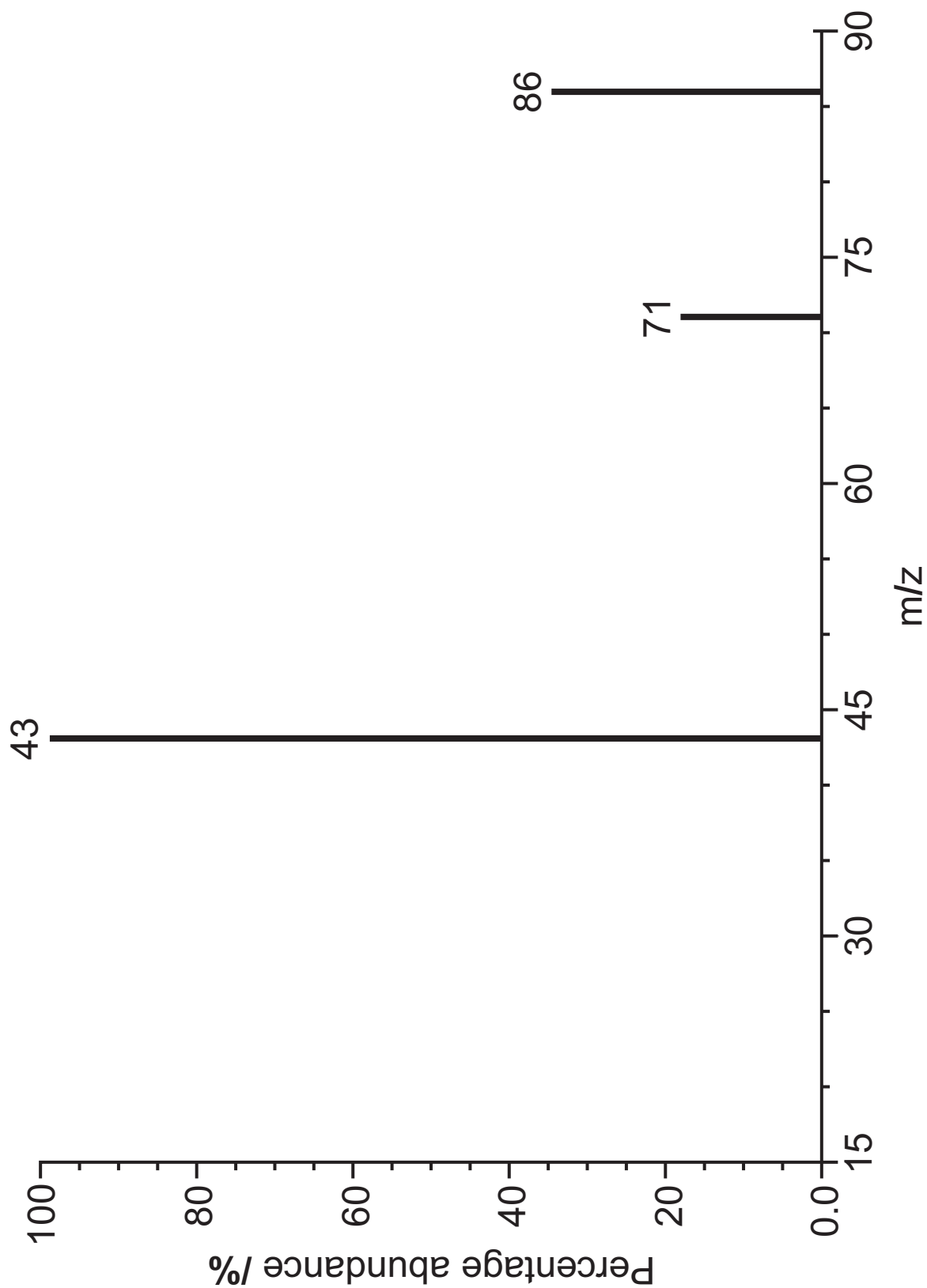
\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

(b) Compound **R** is a branched chain ketone with the molecular formula  $C_5H_{10}O$ .

The mass spectrum of compound **R** is shown below.



- (i) Complete the table below to show the molecular formulae of the ion fragments that cause the peaks at the  $m/z$  values indicated. [2 marks]

$m/z$ value	Molecular formula of ion fragment
43	$C_2H_3O^+$
71	
86	

- (ii) Determine the structural formula and the IUPAC name of the branched chain ketone, **R**. [2 marks]

Structural formula

IUPAC name \_\_\_\_\_

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## SOURCES

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Question Number	Marks
1	
2	
3	
4	
5	
6	
<b>Total Marks</b>	

Examiner Number

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