

OCR A-Level Chemistry A

Module 4: Core organic chemistry

Questions only

All 87 questions in Module 4: Core organic chemistry

Questions

87

Total marks

396

Name

Class or teacher

Date

Instructions

- Answer all questions in the spaces provided.
- Use black ink. Show your working for every calculation.
- You may use a scientific calculator and the OCR Data Sheet.
- Print the separate mark scheme when you are ready to mark your answers.

For marking

Total _____ / 396 Percentage _____ %

Questions from OCR past papers, 2017–2025, reproduced for revision. Practise these topics online, with instant marking:

whiteboardchemistry.com/revision/exam-questions/ocr-a-level-chemistry/?topics=alcohols-and-haloalkanes,alkanes,alkenes,basic-concepts-of-organic-chemistry,organic-synthesis-and-analysis&len=0

Questions

5 topics · 87 questions · 396 marks

Q1 · Alcohols and haloalkanes · June 2017 · Paper 2 (Synthesis and analytical techniques) · Q1 · [1 mark]

This question also needs Group 2 and the halogens.

A chemist compares the rates of hydrolysis of 1-chloropropane and 1-bromopropane in ethanol.

Which reagent in aqueous solution should be used?

Tick (✓) one box.

- ☐ **A** Silver chloride
- ☐ **B** Silver nitrate
- ☐ **C** Potassium chloride
- ☐ **D** Potassium nitrate

Q2 · Alcohols and haloalkanes · June 2017 · Paper 2 (Synthesis and analytical techniques) · Q19 · [15 marks]

This question also needs Carbonyls, carboxylic acids and esters, Electrons, bonding and structure, Reaction rates and equilibrium and Redox and electrode potentials.

This question is about alcohols.

19(a) Construct an equation for the complete combustion of an unsaturated alcohol with 5 carbon atoms.

[1 mark]

Many alcohols, including ethanol, are soluble in water.

19(b)(i) Explain, with the aid of a diagram, why ethanol is soluble in water.

Include relevant dipoles and lone pairs.

[2 marks]

19(b)(ii) The solubility of hexan-1-ol and hexane-1,6-diol in water is shown below in Table 19.1.

Alcohol	Solubility in water / g dm ⁻³
hexan-1-ol	5.9
hexane-1,6-diol	500

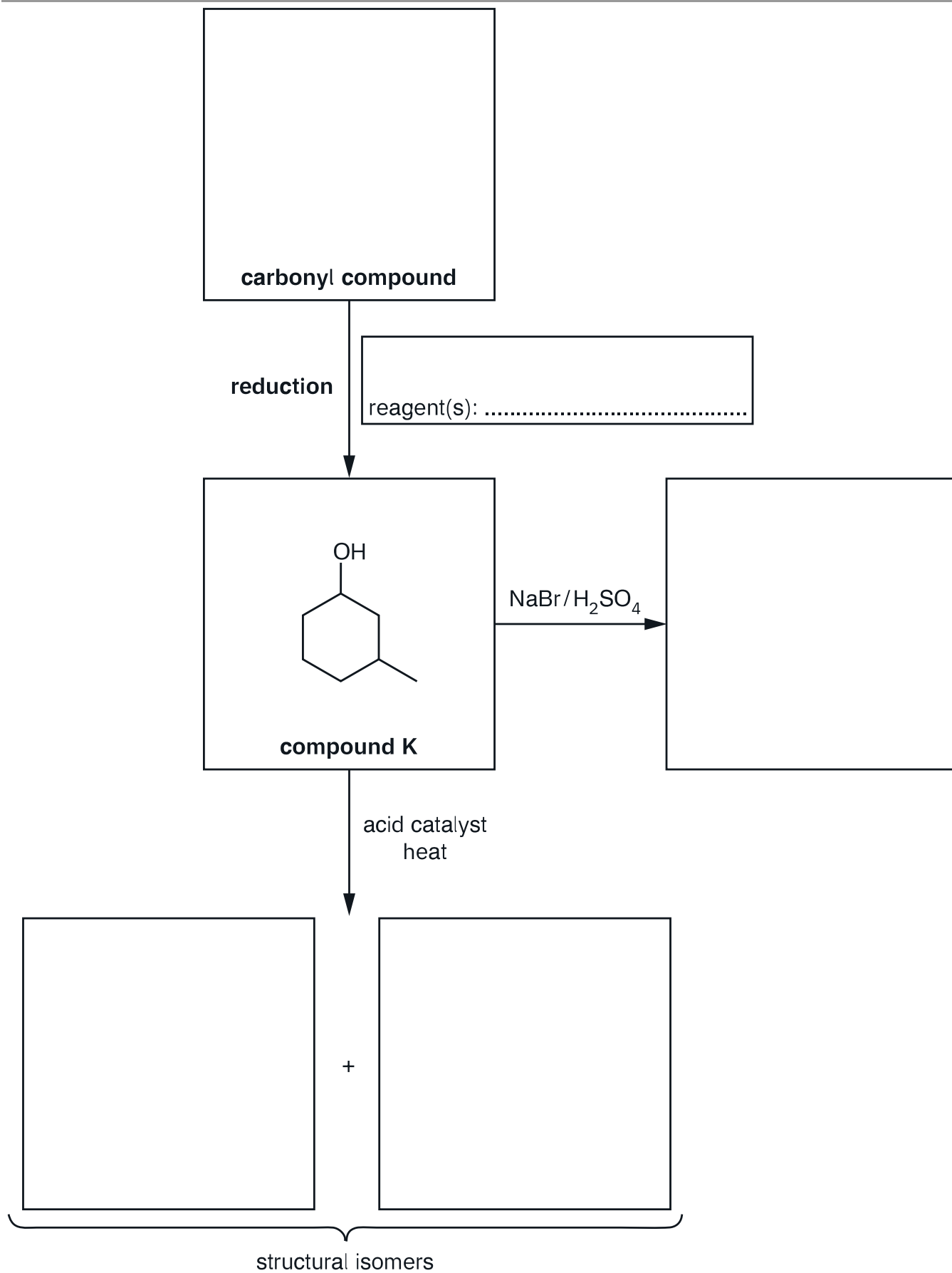
Table 19.1

Explain the difference in solubility of hexan-1-ol and hexane-1,6-diol.

[1 mark]

Alcohols are important in organic synthesis and can be formed by the reduction of carbonyl compounds.

19(c)(i) Complete the flowchart by filling in each box.



[5 marks]

Draw your answer on the figure above.

19(c)(ii) What is the name of compound K?

[1 mark]

19(d) Butan-1-ol can be oxidised to form two different organic products, depending on the reaction conditions used.

Describe both oxidation reactions of butan-1-ol.

For each reaction include

- the structure of the organic product
- a balanced equation
- the essential reaction conditions.

In your equations you may use [O] to represent the oxidising agent.

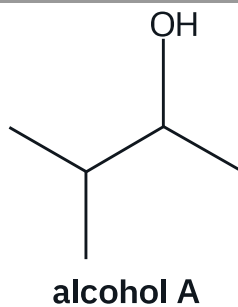
[5 marks]

Q3 · Alcohols and haloalkanes · June 2018 · Paper 2 (Synthesis and analytical techniques) · Q16 · [11 marks]

This question also needs Reaction rates and equilibrium.

This question is about reactions of organic compounds containing carbon, hydrogen and oxygen.

A chemist investigates two reactions of alcohol A, shown below.



16(a)(i) What is the systematic name of alcohol A?

[1 mark]

16(a)(ii) What is the structural formula of alcohol A?

[1 mark]

16(a)(iii) The chemist heats alcohol A with an acid catalyst to form a mixture containing two alkenes.

Draw the structures of the two alkenes formed in this reaction.

[2 marks]

16(a)(iv) The chemist heats alcohol A with sodium chloride and sulfuric acid.

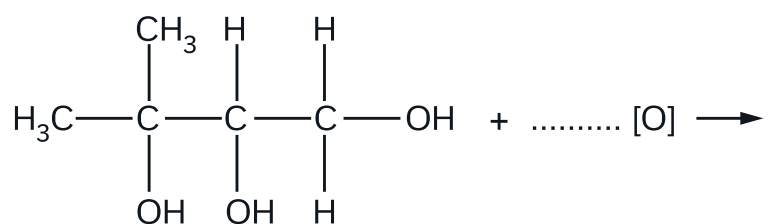
Construct a balanced equation for this reaction.

Show structures for the organic compounds in your equation.

[2 marks]

16(b) Compound B, shown below, is refluxed with excess acidified potassium dichromate(VI) to form a single organic product.

Complete the equation for this reaction.



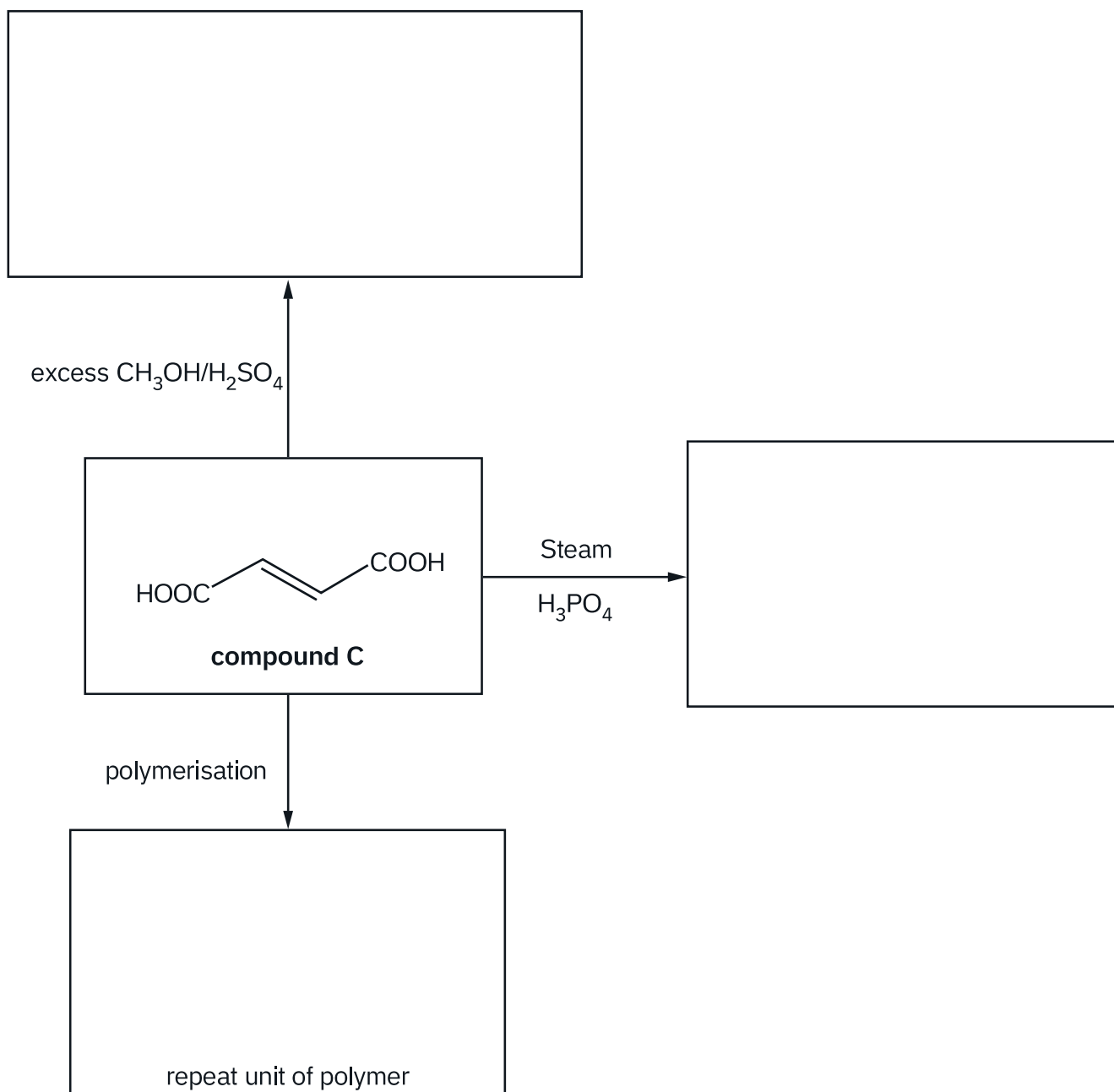
compound B

[2 marks]

Draw your answer on the figure above.

16(c) The flowchart below shows some reactions of compound C.

In the boxes, draw the organic products of these reactions.



[3 marks]

Draw your answer on the figure above.

Q4 · Alcohols and haloalkanes · June 2018 · Paper 2 (Synthesis and analytical techniques) · Q19 · [10 marks]

This question also needs Amount of substance, Enthalpy changes, Group 2 and the halogens and Reaction rates

and equilibrium.

This question is about the hydrolysis of haloalkanes.

19(a) The rate of hydrolysis of a haloalkane depends on the halogen present.

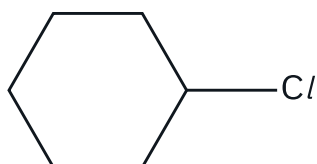
State and explain how the halogen in the haloalkane affects the rate of hydrolysis.

[2 marks]

19(b) Chlorocyclohexane is hydrolysed with aqueous sodium hydroxide.

Outline the mechanism for this reaction.

Show curly arrows, relevant dipoles and the products.



[3 marks]

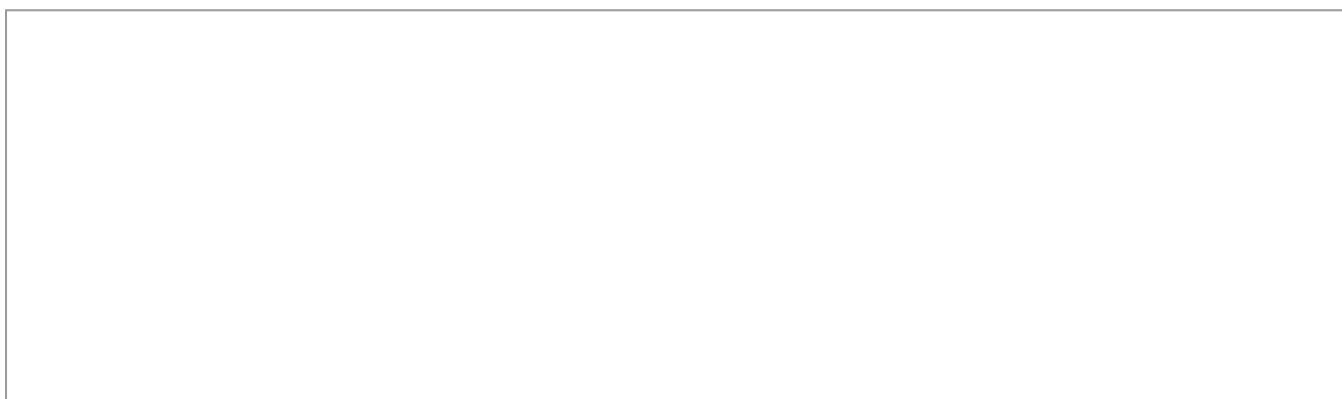
A student hydrolyses a haloalkane, E, using the following method.

- 0.0100 mol of haloalkane E is refluxed with excess NaOH(aq) to form a reaction mixture containing an organic product F.
- The reaction mixture is neutralised with dilute nitric acid.
- Excess AgNO₃(aq) is added to the reaction mixture. 1.88 g of a precipitate G forms.

Organic product, F, has a molar mass of 74.0 g mol⁻¹ and has a chiral carbon atom.

19(c)(i) Draw a labelled diagram to show how the student would carry out the hydrolysis of haloalkane E.

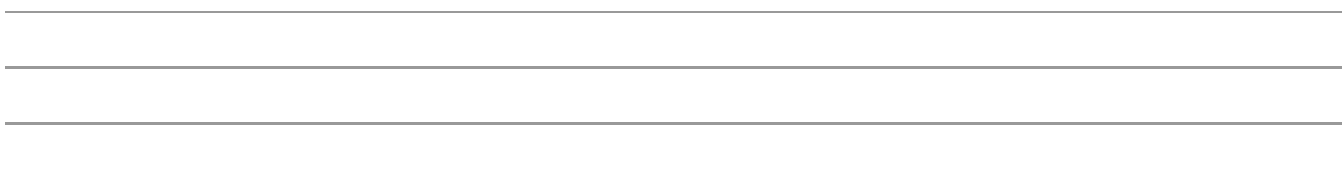
[2 marks]



19(c)(ii) Analyse the information to identify E, F and G.

Show your working.

[3 marks]



Q5 · Alcohols and haloalkanes · June 2018 · Paper 2 (Synthesis and analytical techniques) · Q3 · [1 mark]

Which compound does not react with nucleophiles?

Tick (✓) one box.

- ☐ **A** $\text{CH}_3\text{CH}_2\text{CHO}$
- ☐ **B** CH_3CHCH_2
- ☐ **C** $\text{CH}_3\text{CH}_2\text{COCH}_3$
- ☐ **D** $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$

Q6 · Alcohols and haloalkanes · June 2018 · Paper 2 (Synthesis and analytical techniques) · Q8 · [1 mark]

The breakdown of ozone is catalysed by NO radicals.

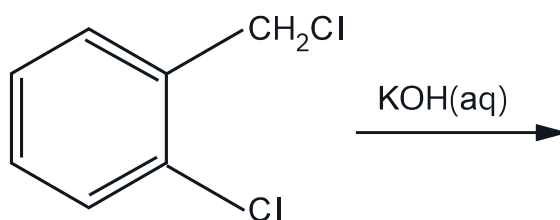
Which equation is a propagation step in the mechanism for this process?

Tick (✓) one box.

- ☐ **A** $\text{NO} + \text{O}_2 \rightarrow \text{N} + \text{O}_3$
- ☐ **B** $\text{NO} + \text{O}_2 \rightarrow \text{NO}_2 + \text{O}$
- ☐ **C** $\text{N} + \text{O}_3 \rightarrow \text{NO} + \text{O}_2$
- ☐ **D** $\text{NO}_2 + \text{O} \rightarrow \text{NO} + \text{O}_2$

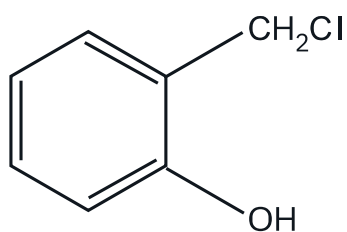
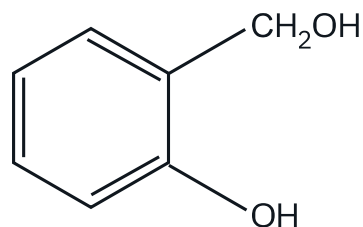
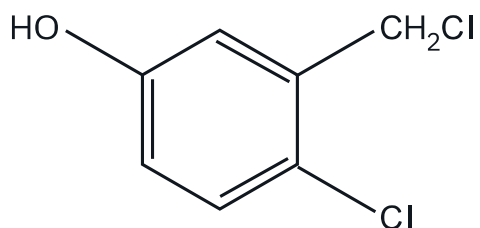
Q7 · Alcohols and haloalkanes · June 2019 · Paper 2 (Synthesis and analytical techniques) · Q6 · [1 mark]

What is the organic product of the reaction below?



Tick (✓) one box.

- ☐ **A**
-

☐ **B**☐ **C**☐ **D****Q8 · Alcohols and haloalkanes · June 2022 · Paper 2 (Synthesis and analytical techniques) · Q1 · [1 mark]**

Which statement is correct for the different rates of hydrolysis of RCl and RBr?

Tick (✓) one box.

- ☐ **A** RBr is hydrolysed faster because Cl is more electronegative than Br.
- ☐ **B** RBr is hydrolysed faster because the C–Cl bond enthalpy is greater than C–Br.
- ☐ **C** RCl is hydrolysed faster because Cl is more electronegative than Br.
- ☐ **D** RCl is hydrolysed faster because the C–Br bond enthalpy is greater than C–Cl.

Q9 · Alcohols and haloalkanes · June 2022 · Paper 2 (Synthesis and analytical techniques) · Q14 · [1 mark]

Which species could react as a nucleophile?

1 NH_3

2 OH^-

3 CH_3NH_2

Tick (✓) one box.

- ☐ **A** 1, 2 and 3
- ☐ **B** Only 1 and 2
- ☐ **C** Only 2 and 3
- ☐ **D** Only 1

Q10 · Alcohols and haloalkanes · June 2022 · Paper 2 (Synthesis and analytical techniques) · Q2 · [1 mark]

Which statement about absorption of radiation is correct?

Tick (✓) one box.

- ☐ **A** Infrared radiation can result in the breakdown of the ozone layer.
- ☐ **B** Ultraviolet radiation can cause some polymers to photodegrade to benefit the environment.
- ☐ **C** Ultraviolet radiation is linked to global warming.
- ☐ **D** Ultraviolet radiation is used in modern breathalysers to measure ethanol in the breath.

Q11 · Alcohols and haloalkanes · June 2022 · Paper 3 (Unified chemistry) · Q3 · [10 marks]

Information about 1-bromobutane and butan-1-ol is shown in the table.

Compound	Melting point / °C	Boiling point / °C	Density / g cm ⁻³
1-bromobutane	-113	102	1.268
butan-1-ol	-90	118	0.810

A student prepares a sample of 1-bromobutane by refluxing 9.25 g of butan-1-ol with sodium bromide and sulfuric acid.

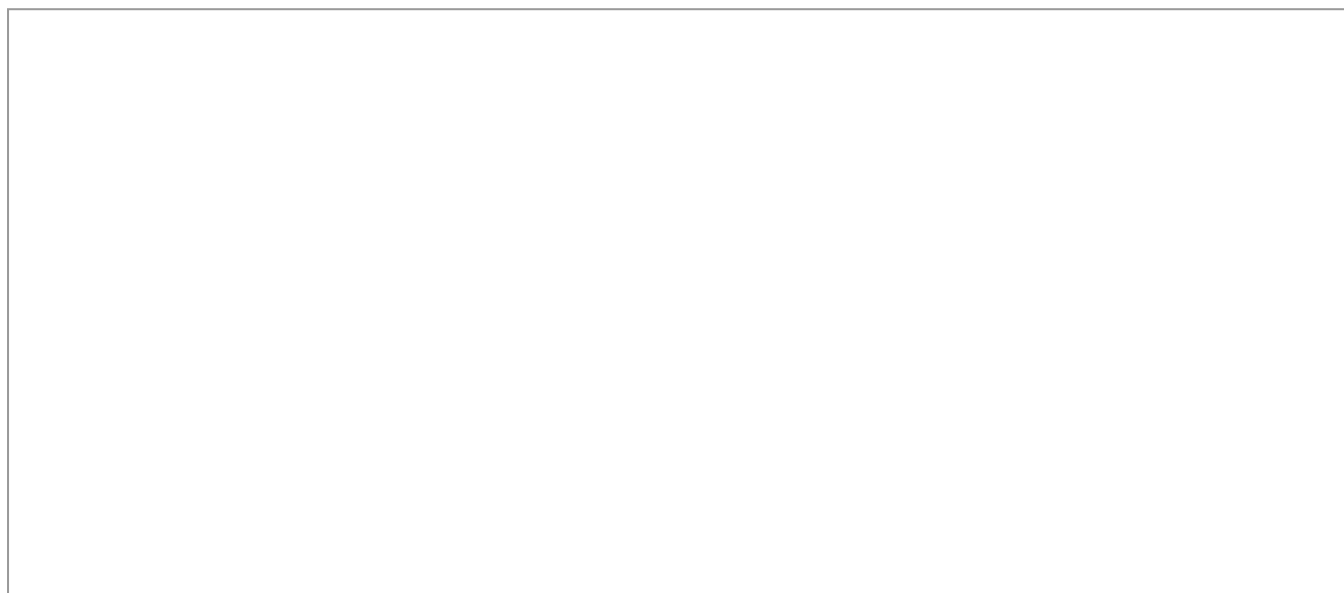
After reflux, the reaction mixture is purified.

The student obtains 6.10 cm^3 of pure 1-bromobutane.

3(a) Draw a diagram to show how the student would have carried out the reflux and calculate the percentage yield of 1-bromobutane that the student obtains.

Describe how the student could have obtained pure 1-bromobutane from the reaction mixture obtained after reflux.

[6 marks]



3(b) Butan-1-ol reacts with sodium bromide and sulfuric acid to form 1-bromobutane by nucleophilic substitution.

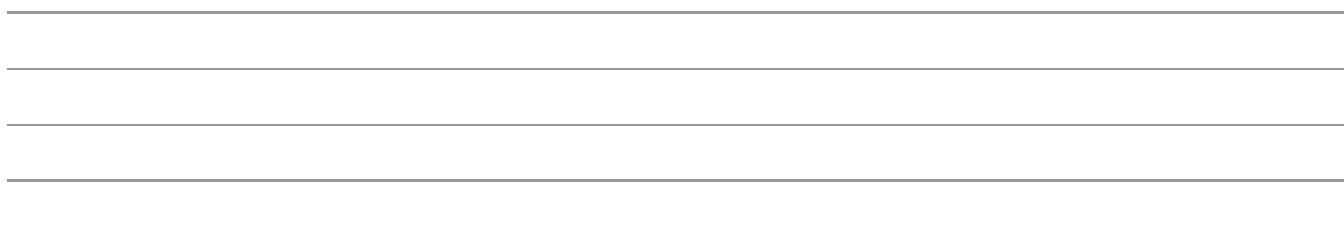
The mechanism for this reaction takes place by two steps.

Step 1 The oxygen atom of the alcohol group accepts a proton to form a positively-charged intermediate.

Step 2 Bromide ions react with the intermediate from Step 1 by nucleophilic substitution to form 1-bromobutane.

Show both steps in this mechanism.

[4 marks]



Q12 · Alcohols and haloalkanes · June 2023 · Paper 2 (Synthesis and analytical techniques) · Q17 · [14 marks]

This question also needs NMR spectroscopy.

This question is about alcohols.

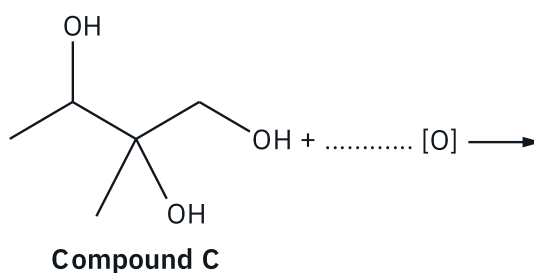
17(a) An **unsaturated** alcohol has 6 carbon atoms and contains **one** C=C bond.

Construct an equation for the complete combustion of this alcohol.

[2 marks]

17(b) Compound C, shown below, is refluxed with excess acidified potassium dichromate(VI) to form a single organic product and one other product.

Complete the equation for this reaction.



[3 marks]

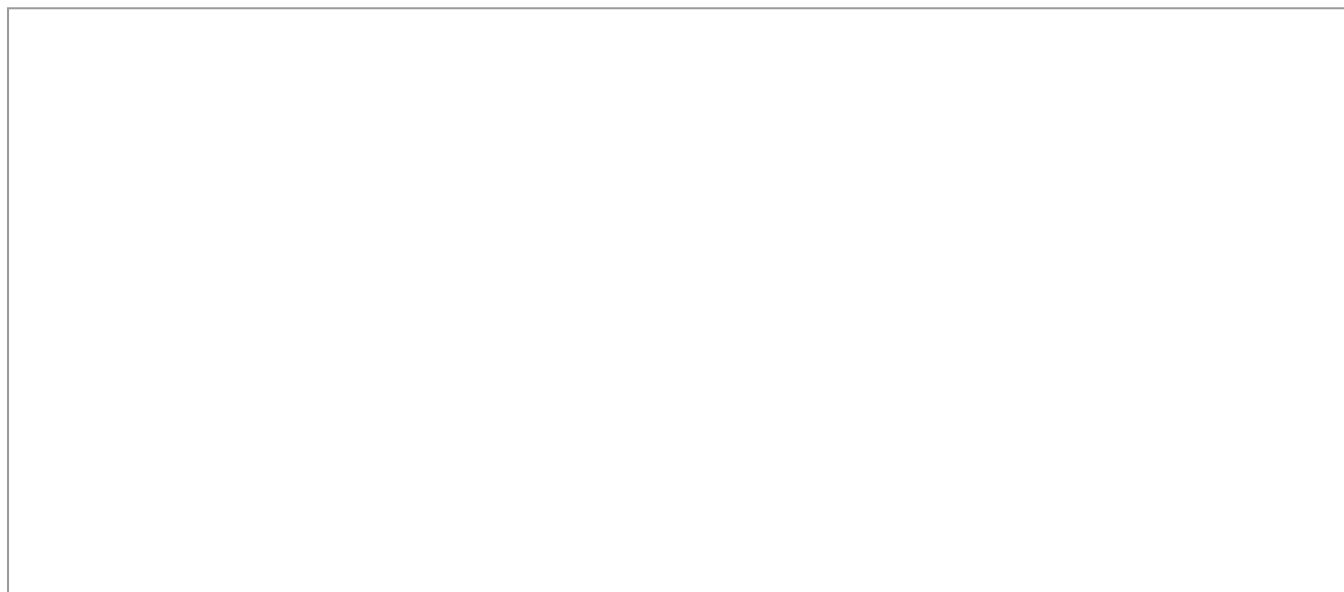
Compound D, shown below, is refluxed with H_2SO_4 , as an acid catalyst, to form a mixture of three isomers with the molecular formula C_7H_{10} .



Compound D

17(c)(i) Draw the structures of the **three** isomers of C_7H_{10} formed from compound D.

[3 marks]



17(c)(ii) A student converts compound D into a diiodoalkane.

Suggest suitable reagents for this reaction.

[1 mark]

17(d) There are 4 structural isomers of $C_4H_{10}O$ that are alcohols.

A student predicts that these structural isomers could be distinguished using carbon-13 NMR spectroscopy.

Explain whether the student is correct.

In your answer, show how the peaks in the carbon-13 NMR spectra are linked to the structure of each alcohol isomer.

[5 marks]

Q13 · Alcohols and haloalkanes · June 2024 · Paper 2 (Synthesis and analytical techniques) · Q3 · [1 mark]

This question also needs Group 2 and the halogens.

A student investigates the rate of hydrolysis of different iodoalkanes using aqueous silver nitrate in ethanol.

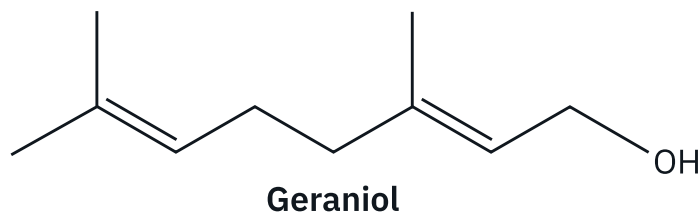
What colour of precipitate is seen?

Tick (✓) one box.

- ☐ **A** Brown
- ☐ **B** Cream
- ☐ **C** White
- ☐ **D** Yellow

Q14 · Alcohols and haloalkanes · June 2024 · Paper 2 (Synthesis and analytical techniques) · Q5 · [1 mark]

Geraniol, shown below, is a component in many natural oils.



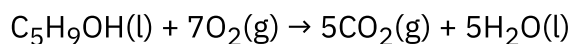
Which pair of reagents identifies both functional groups in geraniol?

Tick (✓) one box.

- ☐ **A** Acidified dichromate(VI) and 2,4-dinitrophenylhydrazine.
- ☐ **B** Bromine water and 2,4-dinitrophenylhydrazine.
- ☐ **C** Bromine water and acidified dichromate(VI).
- ☐ **D** Tollens' reagent and aqueous silver nitrate in ethanol.

Q15 · Alcohols and haloalkanes · June 2024 · Paper 2 (Synthesis and analytical techniques) · Q6 · [1 mark]

4.30 g of the alcohol C_5H_9OH , ($M_r = 86.0$), is burned in oxygen.



Which volume of oxygen gas is needed, in dm^3 , for this complete combustion of C_5H_9OH , at RTP?

Tick (✓) one box.

- ☐ **A** 1.2
- ☐ **B** 2.4
- ☐ **C** 5.8
- ☐ **D** 8.4

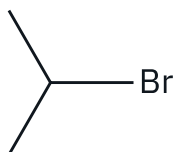
Q16 · Alcohols and haloalkanes · June 2025 · Paper 2 (Synthesis and analytical techniques) · Q19 · [9 marks]

This question is about reactions of haloalkanes.

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

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

Show curly arrows, relevant dipoles and products.



[3 marks]

19(a)(ii) Name this type of mechanism.

[1 mark]

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.

19(b)(i) Suggest suitable reagents for this reaction.

[1 mark]

19(b)(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.

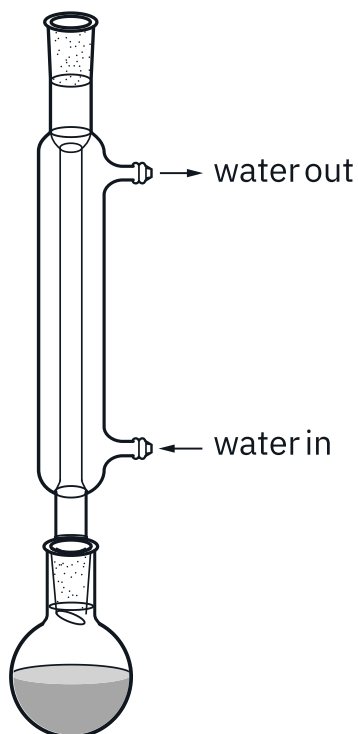
[4 marks]

Q17 · Alcohols and haloalkanes · June 2025 · Paper 2 (Synthesis and analytical techniques) · Q4 · [1 mark]

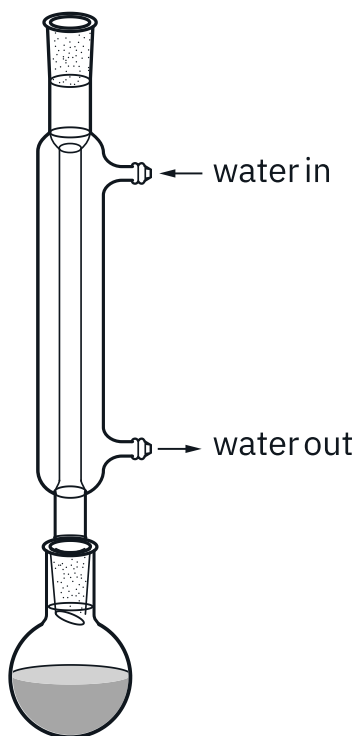
Which diagram shows the correct way to set up apparatus for converting ethanol to ethanoic acid?

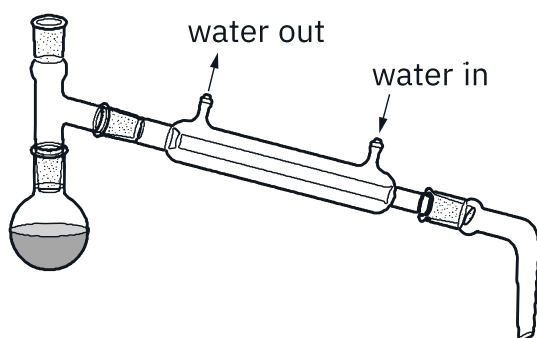
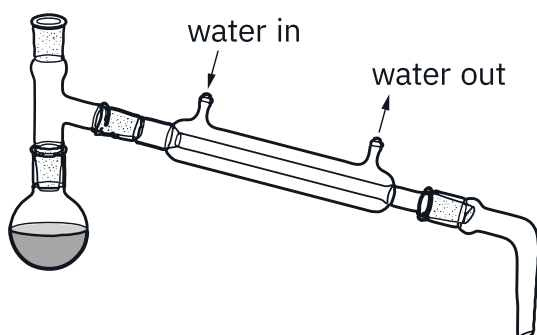
Tick (✓) one box.

☐ **A**



☐ **B**

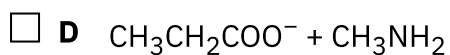
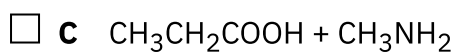
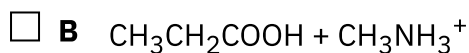
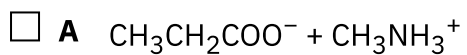


☐ C☐ D

Q18 · Alcohols and haloalkanes · June 2025 · Paper 2 (Synthesis and analytical techniques) · Q7 · [1 mark]

What are the **organic** products of the **acid** hydrolysis of $\text{CH}_3\text{CH}_2\text{CONHCH}_3$?

Tick (✓) one box.



Q19 · Alcohols and haloalkanes · November 2020 · Paper 2 (Synthesis and analytical techniques) · Q14 · [1 mark]

Which of the following reactions produce propan-1-ol?

- 1 The alkaline hydrolysis of 1-chloropropane.
- 2 The acid hydrolysis of propyl methanoate.
- 3 The acid hydrolysis of propanenitrile.

Tick (✓) one box.

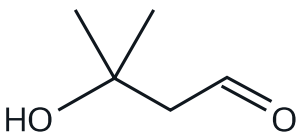
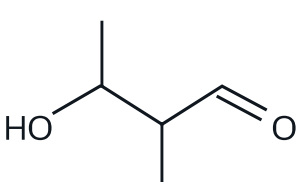
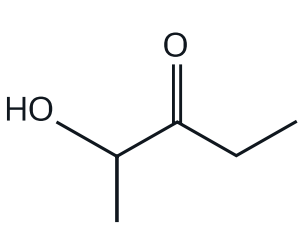
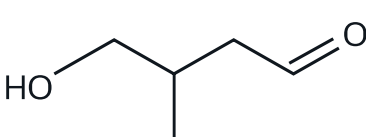
- ☐ **A** 1, 2 and 3
- ☐ **B** Only 1 and 2
- ☐ **C** Only 2 and 3
- ☐ **D** Only 1

Q20 · Alcohols and haloalkanes · November 2020 · Paper 2 (Synthesis and analytical techniques) · Q4 · [1 mark]

This question also needs Amount of substance.

Which compound can be refluxed with acidified potassium dichromate(VI) to form an organic product with molecular formula $C_5H_8O_2$?

Tick (✓) one box.

- ☐ **A**
- 
- ☐ **B**
- 
- ☐ **C**
- 
- ☐ **D**
- 

Q21 · Alcohols and haloalkanes · November 2020 · Paper 2 (Synthesis and analytical techniques) · Q6 · [1 mark]

This question also needs Reaction rates and equilibrium.

Which alcohol reacts with an acid catalyst to form a mixture of stereoisomers?

Tick (✓) one box.

- ☐ **A** 3-methylbutan-2-ol
- ☐ **B** pentan-1-ol
- ☐ **C** 2-methylhexan-2-ol
- ☐ **D** heptan-4-ol

Q22 · Alcohols and haloalkanes · November 2021 · Paper 2 (Synthesis and analytical techniques) · Q17 · [10 marks]

This question also needs Amines, amino acids and polymers, Amount of substance and Aromatic compounds and phenols.

This question is about haloalkanes and polymers.

17(a) Freon-13, is a CFC with the molecular formula CClF_3 .

In the upper atmosphere, the presence of Freon-13 can lead to ozone depletion.

Explain, with the aid of equations, how Freon-13 can lead to this ozone depletion.

Use 'dots' (•) to show the position of unpaired electrons.

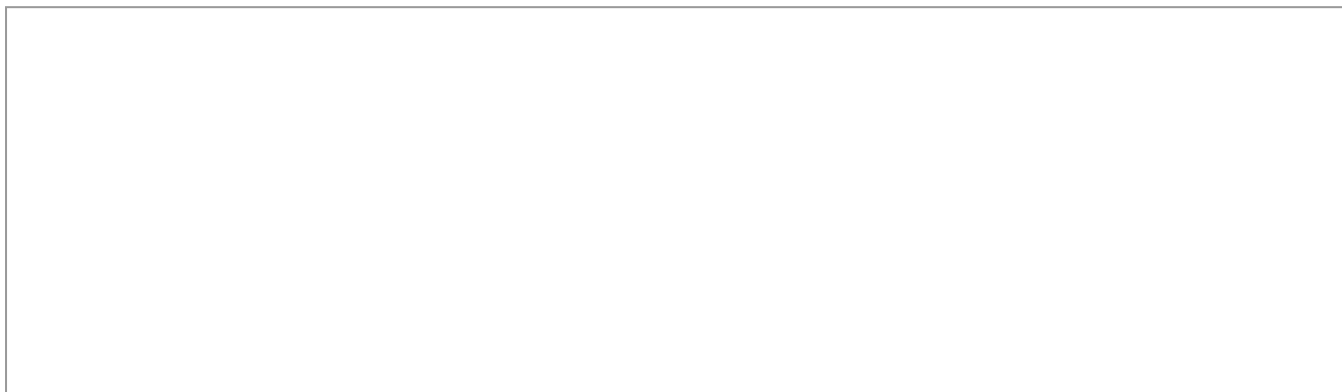
[3 marks]

An oligomer is a polymer with a low molecular mass and a small number of repeat units.

An oligomer made from 2-chloro-1,1,2-trifluoroethene is used as a lubricating oil.

17(b)(i) Draw the repeat unit of this oligomer.

[1 mark]



17(b)(ii) The boiling point of the lubricating oil can be increased by increasing the number of repeat units.

Explain this statement.

[2 marks]



17(c) A polymer can be made from the monomers:

- 1,4-diaminobutane
- benzene-1,4-diacyl dichloride.

Draw the structures of these monomers and one repeat unit of the polymer.

1,4-diaminobutane

benzene-1,4-diacyl dichloride

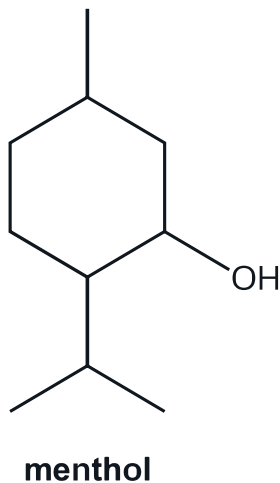
one repeat unit of polymer

[4 marks]

Q23 · Alcohols and haloalkanes · November 2021 · Paper 2 (Synthesis and analytical techniques) · Q7 · [1 mark]

This question also needs Reaction rates and equilibrium.

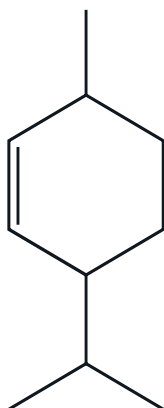
Menthol, shown below, is heated with an acid catalyst.



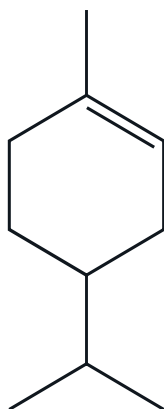
Which structure could be formed?

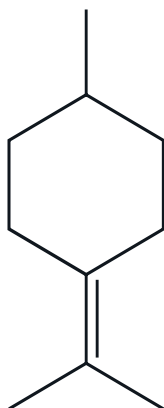
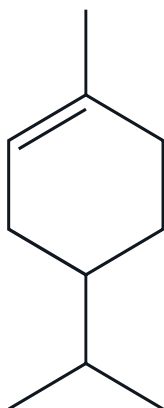
Tick (✓) one box.

☐ **A**



☐ **B**



☐ **C**☐ **D****Q24 · Alkanes · June 2017 · Paper 2 (Synthesis and analytical techniques) · Q14 · [1 mark]**

Ethane reacts with chlorine by radical substitution to form chloroethane.

Which radical(s) is/are present in the mechanism?

1 H•

2 Cl•

3 C₂H₅•

Tick (✓) one box.

☐ **A** 1, 2 and 3

☐ **B** Only 1 and 2

☐ **C** Only 2 and 3

☐ **D** Only 1

Q25 · Alkanes · June 2019 · Paper 2 (Synthesis and analytical techniques) · Q1 · [1 mark]

Which alkane has the highest boiling point?

Tick (✓) one box.

- ☐ **A** $\text{CH}_3(\text{CH}_2)_5\text{CH}_3$
- ☐ **B** $(\text{CH}_3)_3\text{CCH}(\text{CH}_3)_2$
- ☐ **C** $\text{CH}_3(\text{CH}_2)_3\text{CH}(\text{CH}_3)_2$
- ☐ **D** $(\text{CH}_3)_2\text{CHCH}_2\text{CH}(\text{CH}_3)_2$

Q26 · Alkanes · June 2019 · Paper 2 (Synthesis and analytical techniques) · Q2 · [1 mark]

Butane reacts with chlorine in the presence of ultraviolet radiation to form a mixture of organic products.

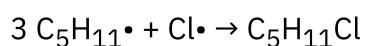
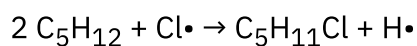
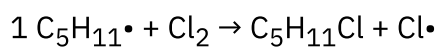
Which equation shows a propagation step in the mechanism for this reaction?

Tick (✓) one box.

- ☐ **A** $\text{Cl}_2 \rightarrow \cdot\text{Cl} + \cdot\text{Cl}$
- ☐ **B** $\cdot\text{Cl} + \cdot\text{C}_4\text{H}_8\text{Cl} \rightarrow \text{C}_4\text{H}_8\text{Cl}_2$
- ☐ **C** $\text{C}_4\text{H}_9\text{Cl} + \cdot\text{Cl} \rightarrow \text{C}_4\text{H}_8\text{Cl}_2 + \cdot\text{H}$
- ☐ **D** $\cdot\text{Cl} + \text{C}_4\text{H}_9\text{Cl} \rightarrow \cdot\text{C}_4\text{H}_8\text{Cl} + \text{HCl}$

Q27 · Alkanes · June 2022 · Paper 2 (Synthesis and analytical techniques) · Q13 · [1 mark]

Which equation(s) could be part of the propagation step in the radical substitution of C_5H_{12} to form $\text{C}_5\text{H}_{11}\text{Cl}$?



Tick (✓) one box.

- ☐ **A** 1, 2 and 3
- ☐ **B** Only 1 and 2
- ☐ **C** Only 2 and 3
- ☐ **D** Only 1

Q28 · Alkanes · June 2022 · Paper 2 (Synthesis and analytical techniques) · Q7 · [1 mark]

Complete combustion of 0.050 mol of an alkane produces 5.40 g of H_2O .

What is the molecular formula of the alkane?

Tick (✓) one box.

- ☐ **A** C_2H_6
- ☐ **B** C_3H_8
- ☐ **C** C_4H_{10}
- ☐ **D** C_5H_{12}

Q29 · Alkanes · June 2023 · Paper 2 (Synthesis and analytical techniques) · Q16 · [15 marks]

This question also needs Amount of substance.

This question is about hydrocarbons.

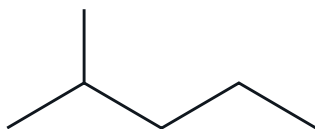
16(a) The boiling points of some hydrocarbons containing 6 carbon atoms are shown below.

Hydrocarbon	Boiling point / °C
2,2-dimethylbutane	50
2-methylpentane	60
hexane	69

State and explain the trend in boiling points shown by these hydrocarbons.

[4 marks]

2-methylpentane reacts with bromine by radical substitution.



2-methylpentane

A mixture of organic products is formed, including 3-bromo-2-methylpentane, and compounds A and B.

16(b)(i) Complete the table below to show the mechanism for the formation of 3-bromo-2-methylpentane and **three** possible equations for termination.

In your equations, use **structural** or **skeletal formulae** and 'dots' (•) for the position of radicals.

Initiation	Equation: Conditions:
Propagation	→ →
Termination	→ → →

[6 marks]

--

16(b)(ii) Organic compound A is formed by the substitution of **all** 14 H atoms in 2-methylpentane by Br atoms.

Write the equation, using **molecular formulae**, for the formation of compound A from 2-methylpentane.

[2 marks]

16(b)(iii) Organic compound B is formed by the substitution of **some** of the 14 H atoms in 2-methylpentane by Br atoms.

0.8649 g of compound B is heated until it is vaporised.

Under the conditions used:

- compound B has a volume of 72.0 cm^3
- the molar gas volume is $40.0 \text{ dm}^3 \text{ mol}^{-1}$.

Determine a possible molecular formula of compound B.

molecular formula =

[3 marks]

Q30 · Alkanes · June 2023 · Paper 2 (Synthesis and analytical techniques) · Q8 · [1 mark]

For complete combustion, 0.100 mol of an alkane requires 22.8 dm³ of O₂, measured at RTP.

Which alkane has undergone complete combustion?

Tick (✓) one box.

☐ **A** pentane

☐ **B** hexane

☐ **C** heptane

☐ **D** octane

Q31 · Alkanes · June 2024 · Paper 2 (Synthesis and analytical techniques) · Q18 · [14 marks]

This question also needs Amines, amino acids and polymers and Carbon–carbon bond formation and synthesis.

This question is about haloalkanes.

Haloalkanes can be synthesised by reacting alkanes with halogens in the presence of ultraviolet radiation.

An alkane reacts with bromine to form 2-bromo-2-methylpropane.

18(a)(i) Write the equation for this reaction, showing the structures of the organic compounds.

Name the reaction mechanism and the type of bond fission that occurs.

[3 marks]

Equation

Name of reaction mechanism

Type of bond fission

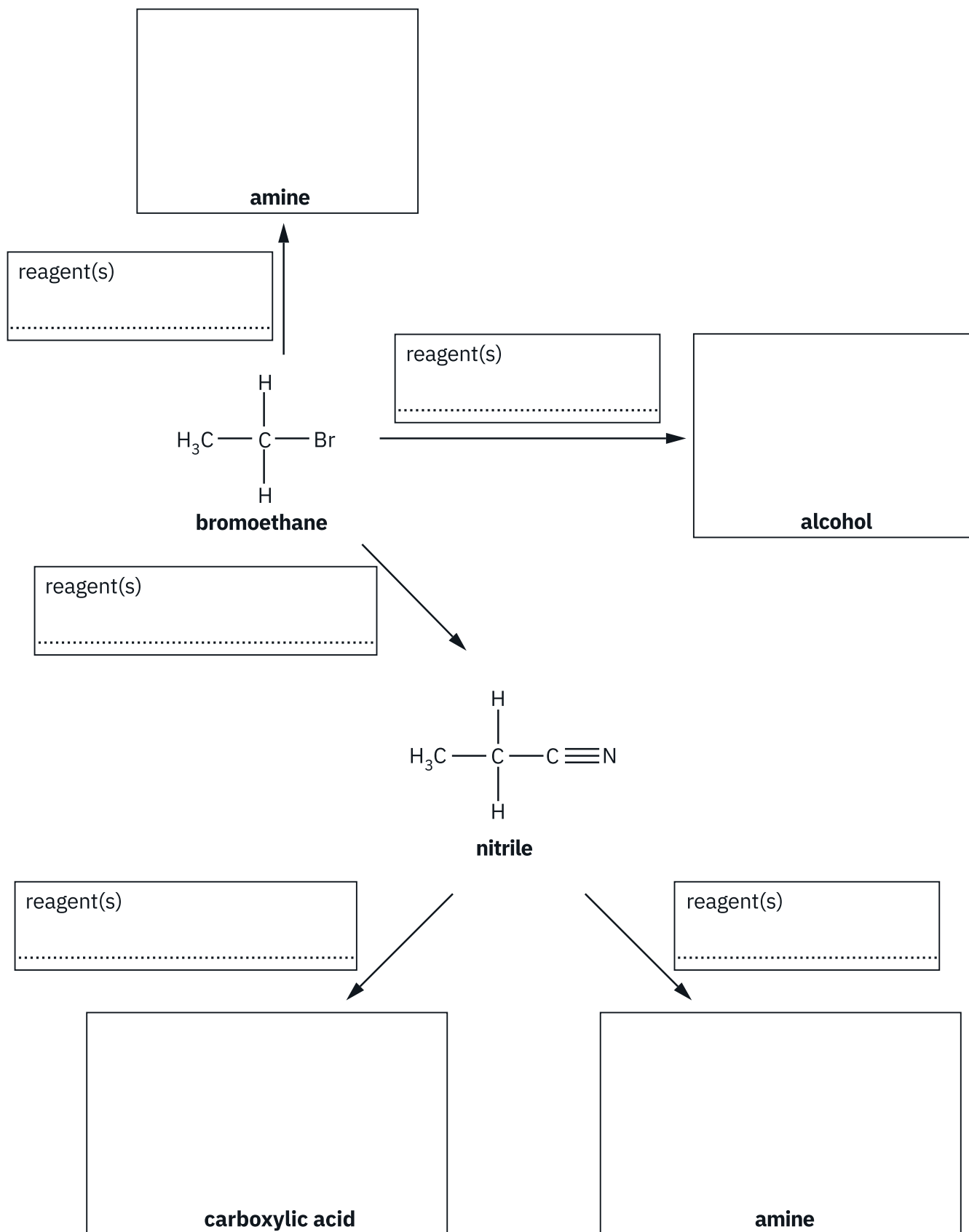
18(a)(ii) Describe **two** limitations of the synthesis of 2-bromo-2-methylpropane from an alkane and bromine.

[2 marks]

1

2

18(b) Complete the flowchart by filling in each box.



[9 marks]

Q32 • Alkanes • June 2024 • Paper 2 (Synthesis and analytical techniques) • Q8 • [1 mark]

The CFC CCl_2F_2 can cause the breakdown of ozone in the upper atmosphere.

Which initiation step could occur with ultraviolet radiation to catalyse this breakdown?

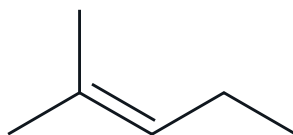
Tick (✓) one box.

- ☐ **A** $\text{CCl}_2\text{F}_2 \rightarrow \cdot\text{C} + \cdot\text{Cl}_2\text{F}_2$
- ☐ **B** $\text{CCl}_2\text{F}_2 \rightarrow \cdot\text{F} + \cdot\text{CCl}_2\text{F}$
- ☐ **C** $\text{CCl}_2\text{F}_2 \rightarrow \cdot\text{Cl} + \cdot\text{CClF}_2$
- ☐ **D** $\text{CCl}_2\text{F}_2 \rightarrow \cdot\text{Cl}_2 + \cdot\text{CF}_2$

Q33 · Alkanes · June 2025 · Paper 2 (Synthesis and analytical techniques) · Q16 · [12 marks]

This question is about hydrocarbons with six carbon atoms.

16(a) Compound A is a hydrocarbon:



Compound A

What is the systematic name of compound A?

[1 mark]

16(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 marks]

Compound B, $\text{CH}_3\text{CH}=\text{C}(\text{CH}_3)\text{CH}_2\text{CH}_3$, exists as E and Z stereoisomers.

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

E	Z
---	---

[2 marks]

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

[2 marks]

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

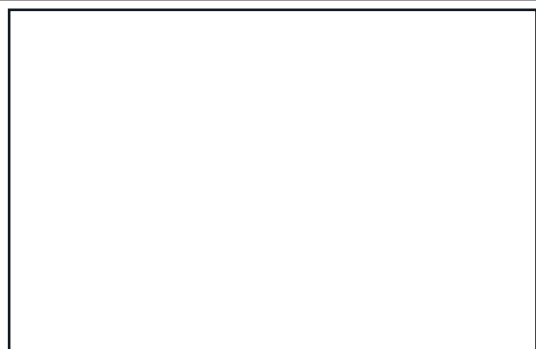
1.0 mol of hexane is mixed with 6.0 mol of oxygen and combusted.

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

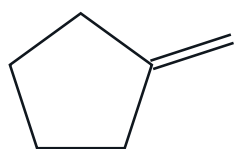
[1 mark]

16(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.

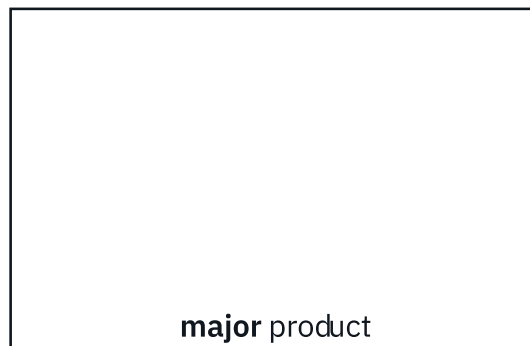


Br_2



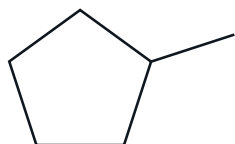
Compound C

HCl



reagent:

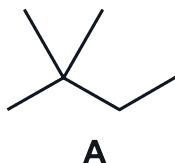
catalyst:



[3 marks]

Q34 · Alkanes · November 2020 · Paper 2 (Synthesis and analytical techniques) · Q16 · [9 marks]

The structure of hydrocarbon A is shown below.



16(a) Hydrocarbon A can be reacted with bromine in the presence of ultraviolet radiation to prepare $(\text{CH}_3)_3\text{CCHBrCH}_3$.

What is the systematic name for $(\text{CH}_3)_3\text{CCHBrCH}_3$?

[1 mark]

$(\text{CH}_3)_3\text{CCHBrCH}_3$ has stereoisomers.

16(b)(i) Explain the term stereoisomers and name this type of stereoisomerism.

Explanation:

Type of stereoisomerism:

[1 mark]

16(b)(ii) Draw 3D diagrams for the stereoisomers of $(\text{CH}_3)_3\text{CCHBrCH}_3$.

[2 marks]

16(c) Complete the table to show the mechanism for the reaction of hydrocarbon A with Br₂ to form (CH₃)₃CCHBrCH₃.

Use skeletal formulae for all organic compounds.

Use 'dots' (•) to show the position of unpaired electrons.

Initiation

.....

Propagation

+ → + ...

..... + ... → + ...

[3 marks]

16(d) State two limitations of using radical substitution in organic synthesis.

[2 marks]

1

2

Q35 • Alkanes • November 2021 • Paper 2 (Synthesis and analytical techniques) • Q4 • [1 mark]

What is the correct equation for the incomplete combustion of butan-1-ol?

Tick (✓) one box.

- ☐ **A** $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} + 1\frac{1}{2}\text{O}_2 \rightarrow 4\text{CO} + 5\text{H}_2$
- ☐ **B** $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} + 2\text{O}_2 \rightarrow 4\text{CO} + 5\text{H}_2$
- ☐ **C** $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} + 4\text{O}_2 \rightarrow 4\text{CO} + 5\text{H}_2\text{O}$
- ☐ **D** $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} + 4\frac{1}{2}\text{O}_2 \rightarrow 4\text{CO} + 5\text{H}_2\text{O}$

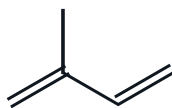
Q36 • Alkenes and addition polymers • June 2017 • Paper 2 (Synthesis and analytical techniques) • Q16 • [20]

marks]

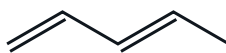
This question also needs Amount of substance.

This question is about unsaturated hydrocarbons.

16(a) Compound A and compound B are isomers.



compound A



compound B

Compound A has a lower melting point than compound B.

Suggest why.

[2 marks]

Compound C, $\text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}_2\text{CH}_2\text{OH}$, exists as cis and trans stereoisomers.

16(b)(i) Name compound C.

[1 mark]

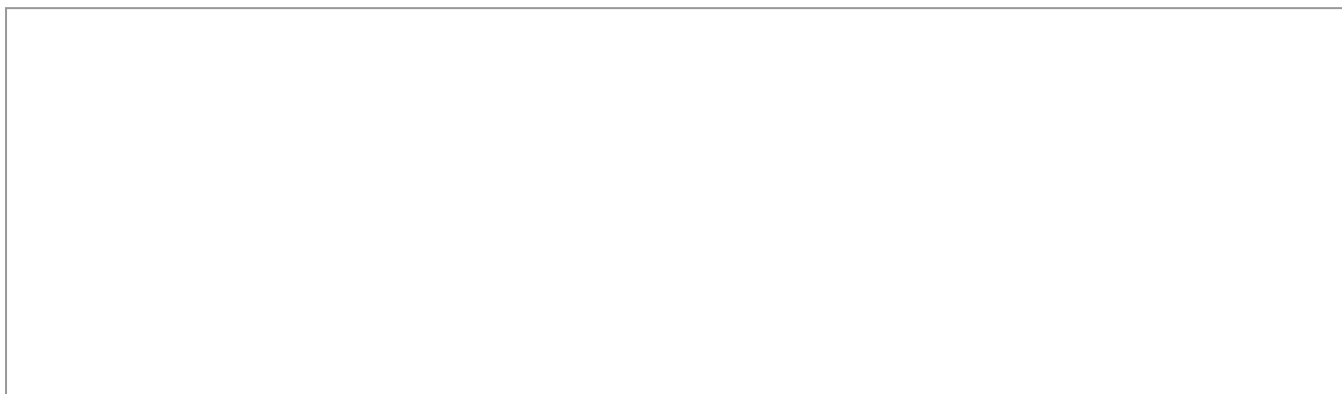
16(b)(ii) Define the term stereoisomers.

[1 mark]

16(b)(iii) Draw the structures of the cis and trans stereoisomers of compound C.

cis trans

[2 marks]



16(c) The C=C group in an alkene contains a π -bond.

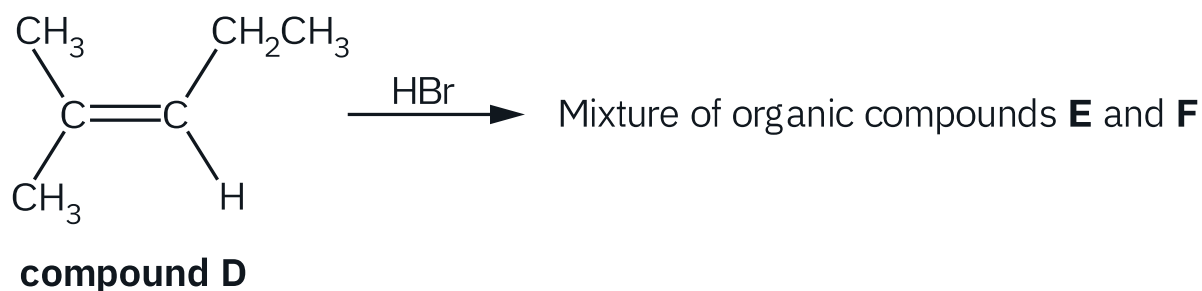
Complete the diagram below to show how p-orbitals are involved in the formation of a π -bond.



[1 mark]

Draw your answer on the figure above.

Compound D, shown below, reacts with hydrogen bromide by electrophilic addition. A mixture of two organic compounds, E and F, is formed.



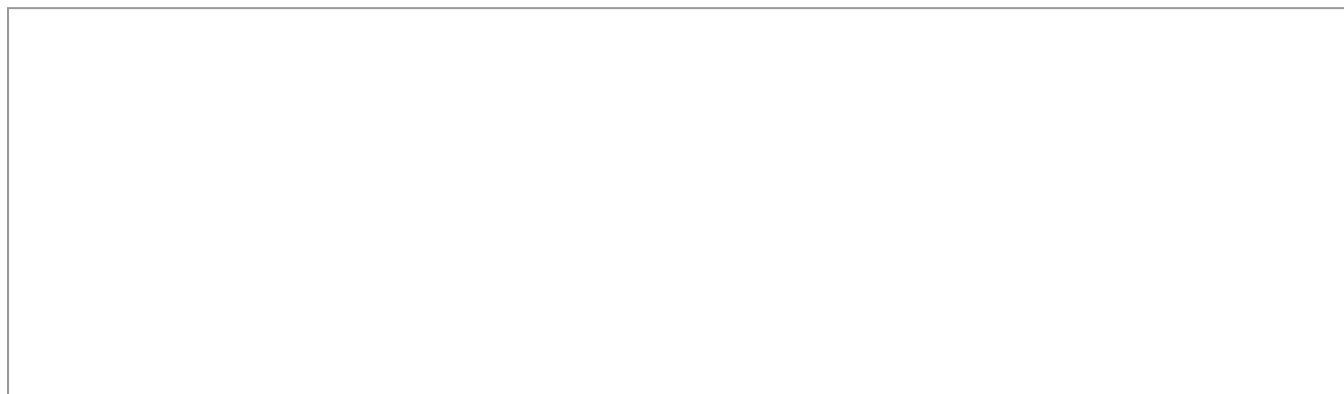
16(d)(i) Suggest how an HBr molecule can act as an electrophile.

[1 mark]

16(d)(ii) Draw the structures of the two organic compounds E and F.

E F

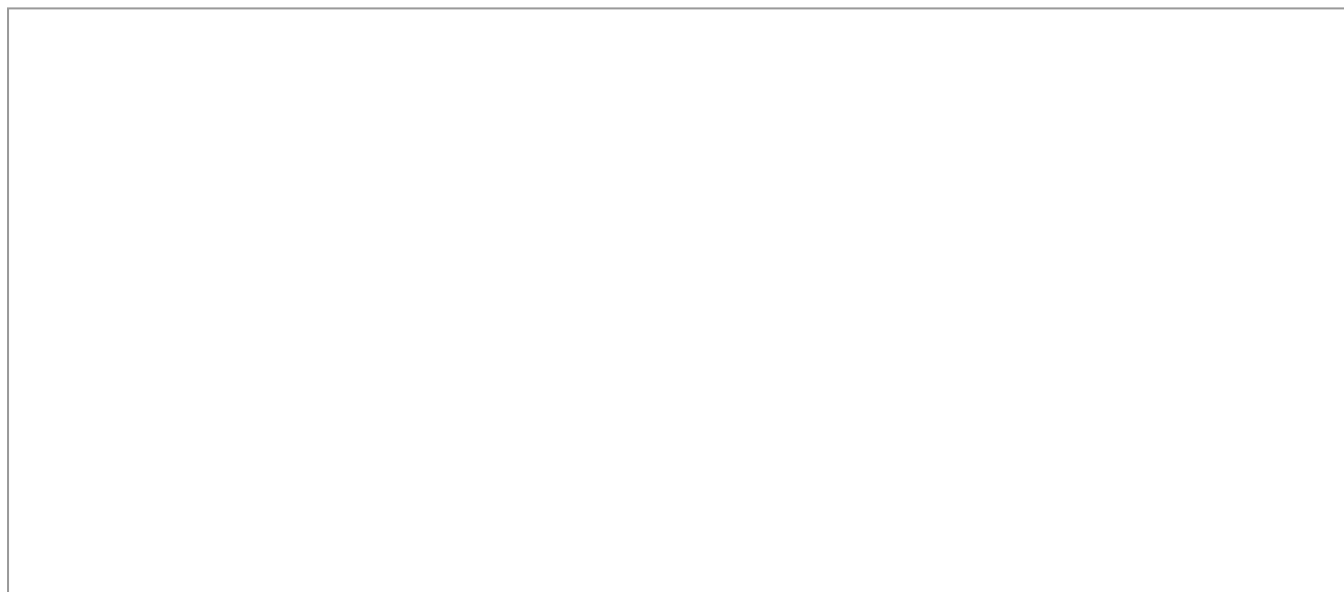
[2 marks]



16(d)(iii) Outline the mechanism of the reaction between compound D and hydrogen bromide to form either compound E or compound F.

Include curly arrows and relevant dipoles.

[3 marks]



16(d)(iv) Which of E or F is the major organic product?

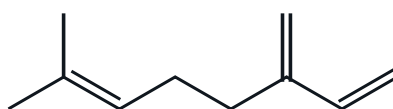
Explain your answer.

[1 mark]

Major organic product

Explanation

Myrcene, $C_{10}H_{16}$, is a naturally occurring hydrocarbon containing more than one carbon-carbon double bond.



myrcene

16(e)(i) Reaction of 204 mg of myrcene with hydrogen gas produces a saturated alkane.

Calculate the volume of hydrogen gas, in cm^3 and measured at RTP, needed for this reaction.

Show your working.

volume = cm^3

[2 marks]

16(e)(ii) β -Carotene is a naturally occurring unsaturated hydrocarbon found in carrots.

A β -carotene molecule contains 40 carbon atoms, has two rings, and a branched chain.

0.0200 mol of β -carotene reacts with 5.28 dm³ of hydrogen gas to form a saturated hydrocarbon.

Using molecular formulae, construct a balanced equation for this reaction.

Include relevant calculations and reasoning.

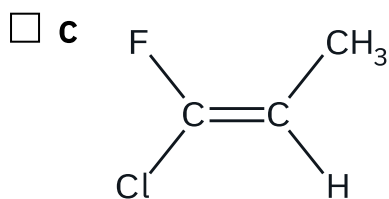
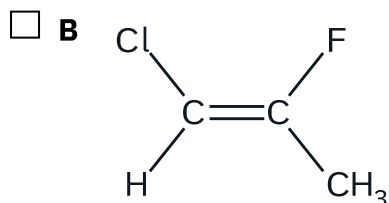
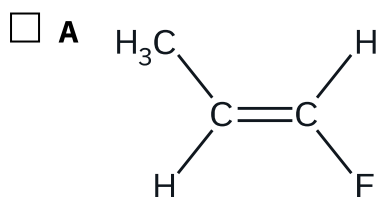
Equation

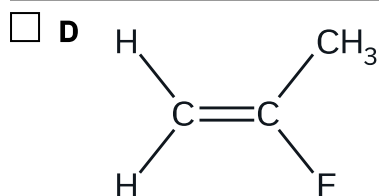
[4 marks]

Q37 · Alkenes and addition polymers · June 2017 · Paper 2 (Synthesis and analytical techniques) · Q4 · [1 mark]

Which molecule is a Z-isomer?

Tick (✓) one box.

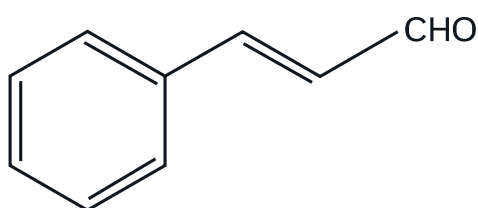




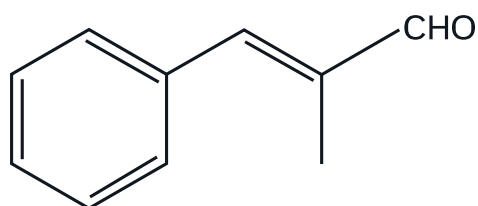
Q38 · Alkenes and addition polymers · June 2018 · Paper 2 (Synthesis and analytical techniques) · Q20 · [18 marks]

This question also needs Amines, amino acids and polymers, Carbon–carbon bond formation and synthesis, Carbonyls, carboxylic acids and esters and Electrons, bonding and structure.

Cinnamaldehyde and methylcinnamaldehyde are naturally occurring organic compounds.



cinnamaldehyde



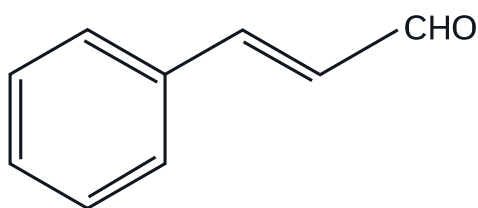
methylcinnamaldehyde

20(a) Methylcinnamaldehyde is an E stereoisomer.

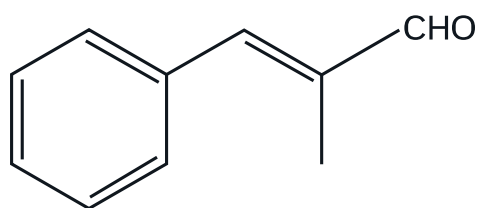
Explain this statement in terms of the Cahn-Ingold-Prelog (CIP) rules.

[2 marks]

A student plans to carry out some chemical tests on both cinnamaldehyde and methylcinnamaldehyde.



cinnamaldehyde



methylcinnamaldehyde

20(b)(i) Suggest a suitable chemical test to confirm that both compounds contain an unsaturated carbon chain.

Your answer should include the reagent and observations.

[1 mark]

20(b)(ii) Describe a chemical test to confirm that both compounds contain an aldehyde functional group.

Your answer should include the reagent and observations.

[1 mark]

20(b)(iii) Describe a chemical test to confirm that cinnamaldehyde and methylcinnamaldehyde contain a carbonyl group.

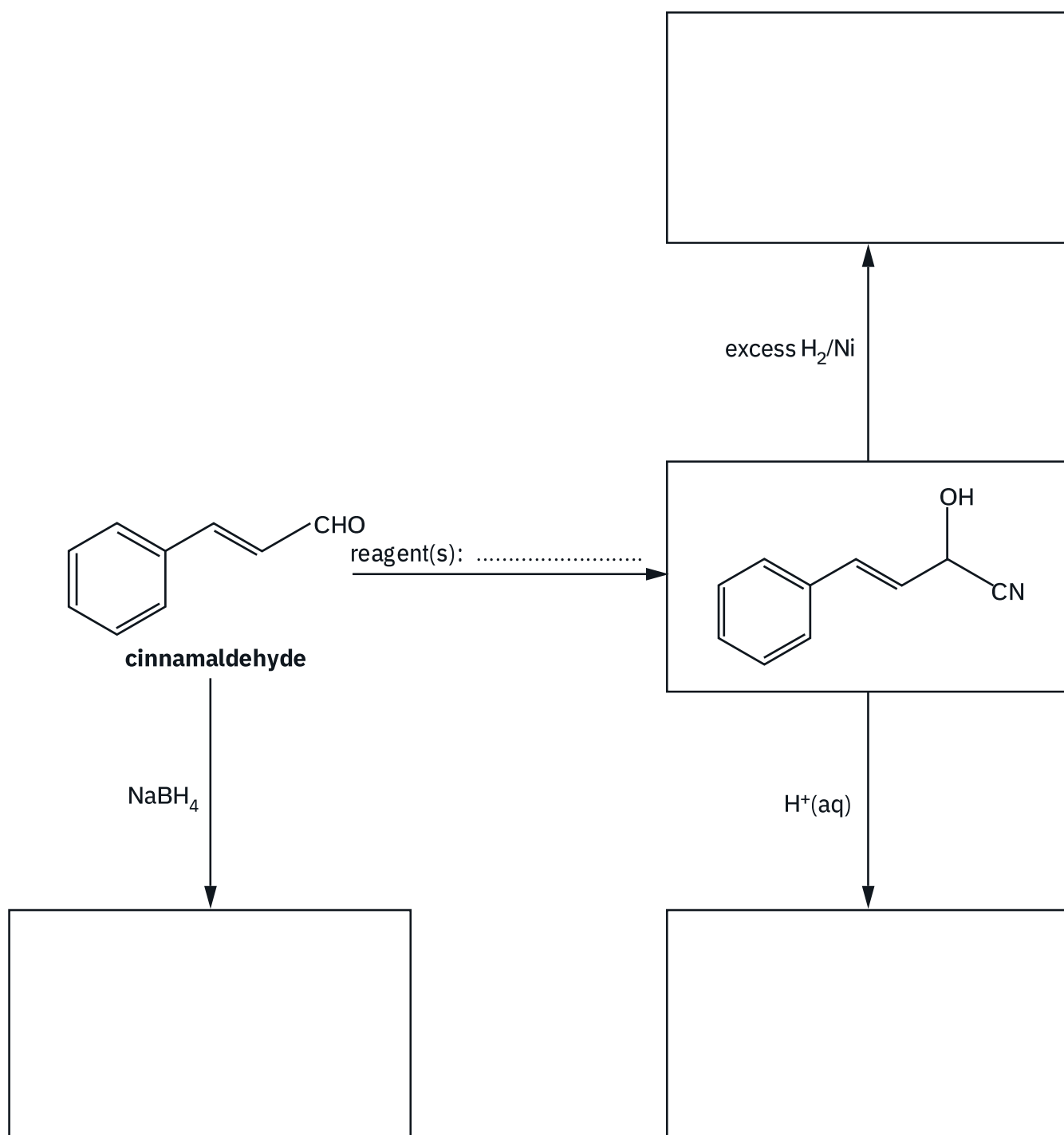
How could the products of this test be used to distinguish between the two compounds?

Your answer should not include spectroscopy.

[3 marks]

20(c) The flowchart below shows some reactions starting with cinnamaldehyde.

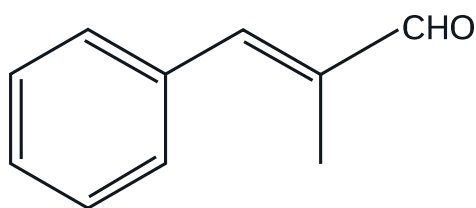
Draw the structures of the missing organic compounds in the boxes and add the missing reagent(s) on the dotted line.



[5 marks]

Draw your answer on the figure above.

20(d) Methylcinnamaldehyde reacts with iodine monochloride, ICl, by electrophilic addition. The reaction produces a mixture containing two different organic products.



methylcinnamaldehyde

The electronegativity values of chlorine and iodine are given in the table below.

Pauling electronegativity value	
Cl	3.0
I	2.5

Outline the mechanism, using the 'curly arrow' model, for the formation of one of the organic products and explain which of the two possible organic products is more likely to be formed.

In your mechanism, you can show the phenyl group as C₆H₅.

[6 marks]

Q13 · [1 mark]

What is the number of stereoisomers that $\text{Ni}(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)_2\text{Cl}_2$ can form?

Tick (✓) one box.

☐ **A** 2

☐ **B** 3

☐ **C** 4

☐ **D** 6

Q40 · Alkenes and addition polymers · June 2019 · Paper 2 (Synthesis and analytical techniques) · Q19 · [21 marks]

This question also needs Amines, amino acids and polymers, Aromatic compounds and phenols, Carbonyls, carboxylic acids and esters and 3 other topics.

This question is about benzene.

Over time, the Kekulé and delocalised models have been used to describe the bonding and structure of a benzene molecule.

19(a)(i) Describe, in terms of orbital overlap, the similarities and differences between the bonding in the Kekulé model and the delocalised model of benzene.

[3 marks]

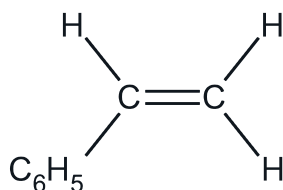
19(a)(ii) Experimental evidence led to the general acceptance of the delocalised model over the Kekulé model.

Describe two pieces of evidence to support the delocalised model of benzene.

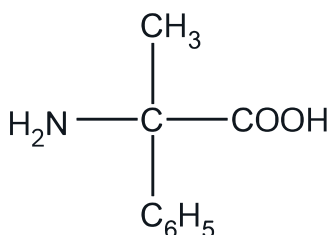
[2 marks]

Benzene can be used as the starting material for the synthesis of compounds D and E, shown below.

In the diagrams C_6H_5 is a phenyl group.



compound D



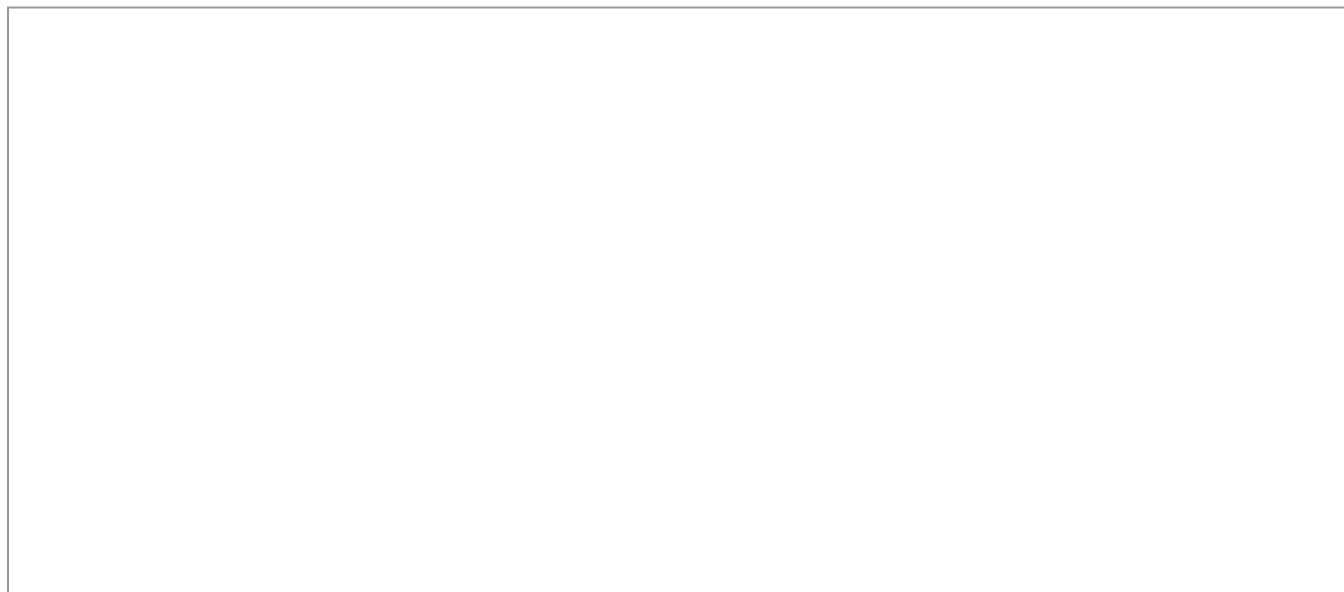
compound E

Compounds D and E can be converted into polymers.

19(b)(i) Draw two repeat units of these polymers.

[3 marks]

Two repeat units of polymer formed from D



Two repeat units of polymer formed from E

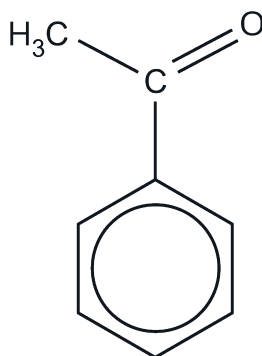
19(b)(ii) State the type of polymer formed from compounds D and E.

[1 mark]

From compound D

From compound E

19(b)(iii) In the synthesis of compounds D and E, benzene is first reacted with ethanoyl chloride, CH_3COCl , to form phenylethanone, shown below.



phenylethanone

The reaction takes place in the presence of aluminium chloride, AlCl_3 , which acts as a catalyst.

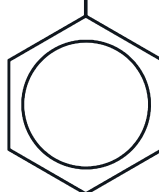
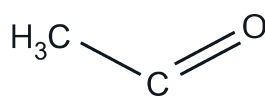
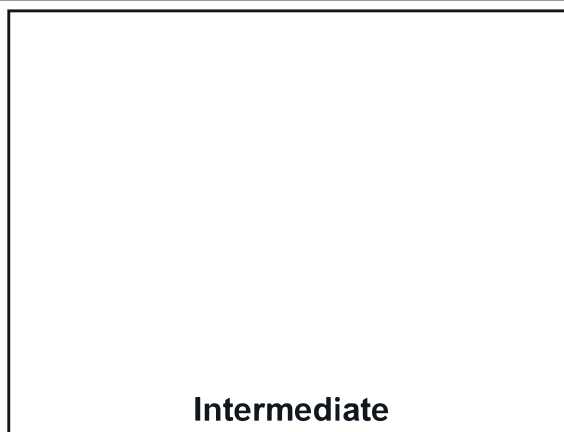
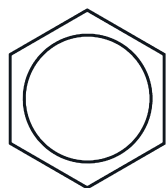
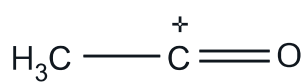
In the mechanism for this reaction,

- ethanoyl chloride first reacts with aluminium chloride to form the $\text{CH}_3-\text{C}^+=\text{O}$ cation
- the $\text{CH}_3-\text{C}^+=\text{O}$ cation then behaves as an electrophile.

Complete the mechanism for the reaction.

Include equations to show the role of the AlCl_3 catalyst, relevant curly arrows and the structure of the intermediate.

Formation of electrophile

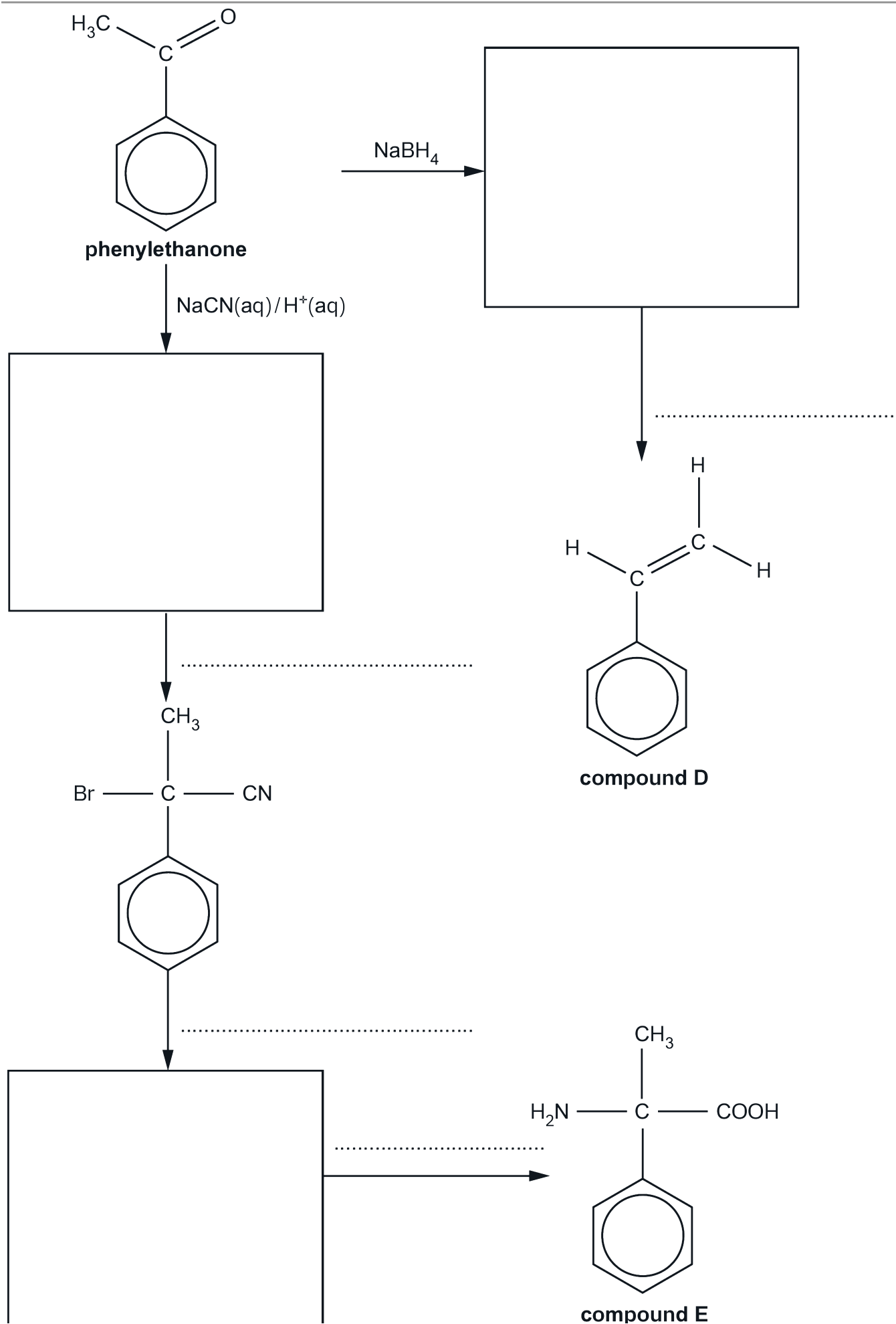


Regeneration of catalyst

[5 marks]

Draw your answer on the figure above.

19(b)(iv) Complete the flowchart for the synthesis of compounds D and E from phenylethanone.

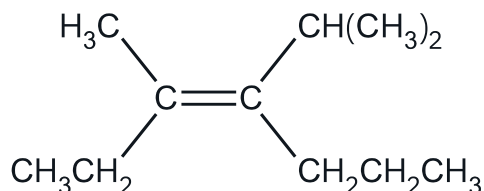


[7 marks]

Draw your answer on the figure above.

Q41 · Alkenes and addition polymers · June 2019 · Paper 2 (Synthesis and analytical techniques) · Q4 · [1 mark]

The structure of a stereoisomer is shown below.



Which term correctly describes this stereoisomer?

Tick (✓) one box.

- ☐ **A** cis-
- ☐ **B** trans-
- ☐ **C** E-
- ☐ **D** Z-

Q42 · Alkenes and addition polymers · June 2019 · Paper 2 (Synthesis and analytical techniques) · Q5 · [1 mark]

Which types of bonds are broken and formed in the reaction of ethene and bromine?

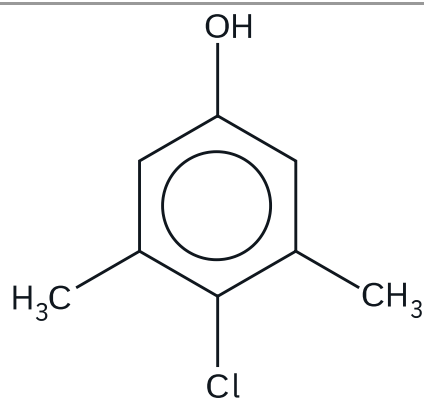
Tick (✓) one box.

- ☐ **A** Types of bond broken: σ · Types of bond formed: π
- ☐ **B** Types of bond broken: π · Types of bond formed: σ
- ☐ **C** Types of bond broken: σ and π · Types of bond formed: π
- ☐ **D** Types of bond broken: σ and π · Types of bond formed: σ

Q43 · Alkenes and addition polymers · June 2019 · Paper 3 (Unified chemistry) · Q4 · [18 marks]

This question also needs Acids and redox reactions, Acids, bases and buffers, Amines, amino acids and polymers and 6 other topics.

Dettol® is a disinfectant containing the antiseptic chloroxylenol, shown below.



chloroxylenol

Chloroxylenol is a weak Brønsted–Lowry acid.

4(a)(i) What is the systematic name of chloroxylenol?

[1 mark]

4(a)(ii) Predict the number of peaks in a ^{13}C NMR spectrum of chloroxylenol.

[1 mark]

4(a)(iii) Name the functional group responsible for the acidity of chloroxylenol and describe a simple test which would confirm the presence of this group.

[2 marks]

Functional group

Test

4(a)(iv) A student measures the pH of the contents in a bottle of Dettol® as 5.14.

The label on the bottle shows the percentage of chloroxylenol in Dettol® as 4.80% i.e. 100 cm³ of Dettol® contains 4.80 g of chloroxylenol.

Assume the following:

- Chloroxylenol is the only acidic component in Dettol®.
- Chloroxylenol is a weak monobasic acid.
- The density of Dettol® is 1.00 g cm⁻³.

Write the equation, using molecular formulae, for the acid dissociation of chloroxylenol.

Calculate the acid dissociation constant, K_a , for chloroxylenol.

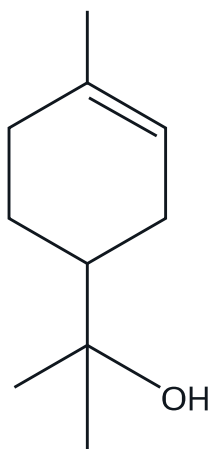
$K_a = \text{mol dm}^{-3}$

[5 marks]

Dettol® contains other chemicals including α -terpineol, shown below.

4(b)(i) α -Terpineol is a chiral compound.

Show with an asterisk, (*), the chiral centre(s) in the structure of α -terpineol.



α -terpineol

[1 mark]

4(b)(ii) α -Terpineol meets the requirements for E / Z isomerism.

However, only one E / Z isomer of α -terpineol exists.

Explain

- why α -terpineol meets the requirements for E / Z isomerism
- whether α -terpineol is an E- or Z- isomer
- why only one E / Z isomer of α -terpineol exists.

[4 marks]

4(b)(iii) α -Terpineol contains two functional groups.

For each functional group, choose a reagent that reacts with that group only.

Draw the structures for the organic products of the reactions.

Show structures for organic compounds.

[4 marks]

Reagent(s)

Name of functional group that reacts

Structure of organic product

Reagent(s)

Name of functional group that reacts

Structure of organic product

Q44 · Alkenes and addition polymers · June 2024 · Paper 2 (Synthesis and analytical techniques) · Q19 · [6 marks]

This question also needs Carbonyls, carboxylic acids and esters.

19 Alkenes and carbonyl compounds take part in addition reactions.

Describe **one** addition reaction of an alkene and **one** addition reaction of a carbonyl compound.

Include reagents and reaction mechanisms.

[6 marks]

Q45 · Alkenes and addition polymers · June 2024 · Paper 2 (Synthesis and analytical techniques) · Q2 · [1 mark]

Hydrogen reacts much more readily with alkenes than with alkanes.

Why is this?

Tick (✓) one box.

- ☐ **A** Alkenes are polar molecules whereas alkanes are not.
- ☐ **B** All atoms in an alkane have a full outer shell of electrons.
- ☐ **C** The bond enthalpy of C–C σ bonds is **higher** than that of π bonds.
- ☐ **D** The bond enthalpy of C–C σ bonds is **lower** than that of π bonds.

Q46 · Alkenes and addition polymers · June 2025 · Paper 2 (Synthesis and analytical techniques) · Q10 · [1 mark]

How many stereoisomers does the compound $\text{CH}_3\text{CH}(\text{Br})\text{CH}=\text{CHCH}(\text{Cl})\text{CH}_3$ have?

Tick (✓) one box.

- ☐ **A** 2
- ☐ **B** 4
- ☐ **C** 6
- ☐ **D** 8

Q47 · Alkenes and addition polymers · June 2025 · Paper 2 (Synthesis and analytical techniques) · Q8 · [1 mark]

Ethene can be reacted with hydrogen bromide.

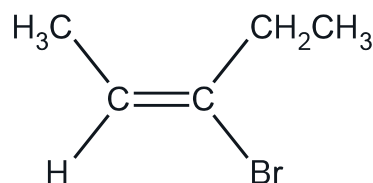
Which statement about this reaction is correct?

Tick (✓) one box.

- ☐ **A** H^- acts as a nucleophile.
- ☐ **B** Br^+ acts as an electrophile.
- ☐ **C** $\text{H}^{\delta+}-\text{Br}^{\delta-}$ acts as an electrophile.
- ☐ **D** $\text{H}^{\delta+}-\text{Br}^{\delta-}$ acts as a nucleophile.

Q48 · Alkenes and addition polymers · November 2020 · Paper 2 (Synthesis and analytical techniques) · Q1 · [1 mark]

What is the name of the compound below?



Tick (✓) one box.

- ☐ **A** E-3-bromopent-2-ene
- ☐ **B** E-3-bromopent-3-ene
- ☐ **C** Z-3-bromopent-2-ene
- ☐ **D** Z-3-bromopent-3-ene

Q49 · Alkenes and addition polymers · November 2020 · Paper 2 (Synthesis and analytical techniques) · Q2 · [1

mark]

This question also needs Electrons, bonding and structure.

Which statement about bonds is correct?

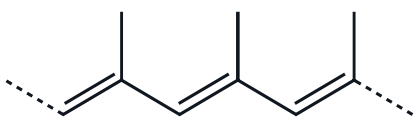
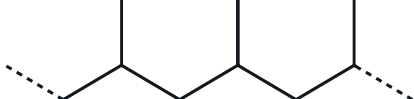
Tick (✓) one box.

- ☐ **A** The C=C bond in ethene is more polar than the C–C bond in ethane.
- ☐ **B** A σ -bond is stronger than a π -bond.
- ☐ **C** The H–C–H bond angle in ethane is greater than the H–C–H bond angle in ethene.
- ☐ **D** A σ -bond is formed from sideways overlap of p orbitals.

Q50 • Alkenes and addition polymers • November 2020 • Paper 2 (Synthesis and analytical techniques) • Q5 • [1 mark]

Which structure shows a section of poly(propene)?

Tick (✓) one box.

- ☐ **A** 
- ☐ **B** 
- ☐ **C** 
- ☐ **D** 

Q51 • Alkenes and addition polymers • November 2021 • Paper 2 (Synthesis and analytical techniques) • Q16 • [17 marks]

But-1-ene, $\text{H}_2\text{C}=\text{CHCH}_2\text{CH}_3$, and buta-1,3-diene, $\text{H}_2\text{C}=\text{CH}-\text{CH}=\text{CH}_2$, are unsaturated compounds used to make many organic products.

But-1-ene and buta-1,3-diene have σ -bonds and π -bonds.

16(a)(i) Explain what is meant by the terms σ -bond and π -bond.

σ -bond:

π -bond:

[2 marks]

16(a)(ii) How many σ - and π -bonds are in one molecule of buta-1,3-diene?

σ -bonds: π -bonds:

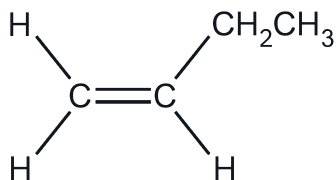
[2 marks]

But-1-ene is reacted with hydrogen bromide, forming a mixture of two saturated organic products.

One of the organic products is formed in a much greater quantity than the other organic product.

16(b)(i) Outline the reaction mechanism for the formation of this major organic product. The structure of but-1-ene has been provided.

Include curly arrows and relevant dipoles.



[4 marks]

16(b)(ii) Explain why one organic product is formed in a much greater quantity than the other organic product.

[2 marks]

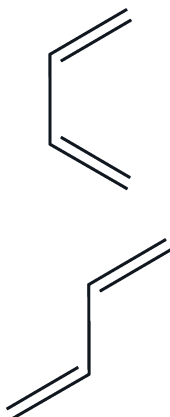
16(b)(iii) Buta-1,3-diene is reacted with an excess of hydrogen bromide, forming a mixture of saturated organic products.

How many saturated organic products could be present in this mixture?

[1 mark]

A student thought that buta-1,3-diene can show stereoisomerism.

The student drew out skeletal formulae for the stereoisomers of buta-1,3-diene:



16(c)(i) Explain the term stereoisomerism.

[1 mark]

16(c)(ii) Explain, with a reason, whether the student is correct or incorrect.

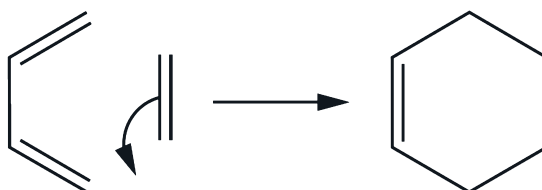
[1 mark]

'Diels-Alder' reactions are used in the synthesis of many important organic compounds.

The Diels-Alder reaction of buta-1,3-diene with ethene is shown below.



16(d)(i) Add curly arrows to the diagram below to complete the mechanism for this Diels-Alder reaction.

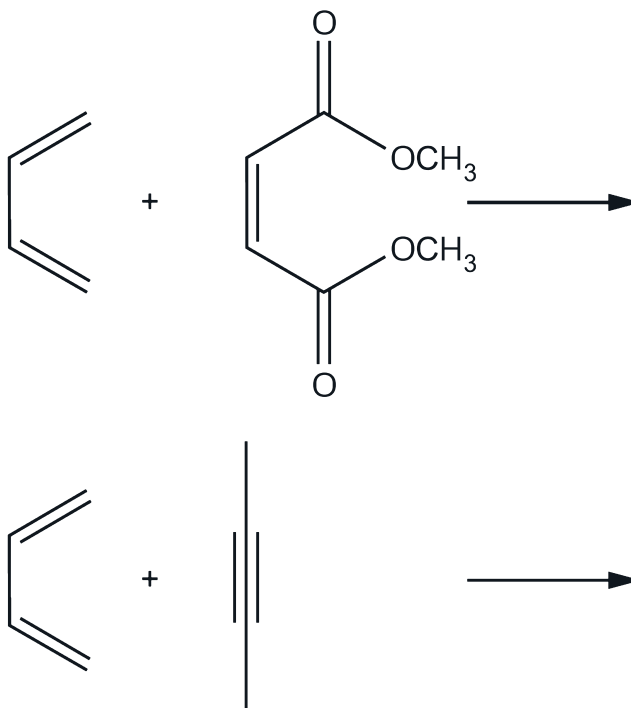


[2 marks]

Draw your answer on the figure above.

16(d)(ii) Two more Diels-Alder reactions of buta-1,3-diene are shown below.

In the boxes, draw the organic product of each reaction.



[2 marks]

Draw your answer on the figure above.

Q52 · Basic concepts of organic chemistry · June 2017 · Paper 2 (Synthesis and analytical techniques) · Q15 · [1 mark]

Which compound(s) is a/are structural isomer(s) of $C_6H_{12}O_2$?

1 hexanoic acid

2 ethyl butanoate

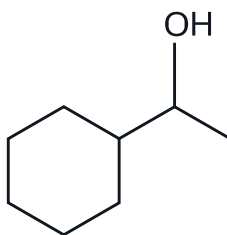
3 propyl propanoate

Tick (✓) one box.

- ☐ **A** 1, 2 and 3
- ☐ **B** Only 1 and 2
- ☐ **C** Only 2 and 3
- ☐ **D** Only 1

Q53 · Basic concepts of organic chemistry · June 2017 · Paper 2 (Synthesis and analytical techniques) · Q2 · [1 mark]

How can the molecule below be described?



Tick (✓) one box.

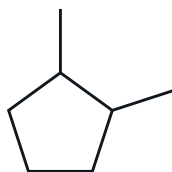
- ☐ **A** Aromatic and alicyclic
- ☐ **B** Aliphatic and unsaturated
- ☐ **C** Aromatic and unsaturated
- ☐ **D** Alicyclic and saturated

Q54 · Basic concepts of organic chemistry · June 2017 · Paper 2 (Synthesis and analytical techniques) · Q9 · [1

mark]

This question also needs Amount of substance.

What is the molecular formula of the compound below?



Tick (✓) one box.

- ☐ **A** C_7H_{10}
- ☐ **B** C_7H_{12}
- ☐ **C** C_7H_{14}
- ☐ **D** C_7H_{16}

Q55 • Basic concepts of organic chemistry • June 2018 • Paper 2 (Synthesis and analytical techniques) • Q11 • [1 mark]

How many straight-chain structural isomers of $C_7H_{15}Cl$ contain a chiral carbon atom?

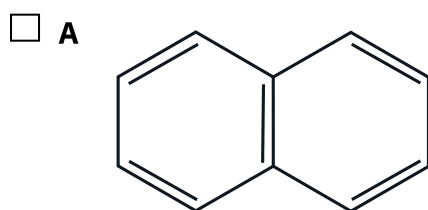
Tick (✓) one box.

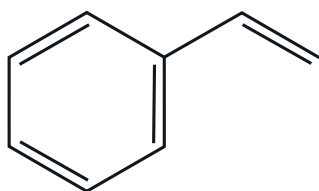
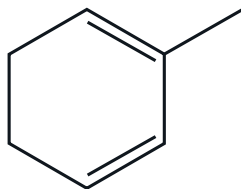
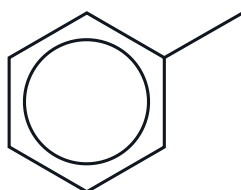
- ☐ **A** 1
- ☐ **B** 2
- ☐ **C** 3
- ☐ **D** 4

Q56 • Basic concepts of organic chemistry • June 2018 • Paper 2 (Synthesis and analytical techniques) • Q4 • [1 mark]

Which structure represents an alicyclic compound?

Tick (✓) one box.



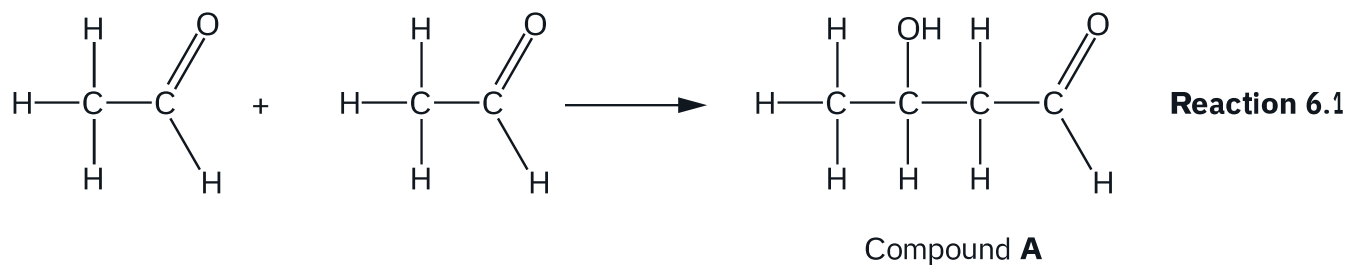
☐ **B**☐ **C**☐ **D****Q57 · Basic concepts of organic chemistry · June 2018 · Paper 3 (Unified chemistry) · Q6 · [12 marks]**

This question also needs Acids, bases and buffers and Reaction rates and equilibrium.

This question is about organic reactions.

Compound A is formed when ethanal is mixed with $\text{OH}^-(\text{aq})$ ions, which act as a catalyst.

The balanced equation is shown in reaction 6.1 below.



6(a)(i) Give the systematic name for compound A.

[1 mark]

6(a)(ii) What type of reaction has taken place?

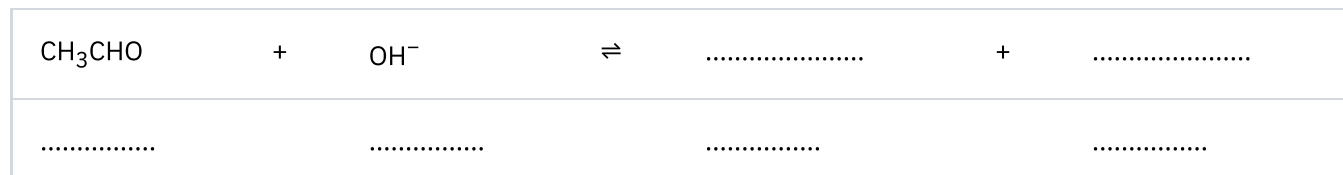
[1 mark]

6(a)(iii) Reaction 6.1 takes place in two steps. OH^- ions act as a catalyst.

In step 1, ethanal reacts with OH^- ions to set up an acid–base equilibrium.

In step 2, compound A is formed.

- Complete the equilibrium for step 1 and label the conjugate acid–base pairs as: A1, B1 and A2, B2.



- Suggest the equation for step 2.

[3 marks]

6(a)(iv) A similar reaction takes place when propanone, $(\text{CH}_3)_2\text{CO}$, is mixed with $\text{OH}^-(\text{aq})$ ions.

Draw the structure of the organic product of this reaction.

[1 mark]

6(b) Many organic reactions use electrophiles as reagents.

Explain the role of electrophiles in organic chemistry.

Your answer should include one reaction of an aliphatic compound and one reaction of an aromatic compound, including relevant mechanisms.

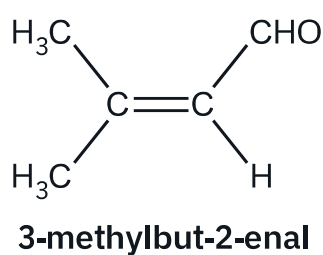
[6 marks]

Q58 · Basic concepts of organic chemistry · June 2019 · Paper 2 (Synthesis and analytical techniques) · Q16 · [15 marks]

This question also needs Amines, amino acids and polymers, Amount of substance and Carbonyls, carboxylic acids and esters.

This question is about unsaturated aldehydes and alcohols.

3-Methylbut-2-enal, shown below, is used as a food flavouring.



3-Methylbut-2-enal is reacted with hydrogen bromide, forming a mixture of two organic products.

One of the organic products forms in a much greater quantity than the other organic product.

16(a)(i) Outline the reaction mechanism for the formation of one of the organic products.

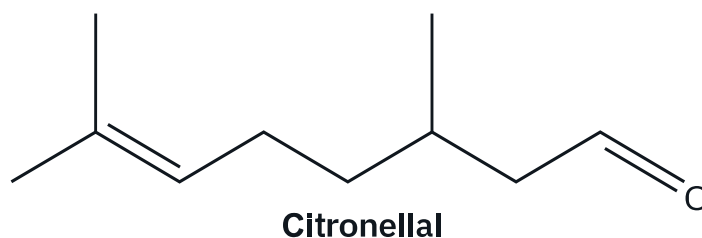
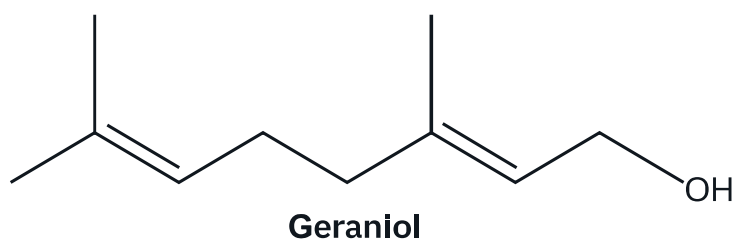
Include curly arrows and relevant dipoles.

[4 marks]

16(a)(ii) Explain why one of the organic products forms in a much greater quantity than the other organic product.

[2 marks]

Geraniol and citronellal, shown below, are isomers present in 'citronella oil', used as an insect repellent.



- Geraniol and citronellal are structural isomers of each other.
- They also show stereoisomerism.

16(b)(i) Describe how the observations from a chemical test would distinguish between geraniol and citronellal.

[2 marks]

16(b)(ii) What is the molecular formula of geraniol?

[1 mark]

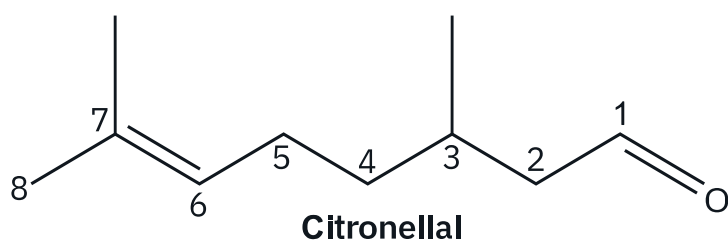
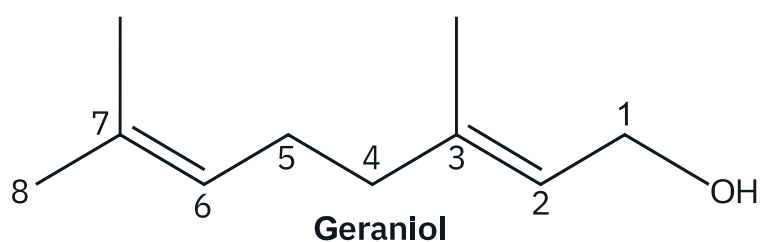
16(b)(iii) Explain why geraniol and citronellal are structural isomers of each other.

[1 mark]

16(b)(iv) Explain the term stereoisomerism.

[1 mark]

16(b)(v) The structures of geraniol and citronellal are repeated below with the carbon atoms numbered.



Explain the types of stereoisomerism shown by geraniol and citronellal.

In your answer,

- refer to the numbered carbon atoms in the structures above
- draw diagrams clearly showing any stereoisomers.

[4 marks]

Geraniol stereoisomers

Citronellal stereoisomers

Q59 · Basic concepts of organic chemistry · June 2019 · Paper 2 (Synthesis and analytical techniques) · Q20 · [10 marks]

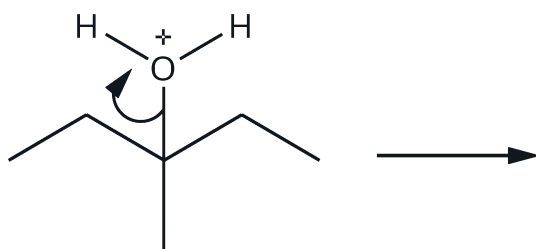
This question is about reaction mechanisms.

Chemists use curly arrows in reaction mechanisms.

20(a)(i) What does a curly arrow show in a reaction mechanism?

[1 mark]

20(a)(ii) Draw structures to show the products in the reaction mechanism below.



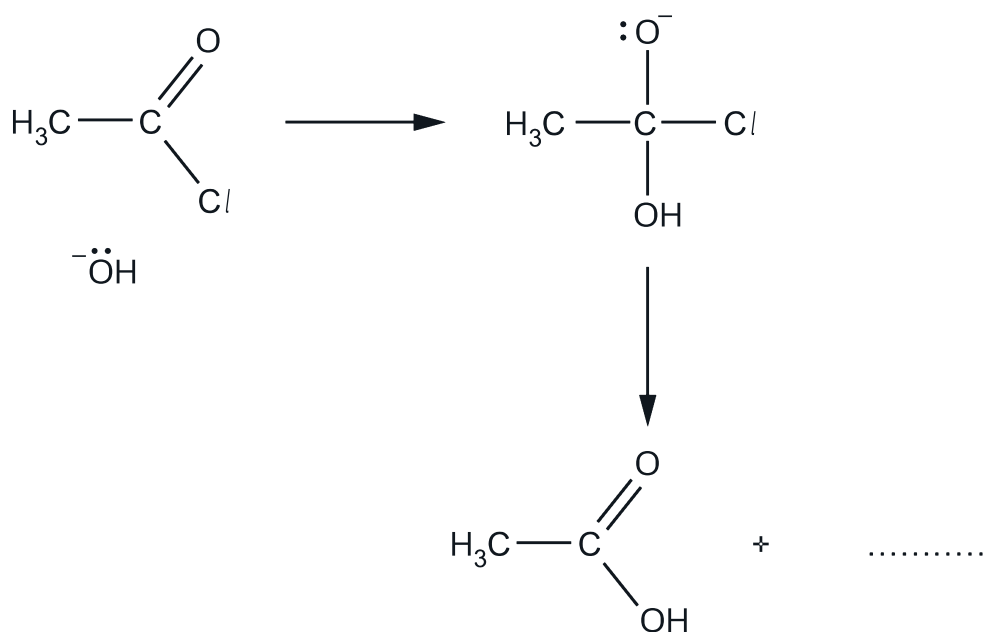
[2 marks]

20(a)(iii) Use the mechanism in (ii) to explain what is meant by heterolytic fission.

[2 marks]

An incomplete reaction mechanism is shown below.

20(b)(i) Complete the mechanism by adding curly arrows and any missing species.



[4 marks]

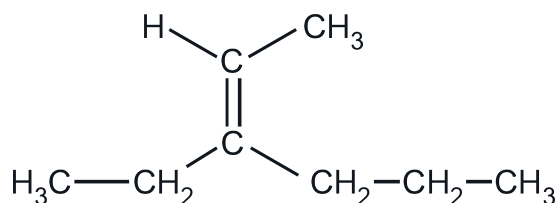
Draw your answer on the figure above.

20(b)(ii) What is the role of OH^- in this mechanism?

[1 mark]

Q60 • Basic concepts of organic chemistry • June 2019 • Paper 2 (Synthesis and analytical techniques) • Q3 • [1 mark]

What is the name of the compound below?



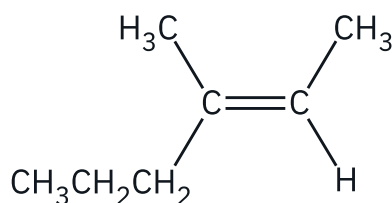
Tick (✓) one box.

- ☐ **A** 3-Propylpent-2-ene
- ☐ **B** 3-Propylpent-3-ene
- ☐ **C** 3-Ethylhex-2-ene
- ☐ **D** 4-Ethylhex-4-ene

Q61 • Basic concepts of organic chemistry • June 2022 • Paper 2 (Synthesis and analytical techniques) • Q16 • [17 marks]

This question is about unsaturated hydrocarbons.

The unsaturated hydrocarbon A, shown below, is reacted with bromine.



Hydrocarbon A

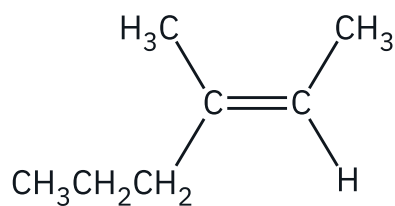
16(a)(i) What is the systematic name of hydrocarbon A?

[1 mark]

16(a)(ii) Outline the mechanism for the reaction of hydrocarbon A with bromine.

The structure of hydrocarbon A has been provided.

Include curly arrows and relevant dipoles.



[3 marks]

Compounds B and C are **branched** hydrocarbons that are structural isomers of C_6H_{12} .

Compounds B and C both have stereoisomers.

- Compound B has cis and trans isomers but does **not** have optical isomers.
- Compound C has optical isomers but does **not** have cis and trans isomers.

16(b)(i) What is meant by the term **structural isomers**?

[1 mark]

16(b)(ii) What is meant by the term **stereoisomers**?

[1 mark]

16(b)(iii) Draw structures for the cis and trans isomers of the branched hydrocarbon B.

cis isomer

trans isomer

[2 marks]

16(b)(iv) Draw 3D structures for the optical isomers of compound C.

Optical isomers

[2 marks]

16(b)(v) Compounds D and E are two more structural isomers of C_6H_{12} .

Compounds D and E do **not** show stereoisomerism.

Table 16.1 shows NMR and infrared (IR) spectral data for D and E.

	Number of peaks in ^1H NMR spectrum	Number of peaks in ^{13}C NMR spectrum	IR peak at 1620–1680 cm^{-1}
D	1	1	No
E	1	2	Yes

Table 16.1

Draw the structures of D and E and explain how the spectral data in Table 16.1 provides evidence for the structures.

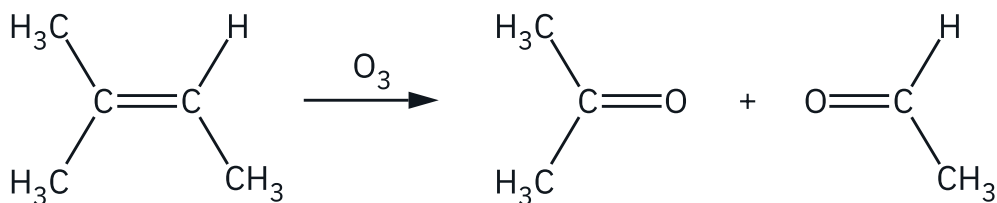
D	E
---	---

[4 marks]

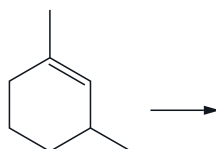
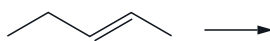
Draw your answer on the figure above.

'Ozonolysis' is used in organic synthesis. Ozone breaks C=C bonds to form carbonyl compounds.

For example, the complete ozonolysis of methylbut-2-ene is shown below.



16(c)(i) Draw the structures of the products you would expect from the ozonolysis of the **two** compounds below.

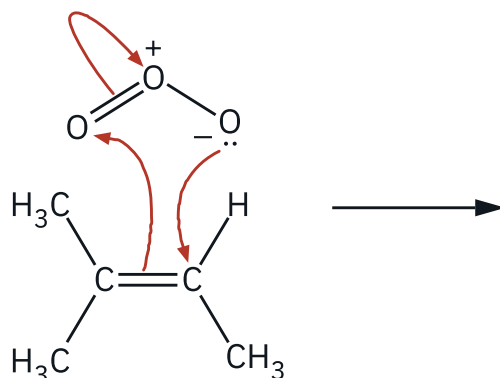


[2 marks]

16(c)(ii) The mechanism for ozonolysis takes place in several steps.

The curly arrows in the first step in the ozonolysis of methylbut-2-ene are shown below.

In the box, draw the structure(s) for the product(s) of this step.

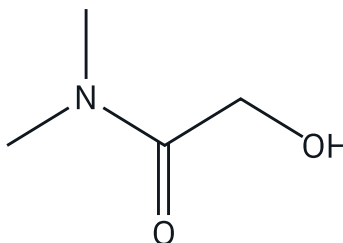


[1 mark]

Draw your answer on the figure above.

Q62 · Basic concepts of organic chemistry · June 2022 · Paper 2 (Synthesis and analytical techniques) · Q4 · [1 mark]

The skeletal formula of an organic compound is shown below.



Which functional groups are present?

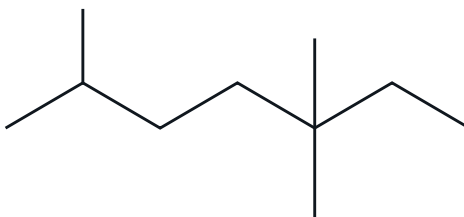
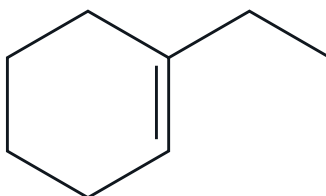
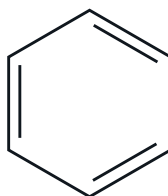
Tick (✓) one box.

- ☐ **A** amide and alcohol
- ☐ **B** amide and carboxylic acid
- ☐ **C** amine and carboxylic acid
- ☐ **D** amine, ketone and alcohol

Q63 · Basic concepts of organic chemistry · June 2023 · Paper 2 (Synthesis and analytical techniques) · Q13 · [1

mark]

Which compound(s) is/are aliphatic?

1**2****3**

Tick (✓) one box.

- ☐ **A** 1, 2 and 3
- ☐ **B** Only 1 and 2
- ☐ **C** Only 2 and 3
- ☐ **D** Only 1

Q64 • Basic concepts of organic chemistry • June 2023 • Paper 2 (Synthesis and analytical techniques) • Q3 • [1 mark]

Propyne, $\text{CH}_3\text{C}\equiv\text{CH}$, is a member of the alkynes homologous series with the $\text{C}\equiv\text{C}$ functional group.

What is the general formula of the alkynes?

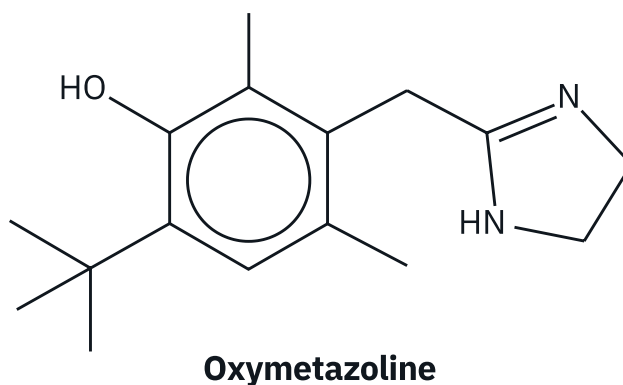
Tick (✓) one box.

- ☐ **A** $\text{C}_n\text{H}_{2n-4}$
- ☐ **B** $\text{C}_n\text{H}_{2n-2}$
- ☐ **C** C_nH_{2n}
- ☐ **D** $\text{C}_n\text{H}_{2n+2}$

Q65 • Basic concepts of organic chemistry • June 2023 • Paper 2 (Synthesis and analytical techniques) • Q5 • [1

mark]

Oxymetazoline, shown below, is used as a decongestant in the treatment of colds.



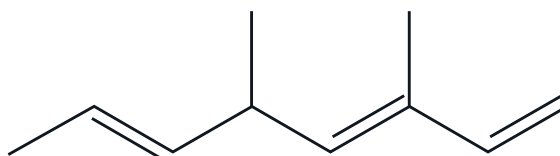
How many H atoms are in one molecule of oxymetazoline?

Tick (✓) one box.

- ☐ **A** 23
- ☐ **B** 24
- ☐ **C** 25
- ☐ **D** 26

Q66 • Basic concepts of organic chemistry • June 2023 • Paper 2 (Synthesis and analytical techniques) • Q7 • [1 mark]

What is the systematic name for the compound below?



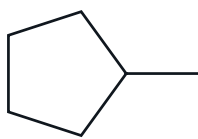
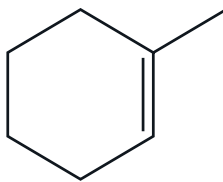
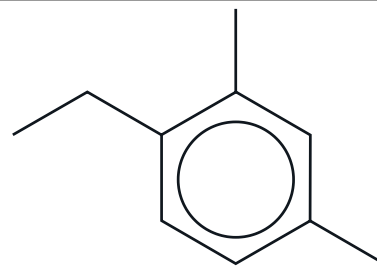
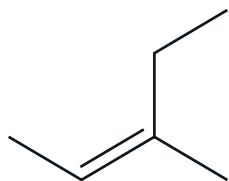
Tick (✓) one box.

- ☐ **A** 3,5-dimethylocta-1,3,6-triene
- ☐ **B** 3,5-dimethylocta-2,5,7-triene
- ☐ **C** 4,6-dimethylocta-1,3,6-triene
- ☐ **D** 4,6-dimethylocta-2,5,7-triene

Q67 • Basic concepts of organic chemistry • June 2024 • Paper 2 (Synthesis and analytical techniques) • Q16 • [6 marks]

This question is about hydrocarbons.

The structures of hydrocarbons A–E are shown below.

**A****B****C****D****E**

16(a) Which hydrocarbons are unsaturated?

[1 mark]

16(b) Which hydrocarbons are alicyclic?

[1 mark]

16(c) Which hydrocarbons have the general formula C_nH_{2n} ?

[1 mark]

16(d) What is the systematic name of hydrocarbon C?

[1 mark]

16(e) Explain why hydrocarbon D is a Z-stereoisomer.

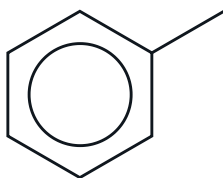
[2 marks]

Q68 • Basic concepts of organic chemistry • June 2025 • Paper 2 (Synthesis and analytical techniques) • Q1 • [1 mark]

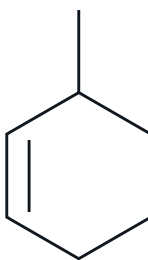
Which compound is alicyclic **and** unsaturated?

Tick (✓) one box.

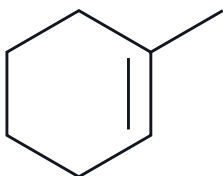
☐ **A**



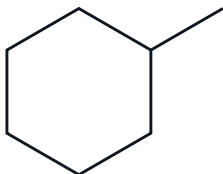
☐ **B**



☐ **C**



☐ **D**



Q69 • Basic concepts of organic chemistry • November 2020 • Paper 2 (Synthesis and analytical techniques) • Q10

• [1 mark]

What is the number of alicyclic structural isomers of C_5H_{10} ?

Tick (✓) one box.

☐ A 3

☐ B 4

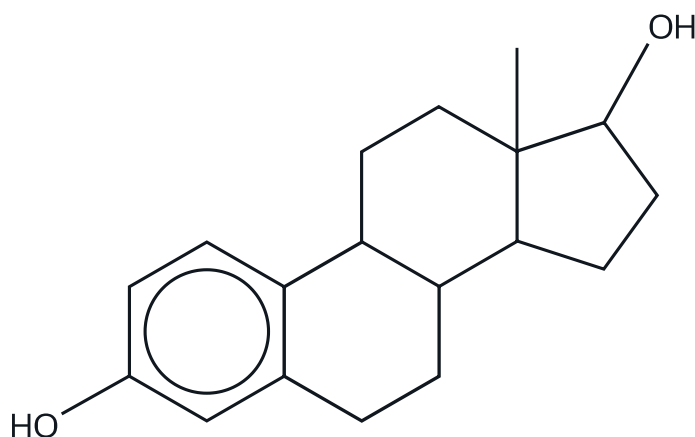
☐ C 5

☐ D 6

Q70 • Basic concepts of organic chemistry • November 2020 • Paper 2 (Synthesis and analytical techniques) • Q12
• [1 mark]

This question also needs Amount of substance.

What is the molecular formula of the steroid molecule below?



Tick (✓) one box.

☐ A $C_{18}H_{24}O_2$

☐ B $C_{18}H_{26}O_2$

☐ C $C_{18}H_{28}O_2$

☐ D $C_{18}H_{30}O_2$

Q71 • Basic concepts of organic chemistry • November 2021 • Paper 2 (Synthesis and analytical techniques) • Q1

[1 mark]

This question also needs Amount of substance.

2-Methylbutane is reacted with chlorine by radical substitution.

What is the number of structural isomers with the molecular formula $C_5H_{11}Cl$ that could be formed?

Tick (✓) one box.

☐ **A** 2

☐ **B** 3

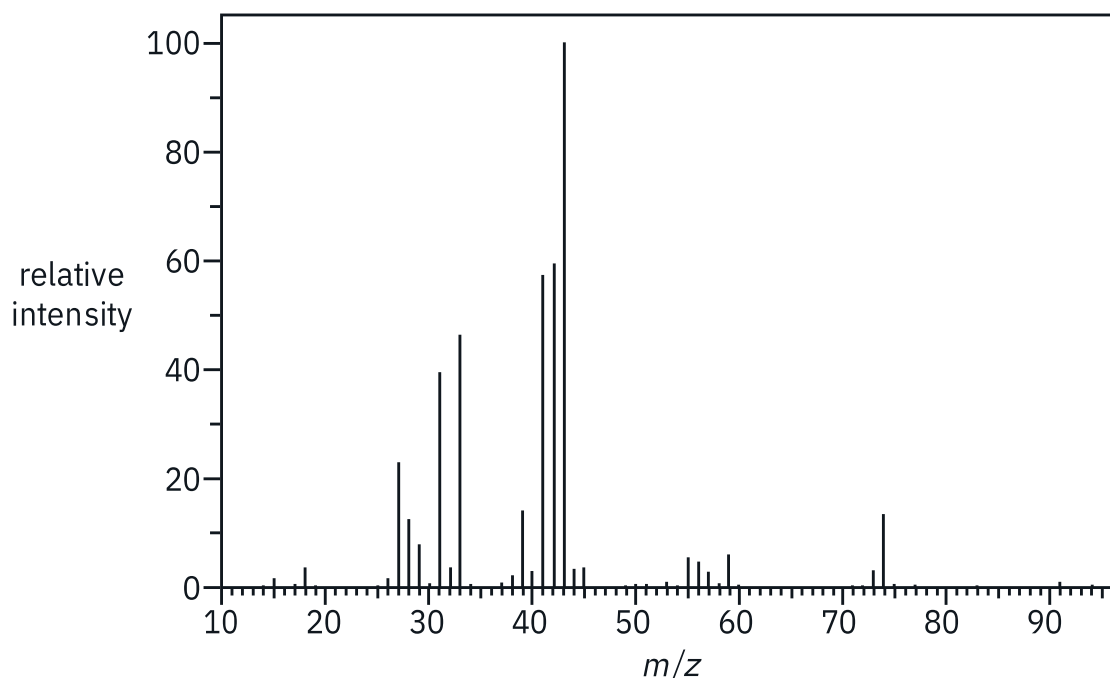
☐ **C** 4

☐ **D** 5

Q72 · Organic synthesis, IR and mass spectra · June 2018 · Paper 2 (Synthesis and analytical techniques) · Q12 · [1 mark]

This question also needs Atomic structure and isotopes.

The mass spectrum of $(\text{CH}_3)_2\text{CHCH}_2\text{OH}$ is shown below.



Which ion is responsible for the peak with the greatest relative intensity?

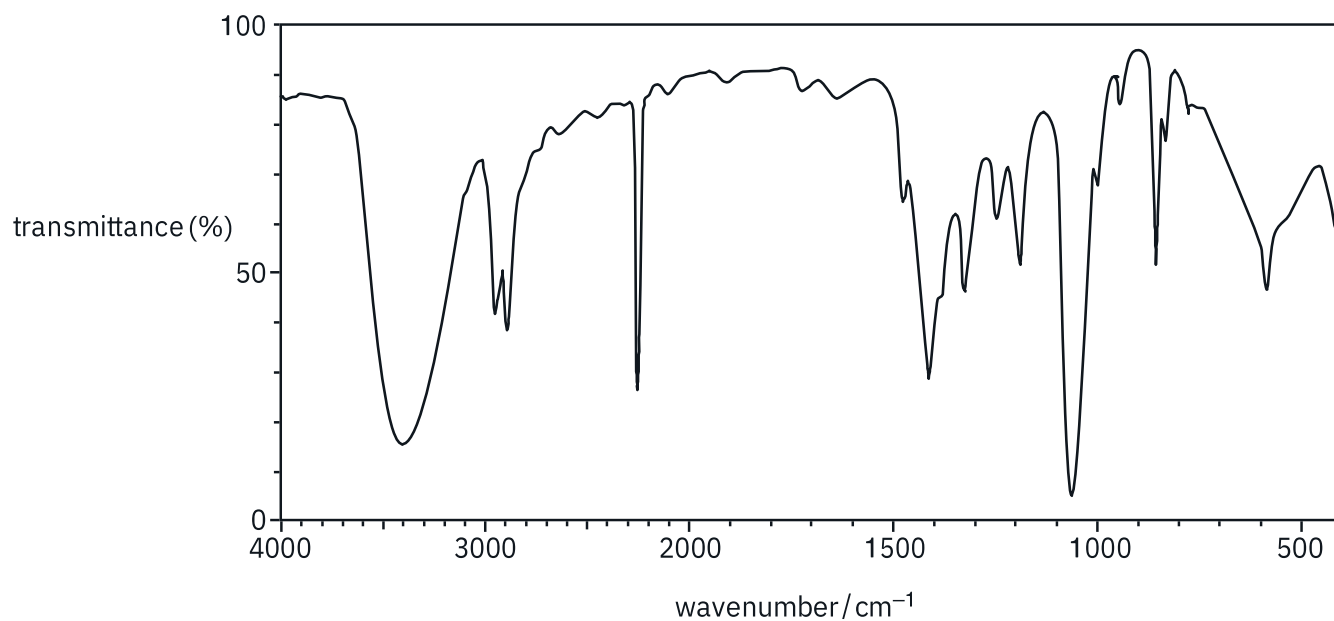
Tick (✓) one box.

- ☐ **A** CHCH_2OH^+
- ☐ **B** $\text{CH}_3\text{CH}_2\text{CH}^+$
- ☐ **C** $(\text{CH}_3)_2\text{CH}^+$
- ☐ **D** CH_3CO^+

Q73 · Organic synthesis, IR and mass spectra · June 2018 · Paper 2 (Synthesis and analytical techniques) · Q9 · [1

mark]

Which compound could have produced the IR spectrum below?



Tick (✓) one box.

- ☐ **A** CH₃CH₂OH
- ☐ **B** CH₃CHOHCN
- ☐ **C** CH₃COOH
- ☐ **D** CH₃CONH₂

Q74 · Organic synthesis, IR and mass spectra · June 2019 · Paper 2 (Synthesis and analytical techniques) · Q21 ·

[6 marks]

This question also needs Amount of substance, Atomic structure and isotopes and NMR spectroscopy.

21 Analysis of an unknown organic compound produced the following results.

[6 marks]

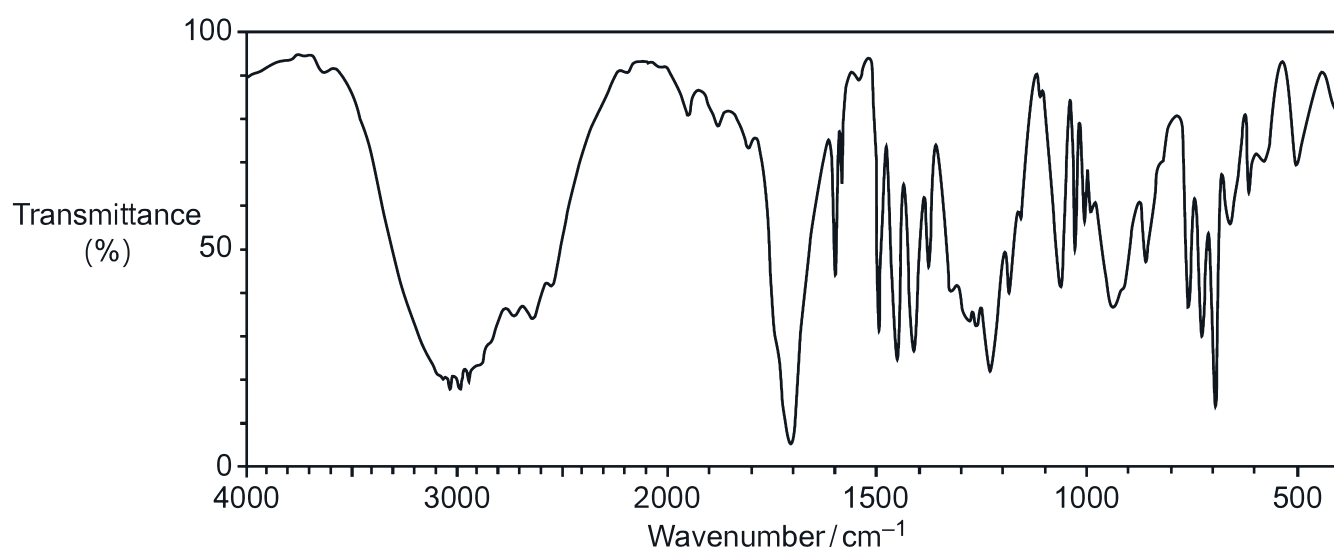
Elemental analysis by mass

C: 73.17%; H: 7.32%; O: 19.51%

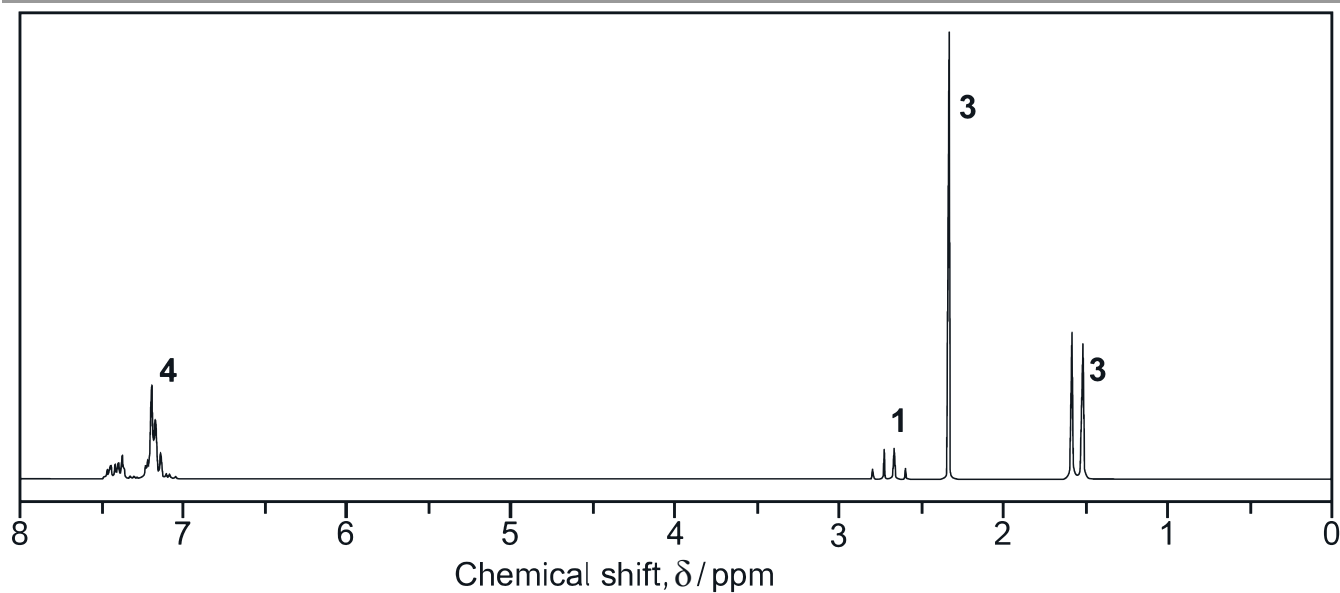
Mass spectrum

Molecular ion peak at $m/z = 164.0$

Infrared spectrum



^1H NMR spectrum in D_2O



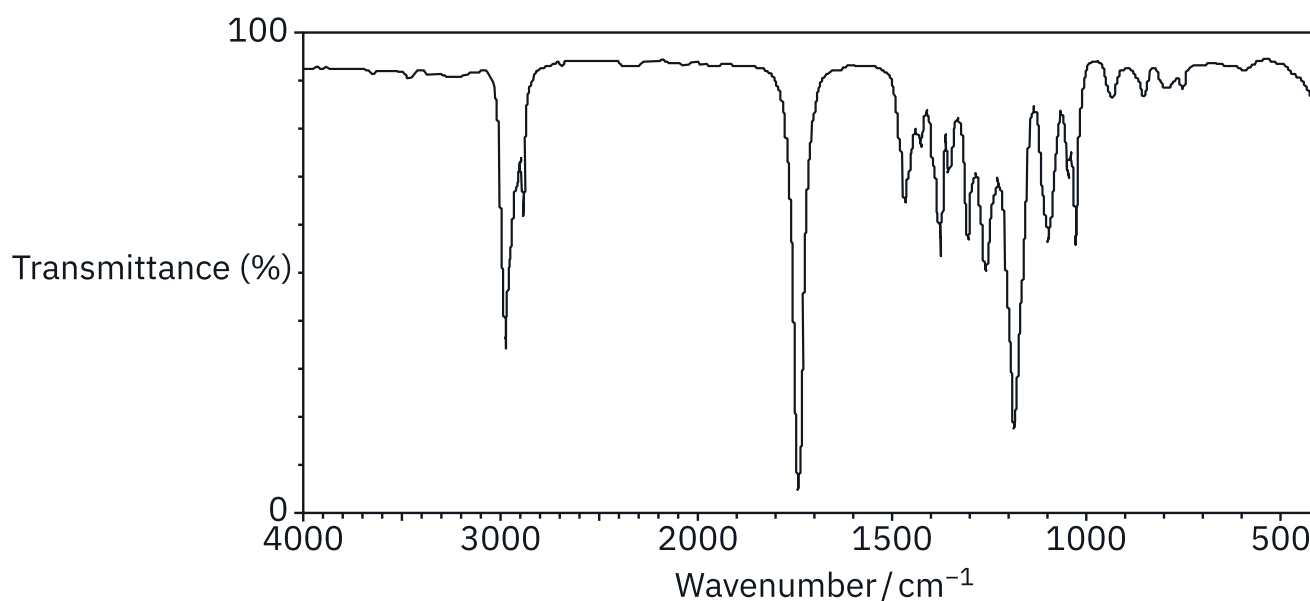
The numbers by the peaks are the relative peak areas.

Use the results to suggest one possible structure for the unknown compound.

Show all your reasoning.

Q75 • Organic synthesis, IR and mass spectra • June 2022 • Paper 2 (Synthesis and analytical techniques) • Q11 • [1 mark]

The infrared spectrum of an organic compound is shown below.



Which compound could have produced this spectrum?

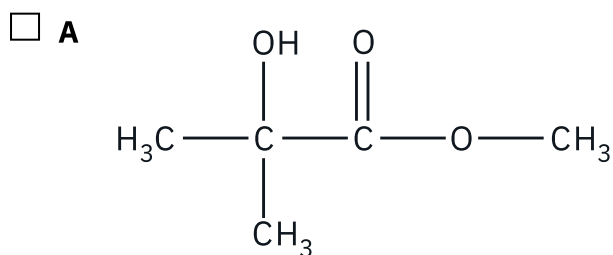
Tick (✓) one box.

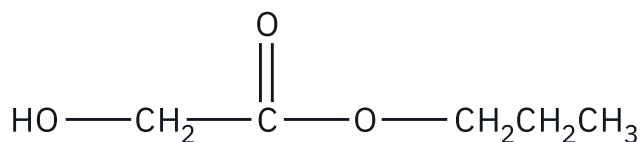
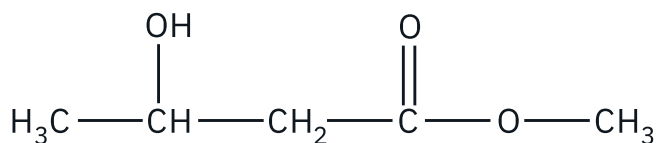
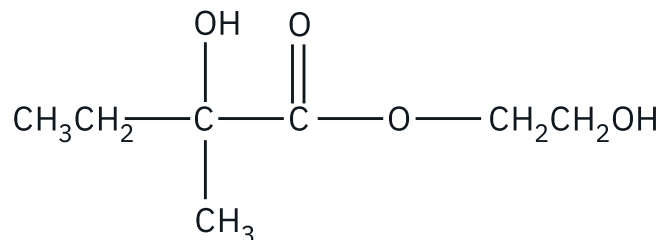
- ☐ **A** $\text{H}_2\text{C}=\text{CHCH}_2\text{CH}_2\text{OH}$
- ☐ **B** $\text{CH}_3\text{COOCH}_2\text{CH}_3$
- ☐ **C** $\text{H}_2\text{NCH}_2\text{COOCH}_3$
- ☐ **D** $(\text{CH}_3)_2\text{CHCONH}_2$

Q76 • Organic synthesis, IR and mass spectra • June 2023 • Paper 2 (Synthesis and analytical techniques) • Q10 • [1 mark]

Which ester is most likely to produce a mass spectrum with a fragment ion at $m/z = 43$?

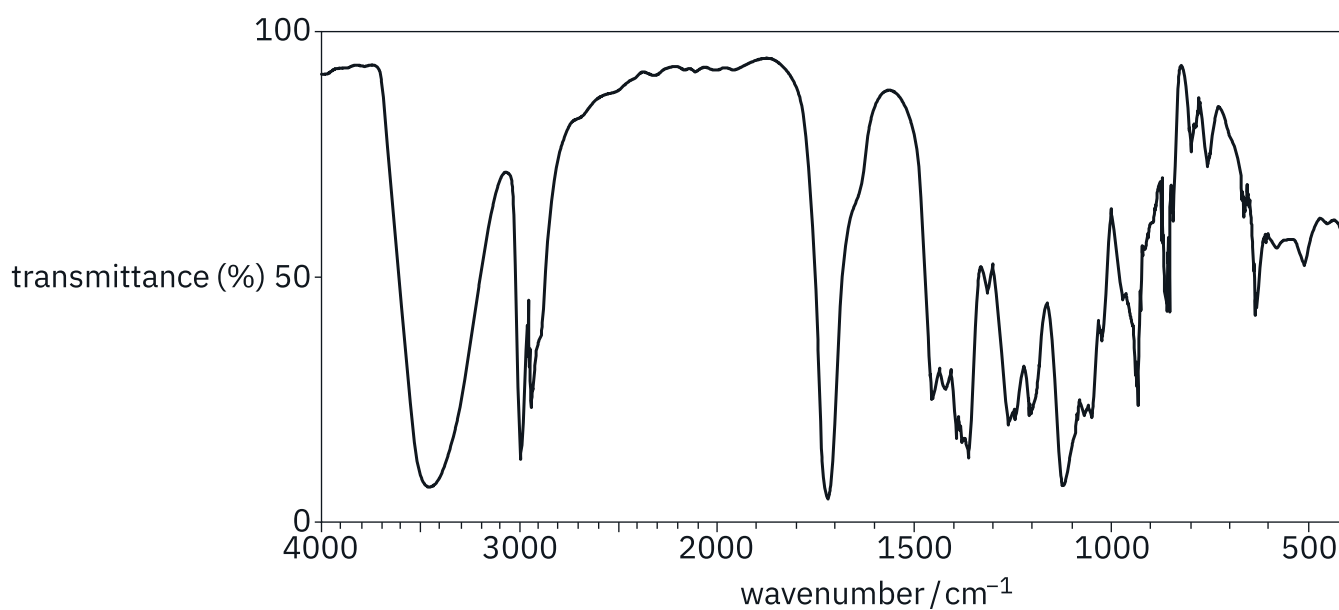
Tick (✓) one box.



☐ **B**☐ **C**☐ **D**

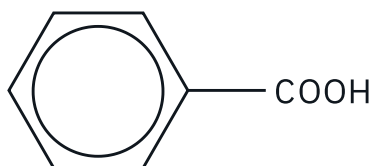
Q77 · Organic synthesis, IR and mass spectra · June 2023 · Paper 2 (Synthesis and analytical techniques) · Q11 · [1 mark]

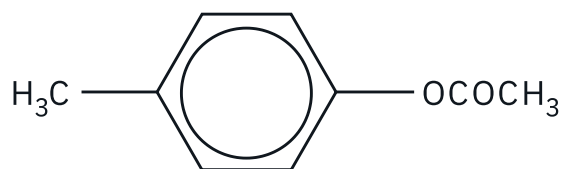
The infrared spectrum of an organic compound is shown below.



Which compound could have produced this spectrum?

Tick (✓) one box.

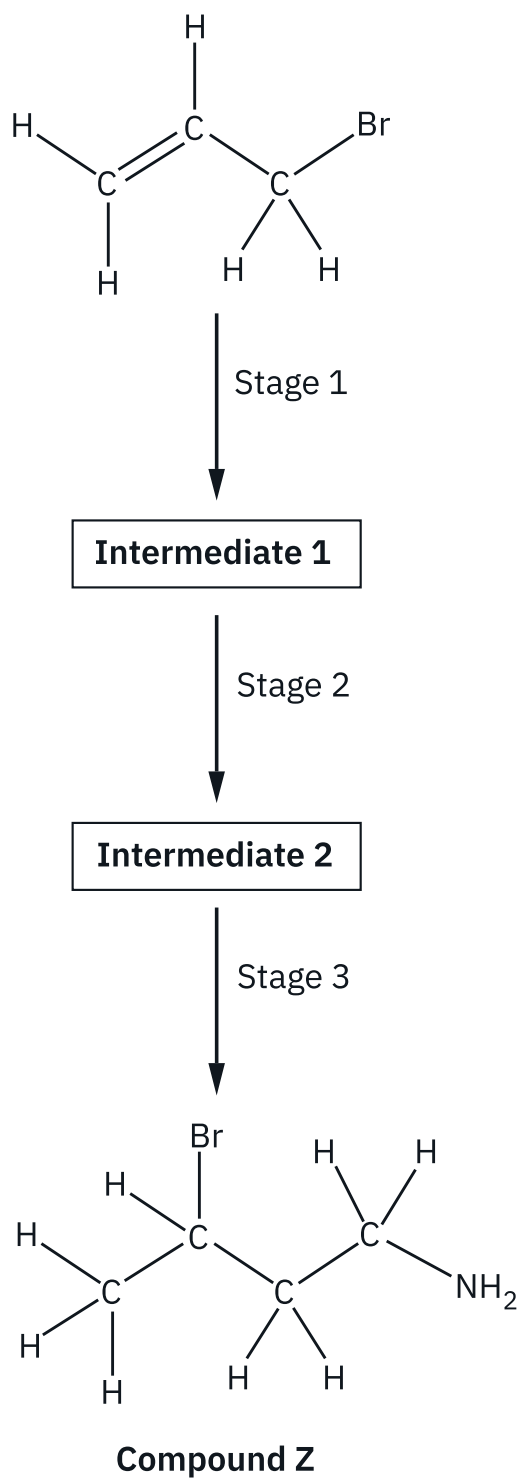
☐ **A**

☐ **B**☐ **C**☐ **D**

Q78 • Organic synthesis, IR and mass spectra • June 2023 • Paper 2 (Synthesis and analytical techniques) • Q19 •

[6 marks]

19 A student intends to synthesise compound Z, as shown in the flowchart below.

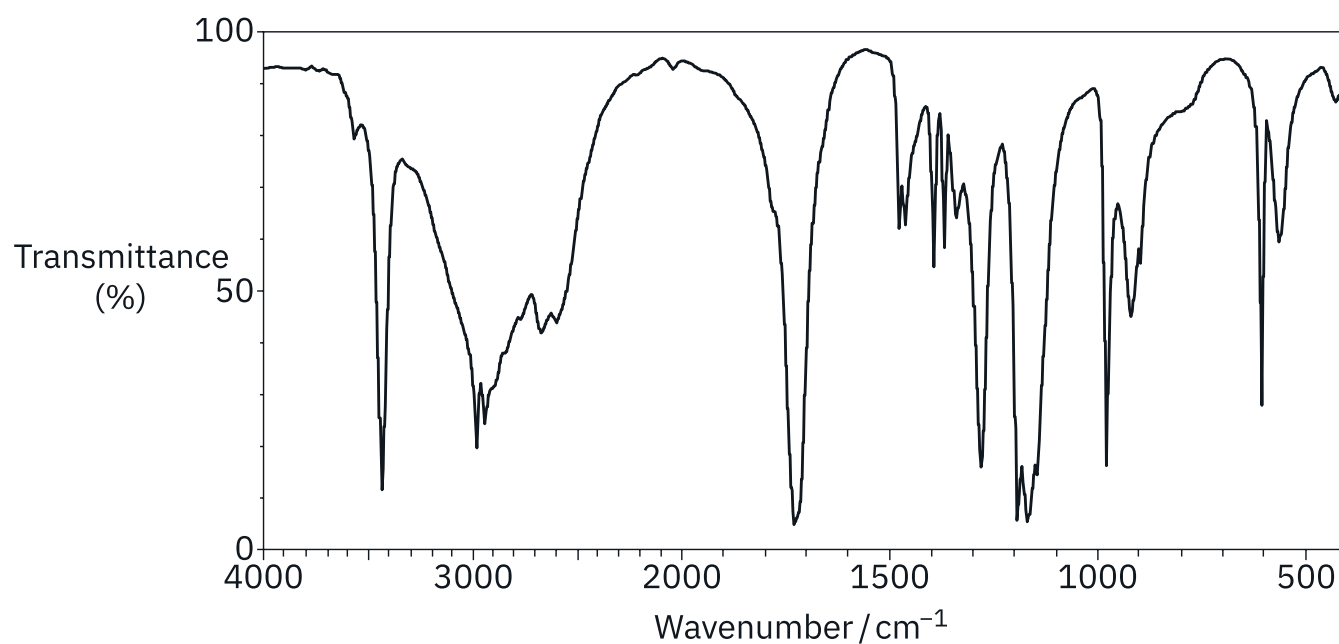


Plan this synthesis showing reagents, the structures of **intermediate 1** and **intermediate 2**, and equations.

[6 marks]

Q79 · Organic synthesis, IR and mass spectra · June 2024 · Paper 2 (Synthesis and analytical techniques) · Q11 · [1 mark]

Which compound could have produced the IR spectrum shown below?



Tick (✓) one box.

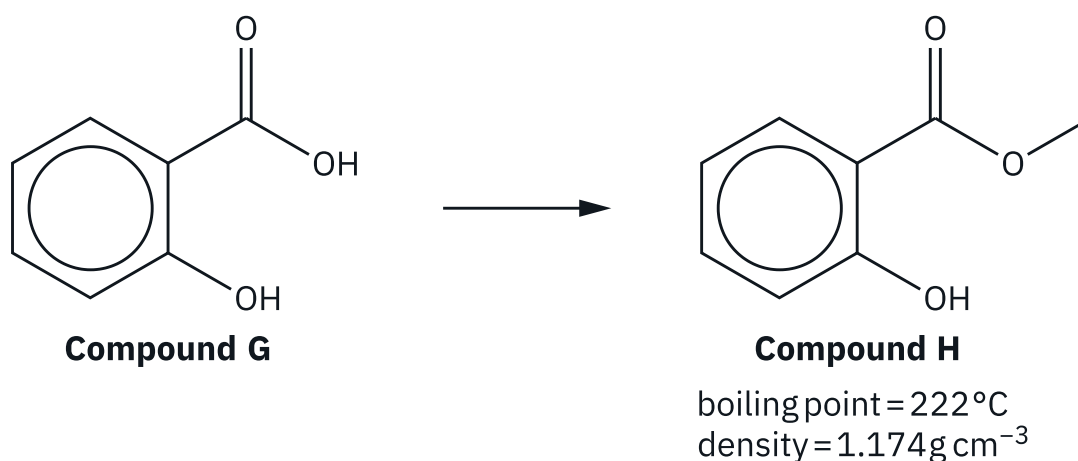
- ☐ **A** HOCH_2CHO
- ☐ **B** $\text{CH}_3\text{CH}_2\text{COOH}$
- ☐ **C** $\text{CH}_3\text{CH}_2\text{COOCH}_3$
- ☐ **D** $(\text{CH}_3)_2\text{C}(\text{OH})\text{COOH}$

Q80 · Organic synthesis, IR and mass spectra · June 2024 · Paper 2 (Synthesis and analytical techniques) · Q23 · [12 marks]

This question also needs Amount of substance and Carbonyls, carboxylic acids and esters.

Oil of wintergreen is a liquid used in medicine to relieve muscle pain.

Compound H is a component in oil of wintergreen and can be synthesised from compound G, as shown below. The boiling point and density of compound H are stated.



A student prepares a sample of compound H by the method below.

Step 1 Reflux 8.97 g of compound G for 30 minutes with an excess of methanol in the presence of a small amount of sulfuric acid as a catalyst.

Step 2 Add an excess of aqueous sodium carbonate, Na₂CO₃(aq).

Two layers are obtained.

Step 3 Purify the impure compound H that forms from the resulting mixture.

The student follows this method and obtains 5.32 g of pure compound H.

23(a) Why does the student use reflux in Step 1?

[1 mark]

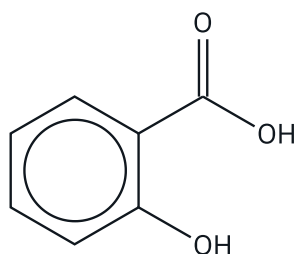
23(b)(i) In Step 2, $\text{Na}_2\text{CO}_3(\text{aq})$ removes the sulfuric acid catalyst **and** any unreacted compound G from the mixture.

Write equations for this removal.

[3 marks]

Removal of sulfuric acid

Removal of unreacted compound G



Compound G

23(b)(ii) Another student suggests that adding aqueous sodium hydroxide would be more effective in removing the sulfuric acid catalyst than $\text{Na}_2\text{CO}_3(\text{aq})$.

Comment on whether the student's suggestion is an improvement for the preparation of compound H.

[1 mark]

23(c) Calculate the percentage yield of compound H.

Give your answer to **three** significant figures.

percentage yield = %

[3 marks]

23(d) Describe how to purify the impure compound H from the two layers in Step 2.

[4 marks]

Q81 • Organic synthesis, IR and mass spectra • June 2024 • Paper 2 (Synthesis and analytical techniques) • Q7 • [1 mark]

Which statement gives a valid scientific reason for global warming?

Tick (✓) one box.

- ☐ **A** Infrared radiation causes bonds in CH₄ molecules to vibrate more.
- ☐ **B** Infrared radiation causes O₂ molecules to vibrate more.
- ☐ **C** Ultraviolet radiation causes bonds in CO₂ to vibrate more.
- ☐ **D** Ultraviolet radiation causes bonds in CFC molecules to break.

Q82 • Organic synthesis, IR and mass spectra • June 2025 • Paper 2 (Synthesis and analytical techniques) • Q12 •

[1 mark]

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

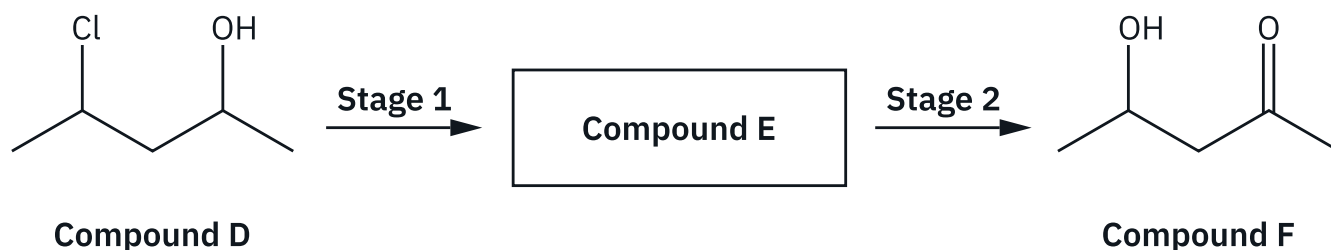
Tick (✓) one box.

- ☐ **A** Catalytic ozone depletion
- ☐ **B** Monitoring toxic gases in the air
- ☐ **C** Measuring ethanol in breathalyser tests
- ☐ **D** Global warming

Q83 · Organic synthesis, IR and mass spectra · June 2025 · Paper 2 (Synthesis and analytical techniques) · Q17 · [6 marks]

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 marks]

Q84 · Organic synthesis, IR and mass spectra · June 2025 · Paper 2 (Synthesis and analytical techniques) · Q23 ·

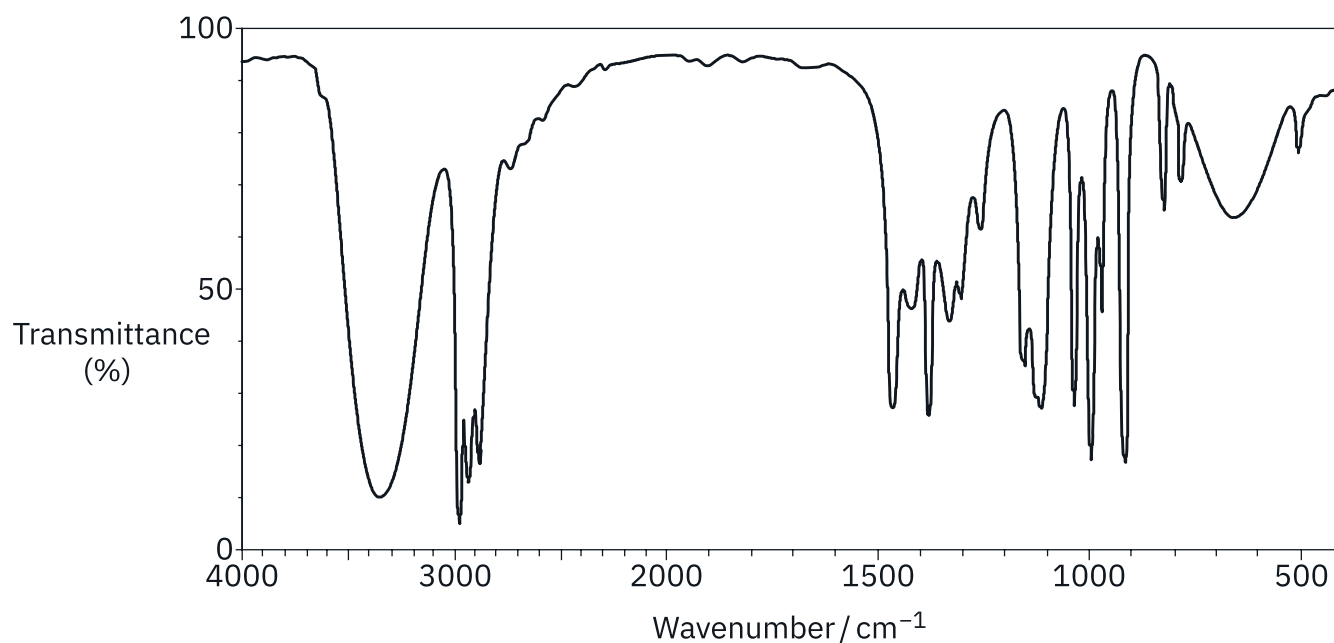
[10 marks]

This question also needs NMR spectroscopy.

This question is about spectral analysis.

23(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.

[4 marks]

Functional group

Reasoning

Possible structure
K
L
M

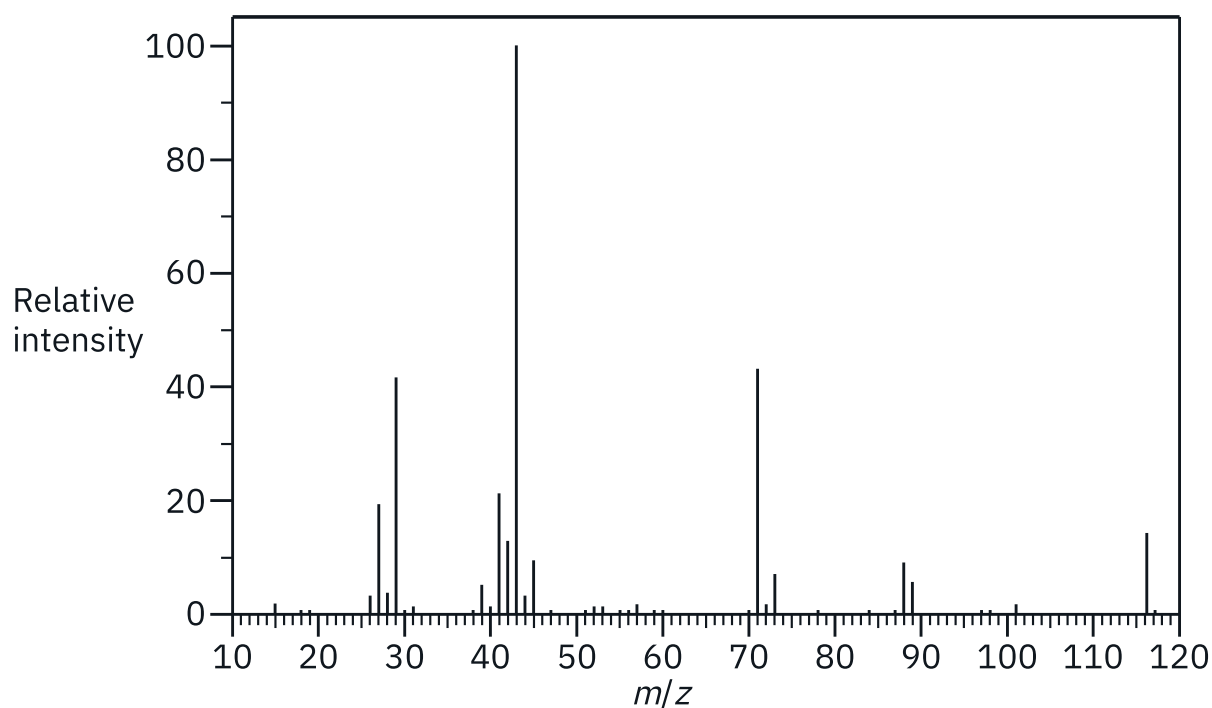
23(b) An unknown organic compound N is analysed and produces the following results.

[6 marks]

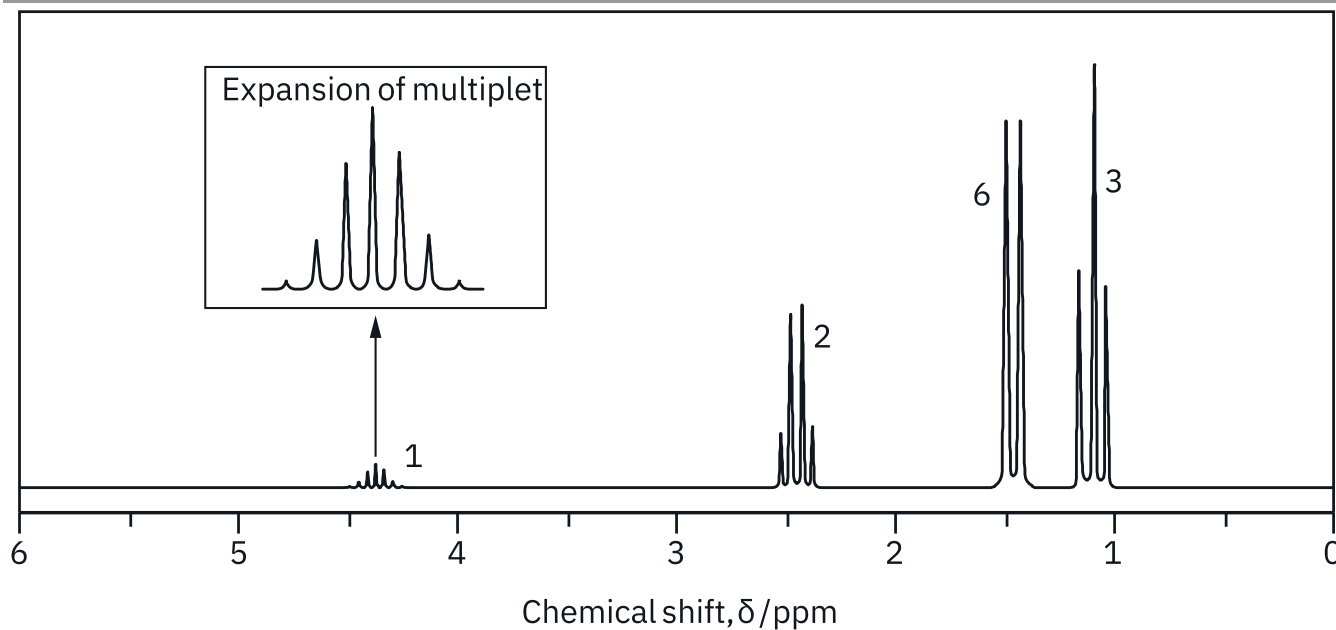
Elemental analysis by mass

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

Mass spectrum



Proton NMR spectrum



The numbers by the peaks are the relative peak areas.

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

Q85 · Organic synthesis, IR and mass spectra · November 2020 · Paper 2 (Synthesis and analytical techniques) · Q20 · [8 marks]

This question also needs Amount of substance and Reaction rates and equilibrium.

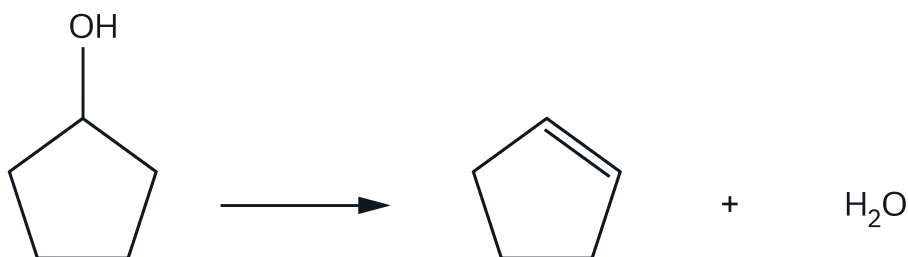
Cyclopentanol can be reacted to form cyclopentene.

Cyclopentene is a liquid with a boiling point of 44 °C and a density of 0.74 g cm⁻³.

A student plans to prepare 4.00 g of cyclopentene by reacting cyclopentanol (boiling point 140 °C)

with an acid catalyst.

Equation

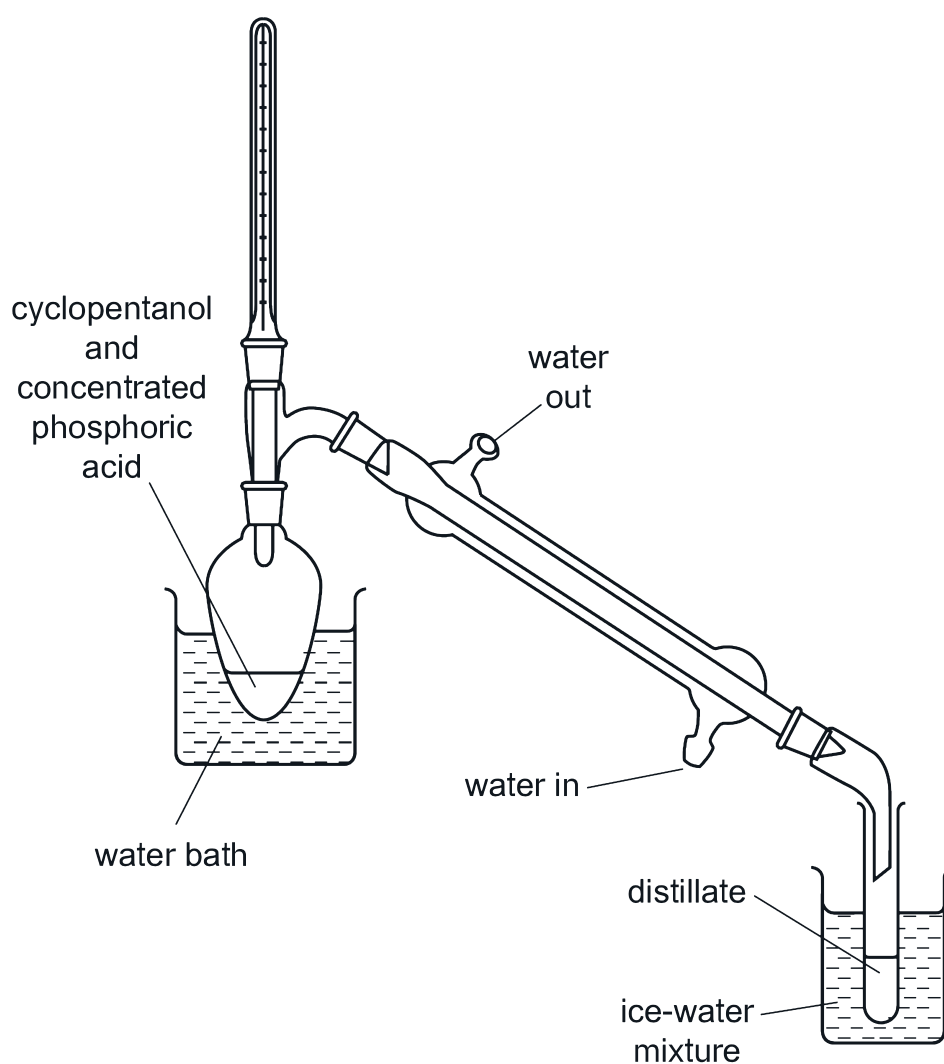


The expected percentage yield of cyclopentene is 64.0%.

Method

The student carries out the preparation using apparatus set up for distillation, as shown below.

1 The reaction mixture is heated gently, and a distillate containing impure cyclopentene is collected.



2 The distillate has an aqueous layer and an organic layer.

The student purifies the cyclopentene from the distillate.

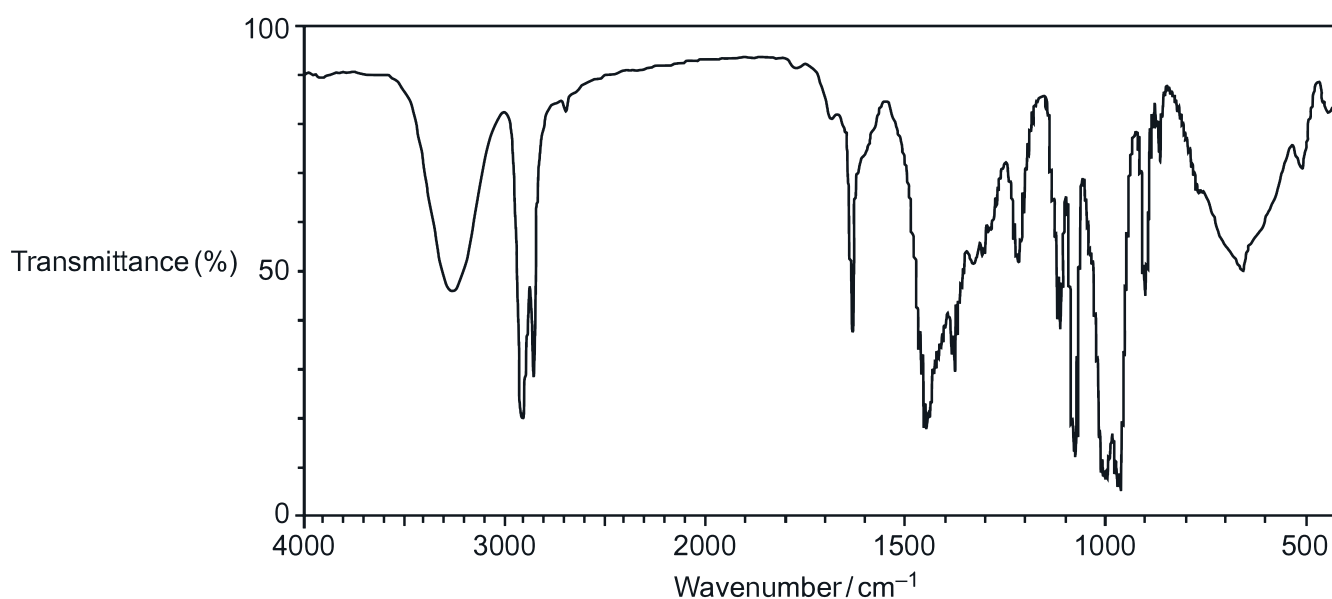
20(a) Calculate the mass of cyclopentanol that the student should use and explain how pure

cyclopentene could be obtained from the distillate.

[6 marks]

20(b) The organic layer in the distillate was analysed by IR spectroscopy.

The IR spectrum is shown below.

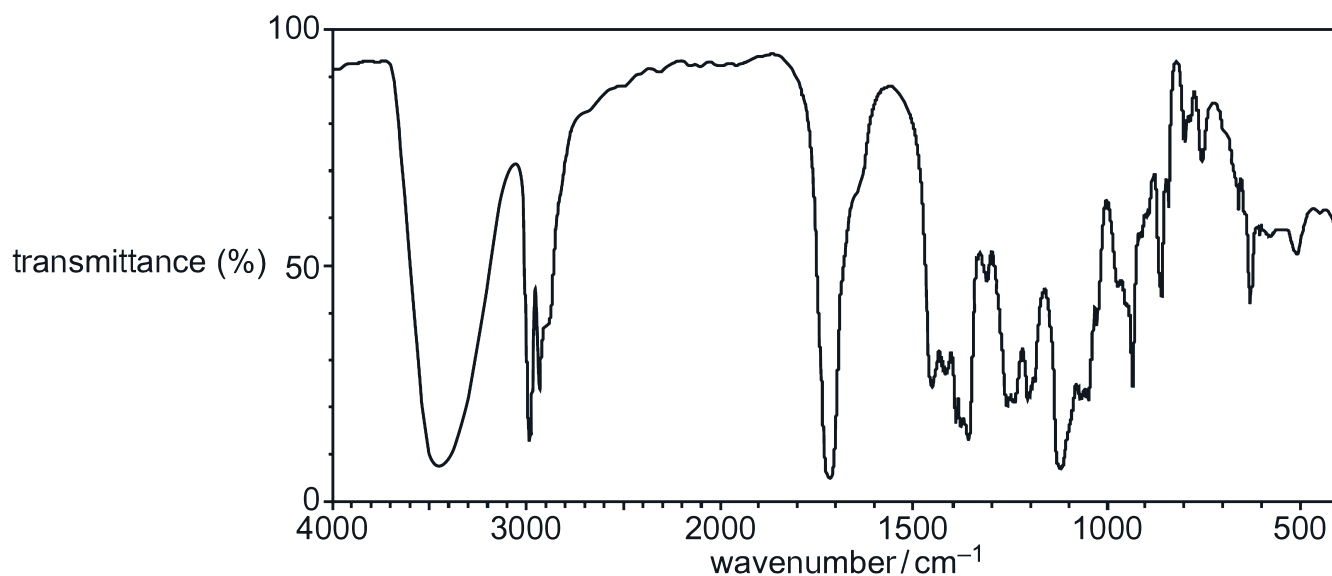


Explain how the IR spectrum of the organic layer suggests that cyclopentene has been formed and that the reaction is incomplete.

[2 marks]

Q86 · Organic synthesis, IR and mass spectra · November 2021 · Paper 2 (Synthesis and analytical techniques) · Q11 · [1 mark]

Which compound could have produced the IR spectrum below?



Tick (✓) one box.

- ☐ **A** $(\text{CH}_3)_2\text{CHCHO}$
- ☐ **B** $(\text{CH}_3)_2\text{CHCOOH}$
- ☐ **C** $\text{CH}_3\text{CH}(\text{OH})\text{CH}=\text{CH}_2$
- ☐ **D** $\text{CH}_3\text{COCH}(\text{OH})\text{CH}_3$

Q87 · Organic synthesis, IR and mass spectra · November 2021 · Paper 2 (Synthesis and analytical techniques) · Q12 · [1 mark]

This question also needs Atomic structure and isotopes.

Which peak would be in the mass spectrum of propanal, $\text{CH}_3\text{CH}_2\text{CHO}$, but not in the mass spectrum of propanone, CH_3COCH_3 ?

Tick (✓) one box.

- ☐ **A** $m/z = 15$
- ☐ **B** $m/z = 29$
- ☐ **C** $m/z = 43$
- ☐ **D** $m/z = 58$

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