



Rewarding Learning

ADVANCED
General Certificate of Education
2023

Centre Number

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Candidate Number

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Life and Health Sciences

Assessment Unit A2 2

assessing

Organic Chemistry

MV24

[AZ021]

WEDNESDAY 14 JUNE, MORNING

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.

Answer **all six** questions.

Write your answers in the spaces provided in this question paper.

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.

Your attention is drawn to the Data leaflet which is used with the question paper.

You may use an electronic calculator.

Quality of written communication will be assessed in Question **5(b)**.

1 (a) Crude oil is a mixture of hydrocarbons that is transported around the world in ships.

(i) State two negative environmental effects associated with an oil spill that occurs at sea. [2 marks]

1. _____

2. _____

(ii) Define the term **hydrocarbon**.
[1 mark]

(iii) Explain how fractional distillation can be used to separate the compounds in crude oil into fractions, some of which are used as fuels. [3 marks]

(iv) Name another process that is used to obtain alkane fuels from the hydrocarbons in crude oil. [1 mark]

(b) The saturated hydrocarbon 2,2,4-trimethylpentane (C_8H_{18}) is used as a fuel.

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

(ii) To which homologous series does 2,2,4-trimethylpentane belong?
[1 mark]

(iii) Write a balanced symbol equation for the complete combustion of 2,2,4-trimethylpentane (C_8H_{18}).
[2 marks]

(c) Combustion of impure hydrocarbon fuels can lead to the formation of products which are considered pollutants.

Name a pollutant from the combustion of impure hydrocarbons that is toxic, and another that causes acid rain.

[2 marks]

Pollutant that is toxic:

Pollutant that causes acid rain:

(d) Car exhausts are fitted with a device that changes nitrogen dioxide into less harmful products.

(i) Name the device fitted to car exhausts. [1 mark]

(ii) Write a balanced symbol equation for the reaction which converts nitrogen dioxide into less harmful products.
[2 marks]

(iii) Name the type of reaction described in **(ii)**. [1 mark]

(e) Alternative fuels made from plants have been developed to have a lower environmental impact than the alkane fuels, petrol or diesel.

(i) Name two alternative fuels that are made from plants. [2 marks]

1. _____
2. _____

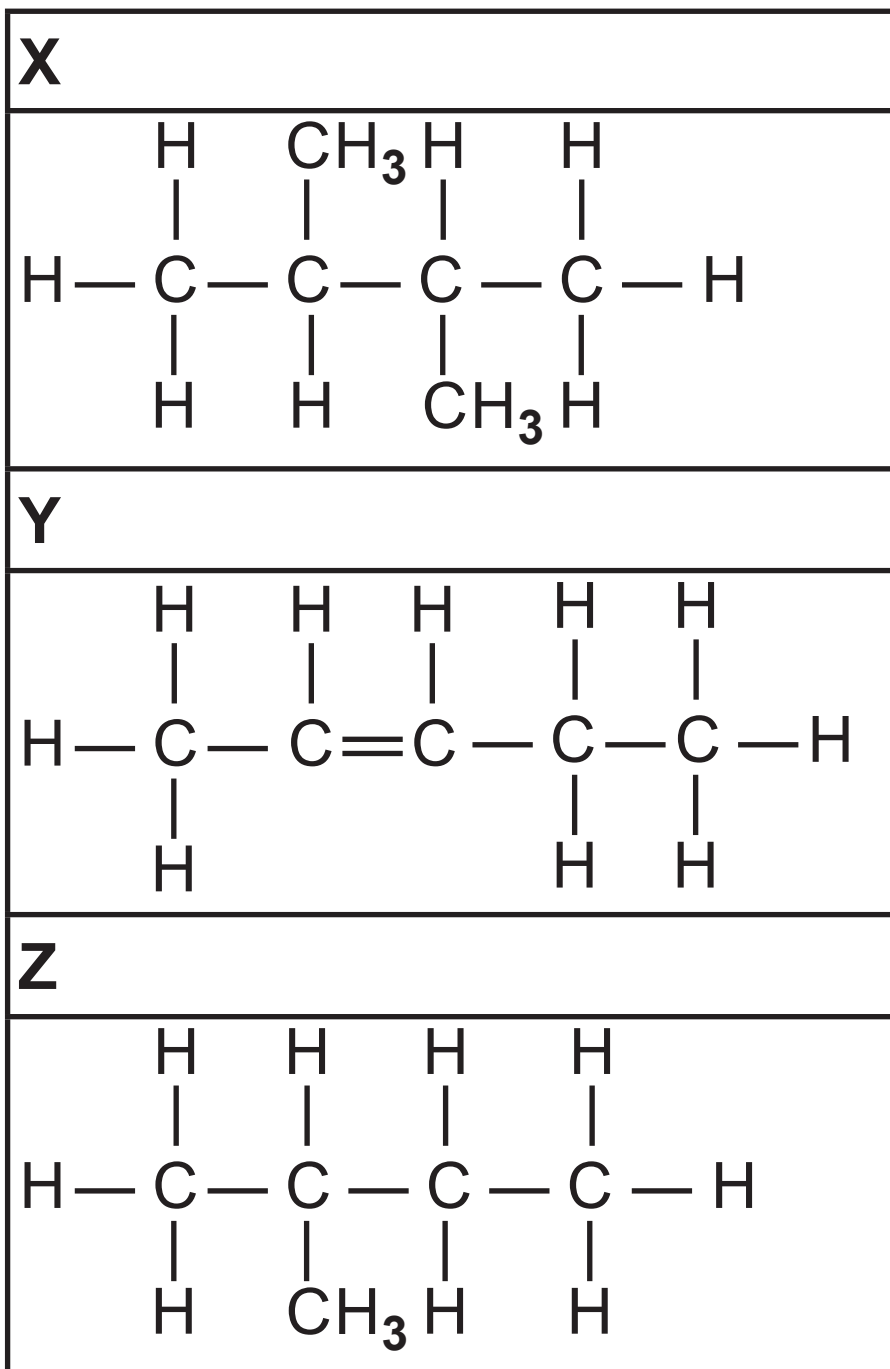
(ii) Suggest why alternative fuels made from plants may be considered less polluting than alkane fuels. [1 mark]

(iii) Suggest why alternative fuels made from plants are less widely used than petrol or diesel. [1 mark]

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(Questions continue overleaf)

- 2 (a) The structural formula of three organic compounds, **X**, **Y** and **Z** are listed below.



(i) Draw the skeletal formula of **X**.
[1 mark]

(ii) State the IUPAC name of **Y**.
[1 mark]

(b) Compounds **Y** and **Z** both exist as colourless liquids at room temperature and pressure.

(i) Name a reagent that could be used to distinguish between them. [1 mark]

(ii) State the colour change that is observed when the reagent described in **(i)** reacts with compound **Y**. [1 mark]

_____ to _____

(iii) Explain why the reagent described in **(i)** **does not react** with compound **Z**. [1 mark]

3 Organic compounds react in a range of different ways depending on the functional group that is present.

(a) Ethene readily reacts with hydrogen bromide.

(i) Explain, **with reference to the bonds present in ethene**, why hydrogen bromide is described as an electrophile in this reaction.

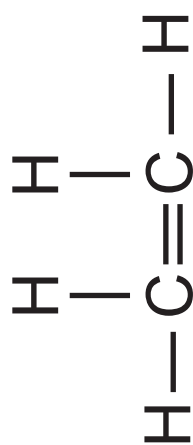
[3 marks]

(ii) Complete the mechanism for the reaction of ethene with hydrogen bromide. [5 marks]

Product

Intermediates

Reactants



(iii) State the IUPAC name of the **product** formed in (ii). [1 mark]

(iv) What is the general name for the type of **organic intermediate** formed in (ii)? [1 mark]

(b) Alkenes such as propene will react with hydrogen in an exothermic reaction.

(i) Write a balanced symbol equation for the reaction of propene with hydrogen. [1 mark]

(ii) Name the catalyst used in this reaction. [1 mark]

(iii) Name the type of reaction taking place when an alkene, such as propene, reacts with hydrogen. [1 mark]

(iv) State a practical application for this **type** of reaction. [1 mark]

(c) Dichloromethane is an important solvent that can be made by reacting methane with chlorine in a photo-catalysed reaction.

(i) Write a balanced symbol equation for the reaction of methane with chlorine forming dichloromethane. [2 marks]

(ii) Suggest why this is described as a photo-catalysed reaction. [1 mark]

(d) Butanal can be produced by the oxidation of butan-1-ol.

(i) State the molecular formula of butanal. [1 mark]

(ii) Name the homologous series to which butanal belongs. [1 mark]

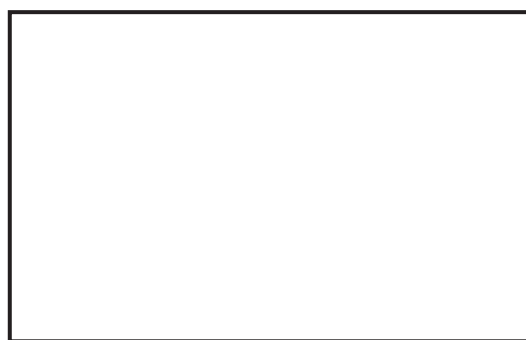
(iii) Butanal produced by oxidation should be removed from the reaction mixture as soon as it forms.

Name the practical technique used to remove the butanal. [1 mark]

(iv) Name a reagent that can be used to show that the compound produced is butanal and not butanoic acid.
[1 mark]

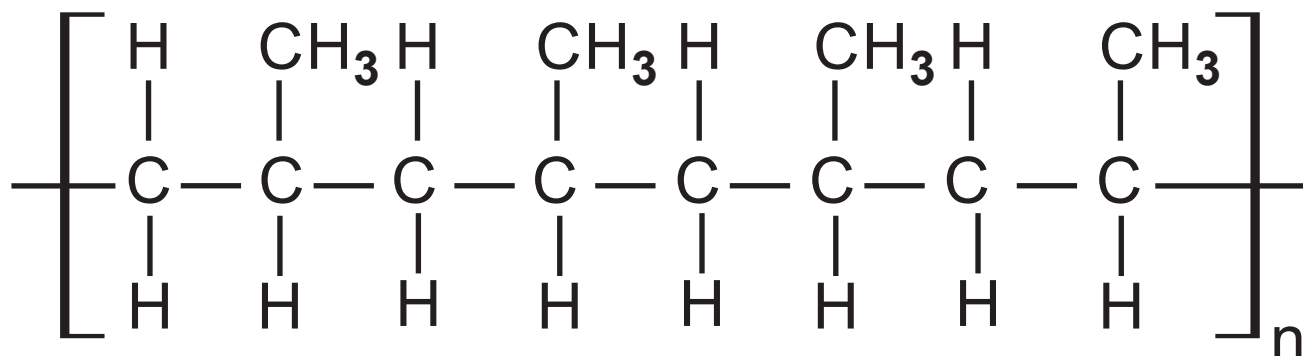
4 (a) The alkene hex-3-ene can exist as two geometric isomers.

(i) Draw the structural formula of the two geometric isomers and classify each as E or Z. [3 marks]



(ii) Explain why hex-1-ene **does not** exist as geometric isomers. [1 mark]

(b) A section of the chain of a non-biodegradable polymer is shown below.



(i) Draw the structural formula and state the IUPAC name of the monomer used to make this polymer.
[2 marks]

IUPAC name: _____

(ii) State a major environmental impact associated with the incineration of polymers and explain how it can be reduced. [2 marks]

Environmental impact:

How it is reduced:

(c) Polylactic acid (PLA) is a type of biodegradable polymer known as a bioplastic.

Suggest why bioplastics such as polylactic acid (PLA) are biodegradable. [2 marks]

(d) An unknown hydrocarbon was found to contain 85.7% carbon by mass.

(i) Determine the empirical formula of the hydrocarbon. [3 marks]

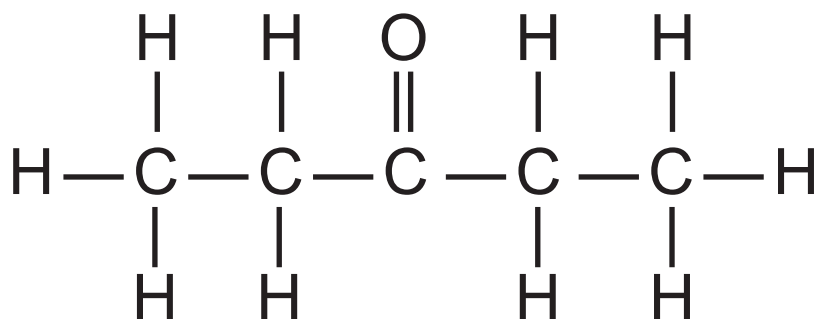
Empirical formula: _____

(ii) The relative molecular mass of the hydrocarbon is 126.

Determine the molecular formula of the hydrocarbon. [1 mark]

Molecular formula: _____

(e) The structural formula and mass spectrum of pentan-3-one are shown below and opposite.

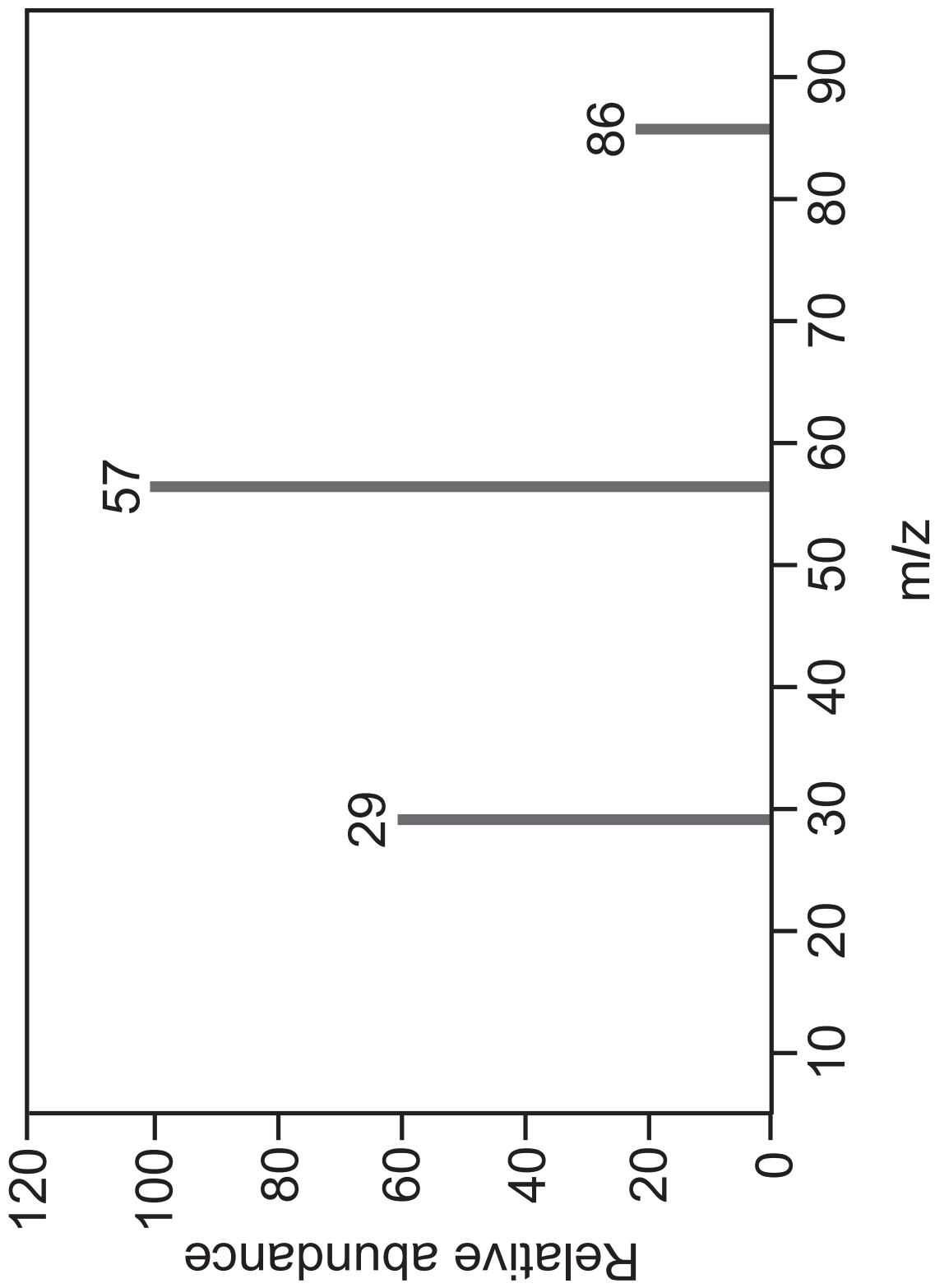


(i) On the mass spectrum for pentan-3-one circle the **base peak**.
[1 mark]

(ii) Draw the structural formulae of the fragment ions that cause the peaks at m/z values of 29 and 57. [2 marks]

$m/z = 29$

$m/z = 57$



5 This question is about the homologous series of alcohols.

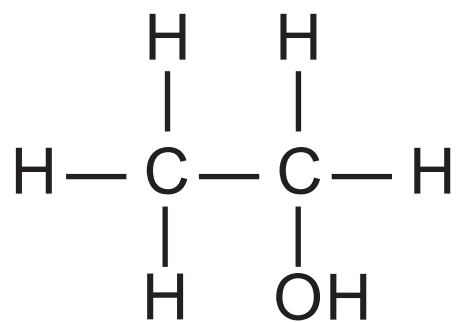
(a) The structural formula of four alcohols labelled **A** to **D** are drawn opposite.

(i) What is the general formula for an alcohol? [1 mark]

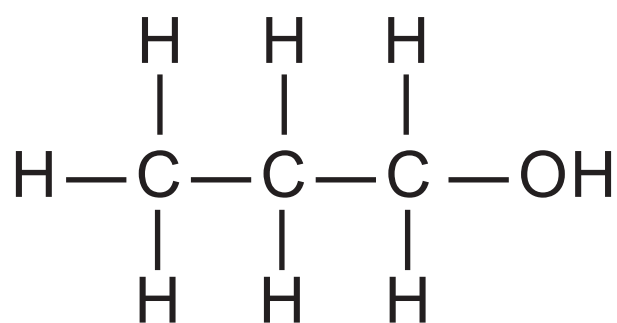
(ii) Explain why alcohol **D** is a secondary alcohol. [1 mark]

(iii) State the IUPAC name of alcohol **B**. [1 mark]

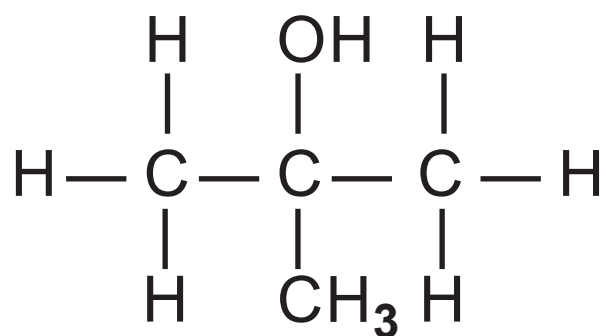
A



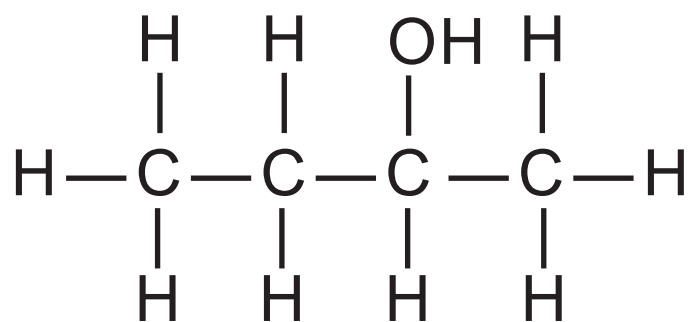
B



C



D



(iv) Draw the structural formula of a straight chain isomer of alcohol **D**.
[1 mark]

(v) State and explain which of the alcohols **A** to **D** could not be oxidised by refluxing it with acidified potassium dichromate(VI). [2 marks]

Alcohol: _____

Explanation: _____

(vi) The molecular formula for alcohol **D** is $C_4H_{10}O$.

Explain why this is also its empirical formula. [1 mark]

(vii) Alcohols can undergo an elimination reaction called dehydration. Name the catalyst used in this reaction. [1 mark]

(viii) Write a balanced symbol equation for the dehydration of alcohol **A**. [1 mark]

(ix) State the IUPAC name of the organic product in **(viii)**. [1 mark]

IUPAC name: _____

(b) Ethanol can be produced industrially by the hydration of ethene using steam or the fermentation of sugars in solution.

- Describe the conditions used in the hydration of ethene using steam.
- Describe the conditions used in the fermentation of sugars in solution.
- Compare the methods. You may wish to refer to yield, purity and speed.

[6 marks]

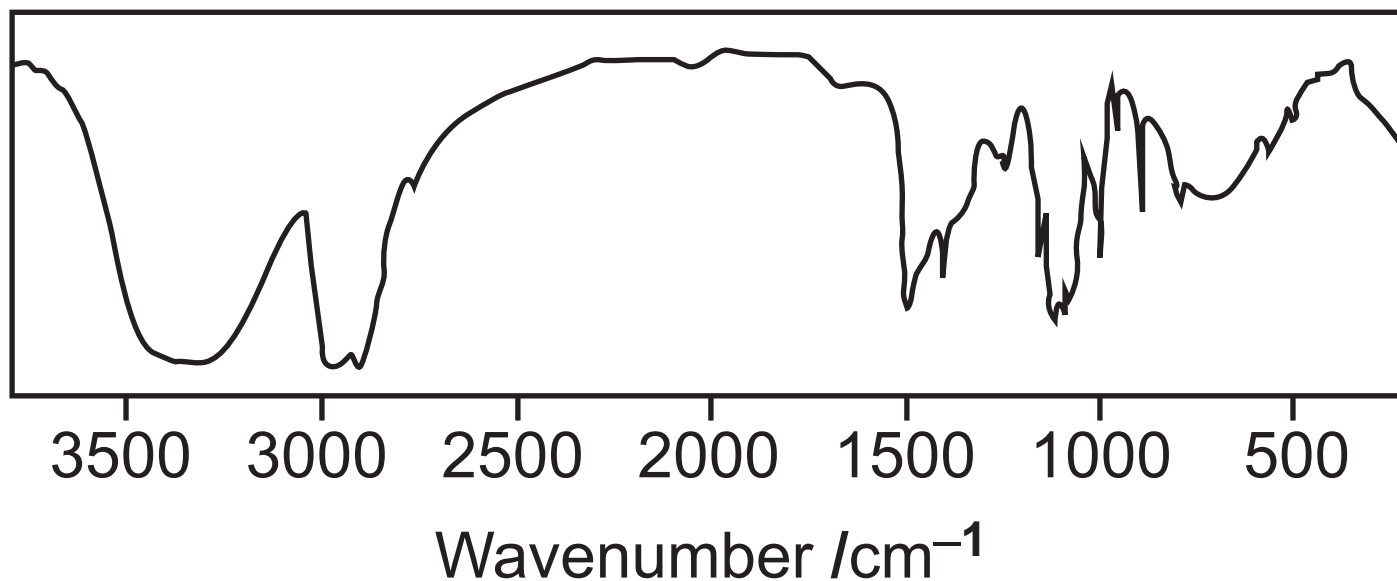
Quality of written communication will be assessed in this question.

Description of the hydration of ethene using steam.

Description of the fermentation of sugars in solution.

Comparison of methods of production.

(c) The infrared (IR) spectrum of a compound is shown below.



(i) What label should go on the **y-axis** of the infrared (IR) spectrum above?
[1 mark]

Wavenumber /cm ⁻¹	Bond
750–1100	C–C (alkanes, alkyl groups)
1000–1300	C–O (alcohols, carboxylic acids)
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)

(ii) Using the table above, explain **fully** why the infrared (IR) spectrum could be that of butan-1-ol but not butanoic acid. [3 marks]

6 Nylon and aspirin are compounds that can be produced on a small scale in a laboratory.

(a) Nylon is an important polymer that can be prepared from 1,6-diaminohexane and hexanedioyl dichloride.

A section of the practical method is given below.

- **2.2 g of 1,6-diaminohexane was dissolved in distilled water.**
- **1.5 g of hexanedioyl dichloride was dissolved in cyclohexane.**
- **5 cm³ of the aqueous solution was poured into a 25 cm³ beaker.**
- **5 cm³ of the cyclohexane solution was carefully poured on top.**

(i) Name the type of polymerisation reaction used to produce nylon.
[1 mark]

(ii) Draw the structural formula for cyclohexane. [1 mark]

(iii) Explain why the cyclohexane solution was carefully poured on top of the aqueous solution. [1 mark]

(iv) State where the greyish film of nylon forms and describe how it can be collected. [2 marks]

(b) Aspirin can be prepared and purified in the laboratory from salicylic acid and ethanoic anhydride.

(i) Describe how the melting point of aspirin prepared in a laboratory can be determined. [3 marks]

(ii) The melting point of pure aspirin is 135°C . If the sample of aspirin produced contained impurities, how would this affect the melting point?
[1 mark]

(c) After recrystallising their aspirin, a student wanted to check if their sample contained any remaining unreacted salicylic acid impurities.

(i) Name the chemical that can be used to check for salicylic acid impurities.
[1 mark]

(ii) State the colour change observed if a sample containing salicylic acid impurities was tested with the reagent in **(i)**. [1 mark]

_____ to _____

(iii) The student's method required them to:

“Wash crystals with a small volume of distilled water to remove soluble impurities.”

At this point some of the aspirin dissolved and was lost.

Suggest an improvement that could be made to this step that would minimise the amount of aspirin that is lost through dissolving. [1 mark]

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(Questions continue overleaf)

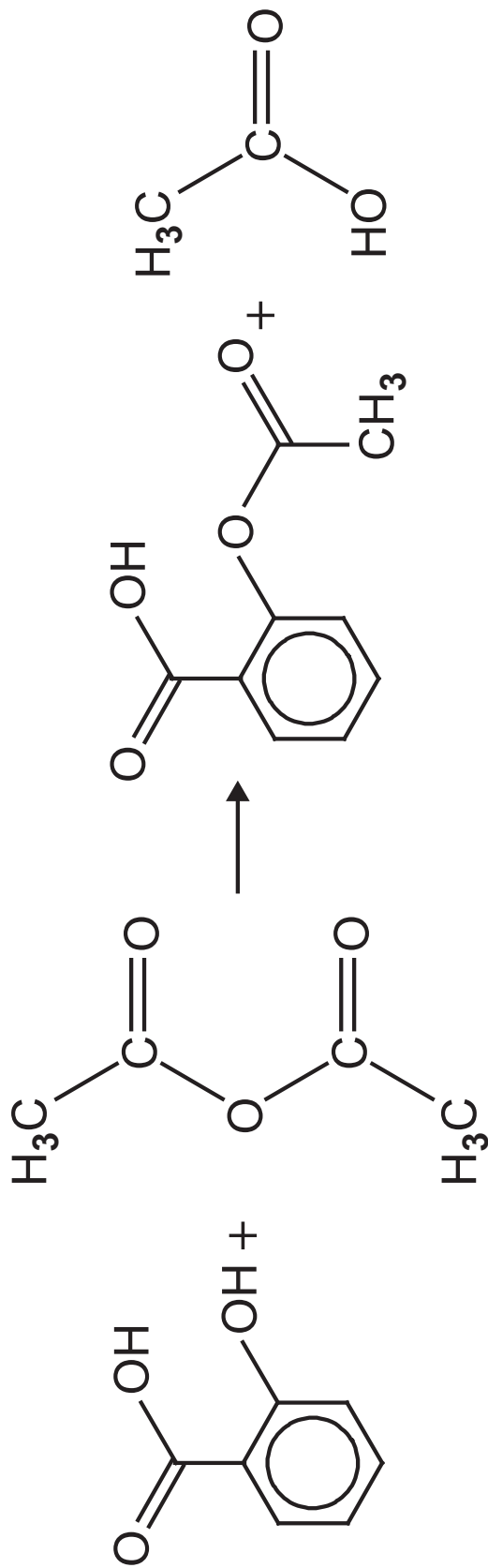
(d) 4.05 g of purified aspirin was made by reacting salicylic acid with an excess of ethanoic anhydride.
The percentage yield for the reaction was 68%.

The equation for the reaction is shown opposite.

(i) Calculate the student's theoretical yield. [1 mark]

Give your answer to 2 decimal places.

Theoretical yield: _____ g



Compound name	salicylic acid	ethanoic anhydride	aspirin	ethanoic acid
Relative Molecular Mass	138	102	180	60

[Turn over

(ii) Using the equation and relative molecular masses given, calculate the mass of salicylic acid used to produce 4.05g of aspirin. [3 marks]

Give your answer to 2 decimal places.

Mass of salicylic acid: _____ g

**This is the end of the
question paper**

SOURCES

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Question Number	Marks
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4	
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6	
Total Marks	

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