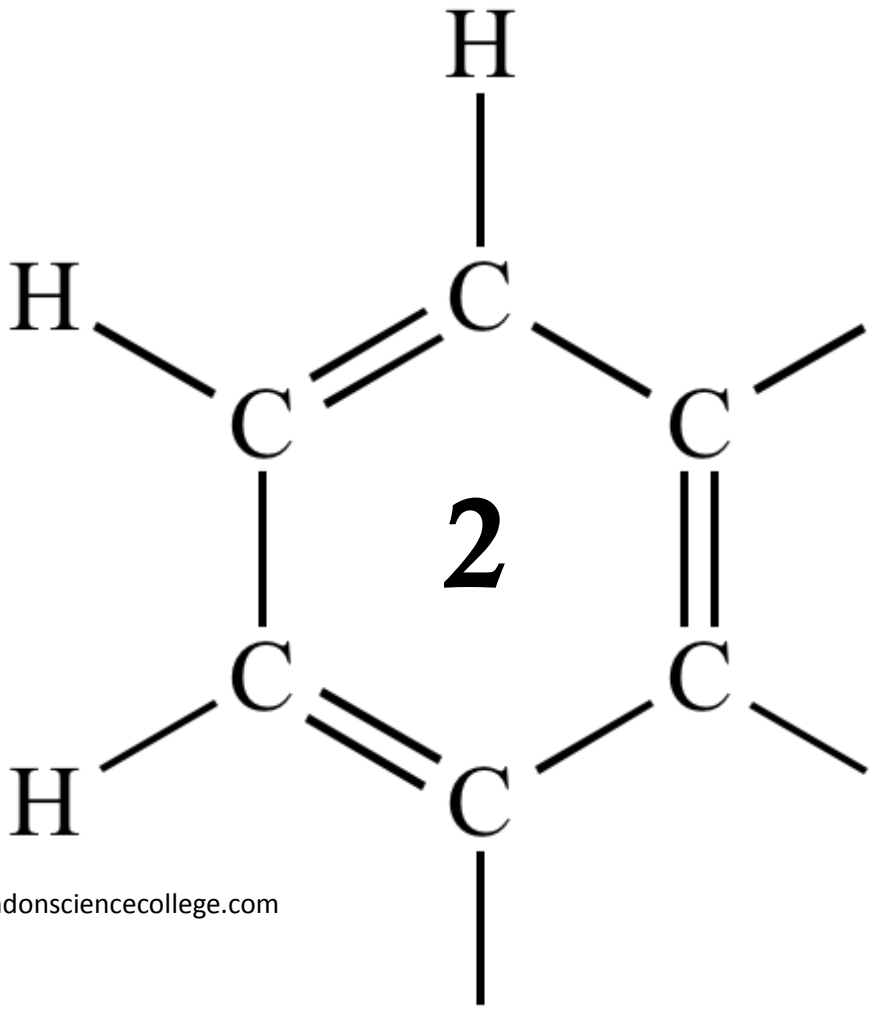
LONDON SCIENCE COLLEGE

AQA AS CHEMISTRY

ALCOHOLS



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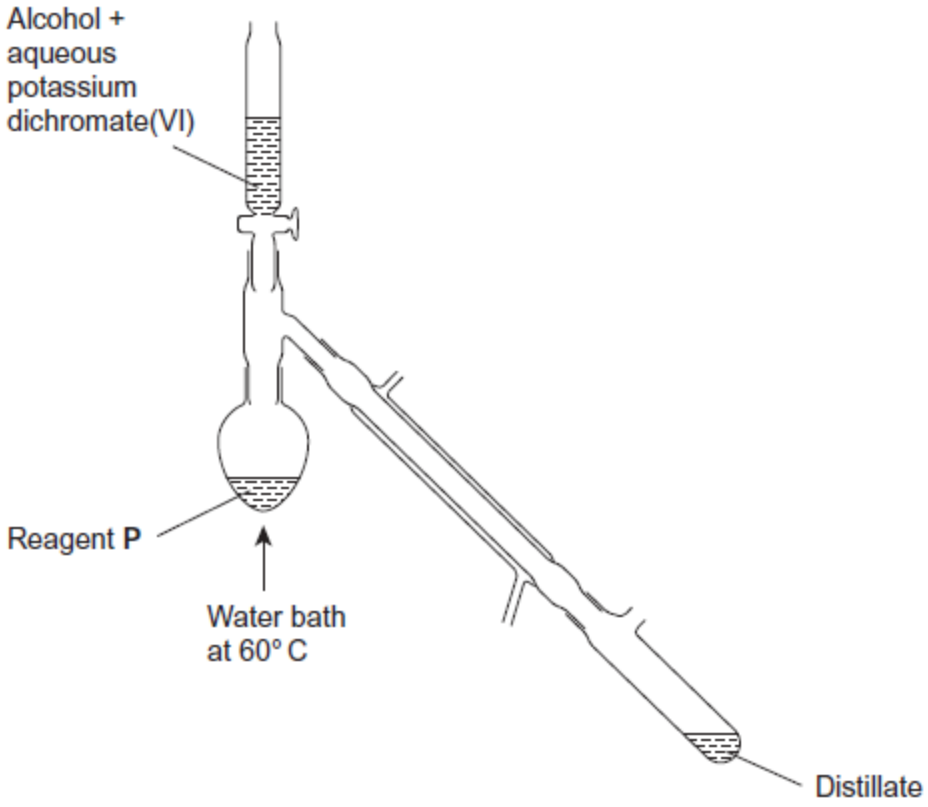
1 This question concerns the oxidation of a primary alcohol.

The experiment was carried out using the distillation apparatus shown in the diagram.
The oxidation product was distilled off as soon as it was formed.



(a) Suggest the identity of reagent **P**.

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(1)

(b) State the chemical change that causes the solution in the flask to appear green at the end of the reaction.

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(1)

(c) Give **one** reason why using a water bath is better than direct heating with a Bunsen burner.

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(1)

(d) Suggest a reagent that could be used to confirm the presence of an aldehyde in the distillate.
State the observation you would expect to make if an aldehyde were present.

Reagent .....

Observation .....

(2)
(Total 5 marks)

2 Ethanol is an important fuel.

(a) A dilute aqueous solution of ethanol can be produced by the fermentation of an aqueous solution of glucose.
It is claimed that the ethanol obtained from this solution is a carbon-neutral biofuel.

Write an equation for this fermentation reaction.

Give **two** other essential conditions for this reaction to produce a good yield of ethanol.

Name a process used to produce a much more concentrated solution of ethanol from a dilute aqueous solution.

State the meaning of the term **carbon-neutral** in the context of this biofuel.

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(Extra space) .....

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(5)

(b) A student carried out a laboratory experiment to determine the enthalpy change when a sample of ethanol was burned. The heat produced was used to warm some water in a copper calorimeter. The student found that the temperature of 75.0 g of water increased by 5.50 °C when 2.40×10^{-3} mol of pure ethanol was burned in air.

Use the student's results to calculate a value, in kJ mol^{-1}, for the enthalpy change when one mole of ethanol is burned.
(The specific heat capacity of water is 4.18 J K^{-1} g^{-1})

Deduce **two** reasons why the student's value for the standard enthalpy of combustion of ethanol is different from a Data Book value of –1279 kJ mol^{-1}.

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(Extra space).....

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(5)

(c) Mean bond enthalpies can be used to calculate enthalpies of reaction.

(i) Give the meaning of the term **mean bond enthalpy**.

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(2)

(ii) Consider the mean bond enthalpy data in the following table.

	C — H	**C — C**	**C — O**	**O=O**	**C=O**	**O — H**
Mean bond enthalpy / kJ mol^{-1}	412	348	360	to be calculated	805	463

Use the data in the table above and the equation shown to calculate a value for the bond enthalpy for the O=O double bond in an oxygen molecule.

$CH_3CH_2OH(g) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(g)$ $\Delta H = -1279$ kJ mol^{-1}

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(3)

(Total 15 marks)

3 A sample of 2-methylpropan-2-ol was contaminated with butan-2-ol. The student separated the two alcohols using chromatography.

Identify a reagent or combination of reagents that the student could use to distinguish between these alcohols. State what would be observed for each alcohol.

Reagent(s) .....

Observation with 2-methylpropan-2-ol .....

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Observation with butan-2-ol .....

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(Total 3 marks)

4 In each of the following questions, you should draw the structure of the compound in the space provided.

(a) Draw the structure of the alkene that would form 1,2-dibromo-3-methylbutane when reacted with bromine.

(1)

(b) Draw the structure of the alcohol with molecular formula $C_4H_{10}O$ that is resistant to oxidation by acidified potassium dichromate(VI).

(1)

(c) Draw the structure of the alkene that has a peak, due to its molecular ion, at *m/z* = 42 in its mass spectrum.

(1)

(d) Draw the structure of the organic product with M_r = 73, made from the reaction between 2-bromobutane and ammonia.

(1)
(Total 4 marks)

5 Baking powder contains sodium hydrogencarbonate and an acid or a mixture of acids. One acid that may be in baking powder is 2,3-dihydroxybutanedioic acid. This has the molecular formula $C_4H_6O_6$ and it is often referred to as tartaric acid.

(a) Draw the structural formula of tartaric acid.

(1)

(b) Write an equation for the reaction of tartaric acid ($C_4H_6O_6$) with sodium hydrogencarbonate to form a salt, carbon dioxide and water.

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(1)

(c) Substances that contain carbonate or hydrogencarbonate ions can be used to confirm the presence of an acid.

Identify **one** other substance that could be used to confirm the presence of acid groups in tartaric acid.
State the observation you would make when this other substance is added to an aqueous solution of tartaric acid.

Substance .....

Observation .....

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(2)

(d) It is known that tartaric acid contains alcohol and carboxylic acid functional groups only. A test can be used to show that tartaric acid contains secondary alcohol groups, **not** tertiary alcohol groups.

(i) Identify a reagent for this test and state the observation you would make for each type of alcohol.

Reagent .....

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Observation for secondary alcohol .....

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Observation for tertiary alcohol .....

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(3)

(ii) Suggest why this test **cannot** be used to distinguish between a primary alcohol and a secondary alcohol.

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(1)

(e) Baking powder usually contains starch. Starch is added to absorb any water vapour that may come into contact with the baking powder when the container is opened.

Deduce a reason why this water vapour needs to be absorbed.

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(1)

(f) Sodium hydrogencarbonate in baking powder forms carbon dioxide during the production of bread and cakes.

Suggest **one** advantage of having an acid in baking powder.

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(1)

(g) Safety information indicates that tartaric acid and its salts can act as muscle toxins. These can cause paralysis and possible death.

Suggest **one** reason why the use of tartaric acid in baking powder is **not** a hazard to health.

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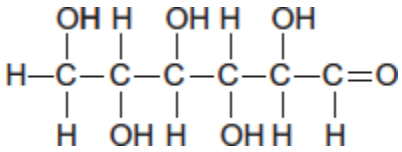
(1)

(Total 11 marks)

6 Glucose is an organic molecule. Glucose can exist in different forms in aqueous solution.

(a) In aqueous solution, some glucose molecules have the following structure.



(i) Deduce the empirical formula of glucose.

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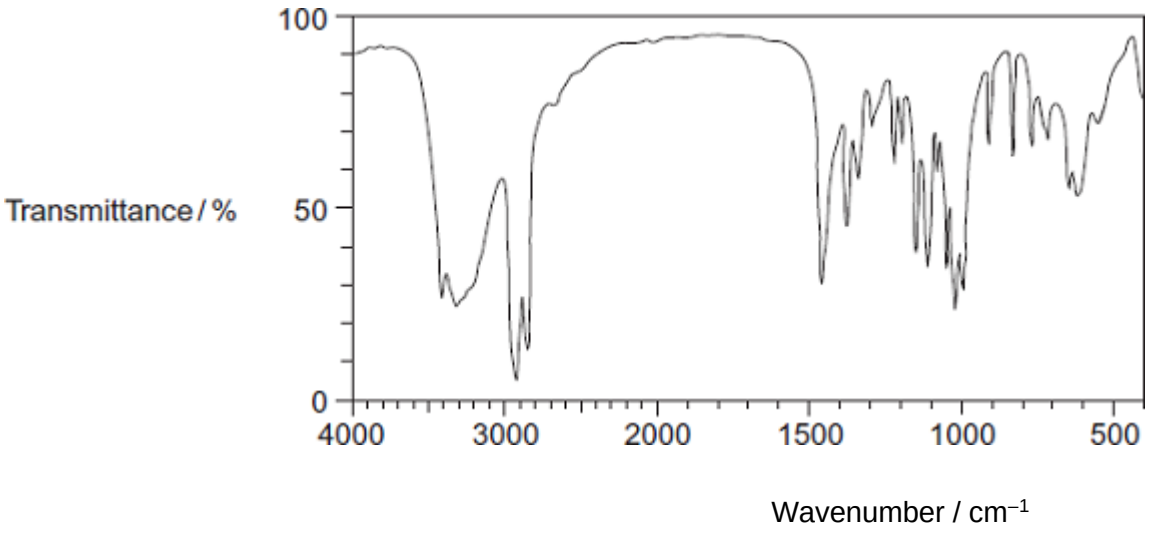
(1)

(ii) Consider the infrared spectrum of solid glucose.



State why it is possible to suggest that in the solid state very few molecules have the structure shown.
You may find it helpful to refer to **Table 1** on the Data Sheet.

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(1)

(b) In the absence of oxygen, an aqueous solution of glucose can be fermented to produce ethanol for use in alcoholic drinks.

Write an equation for this fermentation reaction.
Give **two** other essential conditions for the production of ethanol in this fermentation.

Equation

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Condition 1 .....

Condition 2 .....

(3)

(c) Any ethanol present in the breath of a drinker can be detected by using a breathalyser. The ethanol is converted into ethanoic acid. The breathalyser has negative and positive electrodes. A current is measured and displayed in terms of alcohol content.

The overall redox equation is as follows

$$CH_3CH_2OH(l) + O_2(g) \longrightarrow CH_3COOH(l) + H_2O(l)$$

(i) Draw the displayed formula for ethanoic acid.

(1)

(ii) Deduce a half-equation for the reduction of atmospheric oxygen to water in acidic solution at one electrode of the breathalyser.

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(1)

(iii) Deduce a half-equation for the oxidation of ethanol in water to ethanoic acid at the other electrode of the breathalyser.

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(1)

(iv) The earliest breathalysers used laboratory chemicals to oxidise the ethanol to ethanoic acid. Detection was by a colour change.

Identify a reagent or combination of reagents that you would use in the laboratory to oxidise ethanol to ethanoic acid.
State the colour **change** that you would expect to see.

Reagent or combination of reagents .....

Colour change .....

(2)

(d) The fermentation of glucose from crops is the main method for the production of ethanol. The product is called bioethanol. The European Union has declared that bioethanol is carbon-neutral.

(i) State the meaning of the term *carbon-neutral*.

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(Extra space) .....

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(1)

(ii) Other than carbon-neutrality, state the **main** advantage of the use of glucose from crops as the raw material for the production of ethanol.

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(1)

(iii) Give *one* disadvantage of the use of crops for the production of ethanol.

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(1)
(Total 13 marks)

7 The reaction of butane-1,4-diol with butanedioic acid produces the polymer PBS used in biodegradable packaging and disposable cutlery.
Butanedioic acid is produced by two different processes.

Process 1

- Aqueous sodium hydroxide reacts with 1,4-dibromobutane to make butane-1,4-diol.
- Butane-1,4-diol is oxidised to butanedioic acid.

Process 2

- Glucose reacts with carbon dioxide in the presence of microorganisms to produce butanedioic acid directly.
- The carbon dioxide used in this process is obtained from a local factory that produces bioethanol.

(a) Deduce **one** safety reason and one environmental reason why **Process 2** is preferred to **Process 1**.

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(Extra space) .....

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(2)

(b) (i) Name and outline a mechanism for the following reaction that occurs in **Process 1**.

$$BrCH_2CH_2CH_2CH_2Br + NaOH \longrightarrow BrCH_2CH_2CH_2CH_2OH + NaBr$$

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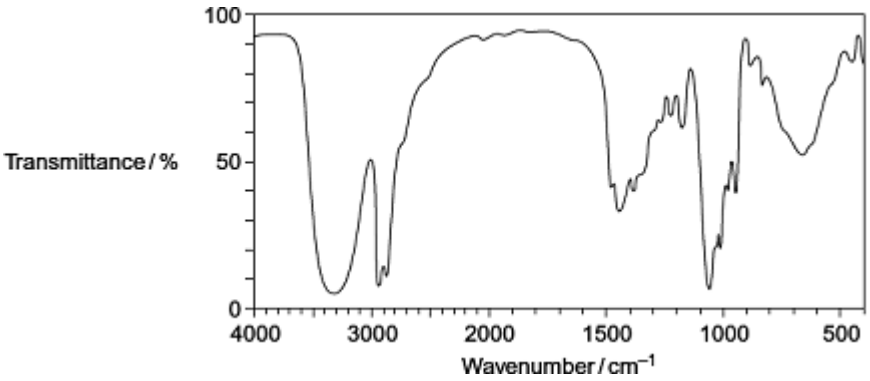
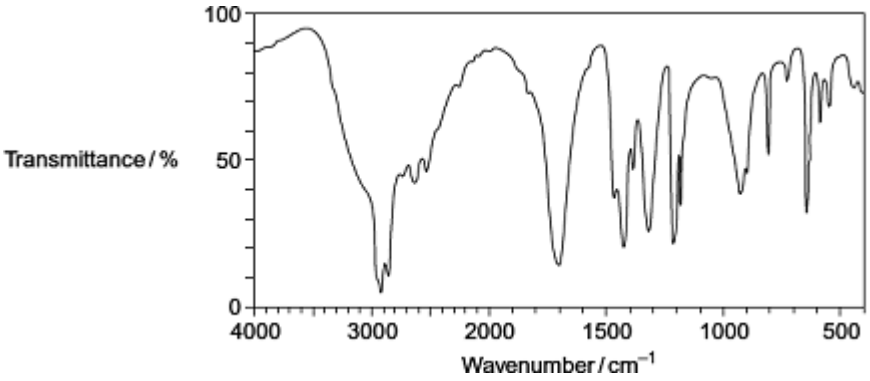
(3)

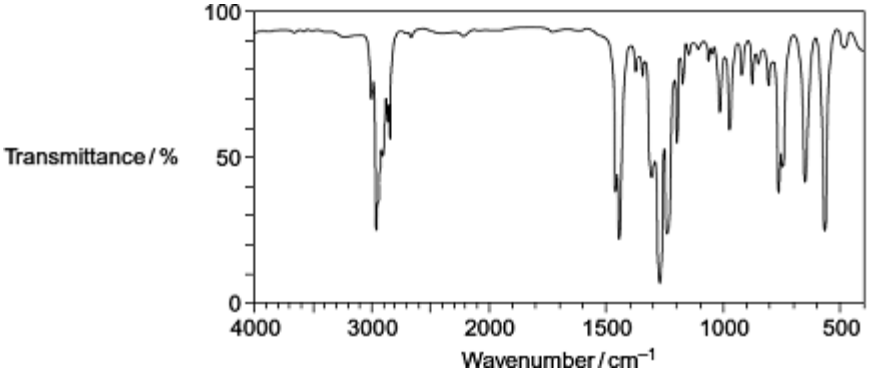
(ii) The infrared spectra shown are those of three compounds.

Compound **A** 1,4-dibromobutane
Compound **B** butane-1,4-diol
Compound **C** butanedioic acid

Identify the compound responsible for each spectrum by writing the correct letter, **A**, **B** or **C**, in the box next to each spectrum.
You may find it helpful to refer to **Table 1** on the Data Sheet.







(3)

(c) In the production of bioethanol, glucose ($C_6H_{12}O_6$) is converted into a dilute aqueous solution of ethanol and carbon dioxide.

Give the name of this process and state **three** essential conditions necessary to produce a good yield of ethanol.

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(4)

(d) State the class of alcohols to which the diol butane-1,4-diol belongs.

Identify a suitable reagent or combination of reagents for the conversion of butane-1,4-diol into butanedioic acid ($HOOCCH_2CH_2COOH$).

Write an equation for this oxidation reaction using [O] to represent the oxidising agent.

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(Extra space) .....

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(3)
(Total 15 marks)

8 The following instructions are from an experimental procedure for the preparation of cyclohexene from cyclohexanol and concentrated phosphoric acid.
Read these instructions and answer the questions that follow.

1 Place 25 cm^3 of cyclohexanol into a round-bottomed flask with some porous pot to act as anti-bumping granules. Add 10 cm^3 of concentrated phosphoric acid carefully while shaking the flask. Cool the flask under the tap if it gets too hot.
Make sure the reagents are thoroughly mixed.

2 Set up an apparatus for simple distillation using this flask.

3 Warm the flask, gently at first, for about 15 minutes. Then increase the heating so that cyclohexene begins to distil over. Collect the fraction that distils below 95 °C.

(a) State the purpose of the anti-bumping granules.

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(1)

(b) Name the part of the distillation apparatus where cyclohexene vapour is changed back into a liquid.
Draw a simple diagram of this part of the apparatus.

Name .....

Diagram

(2)
(Total 3 marks)

9 Some alcohols can be oxidised by an acidified solution of potassium dichromate(Vl).
Aldehydes can be oxidised by Tollens' reagent or by Fehling's solution.

An unknown pure liquid **A** contains only a single alcohol.
Outline a simple procedure to allow you to determine whether **A** is a primary, a secondary or a tertiary alcohol.

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(Total 3 marks)