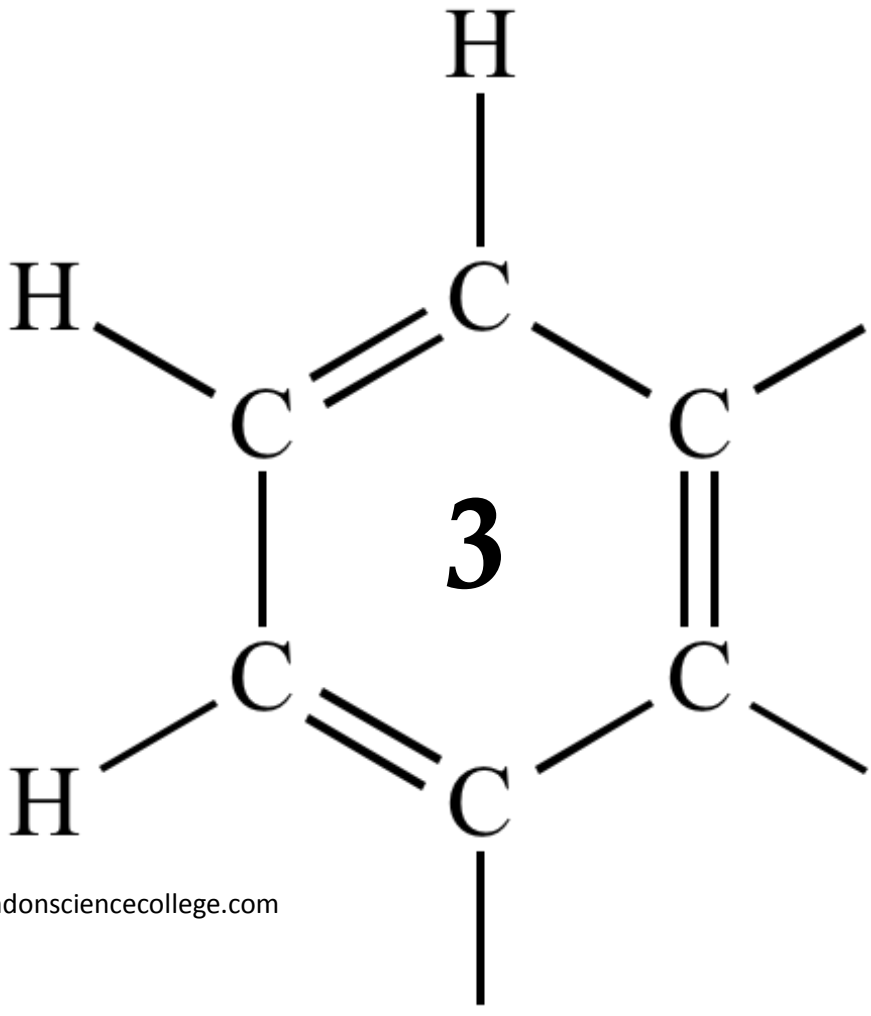
LONDON SCIENCE COLLEGE

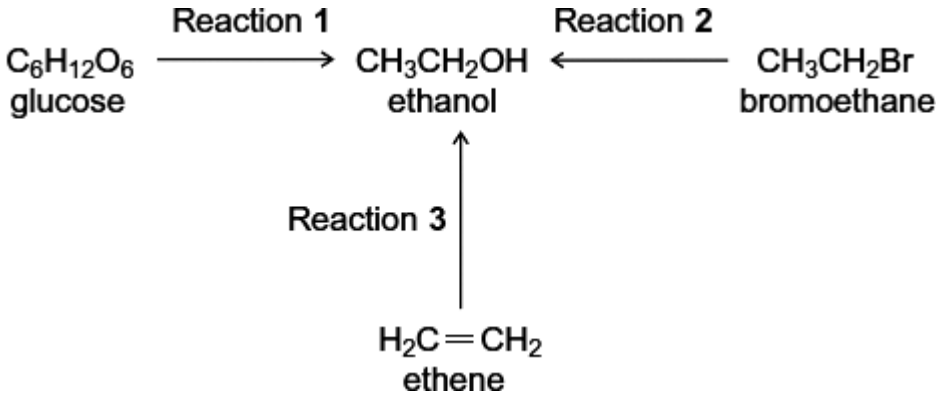
AQA AS CHEMISTRY

ALCOHOLS



3

1 Three different ways of producing ethanol are shown below.



(a) Reaction **1** produces a 15% aqueous solution of ethanol.
It is claimed that the ethanol produced in this way is a carbon-neutral biofuel.

Write an equation for Reaction **1** and name the process.

Write an equation for the complete combustion of ethanol.

Explain why the ethanol produced by this process may **not** be a *carbon-neutral* biofuel.

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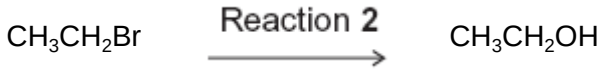
(5)

(b) Give a reagent and conditions for Reaction **2**.



Name and outline a mechanism for Reaction **2**.

Suggest **one** reason, other than safety, why this method is **not** used in industry to make ethanol.

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(Extra space) .....

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(6)

(c) Reaction **3** is used in industry.

Identify a suitable catalyst for Reaction **3**.

Identify the type of reaction.

Give **two** conditions, in addition to the presence of a catalyst, necessary for Reaction **3** to produce a high yield of ethanol.

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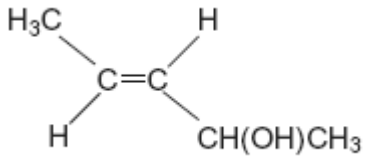
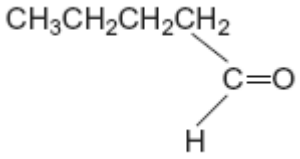
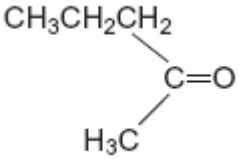
(4)
(Total 15 marks)

2 The table below shows the structures of three isomers with the molecular formula $C_5H_{10}O$

Isomer **1** 	(*E*)-pent-3-en-2-ol
Isomer **2** 	pentanal
Isomer **3** 	

(a) Complete the table by naming Isomer **3**.

(1)

(b) State the type of structural isomerism shown by these three isomers.

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(1)

(c) The compound (*Z*)-pent-3-en-2-ol is a stereoisomer of (*E*)-pent-3-en-2-ol.

(i) Draw the structure of (*Z*)-pent-3-en-2-ol.

(1)

(ii) Identify the feature of the double bond in (*E*)-pent-3-en-2-ol and that in (*Z*)-pent-3-en-2-ol that causes these two compounds to be stereoisomers.

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(1)

(d) A chemical test can be used to distinguish between separate samples of Isomer **2** and Isomer **3**.
Identify a suitable reagent for the test.
State what you would observe with Isomer **2** and with Isomer **3**.

Test reagent .....

Observation with Isomer **2**.....

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Observation with Isomer **3**.....

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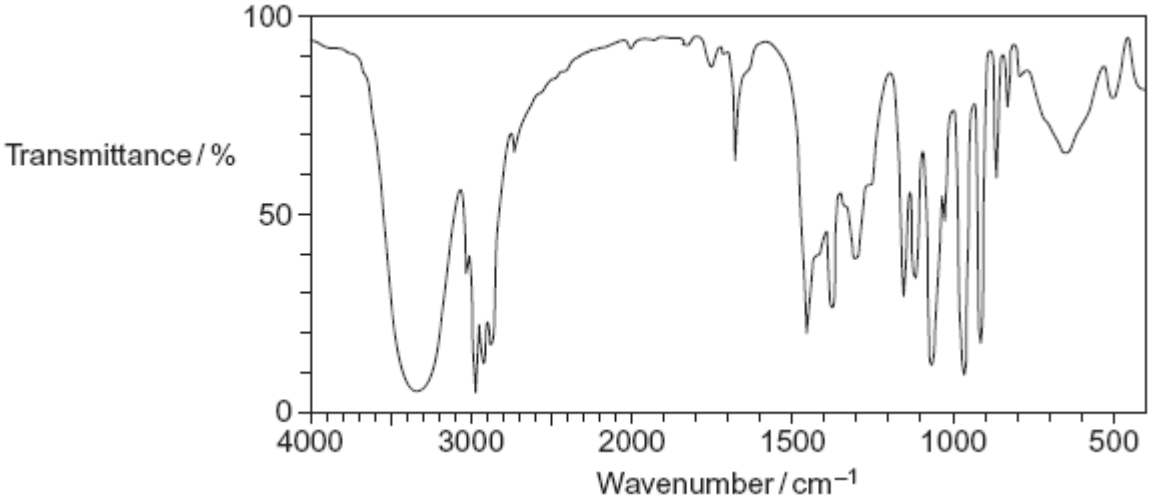
(3)

(e) The following is the infrared spectrum of one of the isomers **1**, **2** or **3**.



(i) Deduce which of the isomers (**1**, **2** or **3**) would give this infrared spectrum. You may find it helpful to refer to **Table 1** on the Data Sheet.

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(1)

(ii) Identify two features of the infrared spectrum that support your deduction.
In each case, identify the functional group responsible.

Feature 1 and functional group .....

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Feature 2 and functional group .....

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(2)
(Total 10 marks)

3 The following pairs of compounds can be distinguished by observing what happens in test-tube reactions.
For each pair, give a suitable aqueous reagent that could be added separately to each compound.
Describe what you would observe in each case.

(a) NaF(aq) and NaCl(aq)

Reagent .....

Observation with NaF(aq) .....

Observation with NaCl(aq) .....

(3)

(b) $BaCl_2(aq)$ and $MgCl_2(aq)$

Reagent .....

Observation with $BaCl_2(aq)$ .....

Observation with $MgCl_2(aq)$ .....

(3)

(c) AgCl(s) and AgI(s)

Reagent .....

Observation with AgCl(s) .....

Observation with AgI(s) .....

(3)

(d) Butan-2-ol(l) and 2-methylpropan-2-ol(l)

Reagent .....

Observation with butan-2-ol(l) .....

Observation with 2-methylpropan-2-ol(l) .....

(3)
(Total 12 marks)

4 A student devised an experiment to investigate the enthalpies of combustion of some alcohols. The student chose the following series of primary alcohols.

Name	Formula
Methanol	CH_3OH
Ethanol	CH_3CH_2OH
Propan-1-ol	$CH_3CH_2CH_2OH$
Butan-1-ol	$CH_3CH_2CH_2CH_2OH$
Pentan-1-ol	$CH_3CH_2CH_2CH_2CH_2OH$
Alcohol **X**	$CH_3CH_2CH_2CH_2CH_2CH_2OH$
Heptan-1-ol	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2OH$

(a) (i) Name alcohol **X**.

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(1)

(ii) State the general name of the type of series shown by these primary alcohols.

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(1)

(iii) Draw the displayed formula of the position isomer of butan-1-ol.

(1)

(iv) Using [O] to represent the oxidising agent, write an equation for the oxidation of butan-1-ol to form an aldehyde.

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(1)

(v) Draw the displayed formula of a functional group isomer of this aldehyde.

(1)

(b) The student carried out a laboratory experiment to determine the enthalpy change when a sample of butan-1-ol was burned.
The student found that the temperature of 175 g of water increased by 8.0 °C when 5.00×10^{-3} mol of pure butan-1-ol was burned in air and the heat produced was used to warm the water.

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

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(3)

(c) (i) Give the meaning of the term *standard enthalpy of combustion*.

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(3)

(ii) Use the standard enthalpy of formation data from the table and the equation for the combustion of butan-1-ol to calculate a value for the standard enthalpy of combustion of butan-1-ol.

	$CH_3CH_2CH_2CH_2OH(l)$	$O_2(g)$	$CO_2(g)$	$H_2O(l)$
$\Delta H_f^{\ominus}$ / kJ mol^{-1}	–327	0	–394	–286

$$CH_3CH_2CH_2CH_2OH(l) + 6O_2(g) \longrightarrow 4CO_2(g) + 5H_2O(l)$$

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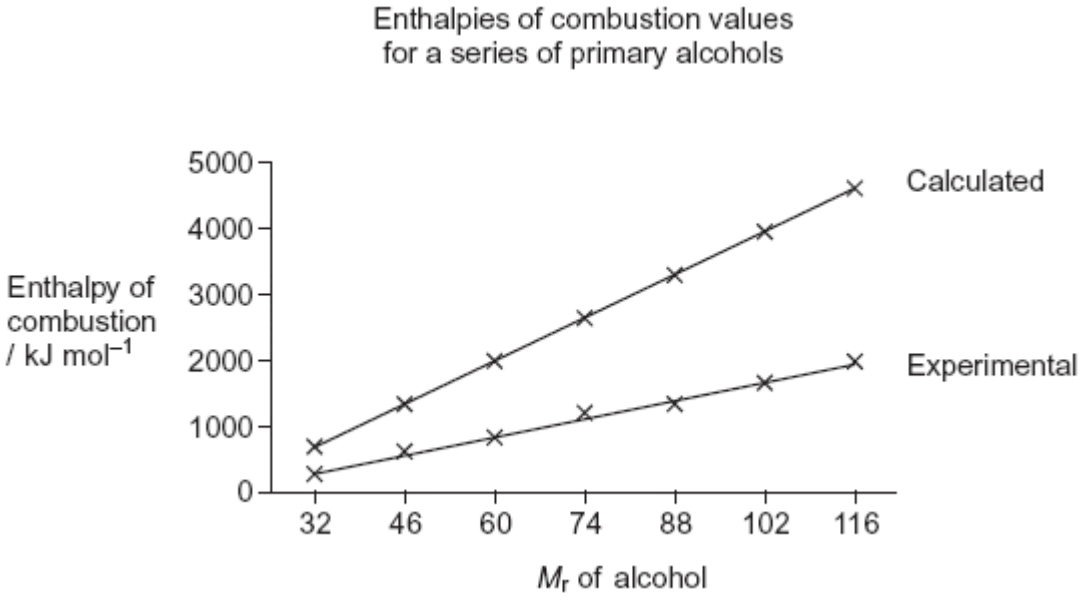
(3)

(d) The student repeated the experiment described in part (b) and obtained an experimental value for the enthalpy of combustion for each alcohol in this series.
These experimental values were then compared with calculated values from standard enthalpies of formation, as shown in the graph below.



(i) In terms of bonds broken and bonds formed, explain why the calculated values of enthalpies of combustion of these alcohols, when plotted against M_r, follow a straight line.

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(2)

(ii) Give **two** reasons why the experimental values obtained by the student are lower than the calculated values using the enthalpy of formation data.

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(2)
(Total 18 marks)

5 Glucose, produced during photosynthesis in green plants, is a renewable source from which ethanol can be made. Ethanol is a liquid fuel used as a substitute for petrol.
The processes involved can be summarised as follows.

Process **1** Photosynthesis in green plants
$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

Process **2** Fermentation of glucose to form ethanol

Process **3** Complete combustion of ethanol
$CH_3CH_2OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$

(a) State **three** essential conditions for the fermentation of aqueous glucose in Process **2**.

Write an equation for the reaction that takes place during this fermentation.

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(4)

(b) It has been claimed that there is no net carbon (greenhouse gas) emission to the atmosphere when ethanol made by Process **2** is used as a fuel.

State the term that is used to describe fuels of this type.

Use the equations for Processes **1, 2** and **3** to show why it can be claimed that there is no net emission of carbon-containing greenhouse gases.

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(3)

(c) Use the information from the equation for Process **3** above and the mean bond enthalpies from the table below to calculate a value for the enthalpy change for this process.

	C–H	C–C	C–O	O–H	C=O	O=O
Mean bond enthalpy / kJ mol^{-1}	+412	+348	+360	+463	+743	+496

Give **one** reason why the value calculated from mean bond enthalpies is different from the value given in a data book.

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(4)

(d) A student carried out a simple laboratory experiment to measure the enthalpy change for Process **3**. The student showed that the temperature of 200 g of water increased by 8.0 °C when 0.46 g of pure ethanol was burned in air and the heat produced was used to warm the water.

Use these results to calculate the value, in kJ mol^{-1}, obtained by the student for this enthalpy change. (The specific heat capacity of water is 4.18 J K^{-1} g^{-1})

Give **one** reason, other than heat loss, why the value obtained from the student's results is less exothermic than a data book value.

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(4)
(Total 15 marks)

6 Ethanol can be oxidised slowly to ethanal. State how a sample of ethanol could be tested to confirm the presence of ethanal. State what you would observe.

Test .....

Observation .....

(Total 2 marks)

7 Ethanal is prepared by heating ethanol with potassium dichromate(VI) in the presence of sulfuric acid. **Figures 1** and **2** show two possible ways of heating this reaction mixture.

Figure 1

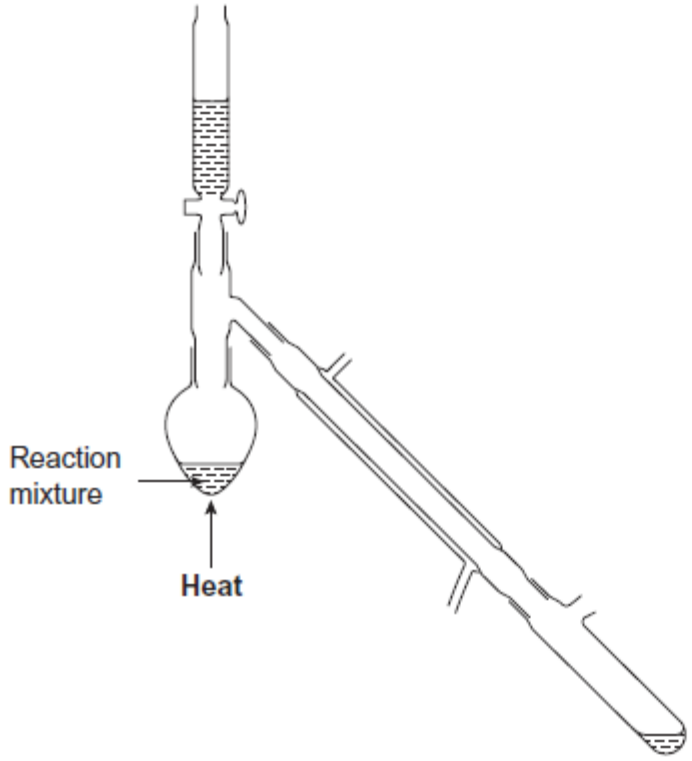
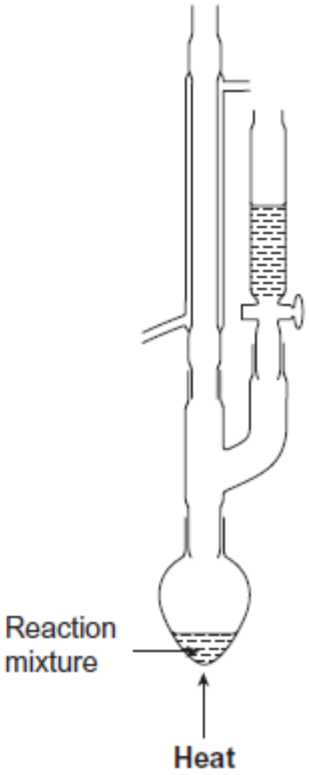


Figure 2



State which arrangement would **not** be suitable for the preparation of ethanal. Explain your answer.

Arrangement .....

Explanation .....

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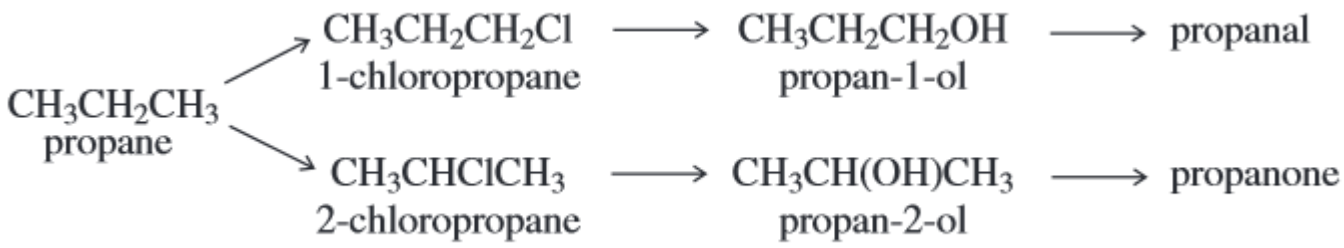
(Total 2 marks)

8 Consider the following scheme of reactions.



(a) State the type of structural isomerism shown by propanal and propanone.

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(1)

(b) A chemical test can be used to distinguish between separate samples of propanal and propanone.

Identify a suitable reagent for the test.
State what you would observe with propanal and with propanone.

Test reagent.....

Observation with propanal.....

Observation with propanone.....

(3)

(c) State the structural feature of propanal and propanone which can be identified from their infrared spectra by absorptions at approximately 1720 cm^{-1}.

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(1)

(d) The reaction of chlorine with propane is similar to the reaction of chlorine with methane.

(i) Name the type of mechanism in the reaction of chlorine with methane.

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(1)

(ii) Write an equation for each of the following steps in the mechanism for the reaction of chlorine with propane to form l-chloropropane ($CH_3CH_2CH_2Cl$).

Initiation step

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First propagation step

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Second propagation step

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A termination step to form a molecule with the empirical formula C_3H_7

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(4)

(e) High resolution mass spectrometry of a sample of propane indicated that it was contaminated with traces of carbon dioxide.

Use the data in the table to show how precise M_r values can be used to prove that thesample contains both of these gases.

Atom	Precise relative atomic mass
^{12}C	12.00000
^{1}H	1.00794
^{16}O	15.99491

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(2)

(Total 12 marks)

9 There are **four** isomeric alcohols with the molecular formula $C_4H_{10}O$

(a) Two of these are butan-l-ol ($CH_3CH_2CH_2CH_2OH$) and butan-2-ol.
The other two isomers are alcohol **X** and alcohol **Y**.

Draw the displayed formula for butan-2-ol.

Alcohol **X** does not react with acidified potassium dichromate(VI) solution.
Give the structure of alcohol **X**.

Name the fourth isomer, alcohol **Y**.

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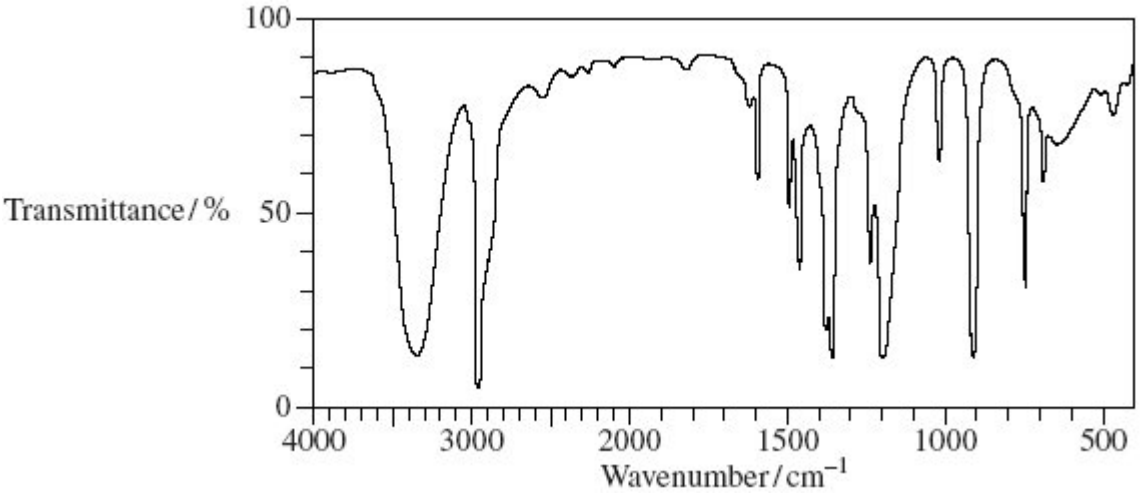
(3)

(b) The infrared spectrum of one of these isomeric alcohols is given below.



Identify **one** feature of the infrared spectrum which supports the fact that this is an alcohol. You may find it helpful to refer to **Table 1** on the Data Sheet.

Explain how infrared spectroscopy can be used to identify this isomeric alcohol.

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(3)

(c) British scientists have used bacteria to ferment glucose and produce the biofuel butan-1-ol.

Write an equation for the fermentation of glucose ($C_6H_{12}O_6$) to form butan-1-ol, carbon dioxide and water only.

State **one** condition necessary to ensure the complete combustion of a fuel in air.

Write an equation for the complete combustion of butan-1-ol and state why it can be described as a *biofuel*.

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(4)

(d) Butan-1-ol reacts with acidified potassium dichromate(VI) solution to produce two organic compounds.

State the class of alcohols to which butan-1-ol belongs.

Draw the displayed formula for **both** of the organic products.

State the type of reaction that occurs and the change in colour of the potassium dichromate(VI) solution.

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(5)
(Total 15 marks)