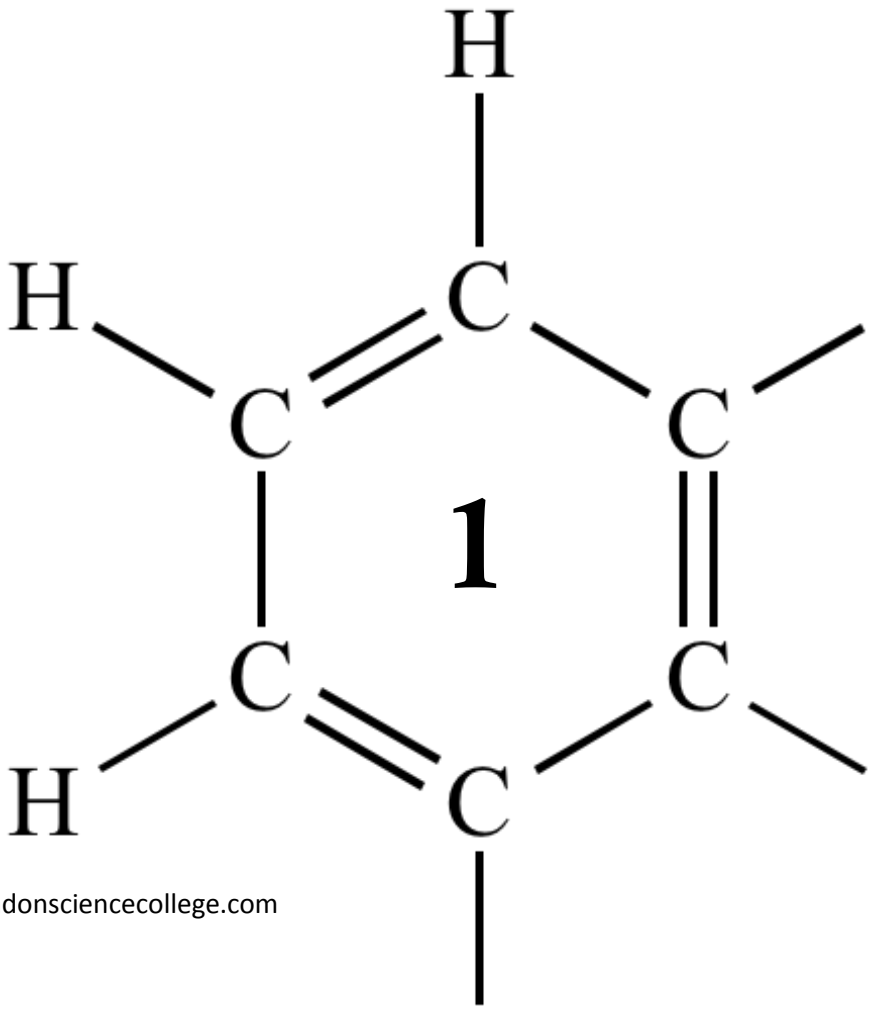
LONDON SCIENCE COLLEGE

AQA AS CHEMISTRY

ALCOHOLS



1 Propane-1,2-diol has the structure $CH_2(OH)CH(OH)CH_3$. It is used to make polyesters and is one of the main substances in electronic cigarettes (E-cigarettes).

A sample of propane-1,2-diol was refluxed with a large excess of potassium dichromate(VI) and sulfuric acid.

(a) Draw the skeletal formula of propane-1,2-diol.

(1)

(b) Write an equation for this oxidation reaction of propane-1,2-diol under reflux, using [O] to represent the oxidizing agent.

Show the displayed formula of the organic product.

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(2)

(c) Draw a labelled diagram to show how you would set up apparatus for refluxing.

(2)

(d) Anti-bumping granules are placed in the flask when refluxing.
Suggest why these granules prevent bumping.

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(1)

(e) Draw the structure of a different organic product formed when the acidified potassium dichromate(VI) is not in excess.

(1)
(Total 7 marks)

2 Propene can be made by the dehydration of propan-2-ol.

What is the percentage yield when 30 g of propene (M_r = 42.0) are formed from 50 g of propan-2-ol (M_r = 60.0)?

A 60% ⬭

B 67% ⬭

C 81% ⬭

D 86% ⬭

(Total 1 mark)

3 Compounds **A**, **B**, **C** and **D** are isomers with the molecular formula $C_4H_{10}O$
They all have a broad absorption in their infrared spectra in the range 3230–3550 cm^{-1}.

(a) Use **Table A on the data sheet** to identify the bond and the functional group present responsible for this absorption.

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(1)

(b) Compounds **A** and **B** are both straight-chain compounds.
A can be oxidised to form **P**.
B can be oxidised to form **Q**.
P and **Q** are isomers with molecular formula C_4H_8O

Tollens' reagent and Fehling's solution can be used to distinguish between isomers **P** and **Q**. The results shown in the table are obtained.

Compound	Observation with Tollens' reagent	Observation with Fehling's solution
P	No visible change	No visible change
Q	Silver mirror formed	Brick-red precipitate formed

Use the information about compounds **P** and **Q** to identify compounds **A** and **B**.
Explain your answer with reference to the functional groups in **P** and **Q**.

Identity of **A** .....

Identity of **B** .....

Explanation .....

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(3)

(c) Isomer **C** is resistant to oxidation.
Isomer **C** reacts to form compound **R** that has an absorption in its infrared spectrum in the range 1620–1680 cm^{-1}.

State the bond that causes the absorption in the range 1620–1680 $^{-1}$.

Give the displayed formula of isomer **C**.

Identify the reagent and give **one** reaction condition needed to convert **C** into **R**.

Bond .....

Displayed formula of **C**

Reagent .....

Condition .....

(4)

(d) Compound **D** is a branched-chain isomer that can be oxidised to form compounds **S** and **T**.

(i) Compound **S** is obtained by distilling it off as it forms during the oxidation.
Compound **T** is formed when the oxidation takes place under reflux.

Identify the functional groups in **S** and **T**.

Explain, with reference to intermolecular forces, why it is possible to obtain compound **S** but not **T** from the reaction mixture by distilling off **S** as soon as it forms.

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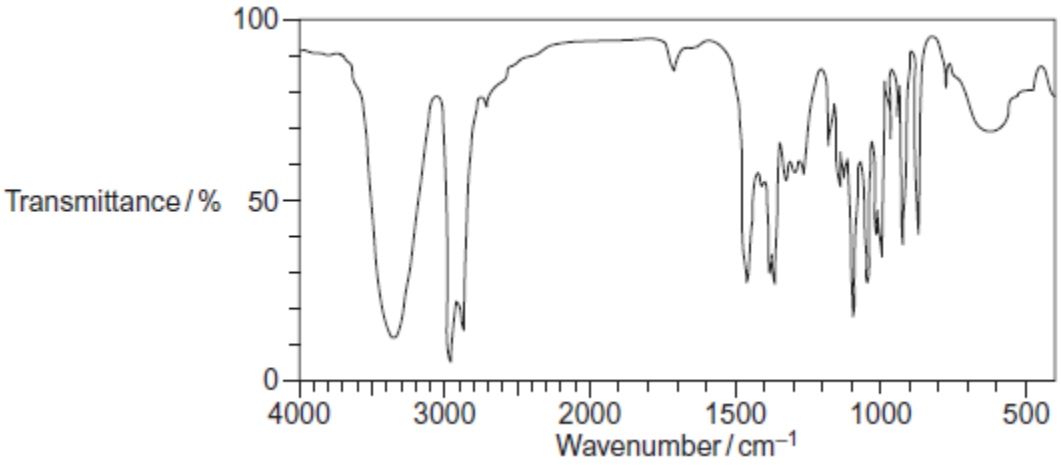
(3)

(ii) A student claims to have oxidised compound **D**.
The infrared spectrum of the product obtained by the student is shown.



Suggest two ways in which the spectrum shows that compound **D** has **not** been oxidised.

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(2)
(Total 13 marks)

4 Alcohols can be prepared from alkenes in various ways.

(a) On a laboratory scale, a mixture of propan-1-ol and propan-2-ol can be prepared from propene in two steps.

In step 1, propene reacts with cold, concentrated sulfuric acid to form intermediate compounds.

In step 2, the intermediate compounds react with water to form the mixture of alcohols.

Name and outline the mechanism for the reaction between propene and concentrated sulfuric acid to form the intermediate compound which gives propan-2-ol in step 2.

Explain why propan-2-ol is the major product of this preparation.

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(7)

(b) On an industrial scale ethanol can be produced from ethene by direct hydration or from glucose by fermentation.

State the conditions for the direct hydration reaction.

State two advantages and two disadvantages of the fermentation method compared with the direct hydration method.

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(6)
(Total 13 marks)

5 Compound **J**, known as leaf alcohol, has the structural formula $CH_3CH_2CH{=}CHCH_2CH_2OH$ and is produced in small quantities by many green plants. The *E* isomer of **J** is responsible for the smell of freshly cut grass.

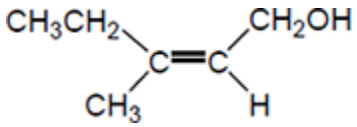
(a) Give the structure of the *E* isomer of **J**.

(1)

(b) Give the **skeletal formula** of the organic product formed when **J** is dehydrated using concentrated sulfuric acid.

(1)

(c) Another structural isomer of **J** is shown below.



Explain how the Cahn-Ingold-Prelog (CIP) priority rules can be used to deduce the full IUPAC name of this compound.

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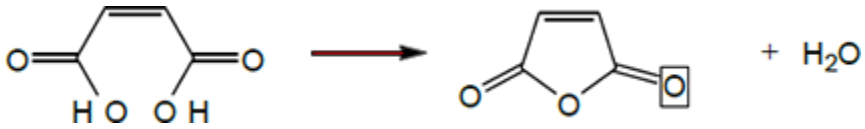
(6)

(d) The effect of gentle heat on maleic acid is shown below.



A student predicted that the yield of this reaction would be greater than 80%.

In an experiment,10.0 g of maleic acid were heated and 6.53 g of organic product were obtained.

Is the student correct? Justify your answer with a calculation using these data.

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(2)
(Total 10 marks)

6 Glucose can decompose in the presence of microorganisms to form a range of products. One of these is a carboxylic acid (M_r = 88.0) containing 40.9% carbon and 4.5% hydrogen by mass.

(a) Deduce the empirical and molecular formulas of the carboxylic acid formed.

Empirical formula = ... Molecular formula = ...

(4)

(b) Ethanol is formed by the fermentation of glucose.
A student carried out this fermentation reaction in a beaker using an aqueous solution of glucose at a temperature of 25 °C in the presence of yeast.

Write an equation for the reaction occurring during fermentation.

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(1)

(c) In industry, this fermentation reaction is carried out at 35 °C rather than 25 °C.

Suggest **one** advantage and **one** disadvantage for industry of carrying out the fermentation at this higher temperature.

Advantage .....

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Disadvantage .....

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(2)

(d) The method used by the student in part (b) would result in the ethanol being contaminated by ethanoic acid.

How does this contamination occur?

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(1)

(e) Give **two** differences between the infrared spectrum of a carboxylic acid and that of an alcohol other than in their fingerprint regions.
Use **Table A** on the Data Sheet.

Difference 1 .....

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Difference 2 .....

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(2)
(Total 10 marks)

7 Which statement about ethanal is correct?

A It reacts with Tollens' reagent to form silver. ⬭

B It has a higher boiling point than ethanol. ⬭

C Its empirical and molecular formulas are different. ⬭

D It belongs to a homologous series with general formula $C_nH_{2n+1}O$ ⬭

(Total 1 mark)

8 Alcohol **A** $(CH_3)_2CHCH(OH)CH_3$ undergoes reactions separately with acidified potassium dichromate(VI) and with concentrated sulfuric acid.

(a) Deduce the IUPAC name for alcohol **A**.

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(1)

(b) Draw the structure of the organic product, **B**, formed when **A** is oxidised in the reaction with acidified potassium dichromate(VI).

(1)

(c) Two isomeric alkenes, **C** and **D**, are formed when **A** is dehydrated in the reaction with concentrated sulfuric acid.

Name the mechanism for this dehydration reaction.

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(1)

(d) Draw the structure of each isomer.

Isomer **C** Isomer **D**

(2)

(e) Name the type of structural isomerism shown by **C** and **D**.

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(1)

(f) List alcohol **A**, product **B** and isomer **C** in order of increasing boiling point.

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(1)

(g) Draw the structure of the isomer of **A** that is **not** oxidised by acidified potassium dichromate(VI).

(1)

(h) Draw the structure of the isomer of **A** that **cannot** be dehydrated to form an alkene by reaction with concentrated sulfuric acid.

(1)
(Total 9 marks)

9 The following pairs of compounds can be distinguished by simple test−tube reactions.

For each pair of compounds, give a reagent (or combination of reagents) that, when added separately to each compound, could be used to distinguish between them.
State what is observed in each case.

(a) Butan−2−ol and 2−methylpropan−2−ol

Reagent .....

Observation with butan−2−ol

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Observation with 2−methylpropan−2−ol

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(3)

(b) Propane and propene

Reagent .....

Observation with propane

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Observation with propene

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(3)

(c) Aqueous silver nitrate and aqueous sodium nitrate

Reagent .....

Observation with aqueous silver nitrate

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Observation with aqueous sodium nitrate

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(3)

(d) Aqueous magnesium chloride and aqueous barium chloride

Reagent .....

Observation with aqueous magnesium chloride

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Observation with aqueous barium chloride

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(3)
(Total 12 marks)

10 (a) Propanone can be formed when glucose comes into contact with bacteria in the absence of air.

(i) Balance the following equation for this reaction of glucose to form propanone, carbon dioxide and water.

.....$C_6H_{12}O_6$ ⟶ .....CH_3COCH_3 + ...CO_2 + ...H_2O

(1)

(ii) Deduce the role of the bacteria in this reaction.

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(1)

(b) Propanone is also formed by the oxidation of propan−2−ol.

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

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(1)

(ii) State the class of alcohols to which propan−2−ol belongs.

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(1)

(c) A student determined a value for the enthalpy change when a sample of propanone was burned. The heat produced was used to warm some water in a copper calorimeter.
The student found that the temperature of 150 g of water increased by 8.0 °C when 4.50×10^{-3} mol of pure propanone 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 propanone is burned.
(The specific heat capacity of water is 4.18 J K^{-1} g^{-1})

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(3)

(d) Define the term **standard enthalpy of combustion**.

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(3)

(e) Use the mean bond enthalpy data in the table and the equation given below the table to calculate a value for the standard enthalpy change when gaseous propanone is burned.

	C−H	**C−C**	**C−O**	**O−H**	**C=O**	**O=O**
Mean bond enthalpy / kJ mol^{-1}	412	348	360	463	805	496

$$CH_3COCH_3(g) + 4O_2(g) \longrightarrow 3CO_2(g) + 3H_2O(g)$$

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(3)

(f) Suggest **two** reasons why the value obtained by the student in part (c) is different from the value calculated in part (e).

Reason 1 .....

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Reason 2 .....

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(2)
(Total 15 marks)