1 This question is about the six alcohols below. butan-2-ol ethane-1,2-diol 2-methylpentan-3-ol 2-methylpropan-2-ol propan-1-ol propan-2-ol (a) Which alcohol is an example of a tertiary alcohol? .....[1] **(b)** Draw the skeletal formula for 2-methylpentan-3-ol. [1] (c) Butan-2-ol and 2-methylpropan-2-ol are structural isomers. (i) What is meant by the term *structural isomer*? .....[1] (ii) Draw another structural isomer of these two alcohols.

(d) Ethane-1,2-diol can be dissolved in water to act as an anti-freeze in car radiators.

Explain why ethane-1,2-diol is very soluble in water.

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.....[2]

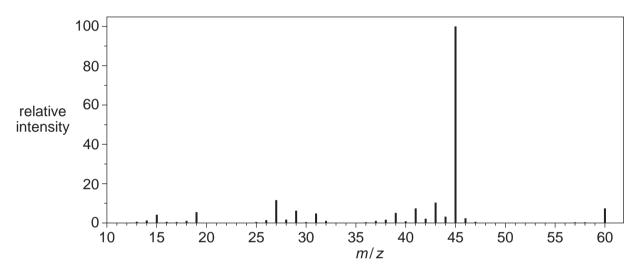
(e)		ane-1,2-diol is heated under reflux with ethanoic acid and a small amount of $\rm H_2$ alyst. Compound <b>A</b> is formed with molecular formula $\rm C_6H_{10}O_4$ .	SO <sub>4</sub>
	Dra	w the structure of compound A.	
(f)	But	an-2-ol is heated with $ extsf{H}_2 extsf{SO}_4$ catalyst.	[2]
(1)	•	A mixture of <b>three</b> alkenes forms, <b>B</b> , <b>C</b> and <b>D</b> .  The alkenes <b>B</b> and <b>C</b> are stereoisomers.	
	(i)	Draw the structures of the two stereoisomers <b>B</b> and <b>C</b> .	
			[2]
	(ii)	What type of stereoisomerism is shown by <b>B</b> and <b>C</b> ?	. [1]
	(iii)	Draw the structure of the other alkene, ${\bf D}$ , that is formed in this reaction.	

**(g)** Alcohol **E** is one of the following alcohols.

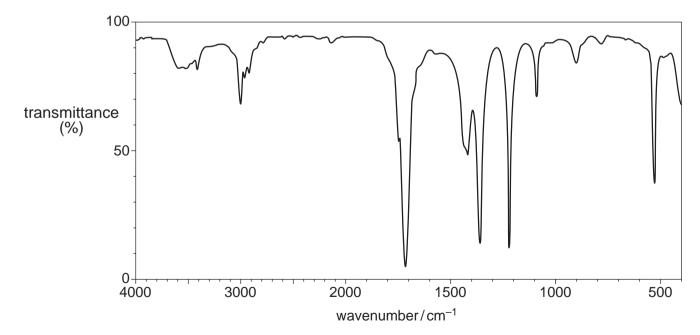
butan-2-ol 2-methylpentan-3-ol propan-1-ol ethane-1,2-diol 2-methylpropan-2-ol propan-2-ol

A student oxidises alcohol **E** by heating under reflux with excess acidified potassium dichromate(VI). An organic product **F** is isolated.

The mass spectrum of the alcohol **E** is shown below.



The infrared spectrum of the organic product **F** is shown below.



- Name or draw the structures of the alcohol E and the organic product F.
- Write an equation for the reaction of alcohol **E** with acidified potassium dichromate(VI).

  Use [O] to represent the oxidising agent, acidified potassium dichromate(VI).

•	In your answer, you should make clear how each structure fits with the information above.

[Total: 19]

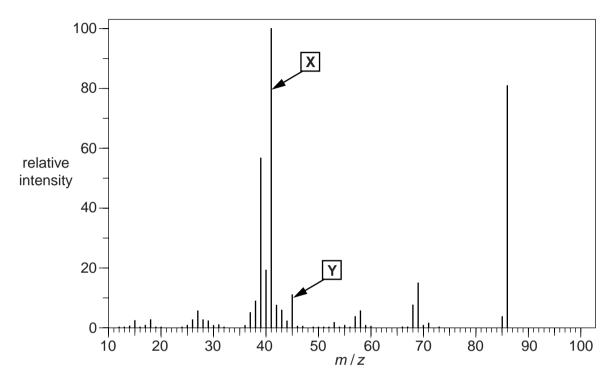
2	(a) C	Compound <b>B</b> , $C_xH_yO$ , can be oxidised to form a ketone	
	0.03	.035 mol of <b>B</b> has a mass of 2.59 g.	
	Con two	compound <b>B</b> reacts with compound <b>D</b> , $C_3H_6O_2$ , in the presence of we compounds <b>E</b> and <b>F</b> .	an acid catalyst to form
		Calculate the molar mass of compound <b>B</b> .	
		• Give the structures of compounds <b>B</b> , <b>C</b> , <b>D</b> , <b>E</b> and <b>F</b> .	
	•••••		
	•••••		
	•••••		
			re1

**(b)** Compound **G** is a branched-chain organic compound that does **not** have *E* and *Z* isomers.

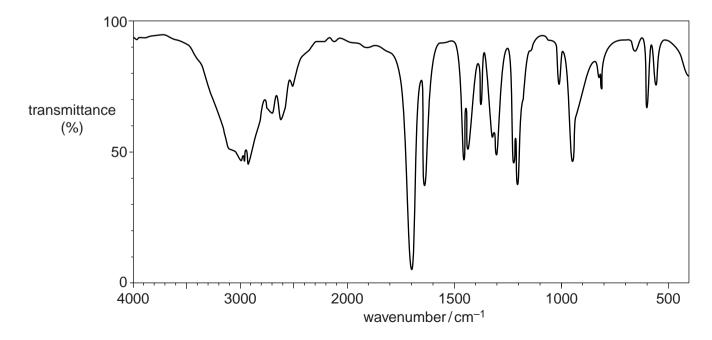
Elemental analysis of compound **G** gave the following percentage composition by mass: C, 55.8%; H, 7.0%; O, 37.2%.

The mass spectrum and infrared spectrum of compound **G** are shown below.

## Mass spectrum



## Infrared spectrum



- Calculate the empirical and molecular formulae for compound G.
- Write the formulae for the particles responsible for peak X and peak Y in the mass spectrum.
- Draw the structure of compound **G**.

Explain fully how you arrive at a structure for compound $oldsymbol{G}$ using all the evidence provided

	furic acid is made from sulfur, oxygen and water in a three-stage process. s can be represented by the following overall equation.
	$2S(s) + 3O_2(g) + 2H_2O(l) \rightarrow 2H_2SO_4(l)$
(a)	Explain why the overall process to make sulfuric acid has an atom economy of 100%.
	[1]
(b)	A factory uses 51.4 tonnes of sulfur to manufacture 147 tonnes of H <sub>2</sub> SO <sub>4</sub> .
	What is the percentage yield of H <sub>2</sub> SO <sub>4</sub> ?
	Give your answer to <b>two</b> significant figures. (1 tonne = $1 \times 10^6$ g)
	percentage yield =% [3]

3

(c)		of the reactions involved in making sulfuric acid converts sulfur dioxide, ${\rm SO}_2$ , into sulfur ide, ${\rm SO}_3$ .
		$2SO_2(g) + O_2(g) \iff 2SO_3(g)  \Delta H = -197 \text{ kJ mol}^{-1}$
		reaction can be carried out at 450 $^{\circ}\mathrm{C}$ and 3 atmospheres pressure in the presence of a $_{5}$ catalyst.
	Und side	er these conditions the position of equilibrium is almost completely on the right-hand .
	(i)	A research chemist investigates this reaction. He uses a temperature of 450 °C and 3 atmospheres pressure. The research chemist does <b>not</b> use the catalyst.
		Predict the changes, if any, on each of the following.
		position of equilibrium
		rate of backward reaction[2]
	(ii)	The temperature of the reaction mixture is <b>increased</b> to 600 °C.
		State and explain what will happen to the position of equilibrium.
		[1]
	(iii)	The pressure of the reaction mixture is <b>decreased</b> to 2 atmospheres.
		State and explain what will happen to the position of equilibrium.
		[1]

(d) Concentrated H<sub>2</sub>SO<sub>4</sub> is used as an acid catalyst in the elimination of water from alcohols.

There are several alcohols that are structural isomers with the formula  $C_5H_{11}OH$ . When these alcohols are heated with  $H_2SO_4$  they form alkenes.

$$C_5H_{11}OH \rightarrow C_5H_{10} + H_2O$$

(i) Pentan-1-ol is a structural isomer of  $C_5H_{11}OH$  that is a primary alcohol.

Draw the structure of another structural isomer of  $C_5H_{11}OH$  that is a primary alcohol.

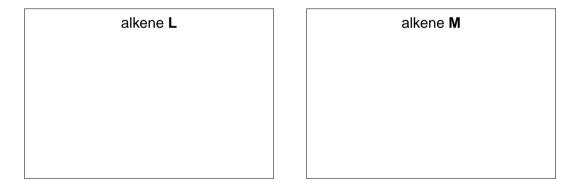
[1]

(ii) Pentan-2-ol is a structural isomer of  $\rm C_5H_{11}OH$  that is a secondary alcohol. Pentan-2-ol is heated with  $\rm H_2SO_4$ .

Three alkenes are formed, L, M and N.

- L and M are stereoisomers.
- N is a structural isomer of the stereoisomers L and M.

Draw the structures for alkenes L, M and N.



alkene N

(iii)	One structural isomer of $C_5H_{11}OH$ is an alcohol that <b>cannot</b> be oxidised by heating with acidified potassium dichromate(VI).
	Draw the structure of this alcohol.
	[1]
	[Total: 13]