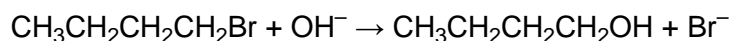


1. Bromobutane, $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$, can be reacted with hot aqueous sodium hydroxide to prepare butan-1-ol.



The butan-1-ol produced can be analysed by mass spectrometry.

- (i) Predict **two** fragment ions that you would expect to see in the mass spectrum of butan-1-ol and state the m/z value of each ion.

.....
.....

[2]

- (ii) State a use of mass spectrometry outside of the laboratory.

.....

[1]

[Total 3 marks]

2. Compound **X** is an atmospheric pollutant emitted from fuel combustion of petrol and diesel vehicles. Compound **X** is a potent human carcinogen.

- Analysis of compound **X** showed the following percentage composition by mass: C, 88.89%; H, 11.1%.
- Mass spectrometry showed a molecular ion peak at $m/z = 54$.
- Compound **X** reacts with H_2 in the presence of a nickel catalyst in a 1 : 2 molar ratio.

Analyse and interpret this information to determine a possible structure for compound **X**.

Show all your working.

[Total 5 marks]

3. (a) Butan-1-ol can be oxidised to form butanal.

(i) State a suitable oxidising mixture for this reaction.

.....

[2]

(ii) State the colour change you would see during this oxidation.

from to

[1]

(b) A sample of the butanal from (a) was analysed using infra-red spectroscopy. The infra-red spectrum contained an absorption in the region $1680\text{--}1750\text{ cm}^{-1}$ but did **not** contain a broad absorption in the region $2500\text{--}3300\text{ cm}^{-1}$.

Refer to the Data Sheet for Chemistry provided.

(i) What does the absorption in the region $1680\text{--}1750\text{ cm}^{-1}$ indicate?

.....

[1]

(ii) What does the absence of a broad absorption in the region $2500\text{--}3300\text{ cm}^{-1}$ indicate?

.....

[1]

(iii) The reaction in (a) was carried out using distillation and **not** reflux.

Explain why.

.....

.....

[2]

[Total 7 marks]

5. (a) When ethanol is heated with acidified potassium dichromate(VI) solution, it can be oxidised to form either ethanal, CH_3CHO (Fig. 1), or ethanoic acid, CH_3COOH (Fig. 2).

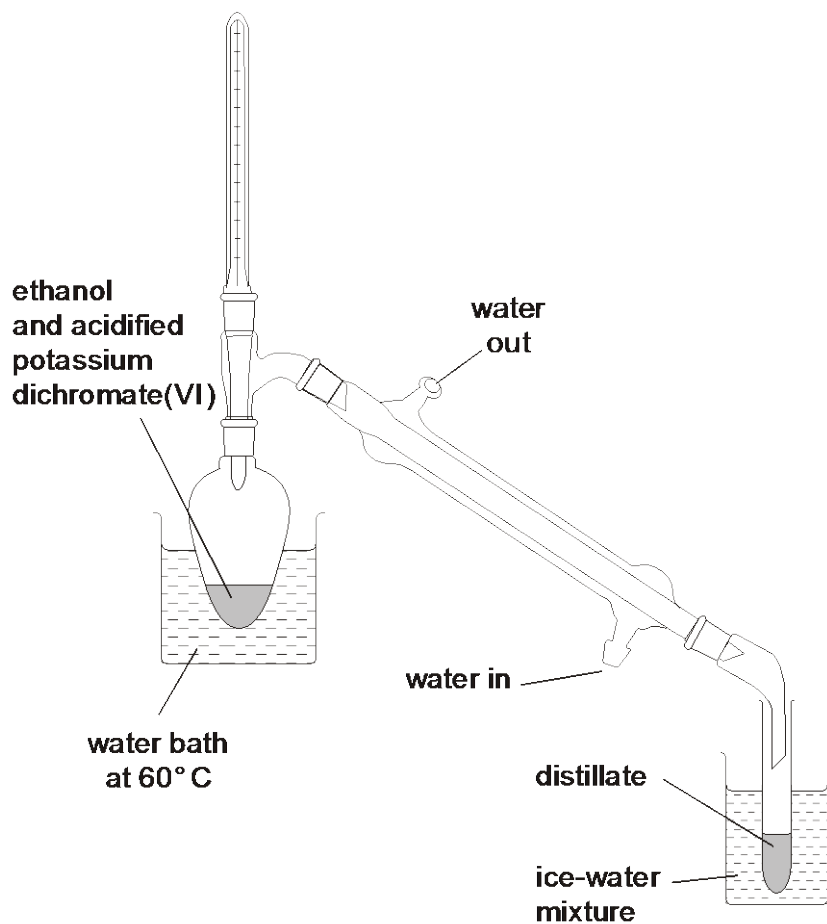


Fig. 1

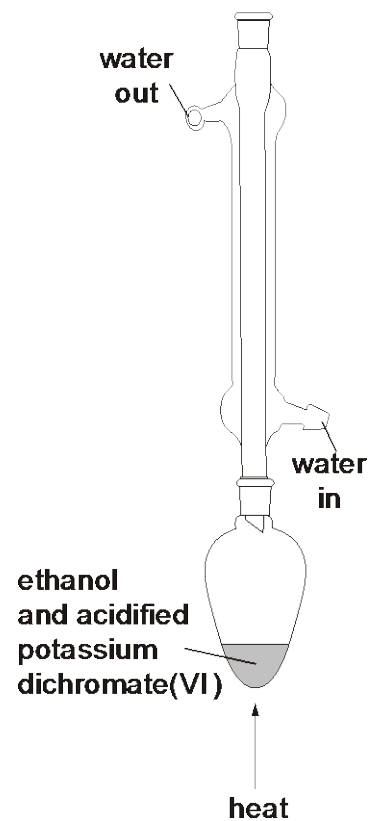


Fig. 2

The boiling points of ethanol, ethanal and ethanoic acid are given in the table below.

	$\text{CH}_3\text{CH}_2\text{OH}$	CH_3CHO	CH_3COOH
boiling point/ °C	78	21	118

Use this table of boiling points to explain

- (i) why the organic product is likely to be ethanal if the apparatus shown in Fig. 1 is used,

.....

- (ii) why the organic product is likely to be ethanoic acid if the apparatus shown in Fig. 2 is used.

.....
.....

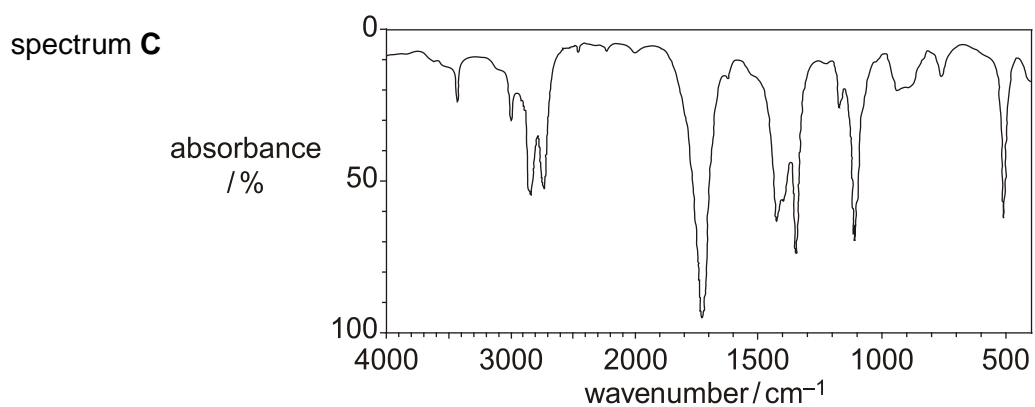
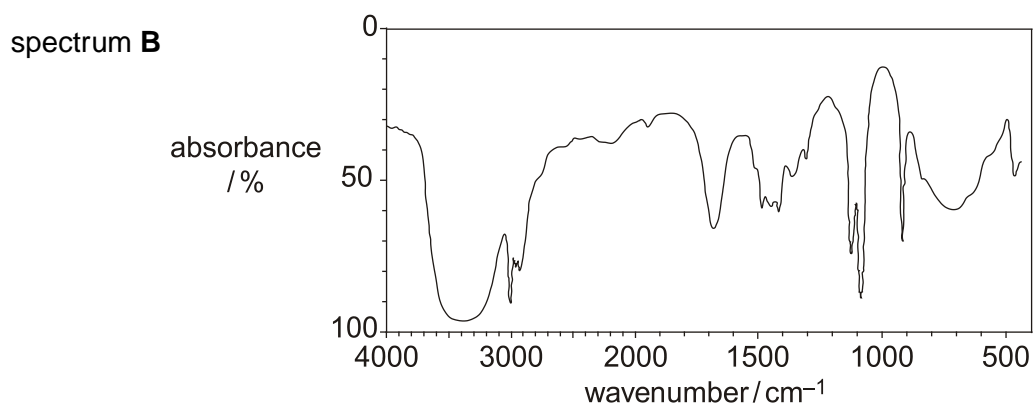
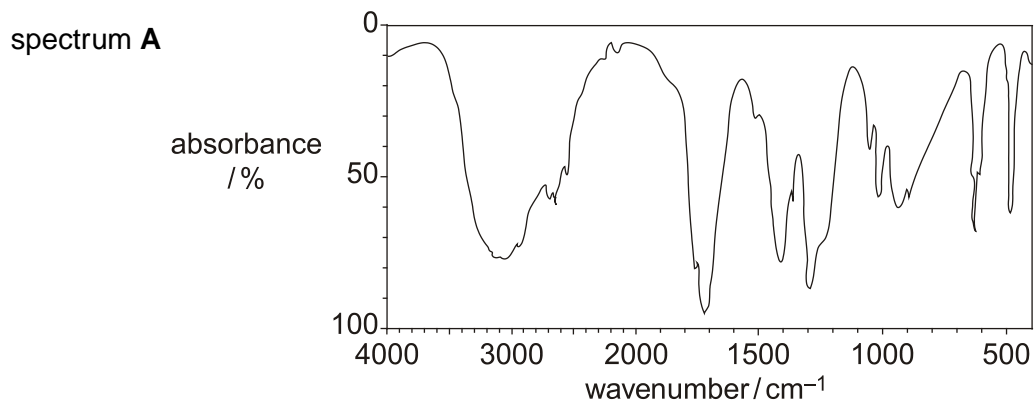
[2]

- (b) Write a balanced equation for the oxidation of ethanol to ethanoic acid. Use (O) to represent the oxidising agent.

.....

[2]

- (c) The ethanal collected using the apparatus shown in Fig. 1 was analysed by infra-red spectroscopy. Use your *Data Sheet* to justify which of the three spectra shown below is most likely to be that of ethanal.



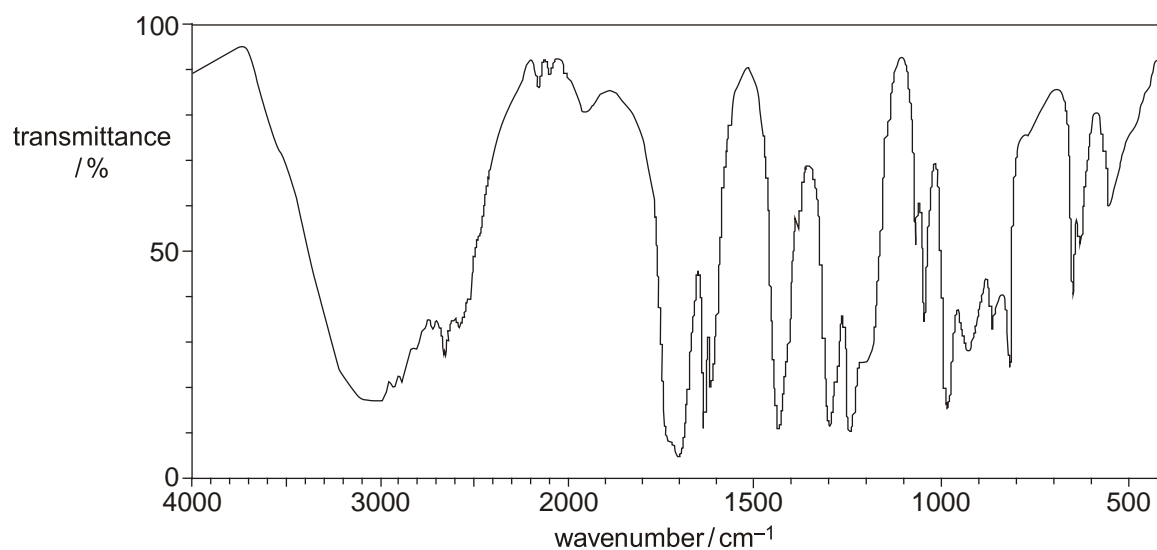
The organic product collected when using the apparatus shown in Fig. 1 is most likely to be that shown by spectrum because.....

.....
.....

[3]

[Total 9 marks]

6. A sample of prop-2-en-1-ol was oxidised and an infra-red spectrum of the organic product was obtained.



By referring to your Data Sheet, decide whether acrolein, $\text{CH}_2=\text{CHCHO}$, or acrylic acid, $\text{CH}_2=\text{CHCOOH}$, was formed.

The infra-red spectrum above is of

because

.....

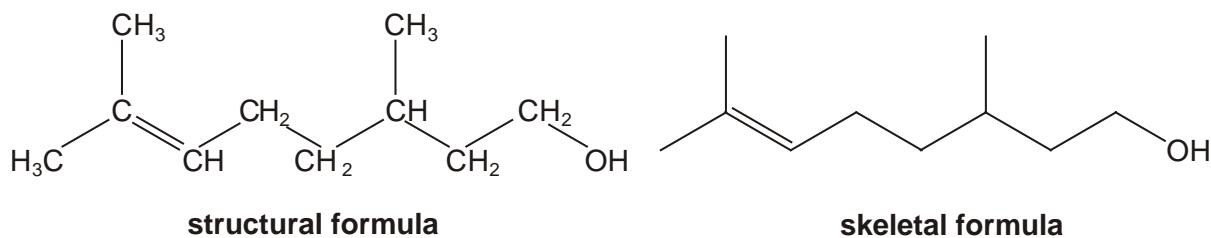
.....

.....

.....

[Total 3 marks]

7. Citronellol, $\text{C}_{10}\text{H}_{20}\text{O}$, occurs naturally in both rose and geranium oils. The structural and skeletal formulae of citronellol are shown below.



- (a) Name the **two** functional groups present in citronellol.

..... and

[2]

- (b) The functional groups in citronellol can be identified either by chemical tests or by infrared spectroscopy.

- (i) State which of the two functional groups you named in (a) is:

1 identified when bromine is added to citronellol,

2 more easily identified from the infra-red spectrum.

[1]

- (ii) State what you would **see** when bromine is added to citronellol.

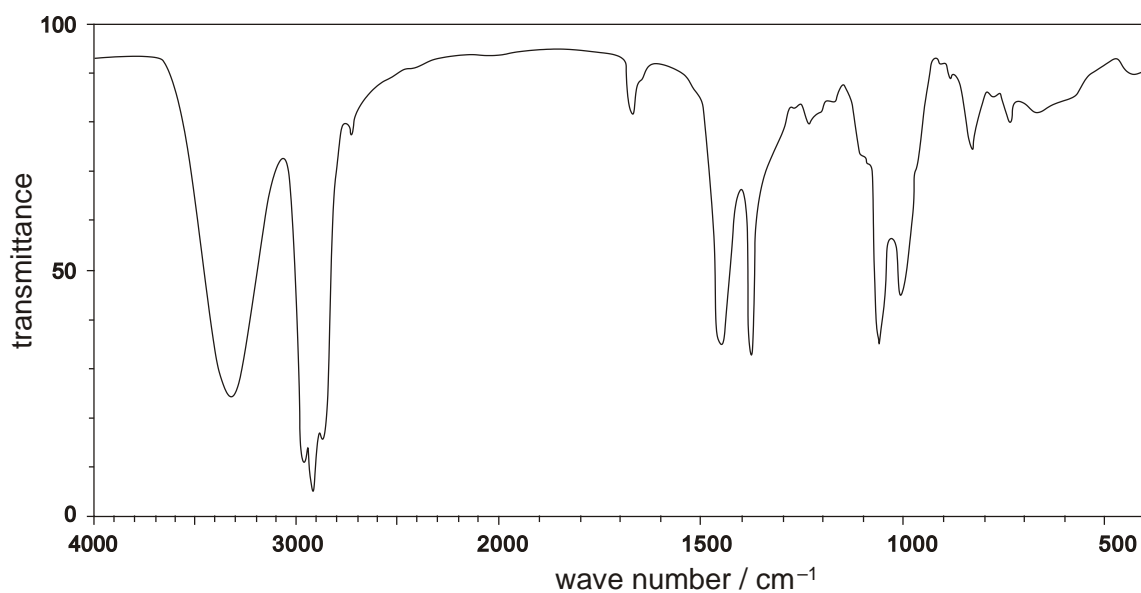
.....

[1]

- (iii) Draw the skeletal formula of the organic product formed when bromine is added to citronellol.

[1]

- (iv) The infra-red spectrum of citronellol is shown below. Mark on this spectrum, with the letter **X**, the absorption that confirms the presence of the functional group that is most easily identified from this spectrum.



[1]

(c) Reaction of a sample of citronellol, $C_{10}H_{20}O$, with hydrogen in the presence of a catalyst results in the formation of a saturated compound **C**.

(i) Suggest a catalyst for this reaction.

.....

[1]

(ii) Determine the molecular formula of the saturated compound **C**.

.....

[1]

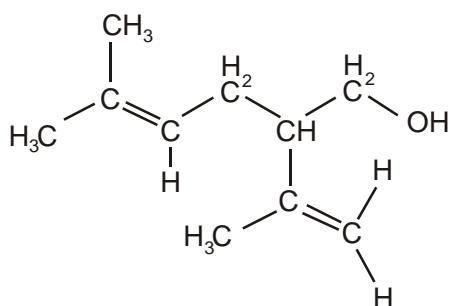
(iii) Construct a balanced equation for this reaction.

.....

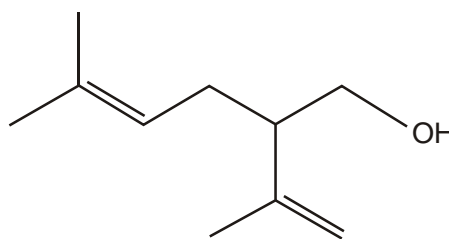
[1]

[Total 9 marks]

8. Lavandulol, $C_{10}H_{18}O$, is a fragrant oil which is found in lavender. The structural and the skeletal formulae of lavandulol are shown below.



structural formula



skeletal formula

(a) (i) Identify **two** different functional groups in lavandulol.

..... and

[2]

(ii) Why does lavandulol **not** have *cis-trans* isomerism?

.....

.....

[1]

- (b) Lavandulol, $C_{10}H_{18}O$, also reacts with bromine to form a saturated organic product.

State what you would see in this reaction and deduce the molecular formula of the organic product.

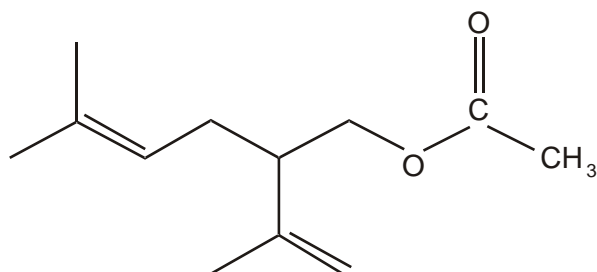
observation

[1]

molecular formula

[2]

- (c) Lavandulol could be converted into an ester **X**, which is also found in lavender oil.



ester **X**

State a reagent and a catalyst that could be used to form ester **X** from lavandulol.

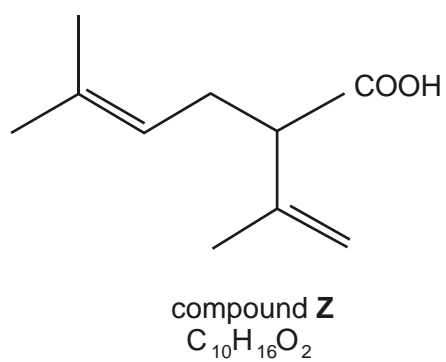
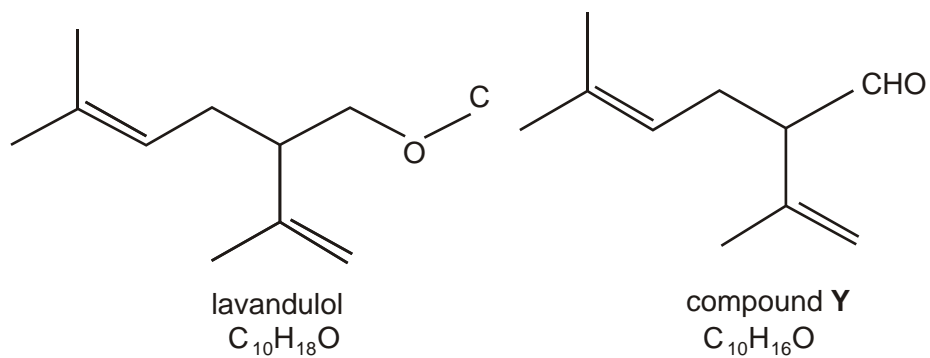
reagent

[1]

catalyst

[1]

(d) Lavandulol can be oxidised to produce either compound **Y** or compound **Z**.



- (i) Write a balanced equation for the oxidation of lavandulol to produce compound **Z**. Use the molecular formulae given above and use [O] to represent the oxidising agent.

.....

[2]

- (ii) An infra-red spectrum of either compound **Y** or compound **Z** was obtained and was found to contain an absorption between $1680 - 1750 \text{ cm}^{-1}$. However, there was no broad absorption between $2500 - 3300 \text{ cm}^{-1}$.

By referring to your *Data Sheet*, use this information to deduce whether the infra-red spectrum was of compound **Y** or of compound **Z**. Show your reasoning.

The infra-red spectrum was of compound because

.....

.....

.....

[2]

[Total 12 marks]