

SMART EXAM RESOURCES
9701 CAMBRIDGE AS CHEMISTRY
TOPIC QUESTIONS AND MARK SCHEMES
TOPIC :ANALYTICAL TECHNIQUES
SUB-TOPIC: Analyse-Infra-red-Spectrum
SET-2-QP-MS

1 Compound **V** is a liquid.

V contains 77.2% carbon, 11.4% hydrogen and 11.4% oxygen by mass.

V has a relative molecular mass of 280.

V contains two types of functional group: a carboxylic acid and an alkene.

A 3.196 g sample of Br_2 reacts completely with 2.800 g of **V**.

Calculate how many alkene functional groups are present in one molecule of **V**. Show your working.

number of alkene functional groups in **V** = [1]

MARK SCHEME:

3.196 g Br ₂ = 3.196 / 159.8 (= 0.02 mol Br ₂) AND 2.8(00) / 280 (= 0.01 mol V) 2 alkene / 2 C=C (groups)	1
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2 Bromoalkanes are used widely in industry, although there is increasing concern about their environmental impact.

Fig. 4.1 shows a reaction scheme involving 1,2-dibromoethane.

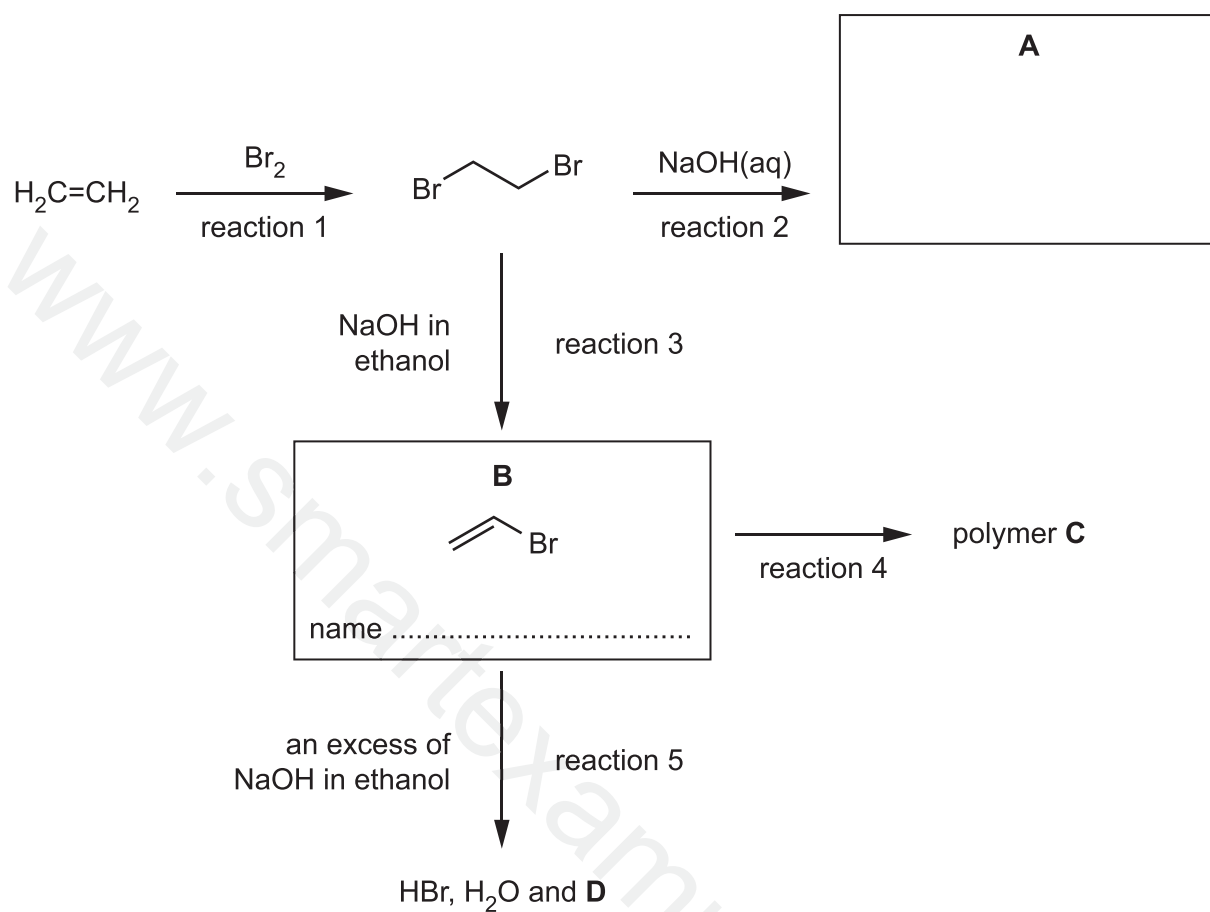


Fig. 4.1

(e) Compound **F** reacts with reagent **G** to form compound **H**.



The infrared spectrum of **H** is shown in Fig. 4.3.

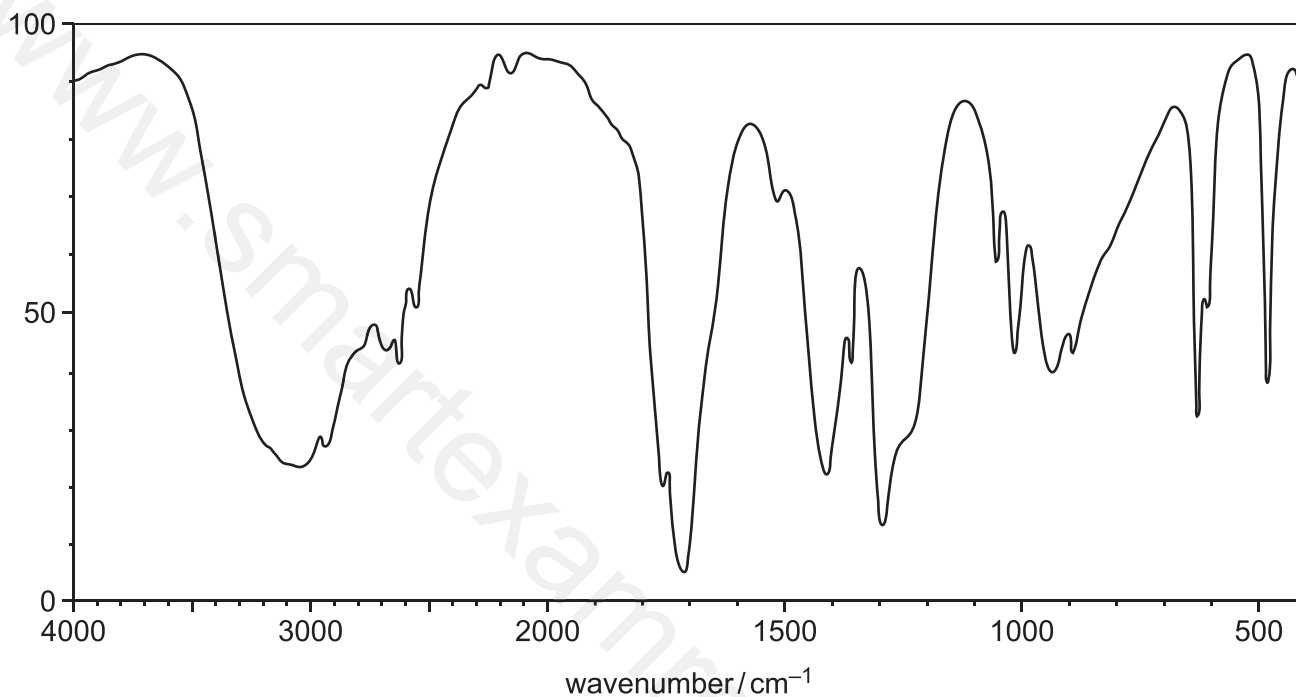


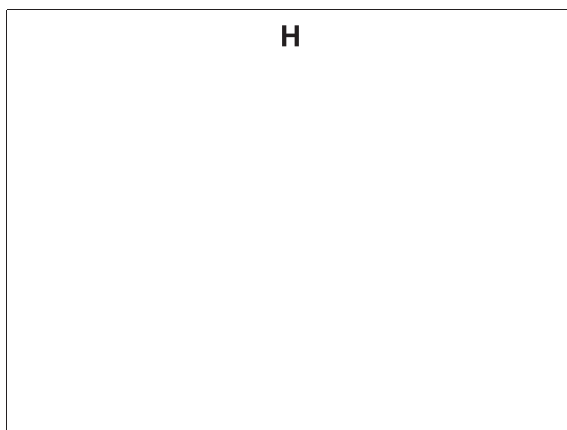
Fig. 4.3

Table 4.2

bond	functional groups containing the bond	characteristic infrared absorption range (in wavenumbers)/cm ⁻¹
C—O	hydroxy, ester	1040–1300
C=C	aromatic compound, alkene	1500–1680
C=O	amide carbonyl, carboxyl ester	1640–1690 1670–1740 1710–1750
C≡N	nitrile	2200–2250
C—H	alkane	2850–2950
N—H	amine, amide	3300–3500
O—H	carboxyl hydroxy	2500–3000 3200–3600

H also shows a molecular ion peak at $m/e = 60$ in its mass spectrum.

- (i) Use the information in (e), Fig. 4.3 and Table 4.2 to deduce the structure of **H**. Explain your answer fully.



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.....
.....


[3]

- (ii) Suggest the role of reagent **G**.

.....

[1]

Mark Scheme:

(i)	<div style="text-align: center;">  </div> <p>M1 identify H =</p> <p>M2 (broad) absorption within the range 3600–2500 cm⁻¹ so O-H (bond) O-H (bond) is equivalent to OH <u>bond</u></p> <p>M3 pt 1 and pt 2 •✓ OR pt 1 and pt 3 •✓</p> <ul style="list-style-type: none"> •pt 1 absorption within the range 1670–1750 cm⁻¹ so C=O (bond) •pt 2 absorption within the range 1040–1300 cm⁻¹ so C-O (bond) •pt 3 (M⁺ at <i>m/e</i> = 60 so it has) molecular mass / Mr = 60 	
(ii)	oxidising agent	1

3 The infrared spectrum of **R** is shown in Fig. 5.3.

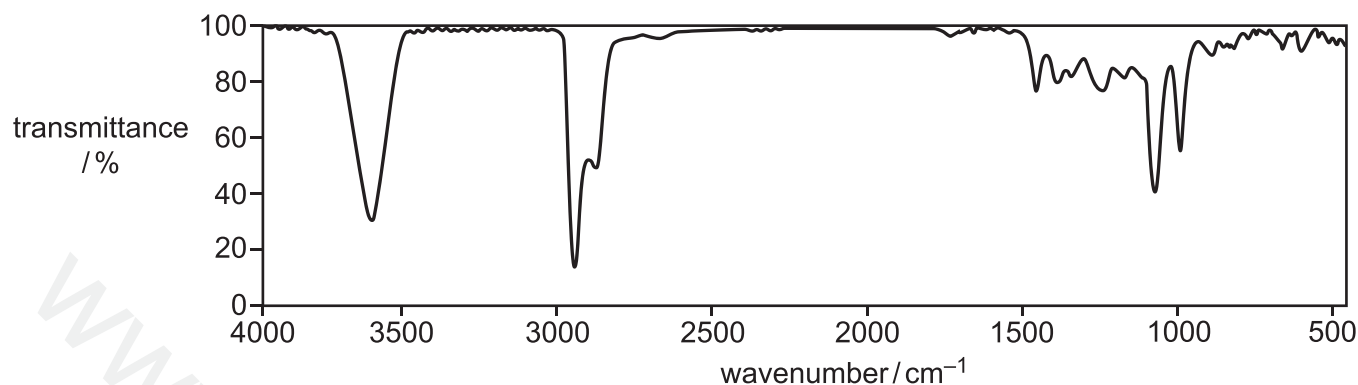


Fig. 5.3

Table 5.1

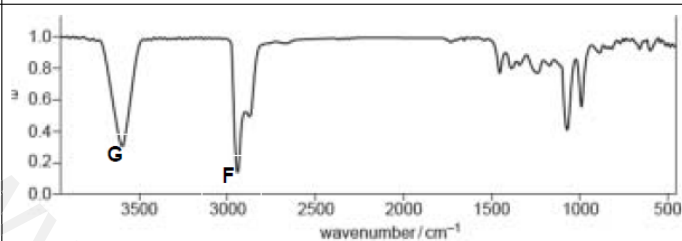
bond	functional groups containing the bond	characteristic infrared absorption range (in wavenumbers)/cm ⁻¹
C–O	hydroxy, ester	1040–1300
C=C	aromatic compound, alkene	1500–1680
C=O	amide carbonyl, carboxyl ester	1640–1690 1670–1740 1710–1750
C≡N	nitrile	2200–2250
C–H	alkane	2850–2950
N–H	amine, amide	3300–3500
O–H	carboxyl hydroxy	2500–3000 3200–3650

Use the absorptions in the region above 1500 cm⁻¹ in Table 5.1 when answering this question.

- Add **F** to Fig. 5.3 to identify the peak that is present in an infrared spectrum of both **Q** and **R**. Identify the bond that corresponds to the absorption for **F**.
.....
- Add **G** to Fig. 5.3 to identify the peak that is **not** present in an infrared spectrum of **Q**. Identify the bond that corresponds to the absorption for **G**.
.....

[2]

Mark Scheme:



2

M1 peak shown around 2850–2950 labelled **F AND** (corresponds to) C—H

M2 peak shown around 3200–3600 labelled **G AND** (corresponds to) O—H (in hydroxy(l) / alcohol)

Compound **W**, $\text{CH}_2=\text{CHCN}$, is used to make an addition polymer which is present in carbon fibres.

- (Propylamine can also be formed in a two-step synthesis from propan-1-ol, as shown in Fig. 6.4.

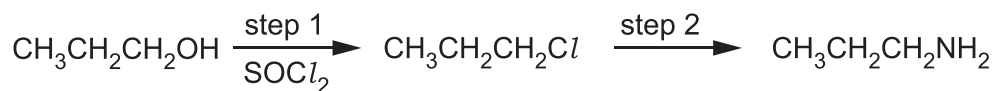


Fig. 6.4

- (i) Name the type of reaction in step 1 in Fig. 6.4.

..... [1]

- (ii) Identify the reagent and conditions for step 2 in Fig. 6.4.

.....
..... [2]

Mark Scheme:

(i)	substitution	1
(ii)	M1 ammonia / NH_3 M2 heat + (M1 in ethanol) under pressure	2

5 Phosphoric(V) acid, H_3PO_4 , is used in both inorganic and organic reactions.

Fig. 3.1 shows a reaction scheme that involves H_3PO_4 in several reactions.

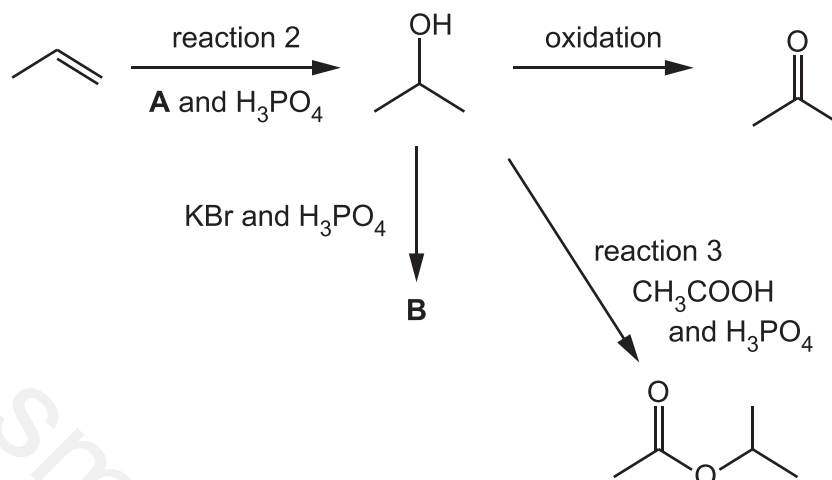


Fig. 3.1

- (i) Identify **A**, which reacts with propene in the presence of H_3PO_4 in reaction 2.

..... [1]

- (ii) Draw the structure of **B**.

[1]

- (iii) Name the type of reaction that occurs in reaction 3.

..... [1]

- (iv) Reaction 3 is monitored using infrared spectroscopy. It is not possible to use the O—H absorption frequency to monitor the reaction.

Use Table 3.2 to identify a suitable bond whose absorption frequency can be used to monitor the progress of reaction 3.

State the change you would see in the infrared spectrum during reaction 3.

bond


change in infrared spectrum

[2]

Table 3.2

bond	functional groups containing the bond	characteristic infrared absorption range (in wavenumbers) / cm^{-1}
C—O	hydroxy, ester	1040–1300
C=C	aromatic compound, alkene	1500–1680
C=O	amide carbonyl, carboxyl ester	1640–1690 1670–1740 1710–1750
C—H	alkane	2850–2950

Mark Scheme:

(i)	H ₂ O / steam	1
(ii)		1
(iii)	condensation	1
(iv)	C=O	1
	absorption changes to frequency / wavenumber / from 1670–1740 to 1710–1750 cm ⁻¹	1