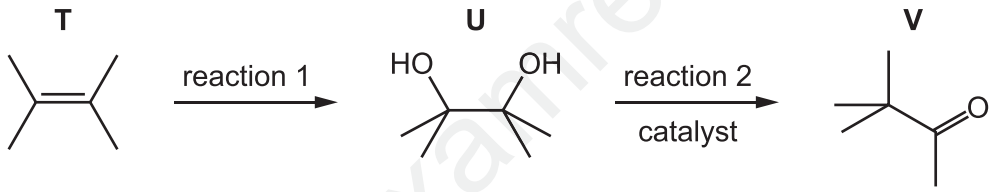
www.smartexamresources.com

1 Compound **T** is an isomer of C_6H_{12}.

A reaction scheme starting with **T** is shown. Reaction 2 occurs in the presence of a catalyst; knowledge of the mechanism for this reaction is not required.



(iii) The progress of reaction 2 can be monitored by infrared spectroscopy.

The absorption caused by O–H bonds is always present because water is used as a solvent.

Identify two absorptions, and the bonds responsible for these absorptions, whose appearance will change significantly during the reaction.

1 .....

.....

2 .....

.....

[2]

MARK SCHEME:

(iii)	**M1** C—O in range 1040–1300 (cm^{-1}) **M2** C=O in range 1670–1740 (cm^{-1})	**2**

www.smartexamresources.com

2 Lactones are cyclic esters. Under suitable conditions, lactones form from molecules that have both an alcohol and a carboxylic acid functional group.
Equation **1** shows an example of the formation of a lactone.

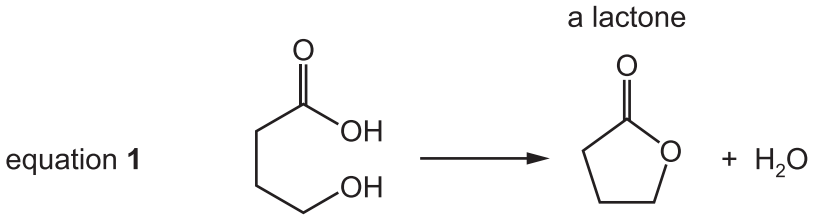


Fig. 5.1 shows the synthesis of lactone **P** from compound **M**.

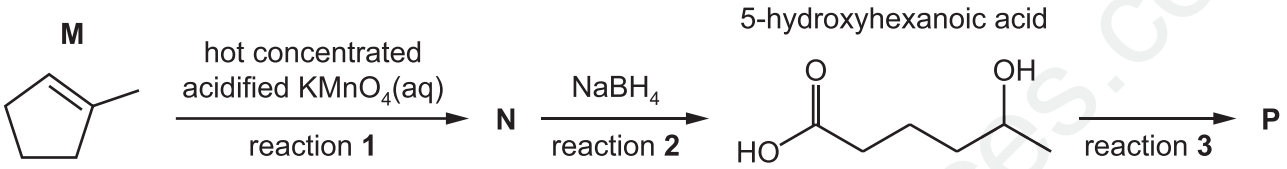


Fig. 5.1

(a) (i) **M** reacts with hot concentrated acidified $KMnO_4$(aq) to form **N**, $C_6H_{10}O_3$, in reaction **1**.

Draw the structure of **N**.

[1]

(ii) **N** is reduced by $NaBH_4$ to form 5-hydroxyhexanoic acid in reaction **2**.

Construct an equation for reaction **2** using molecular formulae.
In the equation, use [H] to represent one atom of hydrogen from the reducing agent.

..... [1]

(iii) Reaction **2** is a nucleophilic addition.

Suggest why reaction **2** creates a mixture of two organic compounds.

.....

..... [2]

www.smartexamresources.com

(iv) Draw lactone **P**, the product of reaction **3**.

[1]

(b) A student monitors the progress of reaction **2** using infrared spectroscopy.

Use Table 5.1 to suggest why it is difficult to distinguish between **N** and 5-hydroxyhexanoic acid using infrared spectroscopy.

.....

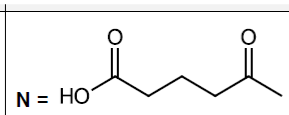
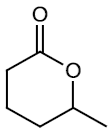
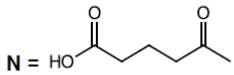
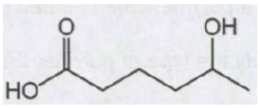
..... [2]

Table 5.1

bond	functional group 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	2850–3100
N–H	amine, amide	3300–3500
O–H	carboxyl hydroxy	2500–3000 3200–3650

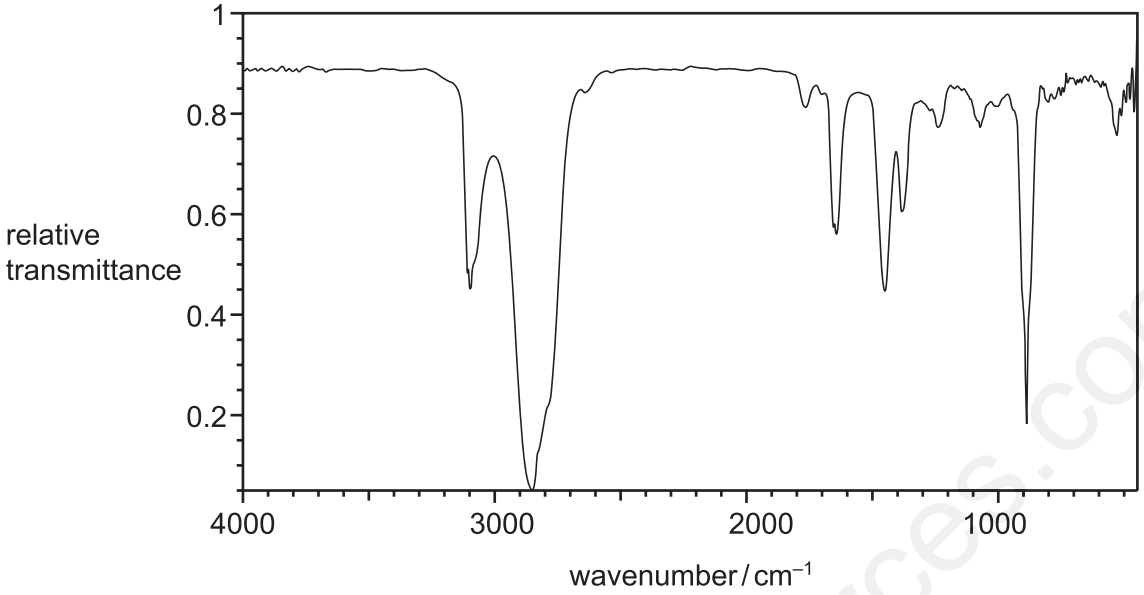
www.smartexamresources.com

MARK SCHEME:

(a)(i)	**N** = 	**1**
(a)(ii)	$C_6H_{10}O_3 + 2[H] \rightarrow C_6H_{12}O_3$	**1**
a)(iii)	**M1** (ketone in) **N** is planar (so can be attacked from either side)	**1**
	M2 because different stereoisomers / optical isomers form	**1**
a)(iv)		**1**
(b)	**N** =  ; **5-hh**  --- **M1** absorptions will overlap / be similar / the same / indistinguishable	**1**

www.smartexamresources.com

3 The infra-red spectrum of 2-methylbut-1-ene is shown.



Predict two main differences that would be seen between the spectra of **Y**, $CH_3CH_2COCH_3$, and of 2-methylbut-1-ene. Give reasons for your predictions.

Your answer should refer only to the region of each spectrum **above 1500 cm^{-1}**.

.....

.....

.....

.....

..... [2]

www.smartexamresources.com

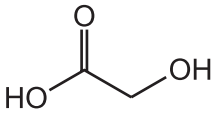
MARK SCHEME:

*Predict **two** differences, with reasons, between spectra of **Y**, $CH_3CH_2COCH_3$ and 2-methylbut-1-ene (shown)* *first difference* **M1** absence of peak/ absorption at 3100 (cm^{-1}) as no longer any =C–H present (in **Y**) *second difference* **M2** peak at 1650 (cm^{-1}) moves to the left to any value / range of values between 1670 and 1740) due to disappearance of C=C (in **Y**) and appearance of C=O (in **Y**) OR absence of peak at 1650 (cm^{-1}) as no longer any C=C present (in **Y**) AND appearance of peak (in **Y**) at (any value / range of values) between 1670-1740(cm^{-1}) due to C=O	**2**

www.smartexamresources.com

4 Reaction 2 needs to take place in the absence of water to prevent formation of compound **C**.

C



If **C** is present in the reaction mixture of reaction 3, a different compound, compound **D**, will also form. Compound **D** has two identical functional groups.

The infrared spectrum of **D** shows strong absorptions at 1100 cm^{-1} and 1720 cm^{-1}, but no absorption due to O–H bonds.

Use the *Data Booklet* to identify the functional group present in **D**.

Explain your answer as fully as you can.

.....

.....

.....

..... [3]

www.smartexamresources.com

MARK SCHEME:

M1 ester **M2** 1100 cm^{-1} linked to C—O **AND** 1720 cm^{-1} linked to C=O **M3** No COOH / carboxylic acid and No OH / alcohol in D (but present in C) **OR** COOH / carboxylic acid and OH / alcohol reacted /lost (in C to form D)	**3**

www.smartexamresources.com

5 Propanone, CH_3COCH_3, is an important organic reagent. Fig. 4.1 shows some reactions of propanone and its derivatives.

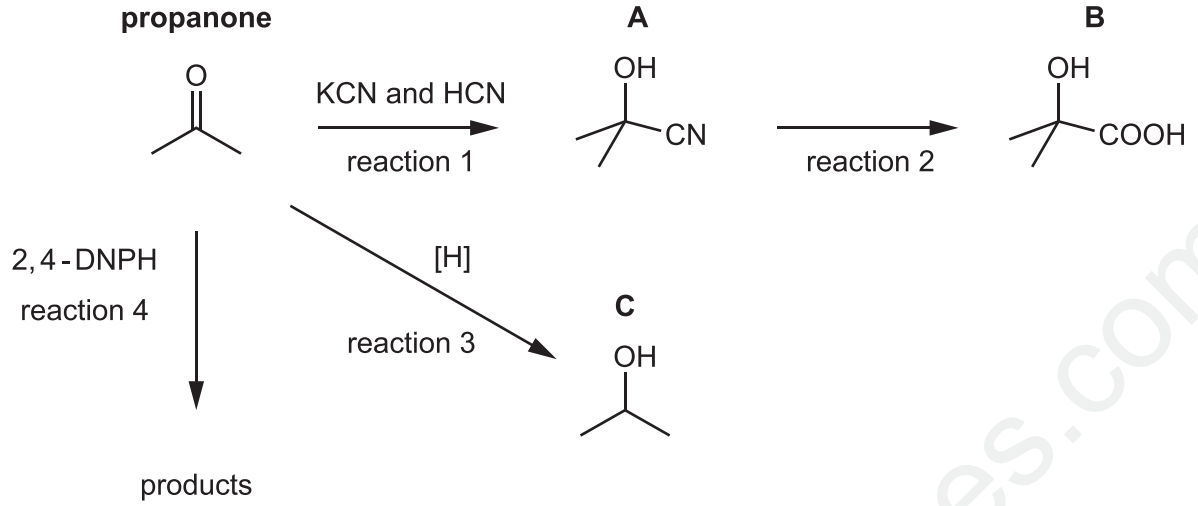
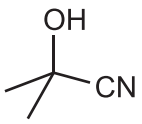


Fig. 4.1

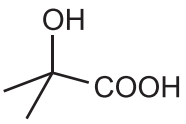
www.smartexamresources.com

(f) Compounds **A**, **B** and **C** can be distinguished using infrared spectroscopy.

A



B



C

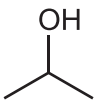


Fig. 4.3 shows the infrared spectrum of one of the compounds.

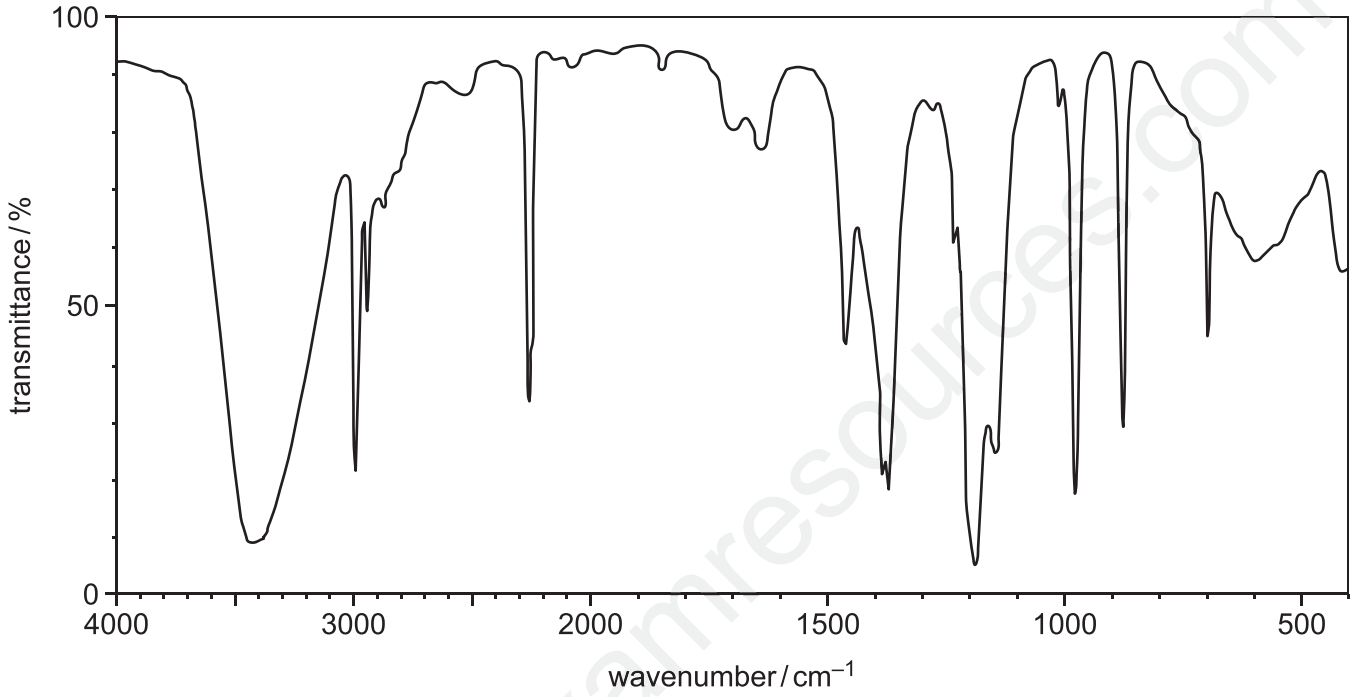


Fig. 4.3

Table 4.1

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 3200–3600

www.smartexamresources.com

(i) Explain why the absorptions at 2850–2950 cm^{-1} are **not** useful to help determine which of the compounds **A**, **B** or **C** produces the infrared spectrum in Fig. 4.3.

Use Table 4.1 to answer this question.

.....

..... [1]

(ii) Identify which of compounds **A**, **B** or **C** produces the infrared spectrum in Fig. 4.3. Explain your answer.

compound .....

explanation .....

.....

.....

[1]

www.smartexamresources.com

Mark Scheme:

(f)(i)	All three have a C—H **OR** CH **bond**	**1**
(f)(ii)	compound **A** **AND** absorption at 2200–2250 cm^{-1} indicates C≡N	**1**

www.smartexamresources.com