

40 The purity of a compound can be determined using infrared spectroscopy.

The table gives the characteristic infrared absorption frequencies for some selected bonds.

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

Propan-2-ol is made by hydration of propene. A sample of the product is obtained.

Which feature of the infrared spectrum of the product would show that **no** propene remains in the product?

- A** absorption in the 2900 cm^{-1} region
- B** strong absorption below 1000 cm^{-1}
- C** the lack of absorption at or near 1250 cm^{-1}
- D** the lack of absorption at or near 1550 cm^{-1}

Important values, constants and standards

molar gas constant	$R = 8.31\text{ J K}^{-1}\text{ mol}^{-1}$
Faraday constant	$F = 9.65 \times 10^4\text{ C mol}^{-1}$
Avogadro constant	$L = 6.02 \times 10^{23}\text{ mol}^{-1}$
electronic charge	$e = -1.60 \times 10^{-19}\text{ C}$
molar volume of gas	$V_m = 22.4\text{ dm}^3\text{ mol}^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0\text{ dm}^3\text{ mol}^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14}\text{ mol}^2\text{ dm}^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18\text{ kJ kg}^{-1}\text{ K}^{-1}$ ($4.18\text{ J g}^{-1}\text{ K}^{-1}$)

- 3 Cycloalkanes show similar chemical properties to alkanes but have the same empirical formula as alkenes.

(a) Define empirical formula.

.....
..... [1]

- (b) Cyclopentane, C_5H_{10} , has four cyclic structural isomers. One of these isomers is **C**, shown in Fig. 3.1.

Complete Fig. 3.1 to show two other cyclic structural isomers of C_5H_{10} .

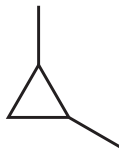
cyclopentane 			C 
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Fig. 3.1

[2]

- (c) Cyclopentane reacts with Cl_2 in the presence of ultraviolet light to form C_5H_9Cl .

(i) The reaction is initiated by the bond fission of Cl_2 .

State the type of bond fission shown in the initiation step.

..... [1]

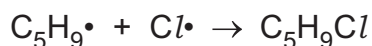
(ii) Complete the equations to show the two propagation steps that follow the initiation step.

propagation 1 $C_5H_{10} + \dots \rightarrow C_5H_9\cdot + \dots$

propagation 2 $C_5H_9\cdot + \dots \rightarrow \dots$

[2]

(iii) The final step is shown.



Give the name for this step in the reaction.

..... [1]

(d) Fig. 3.2 shows a reaction cycle involving cyclopentane, cyclopentene and $\text{C}_5\text{H}_9\text{Cl}$.

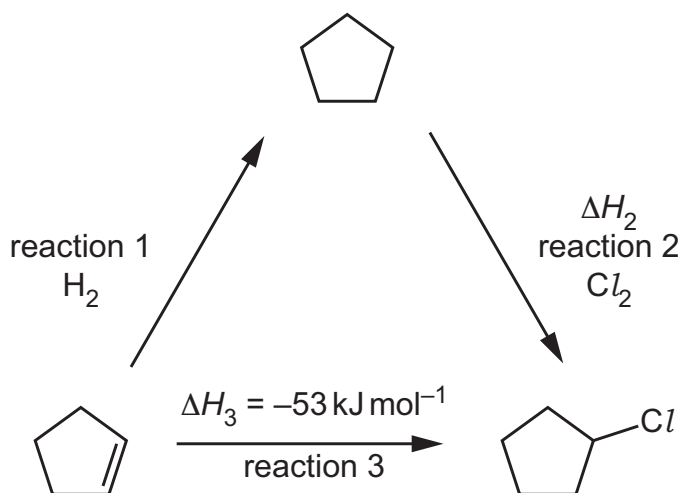


Fig. 3.2

(i) Identify a suitable reagent for reaction 3.

..... [1]

(ii) Use the data in Fig. 3.2 and in Table 3.1 to calculate the enthalpy change of reaction 2, ΔH_2 .

Table 3.1

compound	enthalpy change of combustion, $\Delta H_c / \text{kJ mol}^{-1}$
	-3292
	-3115
H_2	-286

(e) Cyclopentene, C_5H_8 , reacts with hot concentrated acidified $KMnO_4$ to form compound **W**, $C_5H_8O_4$.

(i) Draw the structure of **W**.

[1]

(ii) The infrared spectrum of **W** is shown in Fig. 3.3.

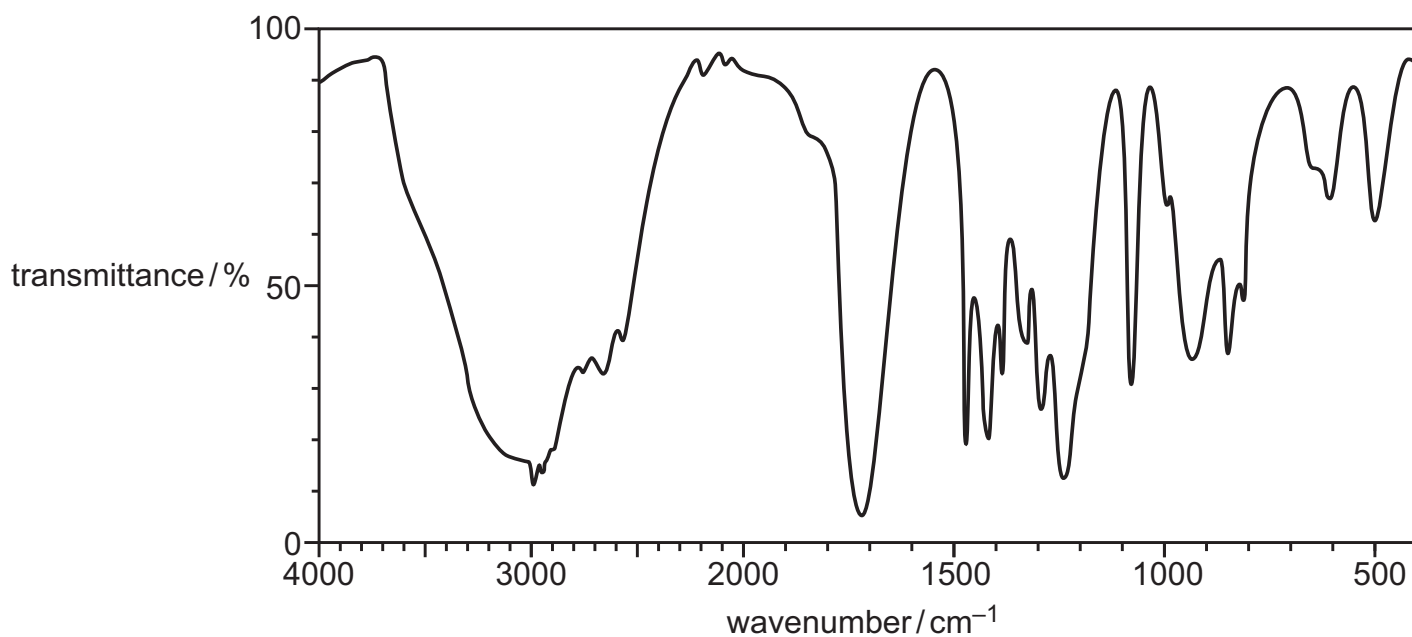


Fig. 3.3

Identify **two** absorptions in the infrared spectrum of **W** that would **not** be present in the infrared spectrum of cyclopentene.

- Write **1** or **2** on Fig. 3.3 against each of these two absorptions.
- Complete Table 3.2 to show which bond is responsible for each absorption that you have identified in Fig. 3.3.

Table 3.2

absorption	1	2
bond responsible		

[2]

Table 3.3

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
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[Total: 13]

4 Fig. 4.1 shows a possible synthesis of propene, C_3H_6 .

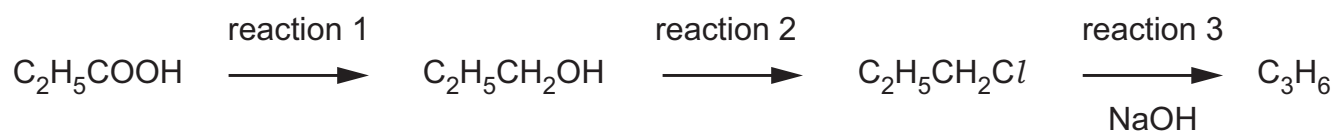


Fig. 4.1

(a) (i) Identify the type of reaction that occurs in reaction 1.

..... [1]

(ii) Suggest a suitable reagent for reaction 2.

..... [1]

(iii) Reaction 3 is an elimination reaction.

Write an equation for this reaction and identify the solvent and conditions used.

equation

solvent and conditions [2]

(iv) $C_2H_5CH_2OH$ can be directly converted to C_3H_6 .

Suggest the reagent and conditions for this conversion.

..... [1]

(b) Under suitable conditions, propene polymerises to form poly(propene).

Poly(propene) exhibits stereoisomerism.

(i) Identify the type of polymerisation that forms poly(propene) from propene.

..... [1]

(ii) Define stereoisomerism.

..... [2]

(iii) Draw a section of poly(propene), showing **two** repeat units.

Use your diagram to identify the type of stereoisomerism shown by poly(propene). Explain your answer.

section of poly(propene)

[3]

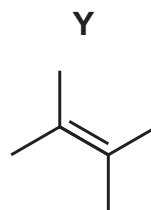
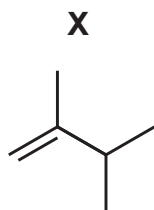
(iv) State **two** difficulties associated with the disposal of poly(propene).

1

2

[2]

(c) Under different conditions, two molecules of propene can combine to form compounds **X** and **Y**.



(i) Name **X**.

..... [1]

(ii) Fig. 4.2 shows the mass spectrum of either compound **X** or compound **Y**.

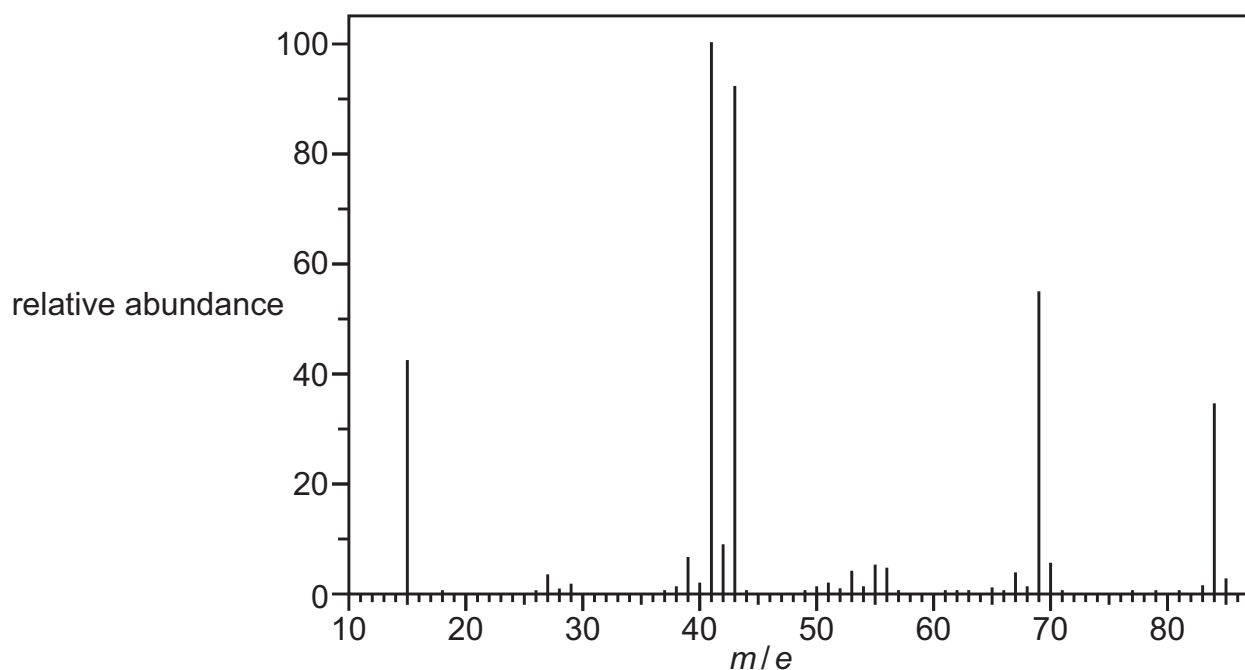


Fig. 4.2

Identify which of **X** and **Y** gives this mass spectrum.

Give **one** reason for your answer, referring to the fragmentation pattern.

.....
.....
..... [1]

(iii) The molecular ion peak in the spectrum in Fig. 4.2 has relative abundance 34.7.

Calculate the relative abundance of the $[M+1]^+$ peak in this spectrum.

relative abundance of $[M+1]^+$ peak = [1]

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