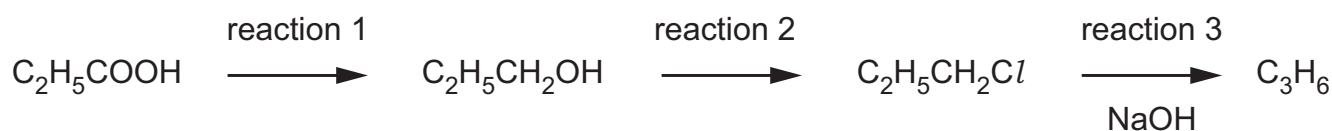


4 Fig. 4.1 shows a possible synthesis of propene,  $C_3H_6$ .



**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]

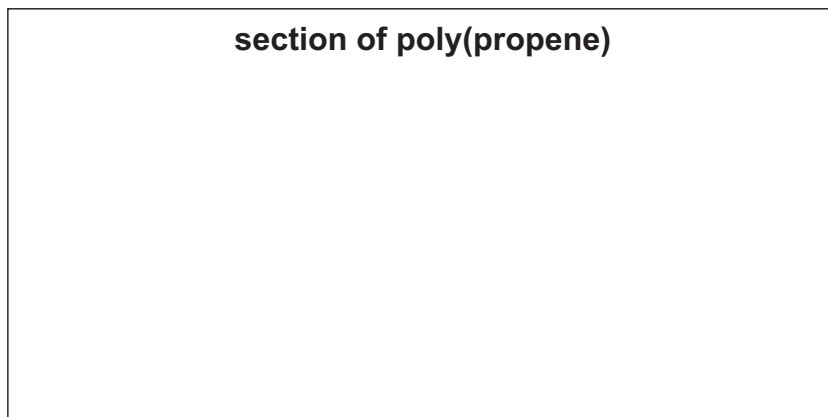
(ii) Define stereoisomerism.

.....

..... [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.



.....

.....

.....

.....

[3]

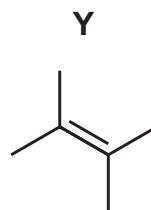
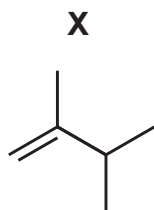
(iv) State **two** difficulties associated with the disposal of poly(propene).

1 .....

2 .....

[2]

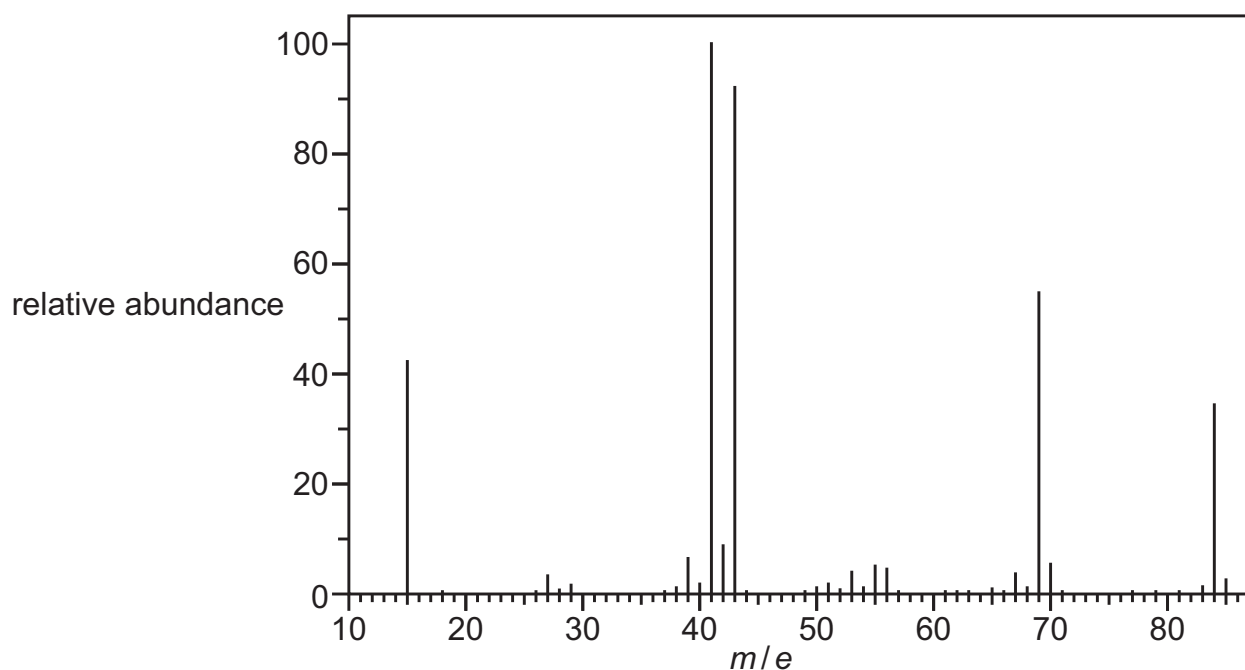
(c) Under different conditions, two molecules of propene can combine to form compounds **X** and **Y**.



(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]

**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)<br>$V_m = 24.0 \text{ dm}^3 \text{ mol}^{-1}$ 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 J g <sup>-1</sup> K <sup>-1</sup> )                                                    |

The Periodic Table of Elements

| Group |   |  |  |  |  |  |  |  |  |  |  |  |  |    |    |    |    |                          |    |  |
|-------|---|--|--|--|--|--|--|--|--|--|--|--|--|----|----|----|----|--------------------------|----|--|
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- 4 Fig. 4.1 shows how propane,  $C_3H_8$ , can be converted to propanoic acid,  $CH_3CH_2COOH$ .

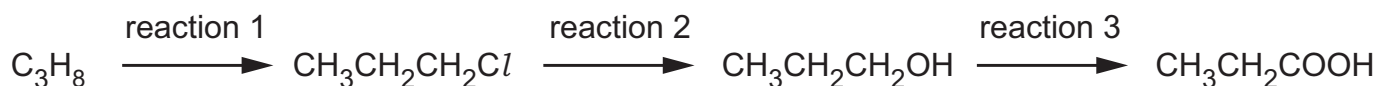
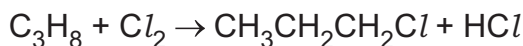


Fig. 4.1

- (a) Reaction 1 in Fig. 4.1 takes place in the presence of sunlight.



The reaction takes place via initiation, propagation and termination steps.

- (i) Name the mechanism shown by reaction 1.

..... [1]

- (ii) Complete the mechanism for reaction 1.

Construct equations to describe the steps of the mechanism.



propagation 1 .....

propagation 2 .....

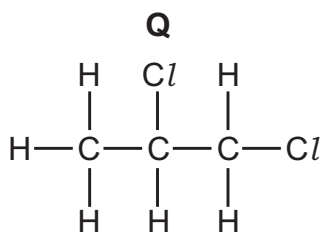
termination .....  $\rightarrow CH_3CH_2CH_2Cl$   
[3]

- (iii) Reaction 1 is initiated by the bond fission of  $Cl_2$ .

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

..... [1]

- (iv) Compound **Q** is a by-product of reaction 1.



Name **Q**.

..... [1]

- (v) The molecular formula of **Q** is  $\text{C}_3\text{H}_6\text{Cl}_2$ .

Identify the types of structural isomerism and stereoisomerism that a molecule with molecular formula  $\text{C}_3\text{H}_6\text{Cl}_2$  can show.

type of structural isomerism .....

type of stereoisomerism .....

[2]

- (b) State the reagent and solvent required for reaction 2.

..... [1]

- (c) Reaction 3 takes place when  $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$  is heated under reflux with acidified potassium dichromate(VI) solution.

- (i) State the colour change that takes place in the reaction mixture.

..... [1]

- (ii) Construct an equation to represent reaction 3. Use [O] to represent an atom of oxygen from the oxidising agent.

..... [1]

(d)  $\text{CH}_3\text{CH}_2\text{COOH}$  reacts with an unsaturated alcohol **R** to form unsaturated ester **S**.

(i) State the **type** of reaction that forms **S**.

..... [1]

(ii) The infrared spectrum of **S** is shown in Fig. 4.2.

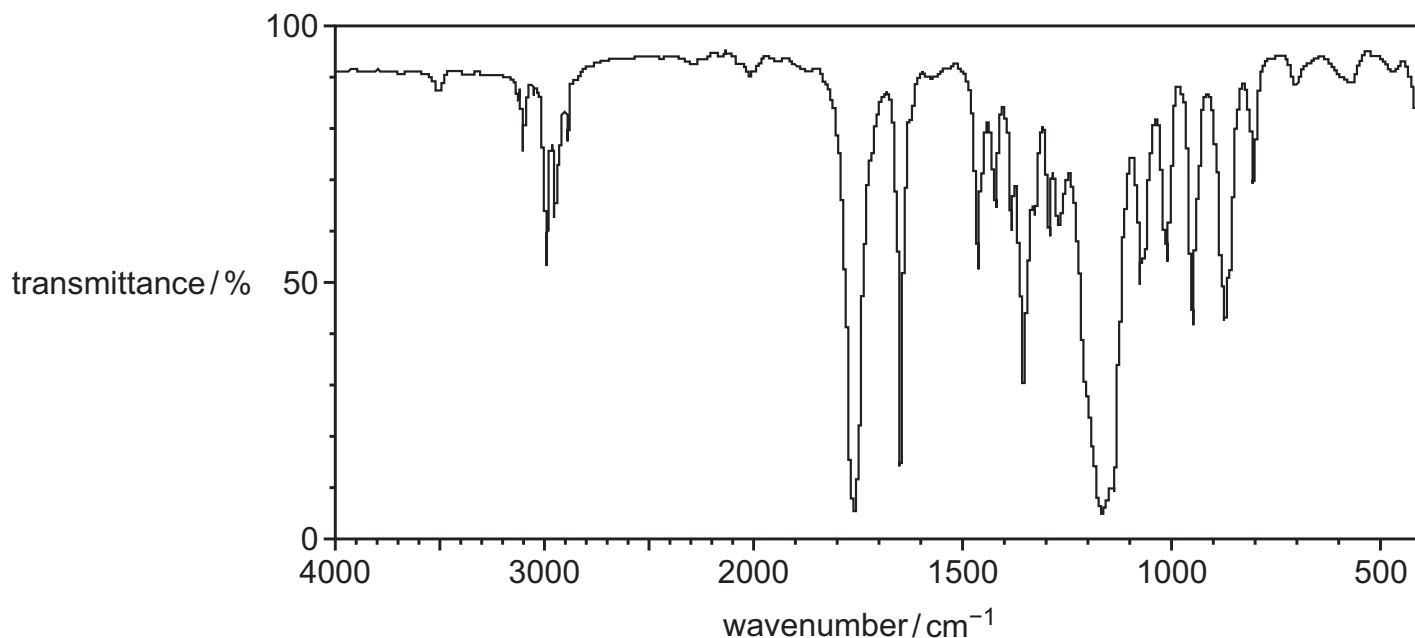


Fig. 4.2

Three absorptions in the infrared spectrum in Fig. 4.2 confirm that **S** is an ester and is unsaturated.

- Write **1**, **2** or **3** on Fig. 4.2 against each of these three absorptions.
- Complete Table 4.1 to show which bond is responsible for each absorption that you have identified in Fig. 4.2.

Table 4.1

| absorption       | 1 | 2 | 3 |
|------------------|---|---|---|
| bond responsible |   |   |   |

[3]



**Table 4.2**

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

(iii) The mass spectrum of **S** shows the following peaks.

**Table 4.3**

| peak               | relative abundance |
|--------------------|--------------------|
| M <sup>+</sup>     | 4.7                |
| [M+1] <sup>+</sup> | 0.31               |

Use Table 4.3 to calculate the number of carbon atoms in **S**.

number of carbon atoms in **S** = ..... [1]

[Total: 16]

### 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)<br>$V_m = 24.0 \text{ dm}^3 \text{ mol}^{-1}$ 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 J g <sup>-1</sup> K <sup>-1</sup> )                                                    |

The Periodic Table of Elements

| Group |   |  |  |  |  |  |  |  |  |  |  |  |  |    |    |    |    |                          |    |  |
|-------|---|--|--|--|--|--|--|--|--|--|--|--|--|----|----|----|----|--------------------------|----|--|
| 1     | 2 |  |  |  |  |  |  |  |  |  |  |  |  | 13 | 14 | 15 | 16 | 17                       | 18 |  |
|       |   |  |  |  |  |  |  |  |  |  |  |  |  |    |    |    |    | 2<br>He<br>helium<br>4.0 |    |  |
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