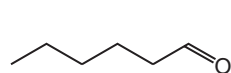
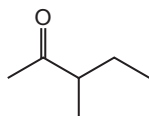


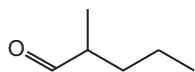
25 The diagrams show skeletal formulas of some isomers of $C_6H_{12}O$.



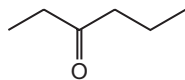
1



2



3



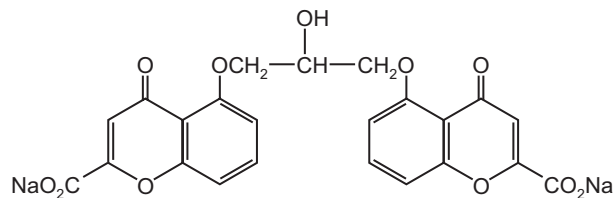
4

Which statement is correct?

- A** 1 and 3 are chain isomers of each other and positional isomers of each other.
B 2 and 3 are functional group isomers of each other and both have a chiral centre.
C 1 and 4 are functional group isomers of each other and both have a chiral centre.
D 2 and 4 are positional isomers of each other and functional group isomers of each other.

26 The structure of disodium cromoglycate is shown.

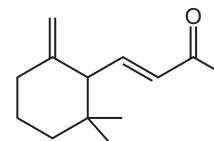
disodium cromoglycate



How many chiral centres are there in this molecule?

- A** 0 **B** 1 **C** 2 **D** 3

26 The structure of the compound γ -ionone is shown.

 γ -ionone

Including γ -ionone, how many stereoisomers exist with this molecular formula?

- A** 1 **B** 2 **C** 4 **D** 8

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

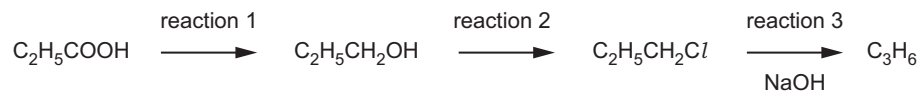


Fig. 4.1

(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**.

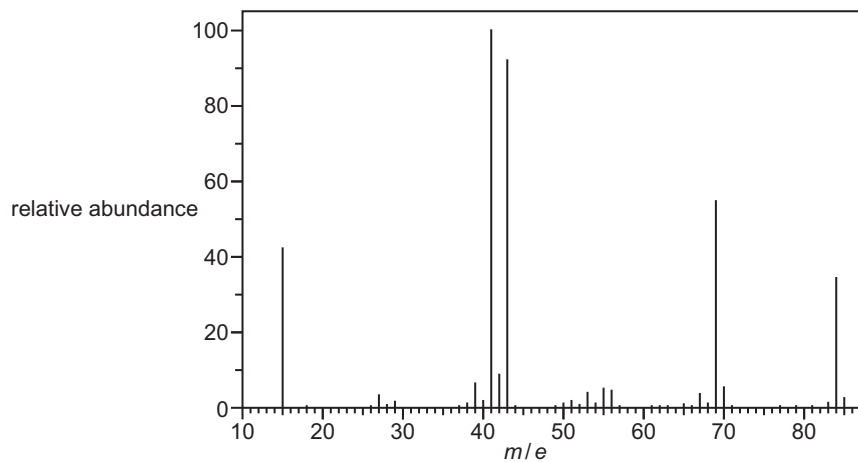


Fig. 4.2

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]

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	$c = 4.18 \text{ kJ kg}^{-1} \text{ K}^{-1}$ ($4.18 \text{ J g}^{-1} \text{ K}^{-1}$)

The Periodic Table of Elements

Group																	
1	2	Key														17	18
		atomic number atomic symbol name relative atomic mass															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Li lithium 6.9	Be beryllium 9.0	Na sodium 23.0	Mg magnesium 24.3														He helium 4.0
11	12																
K potassium 39.1	Ca calcium 40.1	Sc scandium 45.0	Ti titanium 47.9	V vanadium 50.9	Cr chromium 52.0	Mn manganese 54.9	Fe iron 55.8	Co cobalt 58.9	Ni nickel 58.7	Cu copper 63.5	Zn zinc 65.4	Ga gallium 69.7	Ge germanium 72.6	As arsenic 74.9	Se selenium 79.0	Br bromine 79.9	Kr krypton 83.8
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb rubidium 85.5	Sr strontium 87.6	Y yttrium 88.9	Zr zirconium 91.2	Nb niobium 92.9	Mo molybdenum 95.9	Tc technetium —	Ru ruthenium 101.1	Rh rhodium 102.9	Pd palladium 106.4	Ag silver 107.9	Cd cadmium 112.4	In indium 114.8	Sn tin 118.7	Sb antimony 121.8	Te tellurium 127.6	I iodine 126.9	Xe xenon 131.3
55	56	57–71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs caesium 132.9	Ba barium 137.3	lanthanoids					Os osmium 190.2	Ir iridium 192.2	Pt platinum 195.1	Au gold 197.0	Hg mercury 200.6	Tl thallium 204.4	Pb lead 207.2	Bi bismuth 209.0	Po polonium —	At astatine —	Rn radon —
87	88	89–103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
Fr francium —	Ra radium —	actinoids					Hs hassium —	Mt meitnerium —	Ds darmstadtium —	Rg roentgenium —	Cn copernicium —	Nh nihonium —	Fl flerovium —	Mc moscovium —	Lv livermorium —	Ts tennessine —	Og oganeson —

4 Fig. 4.1 shows how propane, C₃H₈, can be converted to propanoic acid, CH₃CH₂COOH.

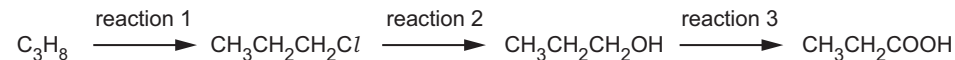
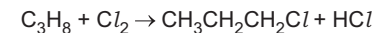


Fig. 4.1

(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

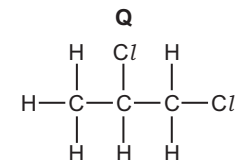
termination $\rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$ [3]

(iii) Reaction 1 is initiated by the bond fission of Cl₂.

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 $C_3H_6Cl_2$.

Identify the types of structural isomerism and stereoisomerism that a molecule with molecular formula $C_3H_6Cl_2$ 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 $CH_3CH_2CH_2OH$ 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) CH_3CH_2COOH 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.

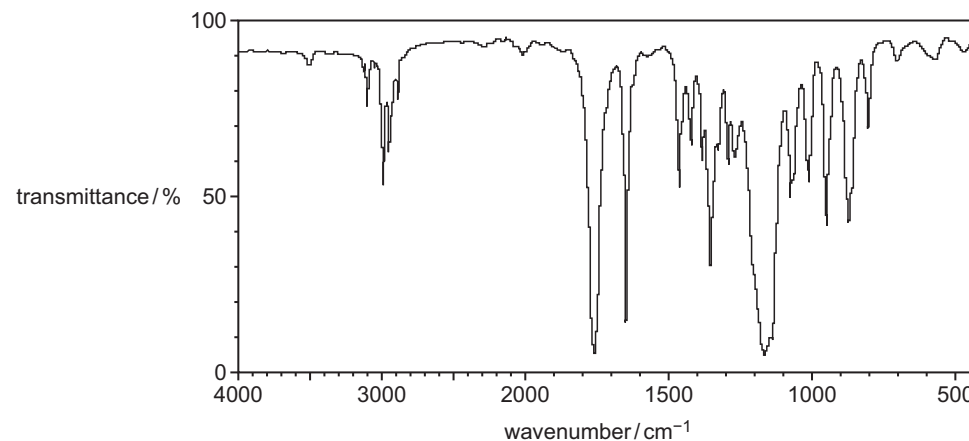


Fig. 4.2

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 (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

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

Table 4.3

peak	relative abundance
M ⁺	4.7
[M+1] ⁺	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) $V_m = 24.0 \text{ dm}^3 \text{ mol}^{-1}$ 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 Jg ⁻¹ K ⁻¹)

The Periodic Table of Elements

Group																	
1	2	Key atomic number atomic symbol name relative atomic mass														18	18
3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	He	He
Li lithium 6.9	Be beryllium 9.0															Ne	Ne
Na sodium 23.0	Mg magnesium 24.3															Ar	Ar
11	12															Ne	Ne
K potassium 39.1	Ca calcium 40.1															Ar	Ar
37	38															Ar	Ar
Rb rubidium 85.5	Sr strontium 87.6															Ar	Ar
55	56															Ar	Ar
Cs caesium 132.9	Ba barium 137.3															Ar	Ar
87	88															Ar	Ar
Fr francium —	Ra radium —															Ar	Ar
57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74
La lanthanum 138.9	Ce cerium 140.1	Pr praseodymium 140.9	Nd neodymium 144.2	Pm promethium —	Sm samarium 150.4	Eu europium 152.0	Gd gadolinium 157.3	Tb terbium 158.9	Dy dysprosium 162.5	Ho holmium 164.9	Er erbium 167.3	Tm thulium 168.9	Yb ytterbium 173.1	Lu lutetium 175.0	75	76	77
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106
Ac actinium —	Th thorium 232.0	Pa protactinium 231.0	U uranium 238.0	Np neptunium —	Pu plutonium —	Am americium —	Cm curium —	Bk berkelium —	Cf californium —	Es einsteinium —	Fm fermium —	Md mendelevium —	No nobelium —	Lr lawrencium —	107	108	109
lanthanoids															actinoids		

4 Compounds **P** and **Q** are structural isomers.



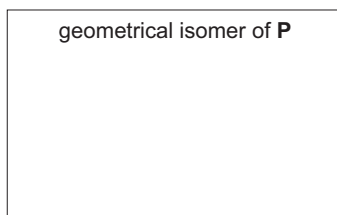
Fig. 4.1

(a) (i) Define structural isomerism.

.....
 [2]

(ii) **P** shows geometrical isomerism.

Draw the geometrical isomer of **P**. Explain why the two isomers are **not** identical.



explanation

 [2]

(iii) Both **P** and **Q** react with aqueous bromine.

Name the mechanism of this reaction.

..... [1]

(iv) **Q** is oxidised by hot concentrated acidified $\text{KMnO}_4(\text{aq})$, forming two different organic products.

Construct an equation for this reaction. Use [O] to represent an atom of oxygen from the oxidising agent.

$(\text{CH}_3)_2\text{C}=\text{CHCH}_3$ [2]

(v) **Q** reacts with $\text{HBr}(\text{g})$ to produce two structural isomers, **R** and **S**, as shown in Fig. 4.2.

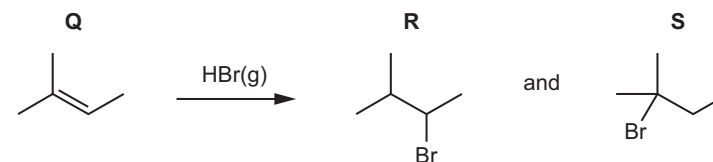


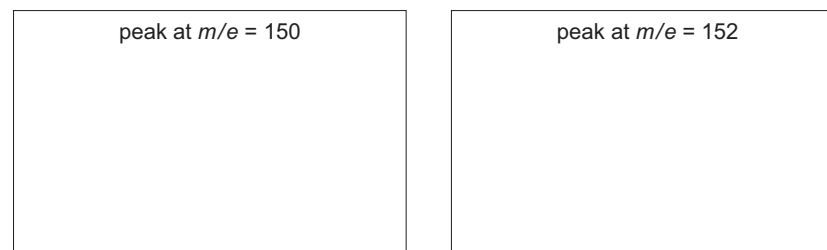
Fig. 4.2

State and explain why isomer **S** is the major product of the reaction.

.....
 [2]

(vi) The mass spectrum of **R** shows peaks at $m/e = 150$ and $m/e = 152$.

Suggest structures for the ions responsible for these peaks.



[2]

(b) Fig. 4.3 shows a synthesis starting from **T**, a different isomer of **R** and **S**.

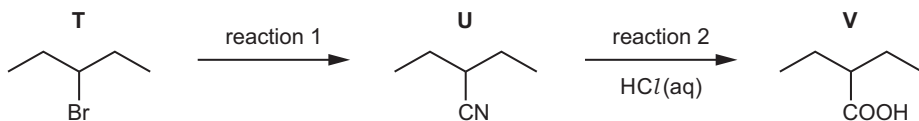


Fig. 4.3

(i) Identify the reagent and conditions for reaction 1.

..... [1]

(ii) Reaction 2 is a hydrolysis reaction.

Construct an equation for reaction 2.

$(\text{C}_2\text{H}_5)_2\text{CHCN}$ [1]

(iii) **V** reacts with propan-2-ol in the presence of a catalytic amount of H_2SO_4 to form organic compound **W**.

Complete Table 4.1 to give details of this reaction.

Table 4.1

	reaction of V with propan-2-ol
type of reaction	
functional group formed	
molecular formula of organic product W	

[3]

[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	$e = -1.60 \times 10^{-19} \text{ C}$
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specific heat capacity of water	$c = 4.18 \text{ kJ kg}^{-1} \text{ K}^{-1}$ ($4.18 \text{ J g}^{-1} \text{ K}^{-1}$)

The Periodic Table of Elements

Group																																			
1	2	Key												13	14	15	16	17	18																
		atomic number atomic symbol name relative atomic mass												1								2													
3	4													5	6	7	8	9	10	11	12								He						
Li lithium 6.9	Be beryllium 9.0													B boron 10.8	C carbon 12.0	N nitrogen 14.0	O oxygen 16.0	F fluorine 19.0	Ne neon 20.2								He helium 4.0								
11	12													13	14	15	16	17	18																
Na sodium 23.0	Mg magnesium 24.3													Al aluminium 27.0	Si silicon 28.1	P phosphorus 31.0	S sulfur 32.1	Cl chlorine 35.5	Ar argon 39.9																
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36																		
K potassium 39.1	Ca calcium 40.1	Sc scandium 45.0	Ti titanium 47.9	V vanadium 50.9	Cr chromium 52.0	Mn manganese 54.9	Fe iron 55.8	Co cobalt 58.9	Ni nickel 58.7	Cu copper 63.5	Zn zinc 65.4	Ga gallium 69.7	Ge germanium 72.6	As arsenic 74.9	Se selenium 79.0	Br bromine 79.9	Kr krypton 83.8																		
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54																		
Rb rubidium 85.5	Sr strontium 87.6	Y yttrium 88.9	Zr zirconium 91.2	Nb niobium 92.9	Mo molybdenum 95.9	Tc technetium —	Ru ruthenium 101.1	Rh rhodium 102.9	Pd palladium 106.4	Ag silver 107.9	Cd cadmium 112.4	In indium 114.8	Sn tin 118.7	Sb antimony 121.8	Te tellurium 127.6	I iodine 126.9	Xe xenon 131.3																		
55	56	57–71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86																		
Cs caesium 132.9	Ba barium 137.3	lanthanoids												Tl thallium 204.4	Pb lead 207.2	Bi bismuth 209.0	Po polonium —	At astatine —																	
87	88	89–103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118																		
Fr francium —	Ra radium —	actinoids												Nh nihonium —	Fl flerovium —	Mc moscovium —	Lv livermorium —	Ts tennessine —	Og oganeson —																
lanthanoids																																			
57	58	59	60	61	62	63	64	65	66	67	68	69	70	71																					
La lanthanum 138.9	Ce cerium 140.1	Pr praseodymium 140.9	Nd neodymium 144.2	Pm promethium —	Sm samarium 150.4	Eu europium 152.0	Gd gadolinium 157.3	Tb terbium 158.9	Dy dysprosium 162.5	Ho holmium 164.9	Er erbium 167.3	Tm thulium 168.9	Yb ytterbium 173.1	Lu lutetium 175.0																					
actinoids																																			
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103																					
Ac actinium —	Th thorium 232.0	Pa protactinium 231.0	U uranium 238.0	Np neptunium —	Pu plutonium —	Am americium —	Cm curium —	Bk berkelium —	Cf californium —	Es einsteinium —	Fm fermium —	Md mendelevium —	No nobelium —	Lr lawrencium —																					