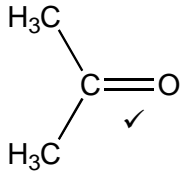
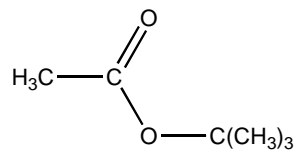
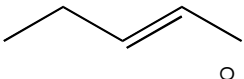
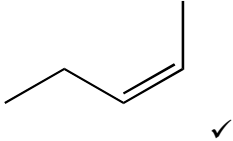
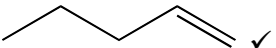
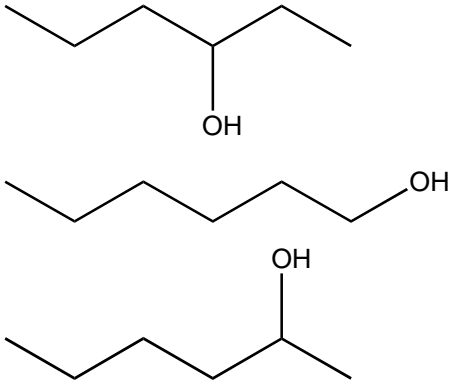


Question		Expected Answers	Marks	Additional Guidance
1	(a)	<p>method 1: fermentation of sugars or carbohydrates OR reaction with yeast with sugar or carbohydrates ✓ $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$ ✓</p> <p>method 2: hydration of ethene OR reaction of ethene with water OR reaction of steam with ethene ✓ $C_2H_4 + H_2O \rightarrow C_2H_5OH$ ✓</p>	4	<p>ALLOW sugar from equation</p> <p>ALLOW C_2H_6O in equation ALLOW correct multiples IGNORE state symbols</p> <p>ALLOW ethene from the equation IGNORE mention of any catalyst ALLOW C_2H_6O in equation OR H_2O over the arrow ALLOW correct multiples IGNORE state symbols</p>
	(b) (i)	<p>$(CH_3)_2CO$ OR</p>  <p>$(CH_3)_2CHOH + [O] \rightarrow (CH_3)_2CO + H_2O$ ✓</p>	2	<p>If name and formula given both need to be correct ALLOW propanone OR acetone IGNORE propone NOT incorrect named compound</p> <p>ALLOW $C_3H_8O + [O] \rightarrow C_3H_6O + H_2O$ ALLOW O instead of [O] ALLOW correct multiples IGNORE state symbols</p>
	(ii)	<p>CH_3CH_2COOH OR propanoic acid ✓</p> <p>Any number or range of numbers between 1750–1640 (cm^{-1}) for C=O ✓</p> <p>Any number or range of numbers between 2500–3300 (cm^{-1}) for O–H ✓</p>	3	<p>ALLOW C=O and O–H marks independent of compound identified i.e. stand alone marks ALLOW correct bonds shown by the appropriate absorption on the IR spectrum IGNORE reference to C–O bond</p>
	(c) (i)	2-methylpropan-2-ol ✓	1	ALLOW methylpropan-2-ol OR tertiarybutanol

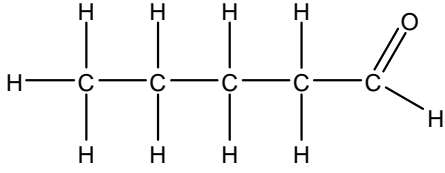
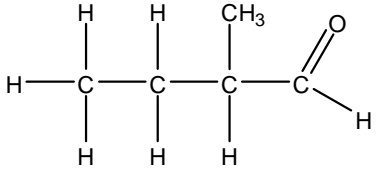
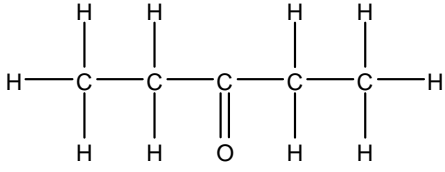
Question		Expected Answers	Marks	Additional Guidance
	(ii)	ester ✓	1	
	(iii)	$\text{CH}_3\text{CO}_2\text{C}(\text{CH}_3)_3$ OR $\text{CH}_3\text{COOC}(\text{CH}_3)_3$ OR  ester group shown ✓ rest of molecule ✓	2	ALLOW skeletal formula OR displayed formula ALLOW ester linkage even if rest of structure is wrong
Total			13	

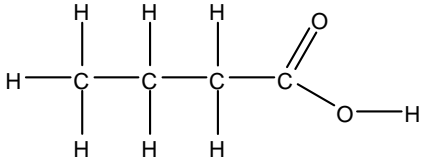
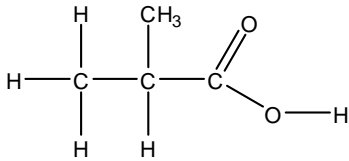
Question	Expected Answers	Marks	Additional Guidance
2 (a)	<p>Structural isomer compounds with the same molecular formula ✓ but with different structural formulae ✓</p> <p>Stereoisomer compounds with the same structural formula ✓ but with different arrangements in space ✓</p> <p>Evidence of using M_r of 70 to calculate molecular formula of C_5H_{10} ✓</p> <p>F and G are</p> <div style="display: flex; justify-content: space-around; align-items: center;">   </div> <p>Correct identification of the <i>E</i> and <i>Z</i> isomers ✓</p> <p>H is  ✓</p> <p><i>E/Z</i> happens because double bonds restricts rotation ✓</p> <p>different groups on each carbon of the double bond ✓</p>	11	<p>ALLOW same molecular formula ✓ but different structures ✓ Second marking point is DEPENDENT on first mark</p> <p>ALLOW compounds with the same structure Second marking point is DEPENDENT on first mark</p> <p>This is the QWC mark</p> <p>IGNORE wrong names of F, G and H</p> <p>ALLOW structural or displayed formulae for F, G and H e.g. H is $CH_3CH_2CH_2CHCH_2$</p> <p>ALLOW identification using <i>trans</i> and <i>cis</i> and ALLOW this marking point as identification of another example of identifying <i>E/Z</i> or <i>cis</i> and <i>trans</i> if not done for F and G</p> <p>ALLOW one mark if no structures drawn but correct names given for F, G and H i.e. <i>E</i>-pent-2-ene, <i>Z</i>-pent-2-ene and pent-1-ene</p> <p>ALLOW ecf on structures if wrong molecular formula used or consistent error or slip such as having just sticks</p>

Question	Expected Answers	Marks	Additional Guidance
(b)	<p>from IR absorption, J contains O–H OR from IR J is an alcohol ✓</p> $C : H : O = \frac{70.59}{12.0} : \frac{13.72}{1.0} : \frac{15.69}{16.0}$ <p>OR 5.8825 : 13.72 : 0.9806 ✓</p> <p>empirical formula = C₆H₁₄O ✓</p> <p>(from mass spectrum), M_r = 102 ✓</p> <p>evidence that it has been shown that the empirical formula is the molecular formulae e.g. M_r of C₆H₁₄O = 102 so empirical formula is molecular formula ✓</p>  <p>One mark for each correct structure ✓ ✓ ✓</p>	8	<p>This is a QWC mark</p> <p>ALLOW two marks for correct empirical formula with no working out</p> <p>This is a QWC mark</p> <p>ALLOW structural or displayed formulae IGNORE incorrect names</p> <p>ALLOW one minor slip in drawing structures e.g. one missing hydrogen but ALLOW ecf for bigger slips such as showing just sticks and no hydrogen atoms ALLOW bond to H in OH</p> <p>ALLOW one mark for three isomers of C₆H₁₃OH whether branched or unbranched as a catch mark if no other mark has been awarded for the structures</p> <p>If more than three isomers of C₆H₁₃OH drawn</p> <ul style="list-style-type: none"> • 1 branched and 3 unbranched award two marks • any other combination award one mark <p>ALLOW one mark for hexan-1-ol, hexan-2-ol and hexan-3-ol if structures not drawn</p>
	Total	19	

Question		er	Marks	Guidance
3	(a)	<p>Any three from:</p> <p>Process 1 has a high atom economy OR has 100% atom economy OR a greater atom economy OR makes only the desired product ✓</p> <p>Process 1 has a very efficient conversion of reactants to products OR not much waste of starting material ✓</p> <p>Process 1 uses a lower pressure ✓</p> <p>Process 1 uses up toxic carbon monoxide ✓</p> <p>Process 1 uses methanol which can be produced from biomass ✓</p>	3	<p>Assume it refers to Process 1</p> <p>ALLOW process 1 has no waste OR process 1 has no co-products OR process 1 needs less separation OR process 1 has fewer other products OR gives only one product ALLOW ORA if process 2 is specified</p> <p>ALLOW ORA if process 2 is specified high percentage yield is not sufficient DO NOT ALLOW if percentage yield is explicitly linked to more waste (products) e.g. process 1 has a high percentage yield so makes little waste (product) scores 0 marks but process 1 makes no waste (product) and it has a high percentage yield scores 1 mark</p> <p>ALLOW ORA if process 2 is specified</p> <p>IGNORE process 2 comes from crude oil a non-renewable source ALLOW process 1 starts from a renewable source if the source is specified e.g. wood, municipal waste or sewage</p> <p>IGNORE reference to catalyst and rate of reaction</p>

Question		er	Marks	Guidance
(b)	(<p>Contains C=O bond because of absorption between 1700 and 1740 cm^{-1} (from the spectrum) ✓</p> <p>does not contain an O–H bond ✓</p> <p>(So was a) ketone OR aldehyde ✓</p> <p>$M_r = 86$ ✓</p> <p>Correct structure ✓</p>	5	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>ALLOW contains a carbonyl group because of absorption within range 1640–1750 cm^{-1} OR contains an aldehyde, ketone or carboxylic acid because of absorption within range 1640–1750 cm^{-1} ✓</p> <p>Mention of only an aldehyde or a ketone is not sufficient it needs reference to the wavenumber</p> <p>LOOK FOR THIS MARK ON THE SPECTRUM</p> <p>ALLOW not a carboxylic acid ✓</p> <p>ALLOW does not have any other characteristic absorbance due to other functional groups</p> <p>ALLOW (so was a) carbonyl compound</p> <p>ALLOW this mark if a structure of an aldehyde or a ketone is given even if the structure has an incorrect number of carbon atoms</p> <p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous)</p> <p>LOOK FOR AN ALDEHYDE or KETONE with FIVE carbon atoms OR a DIALDEHYDE, DIONE OR an OXOALDEHYDE with FOUR carbon atoms – a comprehensive list of correct structures is shown on page 34</p> <p>IGNORE incorrect name</p> <p>DO NOT ALLOW COH for an aldehyde</p>

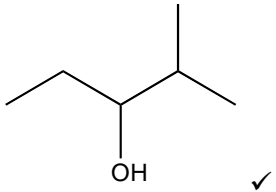
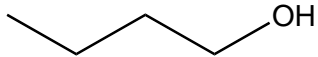
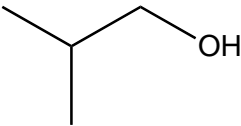
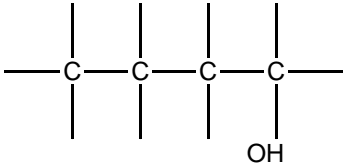
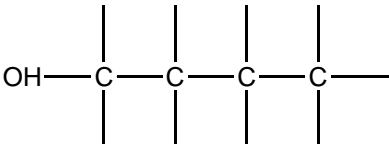
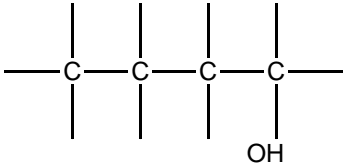
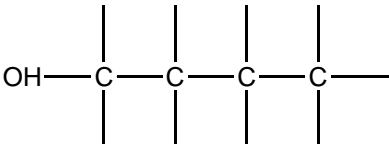
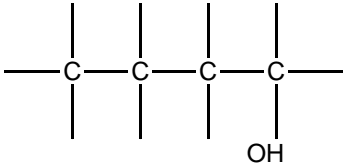
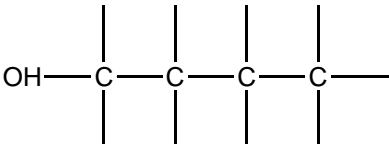
Question	er	Marks	Guidance
	<p style="text-align: center;">  pentanal </p> <p>OR</p> <p style="text-align: center;">  2-methylbutanal </p> <p>OR</p> <p style="text-align: center;">  pentan-3-one </p>		<p>ALLOW as a slip one stick with no H on in a displayed formula</p>

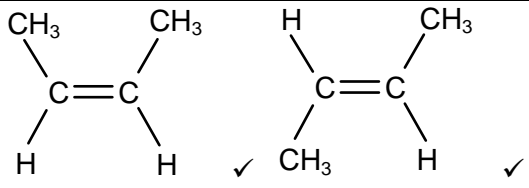
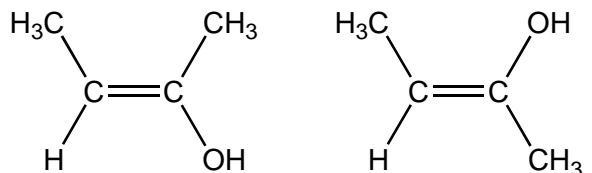
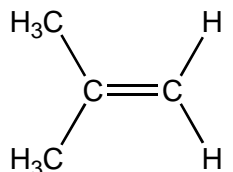
Question		er	Marks	Guidance
(b)	(i)	<p>Correct structure ✓</p> <p>Name of the structure drawn ✓</p>  <p>butanoic acid</p> <p>OR</p>  <p>2-methylpropanoic acid</p>	2	<p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous)</p> <p>All bonds and all hydrogen atoms must be shown in a displayed formula within this question</p> <p>Name must correspond to the correct structure for two marks ALLOW butanoic acid or 2-methylpropanoic acid if the structure drawn is incorrect</p> <p>There is no ECF in this question</p> <p>ALLOW CH₃CH₂CH₂COOH</p> <p>ALLOW (CH₃)₂CHCOOH</p> <p>ALLOW methylpropanoic acid</p>

Question		er	Marks	Guidance
	(c)	Use of propan-1-ol ✓ $\text{CH}_3\text{COOH} + \text{C}_3\text{H}_7\text{OH} \rightarrow \text{CH}_3\text{COOCH}_2\text{CH}_2\text{CH}_3 + \text{H}_2\text{O}$ Correct formulae for the ester ✓ Correctly balanced equation ✓ Add H_2SO_4 OR acid catalyst OR H^+ ✓	4	ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) ALLOW from the equation propanol OR $\text{C}_3\text{H}_7\text{OH}$ is not sufficient ALLOW molecular formula OR correct structural OR displayed OR skeletal formula OR mixture of the above ALLOW propan-2-ol in the equation ALLOW conditions mark over the arrow in the equation
		Total	14	

Question		er	Marks	Guidance
4	(a)	Shape – tetrahedral ✓ Bond angle 109.5° ✓	2	ALLOW 109–110°
	(b)	(Volatile OR non-toxic OR non-flammable OR easily vaporised ✓	1	ALLOW not carcinogenic / not an irritant / not harmful / not hazardous IGNORE cheap / not dangerous / gas / low boiling point DO NOT ALLOW inflammable
	(ii)	(C–F or C–Cl) bonds need a large amount of energy to break ✓	1	ALLOW (the C–F or C–Cl) bonds are strong / bonds have a large bond enthalpy ALLOW the molecule is not polar enough / non-polar molecule is not sufficient ALLOW the activation energy is too high DO NOT ALLOW dissolves IGNORE references to hydrogen bonding
	(c)	$\text{CF}_2\text{Cl}_2 \rightarrow \text{CF}_2\text{Cl} + \text{Cl} \checkmark$ AND ANY TWO FROM Cl catalyses the decomposition of ozone ✓ $\text{Cl} + \text{O}_3 \rightarrow \text{ClO} + \text{O}_2 \checkmark$ $\text{ClO} + \text{O} \rightarrow \text{Cl} + \text{O}_2 \checkmark$	3	ALLOW CF_2Cl_2 (breaks down to) produces chlorine atoms/radicals ALLOW equation with any CFC ALLOW $\text{ClO} + \text{O}_3 \rightarrow \text{Cl} + 2\text{O}_2$ ALLOW $\text{O}_3 + \text{O} \rightarrow 2\text{O}_2$ OR $3\text{O}_2 \rightarrow 2\text{O}_3$ for one mark if the two equations for the steps have not been given IGNORE other propagation equations

Question		Answer	Marks	Guidance
	(d)	Because (more) <u>UV</u> will reach the Earth's surface and risk of (skin) cancer increased/risk of cataracts/crop mutation increased ✓	1	DO NOT ALLOW global warming ALLOW protects from <u>UV</u> which causes skin cancer etc
	(e)	<i>Ideas related to uses</i> CFCs are still entering the atmosphere (from disused items) OR CFCs are still used (for some purposes and by some countries) ✓ <i>Ideas relating to lifetime within the atmosphere</i> CFCs have a long lifetime in the atmosphere OR it takes a long time for CFCs to reach upper atmosphere OR CFCs are inert ✓	2	ALLOW 'stratosphere' for 'upper atmosphere' ALLOW CFCs are still entering the ozone layer
		Total	10	

Question			Expected Answers	Marks	Additional Guidance		
5	(a)	(i)	2-Methylpropan-2-ol ✓	1	ALLOW methylpropan-2-ol		
	(b)			1	Formula must be skeletal AND not include any symbol except for OH		
	(c)	(i)	Same molecular formula but different structural formulae ✓	1	ALLOW Same molecular formula but different arrangement of atoms OR Same molecular formula but different structures OR Same molecular formula but different displayed formulae DO NOT ALLOW Same molecular formula but different spatial arrangement of atoms		
		(ii)	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ OR $(\text{CH}_3)_2\text{CHCH}_2\text{OH}$ ✓ ALLOW  OR 	1	ALLOW displayed formula ALLOW sticks (i.e. no H shown bonded to C)		
					<table border="1"> <tr> <td> ALLOW  sticks OK and -OH is OK </td> <td> DO NOT ALLOW OH shown as below  sticks OK but OH- is not OK </td> </tr> </table>	ALLOW  sticks OK and -OH is OK	DO NOT ALLOW OH shown as below  sticks OK but OH- is not OK
ALLOW  sticks OK and -OH is OK	DO NOT ALLOW OH shown as below  sticks OK but OH- is not OK						
					ALLOW correct ethers		

Question		Expected Answers	Marks	Additional Guidance
	(d)	Has O–H (bonds) OR has hydroxyl (groups) OR has hydroxy (groups) ✓ Forms hydrogen bonds with water (molecules) ✓	2	ALLOW marks from a diagram of hydrogen bonding IGNORE reference to alcohol functional group DO NOT ALLOW 'forms hydrogen bonds'
	(e)	CH ₃ COOCH ₂ CH ₂ OOCCH ₃ 1 mark for each ester end of molecule ✓✓	2	ALLOW displayed formula OR skeletal formula ALLOW sticks CH ₃ COOCH ₂ CH ₂ OH shows one of the two ester groups and scores one mark
	(f) (i)		2	DO NOT ALLOW  i.e. no E
	(ii)	E/Z ✓	1	ALLOW <i>cis-trans</i> IGNORE geometric
	(iii)	CH ₃ CH ₂ CH=CH ₂ OR but-1-ene ✓	1	If but-1-ene given in part (i), ALLOW but-2-ene OR CH ₃ CH=CHCH ₃ i.e. ECF from f(i) DO NOT ALLOW methylpropene: 

Question	Expected Answers	Marks	Additional Guidance
<p>From the evidence, candidates may have identified compound F as propanone, propanal or propanoic acid</p> <ul style="list-style-type: none"> The mark scheme for F = propanone and propanal is shown in the 'Expected Answers' column. The mark scheme for F = propanoic acid is shown in the 'Additional Guidance' column. <p>If F is propanone or propanoic acid, then maximum score = 7; but if F is propanal then maximum score = 6</p>			
(g)	<p>Mark scheme for F = propanone and propanal</p>	7	<p>Mark scheme for F = propanoic acid</p>
	<p>mass spec of E– Remember to check the spectrum Quality of Written Communication – mass spec gives M⁺ or molecular ion of 60 OR mass spec gives parent ion of 60 OR highest <i>m/z</i> (ALLOW <i>m/e</i>) value is 60 ✓</p> <p><i>m/z</i> = 45 indicates loss of CH₃ OR <i>m/z</i> = 45 indicates presence of CH₃CHOH OR CH₂CH₂OH OR C₂H₅O ✓</p>		<p>mass spec of E– Remember to check the spectrum QWC – mass spec gives M⁺ or molecular ion of 60 OR mass spec gives parent ion of 60 OR highest <i>m/z</i> (OR <i>m/e</i>) value is 60 ✓</p> <p><i>m/z</i> = 45 indicates loss of CH₃ OR <i>m/z</i> = 45 indicates presence of CH₃CHOH OR CH₂CH₂OH OR C₂H₅O ✓</p>
	<p>IR of F – Remember to check the spectrum IR shows no broad absorption between 2500 to 3300 cm⁻¹ so no O—H bond OR no broad absorption between 2500 to 3300 cm⁻¹ so not a carboxylic acid ✓</p> <p>IR shows absorption at 1700 cm⁻¹ due to a C=O bond OR absorption at 1700 cm⁻¹ indicates a ketone OR aldehyde present ✓</p>	<p>IR of F– Remember to check the spectrum IR shows (broad) absorption somewhere between 3500 and 2500 cm⁻¹ suggests carboxylic acid OR O—H bond ✓</p> <p>IR shows absorption at 1700 cm⁻¹ due to C=O OR absorption at 1700 cm⁻¹ indicates a carboxylic acid ✓</p>	
	<p>Identification and equation F is CH₃COCH₃ OR propanone ✓</p> <p>E is CH₃CHOHCH₃ OR propan-2-ol ✓</p> <p>CH₃CHOHCH₃ + [O] → CH₃COCH₃ + H₂O ✓</p> <p>If F has been incorrectly identified as propanal, mark identification and equation as ECF, so max = 2 ALLOW E is CH₃CH₂CH₂OH ✓</p> <p>ALLOW: CH₃CH₂CH₂OH + [O] → CH₃CH₂CHO + H₂O ✓</p>	<p>Identification and equation F is CH₃CH₂COOH OR propanoic acid ✓</p> <p>E is CH₃CH₂CH₂OH OR propan-1-ol ✓</p> <p>CH₃CH₂CH₂OH + 2[O] → CH₃CH₂COOH + H₂O ✓</p>	
Total		19	