

Section A (multiple choice)

Question 1: N/A

Question 2: N/A

Question 3: N/A

Question Number	Acceptable Answers	Reject	Mark
4	C		1

Question Number	Acceptable Answers	Reject	Mark
5	B		1

Question Number	Correct Answer	Reject	Mark
6(a)	D		1
(b)	C		1
(c)	A		1

Question Number	Correct Answer	Reject	Mark
7	B		1

Question Number	Acceptable Answers	Reject	Mark
8	C		1

Question Number	Acceptable Answers	Reject	Mark
9	B		1

Question Number	Acceptable Answers	Reject	Mark
10	C		1

Question Number	Acceptable Answers	Reject	Mark
11	D		1

Question Number	Acceptable Answers	Reject	Mark
12	A		1

Question Number	Acceptable Answers	Reject	Mark
13(a)	D		1
(b)	B		1
(c)	A		1

TOTAL FOR SECTION = 20 MARKS

Section B

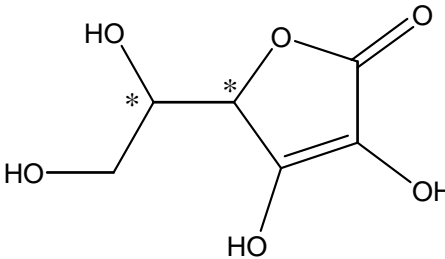
Question 14: N/A

Question Number	Acceptable Answers	Reject	Mark
15 (a)(i)	(vitamin C / ascorbic acid) oxidation / oxidized / oxidised ALLOW oxidisation	Redox / oxidation-reduction / reduction-oxidation	1

Question Number	Acceptable Answers	Reject	Mark
15 (a)(ii)	(very) pale yellow / straw coloured (1) IGNORE 'just before the end-point' blue-black to colourless (both needed) (1) Accept (dark) blue or black ALLOW pale yellow / straw coloured to colourless for 1/2	Just 'yellow' Clear	2

Question Number	Acceptable Answers	Reject	Mark
15 (a)(iii)	<p>Moles $\text{S}_2\text{O}_3^{2-} = 27.85 \times 10^{-3} \times 0.0631$ (1) $(= 1.757335 \times 10^{-3})$</p> <p>moles of I_2 remaining = Moles $\text{S}_2\text{O}_3^{2-} \div 2$ $= 27.85 \times 10^{-3} \times 0.0631 \div 2$ $= 8.786675 \times 10^{-4} = 8.79 \times 10^{-4}$ (1)</p> <p>Moles ascorbic acid = moles I_2 at start – moles I_2 remaining $= 2.00 \times 10^{-3} - 8.786675 \times 10^{-4}$ $= 1.1213325 \times 10^{-3} = 1.12 \times 10^{-3}$ (1)</p> <p>M_r (ascorbic acid) = 176 Mass ascorbic acid in $250 \text{ cm}^3 = 10 \times M_r \times$ moles ascorbic acid $= 10 \times 176 \times 1.1213325 \times 10^{-3}$ (1) $(= 1.97355)$</p> <p>Percentage ascorbic acid in tablet $100 \times \text{mass ascorbic acid in } 250 \text{ cm}^3 \div 2$ $= 100 \times 10 \times 176 \times 1.1213325 \times 10^{-3} \div 2$ $= 98.67726 = 98.7\%$ (1)</p> <p>IGNORE SF except 1 SF Premature rounding gives 98.5% (5)</p> <p>Correct answer with no working scores full marks</p> <p>TE at each stage of the calculation.</p>	Answers greater than 100%	5

Question Number	Acceptable Answers	Reject	Mark
15(a)(iv)	<p>EITHER</p> <p>Using larger mass reduces the percentage error / uncertainty (in weighing)</p> <p>OR</p> <p>Using larger amount reduces the percentage error / uncertainty in weighing</p> <p>OR</p> <p>Reverse discussion of two tablets</p> <p>ALLOW</p> <p>using four tablets gives a more representative sample</p>	<p>Just 'reduces the percentage error'</p> <p>Titration value will be larger (with four tablets) so reduces the percentage error (in volume measurement)</p>	1

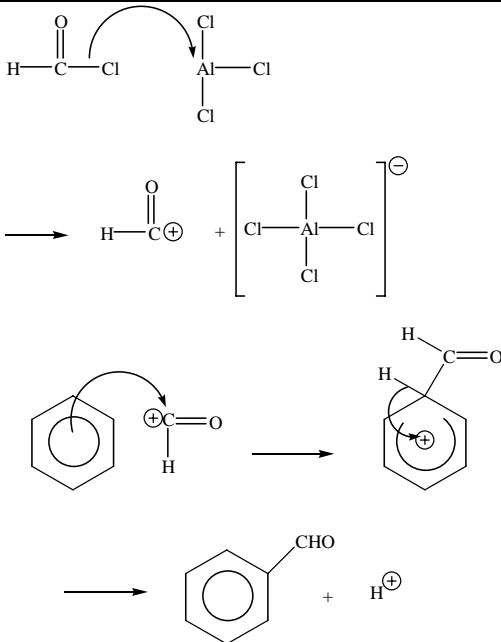
Question Number	Acceptable Answers	Reject	Mark
15 (b)(i)	 <p style="text-align: right;">(2)</p> <p>Mark independently</p> <p>ALLOW any clear indication of chiral centres</p>		2

Question Number	Acceptable Answers	Reject	Mark
15 (b)(ii)	<p>First mark</p> <p>Use of (plane-)polarized light (mentioned somewhere) (1)</p> <p>ALLOW</p> <p>Use a polarimeter</p> <p>Second mark</p> <p>Pure optical isomer / enantiomer) rotates the plane of (plane-) polarized light</p> <p>OR</p> <p>racemic mixture has no effect on the plane of (plane-) polarized light (1)</p> <p>IGNORE</p> <p>optically active / inactive</p> <p>ALLOW</p> <p>rotates plane-polarized light scores 2</p>		2

Question Number	Acceptable Answers	Reject	Mark
15(b)(iii)	(Ester group / vitamin C / it) is hydrolysed ALLOW Vitamin C is oxidized Ester / vitamin C is broken down to form carboxylic acid and alcohol (groups) IGNORE Just 'breaks down'	C=O is broken Just 'oxidation'	1

Total for Q15 = 14 Marks

Question Number	Acceptable Answers	Reject	Mark
16(a)(i)	<p>The delocalization of the (π) electrons of the ring make benzene more stable (than 1,3,5-cyclohexatriene) (1)</p> <p>IGNORE bonding in benzene is strong Substitution retains this (stable) arrangement OR Addition removes this (stable) arrangement (1)</p>		2

Question Number	Acceptable Answers	Reject	Mark
16(a)(ii)	 <p>Formation of electrophile (curly arrow, structural formulae not required). Positive charge may be anywhere on the electrophile ALLOW HCl + CO for HCOCl ALLOW Non-displayed electrophile (1)</p> <p>Curly arrow from benzene ring to electrophile (1)</p> <p>Wheland structure with gap opposite tetrahedral carbon (1)</p> <p>Curly arrow from C—H bond into ring and formation of correct organic product OR Kekulé structures (1)</p> <p>IGNORE Use of AlCl₄⁻ to pick off proton Proton product</p> <p>First curly arrow may come from any part of the delocalisation circle Second curly arrow may come from any part of the C—H bond Positive charge on the Wheland structure may be in any part of the horseshoe</p>	-COH /-HCO	4

Question Number	Acceptable Answers	Reject	Mark
16(a)(iii)	<p>In each step the second mark is dependent on the first</p> <p>Step 2 Potassium dichromate((VI)) / $K_2Cr_2O_7$ / sodium dichromate((VI)) / $Na_2Cr_2O_7$ ALLOW Potassium manganate ((VII)) / $KMnO_4$ Sodium manganate ((VII)) / $NaMnO_4$ (1)</p> <p>Stand alone mark</p> <p>Sulfuric acid / H_2SO_4 (ALLOW nitric acid) (1) Ignore 'concentrated'</p> <p>ALLOW Acidified potassium (/ sodium) dichromate((VI)) OR Acid and potassium (/ sodium) dichromate((VI)) (2)</p> <p>$Cr_2O_7^{2-}$ and H^+ OR acidified dichromate((VI)) (1)</p> <p>Step 3 Lithium tetrahydridoaluminate((III)) / $LiAlH_4$ OR Lithium aluminium hydride (1)</p> <p>Stand alone mark</p> <p>(Dry) ether / ethoxyethane / (di)ethyl ether (1)</p> <p>Sodium borohydride / $NaBH_4$ in ethanol, alkali or water scores 1/2 (1)</p>	<p>Incorrect oxidation number</p> <p>Hydrochloric acid</p> <p>Hydrogen and catalyst / Tin and HCl</p>	4

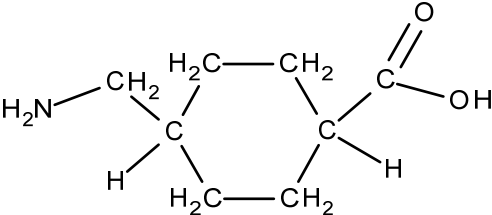
Question Number	Acceptable Answers	Reject	Mark
16(b)	<p>Marking Point 1 Electron density of the ring increased (1)</p> <p>Stand alone mark</p> <p>Marking Point 2 Due to donation of oxygen / OH group lone pair to the ring (1)</p> <p>Marking Point 3 and 4 Any two from</p> <p>in phenol oxygen / OH group attached directly to ring</p> <p>Oxygen / OH group in phenylmethanol too far away / not attached directly to ring</p> <p>(In phenol) lone pair overlaps with the π electrons / delocalised electrons (of the ring) ALLOW p orbital for lone pair for this mark (2)</p>		4

Total for Q16 = 14 Marks

Section C

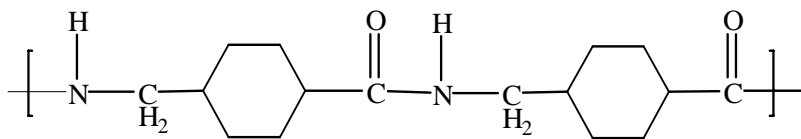
Question Number	Acceptable Answers	Reject	Mark
17(a)(i)	<p>There is a barrier to rotation about a (C=C) bond (1)</p> <p>ALLOW restricted / limited / no rotation</p> <p>Each carbon atom (in the C=C double bond) has (two) different atoms / groups attached (1)</p> <p>IGNORE reference to priority groups</p>	Just 'molecule cannot rotate'	2

Question Number	Acceptable Answers	Reject	Mark
17(a)(ii)	<p>There is a barrier to / restricted rotation about the ring</p> <p>OR</p> <p>The ring behaves like a double bond</p>	<p>Reference to benzene ring</p> <p>Just 'molecule cannot rotate'</p>	1

Question Number	Acceptable Answers	Reject	Mark
17(a)(iii)	 <p>Any diagram of the correct molecule showing the groups (attached to the ring) on same side of the ring</p> <p>OR</p> <p>zwitterion</p> <p>ALLOW</p> <p>Amine group in skeletal form</p>	Omission of amine CH ₂	1

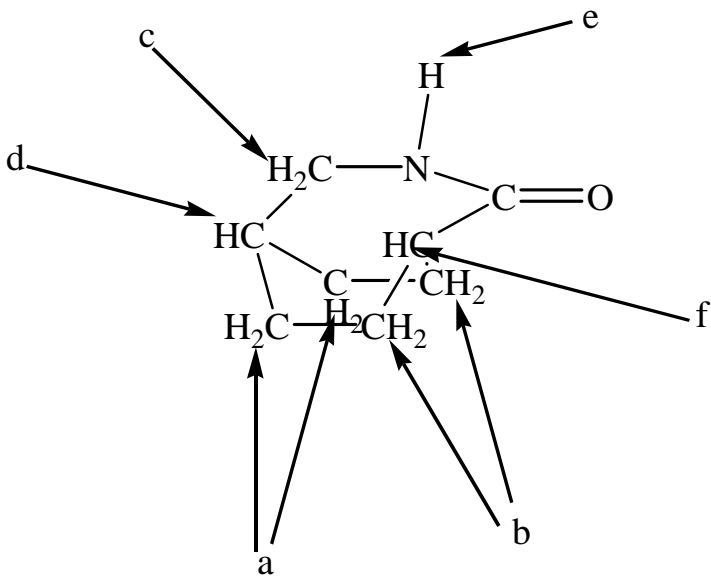
Question Number	Acceptable Answers	Reject	Mark
17(a)(iv)	<p>Tranexamic acid exists as a zwitterion OR Diagram of zwitterion OR Description of zwitterion formation (1)</p> <p>So the (strongest) intermolecular forces are ionic (strong) ALLOW electrostatic for ionic (1)</p> <p>IGNORE H bonding in tranexamic acid if either of the first two marks scored. Otherwise...</p> <p>Hydrogen bonding in tranexamic acid scores 1/2 max</p> <p>Undecane has (only) (much weaker) London / dispersion / van der Waals / temporary induced dipole (-induced dipole) forces / interactions (1)</p>		3

Question Number	Acceptable Answers	Reject	Mark
17(b)(i)	<p>Phosphorus(v) chloride / PCl_5</p> <p>ALLOW phosphorus pentachloride / phosphorus(III) chloride / PCl_3 / phosphorus trichloride</p> <p>Thionyl chloride (sulfur dichloride oxide) / SOCl_2</p>	HCl	1

Question Number	Acceptable Answers	Reject	Mark
17(b)(ii)	 <p>First mark amide linkage ALLOW CONH for amide linkage (1)</p> <p>Second mark Completion of structure (brackets not required) with displayed or skeletal formula (1)</p> <p>Second mark dependent on first</p> <p>Dimer scores amide linkage mark only</p>		2

Question Number	Acceptable Answers	Reject	Mark
17(b)(iii)	Condensation / addition-elimination (polymerization)	Addition (polymerization) Elimination (polymerization) Polyamide formation	1

Question Number	Acceptable Answers	Reject	Mark
17(b)(iv)	Protein / proteins / polypeptide / polypeptides / peptide / peptides ALLOW Enzyme / Enzymes	Nylon Polyamide amino acids	1

Question Number	Acceptable Answers	Reject	Mark
17(c)(i)	<p>Check sequence of letters. Candidates may have labelled the groups of hydrogen atoms with different letters, which is fine.</p> <p>First mark Unique NH (at e) (1)</p> <p>Second mark Unique CH₂ (at c) (1)</p> <p>Third mark CH (at d) and CH (at f) with different unique labels (1)</p> <p>Fourth mark 2CH₂ (at a) and 2CH₂ (at b) with different new labels (1)</p>  <p>The diagram shows a chemical structure of a cyclic amide. It consists of a six-membered ring with a carbonyl group (C=O) and a nitrogen atom (N-H). The ring is completed by a CH₂ group. Attached to the ring are two ethyl groups. Labels with arrows point to specific hydrogen atoms: 'e' points to the NH hydrogen; 'c' points to a CH₂ group in one ethyl branch; 'd' points to a CH group in the same branch; 'a' and 'b' point to CH₂ groups in the other ethyl branch; 'f' points to a CH group in that branch.</p>		4

Question Number	Acceptable Answers	Reject	Mark
17(c)(ii)	<p>C=O amide (stretching vibrations are in the region) (1) 1700-1630 cm⁻¹</p> <p>N—H amide (stretching vibrations are in the region) (1) 3500-3140 cm⁻¹</p> <p>Amide only needs to be mentioned once but...</p> <p>These answers without mention of amide max 1</p> <p>Amides have peaks in these regions max 1</p>	<p>Ketone</p> <p>Amine (for amide)</p>	2

Question Number	Acceptable Answers	Reject	Mark
17(c)(iii)	<p>Any two from</p> <p>In the trans isomer the (amine and acid chloride) groups are too far apart to react intramolecularly / to form M</p> <p>OR</p> <p>Because the groups are on opposite sides of the (plane of the) ring</p> <p>OR</p> <p>More likely to polymerize / react with adjacent molecules. (2)</p> <p>Marks may also be scored by a reverse argument:</p> <p>In the cis isomer the (amine and acid chloride) groups are on the same side of the (plane of the) ring (1)</p> <p>So close enough to react intramolecularly / to form M (1)</p>	bond	2

Total for Q17 = 20 Marks

Question Number	Correct Answer	Mark
18	B	1

Question Number	Correct Answer	Mark
19	A	1

Question Number	Correct Answer	Mark
20	D	1

Section B

Question Number	Acceptable Answers	Reject	Mark
21 (a)(i)	Addition (1) Nucleophilic (1) Either order	SN1 SN2	2

Question Number	Acceptable Answers	Reject	Mark
(a)(ii)	<p>Hydrogen cyanide / HCN (1)</p> <p>Potassium cyanide / KCN/ sodium cyanide/ NaCN (1)</p> <p>OR</p> <p>Potassium cyanide / KCN (1) With hydrochloric acid / sulfuric acid (to generate HCN) (1)</p> <p>Ignore concentration of acids Mark for HCl etc is consequential on KCN</p> <p>OR</p> <p>Hydrogen cyanide / HCN (1) With sodium hydroxide / other base (to make cyanide ions) (1) Mark for NaOH etc is consequential on HCN</p>	<p>Just CN⁻</p> <p>Just CN⁻</p> <p>Just acid/ H⁺ any weak acid</p> <p>Just OH⁻</p>	2

Question Number	Acceptable Answers	Reject	Mark
21 (a)(iii)	<p>Both arrows in first step of mechanism above correctly drawn (1)</p> <p>Correct intermediate with charge (1)</p> <p>Both arrows in second step with correct organic product (CN⁻ is not required) (1)</p> <p>Use of HCN for first step max 2 marks</p> <p>Allow omission of lone pair on CN⁻ and O⁻ Allow curly arrow from negative charge or elsewhere on cyanide ion</p> <p>Allow arrow from O⁻ in 2nd step to H⁺ (no other product or only one product) or H₂O (with OH⁻ formed)</p>	<p>C=O breaking before attack by CN⁻</p> <p>Arrows from atoms when they should be from bonds and vice versa</p>	3

Question Number	Acceptable Answers	Reject	Mark
*21 (a)(iv)	<p>Attack (by nucleophile on the C) is from both sides (equally)/ above and below (at the planar reaction site in the aldehyde group) (1)</p> <p>So a mixture of two enantiomers/(optical)isomers in equal proportions forms OR racemic mixture forms (1)</p> <p>First and second marks are independent</p>	<p>Attack on intermediate in reaction mechanism is from both sides Attack from both ends/two angles</p> <p>Just "both enantiomers form"</p>	2

Question Number	Acceptable Answers	Reject	Mark
(b)	<p>Any named (aqueous) strong acid or its formula.</p> <p>Allow (aqueous) sodium hydroxide followed by named acid or formula</p> <p>Ignore references to concentration</p>	<p>Water</p> <p>H⁺</p> <p>Potassium dichromate + sulfuric acid</p> <p>Carboxylic acids</p>	1

Question Number	Acceptable Answers	Reject	Mark
(c)(i)	2-hydroxypropanoic acid	<p>2-hydroxylpropanoic acid</p> <p>2-hydroxopropanoic acid</p> <p>2-hydroxypropan-1-oic acid</p>	1

Question Number	Acceptable Answers	Reject	Mark
21 (c)(ii)	$ \begin{array}{c} \text{CH}_3 \qquad \text{CH}_3 \\ \qquad \quad \\ -\text{C}-\text{C}-\text{O}-\text{C}-\text{C}-\text{O}- \\ \quad \quad \quad \\ \text{H} \quad \text{O} \quad \text{H} \quad \text{O} \end{array} $ <p>OR</p> $ \begin{array}{c} \text{CH}_3 \qquad \text{CH}_3 \\ \qquad \quad \\ -\text{O}-\text{C}-\text{C}-\text{O}-\text{C}-\text{C}- \\ \quad \quad \quad \\ \text{H} \quad \text{O} \quad \text{H} \quad \text{O} \end{array} $ <p>All bonds in ester link must be shown More than 2 units may be shown but structure shown should be a repeat unit Ignore brackets/n</p>	<p>A dimer</p> <p>Missing H atoms</p> <p>Missing bonds at ends</p>	1

Question Number	Acceptable Answers	Reject	Mark
(c)(iii)	<p>Ester (link/bond) in PLA can be hydrolysed/broken down (by enzymes) OR Ester (link/bond) in PLA can be broken down</p>	Just "it can be hydrolysed"	1

Question Number	Acceptable Answers	Reject	Mark
(c)(iv)	<p>Ethene is (from crude oil so) non-renewable/ milk is from a renewable source/ energy required to make ethene is high/ high temperatures needed to make ethene/ energy requirements for process from sour milk less/ process from milk doesn't use toxic chemicals / process from milk doesn't use cyanide</p> <p>Allow process from ethene requires many steps so expensive/so loss of material occurs at each step /so more reagents needed</p> <p>Ignore references to cost, unless answer gives a reason for lower cost.</p>	<p>Milk is more readily available Greater atom economy</p> <p>No other chemicals needed in process from milk</p> <p>Just "process from ethene requires many steps"</p> <p>Just "cheaper"</p>	1

Section C

Question Number	Acceptable Answers	Reject	Mark
22 (a)	Alcohol; (2)-methylpropan-2-ol (1) Catalyst: sulfuric acid OR any named strong acid Ignore concentration of acid (1) Accept formula for acid	Formula of alcohol Just acid/H ⁺ for catalyst	2

Question Number	Acceptable Answers	Reject	Mark
(b)(i)	Tap funnel / separating funnel	Buchner funnel Filter funnel	1

Question Number	Acceptable Answers	Reject	Mark
(b)(ii)	To neutralize / remove/ react with (excess) acid Allow To neutralize / remove / react with (excess) H ⁺ To remove acidic impurities To remove ethanoic acid To remove the acid (used as a) catalyst Ignore additional comments on quenching or reaction stopping	To purify it To remove excess acid and alcohol Just "to quench acid catalyst/stop reaction"	1

Question Number	Acceptable Answers	Reject	Mark
(b)(iii)	Add (anhydrous) calcium chloride/ sodium sulfate/ magnesium sulfate/ Allow silica gel Allow formulae of drying agents	Conc. sulfuric acid Anhydrous copper sulphate Just "silica"	1

Question Number	Acceptable Answers	Reject	Mark
(b)(iv)	<p>Round bottomed or pear-shaped flask + still head with stopper or thermometer + heat source (1)</p> <p>This mark cannot be given if apparatus is completely sealed /large gaps between components</p> <p>Downwards sloping condenser (with correct water flow) + collection vessel (1)</p> <p>Thermometer in correct position with bulb opposite condenser opening (1)</p> <p>Ignore fractionating column if included between flask and condenser</p>	<p>Conical flask</p> <p>Flat bottomed flask</p>	3

Question Number	Acceptable Answers	Reject	Mark
*22 (c)	<p>First mark (Two signals so) two hydrogen environments (1) This mark may be gained by a description of the only two environments, but reference to hydrogen must be made.</p> <p>Second mark (Numbers of hydrogen in each environment are/ are predicted to be) in ratio 3:9 or 1:3</p> <p>OR</p> <p>Peak due to $(\text{CH}_3)_3$ is 3x higher than peak due to CH_3 (1)</p> <p>Third mark Environments are CH_3COO and $(\text{CH}_3)_3$ (H may have been specified in first marking point) These may be shown on a diagram of the formula of the molecule</p> <p>OR</p> <p>$\text{H}-\text{C}-\text{C}=\text{O}$ (peak at 2.1) and $\text{H}-\text{C}-\text{C}$ (peak at 1.3) (1)</p> <p>Fourth mark Singlets/ no splitting as no H on adjacent C</p> <p>OR</p> <p>Singlets as the hydrogen environments are not adjacent to other H environments Allow "only one peak" for no splitting (1)</p>	Just "the peaks are due to $(\text{CH}_3)_3$ and CH_3	4

Question Number	Acceptable Answers	Reject	Mark
(d)(i)	$\text{CH}_3\text{COOCH}_2\text{CH}(\text{CH}_3)_2$ Or correctly displayed Allow $\text{CH}_3\text{COOCH}_2\text{CH}(\text{CH}_3) \text{CH}_3$		1

Question Number	Acceptable Answers	Reject	Mark
22 (d)(ii)	<p>The H on the CH₃COO</p> <p>Accept circle round all of first methyl group Accept a hydrogen in this environment if rest of molecule is incorrect</p>	<p>Circle round C of first methyl group</p>	1

Question Number	Acceptable Answers	Reject	Mark
(e)(i)	<p>Any acid with 6C (5C + COOH) which is chiral, so will have a branched chain</p> <p>$C_3H_7CH(CH_3)COOH$</p> <p>OR</p> <p>$C_2H_5CH(CH_3)CH_2COOH$</p> <p>OR</p> <p>$(CH_3)_2CHCH(CH_3)COOH$ (1)</p> <p>Infrared indicates (O-H present in a) carboxylic acid (1)</p> <p>High boiling temperature due to hydrogen bonding (between atoms in OH groups so not an ester.) Hydrogen bonds must be possible for structure shown</p> <p>Allow acids can form dimers.</p> <p>Allow TE from formula of straight chain molecule with explanation that London forces are higher in a linear molecule (1)</p> <p>(Optically active so) contains chiral C/ C bonded to four different groups</p> <p>The formula suggested must contain a chiral carbon to score this mark</p> <p>This may be shown by a chiral carbon being labelled in the formula (1)</p> <p>Carbonyl compound/ Carbonyl group/ Aldehyde and ketone absent (as no reaction with 2,4-dinitrophenylhydrazine)/ Allow carboxylic acids do not react with 2,4-dinitrophenylhydrazine/ (1)</p>	<p>Infrared indicates O-H</p> <p>Infrared indicates alkyl group</p> <p>Just "does not contain C=O (group)"</p>	5

Question Number	Acceptable Answers	Reject	Mark
22 (e)(ii)	No because the isomers (which are carboxylic acids) contain same bonds / groups (C=O, C-O, C-H etc) (1) OR Yes because could be distinguished by infrared fingerprint (1)	 Yes because spectrum is unique	1