Mark Scheme

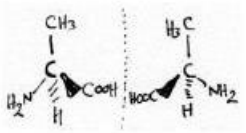
Q1.

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td></td>
<td>This question assesses the student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.

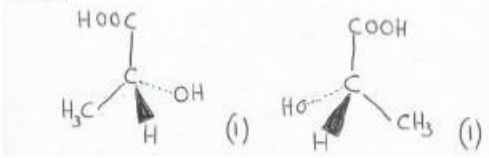
Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5-4</td><td>3</td></tr>
<tr><td>3-2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
</td>
<td>Guidance on how the mark scheme should be applied:
The mark for indicative content should be added to the mark for lines of reasoning. For example, a response with four indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).
If there were no linkages between the points, then the same indicative marking points would yield and overall score of 3 marks (3 marks for indicative content and zero marks for linkages).</td>
<td>(6)</td>
</tr>
</table>

	The following table shows how the marks should be awarded for structure and lines of reasoning		
	<table><tr><th></th><th>Number of marks awarded for structure of answer and sustained lines of reasoning</th></tr><tr><td>Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr><tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr><tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr></table>	More than one indicative marking point may be made within the same comment or explanation Accept annotated diagrams to illustrate the indicative points Ignore reference to other amino acid properties	

	Indicative content IP1 (Similarity) • they are **both** 2-amino acids / alpha amino acids / naturally occurring/ zwitterions IP2 • equation for the reaction with an acid IP3 • equation for the reaction with a base	The zwitterions can be evidenced from each amino acid zwitterion in an equation e.g. $NH_3^+CH(CH_3)COO^-$ / $NH_3^+CH_2COO^-$ e.g. $H^+ + NH_3^+CH_2COO^- \rightarrow NH_3^+CH_2COOH$ or $H^+ + NH_3^+CH(CH_3)COO^- \rightarrow H_3N^+CH(CH_3)COOH$ $OH^- + NH_3^+CH_2COO^- \rightarrow NH_2CH_2COO^- + H_2O$ or $OH^- + NH_3^+CH(CH_3)COO^- \rightarrow NH_2CH(CH_3)COO^- + H_2O$ Allow use of un-ionised amino acid structures If IP2 and 3 not scored then allow 1IP for a suitable description of acid and base behaviour	
	IP4 • alanine has a chiral centre/ asymmetric carbon atom/ non-superimposable mirror images **and** glycine does not IP5 • (an aqueous solution of) alanine rotates the plane (of polarisation) of plane-polarised (monochromatic) light but glycine does not IP6 • diagram to show enantiomers of alanine	Allow reference to four different atoms/groups bonded to central carbon for chiral centre 'Plane' must be stated at least once Wedges must be drawn e.g. Ignore angles and connectivity 	

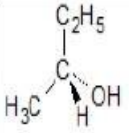
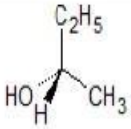
Q2.

Question Number	Answer	Additional Guidance	Mark
(i)	Allow 	Diagram must be 3-dimensional with either wedges or dashes to score 2 marks Ignore orientation of group at the top Ignore vertical bond to H of OH group	(2)

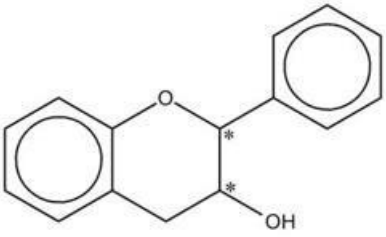
Question Number	Answer	Additional Guidance	Mark
(ii)	• They **rotate** the plane of plane-polarised light (equally) and in opposite/different directions OR Determine in which direction they **rotate** the plane of plane-polarised light	Allow one plane	(1)

Question Number	Answer	Additional Guidance	Mark
(iii)	• Does not accumulate in the environment/does not occupy landfill	Accept answers that outline the benefit of avoiding other means of disposal such as incineration, use of toxic chemicals Ignore just less harm to environment/less harm to animal life/less pollution/less of an "eyesore"/less energy to break it down	(1)

Q3.

Question Number	Acceptable Answer	Additional guidance	Mark
	 (1)  (1) Forms (two) isomers which are non-superimposable **(1)**	Diagram must be 3-dimensional, i.e. include 'wedges'. Allow Br instead of OH Ignore attachment of –OH, CH_3 and C_2H_5 groups Standalone mark Allow a chiral carbon has **four** different groups attached (so they are non-superimposable) Do not award has four different 'molecules' attached	**(3)**

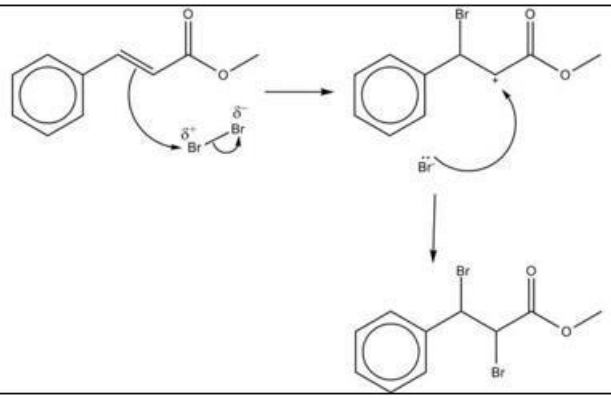
Q4.

Question Number	Answer	Additional Guidance	Mark
			**(1)**

Q5.

Question Number	Answer	Additional Guidance	Mark
(i)	• **M1** arrow from double bond to (δ+)Br in Br_2 (1) • **M2** arrow from bond in Br_2 to $Br^{\delta-}$ (1) • **M3** structure of carbocation (1) • **M4** arrow from **lone pair** on Br^- to C^+ in carbocation **and** final product (1)	Example of mechanism **See below** Penalise lack of dipole only once in M1 and M2 Award C^+ in intermediate on either C from the double bond Do not award M3 if four bonds are shown on carbocation Br atoms can be shown either upwards or downwards in final product Award (0) if just electrophilic substitution mechanism given. If **both** electrophilic substitution and addition shown allow 2 max Penalise errors in structure of methyl cinnamate once only in either M3 or M4	(4)

Example of mechanism



Question Number	Answer	Mark
(ii)	**The only correct answer is C (4)** **A** *is not correct because 2 chiral centres form in reaction, so 4 possible combinations of +/- forms* **B** *is not correct because 2 chiral centres form in reaction, so 4 possible combinations of +/- forms* **D** *is not correct because 2 chiral centres form in reaction, so 4 possible combinations of +/- forms*	(1)

Question Number	Answer	Mark
(iii)	**The only correct answer is D** (rotated) **A** *is not correct because diffracted is the wrong term* **B** *is not correct because reflected is the wrong term* **C** *is not correct because refracted is the wrong term*	**(1)**

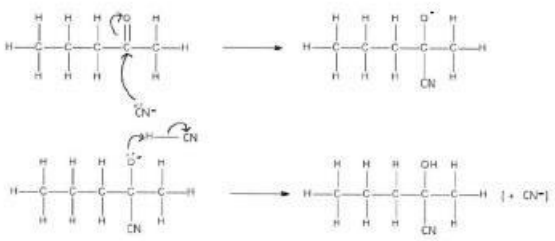
Q6.

Question Number	Acceptable Answers	Additional Guidance	Mark
(i)	An explanation that makes reference to the following points: • glycinate ions / they do not contain a carbon atom with four different atoms / groups attached **or** the glycinate ion is superimposable on its mirror image **(1)** • so there will be no effect (on plane-polarised monochromatic light) **(1)**	An answer that states there will be an effect scores (0) Allow not chiral / achiral / has no enantiomers / has no asymmetric carbon atom Allow the carbon atom attached to NH_2 is only attached to 3 different atoms / groups / is not attached to 4 different atoms / groups Ignore glycinate ions are not optically active / do not exhibit optical isomerism Do not award it is a racemic mixture / there are equal amounts of the two isomers / four different molecules attached M2 is conditional on M1 Do not award the (monochromatic) light will not be polarised	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(ii)	• correct formula of one of the copper species **(1)** • rest of equation correct **(1)**	Example of equation $(CH_3COO)_2Cu + 2\ NH_2CH_2COOH \rightarrow (NH_2CH_2COO)_2Cu + 2CH_3COOH$ Allow $Cu(CH_3COO)_2$ / $Cu(NH_2CH_2COO)_2$ Allow both charges shown e.g. $(CH_3COO^-)_2Cu^{2+}$ Allow displayed / skeletal formulae for organic substances but not molecular formulae Ignore state symbols, even if incorrect Do not award M1 if covalent bond between Cu and O in any species but M2 can still score	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(iii)	An answer that makes reference to any **four** of the following points: Student **1** / higher yield • the crystals were not dry / still damp when they were weighed **(1)** • there are impurities in the crystals **(1)** Student **2** / lower yield • reaction was incomplete **(1)** • not all of the copper(II) glycinate had crystallised / some is left in solution **(1)** • description of a specific handling loss **(1)**	Ignore reference to weighing errors for both students Allow the student did not subtract the mass of filter paper / product container Do not award the crystals contain water of crystallisation / are (partially) hydrated Allow a specific impurity e.g. glycine Allow the reaction reached equilibrium / side reactions occur / by-products form Ignore just 'the solution has not cooled enough' Allow any specific example e.g. some crystals left on the walls of the container / beaker / flask / lost during filtration / lost during transfer Ignore just 'transfer error' / lost when handling	**(4)**

Q7.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following points: • curly arrow from lone pair on C of CN^- to C of ketone group (1) • curly arrow from C=O to, or just beyond, O (1) • intermediate (1) • curly arrow from lone pair on O^- to H and curly arrow from H-CN bond to anywhere on CN (1)	Example of mechanism:  Allow C_3H_7 and CH_3 for propyl and methyl groups Allow CN bond displayed Ignore correct dipoles, penalise an incorrect dipole once only Do not award M3 if C^+ is shown on intermediate For M4, allow curly arrow from lone pair on O^- to H^+ ion / H_2O molecule Penalise incorrect ketone once only in M3 intermediate Penalise curly arrow from -ve charge instead of lone pair once only	(4)

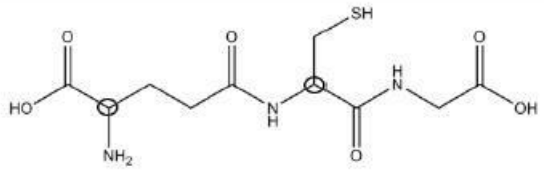
Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following points: • pentan-2-one / ketone is planar about the carbonyl carbon (1) • so the CN^-/ nucleophile attacks (equally) from above and below / either side (of the plane) (1)	Allow bonds about C=O are (trigonal) planar or the carbonyl carbon is (trigonal) planar Do not award planar molecule / reference to planar intermediate / ion Do not award multiple directions	(2)

Q8.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following points: • a racemic mixture / racemate is formed **or** equal amounts / an equimolar mixture of both optical isomers forms **(1)** • intermediate / carbocation is (trigonal) planar around the reaction site / C^+ / central carbon **(1)** • (equal probability of) attack (by nucleophile / hydroxide ions) from either side / above and below / both sides / opposite sides (of the plane) **(1)**	Allow enantiomers / D-L isomers / (+) and (-) isomers Allow the two isomers rotate the plane of plane-polarised light in opposite directions and cancel out Ignore just 'mixture is not optically active' / 'mixture does not rotate the plane of plane-polarised light' Allow the intermediate / carbocation is planar (around the reaction site) Do not award 'the molecule is planar'	(3)

Q9.

Question Number	Answer	Mark
(i)	**The only correct answer is C** (oxidation) *A is incorrect as there is no evidence the species have added to the benzene ring* *B is incorrect as there is no evidence of chemical breakdown due to reaction with water* *D is incorrect as the -NH group and -OH group have lost hydrogen atoms*	(1)

Question Number	Answer	Additional guidance	Mark
(ii)	• both carbon atoms circled	 Allow any other labelling e.g. asterisk / arrow Do not award additional incorrect carbon atoms	(1)

Question Number	Answer	Mark
(iii)	**The only correct answer is B** (glutamic acid and cysteine) ***A*** *is incorrect as aspartic acid has only 4 carbon atoms* ***C*** *is incorrect as the sulfur atom in methionine has a methyl group attached* ***D*** *is incorrect as the sulfur atom in methionine has a methyl group attached and aspartic acid has only 4 carbon atoms*	(1)

Q10.

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(i)	An answer that makes reference to the following points: • 3300 — 2500 (cm^{-1}) **and** O-H (bond) **(1)** • 1725 — 1700 (cm^{-1}) **and** C=O (bond) **(1)**	Allow any value(s) within the range 3300 — 2500 (cm^{-1}) Allow -OH Allow any value(s) within the range 1725 — 1700 (cm^{-1}) Allow 1320 – 1210 (cm^{-1}) **and** C-O	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
(a)(ii)	An answer that makes reference to the following points: • structures 1 and 2 will have an absorption at Either C=C at 1669 — 1645 (cm^{-1}) **or** C—H in an alkene at 3095 — 3010 (cm^{-1}) **(1)** • only structure 2 will have an absorption due to the presence of an alcohol / O—H at 3750 —3200 (cm^{-1}) **(1)** • structure 3 will have none of these absorptions / will not show C=C absorption / C-H absorption for an alkene **(1)**	Reject C=C at 3010 (cm^{-1})	(3)

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)	• calculation of moles of NaOH **(1)** • calculation of mass of NaOH **(1)**	Example of calculation: (moles NaOH = 0.140 x 250) 1000 = 0.035(0) (mol) = 40(.0) x 0.035(0) = 1.4(0) (g) Correct answer with or without working scores 2 marks Allow TE for M2 on moles of NaOH Alternative route, allow M1 for conversion of concentration to 5.6 g dm^{-3} Ignore SF	(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)(i)	An explanation that makes reference to the following points: • (because the) sodium hydroxide has been diluted **(1)** • (the titre will be) smaller **(1)**	Allow Fewer moles of sodium hydroxide present / some sodium hydroxide will have been removed M2 dependent on M1	(2)

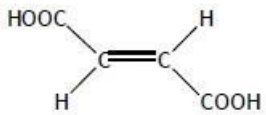
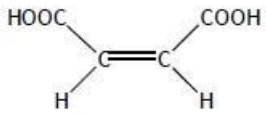
Question Number	Acceptable Answers	Additional Guidance	Mark
(c)(ii)	An explanation that makes reference to the following points: M1 no effect (on the titre) **(1)** M2 because the (number of) moles of sodium hydroxide is unaffected **(1)**	 M2 depends on M1 Allow base / alkali / hydroxide (ions) Allow amount / mass of sodium hydroxide is unaffected	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(c)(iii)	• calculation of percentage uncertainty in burette volume **(1)** • calculation of percentage uncertainty in volumetric flask volume **and** in pipette volume **(1)** • identification of volume with the lowest percentage uncertainty **(1)**	Example of calculation: 2 x (±)0.05 x 100% = (±)0.980392156% 10.20 (±)0.30 x 100% = (±)0.12% 250.0 **and** (±)0.040 x 100% = (±)0.4% 10.0 Volumetric flask has the lowest uncertainty Allow TE for identification in M3 Allow ANY number of SF in answer, from 1 SF up to calculator value	**(3)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(d)(i)	• left-hand side of equation correct **(1)** • right-hand side of equation correct **(1)**	Example of equation $HOOCCH=CHCOOH + 2NaOH \rightarrow NaOOCCH=CHCOONa + 2H_2O$ ALLOW use of molecular formulae or ionic equation: $C_4H_4O_4 + 2NaOH \rightarrow Na_2C_4H_2O_4 + 2H_2O$ $HOOCCH=CHCOOH + 2OH^- (+ 2Na^+) \rightarrow {}^-OOCCH=CHCOO^- + 2H_2O (+ 2Na^+)$ ALLOW Multiples Correct charges Do not award if O–Na covalent bond drawn IGNORE State symbols, even if incorrect	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(d)(ii)	An answer that makes reference to the following points: • (New mean titre) = 20.4(0) (cm^3) / double (the original value) **(1)** • For structure 2, mole ratio / reacting ratio is 1:1 (with NaOH) **(1)**	Mark M1 and M2 independently Allow structure 2 has 1 COOH / 1 acid group	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(e)	<table><tr><th>Structure</th><th>Test with Br_2 water</th><th>Test with acidified $K_2Cr_2O_7$</th></tr><tr><td>HOOCCH=CHCOOH</td><td>✓</td><td>x</td></tr><tr><td>$HOCH_2CH=CHCH_2COOH$</td><td>✓</td><td>✓</td></tr><tr><td>$CH_3CH_2CH_2CH_2CH_2COOH$</td><td>x</td><td>x</td></tr></table> Left hand column correct **(1)** Right hand column correct **(1)**	3 correct ticks with no crosses scores 1 Ignore descriptions of result in terms of colour (changes) / reactions occurring	**(2)**

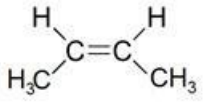
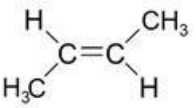
Question Number	Acceptable Answers	Additional Guidance	Mark
(f)(i)	• *E*-isomer:  **(1)** • *Z*-isomer:  **(1)**	ALLOW skeletal or displayed structures ALLOW $-CO_2H$ IGNORE Connectivity to the –COOH group IGNORE bond angles Award one mark if correct structures are drawn, but *E*- and *Z*-isomers labelled the wrong way round Award 1 mark if incorrect molecule used but *E* - and *Z*- isomers are correct	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(f)(ii)	An answer that makes reference to the following points: • restricted / limited rotation (about the C=C double bond)**(1)** • each carbon atom in the double bond is attached to (two) different atoms / different groups (of atoms) / to a H (atom) and a COOH group **(1)**	Allow "no rotation" Do not award the carbons are attached to 2 "different molecules" Mark points M1 and M2 independently	**(2)**

Q11.

Question Number	Answer	Mark
(i)	The only correct answer is **B** (elimination) ***A*** *is not correct because this is a typical reaction of alkenes, not a reaction to form alkenes* ***C*** *is not correct because alcohols are typically oxidised to aldehydes, ketones or carboxylic acids* ***D*** *is not correct because substitution removes just the –OH not an –H as well*	**(1)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following points: • compounds with the same structural formula **(1)** • where the atoms have a different arrangement in space **(1)**	Allow the bonds/groups have different spatial arrangements or orientation or configuration or 3D arrangement Allow have a different displayed formula Do not award where the molecules have a different arrangement in space Do not award a discussion of optical isomerism Do not award just 'cis/trans isomerism / *E*/*Z* isomerism'	**(2)**

Question Number	Answer	Additional Guidance	Mark
(iii)	• any two of structures and/or names correct **(1)** • both structures and names correct. **(1)**	 *Z*/cis-but-2-ene  *E*/trans-but-2-ene Can be in either order. If the isomerism described in (b)(ii) is the position of the double bond allow but-1-ene and either *Z*/cis- or *E*/trans-but-2-ene here. Allow skeletal/displayed formulae	**(2)**

Question Number	Answer	Additional Guidance	Mark
(iv)	• geometric (isomerism)	Accept *cis-trans* / *E-Z*	**(1)**