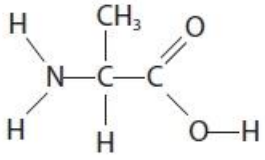
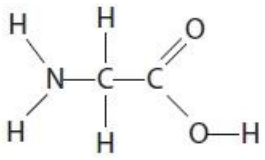
Questions

Q1.

Organic compounds containing nitrogen include amides, amines, amino acids and nitriles.

* Alanine and glycine are amino acids.

Amino acid	Structure
alanine	
glycine	

Compare and contrast the structures, optical activity and reactions with acids and bases of alanine and glycine.

Include diagrams, structures and equations to illustrate your answer.

(6)

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(Total for question = 6 marks)

Q2.

This is a question about polymerisation.

PLA is a biodegradable polyester which is made from 2-hydroxypropanoic acid, $CH_3CH(OH)COOH$.

(i) Draw the two enantiomers of 2-hydroxypropanoic acid.

(2)

(ii) State how separate samples of these two enantiomers could be distinguished in a laboratory.

(1)

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(iii) Biodegradable polyesters break down naturally.

State why this is an advantage.

(1)

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(Total for question = 4 marks)

Q3.

This is a question about the hydrolysis of halogenoalkanes.

The product of the hydrolysis of 2-bromobutane is butan-2-ol. Both molecules are chiral.

State what is meant by the term chiral, using three-dimensional diagrams of the enantiomers of butan-2-ol to illustrate your answer.

(3)

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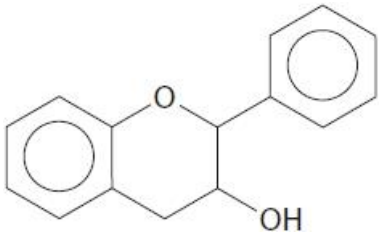
(Total for question = 3 marks)

Q4.

The compound flavan-3-ol is found in tea, fruit and wine.



Clearly label all the chiral carbon atoms in flavan-3-ol.

(Total for question = 1 mark)

Q5.

Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Methyl cinnamate, $C_{10}H_{10}O_2$, is a white crystalline solid used in the perfume industry.

Methyl cinnamate undergoes an addition reaction in the dark with bromine.

(i) Draw the mechanism for the reaction between methyl cinnamate and bromine, Br_2.
Include curly arrows, and relevant lone pairs and dipoles.

(4)

(ii) Deduce the number of optical isomers of the addition product that can exist.

(1)

- ☐ **A** 2
- ☐ **B** 3
- ☐ **C** 4
- ☐ **D** 8

(iii) When plane-polarised light is passed through an optical isomer, the plane of polarisation is

(1)

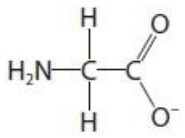
- ☐ **A** diffracted
- ☐ **B** reflected
- ☐ **C** refracted
- ☐ **D** rotated

(Total for question = 6 marks)

Q6.

Some organic compounds contain metals.

Glycinate ions are formed from the amino acid glycine.



glycinate ion

(i) Explain the effect, if any, of an aqueous solution containing glycinate ions on plane-polarised monochromatic light.

(2)

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(ii) A hot aqueous solution of glycine is added to a hot solution of copper(II) ethanoate.

When the mixture is cooled, crystals of copper(II) glycinate are formed.
Write the equation for this reaction.
State symbols are not required.

(2)

(iii) In an experiment, the crystals are filtered, weighed and the percentage yield calculated.

Student **1** obtained a yield of 102.6%.
Student **2** obtained a yield of 56.4%.
The expected yield is 82% and the students carried out the calculation correctly.
Discuss possible reasons for the yields obtained by these students.

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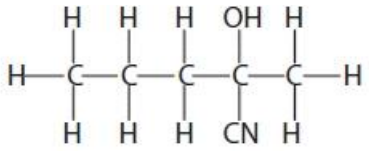
(Total for question = 8 marks)

Q7.

This question is about some carbonyl compounds with the molecular formula $C_5H_{10}O$.

Pentan-2-one reacts with hydrogen cyanide in the presence of cyanide ions to form 2-hydroxy-2-methylpentanenitrile.



2-hydroxy-2-methylpentanenitrile

(i) Draw the mechanism for the reaction between pentan-2-one and hydrogen cyanide in the presence of cyanide ions.

Include curly arrows and any relevant lone pairs.

(4)

(ii) The product of this reaction, 2-hydroxy-2-methylpentanenitrile, has a chiral centre.
Explain why a racemic mixture of 2-hydroxy-2-methylpentanenitrile is formed in this reaction.

(2)

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(Total for question = 6 marks)

Q8.

2-bromobutane can react with aqueous hydroxide ions by an S_N1 mechanism.

Explain why the butan-2-ol produced from a single optical isomer of 2-bromobutane, using this mechanism, is **not** optically active.

(3)

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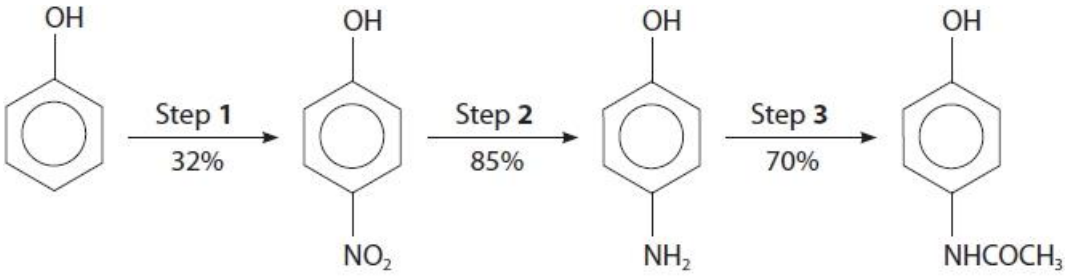
(Total for question = 3 marks)

Q9.

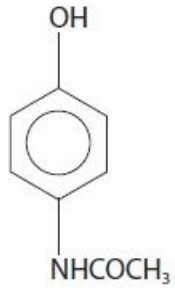
Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

The painkiller paracetamol can be synthesised from phenol in three steps.
The percentage yield for each step is shown.

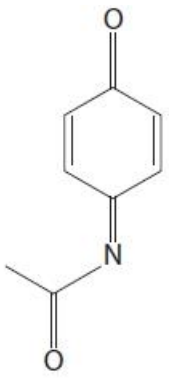


phenol paracetamol

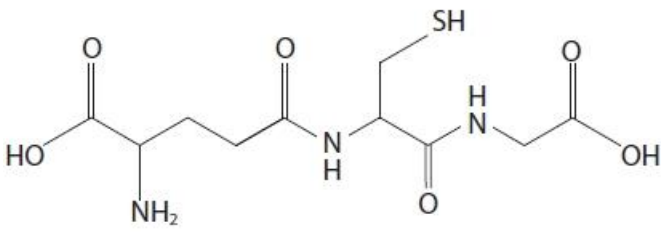
When metabolised in the body, paracetamol forms a toxic compound **Z**.
This is then removed in the liver by a reaction with the tripeptide glutathione.



paracetamol



compound **Z**



glutathione

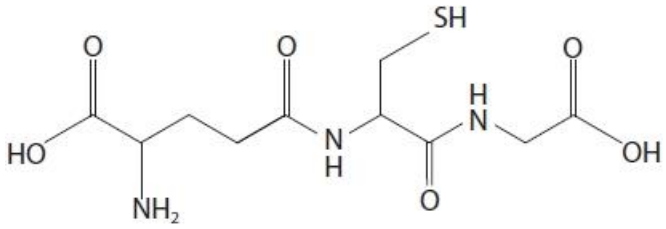
(i) The conversion of paracetamol to compound **Z** is

(1)

- ☒ **A** addition
- ☒ **B** hydrolysis
- ☒ **C** oxidation
- ☒ **D** reduction

(ii) Draw a circle around each of the chiral carbon atoms in glutathione.

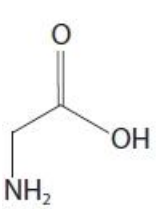
(1)



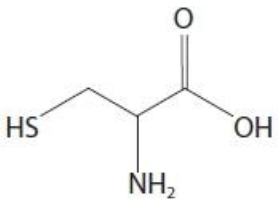
(iii) Glutathione is formed from glycine and two other amino acids.

Which two amino acids combine with glycine to form glutathione?

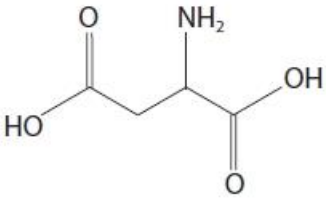
(1)



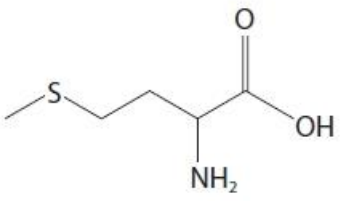
glycine



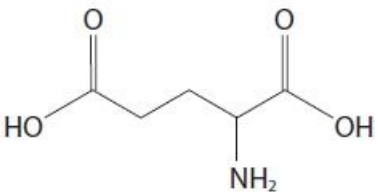
cysteine



aspartic acid



methionine



glutamic acid

- ☒ **A** aspartic acid and cysteine
- ☒ **B** glutamic acid and cysteine
- ☒ **C** glutamic acid and methionine
- ☒ **D** aspartic acid and methionine

(Total for question = 4 marks)

Q10.

(a) This question is about the analysis of an unknown carboxylic acid **X** by three students.

The students analyse the mass spectrum of **X** and find that it has a molecular ion peak at $m / z = 116$.

The three students each propose a different structural formula for compound **X**.

Structure 1 HOOCCH==CHCOOH

Structure 2 $HOCH_2CH{=}{=}CHCH_2COOH$

Structure 3 $CH_3CH_2CH_2CH_2CH_2COOH$

The students are given the infrared spectrum of **X**.

(i) State **two** wavenumber ranges of the infrared absorptions providing evidence that compound **X** is a carboxylic acid. Include the bonds responsible.

(2)

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(ii) One of the students suggests that this infrared spectrum and the data in the Data Booklet **alone** could be used to identify which of the three proposed structures is **X**.

Show that this student's suggestion is correct. Include relevant infrared data in your answer.

(3)

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(b) The students decide to carry out an acid-base titration to obtain further information about compound **X**.

Each student uses solid sodium hydroxide, NaOH, to prepare a solution of concentration 0.140 mol dm^{-3}.
Calculate the mass, in grams, of solid sodium hydroxide that each student should weigh out to prepare 250.0 cm^3 of a 0.140 mol dm^{-3} solution.

(2)

(c) Each of the students makes up 250.0 cm^3 of 0.140 mol dm^{-3} sodium hydroxide solution in a volumetric flask and titrates this solution with the same solution of **X** of known concentration.

Student A

- correctly prepares the 0.140 mol dm^{-3} sodium hydroxide solution and pipettes a volume of 10.0 cm^3 of the solution into a conical flask
- fills a burette with the solution of **X** and carries out a titration
- repeats the procedure until obtaining concordant results
- obtains a mean titre of 10.20 cm^3.

Student B

- dissolves the sodium hydroxide in distilled water and transfers the solution to a volumetric flask
- adds more distilled water to the volumetric flask and mixes the solution
- notices that the volumetric flask has been filled with distilled water several cm^3 beyond the graduation mark
- realises the mistake, removes the extra solution and discards it
- pipettes 10.0 cm^3 of the sodium hydroxide solution into a conical flask and titrates this with the solution of **X**.

Student C

- correctly prepares the 0.140 mol dm^{-3} sodium hydroxide solution
- washes a conical flask thoroughly with distilled water and pipettes 10.0 cm^3 of the sodium hydroxide solution into the wet conical flask
- titrates the contents of the conical flask with the solution of **X**.

(i) Explain how, if at all, Student **B**'s mistake affects the value of the titre.

(2)

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(ii) Explain how, if at all, Student **C**'s use of a wet conical flask affects the value of the titre.

(2)

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(iii) Student **A** uses three pieces of apparatus to measure volumes in this experiment.

- The burette has an uncertainty of ±0.05 cm^3 for each volume reading
- The volumetric flask has an uncertainty of ±0.30 cm^3 for the volume
- The pipette has an uncertainty of ±0.04 cm^3 for the volume

Show by calculation which volume measurement has the lowest percentage uncertainty.

(3)

(d) Student **A** calculates the correct value for the molar mass of compound **X**, using the mean titre of 10.20 cm^3. The results indicate that **X** has **structure 1**.

Structure 1 HOOCCH==CHCOOH
Structure 2 $HOCH_2CH{=}{=}CHCH_2COOH$
Structure 3 $CH_3CH_2CH_2CH_2CH_2COOH$

(i) Write the equation for the reaction between **structure 1** and sodium hydroxide solution. State symbols are not required.

(2)

(ii) Deduce the value that would have been obtained for the mean titre if the structural formula of **X** had been **structure 2**.
Justify your answer.

(2)

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(e) The students could have identified the three structures using chemical tests.

Complete the table to show whether or not the suggested structures react with bromine water and when heated with acidified potassium dichromate(VI).
Use a tick (✓) if a reaction occurs.
Use a cross (✗) if no reaction occurs.

(2)

Structure	Test with bromine water	Test with acidified potassium dichromate(VI)
HOOCCH═CHCOOH		
$HOCH_2CH═CHCH_2COOH$		
$CH_3CH_2CH_2CH_2CH_2COOH$		

(f) The structure HOOCCH==CHCOOH has two stereoisomers.

(i) Draw the structures of these stereoisomers.

(2)

***E*-isomer**

***Z*-isomer**

(ii) State why HOOCCH==CHCOOH has *E*/*Z* isomers.

(2)

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(Total for question = 24 marks)

Q11.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

This question is about alcohols and their reactions.

(i) Some alcohols react with concentrated phosphoric acid to form alkenes.
What is the type of this reaction?

(1)

- ☐ **A** addition
- ☐ **B** elimination
- ☐ **C** oxidation
- ☐ **D** substitution

(ii) When butan-2-ol reacts with concentrated phosphoric acid, two stereoisomers are formed.

Explain what is meant by the term stereoisomers.

(2)

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(iii) Draw the structures and give the names of the two stereoisomers.

(2)

Stereoisomer 1	Stereoisomer 2
Name:	Name:

(iv) Name this type of stereoisomerism.

(1)

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(Total for question = 6 marks)

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.

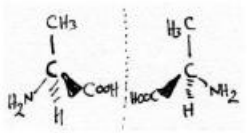
Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

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>

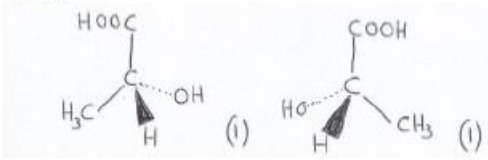
<table>
<tr><td></td><td>The following table shows how the marks should be awarded for structure and lines of reasoning</td><td></td><td></td></tr>
<tr><td></td><td>
<table>
<tr><td></td><td>Number of marks awarded for structure of answer and sustained lines of reasoning</td></tr>
<tr><td>Answer shows 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>
</td><td>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</td><td></td></tr>
</table>

	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 	

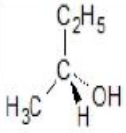
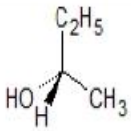
Q2.

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)**

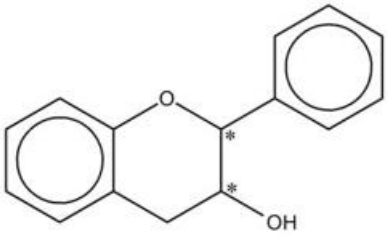
Question Number	Answer	Additional Guidance	Mark
(ii)	• They **rotate** the plane of plane-polarised light (equally) and in opposite/different directions OR Determine in which direction they **rotate** the plane of plane-polarised light	Allow one plane	**(1)**

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)**

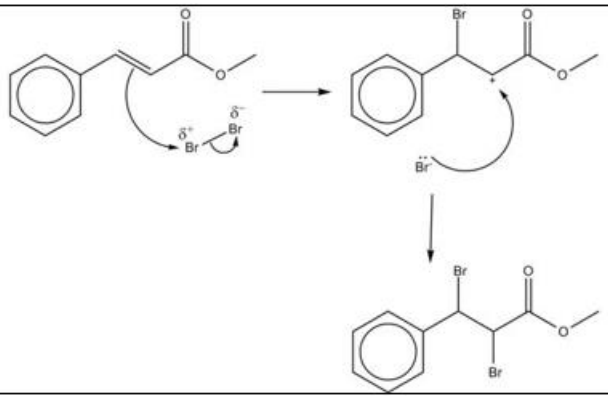
Q4.

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)**

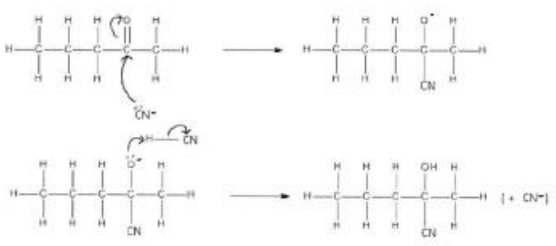
Q6.

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)

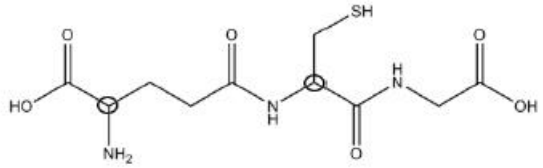
Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following points: • pentan-2-one / ketone is planar about the carbonyl carbon (1) • so the CN^- / nucleophile attacks (equally) from above and below / either side (of the plane) (1)	Allow bonds about C=O are (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)

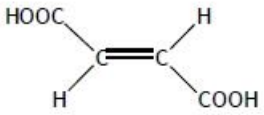
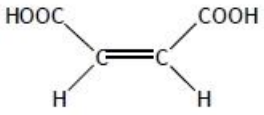
Question Number	Acceptable Answers	Additional Guidance	Mark
(c)(ii)	An explanation that makes reference to the following points: M1 no effect (on the titre) **(1)** M2 because the (number of) moles of sodium hydroxide is unaffected **(1)**	 M2 depends on M1 Allow base / alkali / hydroxide (ions) Allow 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: $\frac{2 \times (\pm)0.05}{10.20} \times 100\% = (\pm)0.980392156\%$ $\frac{(\pm)0.30}{250.0} \times 100\% = (\pm)0.12\%$ **and** $\frac{(\pm)0.040}{10.0} \times 100\% = (\pm)0.4\%$ 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)**

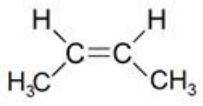
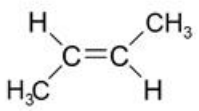
Question Number	Acceptable Answers	Additional Guidance	Mark
(f)(i)	• *E*-isomer:  **(1)** • *Z*-isomer:  **(1)**	ALLOW skeletal or displayed structures ALLOW $-CO_2H$ IGNORE Connectivity to the –COOH group IGNORE bond angles Award one mark if correct structures are drawn, but *E*- and *Z*-isomers labelled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