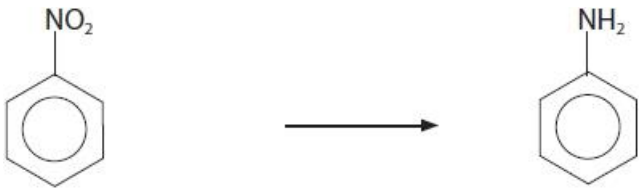
Questions

Q1.

This question is about amines.

Phenylamine is an aromatic amine and butylamine is an aliphatic amine.

Phenylamine can be prepared from nitrobenzene.



Butylamine can be prepared from butanenitrile.

$$C_3H_7CN \rightarrow C_4H_9NH_2$$

Compare and contrast these two preparations of amines.

(3)

.....

.....

.....

.....

.....

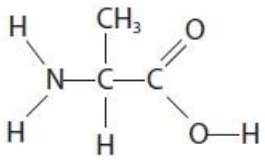
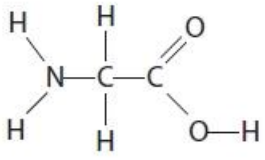
.....

(Total for question = 3 marks)

Q2.

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)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

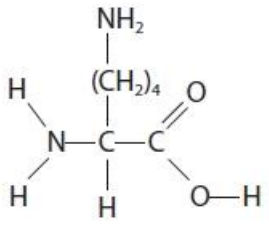
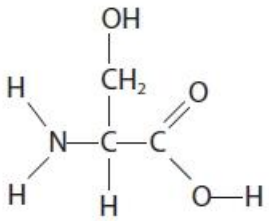
.....

(Total for question = 6 marks)

Q3.

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

Lysine and serine are two more amino acids.

Amino acid	Structure of amino acid
lysine	
serine	

Explain the difference in the volumes of 0.010 mol dm^{-3} hydrochloric acid required to completely react with separate 10.0 cm^3 samples of aqueous lysine and of aqueous serine, both of concentration 0.010 mol dm^{-3}.

(2)

.....

.....

.....

.....

.....

(Total for question = 2 marks)

Q4.

The chemistry of organic compounds containing a chlorine atom is affected by the presence of other groups.

Consider the reaction of ammonia, NH_3, with $CH_3CH_2CH_2Cl$ and with CH_3CH_2COCl.

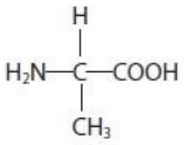
Draw the mechanism for the reaction of $CH_3CH_2CH_2Cl$ with an **excess** of ammonia to form the primary amine. Include curly arrows and relevant lone pairs.

(3)

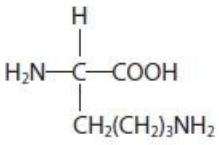
(Total for question = 3 marks)

Q5.

Alanine and lysine are amino acids.



alanine



lysine

(a) Draw the structure of a dipeptide formed when one molecule of alanine reacts with one molecule of lysine.

(1)

(b) The dipeptide formed in part (a) is hydrolysed under **acidic** conditions and the resulting mixture is analysed by column chromatography. The column uses a polar stationary phase.

Explain why lysine leaves the chromatography column after alanine.

(2)

.....

.....

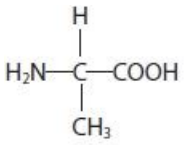
.....

.....

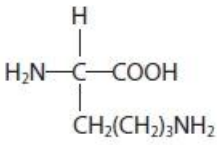
(Total for question = 3 marks)

Q6.

Alanine and lysine are amino acids.



alanine



lysine

Draw the **structure** of the organic product formed when **lysine** reacts with the following reagents:

(3)

aqueous sodium hydroxide, NaOH(aq)

excess dilute hydrochloric acid, HCl(aq)

methanol, with warming, in the presence of a few drops of concentrated sulfuric acid.

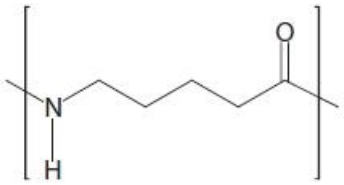
(Total for question = 3 marks)

Q7.

This is a question about polymerisation.

Deduce the single monomer that could be used to produce the polyamide shown.

(1)



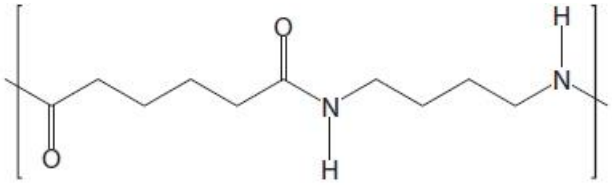
(Total for question = 1 mark)

Q8.

This is a question about polymerisation.

Deduce the two monomers needed to produce the polyamide shown.

(2)

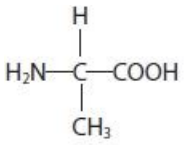


and

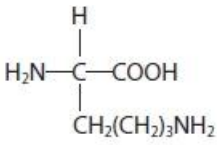
(Total for question = 2 marks)

Q9.

Alanine and lysine are amino acids.



alanine



lysine

Give the systematic (IUPAC) name for **lysine**.

(1)

.....

(Total for question = 1 mark)

Q10.

This question is about nitrogen and some nitrogen compounds.

Butylamine, $C_4H_9NH_2$, reacts with ethanoyl chloride.

$$2C_4H_9NH_2 + CH_3COCl \rightarrow C_4H_9NHCOCH_3 + C_4H_9NH_3^+Cl^-$$

Explain how this equation illustrates that butylamine acts as a nucleophile and as a base.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

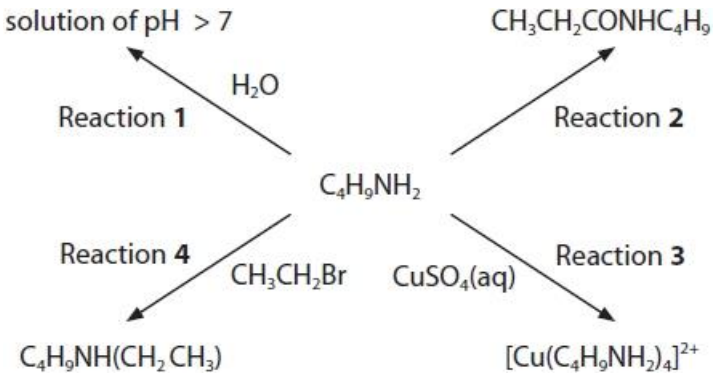
(Total for question = 4 marks)

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 the amines butylamine, $C_4H_9NH_2$, and phenylamine, $C_6H_5NH_2$.

The reaction scheme shows some reactions of butylamine, a primary amine.



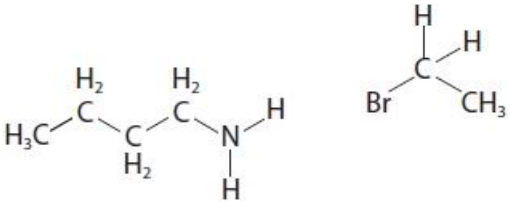
(i) What is the type and mechanism of the reaction in Reaction **4**?

(1)

- ☒ **A** electrophilic addition
- ☒ **B** electrophilic substitution
- ☒ **C** nucleophilic addition
- ☒ **D** nucleophilic substitution

(ii) Complete the diagram to show the mechanism for Reaction **4**.
Include curly arrows, and relevant lone pairs and dipoles.

(4)

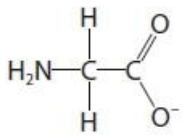


(Total for question = 5 marks)

Q12.

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)

.....

.....

.....

.....

.....

.....

(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.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 8 marks)

Q13.

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

Propylamine, $CH_3CH_2CH_2NH_2$, may be formed from either a nitrile or a halogenoalkane.

(i) Give the reagent and essential condition for the formation of propylamine from a nitrile.

Include an equation for the reaction.

(2)

.....

(ii) Give the reagent and essential conditions for the formation of propylamine from a halogenoalkane.

Include an equation for the reaction.

(3)

.....

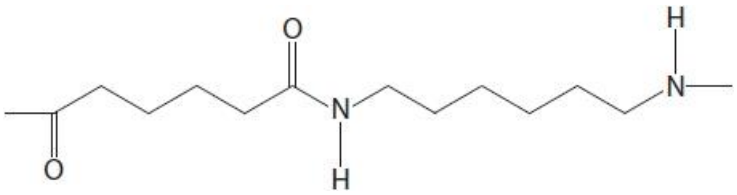
.....

(Total for question = 5 marks)

Q14.

This question is about amines.

A section of a polyamide is shown.



Identify, by name or formula, the amine monomer that reacts to form this polyamide.

(1)

.....

(Total for question = 1 mark)

Q15.

The chemistry of organic compounds containing a chlorine atom is affected by the presence of other groups.

Consider the reaction of ammonia, NH_3, with $CH_3CH_2CH_2Cl$ and with CH_3CH_2COCl.

Predict the mechanism for the reaction of CH_3CH_2COCl with ammonia. Include curly arrows and relevant lone pairs.

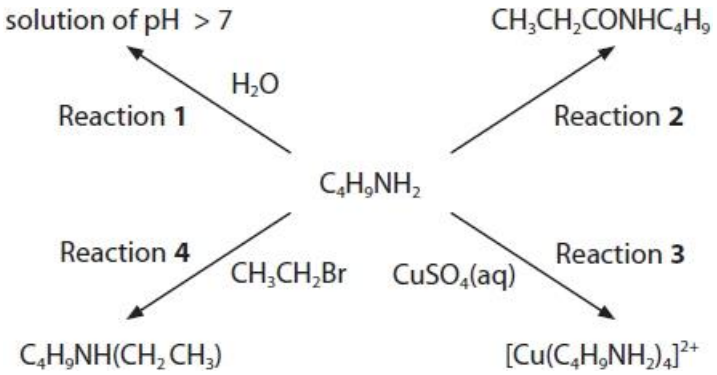
(3)

(Total for question = 3 marks)

Q16.

This question is about the amines butylamine, $C_4H_9NH_2$, and phenylamine, $C_6H_5NH_2$.

The reaction scheme shows some reactions of butylamine, a primary amine.



(i) Write the equation for Reaction **1** to show why the pH of the solution is greater than 7. State symbols are not required.

(1)

(ii) Explain why phenylamine is a weaker base than butylamine.

(3)

.....

.....

.....

.....

.....

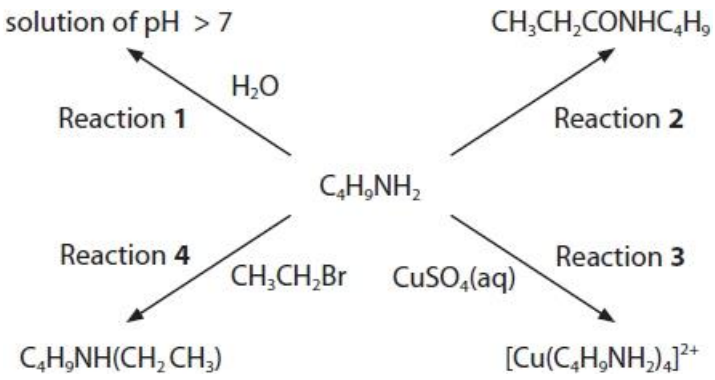
.....

(Total for question = 4 marks)

Q17.

This question is about the amines butylamine, $C_4H_9NH_2$, and phenylamine, $C_6H_5NH_2$.

The reaction scheme shows some reactions of butylamine, a primary amine.



Give the name and structural formula of the compound needed to react with butylamine in Reaction **2**.

(2)

Name.....

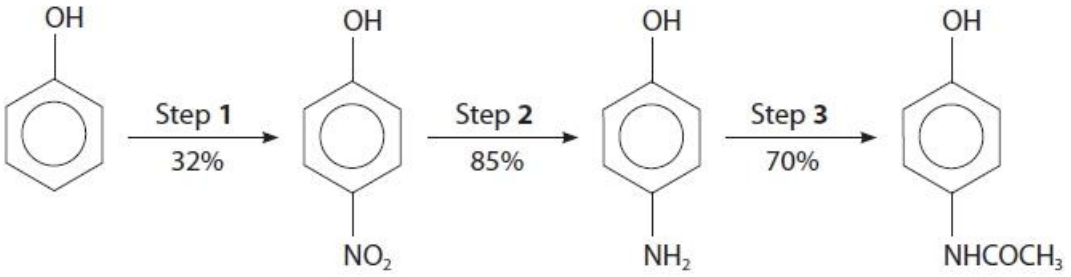
Structural formula.....

(Total for question = 2 marks)

Q18.

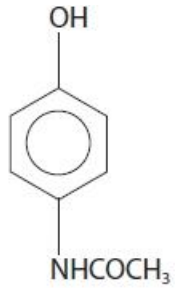
Answer the question with a cross in the box you think is correct ☒ . If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒ .

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

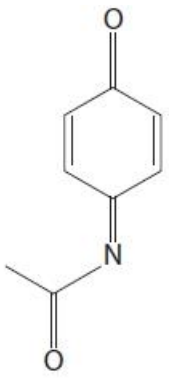


phenol paracetamol

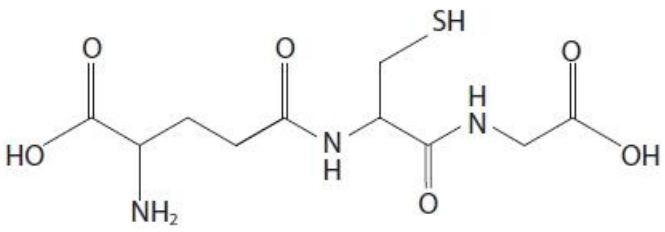
When metabolised in the body, paracetamol forms a toxic compound **Z**.
This is then removed in the liver by a reaction with the tripeptide glutathione.



paracetamol



compound **Z**



glutathione

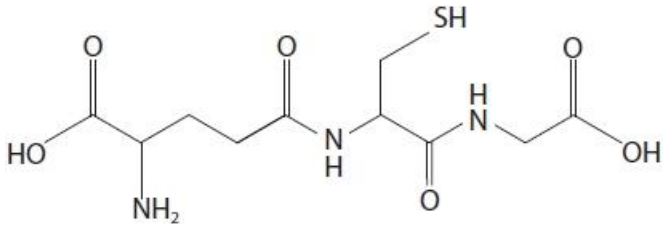
(i) The conversion of paracetamol to compound **Z** is

(1)

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

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

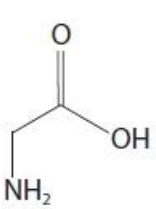
(1)



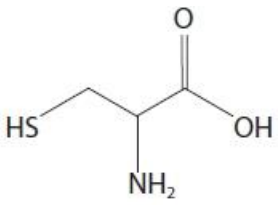
(iii) Glutathione is formed from glycine and two other amino acids.

Which two amino acids combine with glycine to form glutathione?

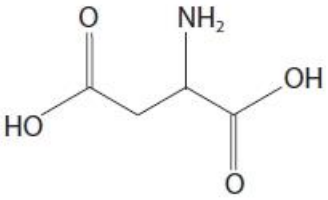
(1)



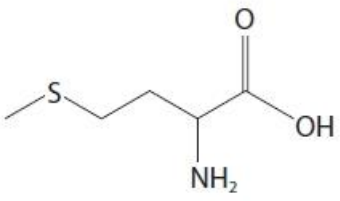
glycine



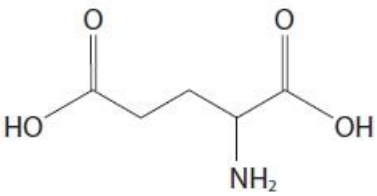
cysteine



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)

Q19.

This question is about amines.

Compare and contrast the basicity of phenylamine and butylamine.

(3)

.....

.....

.....

.....

.....

.....

.....

(Total for question = 3 marks)

Q20.

This question is about amines.

Write the equation for the reaction between propanoyl chloride and pentylamine.
Include the name of the amide formed.

State symbols are not required.

(2)

Name of amide
.....

(Total for question = 2 marks)

Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to • (similarity) both are reduction reactions **(1)** • (difference 1) reagents for preparation of phenylamine are tin and (conc.) hydrochloric acid **(1)** • (difference 2) reagents for preparation of butylamine are either Hydrogen gas **and** nickel catalyst **or** lithium tetrahydridoaluminate(III) **and** (dry) ether **(1)**	Ignore both require hydrogen Allow Iron for tin Do not award dilute hydrochloric acid/ sulfuric acid Lithium aluminium hydride / Lithal / $LiAlH_4$	**(3)**

Q2.

<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.

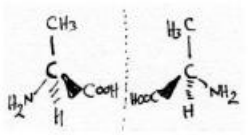
The following table shows how the marks should be awarded for indicative content.
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5-4</td><td>3</td></tr>
<tr><td>3-2</td><td>2</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>

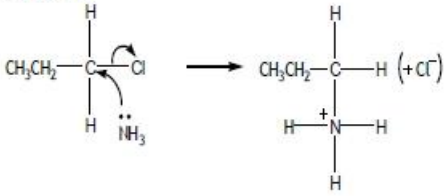
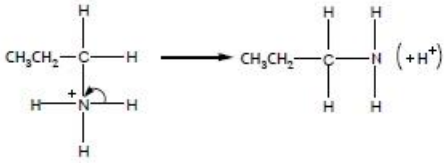
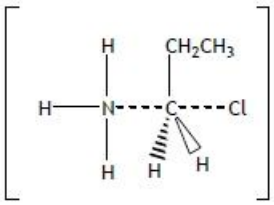
	Indicative content IP1 (Similarity) • they are **both** 2-amino acids / alpha amino acids / naturally occurring/ zwitterions IP2 • equation for the reaction with an acid IP3 • equation for the reaction with a base	The zwitterions can be evidenced from each amino acid zwitterion in an equation e.g. $NH_3^+CH(CH_3)COO^-$ / $NH_3^+CH_2COO^-$ 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	

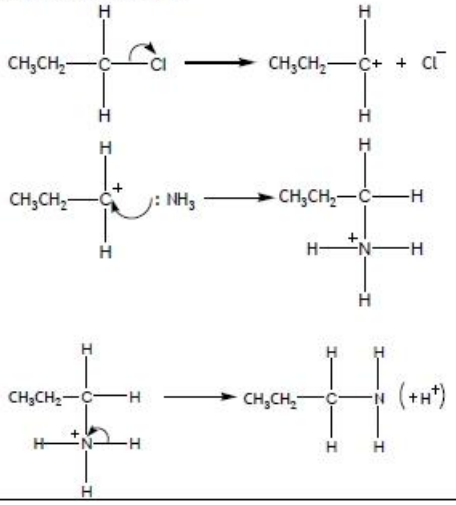
	IP4 • alanine has a chiral centre/ asymmetric carbon atom/ non-superimposable mirror images **and** glycine does not IP5 • (an aqueous solution of) alanine rotates the plane (of polarisation) of plane-polarised (monochromatic) light but glycine does not IP6 • diagram to show enantiomers of alanine	Allow 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 	

Q3.

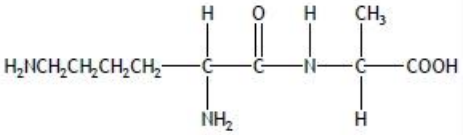
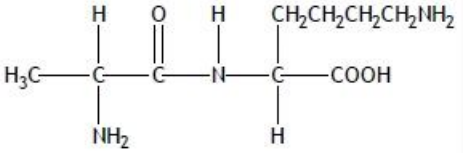
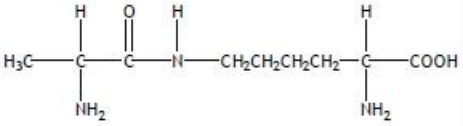
Question Number	Answer	Additional Guidance	Mark
	An explanation which includes • lysine requires twice (the volume of HCl) **(1)** • (because) lysine has two (basic) amine/NH_2 groups whereas serine has one **(1)**	 Allow lysine requires 20.0 cm^3 and serine requires 10 cm^3 Allow lysine has one more (basic) / another amine/ NH_2 group Allow lysine can accept two protons whereas serine can only accept one	**(2)**

Q4.

Question Number	Acceptable Answers	Additional Guidance	Mark
	• first two curly arrows and lone pair shown on the nitrogen **(1)** • structure of intermediate including positive charge **(1)** • third curly arrow and formation of final organic product **(1)**	Ignore correct dipoles Allow non-displayed NH_3^+ for MP2 Ignore involvement of Cl^- / NH_3 or wrong inorganic products for MP3 EITHER   Ignore depiction of transition state e.g. 	**(3)**

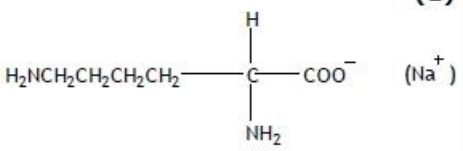
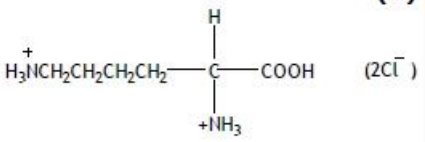
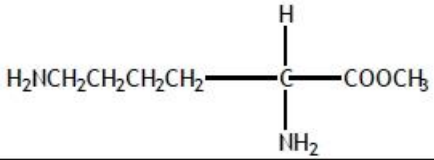
	OR • fission of C-Cl bond curly arrow **and** curly arrow from nitrogen in NH_3 with lone pair shown on N atom to correct carbocation **(1)** • structure of resulting nitrogen-containing intermediate including positive charge **(1)** • curly arrow resulting in breaking of an N-H bond and structure of the final organic product **(1)**	OR AWARD S_N1 mechanism 	

Q5.

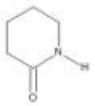
Question Number	Acceptable Answers	Additional Guidance	Mark
(a)	Any one of:  OR  OR 	Must be the dipeptide and not the repeat unit Allow $-CO_2H$ Allow $-H_2N$ Allow –CONH– / -COHN- unless C-H-N Allow zwitterions or cyclic dipeptides Allow skeletal / part-skeletal formulae	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
(b)	An explanation that makes reference to the following points: • (In acidic conditions) lysine (ion) has two positive charges (whereas alanine has only one) **(1)** • (So lysine ion has) has greater attraction for the stationary phase **(1)**	Ignore comments on retention time, solubility, polarity, dipoles or intermolecular forces Allow 'greater positive charge' Allow lysine has 2 NH_2 groups that can be protonated Allow 'greater affinity for stationary phase' 'adheres better to stationary phase' 'better adsorption onto stationary phase' Allow 'polar phase' for 'stationary phase' Allow reverse argument for alanine Mark points M1 and M2 independently	**(2)**

Q6.

Question Number	Acceptable Answers	Additional Guidance	Mark
	• Deprotonated structure **(1)** 	Allow displayed /structural /condensed formulae Allow NH_2- Allow $-CO_2^-$ Allow –COONa but penalise if O–Na covalent bond is shown	**(3)**
	• Protonated structure **(1)** 	**Both** NH_2 groups must be protonated Allow NH_3^+- / $^+H_3N-$ Allow $-CO_2H$	
	• Ester structure **(1)** 	Allow CO_2CH_3 Allow NH_3^+- or NH_2- for each amine group Penalise wrong side chain only once If alanine used throughout then only MP3 can be awarded	

Q7.

Question Number	Answer	Additional Guidance	Mark
	$H_2N - (CH_2)_4 - COOH$	Accept skeletal, structural or displayed formulae Allow $H_2N - (CH_2)_4 - COCl$ Ignore connectivity Allow  Allow use of C_4H_8 here only Penalise missing hydrogens	**(1)**

Q8.

Question Number	Answer	Additional Guidance	Mark
	• $HOOC - (CH_2)_4 - COOH$ or $ClOC - (CH_2)_4 - COCl$ **(1)** • $H_2N - (CH_2)_4 - NH_2$ **(1)**	Accept skeletal, structural or displayed formulae Penalise use of C_4H_8 once only Penalise missing H's once only The monomers can be in either order Do not award monofunctionality	**(2)**

Q9.

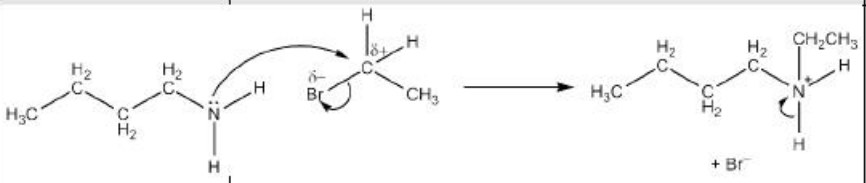
Question Number	Acceptable Answers	Additional Guidance	Mark
	• 2,6-diaminohexanoic acid	Allow 2,6-diaminehexanoic acid Ignore any additional commas or hyphens or spaces Do not award 2,6-diamminohexanoic acid	**(1)**

Q10.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following points: • nucleophiles are electron **pair** donors / attack areas of low electron density / the nitrogen donates its lone **pair** of electrons **(1)** • so the amine group attacks as a (nucleophile) by attacking the $C^{\delta+}$ of the acyl chloride **(1)** • which produces hydrogen chloride **(1)** • it's a base because amine group reacts with the acid / protons (to produce the salt / $C_4H_9NH_3Cl$) **(1)**	Allow the N/ butylamine for 'the amine group' Allow shown in a mechanism Do not award attacks carbocation Allow hydrochloric acid Allow the N/ butylamine for 'the amine group' Allow base is a proton acceptor Do not award just 'hydrogen' for proton Do not award reference to ethanoyl chloride as an acid/donating a proton	**(4)**

Q11.

Question Number	Answer	Mark
(i)	**The only correct answer is D** (nucleophilic substitution) *A is incorrect because the reaction is not an addition or electrophilic* *B is incorrect because the attacking species is not an electrophile* *C is incorrect because the reaction is not an addition*	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)			(4)
	• arrow from lone pair on nitrogen atom to carbon atom **(1)**	Ignore transition state	
	• dipole shown **and** arrow from C-Br bond to Br or just beyond **(1)**	Ignore arrow from Br^- ion to H in intermediate	
	• formula of intermediate including + charge on the N atom and Br^- **(1)**		
	• arrow from N-H bond to N^+ **(1)**		

Q12.

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)**

Q13.

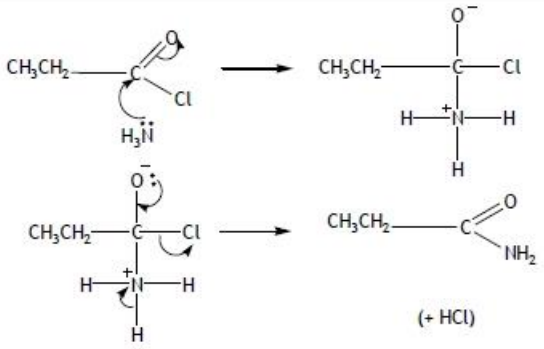
Allow annotated equations to score these marks in both (i) and (ii) **Allow any unambiguous formulae for the organic molecules in both (i) and (ii) such as C_2H_5CN for CH_3CH_2CN**			
Question Number	**Answer**	**Additional Guidance**	**Mark**
(i)	A description which includes • equation **(1)** • $LiAlH_4$ in (dry) ether (followed by dilute acid) or H_2 with Ni / Pt / Pd **(1)**	<u>Example of equation</u> $CH_3CH_2CN + 4[H] \rightarrow CH_3CH_2CH_2NH_2$ $CH_3CH_2CN + 2H_2 \rightarrow CH_3CH_2CH_2NH_2$ Allow names or formulae but both must be correct if given together Allow Lithal Allow hydrogen to be given in the equation or written over the arrow Ignore references to heat or a temperature	**(2)**

Question Number	Answer	Additional Guidance	Mark
(ii)	A description which includes • equation from any halogenoalkane **(1)** • ethanolic/alcoholic ammonia **(1)** • heat **and** under pressure **(1)**	<u>Example of equation</u> $CH_3CH_2CH_2Br + NH_3 \rightarrow CH_3CH_2CH_2NH_2 + HBr$ or $CH_3CH_2CH_2Br + 2NH_3 \rightarrow CH_3CH_2CH_2NH_2 + NH_4Br$ Allow use of state symbol (alc)/(EtOH)/(eth) with NH_3 Allow ammonia to be given in equation or written over the arrow Accept heat **and** in a sealed tube Ignore mechanisms If a contradictory chemical is stated then penalise once against M2 or M3	**(3)**

Q14.

Question Number	Answer	Additional Guidance	Mark
	• amine monomer structure or name	$H_2N(CH_2)_6NH_2$ / 1,6-diaminohexane Accept any mixture of displayed, structural or skeletal formulae Do not award molecular formulae or $H_2N\ C_6H_{12}\ NH_2$ If name and formula given then both must be correct	**(1)**

Q15.

Question Number	Acceptable Answers	Additional Guidance	Mark
	• first two curly arrows and lone pair shown on the nitrogen **(1)** • structure of intermediate including both charges **(1)** • three curly arrows and structure of final organic product **(1)**		**(3)**

Q16.

Question Number	Answer	Additional Guidance	Mark
(i)	• balanced equation	Example of equation $C_4H_9NH_2 + H_2O \rightleftharpoons C_4H_9NH_3^+ + OH^-$ + sign can be on N Product ions must be shown as 2 species Allow arrow for ⇌ Ignore state symbols even if incorrect	(1)

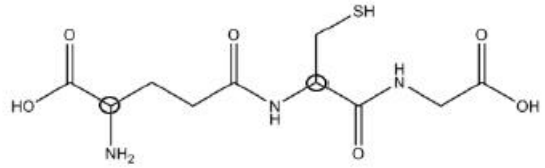
Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following points • lone pair of electrons on the nitrogen atom (1) • the interaction of the lone pair and the pi electrons of the ring (1) • so less able to accept a proton (1) allow 2 possible marking points for reverse argument • butyl group pushes electrons towards lone pair on nitrogen • so it is more able to accept a proton	Allow the lone pair delocalises into the benzene ring	(3)

Q17.

Question Number	Answer	Additional Guidance	Mark
	• correct name (1) • correct formula (1)	Propanoyl chloride Allow propanoic anhydride CH_3CH_2COCl Allow $(CH_3CH_2CO)_2O$ Allow displayed or skeletal formula Allow 1 mark for correct name **and** formula for propanoic acid Allow 1 mark for name and formulae of acyl chloride / acid anhydride with incorrect number of carbon atoms	(2)

Q18.

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)

Q19.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to: • (similarity) both are basic because they have a lone pair of electrons on the nitrogen atom which accepts a proton **(1)** • (difference 1)in $C_6H_5NH_2$ the lone pair of electrons of the nitrogen atom becomes incorporated with the delocalised ring of electrons and so is less able to accept a proton hence a weaker base **(1)** • (difference 2) the alkyl group/ C_4H_9 is electron-releasing / positively inductive and means the lone pair of electrons of the nitrogen atom are more able to accept a proton hence a stronger base **(1)**	Diagrams can be used to score Comparison of basicity/nitrogen's lone pair of electrons/proton acceptance only need to be mentioned once.	**(3)**

Q20.

Answer	Additional Guidance	Mark
• equation **(1)**	$C_2H_5COCl + C_5H_{11}NH_2 \rightarrow C_2H_5CONHC_5H_{11} + HCl$ or  Allow skeletal/structural/combination of formulae Allow $C_2H_5COCl + 2C_5H_{11}NH_2 \rightarrow C_2H_5CONHC_5H_{11} + HCl + C_5H_{11}NH_3Cl$ Do not award molecular formulae	**(2)**
• name **(1)**	N-pentylpropanamide Do not award N-pentylpropylamine	