Question Number	Acceptable Answers	Reject	Mark
1(a)(i)	Lone pair(s) (of electrons on the nitrogen) ALLOW Non-bonded pair(s)	Spare pair	**1**

Question Number	Acceptable Answers	Reject	Mark
1(a)(ii)	$CH_3CH_2CH_2CH_2NH_2 + H_2O \rightleftharpoons CH_3CH_2CH_2CH_2NH_3^+ + OH^-$ ALLOW $\rightarrow$ for $\rightleftharpoons$ IGNORE state symbols even if incorrect Right hand ions must be shown separately ALLOW $C_4H_9NH_2$	Reject near misses	**1**

Question Number	Acceptable Answers	Reject	Mark
1(a)(iii)	**two of:** Butyl / alkyl groups are electron donating / are electron pushing / are electron releasing Two (alkyl) groups in dibutylamine (but only one in butylamine) **Lone pair** (of electrons) on the nitrogen more readily available / higher electron density on the nitrogen or NH_2 or amine group / N more delta negative / N or NH_2 accepts a proton more readily **(2)** Stand alone marks Accept reverse argument for butylamine IGNORE 'electronegativity of nitrogen increasing'		**2**

Question Number	Acceptable Answers	Reject	Mark
1(a)(iv)	**mark** For the idea of the **lone pair** being withdrawn towards the ring Lone pair pulled into the ring Lone pair (of electrons) on the nitrogen overlap Lone pair interacts with π electrons / lone pair interacts with delocalized electrons of the (benzene) ring Lone pair (of electrons) on the nitrogen donated to the (benzene) ring **(1)** NOTE The reference to the lone pair may be found in a later part of the answer and credited **Second mark** EITHER For the idea of the **lone pair** being less available OR The **nitrogen** (atom) must be specified as below e. Lone pair is less readily available Nitrogen (atom) has lower electron density N (atom) or lone pair is less able to accept protons / H^+ **(1)** ALLOW N is less δ^- for second mark		**2**

Question Number	Acceptable Answers		Mark
1(b)	I $(Cu(H_2O)_6^{2+} + 2C_4H_9NH_2) \rightarrow Cu(H_2O)_4(OH)_2 + 2C_4H_9NH_3^+$ ALLOW I $(Cu(H_2O)_6^{2+} + 2C_4H_9NH_2) \rightarrow Cu(OH)_2 + 2C_4H_9NH_3^+ + 4H_2O$ **(2)** II $(Cu(H_2O)_6^{2+} + 4C_4H_9NH_2) \rightarrow Cu(H_2O)_2(C_4H_9NH_2)_4^{2+} + 4H_2O$ ALLOW II $(Cu(H_2O)_6^{2+} + 4C_4H_9NH_2) \rightarrow Cu(C_4H_9NH_2)_4^{2+} + 6H_2O$ **(2)** Each correct equation scores 2 marks: 1 mark for the formula of the copper complex ion and 1 mark for the rest of the equation being correct Ligands can be in either order IGNORE state symbols even if incorrect IGNORE (lack of) square brackets around complex ions		**4**

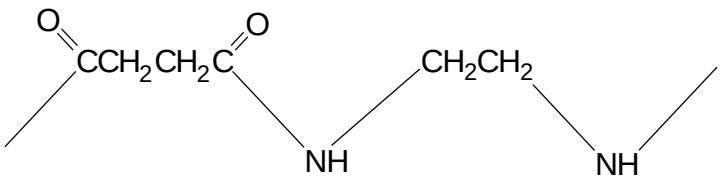
Question Number	Acceptable Answers	Reject	Mark
1(c)	Reaction is a nucleophilic substitution **(1)** It is unusual because benzene normally reacts with electrophiles / by electrophilic substitution OR Positive charge withdraws electrons from the ring (making it susceptible to nucleophilic attack) OR Expect nucleophiles to be repelled by the electron density of the ring **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
2(a)	$H_2NCH_2CH_2NH_2 + 2HCl \rightarrow H_3N^+CH_2CH_2NH_3^+ + 2Cl^-$ **(1)** organic product Positive charges can be on nitrogens Balancing with **HCl** and **Cl^-** **(1)** Chloride ions can be at ends of product ie $ClH_3NCH_2CH_2NH_3Cl$ for right hand side, with or without charges, but if given charges must balance $H_2NCH_2CH_2NH_2 + 2H^+ \rightarrow H_3N^+CH_2CH_2NH_3^+$ **(2)** Reaction with 1 mol HCl for 1 max If molecular formulae used 1 max IGNORE state symbols even if wrong	Covalent bond to Cl, (-Cl)	**2**

Question Number	Acceptable Answers	Reject	Mark
2 (b)(i)	Blue or green or blue-green or lavender ALLOW qualification of blue or green e.g. dark blue, but not with another colour e.g. blue purple	Any other colour e.g. Purple Violet	**1**

Question Number	Acceptable Answers	Reject	Mark
2(b)(ii)	The entropy change of the **system** is positive **(1)** Because there is an increase in the number of particles/entities/moles/molecules OR The number of particles/entities/moles goes from four to seven OR Complex with three molecules goes to a complex with six molecules **(1)** Second mark depends on a positive entropy change	Additional incorrect numbers molecules/ atoms from four to seven	**2**

Question Number	Acceptable Answers	Reject	Mark
2(b)(iii)	They will **rotate** the **plane of plane-** polarised light (equally in opposite directions) Allow They will **rotate** the **plane** of polarised light (equally in opposite directions) OR They will **rotate plane-** polarised light (equally in opposite directions)	Optically active Reflect/ bend/ refract	**1**

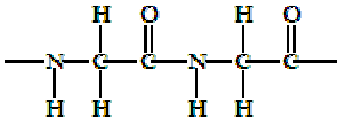
Question Number	Acceptable Answers	Reject	Mark
2(c)(i)	 Amide linkage correct **(1)** Further detail correct, including trailing bonds **(1)** IGNORE brackets ALLOW multiple units Second mark dependent on correct amide link ALLOW fully correct structural formulae for 1 ~~(~~$OCCH_2CH_2CONHCH_2CH_2NH$~~)~~ Can start with NH group		**2**

Question Number	Acceptable Answers	Reject	Mark
2(c)(ii)	Condensation **(1)** Hydrogen chloride/HCl/water/H_2O or another **small** molecule/is produced/lost/formed/removed (as well as the polymer) **(1)** Mark independently	Addition/elimination	**2**

Question Number	Acceptable Answers	Reject	Mark
***2(c)(iii**	**Types of force** Hydrogen bonds **and** (permanent) dipole(-permanent dipole) forces **and** London/van der Waals'/dispersion forces OR Explanation e.g temporary/induced dipoles **(1)** All three needed for 1st mark (which is given even if the forces are later explained incorrectly) **Hydrogen bonds** (Between) the hydrogen atoms on the nitrogen atoms and ... OR (Between) N-H and ... **(1)** ... (the lone pair of electrons on) oxygen/ nitrogen atoms **(1)** These marks can be shown by a diagram **Permanent dipole-permanent dipole forces** Because the C=O / carbon-oxygen bond/the C-N bond is polar/a dipole OR N and/or O are electronegative atoms This mark can be shown by a diagram providing the polarity of the bond is shown **(1)** **London forces** Polymer has large number of/many electrons OR Explanation e.g temporary/induced/fluctuating dipoles **(1)**	Just p.d.- p.d Just v d W Large molecular mass alone	**5**

Question Number	Acceptable Answers	Reject	Mark
3(a)(i)	Formula showing $-NH_3^+$ and $—COO^-$ /$—CO_2^-$ Charges can be anywhere on functional group Rest of the molecule must be correct ALLOW displayed/part displayed formula		**1**

Question Number	Acceptable Answers	Reject	Mark
3(a)(ii)	**Any two from** High energy needed (to overcome) **(1)** strong ionic/electrostatic forces OR strong forces between oppositely charged ions/between positive and negative **(1)** between **different** (zwitter)ions OR between $-NH_3^+$ and $—COO^-$ OR between one molecule and another OR Chains of zwitterions/molecules **(1)**	any reference to intermolecular forces eg (strongly) polar/bond polarity if they state the ionic bond is within the same molecule	**2**

Question Number	Acceptable Answers	Reject	Mark
3(a)(iii)	 Correct peptide link **(1)** Minimum two residues and extension to the rest of the molecule **(1)** ALLOW $-NHCH_2CONHCH_2CO-$ **(2)** Drawn the other way round, i.e. starting with the carbonyl group Brackets around outside with 'n' ie ~~(~~.....~~)~~$_n$ Second mark depends on first		**2**

Question Number	Acceptable Answer	Reject	Mark
***3(b) QWC**	**Key Points** **KP1** Spot (of hydrolysate) on paper/tlc/thin layer chromatogram **(1)** **KP2** Marker spots of known amino-acids/measure R_f **(1)** **KP3** Run in (suitable) solvent/discussion of comparative solubilities in phases **(1)** **KP4** (Spray with) ninhydrin (and heat) [Stand alone mark] **(1)** **KP 5** Marker spots and the unknown spots correspond ALLOW Compare R_f values of marker spots with hydrolysate spots **(1)** OR If 2-d chromatography used (2 different solvents run in two directions at right angles): **KP1** Spot (of hydrolysate) on paper/tlc/thin layer chromatogram **(1)** **KP2** Run in (suitable) solvent in one direction **(1)** **KP3** Develop in suitable/different solvent at right angles OR discussion of comparative solubilities in phases **(1)** **KP4** Spray with ninhydrin (andheat) **(1)** **KP5** Compare hydrolysate spots with same experiment for known amino acids **(1)** OR	Spot one amino acid/protein Water alone as solvent Spot one amino acid	**5**

	if column/GLC/GC used **KP1** Put amino acid mixture **(**Hydrolysate) into column **(1)** **KP2** Separately known amino-acids into column **(1)** **KP3** Detect amino acids in effluent with Ninhydrin/mass spectrometry **(1)** **KP4** Measure retention times/ discussion of comparative solubilities in phases **(1)** **KP 5** Compare retention times **(1)**	Spot one amino acid	