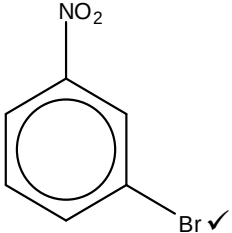
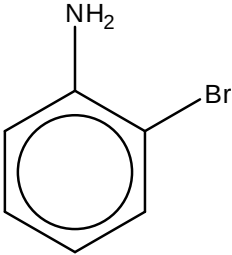
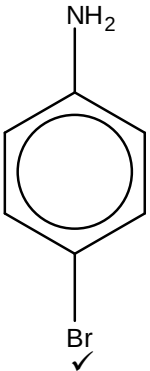


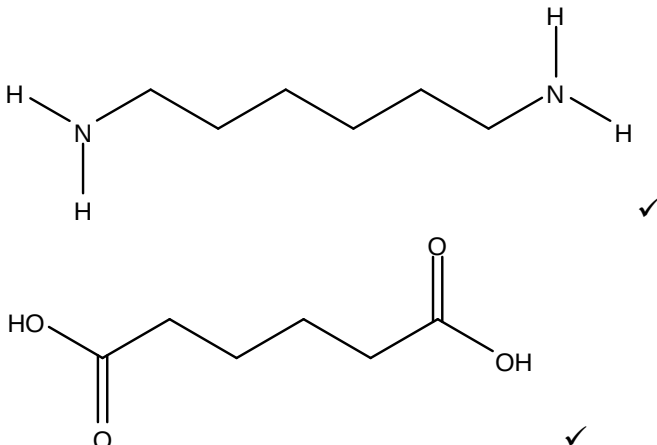
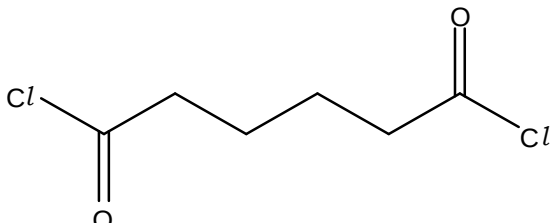
Question	Key	Marks	Guidance
1	A	1	

Question	Key	Marks	Guidance
2	A	1	

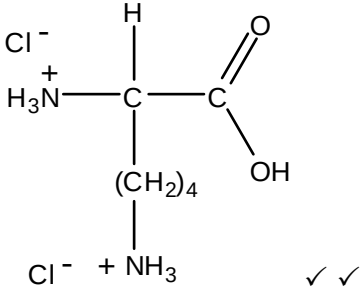
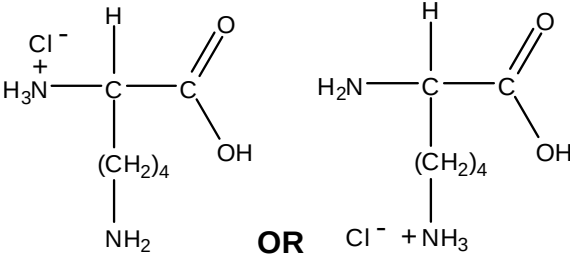
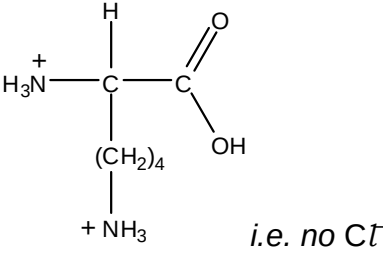
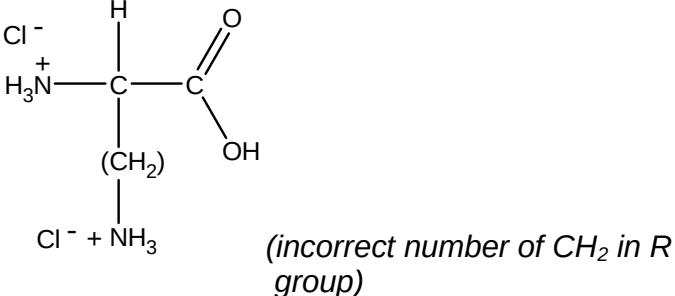
Question	Answer	Marks	Guidance
3	 Reduction: Sn AND (concentrated) HCl ✓		ALLOW Kekulé structure IGNORE names (<i>question asks for formulae</i>) IGNORE reaction conditions even if incorrect IGNORE 'dilute' for HCl IGNORE H₂ IGNORE NaOH if seen as a reagent to convert nitro group into amine e.g 'Sn/(concentrated) HCl then NaOH' scores the mark
	NH₂ is 2,4 directing ✓ Products (1 mark for each):  ✓  ✓	3	IGNORE references to electron donating/withdrawing groups ALLOW –NH₂ activates the ring causing the new group to join at positions 2 and 4. ALLOW ortho and para directing for 2,4 directing IGNORE 6-directing ALLOW Kekulé structure IGNORE names
	Total	21	

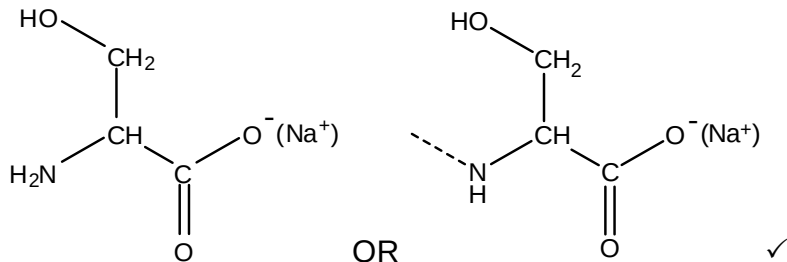
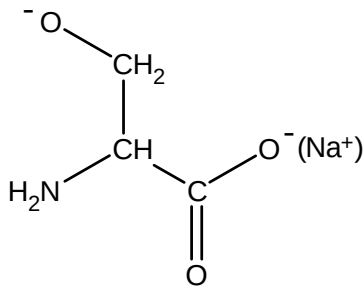
Question	Answer	Marks	Guidance
4	Explanation Nitrogen electron pair OR nitrogen lone pair AND accepts a proton/H^+ ✓ Structure of salt $ \begin{array}{c} \text{OH} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{NH}_3^+ \\ \quad \\ \text{H} \quad \text{H} \end{array} $ AND Cl^- ✓	2	IGNORE NH_2 group donates electron pair ALLOW nitrogen donates an electron pair to H^+ DO NOT ALLOW nitrogen donates lone pair to acid IGNORE comments about the O in the $-OH$ group Compound H is a base is not sufficient (<i>role of lone pair required</i>) DO NOT ALLOW nitrogen/N lone pair accepts hydrogen (<i>proton/H^+ required</i>) ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous ALLOW $ \begin{array}{c} \text{OH} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{NH}_3Cl \\ \quad \\ \text{H} \quad \text{H} \end{array} $ <i>i.e.</i> charges not required IF charges are shown both need to be present ALLOW charge either on N atom or NH_3^+ IF displayed then + charge must be on the nitrogen

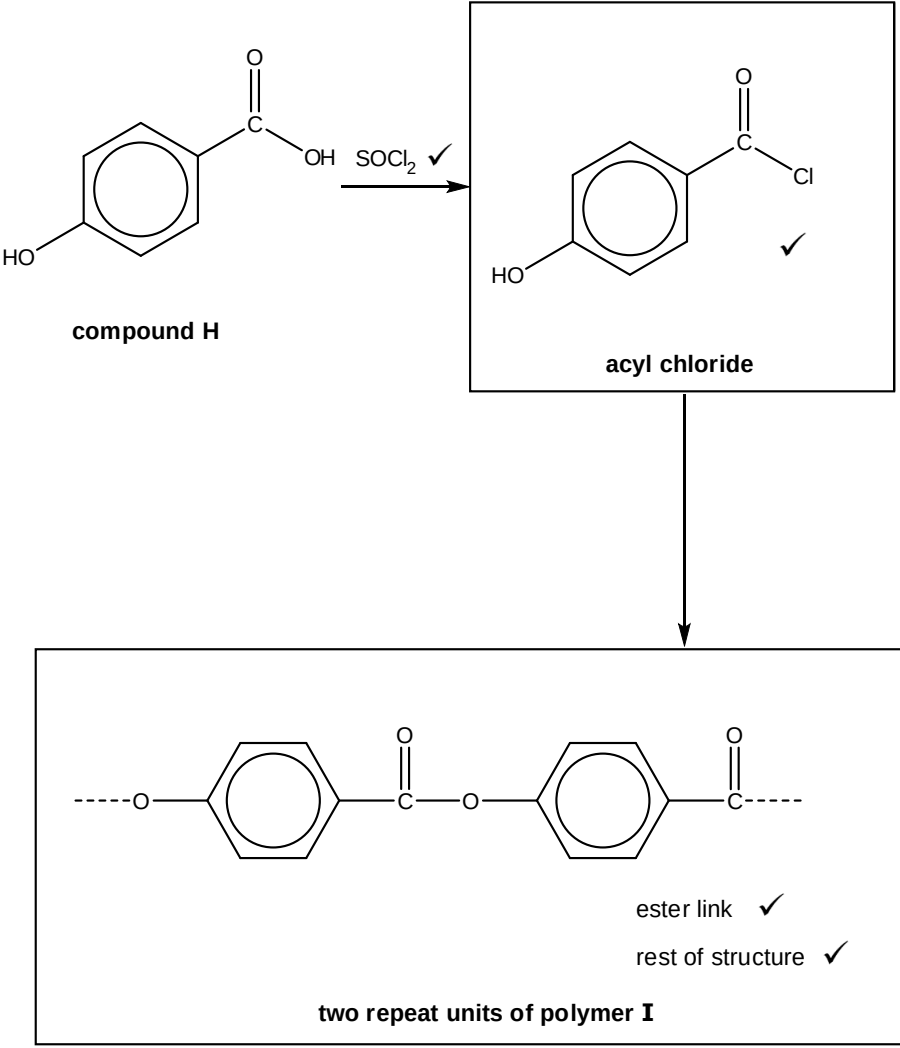
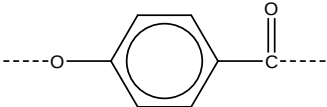
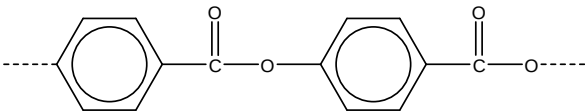
Question	Answer	Marks	Guidance
5	$\text{---O---}\begin{array}{c} \text{H} \\ \\ \text{C} \\ \\ \text{H} \end{array}\text{---}\overset{\text{O}}{\parallel}{\text{C}}\text{---O---}\begin{array}{c} \text{H} \\ \\ \text{C} \\ \\ \text{H} \end{array}\text{---}\overset{\text{O}}{\parallel}{\text{C}}\text{---}$ Ester link ✓ Rest of structure ✓ (polymer J is biodegradable because) the ester / ester bond / ester group / polyester can be hydrolysed ✓	3	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous DO NOT ALLOW more than two repeat units for second marking point. ‘End bonds’ MUST be shown (do not have to be dotted) IGNORE brackets IGNORE n Broken down by water is not sufficient IGNORE references to photodegradable

6	(i)		2	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous ALLOW 
	(ii)	$(n = \frac{21500}{226} =)$ 95 (repeat units) ✓	1	MUST be a whole number. DO NOT ALLOW an answer that uses an incorrect molar mass in the working. ALLOW 96
		Total	14	

Question	Answer	Marks	Guidance
7	C	1	

Question	Answer	Marks	Guidance
8	Correct salt of lysine with both amine groups protonated 	2	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous Note: <i>Ct</i> is required (<i>question asks for salt</i>) ALLOW NH_3Cl <i>i.e</i> charges not required ALLOW 1 mark for  OR  <i>i.e. no Ct</i> IF there is a small slip in the structure ALLOW 1 mark for diammonium salt e.g  <i>(incorrect number of CH₂ in R group)</i>

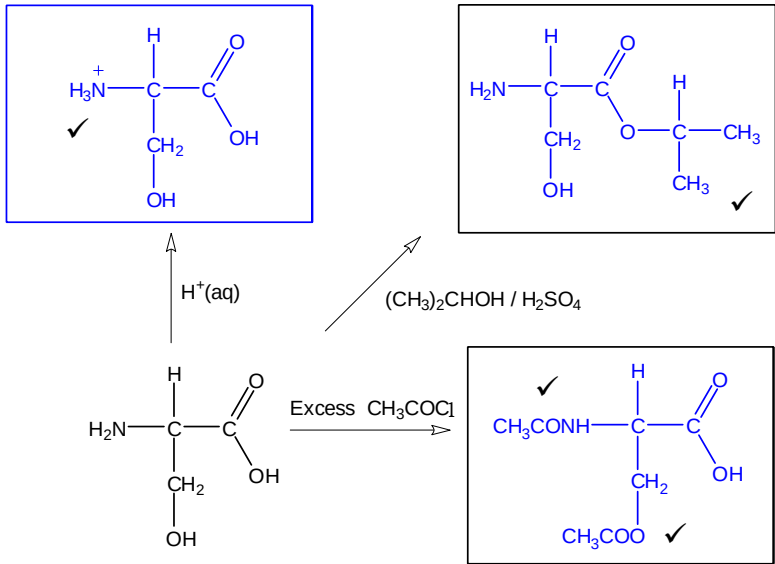
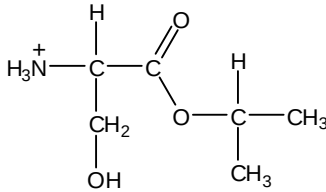
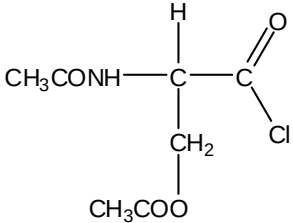
			$\text{Cl}^- + \text{NH}_3$ (H missing from α C atom)
9			3 ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous IGNORE NH_3 (question asks for organic products) ALLOW COO^- OR COONa DO NOT ALLOW negative charge on C atom DO NOT ALLOW COO-Na (covalent bond) BUT ALLOW ECF if seen in subsequent structures DO NOT ALLOW COOH in this structure DO NOT ALLOW (sodium) salt of alcohol group i.e. 

Question	Answer	Marks	Guidance
10	One mark for each correct structure/reagent as shown below  compound H acyl chloride ester link ✓ rest of structure ✓ two repeat units of polymer I	4	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous ALLOW PCl_5 OR PCl_3 for reagent mark. IGNORE references to temperature for reagent mark IGNORE additional reagents shown with $\text{SOCl}_2/\text{PCl}_5/\text{PCl}_3$ e.g. H_2O, AlCl_3, HCl etc. IGNORE names (<i>question asks for structures of organic compounds and formula of reagent</i>) DO NOT ALLOW more than two repeat units ALLOW 1 mark for one correct repeat unit e.g.  'End bonds' MUST be shown (do not have to be dotted) ALLOW the 'O' at either end i.e.  IGNORE brackets IGNORE n

Question	Answer	Marks	AO	Guidance
11	A	1	AO2.5	

Question	Answer	Marks	AO	Guidance
12	A	1	AO2.4	

Question	Answer	Marks	AO	Guidance
13	B	1	AO1.2	

Question	Answer	Marks	AO element	Guidance
14	(i) 	4	AO2.5 ×4	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous ALLOW protonation of NH₂ group in reaction with (CH₃)₂CHOH i.e.  ALL structures must be based on serine For reaction with excess CH₃COCl, IGNORE reaction of COOH to form an acid anhydride ----- ALLOW 1 mark for  (both NH and OH groups reacted but acyl chloride instead of COOH) OR

Question	Answer	Marks	AO element	Guidance
				CH₃CONH—C—C(=O)OH CH₂ CH₃COO <i>(both NH and OH groups reacted but H missing from α C atom)</i> OR CH₃CONH—C—C(=O)OH H CH₂ OH <i>(NH group reacted correctly but rest of serine unchanged)</i> OR NH₂—C—C(=O)OH H CH₂ CH₃COO <i>(OH group reacted correctly but rest of serine unchanged)</i>
(ii)	IF M_r (amino acid) = 131 from titration analysis AWARD	4		

Question			Answer	Marks	AO element	Guidance
			first 3 marks ALLOW 3SF or more throughout IGNORE trailing zeroes, e.g. ALLOW 0.044 for 0.0440 $n(\text{HCl}) = 0.150 \times \frac{25.0}{1000}$ OR 3.75×10^{-3} (mol) ✓ $n(\text{amino acid})$ in 250 cm^3 $= 3.75 \times 10^{-3} \times \frac{250.0}{21.30}$ OR 0.0440 (mol) ✓ $M(\text{amino acid}) = \frac{5.766}{0.0440} = 131 \text{ (g mol}^{-1}\text{)}$ ✓ Amino acid = $(\text{CH}_3)_2\text{CHCH}_2\text{CH}(\text{NH}_2)\text{COOH}$/leucine AND working to show $R = 57$ to justify choice OR evidence to show M_r leucine = 131 to justify choice ✓		AO2.8 AO2.8 AO2.8 AO3.2	ALLOW alternative approaches Calculator: 0.04401408451 ALLOW ECF from incorrect $n(\text{HCl})$ ALLOW ECF from incorrect $n(\text{amino acid})$ ALLOW ECF from incorrect $M(\text{amino acid})$ i.e. ECF for alkyl group closest to calculated $M(\text{alkyl group})$, e.g. for $M(\text{alkyl group}) = 15$, ALLOW $\text{CH}_3\text{CH}(\text{NH}_2)\text{COOH}$ Note: evidence may be shown with table

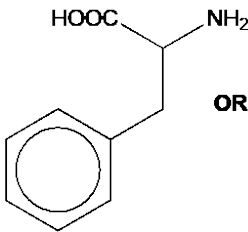
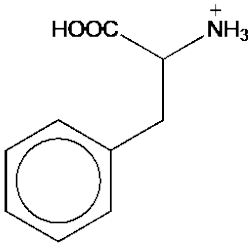
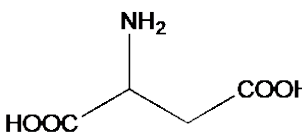
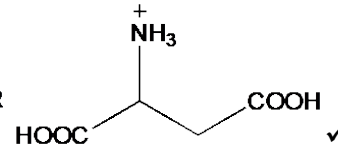
15	IF answer on answer line = 24018, AWARD 2 marks IF answer on answer line = 27600, AWARD 1 mark ----- Relative mass of 200 molecules = $200 \times 138 = 27600$ ✓ M_r of polyester = $27600 - 199 \times 18 = 24018$ ✓	2	AO2.2 ×2	ALLOW ECF from incorrect M_r Alternative method based on repeat unit: M_r of 200 repeat units = $200 \times 120 = 24000$ ✓ M_r of polymer = $24000 + 1 + 17 = 24018$ ✓
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Question	Answer	Marks	AO element	Guidance
16	(i) Polymer from D Polymer from E Amide link ✓ 2 repeat units of correct polymer ✓	3	AO2.5 AO1.2 AO2.5	----- For BOTH structures, ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous 'End bonds' MUST be shown BUT ALLOW ECF IF end bonds omitted in both structures DO NOT ALLOW more than 2 repeat units BUT ALLOW ECF in subsequent structure IGNORE connectivity of C₆H₅ ----- CARE: ALLOW any consistent repeat unit: C₆H₅ and H groups can alternate or be on opposite sides of chain e.g. end -NH- may be at either side e.g. IGNORE brackets IGNORE <i>n</i>

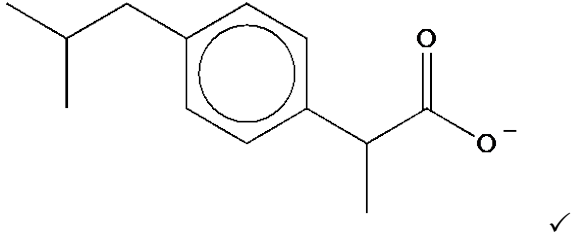
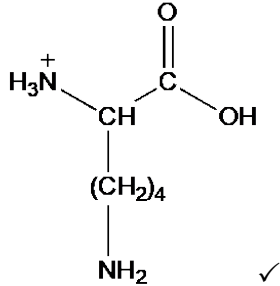
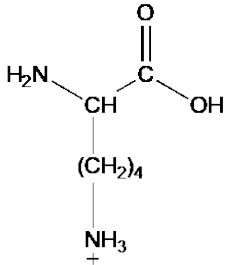
Question			Answer	Marks	AO element	Guidance
			D Addition / polyalkene AND E: Condensation / polyamide ✓	1	AO1.1	DO NOT ALLOW 'additional'

Question	Answer	Marks	AO	Guidance
17	D	1	1.2	

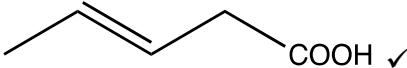
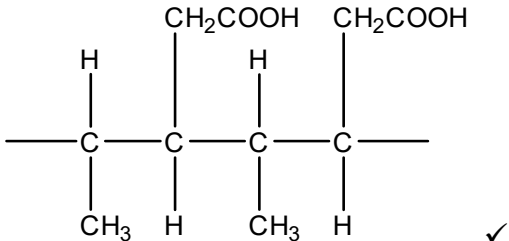
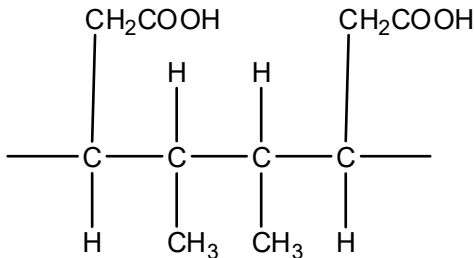
Question	Answer	Marks	AO element	Guidance
18 (i)	$\text{-----}\overset{\text{O}}{\parallel}\text{C}-(\text{CH}_2)_2-\overset{\text{O}}{\parallel}\text{C}-\text{O}-(\text{CH}_2)_4-\text{O}\text{-----}$ Ester link (must be displayed) ✓ Rest of structure ✓	2	1.2 2.5	ALLOW the 'O' or C=O at either end, e.g. $\text{---O---}\overset{\text{O}}{\parallel}\text{C}-(\text{CH}_2)_2-\overset{\text{O}}{\parallel}\text{C}-\text{O}-(\text{CH}_2)_4\text{---}$ $\text{---}(\text{CH}_2)_2-\overset{\text{O}}{\parallel}\text{C}-\text{O}-(\text{CH}_2)_4-\text{O---}\overset{\text{O}}{\parallel}\text{C}\text{---}$ IGNORE brackets IGNORE n End bonds' MUST be shown (solid or dotted) DO NOT ALLOW more than one repeat unit
(ii)	the ester/ ester bond/ ester group /polyester can be broken down ✓ OR It can be hydrolysed ✓	1	3.2	IGNORE references to photodegradable 'Bond breaks' is not sufficient – no reference to ester bond
(iii)	$\begin{array}{c} \text{O} & & \text{O} \\ \parallel & & \parallel \\ \text{C} & \text{---}(\text{CH}_2)_2\text{---} & \text{C} \\ \diagup & & \diagdown \\ \text{HO} & & \text{OH} \end{array} + 2 \text{SOCl}_2 \longrightarrow \begin{array}{c} \text{O} & & \text{O} \\ \parallel & & \parallel \\ \text{C} & \text{---}(\text{CH}_2)_2\text{---} & \text{C} \\ \diagup & & \diagdown \\ \text{Cl} & & \text{Cl} \end{array} + 2 \text{SO}_2 + 2 \text{HCl}$ SOCl₂ in equation ✓ Structure of diacyl dichloride ✓ Complete balanced equation ✓	3	1.1 1.2 2.6	ALLOW alternative approach using PCl₅ or PCl₃

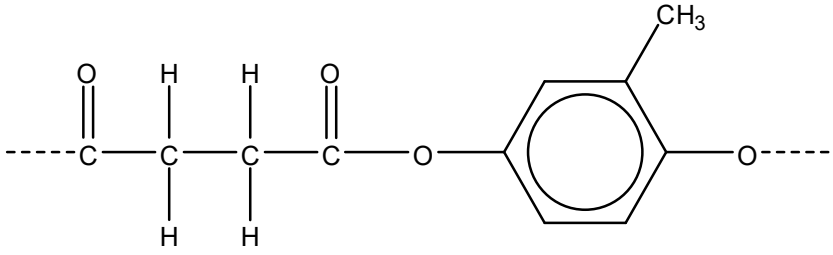
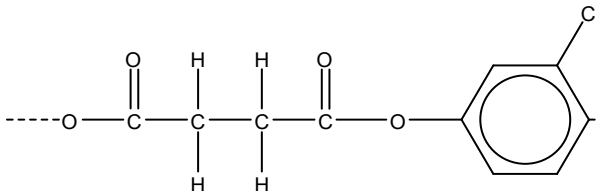
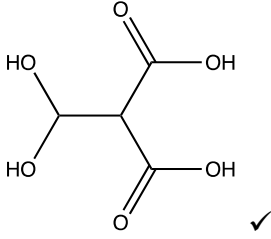
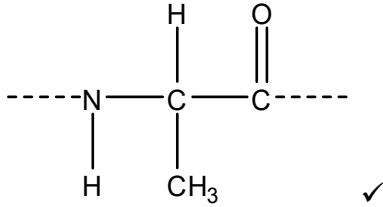
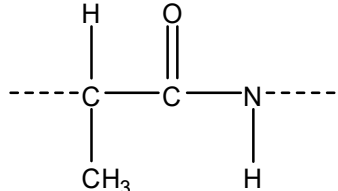
Question	Answer	Marks	AO element	Guidance
19	(i) Ester Amide Amine Carboxylic acid 4 groups correct ✓✓✓ 3 groups correct ✓✓ 2 groups correct ✓	3	1.2×3	IGNORE amino acid ALLOW carboxyl IGNORE attempt to classify amide, e.g. secondary IGNORE formulae (question asks for names) IF > 4 functional groups are shown, • Count 4 groups max but incorrect groups first IGNORE aryl OR alkyl group e.g. benzene, phenyl, aryl, arene, methyl
	(ii) Methanol 1 mark $\text{H}_3\text{C}-\text{OH}$ ✓ Amino Acids 3 marks  HOOC-CH(NH₂)-CH₂-C₆H₅ OR  HOOC-CH(NH₃⁺)-CH₂-C₆H₅ ✓  HOOC-CH(NH₂)-COOH OR  HOOC-CH(NH₃⁺)-COOH ✓ Both amino acids shown with NH₃⁺ ✓	4	2.5×4	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous ALLOW + charge on H of NH₃ group, i.e. NH₃⁺ If BOTH amino acids are shown with NH₃ groups (without the + charge) OR as NH₂⁺ groups, award 2 of the 3 marks for the amino acids If BOTH amino acids are shown as correctly balanced salts, e.g. NH₃Cl, all marks can be awarded.

Question		Answer	Marks	AO element	Guidance
20		Amide link: ✓ 1 repeat unit of correct polymer: ✓	4	AO2.5 ×2 AO1.2 AO2.5	For polymer, DO NOT ALLOW > 1 repeat unit ‘End bonds’ MUST be shown (do not have to be dotted) ALLOW –NH– at either end i.e. IGNORE brackets IGNORE <i>n</i>
Total			10		

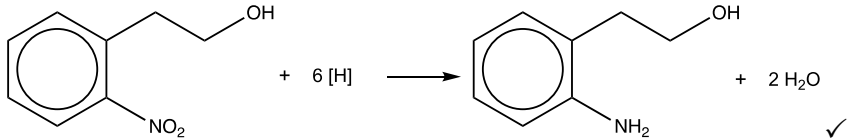
21	(i)	 	2	AO3.2 × 2	IGNORE small slip in carbon chains ALLOW 
	(ii)	More soluble in water ✓	1	AO3.1	Answer must be a comparison ALLOW dissolve faster/quicker IGNORE absorbed more quickly (given in question)
Total			18		

Question	Answer	Marks	AO	Guidance
22	A	1	AO1.1	

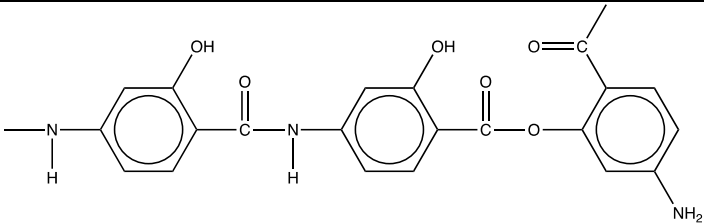
Question	Answer	Marks	AO element	Guidance
23	(c) (i) Pent-3-enoic acid  2 repeat units of polymer 	2	AO1.2 AO2.5	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous ALLOW either the <i>E</i> or <i>Z</i> isomer ALLOW ECF from pent-2-enoic acid OR pent-4-enoic acid ONLY For repeat unit, • 'side bonds' required on either side repeat unit from C atoms • 2 repeat units required IGNORE connectivity of CH₂COOH in poly IGNORE brackets IGNORE <i>n</i> ALLOW any consistent repeat unit: CH₂COOH and CH₃ groups can alternate on opposite sides of chain e.g. 

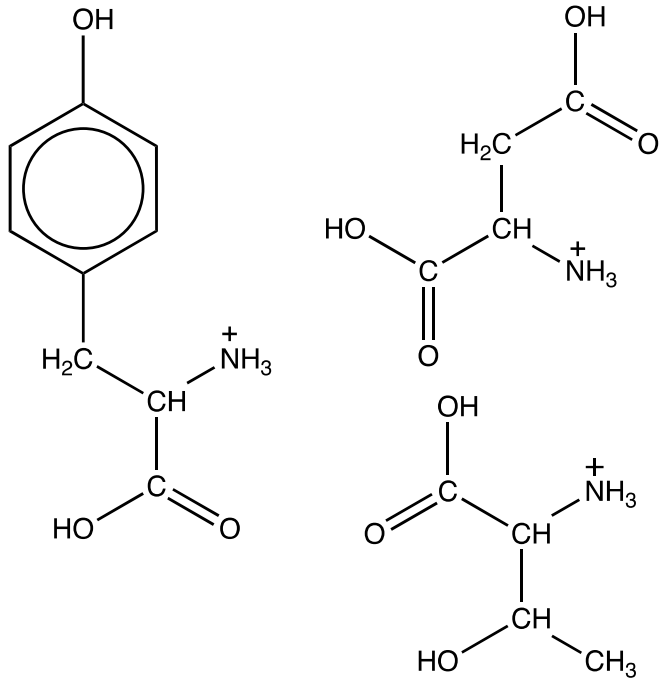
Question			Answer	Marks	AO element	Guidance
19	(c)	(ii)	 ester link ✓ ONE repeat units of correct polymer ✓	2	AO1.2 AO2.5	end –O– may be at either side e.g.  ALLOW CH₃ to be on position 2 or 3 of the aromatic ring ‘End bonds’ MUST be shown (do not have be dotted) IGNORE brackets IGNORE <i>n</i>
19	(c)	(iii)	 ✓	1	AO3.2	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous
19	(d)	(i)	 ✓ ONE repeat unit ONLY	1	AO2.5	end –N– may be at either side e.g.  ‘End bonds’ MUST be shown (do not have be dotted) IGNORE brackets IGNORE <i>n</i>

Question			Answer	Marks	AO element	Guidance
19	(d)	(ii)	IF answer on answer line = 28418, AWARD 2 marks IF answer on answer line = 28400, AWARD 1 mark ----- M_r of 400 molecules = $400 \times 89 = 35600$ ✓ M_r of polymer = $35600 - (399 \times 18) = 28418$ ✓	2	AO2.2 ×2	ALLOW ECF from incorrect repeat unit in 1 ALLOW ECF from incorrect M_r of 400 repeat units Alternative method based on repeat unit: M_r of 400 repeat units = $400 \times 71 = 28400$

24			1	AO2.6	
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Question	Answer	Marks	Guidance
25	C	1	AO1.2

Question	Answer	Marks	AO element	Guidance
26	 Section contains A displayed amide linkage between 2 benzene rings ✓ A displayed ester linkage between 2 benzene rings ✓ Section with at least one 'end bond' and correct positioning of all 3 groups on each benzene ✓	3	AO1.2 ×2 AO3.2	Marking point 3 is dependent on first 2 marks Check bonding around each benzene so C=O position 1, C-O position 2 and C-NH position 4. ALLOW 'end bonds' (with either a solid or dashed line) OR terminal ends e.g. -O- or -OH ALLOW any combination of 'end bonds' as shown in section not a repeat unit IGNORE connectivity of OH and NH₂ groups to benzene

	27	 1 mark for each correct structure with • Either NH_3^+ OR NH_2 ✓✓✓ 1 mark for • all 3 correct structures with NH_3^+ ✓	4	AO2.5 ×4	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous IGNORE connectivity ALLOW + charge on H of NH_3 group, i.e. NH_3^+ If structures are shown with NH_3 groups (without the + charge) OR as NH_2^+ groups allow ECF for subsequent u ALLOW structures shown as correctly balanced salts, e NH_3Cl OR NH_3^+Cl^- all marks can be awarded.
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Question	Answer	Marks	Guidance
28	C	1	

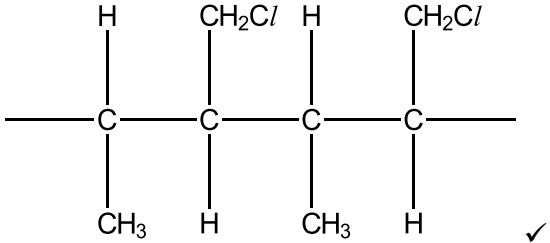
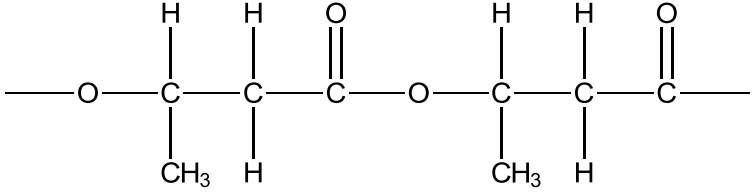
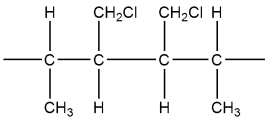
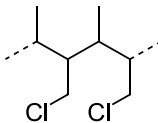
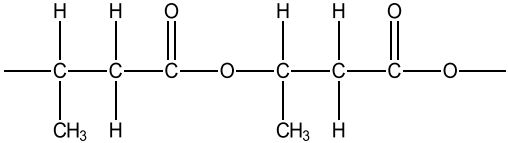
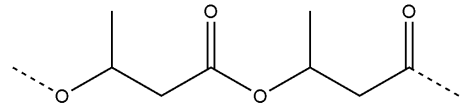
Question	Answer	Marks	Guidance
29	C	1	ALLOW 1.5(0)

Question	Answer	Marks	Guidance
30	A	1	ALLOW HCl

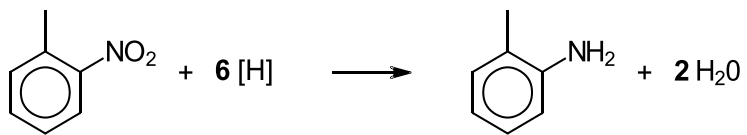
Question			Answer	Marks	Guidance
31	(a)		IF answer on answer line = 73518 AWARD 3 marks IF answer on answer line = 73500 AWARD 2 marks M_r of amino acid = 165 ✓ M_r of 500 molecules = $500 \times 165 = 82500$ ✓ M_r of polymer = $82500 - (499 \times 18) = 73518$ ✓ <i>(final answer must be given to nearest whole number)</i>	3	ALLOW ECF from incorrect M_r of amino acid Alternative method: M_r of repeat unit = 147 ✓ $147 \times 500 = 73500$ ✓ $73500 + 18 = 73518$ ✓ Common error for 2 marks 36518 Use of M_r 91 82500 Not shown 165 in working Common error for 1 mark 45500 Use of M_r 91

Question	Answer	Marks	Guidance
22 (b)	Addition polymer $ \begin{array}{ccccccc} & \text{H} & & \text{H} & & \text{H} & & \text{H} \\ & & & & & & & \\ - & \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - \\ & & & & & & & \\ & \text{H} & & & & \text{H} & & \\ & & & \text{H}_2\text{N}-\text{CH} & & & & \text{HC}-\text{NH}_2 \\ & & & & & & & \\ & & & \text{COOH} & & & & \text{COOH} \end{array} $ ✓ Condensation polymer $ \begin{array}{ccccccc} & \text{H}_2\text{C}=\text{CH} & & & & \text{H}_2\text{C}=\text{CH} & & & \\ & & & & & & & & \\ - & \text{N} & - & \text{CH} & - & \text{C} & - & \text{N} & - & \text{CH} & - & \text{C} & - \\ & & & & & & & & & & & & \\ & \text{H} & & & & \text{O} & & \text{H} & & & & \text{O} & \\ & & & & & & & & & & & & \end{array} $ Amide link ✓ 2 repeat units of correct polymer ✓	3	For BOTH structures, ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous 'End bonds' MUST be shown (with either a solid or dash line) BUT ALLOW ECF IF end bonds omitted in both structures DO NOT ALLOW more than 2 repeat units BUT ALLOW ECF in subsequent structure IGNORE connectivity of side groups in both diagrams ----- CARE: ALLOW any consistent repeat unit: side groups can alternate or be on opposite sides of chain ALLOW NH in amide link i.e. without bond shown ALLOW -NH- at either end IGNORE brackets IGNORE <i>n</i> or subscript numbers ALLOW C₂H₃ as side chain for condensation polymer ALLOW 1 mark if correct structures given by wrong way round

Question	Answer	Marks	Guidance
32	B	1	

Question	Answer	Mark	Guidance
33 (a)	Two repeat units of polymer of 1-chlorobut-2-ene  Two repeat units of polymer of 3-hydroxybutanoic acid  Ester link shown ✓ Two complete repeat units ✓ Type of polymerisation 1-chlorobut-2-ene: addition AND 3-hydroxybutanoic acid: condensation ✓	4	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous IGNORE brackets and use of <i>n</i> or subscript numbers IGNORE connectivity ALLOW alternating side chains i.e.  End bonds MUST be shown (solid or dotted) e.g.  BUT ALLOW ECF IF end bonds omitted in both structures ALLOW any whole repeat units e.g.  End bonds MUST be shown (solid or dotted) e.g.  DO NOT ALLOW only one repeat unit OR more than 2 repeat units BUT ALLOW ECF in subsequent structure DO NOT ALLOW 'additional'

Question			Answer	Mark	Guidance
18	(b)	(i)	(Chlorine containing polymers) produces toxic (products when incinerated) ✓	1	ALLOW suitable alternatives for 'produces' e.g. forms, releases (<i>must be clear that it is a product</i>) ALLOW produces HCl /hydrogen chloride/ hydrochloric acid ALLOW 'poisonous' for toxic IGNORE harmful / pollutant / dangerous
18	(b)	(ii)	Ester / ester bond / ester group / polyester ✓	1	ALLOW displayed formula for an ester functional group $\begin{array}{c} \text{O} \\ \\ \text{---C---O---C} \end{array}$ i.e. ---C---O---C IGNORE reference to hydrogen bonding

34		Reagents Sn AND HCl ✓ Equation  H₂O product AND balancing ✓	2 ALLOW names if no formulae given IGNORE dilute for HCl IGNORE H₂ (with Sn and HCl) IGNORE NaOH if seen as a reagent to convert nitro group into amine e.g. 'Sn/(concentrated) HCl then NaOH' scores the mark ALLOW suitable non-specification alternatives: e.g. Zn AND HCl OR H₂ AND Ni
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