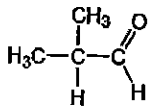
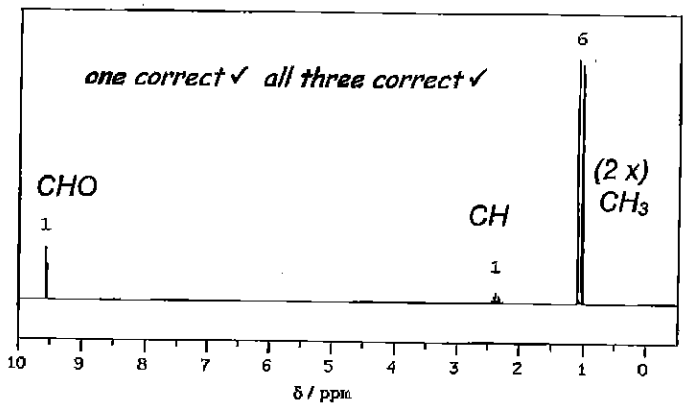
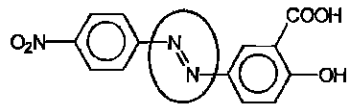
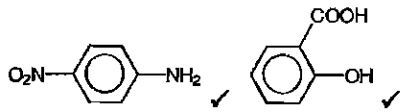
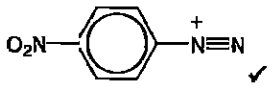
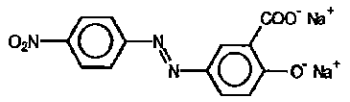
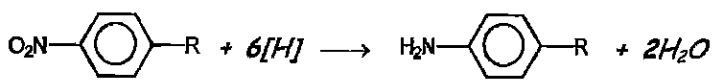
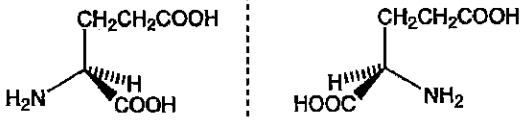
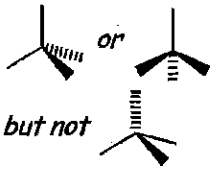
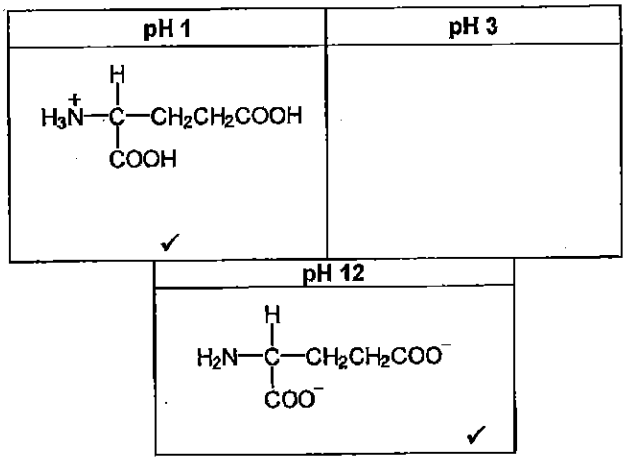
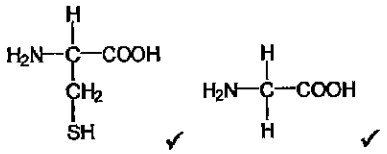
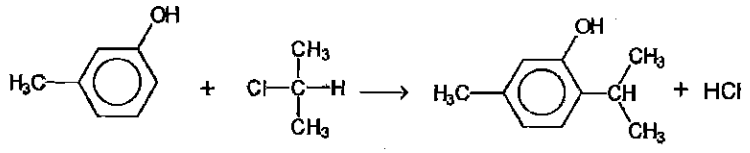
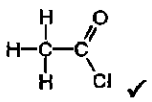
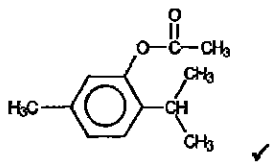
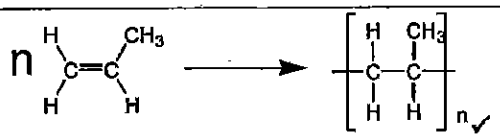
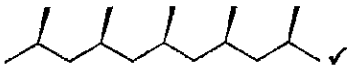
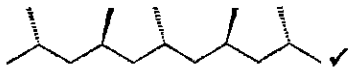
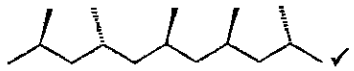
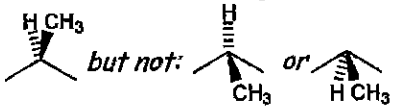
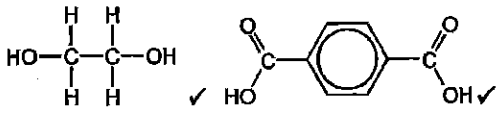
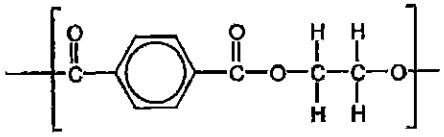
2814 Chains, Rings and Spectroscopy

Qu. No.		Marks
1 (a)	*2-methylpropanal* ✓ $CH_3COCH_2CH_2CH_3$ $CH_3CH_2COCH_2CH_3$ ✓	[2]
(b)	*75 - 130 (°C)* ✓ *(actual value is 103°C)*	[1]
(c) (i)	*yellow/orange/red solid/precipitate AW* ✓	[1]
(ii)	*reference to the identical bp (of pentanones) / unique mp (of derivatives)* ✓	[1]
(d)	*72* ✓	[1]
(e) (i)	*the number/ratio of protons of each 'type'/in each environment AW* ✓	[1]
(ii)	*(they both) have one neighbouring proton / are next to CH* ✓	[1]
(iii)	*any unambiguous formula of 2-methylpropanal* ✓ *eg* 	[1]
(iv)	*allow any unambiguous labelling to link the correct protons to the peak - eg*  *one correct* ✓ *all three correct* ✓ CHO 1 CH 1 (2 x) CH_3 6 10 9 8 7 6 5 4 3 2 1 0 δ / ppm *max 1 mark ecf from the wrong structure for:* *CHO from any aldehyde* *2 x CH_3 from pentan-3-one or methylbutanone* *CH from methylbutanone*	[2]
		[Total: 11]

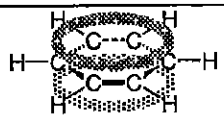
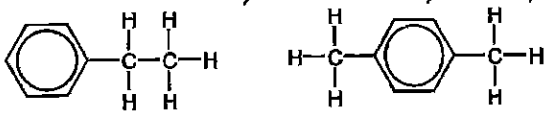
Qu. No.		Marks
2 (a)		[1]
(b)	 ✓ ✓ *(add to the amine)* *$NaNO_2$ / HNO_2 and HCl ✓* *<10°C ✓*  ✓ *then add the phenol alkaline conditions AW ✓* *the + charge must be on the correct N atom* *allow ecf on missing or wrong NO2 position*	[6]
(c)	 *one group ionised ✓* *both groups ionised and rest of structure ✓* *allow ONa or just O⁻, but NOT O-Na*	[2]
(d) (i)	*Tin and (conc) HCl ✓* *allow other suitable reducing agents (but not $NaBH_4$)*	[1]
(ii)	 *correct product ✓* *rest of the equation ✓*	[2]
		[Total: 12]

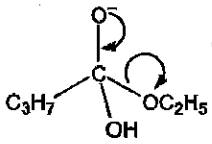
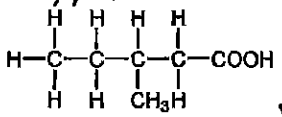
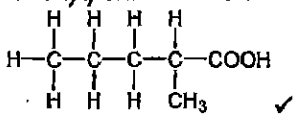
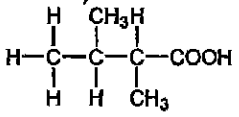
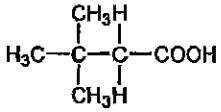
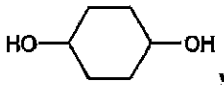
Qu. No.		Marks
3 (a)	*chiral centre / four different groups around a carbon / asymmetric carbon / non-superimposable mirror images* ✓ *diagram - eg*  *one correct 3-D diagram of glutamic acid* ✓ *mirror image / other stereoisomer* ✓ *for the 3-D shape, allow:*  *allow ecf on 3-D errors*	[3]
(b)	 	[2]
(c) (i)	 *allow any valid ionisation*	[2]
(ii)	*condensation* ✓	[1]
(iii)	*heat with (aqueous) acid/base* ✓ *not conc H_2SO_4, HNO_3 and weak acids/bases* *(allow name/formula for any suitable acid/base)*	[1]
		[Total: 9]

Qu. No.		Marks
4 (a)	*antiseptic / kills bacteria / disinfectant AW* ✓	[1]
(b) (i)	 ✓ ✓	*allow use of the bromoalkane* [2]
(ii)	$FeCl_3$ / $AlCl_3$ ✓	[1]
(c)	*(molecular formula =* $C_{10}H_{14}O$*) so* M_r = 150 ✓ *mass thymol per* dm^3 = $3.0 \times 10^{-3} \times M_r$ = 0.45 (gdm^{-3}) / *moles of thymol in* $400cm^3$ = $3.0 \times 10^{-3} \times 0.4$ = 1.2×10^{-3} *(mol)* ✓ *mass per* $400\ cm^3$ = 0.45×0.400 / = $1.2 \times 10^{-3} \times M_r$ = 0.18 *(g) or ecf to at least 2 sig figs* ✓	*allow ecf throughout* *do not allow if rounded to 0.2 g* [3]
(d) (i)	 ✓	[1]
(ii)	$SOCl_2$ / PCl_5 ✓ $CH_3COOH + SOCl_2 \longrightarrow CH_3COCl + SO_2 + HCl$ / $CH_3COOH + PCl_5 \longrightarrow CH_3COCl + POCl_3 + HCl$ ✓	*equation must relate to the reagent chosen* [2]
(iii)	 ✓	*allow any unambiguous structure* [1]
(iv)	*no (broad) peak at 3230-3550(*cm^{-1}*)* ✓ *peak at 1680-1750(*cm^{-1}*)* ✓	*allow any named wavenumber within the ranges* [2]
		[Total: 13]

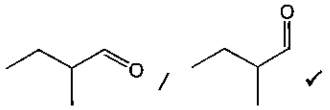
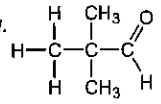
Qu. No.		Marks
5 (a) (i)	 ✓	[1]
(b)	*2-D or 3-D diagram of polypropene to show side chains on the same side labelled* ***isotactic*** *- eg*  ✓ *2-D or 3-D diagram of polypropene to show side chains on alternating sides labelled* ***syndiotactic*** *- eg*  ✓ *2-D or 3-D diagram of polypropene to show side chains on random sides labelled* ***atactic*** *- eg*  ✓ *at least one of the diagrams also shows correct 3-D orientation* ✓ *for 3-D, skeletal as shown, or with labelling of H and CH_3 on the skeletal structure - .eg* 	[4]
(c) (i)	*correct structures - eg*  ✓ ✓	[2]
(ii)	 *ester group* ✓ *correct repeat bracketed* ✓	[2]
		[Total: 9]

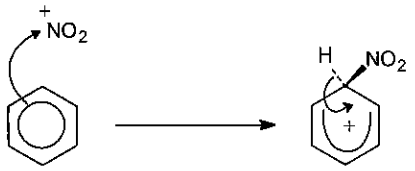
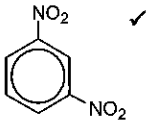
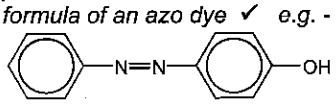
Qu. No.		Marks
6 (a) (i)	*ammonia* ✓	[1]
(ii)	*(nucleophilic) substitution* ✓	[1]
(iii)	*$LiAlH_4$ / Na in ethanol* ✓	[1]
(iv)	*reduction / (nucleophilic) addition* ✓	[1]
(b)	✓ ✓ $C_6H_5CH_2CH_2NH_2 + CH_3COCl \longrightarrow C_6H_5CH_2CH_2NHCOCH_3 + HCl$ *(or use of the acid anhydride to give ethanoic acid as the other product)* *allow ecf on H_2O as the product from ethanoic acid*	[2]
(c)	***basicity*** *a base is a proton acceptor AW* ✓ *lone pair on N (is used to accept the H^+) / dative bond to H^+* ✓ *any of the first three marks can come from a suitable diagram* ***phenylamine*** *phenylamine has lone pair (partially) delocalised around ring* ✓ *so the electron pair is less easily donated / H^+ is less attracted (to the N) AW* ✓ ***2-phenylethylamine*** *electrons are pushed towards the N / positive inductive effect AW* ✓ *so the electron pair is more easily donated / H^+ is more attracted to the N AW* ✓ *the electron density is lower on the N (for phenylamine) / higher (for phenylethylamine)* ✓ ***any 6 out of 7 marks***	[6]
	quality of written communication *at least two sentences with correct spelling, punctuation and grammar* ✓	[1]
		[Total: 11]

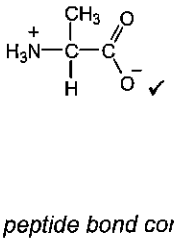
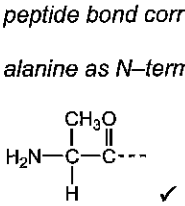
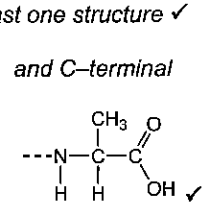
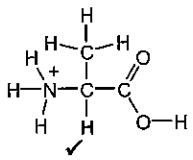
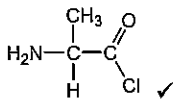
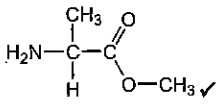
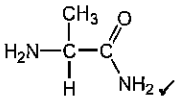
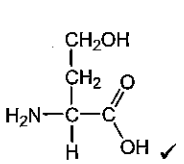
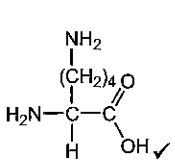
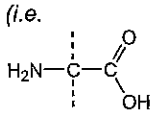
Qu. No.			Marks
7 (a)	 *overlap of p-orbitals* ✓	*any of the first three marks can come from a good diagram*	
	above and below the ring ✓		
	(π) electrons are spread / delocalised around the ring ✓		
	C-C bonds are: same length/strength / in between single and double / σ-bonded AW ✓		[4]
	Quality of written communication *mark for correct use of the terms: pi /π and delocalised* ✓		[1]
(b)	**B** *contains 9.43% H,* *so moles of C = 7.55, moles H=9.4,* *so CH ratio is: 1 : 1.25*		
	empirical formula = C_4H_5 ✓	*allow* C_8H_8 *to* $C_{11}H_{11}$ *as ecf from CH,*	
	use of M_r *and empirical formula to get molecular formula of* **B** = C_8H_{10} ✓		
	structure of **B** *= ethylbenzene or any dimethylbenzene eg* 	*correct structure of* **B** *gets the 2nd and 3rd marks*	
	or ecf for a valid structure from an incorrect M_r ✓		
	so **A** = C_2H_5X / CH_3X *(depending on their structure)* ✓ *or ecf from an incorrect aromatic structure of* **B**	*X = Cl or Br*	[4]
			[Total: 9]

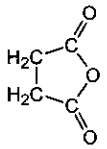
Qu. No.		Marks
8 (a) (i)	*ethyl butanoate* ✓	[1]
(ii)	$CH_3CH_2CH_2COOC_2H_5 + H_2O \longrightarrow CH_3CH_2CH_2COOH + C_2H_5OH$ ✓ *(allow use of molecular formulae)*	[1]
(iii)	$C_3H_7COO^- Na^+ + C_2H_5OH$ ✓ *allow ONa or just O⁻, but NOT O-Na*	[1]
(b) (i)	 *one mark for each curly arrow* ✓✓	[2]
(ii)	*movement of an electron pair* ✓	[1]
(iii)	*donates a (lone) pair of electrons (to the C=O)* ✓	[1]
(c)	*allow any unambiguous structure or name* *3-methylpentanoic acid*  ✓ *2-methylpentanoic acid*  ✓ *2,3-dimethylbutanoic acid*  ✓	[3]
(d)	 ✓	[1]
(e) (i)	 ✓	[1]
(ii)	*3 peaks* ✓ *areas 1:1:4* ✓ *allow 2:2:8*	[2]
		[Total: 14]

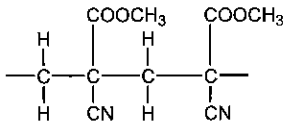
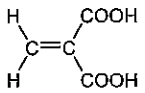
2814 Chains, Rings and Spectroscopy

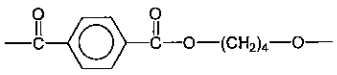
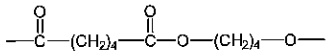
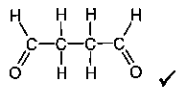
Question	Expected Answers	Marks
1 (a) (i)	*silver mirror* ✓ *(warm) with Tollens' Reagent / ammoniacal silver nitrate* ✓	[2]
(ii)	*carboxylic acid / COOH / COO^- etc* ✓	[1]
(b)	*yellow/red/orange solid* ✓ *with 2,4-dintitrophenylhydrazine / 2,4-DNPH / Brady's Reagent* ✓ *compare m.p. (of the product /solid / ppt) with known values* ✓	[3]
(c)	*86* ✓	[1]
(d) (i)	 ✓	[1]
(ii)	 ✓ *(displayed formulae not essential)*	[2]
(e)	*indentity* ✓ *– e.g.*  *reasoning* ✓ ***either*** *two types of proton / two peaks /* *all CH_3 protons are the same type* ***AW*** ***or*** *no splitting / no protons on the neighbouring C* ***AW*** ✓ *(allow any unambiguous way to identify the correct isomer)*	[2]
		[Total: 12]

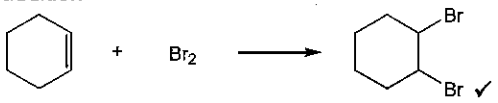
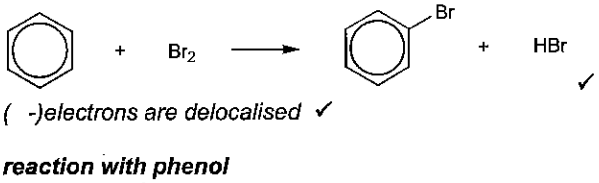
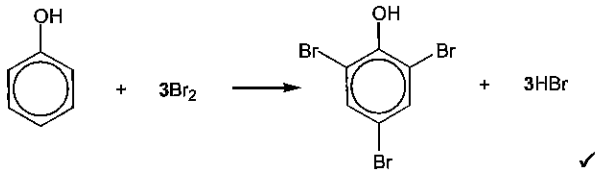
Question	Expected Answers	Marks
2 (a) (i)	$C_6H_6 + HNO_3 \longrightarrow C_6H_5NO_2 + H_2O$ ✓	[1]
(ii)	***conc*** H_2SO_4 ✓	[1]
(b)	***mechanism***	
	NO_2^+ ✓ *curly arrow from bond to electrophile* ✓	
	 *intermediate* ✓ *curly arrow from C–H bond to bond* ✓ *(the 'smile' must end at C2 and C5 and the + charge must not be at the tetrahedral carbon)*	
	involvement of catalyst	
	equation to show formation of $NO_2^+ / H_2NO_3^+$ ✓ *e.g.* $HNO_3 + H_2SO_4 \longrightarrow NO_2^+ + H_2O + HSO_4^-$	
	regeneration of H_2SO_4 ✓ *e.g.* HSO_4^- *shown accepting* H^+ *or equation:* $HSO_4^- + H^+ \longrightarrow H_2SO_4$	[6]
(c)	*accept any dinitrobenzene isomer - eg*  ✓	[1]
(d)	*Sn* ***and*** *(conc) HCl* ✓ *to give* $C_6H_5NH_2$ */ phenylamine* ✓ *(allow any other suitable reducing agents)*	
	equation ✓ $C_6H_5NO_2 + 6[H] \longrightarrow C_6H_5NH_2 + 2H_2O$	
	$NaNO_2 / HNO_2$ ***and*** *HCl* ***and*** *<10°C* ✓ *to give* $C_6H_5N_2^+$ */ diazonium* ✓	
	equation ✓ *e.g.* $C_6H_5NH_2 + H^+ + HNO_2 \longrightarrow C_6H_5N_2^+ + 2H_2O$	
	phenol ***and*** *alkali* ✓ *formula of an azo dye* ✓ *e.g. -* 	[8]
		[Total: 17]

Question	Expected Answers		Marks
3 (a)	 ✓	*(allow any unambiguous structures)*	[1]
(b)	*peptide bond correct on at least one structure* ✓ *alanine as N–terminal…* *and C–terminal*  ✓  ✓	*(ignore the attempted structure of valine as the formula given is not easy to interpret)*	[3]
(c)	*correct ionisation of $-NH_2$ and $-COO^-$ /–COONa groups* ✓	*(do not allow a covalent O–Na bond)*	[1]
(d)	Cl^-  ✓ ✓		[2]
(e)	 ✓  ✓  ✓		[3]
(f)	*any valid isomers which are 2-amino carboxylic acids – e.g.* ***C*** ***D***  ✓  ✓	*(i.e.*  *plus any isomers of C_2H_6O and $C_4H_{11}N$)*	[2]
			[Total: 12]

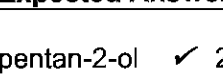
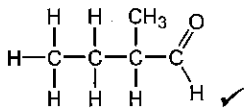
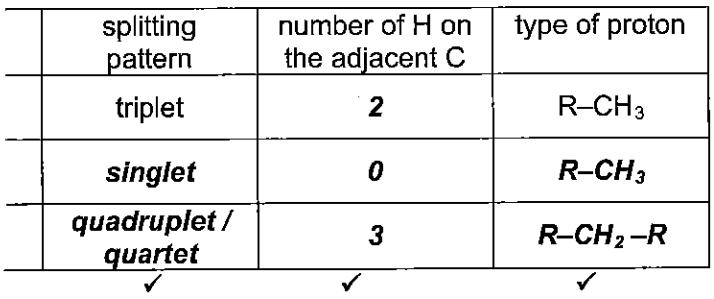
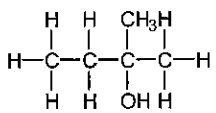
Question	Expected Answers	Marks
4 (a)	*fumaric acid* ***and*** *malic acid identified* ✓ ***one*** *correct explanation* ✓ *- e.g.* *the C=C bond does not rotate /has restricted rotation /* *has different groups on both C=C carbons* ***AW*** ✓ *has a chiral centre / four different groups around a C* ✓	[2]
(b)	*use of NaOH / Na / Na_2CO_3 $NaHCO_3$* ✓ *rest of the equation and balancing* ✓ *- e.g.*  	[2]
(c)	 ✓	[1]
(d) (i)	***in presence of D_2O*** *two peaks* ✓ *relative peak areas 2:1* ✓ *(splitting of peak with area 2) is a doublet /1:1* ✓ *(splitting of peak with area 1) is a triplet/1:2:1* ✓ ***without D_2O*** *five / three more peaks* ✓ *due to the OH protons (not shown in D_2O)* ✓ ***AW***	[6]
QWC	*mark for good communication of how the adjacent /neighbouring hydrogens affect the splitting (e.g. use of the n + 1 rule)*	[1]
(ii)	***shifts*** *peak at δ = 11.0–11.7 ppm* ***and*** *peak at δ = 2.0 – 2.9 ppm* ✓ ***explanation: either ...*** *(only) two environments / molecule is symmetrical* ***AW*** ✓ ***or*** *(peak at δ = 11.0–11.7 ppm is due to) COOH* ***and*** *(peak at δ = 2.0–2.9 ppm is due to) CH_2* ✓	[2]
		[Total: 14]

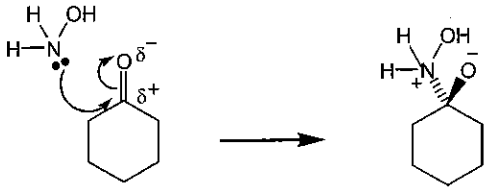
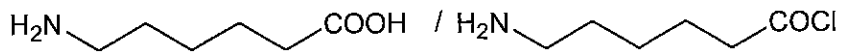
Question	Expected Answers		Marks
5 (a)	*section of the polymer ✓– eg* 	*(structure must show end bonds)* *(do **not** allow connection errors or 'sticks' here)*	[1]
(b)	 *one COOH group ✓* *other COOH group and the rest of the structure ✓*	*(allow $CONH_2$ from the partial hydrolysis of the CN group)*	[2]
(c) (i)	*CH_3OH ✓* *(heat) with **conc** H_2SO_4 ✓*		[2]
(ii)	*HCN / KCN ✓*	*(allow any mixtures that would create HCN in situ)*	[1]
(iii)	*nucleophilic addition ✓*		[1]
(iv)	*H_2O ✓*		[1]
(d)	*M_r $CH_3COCOOH$ = 88* **and** *M_r $CH_2C(CN)COOCH_3$ = 111 ✓* *theoretical yield = 12.6 (kg) / 113.6 (moles) ✓* *@30% = **3.78** kg ✓* *answer rounded to 2 sig figs ✓*	*(allow ecf throughout)*	[4]
			[Total: 12]

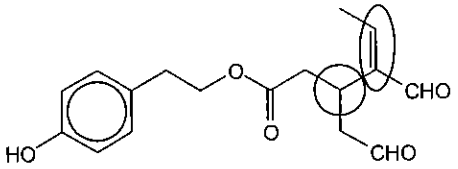
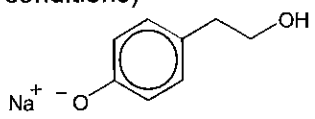
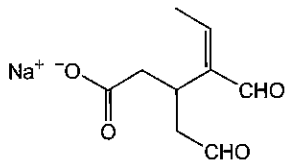
Question	Expected Answers		Marks
6 (a)	*ester bond* ✓ *a correct repeat unit* ✓ ***either:***  ***or:*** 	*(allow ecf for a correct repeat of an anhydride for the 2nd mark)*	[2]
(b)	*condensation* ✓		[1]
(c)	*any sequence with H every second position and at least one F and one G – eg* *–F–H–F–H–G–H–F–H–G–H–* ✓		[1]
(d) (i)	$NaBH_4$ / $LiAlH_4$ ✓		[1]
(ii)	*any unambiguous name or structure – eg*  ✓	*(do not allow –COH for the aldehyde group)*	[1]
(iii)	$OHC(CH_2)_2CHO + 4[H] \longrightarrow HO(CH_2)_4OH$ ✓		[1]
(iv)	*peak at 1680–1750 (cm^{-1}) for* ***J*** ✓ *peak at 3230–3550 (cm^{-1}) for* ***H*** ✓	*(allow any named value in between the ranges)* *(ignore reference to the C–O peak)*	[2]
			[Total: 9]

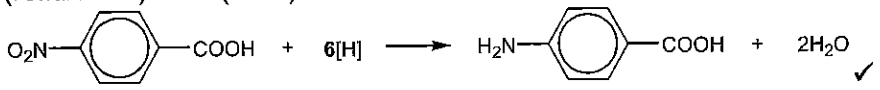
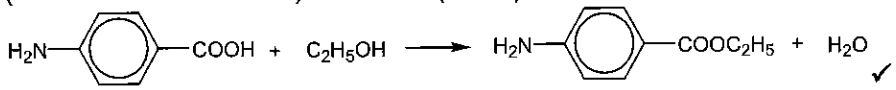
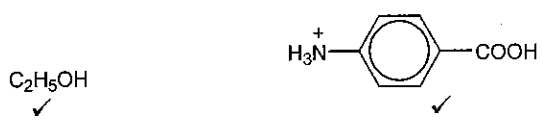
Question	Expected Answers	Marks
7 (a)	***reaction with cyclohexene*** *addition* ✓  *(-)electrons are localised / not delocalised* ✓ ***reaction with benzene*** *substitution* ✓  *(-)electrons are delocalised* ✓ ***reaction with phenol*** *substitution* ✓  *lone pair of electrons from O are delocalised around the ring* ✓ ***explaining reactivity in the context of any compound*** *valid discussion of relative electron density (around the ring)* ✓ *valid discussion of relative polarisation of the bromine* ***or*** *the (electrostatic) attraction of electrophiles to the ring* ✓ *correct use of the term electrophilic / electrophile* ✓ ***any 11 out of 12 marks***	[11]
QWC	*mark for at least two sentences or bullet points in context with correct spelling, punctuation and grammar* ✓	[1]
(b)	***K*** ***L***  *allow any dimethyl benzene or ethylbenzene*	[2]
		[Total: 14]

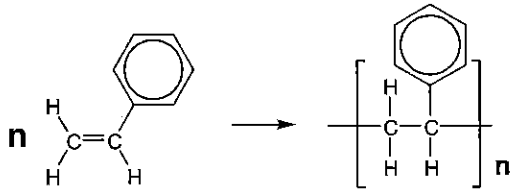
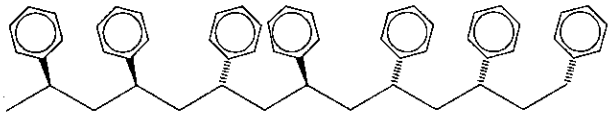
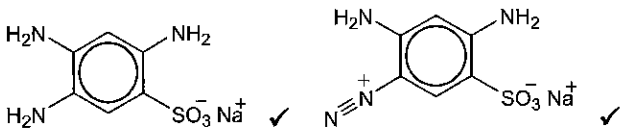
2814 Chains, Rings and Spectroscopy

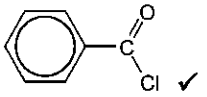
Question	Expected Answers		Marks
1(a)(i)	pentan-2-ol ✓ 2-methylbutan-1-ol ✓		2
(ii)	any arrangement of the four groups - e.g.  ✓	do not allow HO connection error allow C_3H_7	1
(b)	first mark for any aldehyde attempted ✓ second mark for correct structure or name of 2-methylbutanal – e.g.  ✓		2
(c)(i)	 one mark for each column		3
(ii)	 ✓	allow the correct name 2-methybutan-2-ol	1
(iii)	(extra) peak (due to OH) ✓ range 3.5–5.5 ppm ✓		2
			Total: 11

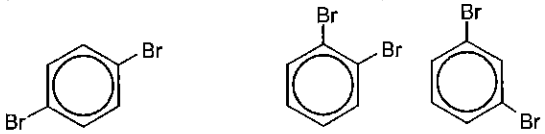
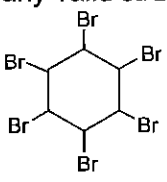
Question	Expected Answers		Marks
2(a)(i)	orange solid / ppt (when added to) 2,4-DNPH / Brady's Reagent ✓		
(ii)	(when warmed) with ammoniacal silver nitrate (solution) / Tollens' Reagent ✓ **no** silver (mirror) / reaction ✓	or no green colour with acidified dichromate allow 'no reaction' only if a suitable reagent used	1 2
(iii)	 dipole on C=O ✓ curly arrow breaking □ bond ✓ curly arrow from lone pair on N in the direction of the carbonyl C ✓		3
(iv)	M_r caprolactam = 113 ✓ mass of cyclohexanone needed = 98 / M_r = 0.867 tonnes or ecf ✓ scale for 99% yield = mass * 100/99 = **0.88** tonnes or ecf ✓ (or any number rounding to 0.876 tonnes)		3
(b)	a single molecule with six carbon atoms in a straight chain ✓ correct end groups on a straight chain ✓- e.g. 		2
			Total: 11

Question	Expected Answers		Marks
3(a)(i)	same structure / displayed formula / order of bonds different 3-D / spatial arrangement ✓		1
(ii)	 chiral centre circled ✓ C=C double bond circled ✓		2
(b)(i)	substitution: phenol / benzene / arene ✓ addition: alkene ✓	(allow C=C, but not just 'double bond')	2
(ii)	$C_{17}H_{20}O_5$ + 4[H] ⟶ $C_{17}H_{24}O_5$ ✓ (or correct structure)		1
(iii)	correct products of hydrolysis (in acid or alkali conditions) ✓✓   ionisation of phenolic group **and** carboxylate group for alkali conditions ✓	Na^+ is not essential, but do not allow covalent Na-O	3
(c)(i)	304 ✓		1
(ii)	1000–1300 (cm^{-1}) due to C–O ✓ 1680–1750 (cm^{-1}) due to C=O ✓ 3230–3550 (cm^{-1}) due to O-H ✓		3
(d)	only one (stereo)isomer is active / effective / needed **AW** ✓ natural oil contains one optical/stereoisomer isomer **and** lab synthesis contains a mixture ✓ **AW**		2
			[Total: 15]

Question	Expected Answers	Marks
4(a)(i)	$LiAlH_4$ (in ether) / Na in ethanol ✓	1
(ii)	reduction/hydrogenation /redox ✓ allow addition	1
(b)(i)	$C_2H_5NH_3^+ Cl^-$ ✓ + and - not essential, but both or neither must be present	1
(ii)	$C_2H_5NH_3^+ CH_3COO^-$ ✓	1
(c)	ethylamine is a stronger base / accepts a proton more readily than phenylamine ✓ (can be implied) **phenylamine** lone pair on N is (partially) delocalised / incorporated into the benzene ring / p-orbital overlap described **AW** ✓ **ethylamine** C_2H_5 has a positive inductive effect / electrons move towards the N **AW** ✓ **comparison to explain relative basicity** discussion of negative charge / electron density on the nitrogen ✓ discussion of the ease of donation/availability of the lone pair of electrons on the N ✓ (ignore any reference to the inductive effect for phenylamine) **any 4 out of 5 marks**	4
QWC	mark for well organised response with correct use of **one** of the terms: **inductive effect**, **delocalised, mesomeric**	1
(d)	correct formula of 4-nitrobenzoic acid as starting material ✓ correct formula of 4-aminobenzoic acid or ethyl-4-nitrobenzoate ✓ **reduction of nitro group** (reflux with) Sn + (conc) HCl ✓  ✓ **esterification** (reflux / distil / heat with) ethanol + (conc.) H_2SO_4 ✓  ✓ (steps can be in either order)	6
(e)	 ✓ ✓	2
		Total: 17

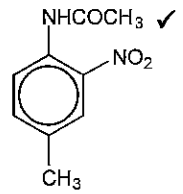
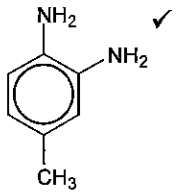
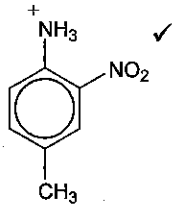
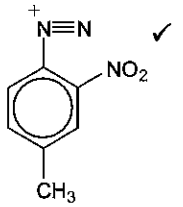
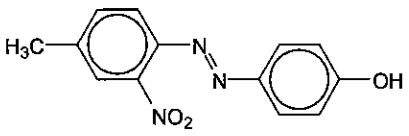
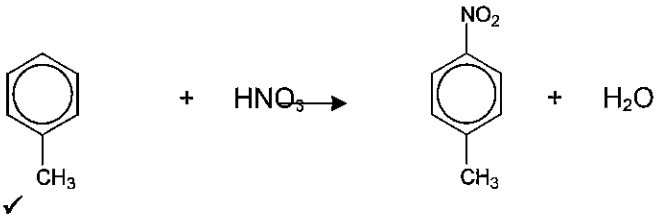
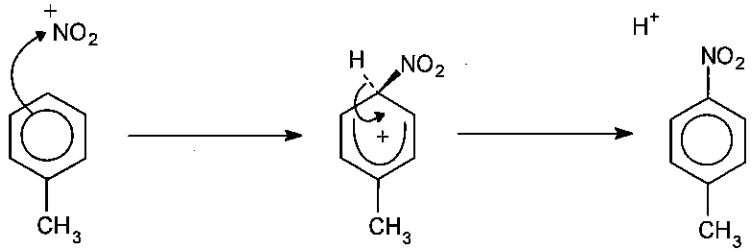
Question	Expected Answers		Marks
5(a)(i)	addition ✓		1
(ii)	 monomer ✓ repeat unit with 'side bonds' ✓	allow one or more repeats	2
(iii)	 benzene rings on every second carbon in random directions ✓ diagram also shows correct use of 3-D bonds ✓	allow ecf from (ii)	2
(iv)	isotactic has side chains on the same side **AW** ✓		1
(b)	 ✓ ✓ add the amine to HCl + $NaNO_2$ /HNO_2 ✓ temp < 10 °C ✓ add to alkaline phenol ✓		5
		Total: 11	

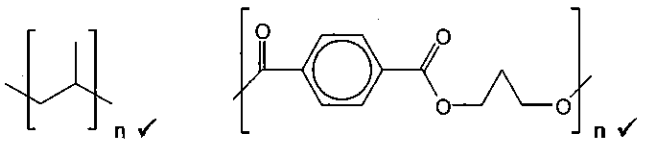
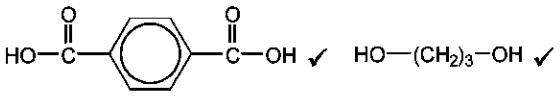
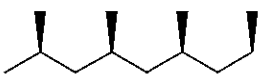
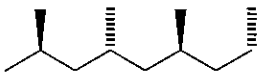
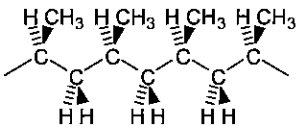
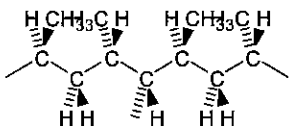
Question	Expected Answers	Marks
6(a)(i)	 ✓	1
(ii)	$C_6H_5COOH + PCl_5 \longrightarrow C_6H_5COCl + HCl + POCl_3$ $+ SOCl_2 \qquad\qquad + SO_2$ reagent ✓ balanced equation ✓	2
(b)	**ester** eg $C_6H_5COCl + C_2H_5OH \longrightarrow C_6H_5COOC_2H_5 + HCl$ alcohol / correct name/formula of a suitable example ✓ equation ✓ **amide** eg $C_6H_5COCl + C_2H_5NH_2 \longrightarrow C_6H_5CONHC_2H_5 + HCl$ $C_6H_5COCl + 2NH_3 \longrightarrow C_6H_5CONH_2 + NH_4Cl$ amine / ammonia / correct name/formula of a suitable example ✓ equation ✓	4
(c) (i)	$FeCl_3$ / $AlCl_3$	1
(ii)	electrophilic substitution	1
		Total: 9

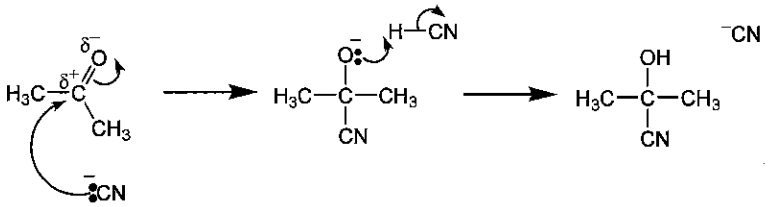
Question	Expected Answers	Marks
7(a)	**cyclohexene** (electrophilic) addition ✓ $C_6H_{10} + Br_2 \longrightarrow C_6H_{10}Br_2$ ✓ **benzene** (electrophilic) substitution ✓ $C_6H_6 + Br_2 \longrightarrow C_6H_5Br + HBr$ ✓ needs a / halogen carrier / catalyst/ Fe / $FeBr_3$ / $AlBr_3$ etc ✓ **relative reactivites** benzene is: (more) stable / less reactive / less susceptible to electrophiles ✓ **AW ora** (□)-electron electron density in benzene is low **ora** ✓ comparison of the relative ability to attract /polarise the electrophile or relative ability to donate an electron pair ✓ **QWC** mark for at least two sentences/bullet points in context with correct spelling, punctuation and grammar	8 1
(b)(i)	$^{30.5}/_{12.0}$ = $^{1.7}/_{1.0}$ = $^{67.8}/_{79.9}$ = *2.54* *1.7* *0.85* ✓ *3* : *2* : *1* empirical formula = C_3H_2Br ✓	2
(ii)	(M_r of C_3H_2Br = 117.9 = $^{235.8}/_{2}$, so) molecular formula = $C_6H_4Br_2$ ✓  one correct structure ✓ all three correct ✓	3
(c)	any valid structure for 1,2,3,4,5,6-hexabromocyclohexane – e.g.  ✓ $C_6H_6 + 3Br_2 \longrightarrow C_6H_6Br_6$ ✓	2
		Total: 16

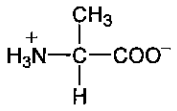
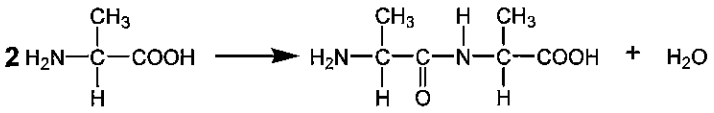
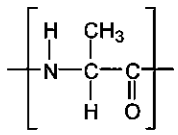
2814 Chains, Rings and Spectroscopy

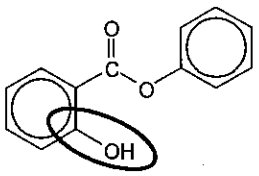
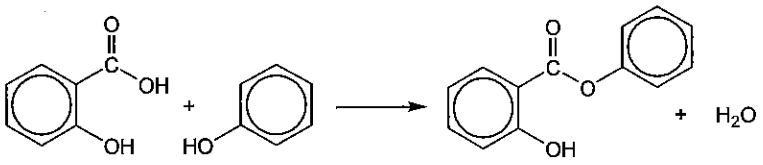
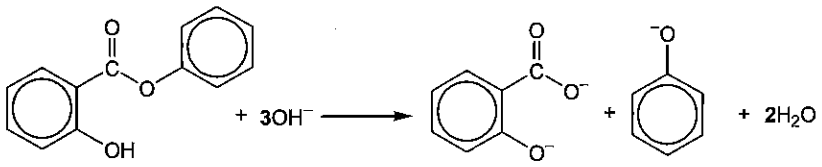
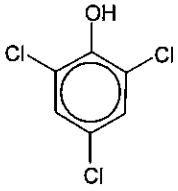
Qu.	Expected Answers		Marks
1 (a) (i)	$NaOH/Na/Na_2CO_3/NaHCO_3$ ✓		[1]
(ii)	...$COO^- Na^+$ ✓ (rest of the structure the same)	Na^+ is not essential, but do not allow Na-O	[1]
(b)	$CH_3CHClCOOH$ ✓		
	$FeCl_3/AlCl_3$ ✓		
	equation with HCl ✓		[3]
(c)	**chiral**		
	(stereoisomers are) non-superimposable (mirror images)/asymmetric/correct 3-D diagrams of both isomers of ibuprofen drawn ✓		
	the chiral centre on ibuprofen is identified, either by a label or shown in the centre of a 3-D diagram of ibuprofen ✓	allow ecf on 3-D or side chain errors	
	(is caused by) a C atom with four different groups attached ✓		
	disadvantages of producing a mixture		
	only one isomer may be active/one may be inactive ✓,		
	a higher dose is needed **AW** ✓		
	the other (stereo) isomer may cause harm/side effects ✓		
	separation of the isomers may be expensive/difficult ✓		
	ANY 6 out of 7 marks		[6]
	QWC mark for at least two sentences with correct spelling, punctuation and grammar. ✓		[1]
			[Total: 12]

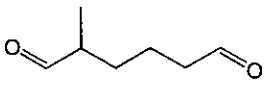
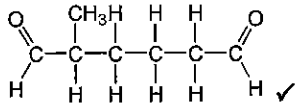
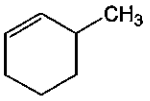
Qu.	Expected Answers	Marks
2 (a)	**A**  ✓ **B**  ✓ or with $-NH_3^+$ or $-NH_3Cl$ on either group on **B** **C**  ✓ **D**  ✓ allow $-NH_3Cl$ on **C** allow $-N=N^+$, $-N_2^+$, $-N_2Cl$ but not $-N\equiv N^+$ on **D**	[4]
(b) (i)	add to phenol ✓ in alkaline conditions/NaOH (below 10°C) ✓	[2]
(ii)	 or with $-\bar{O}$ on the phenol allow ecf from any diazonium ion in (a) and allow any phenol and any point of connection to the phenolic ring *azo group between two benzene rings* ✓ *correct substitients on the rings* ✓	[2]
(c) (i)	 ✓	[1]
(ii)	to form NO_2^+ in words/shown by an attempt at an equation using H_2SO_4 ✓ correct equation(s) ✓ eg $H_2SO_4 + HNO_3 \longrightarrow NO_2^+ + H_2O + HSO_4^-$ / $2H_2SO_4 + HNO_3 \longrightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$	[2]
(iii)	 curly arrow from π bond to electrophile ✓ intermediate ✓ curly arrow from C–H bond to π bond ✓	[3]
		[Total: 14]

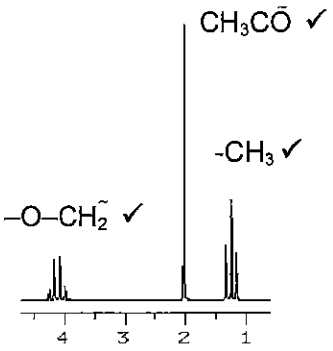
Qu.	Expected Answers		Marks
3 (a)	 n ✓ n ✓	brackets and n not essential allow ecf if no end bonds on both	[2]
(b)	PP is addition ... which breaks (C=C) double bond/no other products formed ✓ PTT is condensation .... which produces H_2O or small molecule ✓		[2]
(c)	 ✓ ✓	or the acid chloride	[2]
(d)	both are polypropene ✓ idea of isotactic (side chains on the same side) and syndiotactic (side chains are on alternating sides) ✓ diagrams for both polymers show correct 3-D with zig-zag backbone and correct wedge/dottybonds ✓ - eg  isotactic  syndiotactic or  	the first two marks can be from incorrect or non-3D diagrams	[3]
(e)	(in PTT but not PP) 1680–1750 (cm^{-1}) ✓ 1000–1300 (cm^{-1}) ✓		[2]
			[Total: 11]

Qu.	Expected Answers		Marks
4 (a) (i)	arrow from **lone pair** of :CN⁻ to C ✓		
	dipole and curly arrow breaking π-bond on C=O ✓		
	structure of the intermediate ✓	lone pair is not essential on intermediate	
	curly arrow to H of $HCN/H_2O/H^+$ ✓		
	structure of the organic product ✓		
	eg 	CN^- product is not essential	[5]
(b)	reduction/redox ✓		
	$LiAlH_4$ + ether/Na + ethanol/H_2 + Ni/Pt ✓		
	$CH_3CH_2CN + \mathbf{4}[H] \longrightarrow CH_3CH_2CH_2NH_2$ ✓	allow $\mathbf{2}H_2$ in the equation if Na + Ethanol or H_2 + Ni is chosen	
	hydrolysis ✓		
	(reflux/heat with) HCl/H_2SO_4 with some evidence of water eg dil/(aq)/H_2O shown in the equation ✓	allow 'conc' for HCl but not for H_2SO_4	
	equation – eg $CH_3CH_2CN + \mathbf{2}H_2O \longrightarrow CH_3CH_2COOH + NH_3$ / $CH_3CH_2CN + \mathbf{2}H_2O + H \longrightarrow CH_3CH_2COOH + NH_4$ ✓		[6]
			[Total: 11]

Qu.	Expected Answers	Marks
5 (a) (i)	ammonia which is ethanolic/heated in a sealed tube ✓	[1]
(ii)	$CH_3CHClCOOH + NH_3 \longrightarrow CH_3CH(NH_2)COOH + HCl$ ✓ or with any ionisation of the amino groups – eg $CH_3CHClCOOH + NH_3 \longrightarrow CH_3CH(NH_3Cl)COOH$ / $CH_3CHClCOOH + 2NH_3 \longrightarrow CH_3CH(NH_2)COOH + NH_4Cl$	[1]
(b) (i)	structure of zwitterion ✓ eg 	[1]
(ii)	structure of organic product ✓ equation ✓ eg  allow –CONH- for the peptide linkage	[2]
(c) (i)	 ✓ brackets not essential	[1]
(ii)	hydrolysis ✓ (reflux/heat with) HCl/H_2SO_4 with some evidence of water eg dil/(aq)/6M ✓ allow aqueous NaOH/KOH or a protease enzyme	[2]
(d)	two peaks ✓ relative areas 3:1 ✓ due to the $-CH_3$ and -CH ✓ allow ecf on the second and third marks if extra peaks are given for COOH and NH_2	[3]
		[Total: 11]

Qu.	Expected Answers		Marks
6 (a)	 ✓		[1]
(b)	 reactants ✓ products ✓		[2]
(c)	 hydroxybenzoate and phenol as products ✓ ionisation of at least one of the phenol groups ✓ all correct and balanced ✓		[3]
(d) (i)	(electrophilic) substitution ✓		[1]
(ii)	any 2/4/6 chlorinated phenol – eg  ✓	allow chlorination of phenolic esters	[1]
(iii)	lone/non-bonding pair of … ✓ …. electrons from the O delocalised are around the ring ✓ so greater (π-) electron density(around the ring) **ora** ✓ which attracts/polarises the electrophile (more) **ora** ✓	do not allow 'attacked by /susceptible to' electrophiles for the last mark	[4]
			[Total: 12]

Qu.	Expected Answers		Marks
7 (a) (i)	silver mirror (on warming) with *Tollens' reagent/ammoniacal silver nitrate* ✓		[1]
(ii)	add to 2,4-DNPH/Brady's reagent ✓ measure the m.p. (of the solid from 2-4-DNPH) ✓ compare with known values to identify the aldehyde ✓	measure the b.p. (of the aldehyde) gets both the first 2 marks	[3]
(b) (i)	methanal + butanal ✓	allow C_3H_7CHO	[1]
(ii)	propanone ✓ + ethanal ✓	allow correct names or structures but they must not contradict	[2]
(c) (i)	*eg*  /  ✓		[1]
(ii)	 ✓		[1]
			[Total: 9]

Qu.	Expected Answers		Marks
8	**molecular formula from % data and mass spectrum** M_r = 88 ✓ $^{54.5}/_{12.0}$ = 4.54 $^{9.1}/_{1.0}$ = 9.1 $^{36.4}/_{16.0}$ = 2.28 ratio = 2 : 4 : 1 / empirical formula = C_2H_4O ✓ (M_r of C_2H_4O = 44 = $^{88}/_{2}$, so) molecular formula = $C_4H_8O_2$ ✓ alternative method for the 2nd mark calculating mass out of 88 for each element: 88 x $^{54.5}/_{100}$ = 48 88 x $^{9.1}/_{100}$ = 8 88 x $^{36.4}/_{100}$ = 32 $^{48}/_{12}$ = 4 C $^{8}/_{1}$ = 8 H $^{32}/_{16}$ = 2 O **structural formula from n.m.r. spectrum** X is an ester ✓ X is ethyl ethanoate/$CH_3COOCH_2CH_3$ ✓ the part of the molecule responsible for each peak identified – eg  splitting of one of the peaks is explained in terms of the n + 1 rule – eg '1:2:1 as next to CH_2'✓ Well organised answer with any **two** of the following technical terms used correctly: **singlet**, **triplet**, **quadruplet/quartet**	allow any method to identify which peak is being referred to the –CH_3 mark is available if methyl propanoate is chosen	[9] [1]
			[Total: 10]

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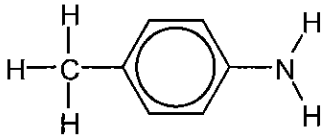
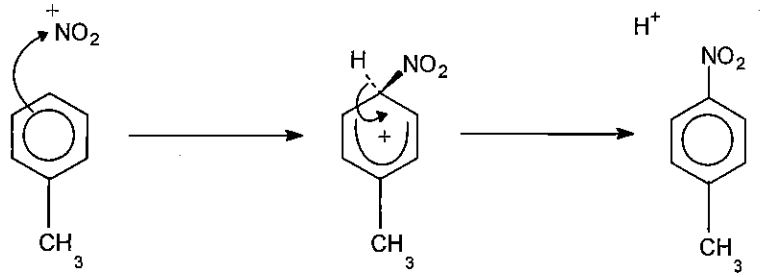
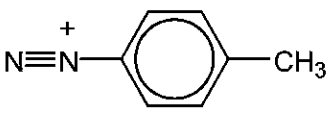
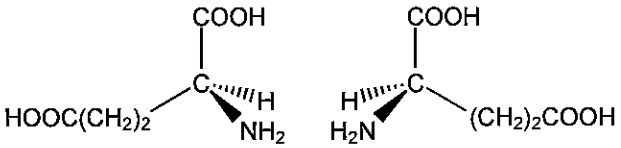
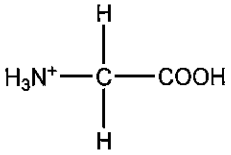
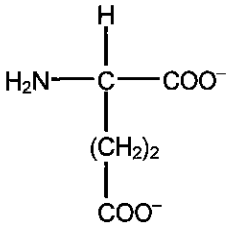
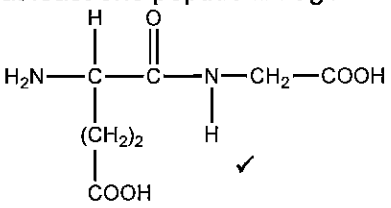
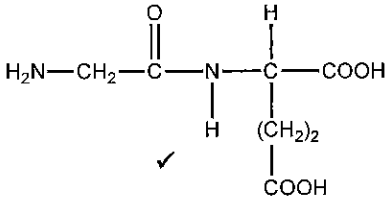
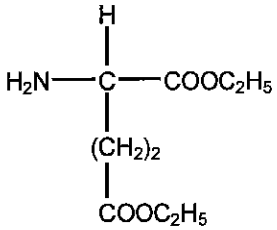
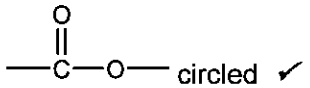
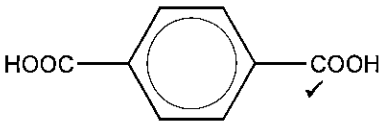
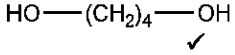
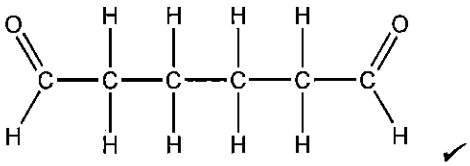
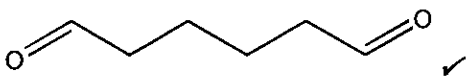
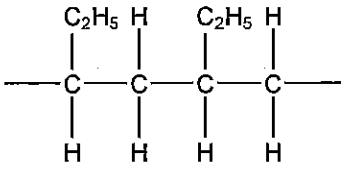
Qu.	Expected answers	Marks
1 (a)	 allow $-NH_2$ and $-CH_3$ not fully displayed here	1
(b)	**Stage 2** **reagents:** conc. HNO_3 **and** conc H_2SO_4 ✓ **conditions:** warm / reflux / stated temp (allow 30 – 60 °C) ✓ **balanced equation:** $HNO_3 + C_6H_5CH_3 \longrightarrow CH_3C_6H_4NO_2 + H_2O$ ✓ allow NO_2 to give H **Stage 3** **reagents:** Sn / Fe **and** conc HCl ✓ **conditions:** heat/reflux ✓ **balanced equation:** $CH_3C_6H_4NO_2 + 6[H] \longrightarrow CH_3C_6H_4NH_2 + 2H_2O$ ✓ **Mechanism for stage 2** $HNO_3 + H_2SO_4 \longrightarrow NO_2 + H_2O + HSO_4^-$ ✓  curly arrow from π ring to NO_2 ✓ correct intermediate ✓ (no methyl group loses this mark) curly arrow from C–H bond back to re-form π ring ✓ correct products ✓ (allow ECF on no methyl group here) **Quality of Written Communication** Answer is well organised and clearly identifies: stage 1 as **substitution / nitration and** stage 2 as **reduction / redox** (allow **hydrogenation**) ✓	11 1
(c) (i)	 allow $^+N{=}\bar{N}$, $\bar{N}_2$ or $\bar{N}_2Cl$ but not $^+N{\equiv}\bar{N}$	1
(ii)	**C atoms:** 17 **H atoms:** 14	2
		16

Qu.	Expected answers	Marks
2 (a)	$H_2NCH(R)COOH$ ✓ (allow any order as long as CH not split)	1
(b)	glutamic acid has / glycine does not have ... a chiral carbon / four different groups attached to a carbon ✓ glutamic acid forms two non-superimposable (mirror images) / is asymmetric ✓  allow ECF on side group errors correct 3-D diagram of one isomer of glutamic acid ✓ attempt at a 3-D diagram to show the other isomer ✓ allow poor connectivity here	4
(c) (i)	 ✓ allow poor connectivity here too	1
(ii)	 one COO^- ✓ rest of the molecule ✓	2
(d)	at least one peptide linkage ✓ allow CONH  ✓  ✓ or the dipeptide formed using the glutamic acid side chain	3
(e) (i)	(conc) H_2SO_4 ✓ allow HCl or H^+ .... but not anything with H_2O present	1
(ii)	 one ester group ✓ rest of the structure ✓	2
		14

Qu.	Expected answers		Marks
3 (a)	 circled ✓	allow the right hand carbon included	1
(b) (i)	hexan(e)dioic acid	ignore -1,6-	1
(ii)	 ✓  ✓	do not allow C_6H_4 here do not allow $O\tilde{H}$ here	2
(c) (i)	 ✓	must be fully displayed here allow one mark for two correct structures of hexanal	
	 ✓		2
(ii)	$C_6H_{10}O_2 + 2[O] \longrightarrow C_6H_{10}O_4$	allow correct structural / displayed / skeletal formula	1
(iii)	(O–H) absorption appears at 2500–3300 (cm^{-1})		1
(d)	 ✓		1
(e)	**ecoflex®** = condensation **and poly(but-1-ene)** = addition		1
(f)	atactic has side chains on <u>random</u> sides ✓	do not allow just 'regular' / 'irregular', nor just 'groups'	
	isotactic has side chains on the same side **AW** ✓	allow one mark for a correct (2D or 3D) diagram of isotactic with at least 6C if not scored in words	2
			12

<table>
<tr><th>Qu.</th><th>Expected answers</th><th></th><th>Marks</th></tr>
<tr><td>4 (a)</td><td>mol of CO_2 = 6 × 2.5 × 10^{-3} / 1.50 × 10^{-2} ✓
1.50 × 10^{-2} × 24000 = 36(0) cm^3 ✓

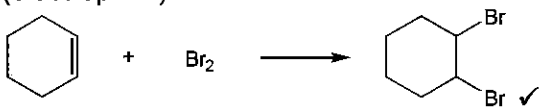
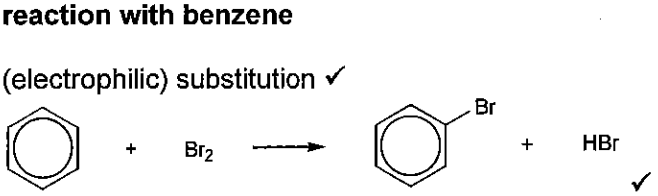
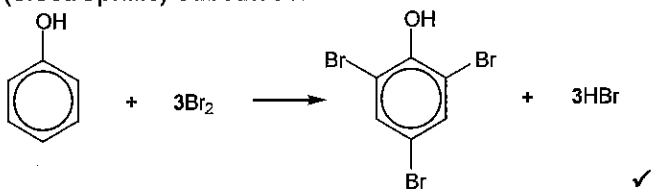
mol of H_2O = 3 × 2.5 × 10^{-3} / 7.50 × 10^{-3} ✓
7.50 × 10^{-3} × 18 = 0.135 / 0.14 g ✓</td><td></td><td>4</td></tr>
<tr><td>(b) (i)</td><td>carboxylic acid / (CO)OH (protons)</td><td></td><td>1</td></tr>
<tr><td>(ii)</td><td>D replaces OH protons / OH protons are labile ✓
peak (for OH protons) disappears ✓</td><td></td><td>2</td></tr>
<tr><td>(iii)</td><td>(E is the correct structure because …)

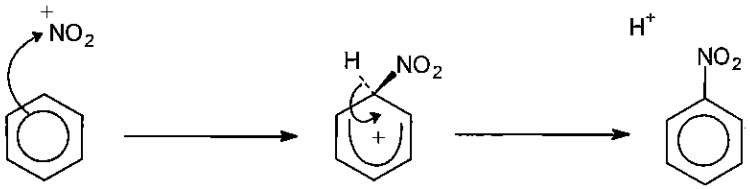
peaks Y and Z are each due to two (equivalent) protons AW✓

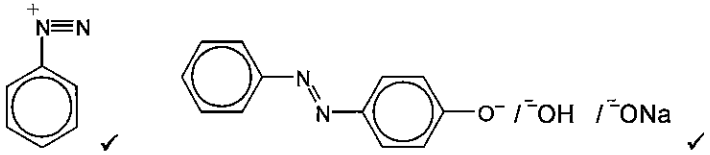
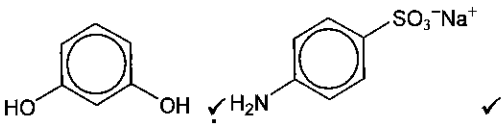
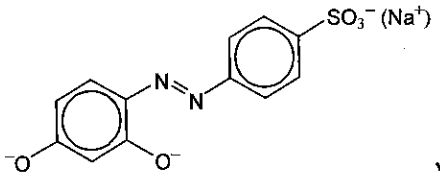
<table><tr><th></th><th>comparing peak areas</th><th>comparing the number of peaks</th></tr><tr><td>structure E either of: ✓</td><td>peaks Y and Z are caused by CH_2 and two CH</td><td>has three environments / H_a, H_b, H_c are labelled on the structure</td></tr><tr><td>structure F either of: ✓</td><td>would give one peak areas 3:1</td><td>would give four peaks (inc. COOH)</td></tr></table></td><td>no marks if they choose structure F</td><td>3</td></tr>
<tr><td></td><td></td><td></td><td>10</td></tr>
</table>

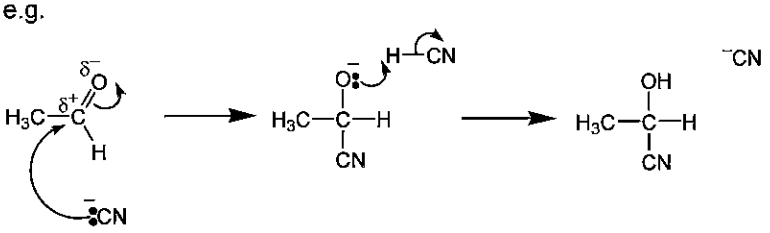
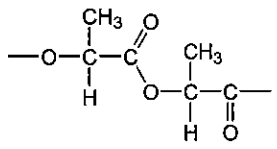
Qu.	Expected answers		Marks
5 (a)	alkene / C=C double bond ✓	do not allow just C=C / CHO	
	aldehyde / carbonyl ✓		2
(b) (i)	same structural/displayed formula but different 3D/spatial arrangement ✓	allow same order of bonds if same atoms specified	1
(ii)	circles alkene at position 2 ✓		
	(double bond has) restricted rotation ✓ (allow 'does not rotate')		
	both C in the double bond must be bonded to 2 different atoms / groups / this molecule has four distinguishable groups **AW** ✓		3
(c)	$C_{10}H_{16}O + 13½O_2 \longrightarrow 10CO_2 + 8H_2O$		1
(d) (i)	$NaBH_4$/ $LiAlH_4$ (in ether)		1
(ii)	$C_{10}H_{16}O + 2[H] \longrightarrow C_{10}H_{18}O$		1
(e) (i)	CN^- ✓	allow use of R or a bond to represent the side chain	
	curly arrow from lone pair of $:CN^-$ to C of carbonyl ✓		
	dipoles on carbonyl **and** curly arrow to show breaking of the π-bond ✓		
	intermediate ✓		
	curly arrow from O^- to H in HCN/ H^+/ H_2O ✓		5
(ii)	**type of reaction:** hydrolysis ✓		
	reagent: suitable named acid – e.g. H_2SO_4 / HCl ✓		
	contidtions: evidence of water – e.g. (aq)/dil **and** heat/reflux ✓		3
			17

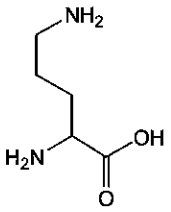
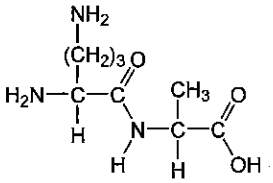
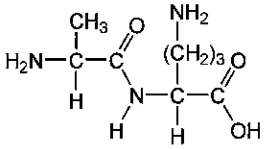
Qu.	Expected answers		Marks
6	M_r = 72 ✓ correct peak shown on diagram or described ✓		
	Compound A is a ketone (because positive test with 2,4-DNPH and negative result with Tollens') ✓ **A** must be $CH_3CH_2COCH_3$ / butanone ✓	allow minor errors in naming(e.g. missing 'di' '2,2' if the structure is correct	
	Compound B n.m.r has all Hs in the same environment/equivalent/one type **AW** ✓ molecular formula is C_5H_{12} / any valid structure ✓ **B** must be $C(CH_3)_4$ / 2,2-dimethylpropane ✓ (subsumes previous mark)	allow ECF from the wrong M_r only where it still makes chemical sense	
	Compound C is a carboxylic acid / contains COOH **AW** (because i.r.shows O–H / COOH at 2500–3300 cm^{-1} and C=O at 1680–1750 cm^{-1}) ✓ structure of any carboxylic acid shown ✓ **C** is CH_2=CHCOOH ✓ (subsumes previous mark)		**10**
			10

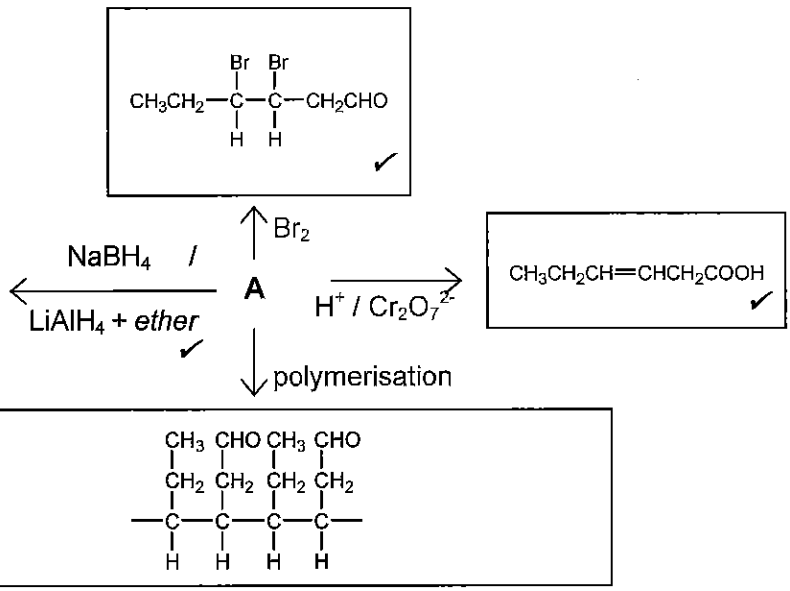
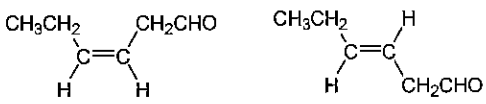
Qu.	Expected answers		Marks
7	**reaction with cyclohexene**		
	(electrophilic) addition ✓	allow 'added', 'adds' etc	
	 ✓	allow molecular formulae in the equations	
	(π-)electrons are localised / not delocalised ✓		
	reaction with benzene		
	(electrophilic) substitution ✓		
	 ✓	allow Br^+ to give H^+ in the equation	
	(π-)electrons are delocalised ✓		
	reaction with phenol		
	(electrophilic) substitution ✓		
	 ✓		
	lone pair of electrons from O are delocalised around the ring ✓		
	explaining reactivity in the context of any compound		
	valid discussion of relative electron density (around the ring) ✓		
	valid discussion of relative polarisation of the bromine **or** the (electrostatic) attraction of electrophiles to the ring ✓		
		any 10 out of 11 marks	**10**
QWC	Mark for at least two sentences or bullet points in context with correct spelling, punctuation and grammar ✓		**1**
			11

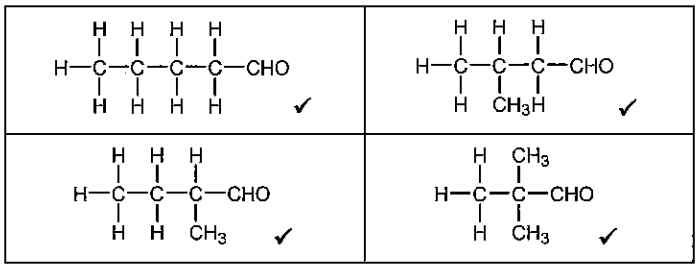
Qu.	Expected Answers	Marks
1 (a) (i)	HNO_3 + H_2SO_4 ✓ (both acids) conc ✓ 50–60°C ✓	3
(ii)	NO_2 ✓	1
(iii)	H_2SO_4 + HNO_3 ⟶ NO_2^+ + H_2O + HSO_4^- / $2H_2SO_4$ + HNO_3 ⟶ NO_2^+ + H_3O^+ + $2HSO_4^-$ ✓	1
(iv)	 curly arrow from π bond to electrophile ✓ intermediate ✓ curly arrow from C–H bond to π bond ✓ correct products ✓	4
(v)	moles benzene = $^{3.9}/_{78}$ = 0.050 ✓ actual moles of nitrobenzene formed = $^{4.9}/_{123}$ = 0.040 / 0.0398 **or** theoretical mass nitrobenzene = 0.050 x 123 = 6.15 (g) ✓ % yield = $^{\text{actual}}/_{\text{theoretical}}$ mass/moles = = 79.67% = **80%** ✓ 80% without working only scores 1 mark	3
(b) (i)	$AlBr_3$ / Fe / $FeBr_3$ ✓ **ALLOW** $AlCl_3$	1
(ii)	bromine decolourised ✓ white/cream solid/ppt. ✓ 2,4,6-tribromophenol identified by name/structure ✓ lone pair from O (of O–H) is delocalised into the ring (or orbital diagram to show) ✓ increases the (π) electron density(around the ring) ✓ Br–Br more polarised / more attracted ✓ **ora** for benzene	6
QWC	for correct use of **one** of the terms **electrophile / electrophilic / activation**	1
		[Total: 20]

Qu.	Expected Answers		Marks
2 (a)	**step 1** HNO_2 + HCl / $NaNO_2$ + HCl ✓ below 10°C ✓ **step 2** add to phenol in alkaline conditions / NaOH (below 10°C) ✓  ✓ ✓	**ALLOW** C_6H_5 not displayed **ALLOW** any substitution position in the dye	5
(b) (i)	N=N̄ circled ✓		1
(ii)	12 carbons ✓ 9 hydrogens ✓		2
(iii)	 ✓ ✓	**DO NOT ALLOW** connection errors here **ALLOW** $-SO_3H$	2
(c)	 ✓	**ALLOW** just one $\bar{O}$	1
			[Total: 11]

Qu.	Expected Answers		Marks
3 (a) (i)	**mechanism** arrow from **C** of CN to C ✓ dipole and curly arrow breaking π-bond on C=O ✓ structure of the intermediate ✓ curly arrow to H of HCN / H_2O / H^+ ✓ e.g.  **reagents:** HCN + KCN / H_2SO_4 + KCN ✓	**ALLOW** NaOH / HCN	**5**
(ii)	**type of reaction:** hydrolysis ✓ **equation:** – e.g. $CH_3CH(OH)CN + 2H_2O \longrightarrow CH_3CH(OH)COOH + NH_3$ / $CH_3CH(OH)CN + 2H_2O + H \longrightarrow CH_3CH(OH)COOH + NH_4$ H_2O / NH_3 ✓ rest of the equation and balancing ✓		**3**
(b)	lactic acid has a chiral centre / optical isomers ✓ laboratory sample has both optical isomers / stereoisomers fermentation would contain only one optical isomer **AW** ✓	**DO NOT ALLOW** just 'isomers'	**2**
(c) (i)	 ester link ✓ rest of structure also correct ✓		**2**
(ii)	**renewable** = made from plants that can be grown **AW** **biodegradable** = broken down by bacteria etc **AW** **reason linked to biodegradability** e.g. less landfill / less harm to animals / broken down by hydrolysis / no need to burn so no harmful gases etc **AW ora** **reason linked to renewability** e.g. does not increase atmospheric CO_2 **AW ora**	**ANY two for ✓✓**	**2**
(d)	$2CH_3CH(OH)COOH \longrightarrow C_6H_8O_4 + 2H_2O$ H_2O as product / 2x lactic acid as reactants ✓ rest of the equation correct and balanced ✓	**ALLOW** any combination of molecular or structural formulae	**2**
			[Total: 16]

Qu.	Expected Answers		Marks
4 (a) (i)	$CH_2CH_2CH_2NH_2$ / ringed on structure ✓	**IGNORE** 'propylamine' but 'con' if named as an amide	1
(ii)	 two $-NH_2$ and skeletal $-COOH$ ✓ rest of the molecule correct ✓	**ALLOW** ecf from non-skeletal COOH	2
(b) (i)	$^+H_3NCH(CH_2CH_2CH_2NH_3^+)COOH$ one NH_2 protonated ✓ both NH_2 protonated ✓	**IGNORE** Cl^- **ALLOW** $-NH_3Cl$	2
(ii)	$H_2NCH(CH_2CH_2CH_2NH_2)COO^-$ ✓	**IGNORE** Na^+ **ALLOW** COONa **ALLOW** ecf from **(i)** on minor structural errors	1
(c)	$PCl_5 \longrightarrow POCl_3 + HCl$ / $SOCl_2 \longrightarrow SO_2 + HCl$ ✓ ✓ ✓ ✓✓ ✓ (allow $PCl_3 \longrightarrow H_3PO_3$ for the first two marks)		3
(d)	one peptide linkage correct ✓   one correct dipeptide ✓ second dipeptide with R groups swapped ✓	**ALLOW** CONH not displayed max one mark if COONH linkage **ALLOW** ornithine linked by either NH_2 group **ALLOW** $C_3H_6NH_2$ for the side chain **ALLOW** ecf for last mark for idea of swapping side chains as long as a peptide is attempted	3
			[Total: 12]

Qu.	Expected Answers	Marks
5 (a)	hex-3-en ..... al ✓ ✓	**ALLOW** 'ene' **ALLOW** '-1-al' 2
(b)	 addition polymer attempted with two repeats ✓ correct side chains ✓	5
(c)	 *cis* ✓ *trans* ✓	**ALLOW** one mark for two correct structures with incorrect labels **ALLOW** ecf on minor side chain errors 2
		[Total: 9]

Qu.	Expected Answers		Marks
6 (a)	**To confirm aldehyde or ketone** 2,4-dinitrophenylhydrazine / Brady's reagent ✓ red / orange / yellow ... solid / ppt / crystals ✓ **To distinguish between aldehyde or ketone** warm with ✓ ammoniacal silver nitrate / Tollens' reagent ✓ → silver (mirror) ✓ / acidified $Cr_2O_7^{2-}$ → green	**DO NOT ALLOW** recrystallise etc for the 2nd mark **ALLOW** any other suitable tests e.g. Fehlings, MnO_4	5
(b) (i)	**M** written next to the peak at *m/e* = 106 ✓		1
(ii)	C_7H_6O / C_6H_5CHO C = 7 ✓H = 6 and O ✓	**ALLOW** ecf on H5 if the peak at 105 labelled	2
(c)	 ✓ ✓ ✓ ✓		4
(d)			9

	D	E	F
No of peaks and areas	3 peaks ratio 3:1:6 ✓	4 peaks ratio: 3:2:2:3✓	2 peaks ratio: 2:3 /4:6✓
chemical shifts (ppm)	2.0–2.9 (×2) 0.7–1.6 ✓	2.0–2.9 (×2) 0.7–1.6 1.2–1.4 ✓	2.0–2.9 0.7–1.6 ✓
splitting AW to describe	singlet doublet / 1:1 ✓ (multiplet)	singlet 2 x triplet / 1:2:1 ✓ (multiplet)	triplet / 1:2:1 quartet 1:3:3:1 ✓

on **D** and **E**, **IGNORE** any splitting given for the multiplet

QWC	For at least **two** relevant sentences in which the meaning is clear with correct spelling, punctuation and grammar (**ALLOW** bullet points and note form where appropriate).	1

[Total: 22]

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