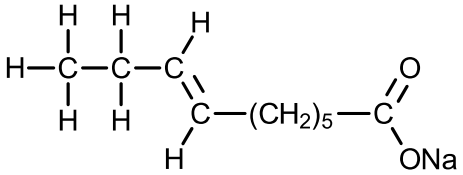
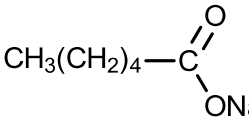
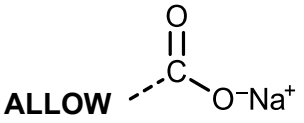
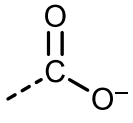
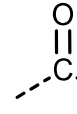
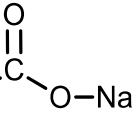
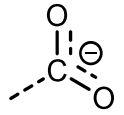
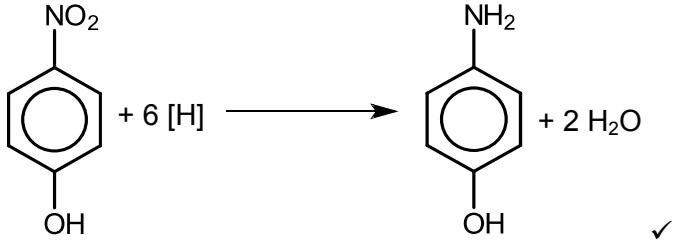
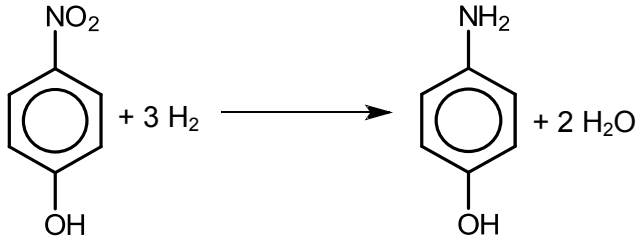
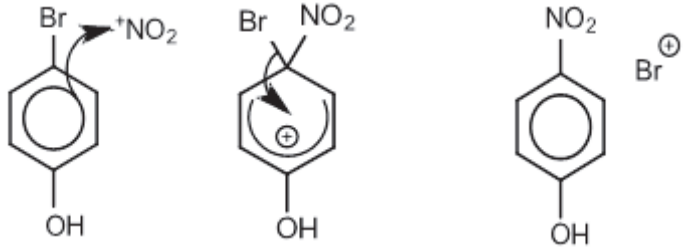
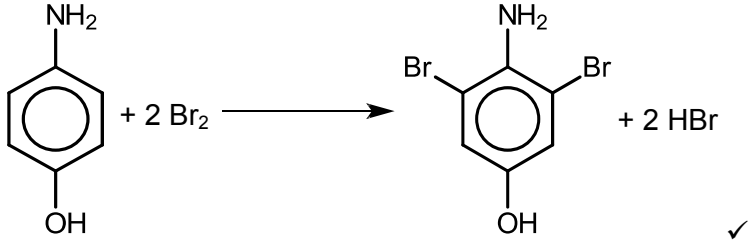
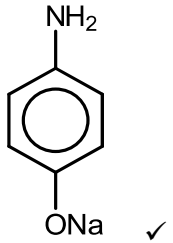
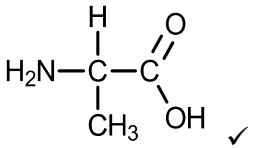
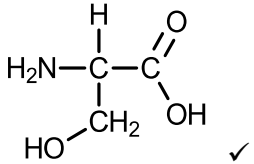
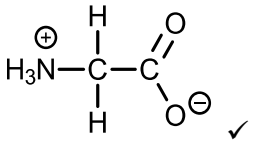
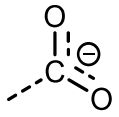
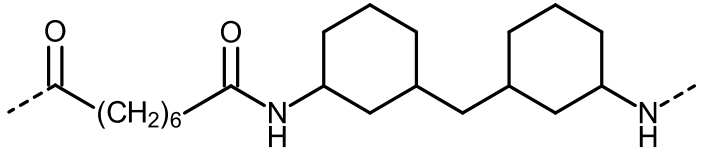
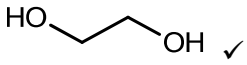
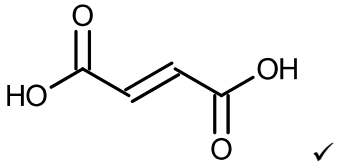
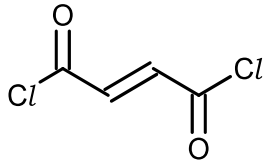
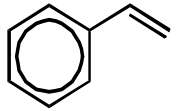
Question			Answer	Marks	Guidance
1	(a)	(i)	propane-1,2,3-triol ✓	1	**ALLOW** absence of 'e' after 'propan' **ALLOW** 1,2,3-propanetriol **ALLOW** absence of hyphens 1, 2 and 3 must be clearly separated: **ALLOW** full stops: 1.2.3 **OR** spaces: 1 2 3 **DO NOT ALLOW** 123 **IGNORE** glycerol
		(ii)	  One mark for decenoate salt **OR** decenoic acid ✓ One mark for hexanoate salt **OR** hexanoic acid ✓ One mark for **BOTH correct** products shown as salts (with or without Na^+) ✓	3	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous **DO NOT ALLOW** *cis* structure **ALLOW**  **OR**   **DO NOT ALLOW**  (covalent bond)  **ALLOW** delocalised carboxylate **IGNORE** glycerol
	(b)		one of the fatty acids is *trans* ✓ which may increase / cause / produce (the level of) 'bad'/LDL cholesterol ✓ **QWC** cholesterol MUST be spelt correctly	2	**ALLOW** one of the products is TRANS **ALLOW** reduces (the level of) 'good'/HDL cholesterol
			Total	**6**	

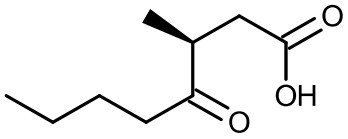
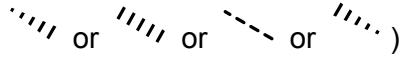
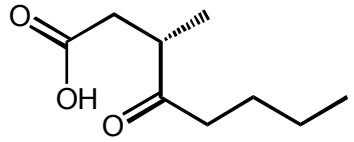
Question			Answer	Marks	Guidance
2	(a)		**Nitrogen** lone pair accepts a proton/H^+ ✓ *Requires position of lone pair on N*	1	**DO NOT ALLOW** Nitrogen/N lone pair accepts hydrogen *Proton/H^+ is required* **ALLOW nitrogen** donates a lone pair **IGNORE** NH_2 group donates a lone pair
	(b)		 ✓	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous **DO NOT ALLOW** 
	(c)		 ✓ curly arrow from ring to $^+NO_2$ ✓ correct intermediate ✓ curly arrow from C–Br to reform ring ✓ correct products **MUST HAVE** Br^+	4	**ALLOW** $^+NO_2$ **OR** NO_2^+ **ALLOW** first curly arrow from the ring **OR** from within the ring to any part of the NO_2^+ including the + charge **DO NOT ALLOW** intermediate with broken ring covering less than half the ring or incorrect orientation of broken ring + must be within the broken ring **ALLOW** non-delocalized (Kekulé) structures with carbocation on either side of Br/NO_2 substituents **DO NOT ALLOW** M1 if a second arrow used on the diagram **DO NOT ALLOW** M3 ecf if arrow does not come from C-Br bond If OH missing on intermediate **do not** award M2. If OH missing on final product **do not** award M4
	(d)	(i)	hydrochloric acid/HC*l* ✓	1	**ALLOW** conc / dilute HC*l*

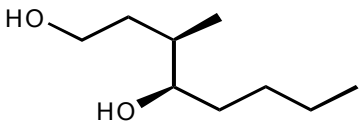
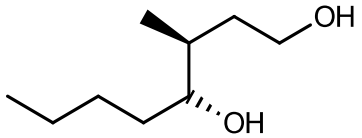
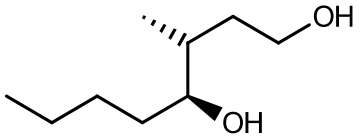
Question			Answer	Marks	Guidance
		(ii)	4-amino-3,5-dibromophenol ✓	1	**ALLOW** 3,5-dibromo-4-aminophenol **ALLOW** 2,6-dibromo-4-hydroxyphenylamine **ALLOW** 2,6-dibromo-4-hydroxy(-1-)aminobenzene **OR** (1-)amino-2,6-dibromo-4-hydroxybenzene **ALLOW** absence of hyphens numbers must be clearly separated **ALLOW** full stops **OR** spaces
		(iii)	 ✓	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous
		(iv)	 ✓	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous **ALLOW** $-O^-Na^+$ **OR** $-O^-$ **DO NOT ALLOW** –O-Na
	(e)	**(i)**	dyes/dyestuffs/pigments/food colourings ✓	1	**ALLOW** indicators / biological stains **DO NOT ALLOW** unqualified paint or food

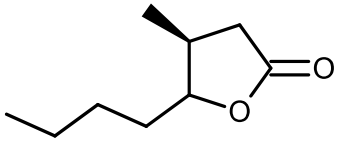
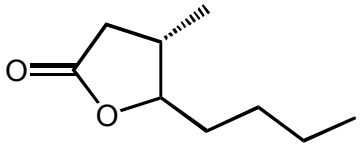
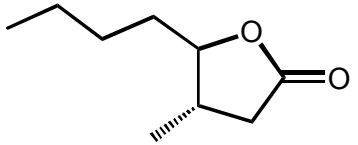
Question			Answer	Marks	Guidance
		(ii)		5	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous *No alternative pathway possible*
			reaction **1** HNO_2 (with or without HC*l*) **OR** $NaNO_2$ + HC*l* ✓		**ALLOW dilute** H_2SO_4 but **NOT** conc H_2SO_4 **ALLOW** conc HC*l*
			temp **<**10 °C ✓		
			compound **B** =  ✓		
			reaction **2** CuI ✓		
			reaction **3** alkali(ne) ✓		**ALLOW** KOH**(aq)**/NaOH**(aq)**/OH^-**(aq)** **IGNORE** temp < 10^oC **DO NOT ALLOW** heat/boil/warm **DO NOT ALLOW** use of phenol in M5
			Total	**16**	

Question			Answer	Marks	Guidance
3	(a)	(i)	**monomers** join/bond/add/react/form polymer/form chain **AND** another product/small molecule *e.g.* H_2O/HC*l* ✓	1	**IGNORE** 'two' when referring to monomers, *i.e.* (two) monomers…
		(ii)	 ✓  ✓	2	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous **ALLOW** zwitterions
		(iii)	The pH at which the zwitterion exists ✓  ✓	2	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous **ALLOW** pH at which there is no **overall**/**net** charge **IGNORE** pH at which there is no charge/ neutral charge *ie overall/net is required* **ALLOW** pH at which contains COO^- **AND** NH_3^+  **ALLOW** delocalized carboxylate **ALLOW** + on N or H; - must be on O
	(b)	(i)	Adsorption ✓	1	**DO NOT ALLOW** absorption **ALLOW** partition **ALLOW** adsorbtion
		(ii)	R_f = 0.53 to 0.62 ✓ Amino acid is methionine ✓	2	Values vary if distance measured to middle or top of spot Independent marks. No need to show working as question asks for estimate of R_f

Question			Answer	Marks	Guidance
	(c)		 amide link ✓ correct structure ✓	2	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous **ALLOW** 'terminal' —NH— at other end 'End bonds' **MUST** be shown (solid or dotted) **IGNORE** brackets and/or *n* **DO NOT ALLOW** aromatic rings in amine residue **ALLOW** CONH for amide link
	(d)	(i)	 ✓  ✓ Penalise connectivity once (i.e. not –HO)	2	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous For dicarboxylic acid: **ALLOW** dioyl chloride  **DO NOT ALLOW** the CIS monomer
		(ii)	 ✓	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous
			Total	**13**	

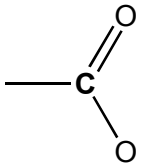
Question			Answer	Marks	Guidance
4	(a)	(i)	**F =**  **AND** reagent $NaBH_4$ ✓ **NB One mark for BOTH**	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formulae **OR** combination of above as long as unambiguous Wedge out of the paper is required i.e.() **DO NOT ALLOW** dashed wedge on methyl group in this orientation () **ALLOW** 
		(ii)	Colour changes from orange to green / blue / green blue ✓	1	
		(iii)	to ensure carboxylic acid is formed **OR** prevents formation of aldehyde **OR** distillation only makes the aldehyde ✓	1	
		(iv)	(nucleophilic) addition ✓	1	**ALLOW** redox **OR** reduction
	(b)		2,4-DNP(H) ✓ orange precipitate ✓	2	**ALLOW** Brady's (reagent) **ALLOW** orange/red/yellow for colour of the 2,4-DNP(H) precipitate **ALLOW** solid/crystals in place of precipitate **IGNORE** any reference to recrystallising/melting points

Question			Answer	Marks	Guidance
4	(c)	(i)	One of:  **OR**  **OR**  for one mark ✓ optical (isomerism) ✓	2	For bold wedge **ALLOW**  or  or  For dashed wedge **ALLOW**  or  or  or  **DO NOT ALLOW** any other representation of the structure, *i.e.* anything not skeletal **ALLOW** open wedges **ALLOW** isomers shown in any alternative correct orientation
		(ii)	If answer = 63.5 award 3 marks moles of **E** used = 4.56/160(.0) / 0.0285 (mol) ✓ moles of **G** formed = 3.15/174(.0) / 0.0181 (mol) ✓ yield = 0.0181/0.0285 × 100% / 63.5% ✓	3	0.0285 mol is exact calculator value 0.0181 mol is to 3sf (calculator value 0.0181034…) **IGNORE** trailing numbers in this answer **ALL ANSWERS MUST** be to a minimum of 3sf, the final answer must be to 3 sf (calculator value gives 63.520871%) (rounding of moles of **G** gives 63.508772%) **ALLOW** ecf from incorrect Mr or moles unless the yield is >100%

Question			Answer	Marks	Guidance
		(iii)	 for first mark ✓ Other product = H_2O for second mark ✓	2	**ALLOW** abbreviation of alkyl chain Wedge out of the paper is required i.e.( or  or ) **DO NOT ALLOW** dashed wedge on methyl group in this orientation ( or  or  or ) **ALLOW**  Be careful with orientation of lactone: **ALLOW** 
			Total	**13**	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>5</td><td>(a)</td><td></td><td>
<table>
<tr><td></td><td>C</td><td>H</td><td>O</td></tr>
<tr><td>%</td><td>73.15%</td><td>7.37%</td><td>19.48%</td></tr>
<tr><td>mol</td><td>6.10</td><td>7.37</td><td>1.22</td></tr>
<tr><td>ratio</td><td>5</td><td>6</td><td>1</td></tr>
</table>
molar ratio (C:H:O) = 6.10 : 7.37 : 1.22 OR = 5:6:1
OR empirical formula = C_5H_6O ✓
M_r is 164 so molecular formula = $C_{10}H_{12}O_2$ ✓
</td><td>2</td><td>ALLOW alternative method
73.15% × 164 = 120 } ratio = 10 OR 5
7.37% × 164 = 12.1 } 12 OR 6
19.48% × 164 = 31.9 } 2 OR 1
✓ ✓

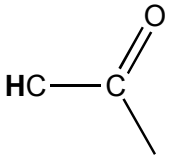
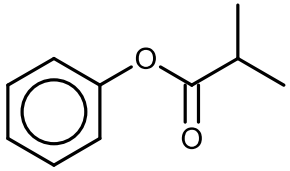
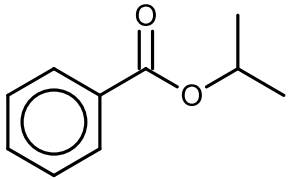
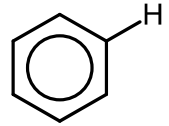
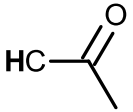
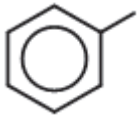
This mark is for some evidence of using M_r, which is twice the value that you would obtain from the empirical formula</td></tr>
<tr><td></td><td>(b)</td><td></td><td>seven ✓</td><td>1</td><td></td></tr>
<tr><td></td><td>(c)</td><td>(i)</td><td>TMS is the standard (for chemical shift measurements) ✓</td><td>1</td><td>ALLOW TMS is the reference OR for calibration
IGNORE unreactive / volatile / it gives a sharp peak
ALLOW TMS = 0 ppm / TMS is used for comparison</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>(relative) number of protons/hydrogens in each environment / peak / region
OR three proton environments with protons in ratio 5:1:6 ✓</td><td>1</td><td>ALLOW (relative) number of each type of proton/hydrogen
IGNORE number of protons in the compound</td></tr>
<tr><td></td><td></td><td>(iii)</td><td>^{13}C NMR Analysis (1 mark)

The peak at 185ppm suggests an ester group /
 

AND one of the following:

The peaks between 120ppm and 160ppm indicate a benzene ring
OR the peaks at 18ppm AND 36ppm suggest C-C ✓</td><td>7</td><td>FULL ANNOTATIONS WITH TICKS, CROSSES,CON ETC MUST BE USED

Inclusion of an incorrectly assigned ^{13}C peak CONS M1</td></tr>
</table>

Question	Answer	Marks	Guidance
	^{1}H ANALYSIS (4 marks) Doublet / peak at 1.2 shows R-C**H AND** 6 H's / 2 CH_3 (in this environment) ✓ Multiplet / septet / heptet / peak split into 7 / peak at 2.7ppm indicates  ✓ The doublet suggests that two CH_3 groups are attached to a CH **OR** the multiplet / septet / heptet suggests that the CH group is attached to two CH_3 groups ✓ ✎ **QWC** must spell **one** of *multiplet*, *septet*, *heptet* **OR** *doublet correctly* Peak at 7.3ppm indicates a benzene ring **AND** 5 H's ✓ **Compound identification (2 marks)** **IF** identified as  then **two** marks ✓✓ **IF** identified as  then **one** mark ✓		Candidates may quote δ values as ranges taken from Data Sheet, so **ALLOW** tolerance (ppm) eg  6.5–8 aromatic  2.0–2.9 carboxyl 0.7–2.0 alkyl R—C**H** **ALLOW** peaks labelled on the spectrum If **QWC** word is not used, MAX 3 for proton NMR **ALLOW** C_6H_5 **IGNORE** reference to phenol Allow  as C_6H_5 if they state that the benzene ring has 5 H's
	Total	**12**	