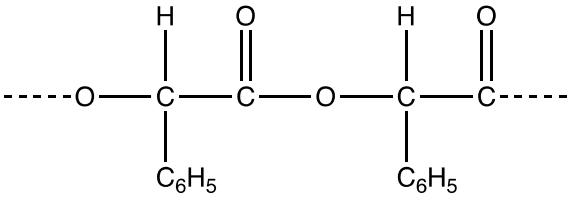
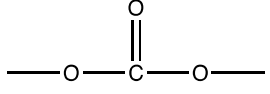
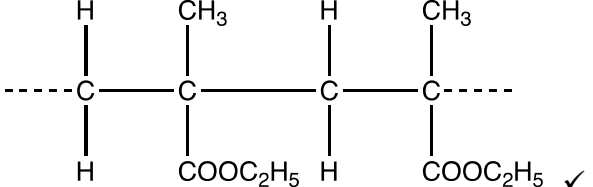
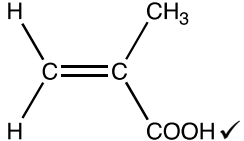
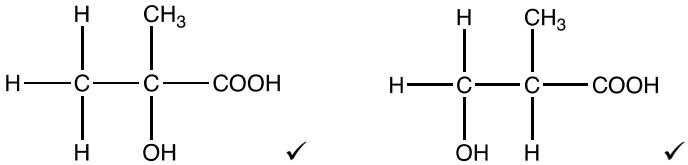
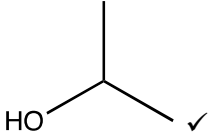
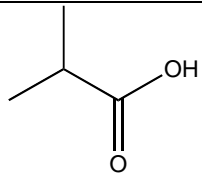
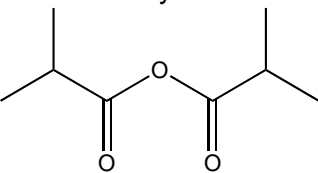


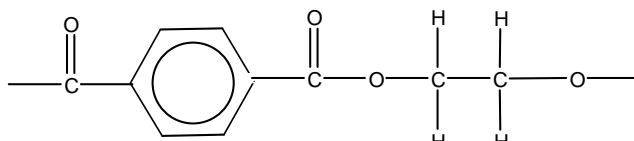
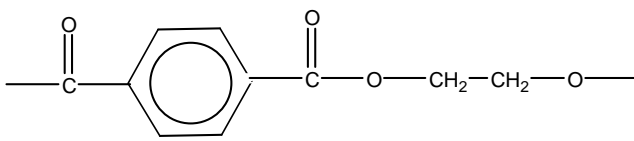
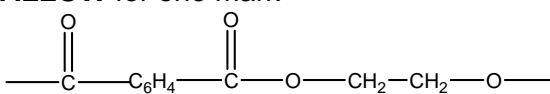
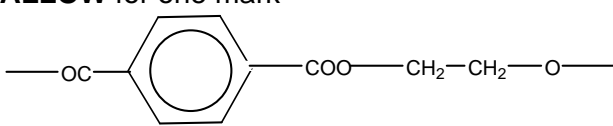
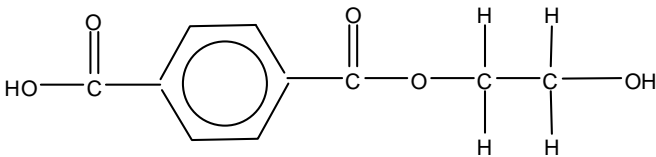
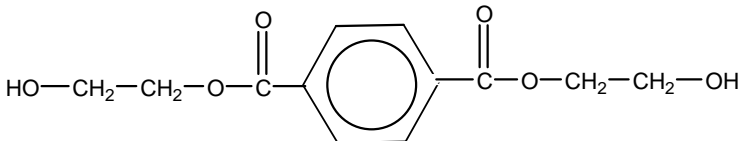
Question	Answer	Mark	Guidance
1	<p>(a) monomers join/bond/add/react/form polymer/form chain AND another product/small molecule e.g. H₂O/HCl ✓</p> <p>QWC must spell AND use 'monomer(s)' correctly throughout</p>	1	<p>IGNORE 'two' when referring to monomers, ie (two) monomers</p>
	<p>(b) (i)</p> <div style="text-align: center;">  </div> <p>ester link ✓</p> <p>Note: Any ester link shown must be correct</p> <p>rest of the structure ✓</p>	2	<p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous)</p> <p>ALLOW benzene ring for C₆H₅</p> <p>'End bonds' MUST be shown (do not have to be dotted)</p> <p>ALLOW one or more repeat units but has to have a whole number of repeat units (<i>ie</i> does not have to be two)</p> <p>For ester, DO NOT ALLOW </p> <p>ALLOW structure with no O at left end and COO at right end</p> <p>IGNORE brackets</p> <p>IGNORE <i>n</i></p>
	<p>(ii)</p> <div style="text-align: center;">  </div>	1	<p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous)</p> <p>ALLOW one or more repeat units but has to have a whole number of repeat units (<i>ie</i> does not have to be two)</p> <p>'End bonds' MUST be shown (do not have to be dotted)</p> <p>IGNORE brackets</p> <p>IGNORE <i>n</i></p>

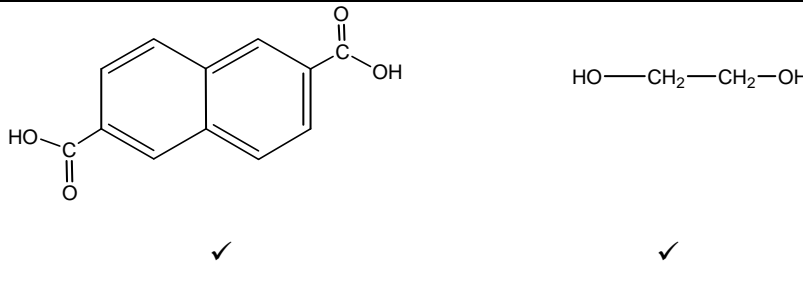
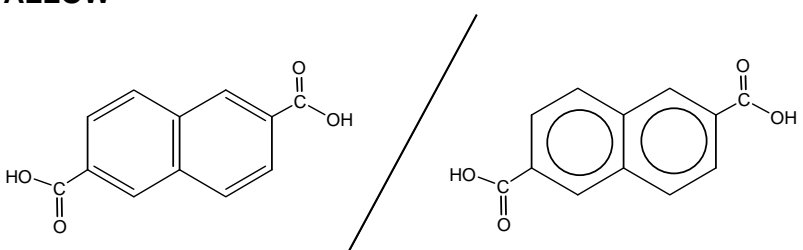
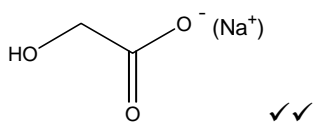
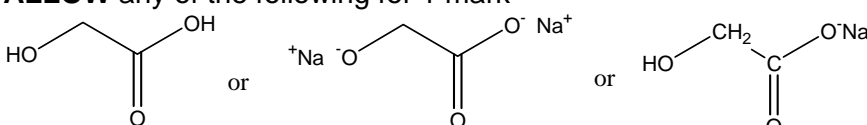
Question	Answer	Mark	Guidance
(c)	<p>compound C</p>  <p>compound D and compound E</p> 	3	<p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) ALLOW CH₂C(CH₃)COOH</p> <p>ALLOW D and E by ECF from an incorrect structure of C provided that C contains a double bond and molecular formulae of D and E is C₄H₈O₃ with H₂O added across double bond</p>
(d) (i)		1	<p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) e.g. (CH₃)₂CHOH</p> <p>DO NOT ALLOW –HO</p> <p>IGNORE working (<i>ie</i> other structures) provided correct structure of propan-2-ol is shown</p> <p>IGNORE name (even if wrong)</p>

Question		er	Mark	Guidance
(d)	(ii)	 <p>OR acid anhydride:</p> 	1	<p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) OR (2-)methylpropanoic acid</p> <p>DO NOT ALLOW incorrect name (will CON a correct structure)</p> <p>ALLOW acyl chloride: $(\text{CH}_3)_2\text{CHCOCl}$</p> <p>IGNORE working provided correct structure of propan-2-ol is shown</p>
	(iii)	<p>Hydrogen bonds form with water ✓ Note: Can be shown in diagram as dashed line, <i>ie</i> ---- (no label required)</p> <p>DO NOT CON 'hydrogen bond' from an incorrect hydrogen bond in diagram</p> <p>Mandelic acid forms more hydrogen bonds (with water) ✓ ORA</p> <p>Mandelic acid has an extra OH OR 2 OH groups OR has a COOH group ✓ ORA</p>	3	<p>ANNOTATIONS MUST BE USED</p> <p>ALLOW a diagram showing hydrogen bonds with water, dipole and lone pair are not required ALLOW a hydrogen bond to C=O, <i>ie</i> C=O---H-O IGNORE bond angles Diagram does not need to show all of mandelic acid (IGNORE if wrong)</p> <p>ALLOW any comparison of numbers of hydrogen bonds provided that mandelic acid has more hydrogen bonds</p> <p>DO NOT ALLOW 'No -OH groups in ester (as there are)' DO NOT ALLOW reference to -OH^- / hydroxide</p> <p>IGNORE reference to carbon chain and van der Waals' forces</p> <p>Note: If a response compares Ester 1 with Ester 2 rather than with mandelic acid, maximum of 2 marks: 1st mark hydrogen bonds 2nd mark Ester 2 has more Os/oxygens OR Ester 2 forms more hydrogen bonds</p>

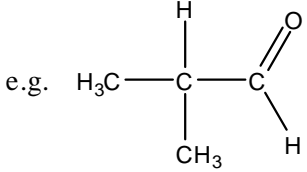
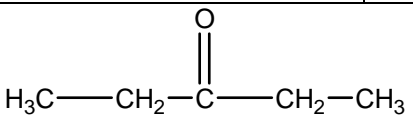
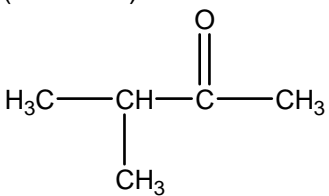
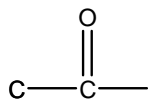
Question		Answer	Mark	Guidance
	(d)	(iv)	To test for (adverse) side effects OR to test toxicity OR to test for irritation ✓	1 ALLOW a stated adverse side effect, <i>eg</i> allergy, carcinogenic, etc IGNORE references to optical isomers, chirality, etc IGNORE vague statements such as harmful to skin, dangerous to skin, corrosive to skin, reacts with skin ALLOW company liable to litigation/damages
			Total	13

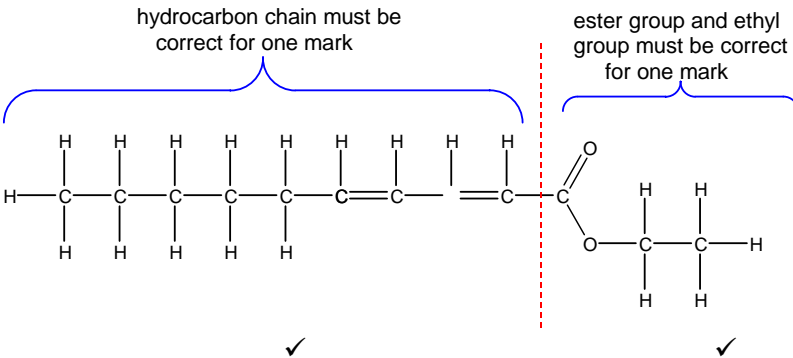
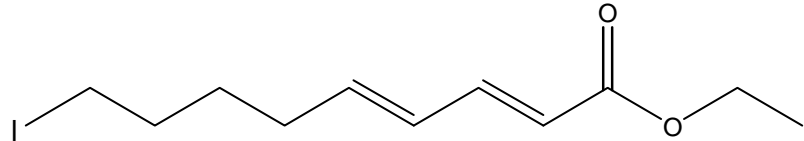
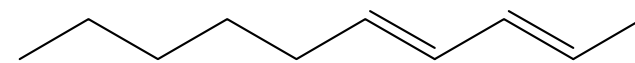
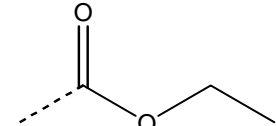
2		<p>Equations $\text{CH}_3\text{COCHO} + 4[\text{H}] \longrightarrow \text{CH}_3\text{CHOHCH}_2\text{OH} \checkmark$ $\text{CH}_3\text{COCHO} + [\text{O}] \longrightarrow \text{CH}_3\text{COCOOH} \checkmark$</p> <p>Reduction reagents and observation Methylglyoxal is reduced by $\text{NaBH}_4 \checkmark$</p> <p>Oxidation reagents and observation Methylglyoxal is oxidised by H_2SO_4 AND $\text{K}_2\text{Cr}_2\text{O}_7 \checkmark$ Observation: turns green OR blue \checkmark</p> <p>OR Methylglyoxal is oxidised by Tollens' reagent \checkmark Observation: Silver (mirror) \checkmark</p>	<p>1 1 1 2</p>	<p>ANNOTATIONS MUST BE USED Throughout question, ALLOW correct structural OR displayed OR skeletal formula DO NOT ALLOW molecular formulae</p> <p>ALLOW partial reduction (ie reduction of either C=O group) [H] implies reduct [O] implies oxidat</p> <p>reduced AND reagent are both required for the mark ALLOW link to equation with [H] for reduction ALLOW LiAlH_4 as alternative for NaBH_4 ALLOW any recognisable attempt at name IGNORE any reference to acids</p> <p>oxidised AND reagent are both required for the mark ALLOW link to equation with [O] for oxidation ALLOW $\text{Na}_2\text{Cr}_2\text{O}_7$ instead of $\text{K}_2\text{Cr}_2\text{O}_7$ ALLOW H^+ AND $\text{Cr}_2\text{O}_7^{2-}$ OR H^+ AND CrO_4^{2-}</p> <p>If name given, ALLOW dichromate OR dichromate(VI) ALLOW acidified dichromate ALLOW any strong acid If formulae used, formulae must be correct</p> <p>ALLOW AgNO_3 in ammonia OR ammoniacal AgNO_3</p> <p>ALLOW oxidised by manganate Observation: decolourised</p> <p>Note: If one reaction is identified as oxidation, assume the other is reduction (and vice versa)</p>
		Total	5	

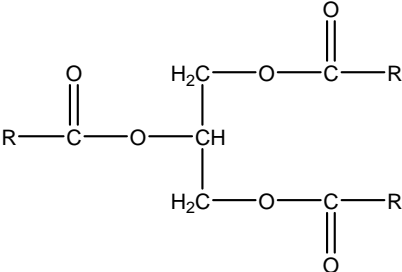
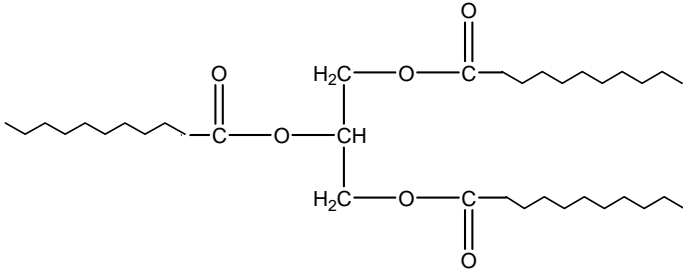
Question	Expected Answers	Marks	Additional Guidance
3 a i	 <p>✓✓ Ester group must be displayed to get both marks and must contain 4 Os</p>	2	<p>ALLOW for both marks</p>  <p>ALLOW for one mark</p>  <p>ALLOW for one mark</p>  <p>ALLOW Kekulé structure / (CH₂)₂ ALLOW one mark if end bonds missing ALLOW 1 mark if the CH₂CH₂ is drawn skeletally ALLOW for</p>  <p>ALLOW <u>1 mark</u> if repeat unit shows a displayed ester group and contains a benzene ring and two other carbons</p> <p>DO NOT ALLOW -OCC₆H₄COOCH₂CH₂O-</p>
	 <p>✓</p>	1	<p>ALLOW Kekulé structure/ (CH₂)₂ CO₂ for ester groups C₆H₄ if already penalised in a(i)</p>

Question		Expected Answers	Marks	Additional Guidance
b	i	$C_7H_5O_2$	1	ALLOW any order of elements ALLOW $C_{14}H_{10}O_4 \rightarrow C_7H_5O_2$ or $C_{14}H_{10}O_4 = C_7H_5O_2$
	ii	 <p>Penalise incorrect bond linkage in 2b(ii) only. Do not penalise elsewhere on the paper</p>	2	ALLOW COOH/CO ₂ H ALLOW  ALLOW HO(CH ₂) ₂ OH
c	i		2	ALLOW any of the following for 1 mark  DO NOT ALLOW any other response
	ii	(PGA is) (bio)degradable OR photodegradable OR hydrolysed (but hydrocarbon based polymers are non-biodegradable) ✓ One of (bio)degradable OR photodegradable OR hydrolysed must be spelt correctly – if one spelt correctly and another incorrectly spelt – ALLOW mark	1	ALLOW broken down by <u>bacteria</u> (must be spelt correctly) ALLOW degrade as alternative to degradable ALLOW undergoes hydrolysis as alternative to hydrolysed IGNORE any additional information if the additional information is correct e.g. biodegradable and doesn't produce toxic gases DO NOT ALLOW any additional information if the additional information is incorrect e.g. biodegradable and can be recycled
Total			9	

Question		Expected Answers	Marks	Additional Guidance	
4	a	Alternative approaches		4	<p>ALLOW ammoniacal AgNO_3 / $\text{Ag}^+(\text{NH}_3)_2$ / $\text{Ag}^+(\text{NH}_3)$ ALLOW acidified dichromate OR Fehlings as an alternative to Tollens – observation ‘turn green’ OR ‘red precipitate’ respectively ALLOW acidified manganate(VII) and observation as either brown precipitate/decolourised/pale pink 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 melting points ALLOW PCl_5 as a test for the acid – observation would be ‘white fumes (of HCl)’</p> <p>ALLOW detection of (carboxylic) acid by reacting with an alcohol to make an ester but no mark for the observation.</p> <p>DO NOT ALLOW detection of (carboxylic) acid by pH or indicator</p> <p>Please annotate, use ticks to show where marks are awarded</p>
		<p>Tollens’ test AND ‘silver precipitate/mirror’ ✓ is the aldehyde ✓</p> <p>react with 2,4-DNP(H) and ‘orange precipitate’ ✓</p> <p>must be the ketone ✓</p>	<p>Tollens’ test AND ‘silver precipitate/mirror’ ✓ is the aldehyde ✓</p> <p>react with carbonate/hydrogencarbonate/Na/Mg and ‘fizzes/bubbles/ effervesces/ gas evolved’ ✓</p> <p>must be the (carboxylic) acid ✓</p>		
	b	<p>2,4-DNP(H) AND orange precipitate ✓ is either aldehyde OR ketone ALLOW carbonyl OR $\text{C}=\text{O}$ ✓</p> <p>Tollens’ test & ‘silver ppt/mirror’ ✓ is the aldehyde ✓</p>	<p>2,4-DNP(H) and no orange precipitate ✓ is the (carboxylic) acid ✓</p> <p>Tollens’ test & ‘silver ppt/mirror’ ✓ is the aldehyde ✓</p>		
		<p>Peak in range 2500–3300 (cm^{-1}) or (around) 3000 shows O–H ✓ [need wavenumber (or range) and O–H bond]</p>	1	<p>DO NOT ALLOW single peak quoted within range 2500–3300 other than 3000 (cm^{-1}) for OH DO NOT ALLOW range 3200–3550 (cm^{-1}) IGNORE any reference to C–O or C=O</p>	

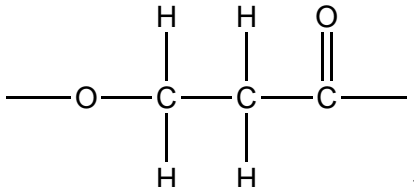
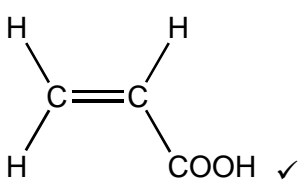
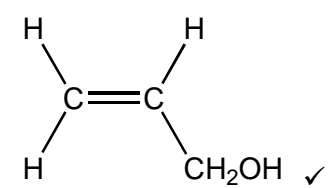
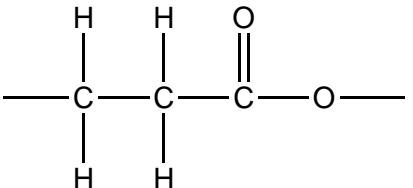
Question		Expected Answers	Marks	Additional Guidance
c		<p>Alternative approaches depending on whether or not the aldehyde is correct</p>		<p>ALLOW 3-methylbutanal , any correct unambiguous structure ALLOW two marks for correct aldehyde with no explanation</p> <p>ALLOW doublet/peak at 0.9ppm due to R-CH ALLOW the splitting shows adjacent to CH/environment that contains 1 H/proton</p> <p>ALLOW 6 Hs/ protons in same environment DO NOT ALLOW 6 Hs in same environment next to CHO</p> <p>e.g. </p> <p>would score two marks if the doublet and the peak areas were correctly explained</p>
		<p>Doublet indicates adjacent C is bonded to only 1H OR (relative) peak area indicates 2 x CH₃ (in the same environment) ✓</p> <p>If aldehyde is correct (CH₃)₂CH—CH₂—CHO ✓✓</p> <p><i>If aldehyde is correct only need to explain doublet OR peak areas</i></p> <p>Doublet indicates adjacent C is bonded to only 1H ✓ AND (relative) peak area indicates 2 x CH₃ (in the same environment) ✓</p> <p>If aldehyde identified is incorrect ✗</p> <p><i>if aldehyde is incorrect must explain both doublet or peak areas</i></p>		
d	i	 ✓ ketone 3	1	ALLOW displayed/skeletal formulae
	ii	<p>There are 4 (different C) environments ✓ (therefore) it is ketone 2 /</p>  ✓	3	<p>ALLOW 2 Cs are in same environment/equivalent</p> <p>ALLOW 3-methylbutan(-2-)one/ any correct unambiguous structure</p> <p>ALLOW 2-methylbutan-3-one</p> <p>ALLOW</p> 
Total			12	

Question		Expected Answers	Marks	Additional Guidance
5	a i	The time (from the injection of the sample) for the component to leave the column ✓	1	ALLOW time from injection to detection ALLOW time spent in column ALLOW time taken to reach detector
	ii	They have similar retention times ✓	1	ALLOW both are esters therefore partition/adsorption/retention times will be very similar ALLOW ECF if they describe R_f values in part a(i) ALLOW same retention times
	iii	Butylbutanoate ✓	1	ALLOW butyl butanoate ALLOW but-1-yl butanoate DO NOT ALLOW butanyl butanoate
	b i	<p>hydrocarbon chain must be correct for one mark</p>  <p>ester group and ethyl group must be correct for one mark</p>	2	<p>ALLOW any correct unambiguous structure/ $\text{CH}_3(\text{CH}_2)_4\text{CHCHCHCHCOOCH}_2\text{CH}_3$ / $\text{CH}_3(\text{CH}_2)_4\text{CHCHCHCHCOOC}_2\text{H}_5$ $\text{CH}_3(\text{CH}_2)_4(\text{CH})_4\text{COOCH}_2\text{CH}_3$ DO NOT ALLOW $\text{C}_5\text{H}_{11}\text{CHCHCHCHCOOCH}_2\text{CH}_3$ etc ALLOW CO_2 for ester</p>  <p>ALLOW 1 mark for correct 2,4-decadiene structure e.</p>  <p>ALLOW 1 mark for correct ethyl ... oate structure e.</p>  <p>or $-\text{CO}_2\text{C}_2\text{H}_5$ or $-\text{COOC}_2\text{H}_5$</p>

Question	Expected Answers	Marks	Additional Guidance
ii	 <p>The diagram shows a central carbon atom bonded to a hydrogen atom and three oxygen atoms. Each oxygen atom is part of an ester linkage to a carbonyl group (C=O) which is further bonded to an R group. The three ester groups are attached to the central carbon via their oxygen atoms, forming a triglyceride structure.</p>	1	<p>ALLOW</p>  <p>The diagram shows a triglyceride structure with three long-chain fatty acid groups (represented by zigzag lines) attached to a central glycerol backbone. The orientation of the three fatty acid chains is arbitrary.</p> <p>any orientation of the three fatty acids</p>
c	<ol style="list-style-type: none"> 1. react phenylethanal with $\text{H}_2\text{SO}_4/\text{K}_2\text{Cr}_2\text{O}_7$ ✓ 2. to get phenylethanoic acid/$\text{C}_6\text{H}_5\text{CH}_2\text{COOH}$ ✓ <p>mark 2 can be scored if dichromate is used without being acidified</p> <ol style="list-style-type: none"> 3. react phenylethanal with NaBH_4 ✓ 4. to get 2-phenylethanol/$\text{C}_6\text{H}_5\text{CH}_2\text{CH}_2\text{OH}$ ✓ <p>mark 3 must be correct to score mark 4</p> <ol style="list-style-type: none"> 5. react phenylethanoic acid with 2-phenylethanol. If both already correctly named ALLOW acid and alcohol ✓ 6. H_2SO_4 if linked to the reaction of an alcohol and acid ✓ 7. reflux in either (1) or (5) or catalyst used in (5) ✓ <p>QWC must spell catalyst or reflux correctly</p>	7	<p>ALLOW H^+ & $\text{Cr}_2\text{O}_7^{2-}$ or $\text{H}_2\text{SO}_4/\text{Na}_2\text{Cr}_2\text{O}_7$ - any other oxidising agent or other named acid – please consult with TL</p> <p>ALLOW LiAlH_4 as alternative to NaBH_4</p> <p>phenylethanoic acid & phenylethanol must be unambiguously identified by either name or formula</p> <p>DO NOT ALLOW or oxidised to form(a carboxylic) acid or reduced to form alcohol for marks 2 and 4</p> <p>ALLOW conc H_2SO_4 DO NOT ALLOW dilute or $\text{H}_2\text{SO}_4(\text{aq})$ DO NOT ALLOW just acid catalyst DO NOT ALLOW HCl, HNO_3</p> <p>Please annotate, use ticks to show where marks are awarded</p>
	Total	13	

if either phenylethanoic acid or 2-phenylethanol not prepared – automatically lose two marks

Question			er	Mark	Guidance
6	(a)	(i)	<p>One mark is for positive carbonyl test (Add) 2,4-dinitrophenylhydrazine AND orange/yellow/red precipitate ✓</p> <p>One mark is for negative aldehyde test EITHER (Add) Tollens' reagent/Tollens' test AND no change OR no reaction OR no silver (mirror)</p> <p>OR (Add) H₂SO₄ AND K₂Cr₂O₇ AND no change OR no reaction OR no green colour ✓</p>	2	<p>ALLOW errors in spelling ALLOW 2,4(-)DNP OR 2,4(-)DNPH ALLOW Brady's reagent or Brady's Test ALLOW solid OR crystals OR ppt as alternatives for precipitate</p> <p>ALLOW AgNO₃/NH₃ (Formulae must be correct) OR ammoniacal silver nitrate</p> <p>ALLOW Fehling's solution OR Benedict's solution AND no (brick-red) precipitate</p> <p>ALLOW any response that implies that nothing happens ie no change OR no reaction OR no silver (mirror)</p> <p>ALLOW 'the aldehyde/pentanal gives a silver mirror'</p> <p>ALLOW H⁺ AND Cr₂O₇²⁻ (Formulae must be correct)</p> <p>ALLOW any response that implies that nothing happens</p> <p>IGNORE responses using NaBH₄ (as no observations)</p> <p>NOTE: a(ii) is marked completely independently of a(i)</p>
		(ii)	<p>1st mark Take melting point of orange crystals/derivative/product from 2,4-DNP ✓</p> <p>2nd mark Compare melting point with known values OR compare melting point with value in database/reference book ✓</p>	2	<p>Mark independently of response for 1st mark</p> <p>DO NOT ALLOW 1st or 2nd marks for taking and comparing boiling points OR chromatograms</p>

Question	er	Mark	Guidance
(b) (<p>Synthesis 1</p>  <p>Ester linkage must be fully displayed ✓</p> <p>Synthesis 2</p>  	6	<p>NOTE: ALL Structures MUST have Hs shown IGNORE bond angles</p> <p>DO NOT ALLOW more than one repeat unit IGNORE brackets and 'n'</p> <p>ALLOW terminal O— on right (OR C=O on left), i.e.</p>  <p>ALLOW end bonds shown as ----- DO NOT ALLOW if structure has no end bonds</p>

Question		er	Mark	Guidance
		<p>Synthesis 3</p> <p>✓</p> <p>✓</p>		<p>Mark each structure independently</p> <p>HO- must be connected correctly on BOTH structures</p> <p>DO NOT ALLOW more repeat units IGNORE brackets and 'n'</p> <p>ALLOW terminal O— on right (OR C=O on left), i.</p> <p>ALLOW end bonds shown as ----- DO NOT ALLOW if structure has no end bonds</p> <p>DO NOT ALLOW ECF from wrong structure in previous boxes</p>
(b)	(i)	<p>Synthesis 1: condensation AND Synthesis 2: addition AND Synthesis 3: condensation ✓</p>	1	<p>All three correct responses required for the mark</p>
Total			11	