

GCE

Chemistry A

Unit **F324**: Rings, Polymers and Analysis

Advanced GCE

Mark Scheme for June 2016

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

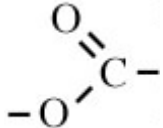
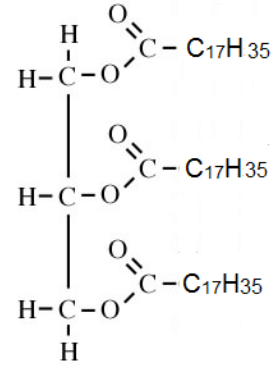
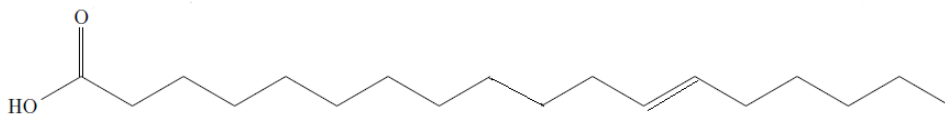
Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

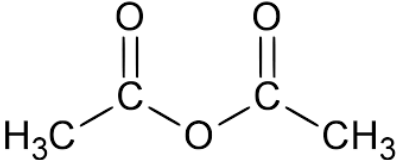
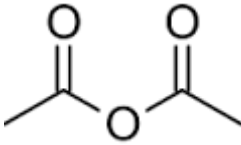
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Abbreviations, annotations and conventions

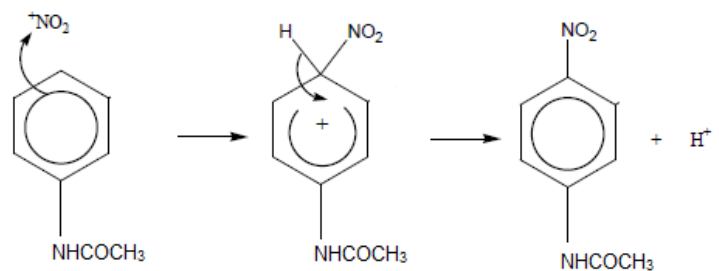
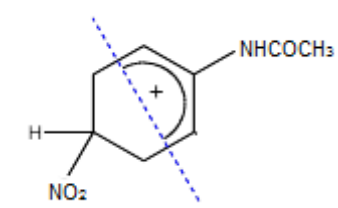
Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
()	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

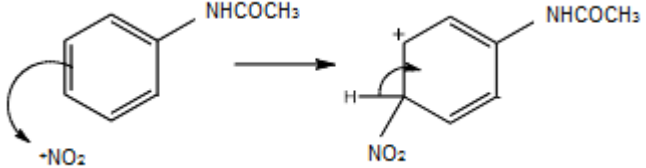
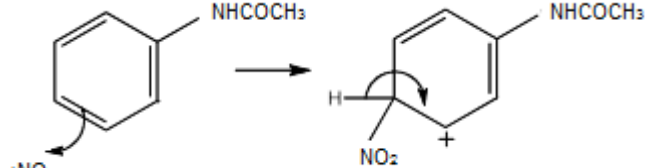
Question		Answer	Mark	Guidance
1	(a)	Stearic acid/octadecanoic acid AND Saturated (fat) ✓	1	ALLOW stearic acid AND no C=C double bonds IGNORE comments about LDL and cholesterol DO NOT ALLOW stearic acid is a trans fatty acid
	(b)	$C_{17}H_{35}COOH + NaOH \rightarrow C_{17}H_{35}COO^-Na^+ + H_2O$ ✓	1	ALLOW $C_{17}H_{35}COONa$ IGNORE state symbols
	(c)	At least one ester link fully displayed in a triglyceride structure ✓  Correct triglyceride structure ✓ 	2	ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above for the rest of the structure
	(d) (i)	M1 Correct structure of a mono unsaturated fatty acid with 18 C ✓ M2 Correct position of double bond (12) in a mono unsaturated fatty acid AND trans arrangement ✓	2	Must be skeletal formula for M1  DO NOT ALLOW cis isomer for M2

Question		Answer	Mark	Guidance
	(ii)	Each carbon atom in the double bond is attached to (two) different groups/atoms ✓	1	ALLOW Each carbon atom of the double bond is attached to a H atom DO NOT ALLOW functional group for group DO NOT ALLOW the carbon atoms are attached to different groups IGNORE two of the substituent groups are the same
		Total	7	

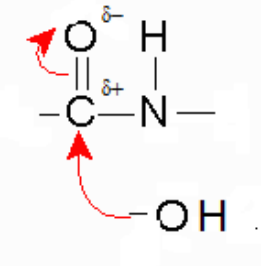

Question			Answer	Mark	Guidance
2	(a)	(i)	$\text{H}_2\text{N}(\text{CH}_2)_6\text{NH}_2$ <div style="text-align: right;">✓</div> $\text{HOOC}(\text{CH}_2)_4\text{COOH}$ <div style="text-align: right;">✓</div>	2	<p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous</p> <p>ALLOW acid chloride, $\text{ClOC}(\text{CH}_2)_4\text{COCl}$</p>
		(ii)	<p><u>Type of condensation polymer</u> Polyamide</p> <p>AND</p> <p><u>Use of condensation polymer</u> Fibres in clothing</p> <div style="text-align: right;">✓</div>	1	<p>Both answers required for one mark</p> <p>ALLOW nylon IGNORE numbers IGNORE polypeptide DO NOT ALLOW kevlar</p> <p>ALLOW any common use for nylon e.g. fibre, clothing, rope, fishing net, bristles, brushes, bags, cable ties etc. DO NOT ALLOW distinctive uses associated with kevlar or other polymers e.g. bullet-proof vests, crash helmets, bottles, cups IGNORE plastic</p>
	(b)	(i)	<p><u>Ethanoic anhydride</u></p>  <div style="text-align: right;">✓</div> <p><u>Other organic compound</u> CH_3COOH</p> <div style="text-align: right;">✓</div>	2	<p>ALLOW skeletal formula</p>  <p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous</p> <p>IGNORE names</p>

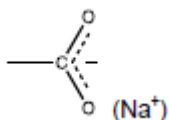
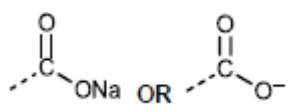
Question	Answer	Mark	Guidance
	<p>(ii) FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 2.66 (g) award 3 marks IF answer = 4.36 (g) award 2 marks (% yield not used) IF answer = 7.14 (g) award 2 marks (% yield used incorrectly)</p> <p>$n(\text{phenylamine}) = 3.00/93.0 = 0.0323 \text{ mol}$ ✓</p> <p>$n(\text{compound A}) = (0.0323 \times 0.61) = 0.0197 \text{ mol}$ ✓</p> <p>Mr (compound A) = 135 AND Mass of compound A = $(135)(0.0197) = 2.66 \text{ g}$ ✓</p> <p>OR</p> <p>$n(\text{phenylamine}) = 3.00/93.0 = 0.0323 \text{ mol}$ ✓</p> <p>Mr (compound A) = 135 AND Theoretical mass of compound A = $(0.0323 \times 135) = 4.36$ ✓</p> <p>Actual mass of compound A = $(4.36 \times 0.61) = 2.66 \text{ g}$ ✓</p>	3	<p>ANNOTATE WITH TICKS AND CROSSES ETC.</p> <p>ALLOW 3 SF: 0.0323 up to calculator value of 0.032258064 correctly rounded</p> <p>ALLOW 3 SF up to calculator value</p> <p>Penalise rounding to 2 SF once ALLOW ECF on incorrectly rounded values</p> <p>Final answer must be expressed to 3 significant figures</p> <p>ALLOW ecf from incorrect Mr</p> <p>IF answer = 2.65 (g) award 2 marks unless this alternative method is used (3 marks) 93 g gives 135 g 3.00 g gives $135/93 \times 3.00 = 4.35 \text{ g}$ $4.35 \times 0.61 = 2.65 \text{ g}$</p>

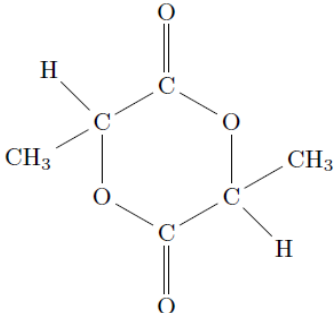
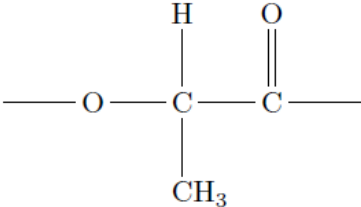
Question	Answer	Mark	Guidance
	<p>(iii) M1 $\text{H}_2\text{SO}_4 + \text{HNO}_3 \rightarrow \text{HSO}_4^- + \text{H}_2\text{O} + \text{NO}_2^+$ ✓</p> <p>M2 curly arrow from π ring OR from within the ring to $^+\text{NO}_2$ ✓</p>  <p>M3 correct intermediate (with charge) ✓</p> <p>M4 curly arrow from C-H to reform ring AND correct products ✓</p>	5	<p>ANNOTATE WITH TICKS AND CROSSES ETC. Equation to show formation of the electrophile</p> <p>ALLOW $2\text{H}_2\text{SO}_4 + \text{HNO}_3 \rightarrow 2\text{HSO}_4^- + \text{H}_3\text{O}^+ + \text{NO}_2^+$</p> <p>ALLOW $\text{H}_2\text{SO}_4 + \text{HNO}_3 \rightarrow \text{HSO}_4^- + \text{H}_2\text{NO}_3^+$ AND $\text{H}_2\text{NO}_3^+ \rightarrow \text{H}_2\text{O} + \text{NO}_2^+$</p> <p>Penalise missing or incorrect $-\text{NHCOCH}_3$ on intermediate only (M3)</p> <p>DO NOT ALLOW intermediate with the π-system covering less than half the ring</p>  <p>ALLOW + charge anywhere inside the 'horseshoe' Horseshoe must have open end towards NO_2</p> <p>ALLOW Kekulé mechanism</p>


Question	Answer	Mark	Guidance
	<p>M5 Regeneration of the catalyst: $H^+ + HSO_4^- \rightarrow H_2SO_4$ ✓</p>		<p>  </p> <p>ALLOW $H_3O^+ + HSO_4^- \rightarrow H_2SO_4 + H_2O$</p>
	<p>(c) <u>reagents for step 1</u> Nitrous acid/HNO₂ (and HCl) ✓</p> <p><u>conditions for step 1</u> $\leq 10^\circ C$ ✓</p> <p><u>compound C</u></p> 	4	<p>ALLOW NaNO₂ + HCl</p> <p>IGNORE reference to concentration</p> <p>ALLOW -OH ionised as -O⁻</p> <p>ALLOW KOH(aq)/NaOH(aq)/OH⁻(aq)</p>

Question			Answer	Mark	Guidance
			<u>conditions for step 2</u> alkaline/alkali ✓		ALLOW dilute NaOH or stated concentration IGNORE NaOH/KOH (must be aqueous) If temperature stated must be below 10°C DO NOT ALLOW heat/boil/warm
			Total	17	

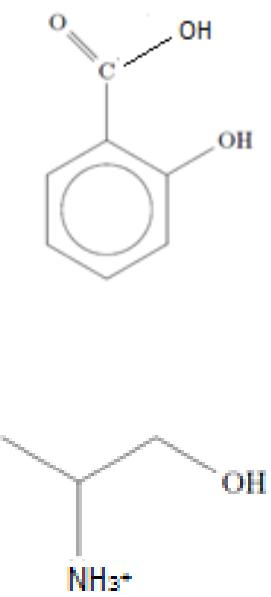
Question		Answer	Mark	Guidance
3	(a)	 <p>Curly arrow from OH⁻ to C(δ^+) ✓ Dipole correct AND curly arrow from C=O bond to O(δ^-) ✓</p>	2	First curly arrow must come from either a lone pair on O or negative charge on O
	(b)	<p>Measure distance moved by spot / distance moved by solvent ✓</p> <p>Compare (R_f) value with data book values/known values ✓</p> <p>Two amino acids have the same/similar R_f value OR similar adsorption ✓ OR move the same/similar distance ✓</p>	2 1	<p>ALLOW attempt at calculation of R_f value using distances measured on the chromatogram IGNORE explanation of how chromatography works</p> <p>ALLOW One spot contains two amino acids ALLOW Two amino acids have not separated IGNORE relative solubility ALLOW two of the amino acids have similar structures</p>
	(c) (i)	<p>The pH at which the amino acid exists as a <u>zwitterion</u> ✓</p> <p> QWC: zwitterion spelled correctly in the correct context</p>	1	<p>DO NOT ALLOW PH/ph</p> <p>ALLOW zwitter ion</p>

Question	Answer	Mark	Guidance
(ii)	$ \begin{array}{c} \text{H} \\ \\ \text{H}_2\text{N} - \text{C} - \text{COO}^- \\ \\ \text{CH}_2 \\ \\ \text{COO}^- \end{array} $	1	<p>ALLOW correct structural OR displayed OR skeletal formulae OR combination of above as long as unambiguous</p> <p>Two COO⁻ groups are required in the structure</p> <p>ALLOW -COO⁻Na⁺ OR -COONa</p> <p>ALLOW delocalised carboxylate</p> <p>ALLOW</p>  <p>DO NOT ALLOW -COO-Na OR -O-Na (covalent bond)</p> 
(iii)	<p>M1 structure</p> $ \begin{array}{ccccccc} \text{H} & \text{O} & & \text{H} & \text{O} & & \text{H} \\ & & & & & & \\ \text{H}_2\text{N} - \text{C} - & \text{C} - \text{N} - & \text{C} - & \text{C} - & \text{C} - & \text{N} - & \text{C} - \text{COOH} \\ & & & & & & \\ \text{H} & & \text{H} & \text{H} & & \text{H} & \text{CH}_2 \\ & & & & & & \\ \text{C}_2\text{H}_5 & & \text{CH}_3 & & & & \text{COOH} \end{array} $ <p>M2 correct structure has three chiral centres</p> $ \begin{array}{ccccccc} \text{H} & \text{O} & & \text{H} & \text{O} & & \text{H} \\ & & & & & & \\ \text{H}_2\text{N} - \text{C} - & \text{C} - \text{N} - & \text{C} - & \text{C} - & \text{C} - & \text{N} - & \text{C} - \text{COOH} \\ & & & & & & \\ \text{H} & & \text{H} & \text{H} & & \text{H} & \text{CH}_2 \\ & & & & & & \\ \text{C}_2\text{H}_5 & & \text{CH}_3 & & & & \text{COOH} \end{array} $	2	<p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous</p> <p>ALLOW tripeptide with the 3 amino acids in any order</p> <p>ALLOW cyclic tripeptide</p> <p>Isoleucine has two chiral centres, aspartic acid has one chiral centre and glycine has none.</p> <p>ALL three correct for one mark</p> <p>ALLOW chiral centres correctly identified if the three amino acids are part of a polypeptide chain</p>
	Total	9	

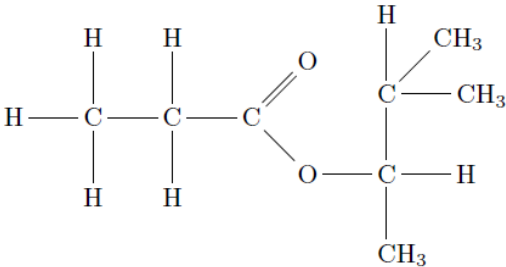
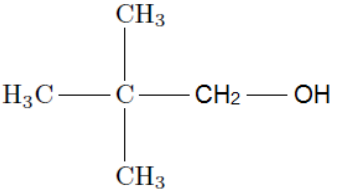
Question		Answer	Mark	Guidance
4	(a)	2(-)hydroxypropanoic acid ✓	1	DO NOT ALLOW 2-hydroxypropanoic acid IGNORE other dashes, commas and spaces
	(b)	Lactic acid synthesised in the laboratory will contain optical isomers/two optical isomers OR Lactic acid produced by bacteria will be present as one optical isomer ✓	1	ALLOW enantiomer for optical isomer ALLOW racemic mixture IGNORE stereoisomer
	(c)	 ✓	1	ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous
	(d) (i)	 ✓	1	ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous DO NOT ALLOW more than one repeat unit DO NOT ALLOW if structure has no end bonds IGNORE brackets unless they are used to pick out the repeat unit from a polymer chain IGNORE n

Question	Answer	Mark	Guidance
	<p>(ii) (Ester links in PLA are) hydrolysed ✓</p> <p>Any two from:</p> <ul style="list-style-type: none"> • Ester (links in the polymer) OR (PLA is a) polyester • Monomer/lactic acid/product (is soluble because it) forms hydrogen bonds to water • polymer is photodegradable • the C=O bond absorbs radiation/uv/light <p style="text-align: right;">✓✓</p> <p> QWC: hydrolysed/hydrolysis/hydrolyses spelled correctly in the correct context</p>	3	<p>ANNOTATE WITH TICKS AND CROSSES ETC.</p> <p>ALLOW (ester) hydrolysis/(ester) hydrolyses IGNORE acid/alkaline (hydrolysis)</p> <p>IGNORE PLA forms hydrogen bonds to water</p> <p>IGNORE biodegradable</p> <p>IGNORE infrared radiation</p> <p>Maximum of 2 marks if hydrolysed/hydrolysis/hydrolyses does not appear in the answer ALLOW (ester) hydrolyzed</p>
	Total	7	

Question			Answer	Mark	Guidance															
5	(a)	(i)	<table border="1"> <thead> <tr> <th colspan="3">¹H NMR spectrum for 2-aminopropan-1-ol</th> </tr> <tr> <th>Chemical shift, δ/ppm</th> <th>Relative peak area</th> <th>Splitting pattern</th> </tr> </thead> <tbody> <tr> <td>0.8 – 2.0</td> <td>3</td> <td>doublet</td> </tr> <tr> <td>2.3 – 3.0</td> <td>1</td> <td>multiplet</td> </tr> <tr> <td>3.3 – 4.2</td> <td>2</td> <td>doublet</td> </tr> </tbody> </table> <p style="text-align: right;">✓✓✓</p>	¹ H NMR spectrum for 2-aminopropan-1-ol			Chemical shift, δ /ppm	Relative peak area	Splitting pattern	0.8 – 2.0	3	doublet	2.3 – 3.0	1	multiplet	3.3 – 4.2	2	doublet	3	<p>One mark for each correct row</p> <p>ALLOW δ values as a range or a value within the specified range.</p> <p>ALLOW δ values +/- 0.2 ppm.</p> <p>ALLOW a response that implies a splitting into two for a doublet etc.</p> <p>ALLOW sextet/hextet/six (or more than 5) as alternative to multiplet</p> <p>Relative peak area = $\text{CH}_3/3\text{H}$ etc. penalise once</p>
¹ H NMR spectrum for 2-aminopropan-1-ol																				
Chemical shift, δ /ppm	Relative peak area	Splitting pattern																		
0.8 – 2.0	3	doublet																		
2.3 – 3.0	1	multiplet																		
3.3 – 4.2	2	doublet																		
		(ii)	<p><u>M⁺ peak at 75 (peak 1)</u> $\text{CH}_3\text{CH}(\text{NH}_2)\text{CH}_2\text{OH}^+/\text{C}_3\text{H}_9\text{NO}^+$</p> <p style="text-align: right;">✓</p> <p><u>Fragment peak at 44 (peak 2)</u> $\text{CH}_3\text{CH}(\text{NH}_2)^+/\text{C}_2\text{H}_6\text{N}^+$</p> <p style="text-align: right;">✓</p>	2	<p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous</p> <p>Positive charge is essential but ALLOW maximum of one mark if both formulae are correct AND neither species has a positive charge</p>															
5	(b)	(i)	<p>Ethanolic ammonia OR ammonia/NH_3 AND ethanol</p> <p style="text-align: right;">✓</p>	1	<p>ALLOW ammonia in a sealed tube</p> <p>ALLOW dilute ethanolic ammonia/NH_3</p> <p>IGNORE heat</p> <p>ALLOW alcohol for ethanol</p> <p>DO NOT ALLOW any reference to water or hydroxide ions</p>															
		(ii)	<p>(compound D)</p> <div style="text-align: center;"> </div> <p style="text-align: right;">✓</p>	1	<p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous</p>															

Question		Answer	Mark	Guidance	
	(c)	(i)	Alcohol AND Amide/peptide	1	IGNORE phenol IGNORE hydroxyl/hydroxy IGNORE attempts to classify alcohol or amide as primary, secondary or tertiary DO NOT ALLOW hydroxide
		(ii)	 <p>The first structure is 3-hydroxybenzoic acid, shown as a benzene ring with a carboxylic acid group (-COOH) at the top and a hydroxyl group (-OH) at the meta position (3-position). The second structure is 2-amino-3-methylbutan-1-ol, shown as a four-carbon chain with a hydroxyl group (-OH) on the first carbon, an amino group (-NH₃⁺) on the second carbon, and a methyl group on the third carbon.</p>	2	ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above ALLOW correct structural OR displayed OR skeletal formulae OR combination of above as long as unambiguous ALLOW + on N or H i.e. ⁺ NH ₃ or NH ₃ ⁺ ALLOW NH ₃ ⁺ Cl ⁻
			Total	10	

Question		Answer	Mark	Guidance
6	(a)	<p><u>Reducing agent</u> NaBH₄ / sodium tetrahydridoborate(III) / sodium borohydride ✓</p> <p><u>Equation</u> CH₃(CH₂)₃CHO + 2[H] → CH₃(CH₂)₃CH₂OH ✓</p>	2	<p>ALLOW LiAlH₄ / lithium tetrahydridoaluminate(III)/lithium aluminium hydride</p> <p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above</p> <p>ALLOW C₄H₉CHO + 2[H] → C₅H₁₁OH</p> <p>ALLOW molecular formulae: C₅H₁₀O + 2[H] → C₅H₁₂O</p> <p>DO NOT ALLOW –COH for aldehyde</p>
	(b)	<p>M1 Compound F structure is a secondary alcohol with the formula C₅H₁₁OH ✓</p> <p>M2 Compound F = CH₃CH(OH)CH(CH₃)CH₃ ✓</p> <p>M3 Compound G = CH₃COCH(CH₃)CH₃ ✓</p>	7	<p>ANNOTATE WITH TICKS AND CROSSES ETC.</p> <p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous</p> <p>IGNORE names if structures are given</p> <p>ALLOW 3-methylbutan-2-ol if structure not given</p> <p>ALLOW ECF from an incorrect secondary alcohol for M3 e.g. pentan-2-ol → pentan-2-one e.g. pentan-3-ol → pentan-3-one</p> <p>ALLOW (3-)methylbutanone if structure not given</p> <p>IGNORE any discussion of the reactions of compound G with 2,4-dinitrophenylhydrazine and/or Tollens' reagent.</p> <p>ALLOW 3 SF up to calculator value correctly rounded</p>

Question	Answer	Mark	Guidance
	<p>M4 $n(\text{NaOH}) = (0.125 \times 22.8/1000) = 0.00285 \text{ (mol)}$ ✓</p> <p>M5 $M(\text{compound H}) = (0.211/0.00285) = 74(.0) \text{ (g mol}^{-1}\text{)}$ ✓</p> <p>M6 Compound H = / $\text{CH}_3\text{CH}_2\text{COOH}$ ✓</p> <p>M7 Compound I =</p>  <p style="text-align: right;">✓</p>		<p>IF $M(\text{compound H}) = 74$ award 2 marks (M4 + M5)</p> <p>ALLOW ECF from incorrect calculation of amount of NaOH</p> <p>ALLOW propanoic acid if structure not given</p> <p>ALLOW ECF from incorrect compound F (alcohol) and/or incorrect compound H (carboxylic acid) to form compound I (ester).</p> <p>Compounds F, G, H and I must be placed in the correct box or correctly labelled for M2, M3, M6 and M7</p>
(c)	<p>The structural isomer is:</p>  <p style="text-align: right;">✓</p>	1	<p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous</p> <p>ALLOW 2,2-dimethylpropan-1-ol</p>
	Total	10	

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