

Question	Key	Marks	Guidance
1	D	1	

Question	Key	Marks	Guidance
2	A	1	

Question	Key	Marks	Guidance
3	A	1	

Question	Key	Marks	Guidance
4	A	1	

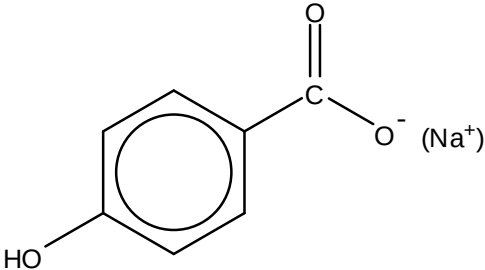
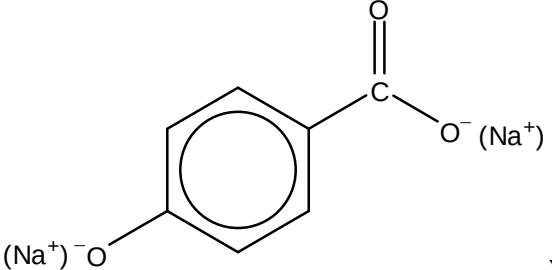
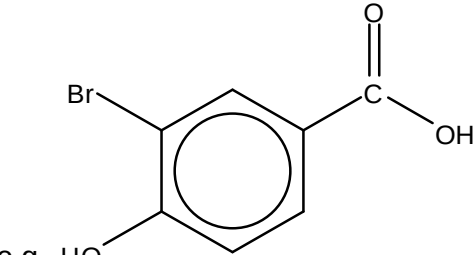
	5		Functional groups Phenol AND ketone ✓ Explanation	3	DO NOT ALLOW any other functional groups for first marking point.
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			Links phenol to (weak) acidity AND no reaction with Na_2CO_3 (so not carboxylic acid) ✓ Links 2,4-DNP(H) or Brady's reagent observation to carbonyl AND Tollens' reagent observation (so not an aldehyde) ✓	ALLOW identity of functional groups in the explanation if not stated on functional group prompt line. ALLOW "aldehyde or ketone" in place of carbonyl
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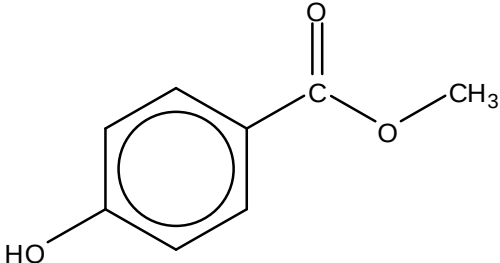
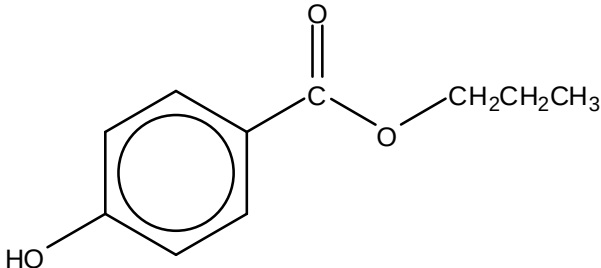
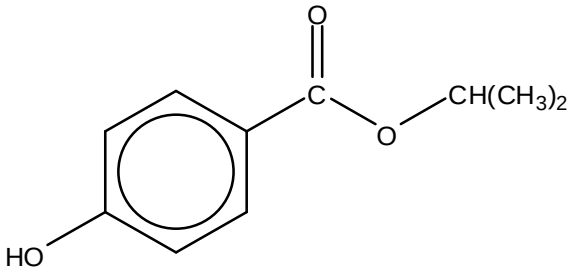
Question	Answer	Marks	Guidance
6	B	1	

7	(i)	Bromine/ Br ₂ AND goes colourless/decolourised ✓	1	³ Note: both reagent and observation are required ALLOW bromine water/ Br ₂ (aq)
	(ii)	Tollens' (reagent) AND Silver (mirror/precipitate/ppt/solid) ✓	1	Note: both reagent and observation are required for the mark. ALLOW ammoniacal silver nitrate OR Ag ⁺ /NH ₃ ALLOW black ppt OR grey ppt

Question			Answer	Marks	Guidance
		(iii)	(Add) 2,4-dinitrophenylhydrazine AND orange/yellow/red precipitate✓ Take melting point (of crystals) ✓ Compare to known values/database ✓	3	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 Mark second and third points independently of response for first marking point DO NOT ALLOW 2nd and 3rd marks for taking and comparing boiling points OR chromatograms

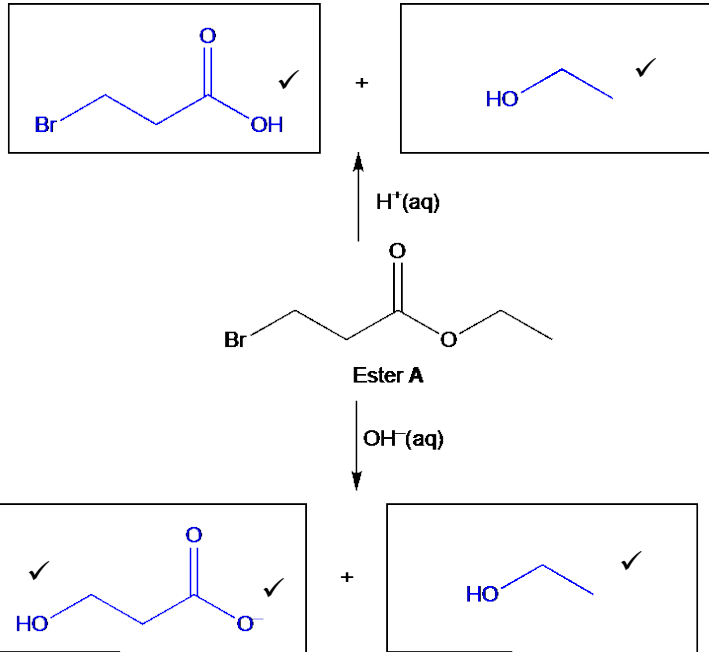
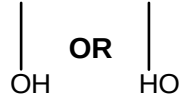
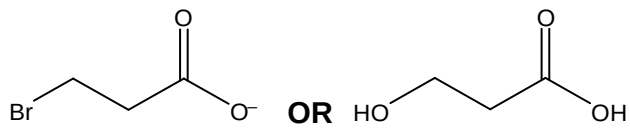
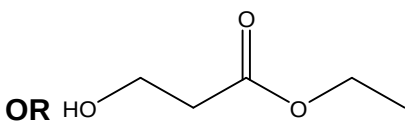
Question		Answer	Marks	Guidance
8	(a)	Product from Na₂CO₃  ✓ Product from NaOH(aq)  ✓ Product from Br₂  e.g. HO ✓	3	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous ALLOW -COO⁻ OR -COONa DO NOT ALLOW negative charge on C atom DO NOT ALLOW -COO-Na (covalent bond) IGNORE connectivity of phenol OH group <i>(marks are for correct conversions)</i> ALLOW 1 mark if top two structures are shown in wrong boxes ALLOW substitution of any H from benzene ring ALLOW multiple substitution, <i>i.e.</i> di-, tri- and tetrabromo products. IGNORE connectivity of phenol OH group <i>(marks are for correct conversions)</i>

Question	Answer	Marks	Guidance
9	(i) FIRST CHECK ANSWER ON ANSWER LINE IF answer = 7.5×10^{-4} award 2 marks ----- [K] in mol dm⁻³ $\frac{9.13 \times 10^{-2}}{166} = 5.50 \times 10^{-4} \text{ (mol dm}^{-3}\text{) } \checkmark$ [L] from peak areas $5.50 \times 10^{-4} \times \frac{5.9}{4.3} \text{ OR } 5.50 \times 10^{-4} \times 1.37 \dots$ $= 7.5 \times 10^{-4} \text{ (mol dm}^{-3}\text{) } \checkmark$ 2 SF Required	2	If there is an alternative answer, Apply ECF Alternative method [K] in g dm⁻³ with peak area of 5.9 $9.13 \times 10^{-2} \times \frac{5.9}{4.3} \text{ OR } 9.13 \times 10^{-2} \times 1.37$ $= 0.125 \text{ OR } 0.13 \text{ (g dm}^{-3}\text{) } \checkmark$ Calculator: 0.125272093 [L] in mol dm⁻³ $\frac{0.125}{166} = 7.5 \times 10^{-4}$ OR $\frac{0.13}{166} = 7.8 \times 10^{-4} \text{ (mol dm}^{-3}\text{) } \checkmark$ ----- Common errors: Award 1 mark for: • 0.099 (from $\frac{9.13 \times 10^{-2}}{166} \times 180$) • 6.9×10^{-4} (from $\frac{0.125}{180}$) • 7.2×10^{-4} (from $\frac{0.13}{180}$) • 7.0×10^{-4} (from $\frac{0.25272093}{180}$)

Question	Answer	Marks	Guidance
(ii)	ester J  esters L and M  	3 ✓ ✓ ✓ Total	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous L and M can be identified either way round IGNORE 'C₃H₇' in L and/or M as ambiguous (<i>question requires structures</i>) IGNORE connectivity of phenol OH group (<i>marks are for structures of alkyl groups</i>) 12

Question	Answer	Marks	AO	Guidance
10	C	1	AO1.2	

11	Tollens' (reagent) ✓	2	AO1.2	ALLOW ammoniacal silver nitrate OR Ag ⁺ /NH ₃
Question	Answer	Marks	element	Guidance
	Silver (mirror/precipitate/ppt/solid) with citronellal/the aldehyde ✓		×2	ALLOW black ppt OR grey ppt IGNORE references to acidified dichromate reacting with both compounds ----- ALLOW 2,4-DNP/2,4-DNPH ALLOW Brady's reagent ✓ Yellow/orange/red precipitate with citronellal/aldehyde/carbonyl group ✓ ----- IF other reagents are seen, contact your Team Leader

Question	Answer	Marks	AO element	Guidance
12 (a) (i)	ethyl 3-bromopropanoate ✓	1	AO1.2	ALLOW one word: ethyl3-bromopropanoate OR more words, e.g. ethyl 3-bromo propanoate IGNORE lack of hyphens, or addition of commas
	(ii) 	5	AO2.5 x5	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous ALLOW in either order ALLOW any vertical bond to the OH group e.g. ALLOW  DO NOT ALLOW OH– ALLOW in either order For reaction with OH[–], ALLOW one mark for  OR 

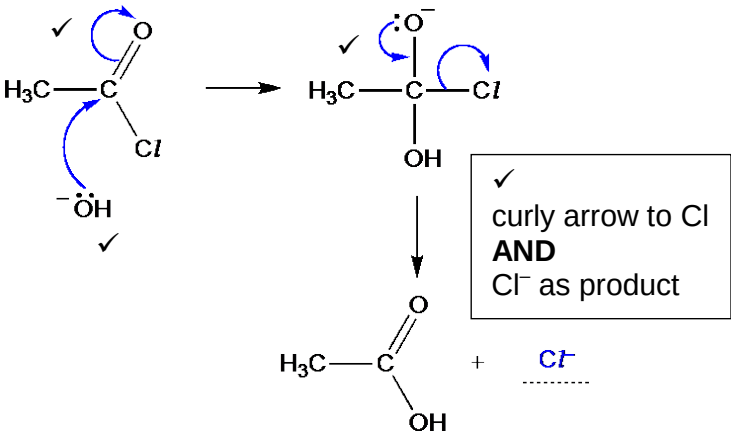
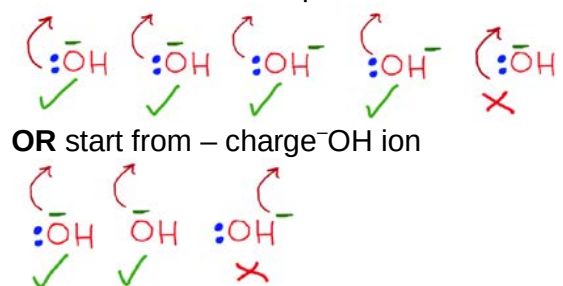
Question		Answer	Marks	element	Guidance
		hydrolysis ✓	1	AO1.1	IGNORE 'acid' and 'alkaline' IGNORE nucleophilic substitution

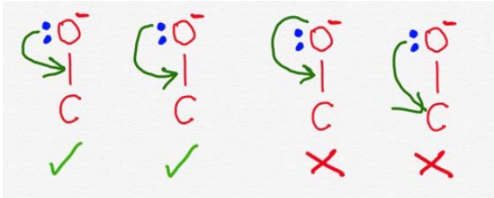
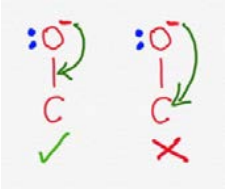
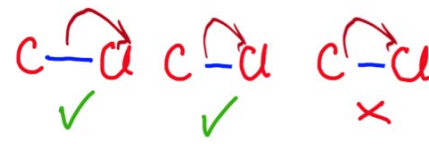
13	Refer to marking instructions on page 4 of mark scheme	6	AO3.3	Indicative scientific points may include:
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Question	Answer	Marks	element	Guidance
	<i>for guidance on marking this question.</i> Level 3 (5-6 marks) Correct calculation of the mass of (CH₃)₂CHCHO. AND Planned synthesis includes oxidation of aldehyde and formation of ester C with most of the reagents and conditions identified and equations are mostly correct. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3-4 marks) Calculation of the mass of (CH₃)₂CHCHO is partly correct AND Planned synthesis includes oxidation of aldehyde and formation of ester C with some of the reagents and conditions identified OR Attempts to calculate mass of (CH₃)₂CHCHO but makes little progress AND Planned synthesis includes oxidation of aldehyde and formation of ester C with most of the reagents and conditions identified and equations for each step are mostly correct <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i>		×6	<u>Calculation of mass of (CH₃)₂CHCHO</u> Using moles $n(\text{ester}) = \frac{12.75}{102.0}$ = 0.125 (mol) $n((\text{CH}_3)_2\text{CHCHO}) = 0.125 \times \frac{100}{40}$ = 0.3125 (mol) - Mass of (CH₃)₂CHCHO = 72.0 × 0.3125 = 22.5 g Using mass - Theoretical mass of ester = 12.75 × $\frac{100}{40}$ = 31.875 (g) - Theoretical $n((\text{CH}_3)_2\text{CHCHO}) = \frac{31.875}{102}$ = 0.3125 (mol) - Mass of (CH₃)₂CHCHO = 72.0 × 0.3125 = 22.5 g ALLOW small slip/rounding errors such as errors in Mr e.g. use of 71 instead of 72 for (CH₃)₂CHCHO ----- <i>Examples of partly correct calculations</i> Mass = 3.60 g from $0.125 \times \frac{40}{100} \times 72$ (% yield inverted) Mass = 9.00 g from 0.125×72 (% yield omitted)

Question			Answer	Marks	element	Guidance
			Level 1 (1-2 marks) Calculation of the mass of $(\text{CH}_3)_2\text{CHCHO}$ is partly correct OR Planned synthesis includes both steps with some of the reagents and conditions identified OR Attempts equations for both steps but these may contain errors OR Describes one step of the synthesis with reagents, conditions and equation mostly correct <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks No response or no response worthy of credit.			<u>Synthesis: reagents and conditions</u> Step 1: Oxidation of aldehyde $(\text{CH}_3)_2\text{CHCHO}$ • Reagents: $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$ • Conditions: reflux • Equation: $(\text{CH}_3)_2\text{CHCHO} + [\text{O}] \rightarrow (\text{CH}_3)_2\text{CHCOOH}$ Step 2: Formation of ester C • Reagents: methylpropanoic acid/$(\text{CH}_3)_2\text{CHCOOH}$ and methanol/CH_3OH • Conditions: acid (catalyst) reflux/heat • Equation: $(\text{CH}_3)_2\text{CHCOOH} + \text{CH}_3\text{OH} \rightarrow (\text{CH}_3)_2\text{CHCOOCH}_3 + \text{H}_2\text{O}$ IGNORE attempts to form methanol in synthesis
(e)	(ii)			2	AO2.7 × 2	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous

Question			Answer	Marks	element	Guidance
			Y (43) = $(\text{CH}_3)_2\text{CH}^+$ ✓ Z (71) $(\text{CH}_3)_2\text{CHCO}^+$ ✓ <i>If '+' charge is missing/incorrect but the structures of both fragments are correct, award one mark</i>			ALLOW positive charge to be anywhere on the structure For Y and Z, ALLOW structure of a feasible fragment ion formed from ester C Ester C e.g. Y (43) = CH_3OC^+ Z (71) = $^+\text{CCOOCH}_3$ ALLOW 1 mark if both correct ions are shown but in the incorrect columns ALLOW 1 mark for both correct ions if one or both have an 'end bond' ALLOW 1 mark if both ions are shown using correct molecular formulae
			Total	22		

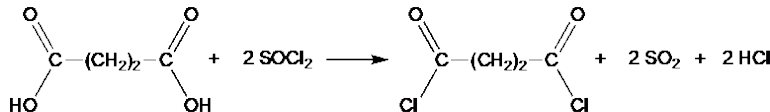
Question	Answer	Marks	element	Guidance
14 (i)		4	AO3.2 x4	IGNORE any dipoles shown NOTE: curly arrows can be straight, snake-like, etc. but NOT double headed or half headed arrows Curly arrow from OH^- must - go to the C of $\text{C}=\text{O}$ AND - start from, OR be traced back to any point across width of lone pair on O of OH^-  OR start from – charge OH^- ion  Curly arrow from $\text{C}=\text{O}$ bond must start from, OR be traced back to, any part of $\text{C}=\text{O}$ bond and go to O Curly arrow from O^- must

Question	Answer	Marks	element	Guidance
				- go to C=O bond AND - start from, OR be traced back to, any point across width of lone pair  OR start from '–' charge of O[–]  Curly arrow from C–Cl bond must start from, OR be traced back to, any part of C–Cl bond and go to Cl 
(b) (ii)	(OH [–]) donates an electron pair/lone pair OR (OH [–] acts as a) nucleophile ✓	1	AO1.2	

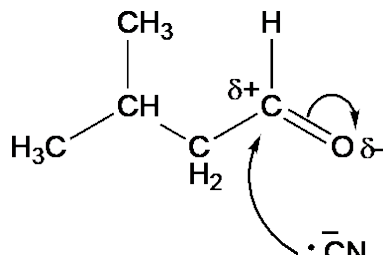
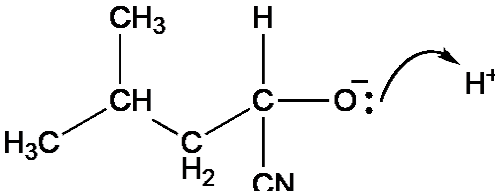
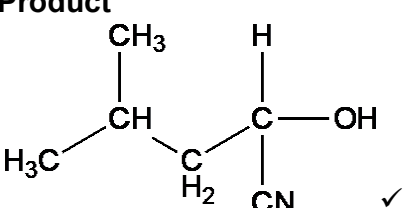
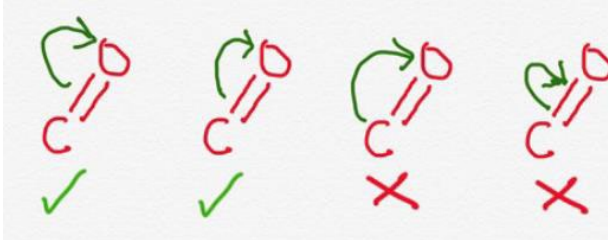
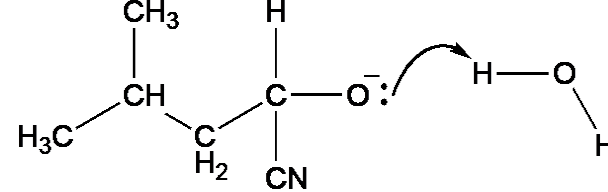
Question	Answer	Marks	AO	Guidance
15	A	1	1.1	

Question	Answer	Marks	AO	Guidance
16	A	1	1.1	

Question	Answer	Marks	AO	Guidance
17	D	1	1.2	

		18	 SOCl₂ in equation ✓ Structure of diacyl dichloride ✓ Complete balanced equation ✓	3		ALLOW alternative approach using PCl ₅ or PCl ₃
					1.1	
					1.2	
					2.6	

[illegible]

Question	Answer	Marks	element	Guidance
(i)	Mechanism 3 marks  Curly arrow from CN^- to C atom of $\text{C}=\text{O}$ ✓ Dipole shown on $\text{C}=\text{O}$ bond, $\text{C}^{\delta+}$ and $\text{O}^{\delta-}$, AND curly arrow from $\text{C}=\text{O}$ bond to O atom ✓  Curly arrow from lone pair OR – charge on O^- of correct intermediate to H^+ ✓ Product 1 mark  Name of mechanism 1 mark Nucleophilic addition ✓	5	1.2 1.2 2.5 2.5 1.1	ANNOTATE ANSWER WITH TICKS AND CROSSES Curly arrow must come from lone pair on C of CN^- OR CN^- OR from minus sign on C of CN^- ion (then lone pair on CN^- does not need to be shown) Curly arrow from $\text{C}=\text{O}$ bond must start from, OR be traced back to, any part of $\text{C}=\text{O}$ bond and go to O  ALLOW curly arrow to H atom of H_2O, i.e.  IGNORE attempt to draw curly arrow showing breaking of $\text{H}-\text{O}$ in H_2O IGNORE lack of dipole on H_2O

Question	Answer	Marks	AO element	Guidance
20	D	1	AO2.1	

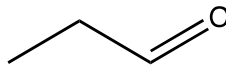
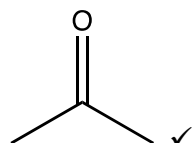
Question	Answer	Marks	AO element	Guidance
21	B	1	AO1.2	

Question	Answer	Marks	AO element	Guidance
22	A	1	AO1.2	

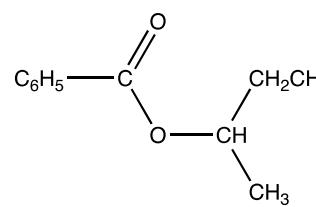
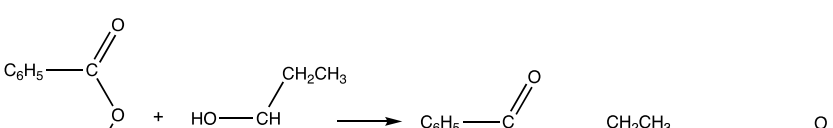
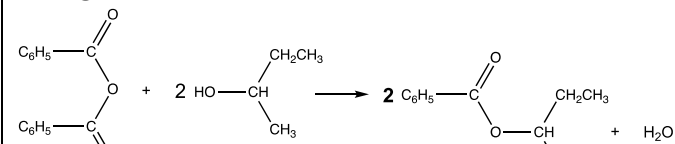
	Question	Answer	Marks	AO element	Guidance
23	(a) (i)	3-methylbut-2-enal ✓	1	AO1.2	IGNORE lack of hyphens, or addition of commas
	(ii)	Reaction scheme for part (ii): Prenal (3-methylbut-2-enal) reacts with NaBH_4 to form 3-methylbut-2-en-1-ol (boxed, ✓). From 3-methylbut-2-en-1-ol, two pathways are shown: Left pathway: 3-methylbut-2-en-1-ol is oxidized using $\text{Cr}_2\text{O}_7^{2-}$ AND H^+ (✓) to form 3-methylbut-2-enoic acid (boxed, ✓). This acid then reacts with $(\text{CH}_3)_2\text{CHOH}$ (✓) to form 3-methylbut-2-enoic isopropyl ester (✓). Right pathway: 3-methylbut-2-en-1-ol is hydrogenated using H_2 AND Ni (✓) to form 3-methylbutan-1-ol (boxed, ✓). This alcohol then reacts with CH_3COOH (✓) to form 3-methylbutyl acetate (✓).	7	AO1.2 ×4 AO2.5 ×3	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous ALLOW names of reagents and catalyst For oxidation, ALLOW $\text{K}_2\text{Cr}_2\text{O}_7$ for $\text{Cr}_2\text{O}_7^{2-}$ ALLOW H_2SO_4 for H^+ For left hand side esterification IGNORE $\text{C}_3\text{H}_7\text{OH}$ IF esterification is given instead of hydrogenation contact your Team Leader

Question	Answer	Marks	AO	Guidance
24	B	1	AO1.2	

Question			Answer	Marks	AO element	Guidance
25	(a)	(i)	(Add) 2,4-dinitrophenylhydrazine AND orange/yellow/red precipitate ✓ Take melting point (of crystals) ✓ Compare to known values/database ✓	3	AO1.2 × 3	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 Mark second and third points independently of response for first marking point DO NOT ALLOW 2 nd and 3 rd marks for taking and comparing boiling points OR chromatograms
	(a)	(ii)	Tollens' (reagent) AND Silver (mirror/precipitate/ppt/solid) ✓	1	AO1.2	ALLOW ammoniacal silver nitrate OR Ag ⁺ /NH ₃ ALLOW black ppt OR grey ppt ALLOW Cr ₂ O ₇ ²⁻ /H ⁺ AND Turns green ✓ IGNORE reference to conditions, e.g. Heat or reflux ----- IF other reagents are seen e.g. Fehling's or Benedict's, contact your Team Leader

Question		Answer	Marks	element	Guidance
25	(b)	Initial ratios C, $\frac{62.07}{12.0}$: H, $\frac{10.34}{1.0}$: O, $\frac{27.59}{16.0}$ OR C, 5.1725 : H, 10.34 : O, 1.724 OR C, 3 : H, 6 : O, 1 ✓ (Molecular formula =) C₃H₆O AND Evidence of 58 in working or from labelled peak in one of the spectra ✓ For F evidence for fragment ion m/z=29 linked to CH₃CH₂(⁺) OR CHO(⁺) ✓ F =  AND G =  ✓	4		CHECK spectra for annotations that may be worthy of credit AO1.2 Mark can be awarded from a correct molecular formula AO2.5 AO3.2 AO3.2 IGNORE m/z=15 (as this is not unique) IGNORE m/z=43 IGNORE incorrect fragments IGNORE charges on fragment ions ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous

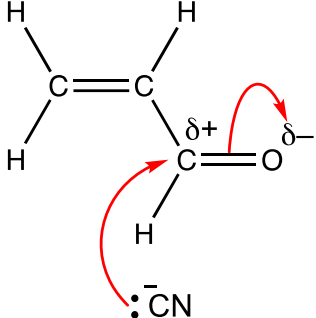
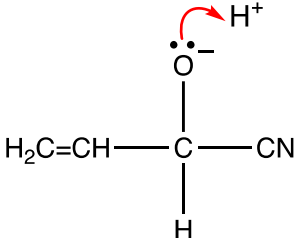
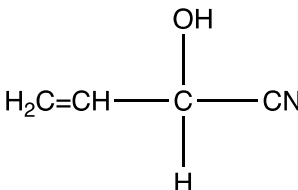
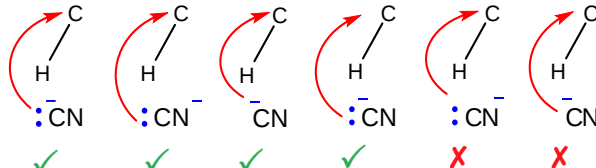
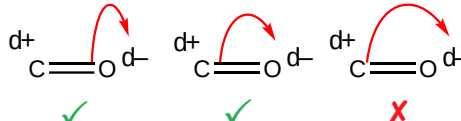
Question			Answer	s	element	Guidance
26	(a)		$\text{C}_2\text{H}_5\text{COOH} + \text{KOH} \rightarrow \text{C}_2\text{H}_5\text{COOK} + \text{H}_2\text{O} \checkmark$ $2\text{HCOOH} + \text{Mg} \rightarrow (\text{HCOO})_2\text{Mg} + \text{H}_2 \checkmark$	2	×2	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous IGNORE state symbols and use of equilibrium sign ALLOW $\text{KC}_2\text{H}_5\text{COO}$ DO NOT ALLOW a missing charge (e.g. $\text{C}_2\text{H}_5\text{COO}^-\text{K}$) the 1st time seen but IGNORE for next equations. For salts, ALLOW $\text{C}_2\text{H}_5\text{COO}^-\text{K}^+$ OR $\text{C}_2\text{H}_5\text{COO}^- + \text{K}^+$ DO NOT ALLOW $-\text{COO}-\text{K}$ (covalent bond) the 1st time seen but IGNORE for next equations.

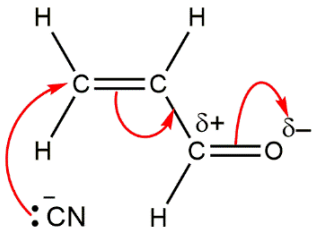
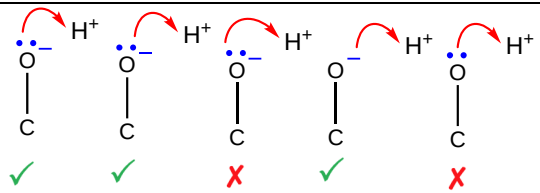
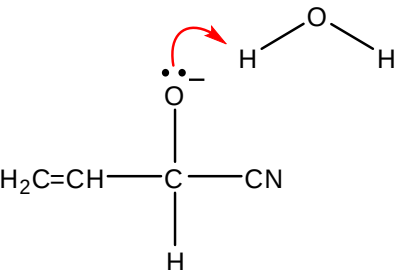
27	Structure of ester product ✓  Correct balanced equation ✓ 	2	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous AO3.1 AO3.2 ALLOW 
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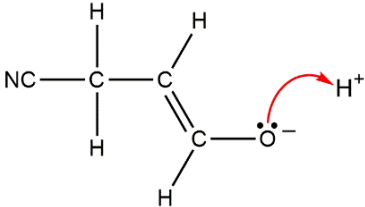
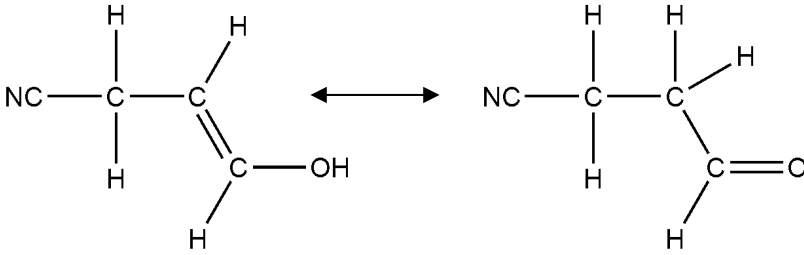
Question	Answer	Marks		Guidance
28	A	1	AO1.2	

Question	Answer	Marks		Guidance
29	D	1	AO1.2	

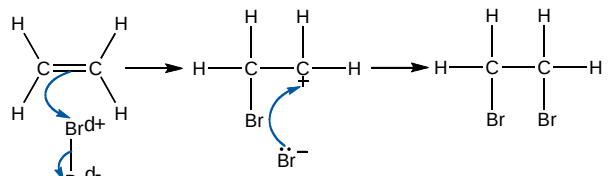
Question	Answer	Marks	AO element	Guidance
30 (a)	Reaction scheme for 30(a): Starting material: 3-hydroxybenzoic acid Reactions: - Reaction with Br_2 yields 3-bromo-3-hydroxybenzoic acid (top left box, ✓). - Reaction with $\text{Na}_2\text{CO}_3(\text{aq})$ yields 3-hydroxybenzoate sodium salt (top right box, ✓). - Reaction with Propanoic anhydride $(\text{CH}_3\text{CH}_2\text{CO})_2\text{O}$ yields 3-(propanoate)benzoic acid (bottom left box, ✓) and propanoic acid (bottom right box, ✓).	4	AO2.5 ×4	IGNORE connectivity of phenol OH group and COOH group throughout (<i>marks are for correct conversions</i>) Br₂ ALLOW Br substitution at any position on ring ALLOW up to 4 Br atoms onto ring Na₂CO₃ ALLOW COO⁻ OR COONa (CH₃CH₂CO)₂O IGNORE reaction of COOH to form an acid anhydride ALLOW structures in bottom 2 boxes in either order

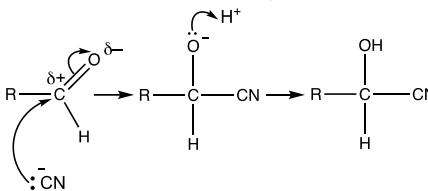
Question	Answer	Marks	Guidance
31 (a) (i)	NOTE: curly arrows can be straight, snake-like, etc. but NOT double headed or half headed arrows Nucleophilic attack 2 marks  Curly arrow from :CN^- to C of C=O ✓ Correct dipole shown on C=O AND curly arrow showing breaking of C=O ✓ Intermediate 1 mark  Correct intermediate AND curly arrow from O^- to H^+ ✓ DO NOT ALLOW δ^- on O of intermediate IGNORE connectivity of $\text{H}_2\text{C=CH-}$ Product 1 mark  Correct product ✓	4 AO1.2 ×2 AO2.5 ×2	ANNOTATIONS MUST BE USED 1st curly arrow must - go to the C atom of C=O AND - start from, OR be traced back to any point across width of lone pair on C of :CN^- OR :CN^- OR start from $-$ charge on C of :CN^- (then lone pair on CN^- does not need to be shown)  2nd curly arrow must - start from, OR be traced back to any part of $\delta^+\text{C=O} \delta^-$ bond AND - go to $\text{O}^{\delta-}$ (across width of $\text{O}^{\delta-}$)  3rd curly arrow must - go to H^+ AND - start from, OR be traced back to any point across width of lone pair on :O^- OR start from $-$ charge of O^- of intermediate (then lone pair on O^- does not need to be shown)

Question	Answer	Marks	Guidance
	Possible alternative 1,4 (conjugate) addition can be credited as follows (not in specification): ----- Nucleophilic attack 2 marks  Curly arrow from CN^- to C of CH_2 of $\text{C}=\text{C}$ ✓ Curly arrow from $\text{C}=\text{C}$ to C-C AND curly arrow showing breaking of $\text{C}=\text{O}$ ✓ -----		 NOTE: For arrow to H^+ ALLOW arrow to H of H_2O i.e.  IGNORE attempt to draw curly arrow showing breaking of H-O in H_2O IGNORE lack of dipole on H_2O IGNORE absence of OH^- as 2nd product Otherwise this more difficult mechanism could cost 2 marks

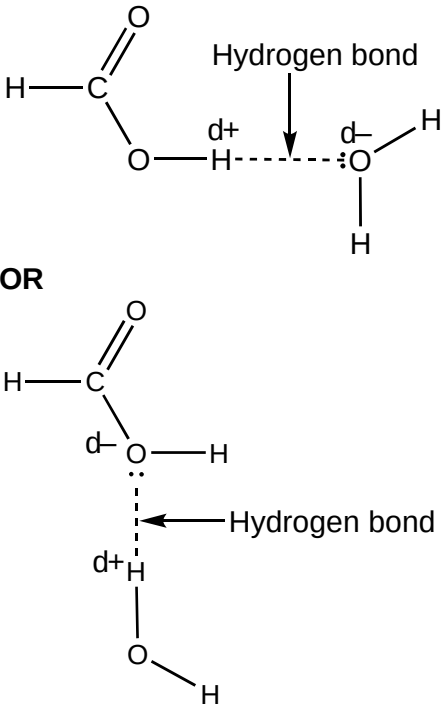
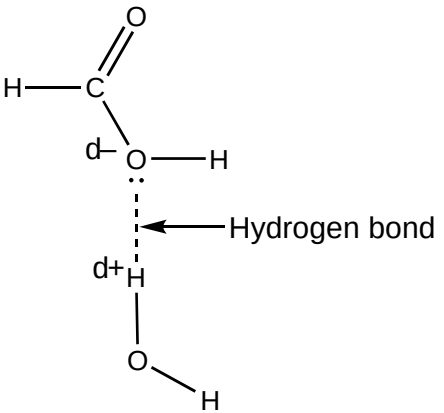
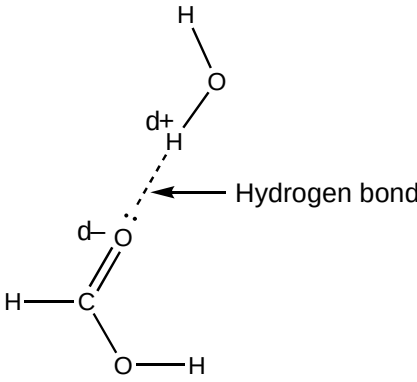
Question			Answer	Marks		Guidance
31	(a)	(ii)	Intermediate 1 mark  Correct intermediate AND curly arrow from O⁻ to H⁺ ✓ DO NOT ALLOW δ⁻ on O of intermediate Product 1 mark Either tautomer as correct product ✓ 			Product mark can only be given here if clear from mechanism that there is nucleophilic attack of CH₂ in C=C. Same product could be seen with an attempt at electrophilic addition across C=C.
			Nucleophilic addition ✓	1	AO1.1	

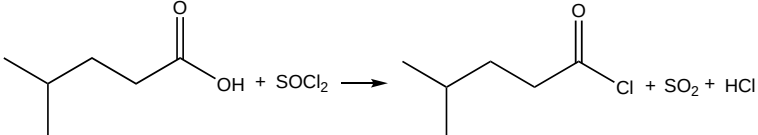
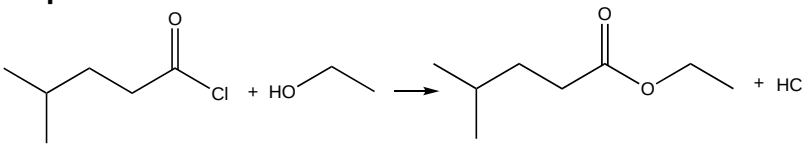
Question	Answer	Marks	Guidance
32	Mark organic product first: A correct ester of $(\text{CH}_3)_3\text{COH}$ ✓ e.g. $(\text{CH}_3)_3\text{COOCCH}_3$ Reagent and/or catalyst: Reagent to match ester shown suitable carboxylic acid AND acid / H^+ catalyst, e.g. $\text{CH}_3\text{COOH}/\text{H}_2\text{SO}_4$ OR suitable acyl chloride e.g. CH_3COCl OR suitable acid anhydride e.g. $(\text{CH}_3\text{CO})_2\text{O}$ ✓	2	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous IGNORE additional byproducts e.g. H_2O, HCl or carboxylic acid (from acid anhydride) For 2 marks, the reagent must be consistent with the product given e.g. $(\text{CH}_3)_3\text{COOCCH}_3$ then correct reagent is $\text{CH}_3\text{COOH} / \text{H}_2\text{SO}_4$ ALLOW 1 mark if correct reagents given but no or incorrect organic product shown ALLOW 1 mark if ester is given with an R group i.e. $(\text{CH}_3)_3\text{COOCR}$ AND reagent is consistent e.g. RCOOH OR just states 'carboxylic acid and acid' ALLOW names of reagents e.g. ethanoic acid and sulfuric acid. DO NOT ALLOW other additional reagents e.g. $\text{Cr}_2\text{O}_7^{2-}$ IGNORE concentration e.g. dilute/concentrated IGNORE conditions e.g. reflux/distillation IGNORE use of acid catalyst with acyl chloride or acid anhydride

Question	Answer	Marks	Guidance
33	Refer to marking instructions on page 5 of mark scheme for guidance on marking this question. Level 3 (5–6 marks) Describes addition reactions including the mechanisms of one alkene AND one carbonyl compound AND some additional details <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Describes an addition reaction including the mechanism of one alkene OR one carbonyl compound AND some additional details OR Describes addition reactions including an attempt to give the mechanisms of one alkene AND one carbonyl compound <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) Selects suitable reagents for addition reactions of one alkene AND one carbonyl compound. OR Attempts to describe an addition reaction including an attempt to give the mechanism of one alkene OR one carbonyl compound. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i>	6	Indicative scientific points may include: Reaction of alkene and mechanism - Suitable reaction, e.g. alkene and Br₂ OR X₂ OR HX OR H₂O OR H₂ OR polymerisation <i>May be shown within mechanism</i> - Mechanism, e.g.  ALLOW mechanism for H₂ AND H₂O to be shown as electrophilic addition even though incorrect - consider impact on communication statement. ALLOW suitable non-specification alternative e.g. HCN Additional details (NOT INCLUSIVE) - Electrophilic addition - Systematic names of reactants and/or products - Details of functional group interconversion e.g. alkene to dibromo - Details on reagents required e.g. - H₂ with Ni Catalyst - H₂O(g) with H₃PO₄ catalyst - Explanation of major and minor product from electrophilic addition of HX with unsymmetrical alkene - Explanation of carbocation intermediate stability - Heterolytic fission

Question	Answer	Marks	Guidance
	0 marks No response or no response worthy of credit.		<u>Reaction of carbonyl compound and mechanism</u> Suitable reactions, e.g. - Aldehyde or ketone and HCN OR H^- e.g. $\text{RCHO} + \text{HCN} \rightarrow \text{RCH(OH)CN}$ <i>May be shown within mechanism</i> - Mechanisms, e.g.  OR H_2O instead of H^+ for 2nd stage ALLOW suitable non-specification alternative e.g. H_2O, NH_3, 1° amine IGNORE reactions with carboxylic acids (or derivatives) i.e. addition-elimination mechanism (condensation reaction) Additional details (NOT INCLUSIVE) - Nucleophilic addition - Systematic names of reactants and/or products - Details of functional group interconversion e.g. aldehyde to hydroxynitrile - In reduction, aldehydes form 1° alcohols and ketones form 2° alcohols - Details on reagents required e.g. - formation of hydroxynitriles with $\text{NaCN}/\text{H}^+(\text{aq})$ - formation of alcohols with NaBH_4 - Heterolytic fission

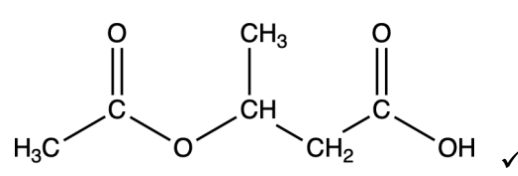
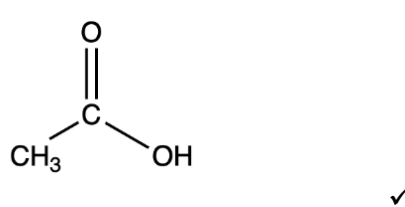
Question	Answer	Marks	Guidance
			Aspects of the communication statement being met might typically include: • Curly arrows starting from lone pairs / negative charges / bonds. • All reactants and intermediates have relevant charges and dipoles. • Mechanisms given are chemically feasible for the reactions. • No additional incorrect reactants have been included.

Question	Answer	Marks	Guidance
34 (a)	Diagram showing a hydrogen bond between a water molecule and a HCOOH (<i>dipoles and lone pairs not required</i>) AND Hydrogen bonding / H-bond stated OR labelled on diagram ✓  OR  H bond originates from lone pair on δ^- O and goes to δ^+ H (on another molecule) ✓	2	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous ALLOW hydrogen bond to HCOO⁻ (methanoate ion) DO NOT ALLOW H bond from H-C DO NOT ALLOW any marks for a diagram containing O₂H Hydrogen bond does NOT need to be labelled but it must be different from the covalent bond if it is not labelled. IF more than one hydrogen bond is shown they must ALL be correct to award each mark. ALLOW H bond between C=O and H₂O, i.e.  DO NOT ALLOW δ^+ on H atom of C-H All Hydrogen bonds must hit a lone pair ALLOW only one lone pair on O atom DO NOT ALLOW more than 2 lone pairs on O atom

Question	Answer	Marks	Guidance
34 (b) (i)	ethyl 4-methylpentanoate ✓	1	ALLOW one word: ethyl4-methylpentanoate OR more words, e.g. ethyl 4-methyl pentanoate DO NOT ALLOW 1-ethyl-4-methylpentanoate IGNORE lack of hyphens, extra hyphens, full stops instead of commas, extra spaces DO NOT ALLOW the following for methyl: methy, meth, methly, methanyl DO NOT ALLOW the following for ethyl: ethy, eth, ethly, ethanyl
34 (b) (ii)	Step 1  Step 2  SOCl₂ used in Step 1 ✓ Acyl chloride: (CH₃)₂CHCH₂CH₂COCl correct ✓ <i>Seen anywhere</i> Step 1 correct equation ✓ Step 2 correct equation ✓	4	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous e.g. (CH₃)₂CHCH₂CH₂COOH + SOCl₂ → (CH₃)₂CHCH₂CH₂COCl + SO₂ + HCl (CH₃)₂CHCH₂CH₂COCl + C₂H₅OH → (CH₃)₂CHCH₂CH₂COOC₂H₅ + HCl DO NOT ALLOW incorrect connectivity on OH BUT ALLOW ECF on subsequent structures ALLOW suitable non-specification alternatives for step 1 e.g. PCl₃, PCl₅, COCl₂ e.g. 3(CH₃)₂CHCH₂CH₂COOH + PCl₃ → 3(CH₃)₂CHCH₂CH₂COCl + H₃PO₃ (CH₃)₂CHCH₂CH₂COOH + PCl₅ → (CH₃)₂CHCH₂CH₂COCl + POCl₃ + HCl (CH₃)₂CHCH₂CH₂COOH + COCl₂ → (CH₃)₂CHCH₂CH₂COCl + HCl + CO₂

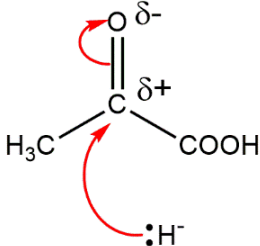
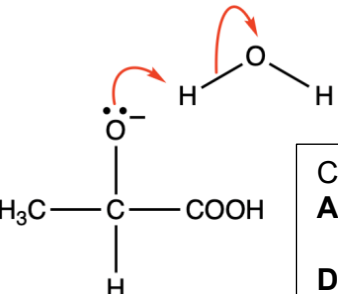
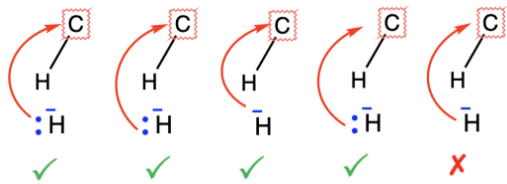
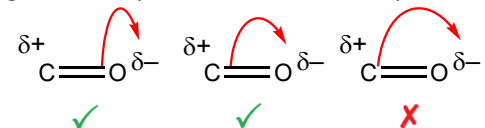
Question	Answer	Marks	Guidance
35	B	1	

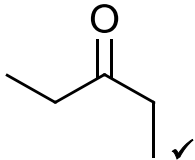
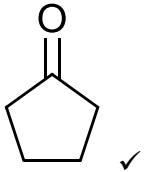
Question	Answer	Marks	Guidance
36	D	1	ALLOW A

37			 	2	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous e.g. $\text{CH}_3\text{COOCH}(\text{CH}_3)\text{CH}_2\text{COOH}$ CH_3COOH ALLOW products in either box IGNORE Connectivity BUT DO NOT ALLOW -HO
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Question			Answer	Mark	Guidance
38	(a)		An atom/ group of atoms/part of molecule responsible for the characteristic reactions (of a compound) ✓	1	ALLOW 'part of an organic compound' for 'part of molecule' ALLOW 'chemical properties' OR 'reactions' OR 'reactivity' for 'characteristic reactions' IGNORE references to physical properties
38	(b)		2,4-DNP ✓ Red/orange/yellow precipitate ✓	2	ALLOW 2,4-dinitrophenylhydrazine OR 2,4-DNPH OR Brady's (Reagent) ALLOW ppt OR solid OR crystals as an alternative for precipitate Mark second point independently of response for first marking point

Question		Answer	Mark	Guidance																			
38	(c)	<table><thead><tr><th rowspan="2">Chemical test</th><th colspan="3">Expected observations</th></tr><tr><th>Pyruvic acid</th><th>Methylglyoxal</th><th>Acetol</th></tr></thead><tbody><tr><td>Tollens' reagent</td><td>no change</td><td>Silver mirror</td><td>no change OR Silver mirror</td></tr><tr><td>Na₂CO₃(aq)</td><td>Effervescence OR Bubbles OR Fizzing</td><td>no change</td><td>no change</td></tr><tr><td>Cr₂O₇²⁻(aq)/ H⁺(aq)</td><td>no change (orange solution)</td><td>(Orange to) Green (solution)</td><td>(Orange to) Green (solution)</td></tr></tbody></table> One row correct ✓ Two rows correct ✓✓ Three rows correct ✓✓✓	Chemical test	Expected observations			Pyruvic acid	Methylglyoxal	Acetol	Tollens' reagent	no change	Silver mirror	no change OR Silver mirror	Na ₂ CO ₃ (aq)	Effervescence OR Bubbles OR Fizzing	no change	no change	Cr ₂ O ₇ ²⁻ (aq)/ H ⁺ (aq)	no change (orange solution)	(Orange to) Green (solution)	(Orange to) Green (solution)	3	ALLOW alternatives for 'no change' such as 'no observation', 'no reaction', 'nothing' or 'X' For Tollen's ALLOW Silver/Grey/Black AND precipitate/ppt/solid ALLOW acetol to give a positive result (<i>it is an alpha hydroxy ketone so can tautomerize to give an aldehyde, not covered in the specification</i>) For Na₂CO₃ IGNORE gas / CO₂ formed i.e. must be an observable change IGNORE test with limewater BUT DO NOT ALLOW other gas tests If no other marks awarded, ALLOW 1 mark for a correct column
Chemical test	Expected observations																						
	Pyruvic acid	Methylglyoxal	Acetol																				
Tollens' reagent	no change	Silver mirror	no change OR Silver mirror																				
Na ₂ CO ₃ (aq)	Effervescence OR Bubbles OR Fizzing	no change	no change																				
Cr ₂ O ₇ ²⁻ (aq)/ H ⁺ (aq)	no change (orange solution)	(Orange to) Green (solution)	(Orange to) Green (solution)																				

Question	Answer	Mark	Guidance
38 (d)	NOTE: curly arrows can be straight, snake-like, etc. but NOT double headed or half headed arrows Nucleophilic attack 2 marks  Curly arrow from H⁻ to C of C=O ✓ Correct dipole shown on C=O AND curly arrow showing breaking of C=O ✓ Intermediate 1 mark  Correct intermediate AND curly arrow from O⁻ to H in H₂O ✓ DO NOT ALLOW δ⁻ on O of intermediate IGNORE attempt to draw curly arrow showing breaking of H-O in H₂O IGNORE lack of dipole on H₂O IGNORE absence of OH⁻ as 2nd product IGNORE connectivity of H₃C-	4	ANNOTATIONS MUST BE USED 1st curly arrow must - go to the C atom of C=O AND - start from, OR be traced back to any point across width of lone pair on ⁻:H OR start from – charge on ⁻H (then lone pair on H⁻ does not need to be shown)  IF the carboxylic acid is attacked, in addition to the ketone, then ALLOW first two marks provided all arrows and dipoles are correct 2nd curly arrow must - start from, OR be traced back to any part of δ⁺C=O δ⁻ bond AND - go to O δ⁻ (across width of O δ⁻). 

Question			Answer	Mark	Guidance
39			Pentan-3-one  Cyclopentanone 	2	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous IGNORE non-organic products e.g. CO₂, O=C=O, H₂O etc