

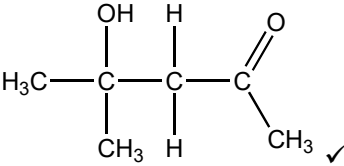
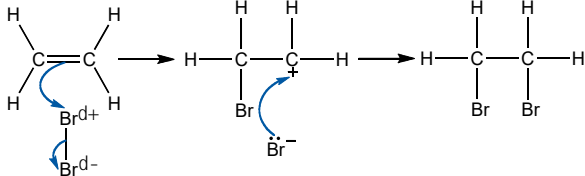
Mark Scheme

Question	Key	Marks	Guidance
1	D	1	
2	A	1	

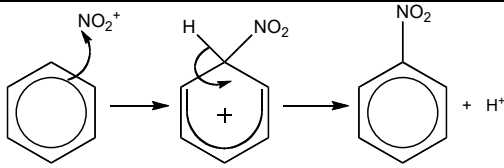
Mark Scheme

Question			Answer	Marks	Guidance
3	(a)	(i)	3-hydroxybutanal ✓	1	<p>ALLOW 3-hydroxybutan-1-al</p> <p>IGNORE lack of hyphens or addition of commas</p> <p>ALLOW 4-oxobutan-2-ol OR 1-oxobutan-3-ol</p> <p>DO NOT ALLOW</p> <ul style="list-style-type: none"> • 3-hydroxybutal • 3-hydroxybutanal
		(ii)	Addition ✓	1	<p>IGNORE nucleophilic OR electrophilic OR radical</p> <p>DO NOT ALLOW addition–elimination, condensation, polymerisation</p>
		(iii)	<p>ALLOW any formula provided that number and type of atoms and charge are correct, e.g. For CH₃CHO, ALLOW CH₃COH, C₂H₄O, etc.</p> <p>-----</p> <p>Step 1:</p> <ul style="list-style-type: none"> • Correct equation ✓ • One correct acid–base pair ✓ i.e. A1 and B1 OR A2 and B2 $\begin{array}{ccccccc} \text{CH}_3\text{CHO} & + & \text{OH}^- & \rightleftharpoons & ^-\text{CH}_2\text{CHO} & + & \text{H}_2\text{O} \\ \text{OR} & & & & & & \\ \text{CH}_3\text{CHO} & + & \text{OH}^- & \rightleftharpoons & \text{CH}_3\text{CO}^- & + & \text{H}_2\text{O} \\ & \text{A1} & \text{B2} & & \text{B1} & \text{A2} & \\ \text{OR} & & & & & & \\ & \text{A2} & \text{B1} & & \text{B2} & \text{A1} & \end{array}$ <p>Step 2:</p> $\text{CH}_3\text{CHO} + ^-\text{CH}_2\text{CHO} + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{CHOHCH}_2\text{CHO} + \text{OH}^- \checkmark$	3	<p>Throughout, IGNORE 'connectivity in any formula or structures shown.</p> <p>Examples in Answer column and in 6a(iv) guidance below</p> <p>-----</p> <p>Step 1: ALLOW H⁺ transfer from OH⁻, i.e.</p> $\begin{array}{ccccccc} \text{CH}_3\text{CHO} & + & \text{OH}^- & \rightleftharpoons & \text{CH}_3\text{CH}_2\text{O}^+ & + & \text{O}^{2-} \checkmark \\ & \text{B2} & \text{A1} & & \text{A2} & \text{B1} & \checkmark \\ \text{OR} & & & & & & \\ & \text{B1} & \text{A2} & & \text{A1} & \text{B2} & \end{array}$ <p>Step 2:</p> $\text{CH}_3\text{CHO} + \text{CH}_3\text{CH}_2\text{O}^+ + \text{O}^{2-} \rightarrow \text{CH}_3\text{CHOHCH}_2\text{CHO} + \text{OH}^- \checkmark$

Mark Scheme

Question	Answer	Marks	Guidance
	For $^-CH_2CHO$: ALLOW CH_2CHO^- ; CH_3CO^- ; $C_2H_3O^-$ For $CH_3CHOHCH_2CHO$, ALLOW $C_4H_8O_2$		For $CH_3CH_2O^+$: ALLOW CH_3CHOH^+ , $C_2H_5O^+$
(iv)		1	ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous For connectivity, ALLOW $\begin{array}{ccccccc} & & CH_3- & C_3H- & OH- \\ OH & CH_3 & & & \end{array}$ (Connectivity not being assessed)
(b)	<p>Refer to marking instructions on page 5 of mark scheme for guidance on marking this question.</p> <p>Level 3 (5–6 marks) Describes, in detail, electrophilic reactions and mechanisms of one aliphatic AND one aromatic compound. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3–4 marks) Describes, in detail, an electrophilic reaction and mechanism of one aliphatic OR one aromatic compound. OR Describes electrophilic reactions and mechanisms of one aliphatic AND one aromatic compound, with few omissions/errors. <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i></p>	6	<p>Indicative scientific points may include:</p> <p><u>Explanation of role of electrophiles in organic chemistry</u></p> <p><u>Reaction of aliphatic compound and mechanism</u></p> <ul style="list-style-type: none"> Suitable reaction, e.g. ethene and Br_2 <i>May be shown within mechanism</i> Mechanism, e.g.  <p><u>Reaction of aromatic compound and mechanism</u></p> <ul style="list-style-type: none"> Suitable reaction, e.g. benzene + Cl_2; HNO_3 <i>May be shown within mechanism</i> Mechanism, e.g.

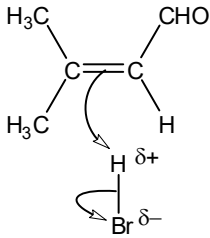
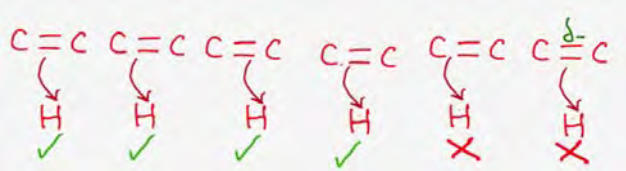
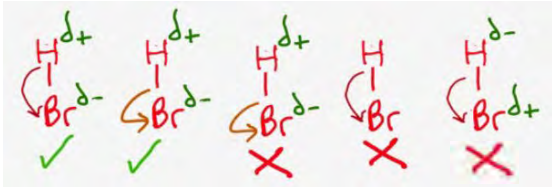
Mark Scheme

Question	Answer	Marks	Guidance
	<p>Level 1 (1–2 marks) Selects suitable reagents for electrophilic reactions of one aliphatic AND one aromatic compound. OR Attempts to describe an electrophilic reaction and mechanism of one aliphatic OR one aromatic compound, with omissions/errors.</p> <p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks No response or no response worthy of credit.</p>		 <p>Examples of a detailed description (NOT INCLUSIVE)</p> <ul style="list-style-type: none"> • Electrophile as electron pair acceptor • Types and names of mechanisms • Equations for generation of electrophile and regeneration of catalyst • Accurately positioned and directed curly arrows and charges/ dipoles included • Explanation of major and minor product from electrophilic addition
Total		12	

Mark Scheme

Question	Answer	Marks	AO element	Guidance
4	C	1	AO1.2	

Mark Scheme

Question	Answer	Marks	AO element	Guidance
5	(a) (i)	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES</p>  <p>Curly arrow from C=C bond to H of H-Br ✓ DO NOT ALLOW partial charge on C=C</p> <p>Correct dipole shown on H-Br AND curly arrow showing breaking of H-Br bond ✓</p>	4	<p>NOTE: curly arrows can be straight, snake-like, etc. but NOT double headed or half headed arrows</p> <p>1st curly arrow must</p> <ul style="list-style-type: none"> go to the H atom of H-Br <p>AND</p> <ul style="list-style-type: none"> start from, OR be traced back to any point across width of C=C  <p>2nd curly arrow must</p> <ul style="list-style-type: none"> start from, OR be traced back to any part of $\delta^+ \text{H}-\text{Br}^{\delta-}$ bond <p>AND</p> <ul style="list-style-type: none"> go to $\text{Br}^{\delta-}$ 

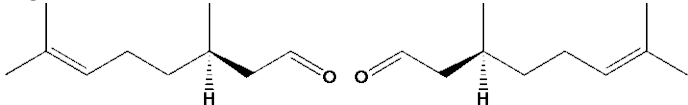
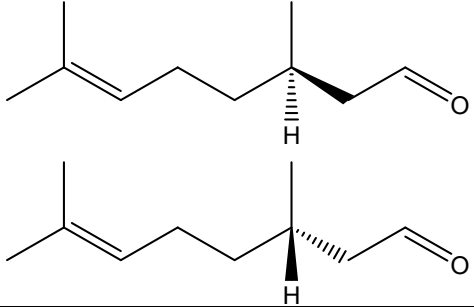
Mark Scheme

Question			Answer	Marks	AO element	Guidance
			intermediate/carbocation ✓ (major product forms from a) tertiary carbocation OR carbocation bonded to more C atoms / more alkyl groups OR carbocation bonded to no H atoms ✓		AO1.1 AO1.2	ALLOW carbonium ion or cation IGNORE descriptions of the major/minor product in terms of Markownikoff's rule e.g. H atom joins to C with most H IGNORE references to stability of the product ----- ALLOW ORA , i.e. (minor product forms from) least/less stable intermediate/carbocation ✓ (minor product forms from a) secondary carbocation OR carbocation bonded to fewer C atoms / more alkyl groups OR carbocation bonded to H atoms ✓ -----
	(b)	(i)	Tollens' (reagent) ✓	2	AO1.2	ALLOW ammoniacal silver nitrate OR Ag ⁺ /NH ₃

Mark Scheme

Question			Answer	Marks	AO element	Guidance
			Silver (mirror/precipitate/ppt/solid) with citronellal/the aldehyde ✓		×2	<p>ALLOW black ppt OR grey ppt</p> <p>IGNORE references to acidified dichromate reacting with both compounds</p> <p>-----</p> <p>ALLOW 2,4-DNP/2,4-DNPH ALLOW Brady's reagent ✓</p> <p>Yellow/orange/red precipitate with citronellal/aldehyde/carbonyl group ✓</p> <p>-----</p> <p>IF other reagents are seen, contact your Team Leader</p>
	(b)	(ii)	C ₁₀ H ₁₈ O ✓	1	AO1.2	DO NOT ALLOW C ₁₀ H ₁₇ OH
	(b)	(iii)	<p>Same molecular formula AND Different structural formulae ✓</p> <p>OR</p> <p>Both (geraniol and citronellal) have the molecular formula C₁₀H₁₈O AND Different structural formulae ✓</p>	1	AO1.1	<p>Same formula is not sufficient <i>(no reference to molecular)</i></p> <p>Different arrangement of atoms is not sufficient <i>(no reference to structure/structural)</i></p> <p>For structural formulae, ALLOW structure/displayed/skeletal formulae/functional groups</p> <p>DO NOT ALLOW any reference to spatial/space</p> <p>ALLOW ECF from incorrect molecular formula in (b)(ii)</p>
		(iv)	Same structural formula	1	AO1.1	ALLOW structure/displayed/skeletal formula

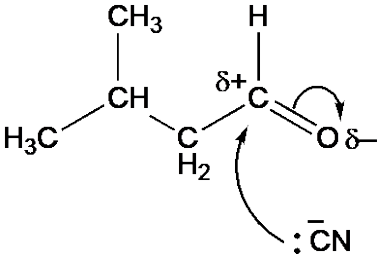
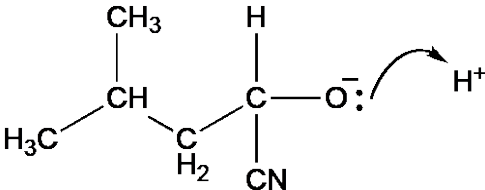
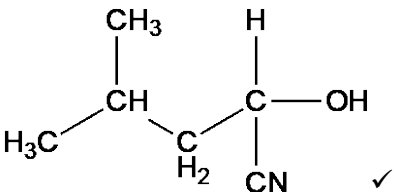
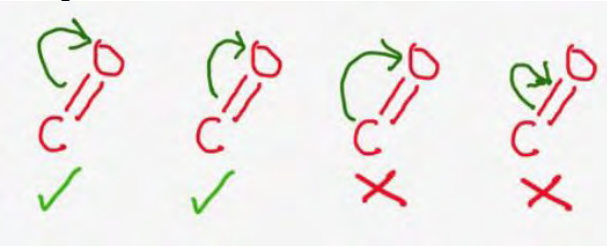
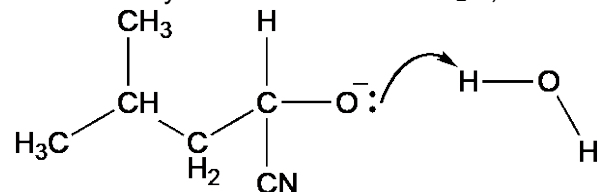
Mark Scheme

Question	Answer	Marks	AO element	Guidance
	<p>Citronellal: chiral/asymmetric C at carbon-3 OR carbon-3 is bonded to 4 different groups AND optical isomerism ✓</p> <p>Two 3D structures of citronellal that are mirror images ✓</p> <p>e.g.</p> 		<p>AO1.2</p> <p>AO2.5</p>	<p>ALLOW identification of carbon-3 from 3D structure citronellal if not stated in text or diagram</p> <p>IGNORE connectivity of groups around chiral C</p> <p>In citronellal, ALLOW C₆H₁₁ OR R to represent alkenyl chain ALLOW C₂H₃O to represent CH₂CHO</p> <p>IF structural formula of alkenyl chain is used IGNORE one small slip in one/both isomers e.g. (CH₃)₂CHCH₂CH₂ (<i>missing carbon-7</i>)</p> <p>ALLOW two 3D structures with 2 groups swapped e.g.</p> 
	Total	13		

Mark Scheme

Question	Answer	Marks	AO element	Guidance
6	C	1	2.3	

Mark Scheme

Question	Answer	Marks	AO element	Guidance
(c) (i)	<p>Mechanism 3 marks</p>  <p>Curly arrow from CN^- to C atom of $\text{C}=\text{O}$ ✓</p> <p>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 ✓</p>  <p>Curly arrow from lone pair OR – charge on O^- of correct intermediate to H^+ ✓</p> <hr/> <p>Product 1 mark</p>  <hr/> <p>Name of mechanism 1 mark</p> <p>Nucleophilic addition ✓</p>	5	<p>1.2</p> <p>1.2</p> <p>2.5</p> <p>2.5</p> <p>1.1</p>	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES</p> <p>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)</p> <p>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</p>  <hr/> <p>ALLOW curly arrow to H atom of H_2O, i.e.</p>  <p>IGNORE attempt to draw curly arrow showing breaking of $\text{H}-\text{O}$ in H_2O</p> <p>IGNORE lack of dipole on H_2O</p>

Mark Scheme

Question		Answer	Marks	AO element	Guidance
	(ii)	Heterolytic One (bonded) atom/O receives both/2 electrons ✓ Fission Breaking of a covalent bond ✓	2	1.2	ALLOW 2 electrons go to one (bonded) atom/O DO NOT ALLOW both pairs of electrons go to O IGNORE formation of ions/radicals For O atom, ALLOW species DO NOT ALLOW element or molecule ALLOW π bond in C=O breaks IGNORE breaking of C=O bond (no reference to only one bond breaking) 'Bond breaking' is not sufficient (no reference to covalent)