Question	Key	Marks	Guidance
1	D	1	
2	А	1	

Question	Answer	Marks	Guidance
3 (a) (i)	3-hydroxybutanal ✓	1	ALLOW 3-hydroxybutan-1-al IGNORE lack of hyphens or addition of commas ALLOW 4-oxobutan-2-ol OR 1-oxobutan-3-ol DO NOT ALLOW 3-hydroxybutal 3-hydroxylbutanal
(ii)	Addition ✓	1	IGNORE nucleophilic OR electrophilic OR radical DO NOT ALLOW addition–elimination, condensation, polymerisation
(iii)	ALLOW any formula provided that number and type of atoms and charge are correct, e.g. For CH ₃ CHO, ALLOW CH ₃ COH, C ₂ H ₄ O, etc. Step 1: Correct equation ✓ One correct acid–base pair ✓ i.e. A1 and B1 OR A2 and B2 CH ₃ CHO + OH ⁻ ⇒ CH ₂ CHO + H ₂ O OR CH ₃ CHO + OH ⁻ ⇒ CH ₃ CO ⁻ + H ₂ O A1 B2 B1 A2 OR A2 B1 B2 A1 Step 2: CH ₃ CHO + CH ₂ CHO + H ₂ O → CH ₃ CHOHCH ₂ CHO + OH ⁻ ✓	3	Throughout, IGNORE 'connectivity in any formula or structures shown. Examples in Answer column and in 6a(iv) guidance below

Question	Answer	Marks	Guidance
	For CH ₂ CHO: ALLOW CH ₂ CHO ⁻ ; CH ₃ CO ⁻ ; C ₂ H ₃ O ⁻ For CH ₃ CHOHCH ₂ CHO, ALLOW C ₄ H ₈ O ₂		For CH ₃ CH ₂ O ⁺ : ALLOW CH ₃ CHOH ⁺ , C ₂ H ₅ O ⁺
(iv)	H ₃ C — C — C — C — C — C — C — C — C — C —	1	ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous For connectivity, ALLOW CH ₃ - C ₃ H- OH- OH CH ₃ (Connectivity not being assessed)
(b)	Refer to marking instructions on page 5 of mark scheme for guidance on marking this question. Level 3 (5–6 marks) Describes, in detail, electrophilic reactions and mechanisms of one aliphatic AND one aromatic compound. There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated. 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. There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.	6	Indicative scientific points may include: Explanation of role of electrophiles in organic chemistry Reaction of aliphatic compound and mechanism • Suitable reaction, e.g. ethene and Br ₂ May be shown within mechanism • Mechanism, e.g. H Brd+ H Br Br Reaction of aromatic compound and mechanism • Suitable reaction, e.g. benzene + Cl ₂ ; HNO ₃ May be shown within mechanism • Mechanism, e.g.

Question	Answer	Marks	Guidance
	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. There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant. O marks No response or no response worthy of credit.		Examples of a detailed description (NOT INCLUSIVE) • 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	

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

	Questic	on	Answer	Marks	AO element	Guidance
5	(a)	(i)	H ₃ C H ₃ C H ₃ C H H H H H H CHO H CHO H CHO H CHO H H CHO H H H H H H H H H H H H	4	AO1.2	NOTE: curly arrows can be straight, snake-like, etc. but NOT double headed or half headed arrows 1st curly arrow must • go to the H atom of H–Br AND • start from, OR be traced back to any point across width of C=C C=C C=C C=C C=C C=C C=C C=C C=C C=

Question	Answer	Marks	AO element	Guidance
	Correct carbocation AND curly arrow from Br⁻ to C⁺ of carbocation ✓ DO NOT ALLOW δ+ on C of carbocation		AO2.5	IGNORE connectivity of CHO and CH ₃ groups in carbocation and product e.g. ALLOW CHO CHO OR
	H ₃ C CHO CH_3 CHO H_3 C CHO H_3 C CHO H_3 C CHO CH_3 CHO $CORRECTED TO THE STANDARD THE $		AO2.5	ALLOW COH for CHO (reaction does not involve this group) 3rd curly arrow must • go to the C+ of carbocation AND • start from, OR be traced back to any point across width of lone pair on :Br • OR start from – charge of Br ion (Lone pair NOT needed if curly arrow shown from – charge of Br ion) IF Br ₂ is used instead of HBr contact your Team Leader
(a) (ii)	(major product forms from) most/more stable	2		For carbocation,

Question	Answer	Marks	AO element	Guidance
Question	Answer 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 ✓	Marks		Guidance 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

C	uesti	on	Answer	Marks	AO 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
	(b)	(ii)	C ₁₀ H ₁₈ O ✓	1	AO1.2	DO NOT ALLOW C ₁₀ H ₁₇ OH
	(b)	(iii)	Same molecular formula AND Different structural formulae ✓ OR Both (geraniol and citronellal) have the molecular formula C ₁₀ H ₁₈ O AND Different structural formulae ✓	1	AO1.1	Same formula is not sufficient
		(iv)	Same structural formula	1	AO1.1	ALLOW structure/displayed/skeletal formula

Question	Answer	Marks	AO element	Guidance
	AND Different arrangement (of atoms) in space OR different spatial arrangement (of atoms) ✓			DO NOT ALLOW same empirical formula OR same general formula IGNORE same molecular formula Reference to E/Z isomerism or optical isomerism is not sufficient
(V)	Geraniol: (Carbon-carbon) double bond at carbon-2(,3) AND E OR Z ✓ Structure of Z geraniol (E isomer is shown in question) OH ✓	4	AO1.2	ANNOTATE ANSWER WITH TICKS AND CROSSES ETC CHECK diagrams of citronellal and geraniol for annotations that may be worthy of credit DO NOT ALLOW isomerism at C=C at carbon 6(,-7) ALLOW identification of carbon-2(,3) from correct Z geraniol isomer if not stated in text or diagram IGNORE cis OR trans isomerism (none of the substituent groups attached to the C=C are the same) IGNORE geometric ALLOW type of isomerism from E/Z labels, even if incorrectly assigned In geraniol, ALLOW C ₆ H ₁₁ OR R to represent alkenyl chain ALLOW CH ₃ O to represent CH ₂ OH

Question	Answer	Marks	AO element	Guidance
	Citronellal: chiral/asymmetric C at carbon-3 OR carbon-3 is bonded to 4 different groups AND optical isomerism ✓		AO1.2	ALLOW identification of carbon-3 from 3D structure citronellal if not stated in text or diagram
	Two 3D structures of citronellal that are mirror images ✓ e.g.		AO2.5	IGNORE connectivity of groups around chiral C In citronellal, ALLOW C ₆ H ₁₁ OR R to represent alkenyl chain ALLOW C ₂ H ₃ O to represent CH ₂ CHO IF structural formula of alkenyl chain is used IGNORE one small slip in one/both isomers e.g.(CH ₃) ₂ CHCH ₂ CH ₂ (missing carbon-7) ALLOW two 3D structures with 2 groups swapped e.g.
	Total	13		H

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Question	Answer	Marks	AO element	Guidance
6	С	1	2.3	

C	Question		Answer	Marks	AO element	Guidance
7	(a)	(i)	(series of organic compounds with the) same functional group OR same/similar chemical properties/reactions ✓ each successive/subsequent member differs by CH ₂ ✓	2	1.1 ×2	IGNORE reference to physical properties IGNORE same general formula DO NOT ALLOW same empirical OR molecular formula Differs by CH ₂ is not sufficient (<i>no successive</i>)
		(ii)	C ₂₄ H ₄₈ O ✓	1	2.1	
	(b)		F/aldehyde AND Tollens' (reagent) AND Silver (mirror/precipitate/ppt/solid) ✓ G/alkene/C=C AND Bromine/Br₂ AND goes colourless/decolourised ✓ G/ketone AND 2,4-dinitrophenylhydrazine AND orange/yellow/red precipitate ✓ G/ketone AND Tollens' (reagent) AND	4	2.3 3.3	IGNORE use of 2,4-DNP with F ALLOW ammoniacal silver nitrate OR Ag ⁺ /NH ₃ ALLOW black ppt OR grey ppt ALLOW bromine water/ Br ₂ (aq) ALLOW errors in spelling for 2,4-DNP 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 ALLOW ammoniacal silver nitrate OR Ag ⁺ /NH ₃ ALLOW black ppt OR grey ppt
			no silver mirror/no change/no reaction ✓		3.3	ALLOW alterative approach using acidified potassium dichromate for tests with F and/or G, with correct observations, alongside use of 2,4-DNP

(c) (i) Mechanism 3 marks 5 CH ₃ H CH ₃ C CH ₂ S+ CH ₂ O 8- Curly arrow from CN to C atom of C=O ✓ Dipole shown on C=O bond, C* and O 8-, AND curly arrow from C=O bond to O atom ✓ CH ₃ H CH ₄ C CH ₂ S+ Curly arrow from C=O bond must start from, OR be traced back to, any part of C=O bond and go to O CURLY arrow from lone pair OR – charge on O of correct intermediate to H* Product 1 mark CH ₃ H CH ₄ C CH ₃ H CH CH ₃ H CH CH ₃ H CH CH CH ₃ H CH CH CH CH CH CH CH CH CH	Question	Answer	Marks	AO element	Guidance
Nucleophilic addition ✓ 1.1		Mechanism CH ₃ H ₃ C CH CH CH CH CH CH CH CH CH		1.2	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 C=O bond must start from, OR be traced back to, any part of C=O bond and go to O ALLOW curly arrow to H atom of H ₂ O, i.e. CH ₃ H H ₃ C CH CCH CCH CCH CCH CCH CCH CCH

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)