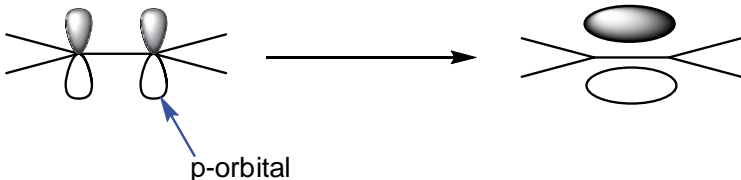
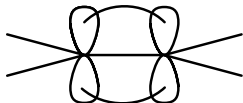
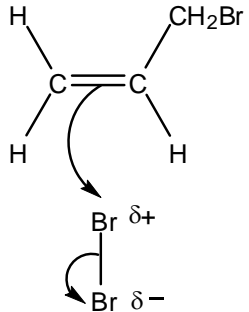
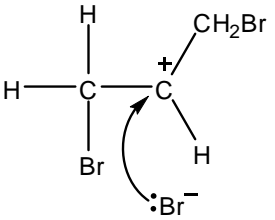
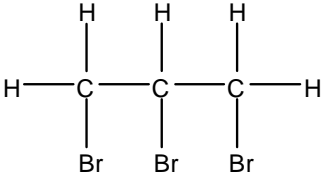
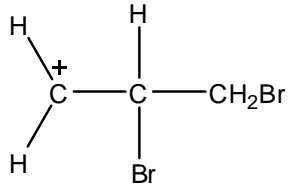
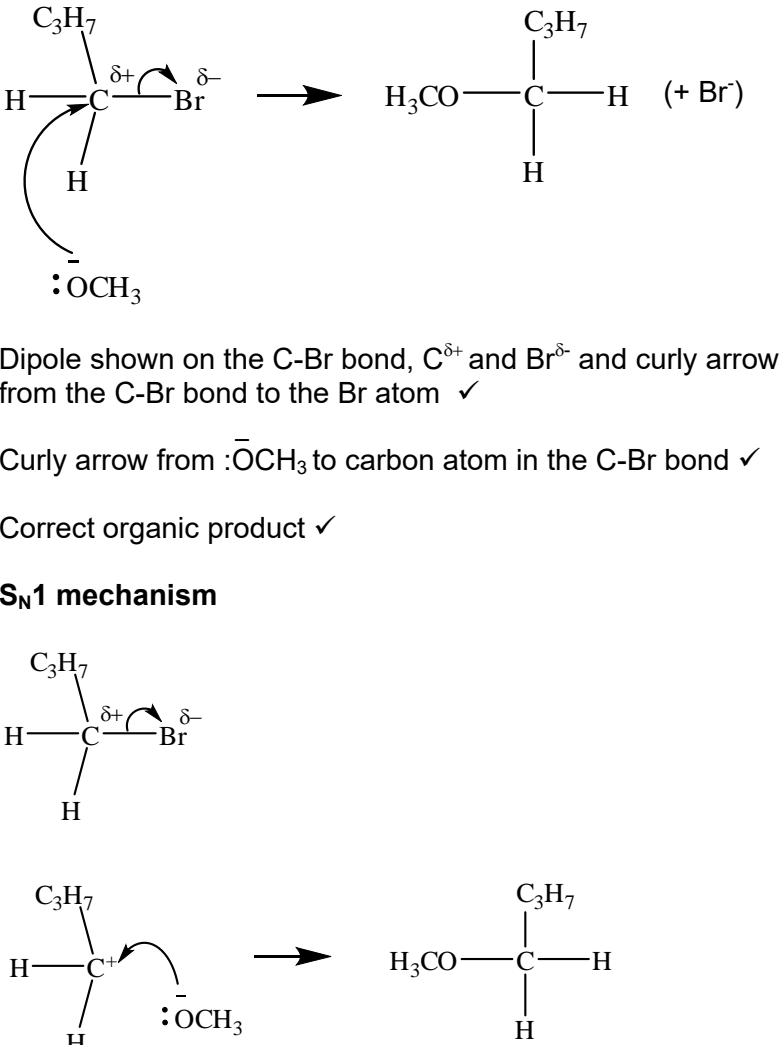
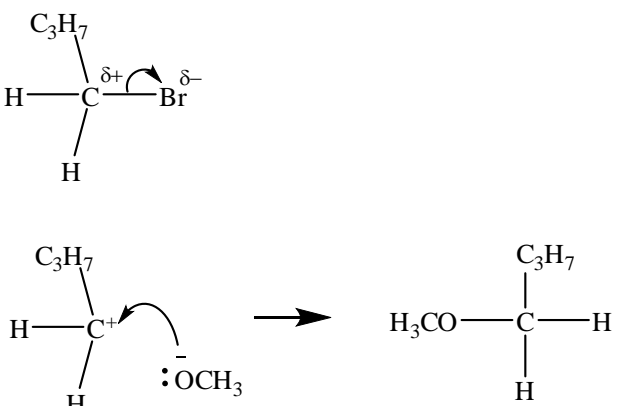


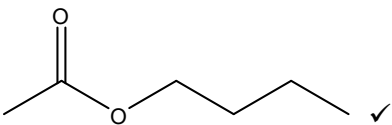
		Answer	Mark	Guidance
1	(a)	 <p>First mark diagram on left with p-orbitals labelled OR unlabelled diagram AND the statement: (sideways) overlap of p orbitals ✓</p> <p>Second mark (labelled) diagram on right showing π-bond ✓</p>	2	<p>Note: A diagram is required for each mark</p> <p>DO NOT ALLOW C=C in one diagram but ALLOW ECF for subsequent use in another diagram.</p> <p>The bonds shown in the diagram are required ALLOW ECF for missing bonds in second diagram IGNORE any atoms joined to the bonds</p> <p>ALLOW a diagram where the p-orbitals are linked for second mark.</p> <p>e.g. </p>
	(b) (i)	(series of compounds with the) same functional group OR same/similar chemical properties OR same/similar chemical reactions ✓ each successive/subsequent member differing by CH_2 ✓	2	<p>IGNORE reference to physical properties</p> <p>IGNORE same general formula (<i>in question</i>)</p> <p>Differs by CH_2 is not sufficient (<i>no successive</i>)</p> <p>DO NOT ALLOW same empirical OR have the same molecular formula</p>
	(ii)	$\text{C}_n\text{H}_{2n-1}\text{Br}$ ✓	1	ALLOW $\text{C}_n\text{H}_{2n-1}\text{X}$ ONLY if X is specified as Br (<i>question asks for bromide</i>)
	(iii)	3-bromoprop(-1-)ene ✓	1	ALLOW 1-bromoprop-2-ene
	(c) (i)	Movement of an electron pair ✓	1	ALLOW movement of a lone pair OR movement of a bond
	(ii)	Electron pair donor ✓	1	ALLOW can donate a lone pair

		Answer	Mark	Guidance
(d)	(i)	<p>curly arrow from HO^- to carbon atom of C-Br bond ✓</p> <p>Dipole shown on C-Br bond, $\text{C}^{\delta+}$ and $\text{Br}^{\delta-}$, AND curly arrow from C-Br bond to Br atom ✓</p> <hr/> <p>correct organic product AND Br^- ✓</p>	3	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>Curly arrow must come from lone pair on O of HO^- OR OH^- OR from minus sign on HO^- ion (No need to show lone pair if curly arrow came from negative charge on O)</p> <p>-----</p> <p>ALLOW $\text{S}_{\text{N}}1$ mechanism:</p> <p>Dipole shown on C-Br bond, $\text{C}^{\delta+}$ and $\text{Br}^{\delta-}$, AND curly arrow from C-Br bond to Br atom ✓</p> <p>Correct carbocation AND curly arrow from HO^- to carbocation Curly arrow must come from lone pair on O of HO^- OR OH^- OR from minus sign on HO^- ion (No need to show lone pair if curly arrow came from negative charge on O) ✓</p> <p>correct organic product AND Br^- ✓</p> <p>-----</p>
	(ii)	Nucleophilic substitution ✓	1	

	Answer	Mark	Guidance
(e)	<p>(i)</p> <p>Curly arrow from double bond to Br of Br–Br ✓</p> <p>Correct dipole shown on Br–Br AND curly arrow showing breaking of Br–Br bond ✓</p>  <p>Correct carbocation with + charge on C with 3 bonds AND curly arrow from Br⁻ to C⁺ of carbocation ✓</p>  <p>Correct product: ✓</p> 	4	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>Curly arrow must start from bond and go to correct atom</p> <p>DO NOT ALLOW any other partial charges e.g. shown on double bond</p> <p>ALLOW carbocation on terminal CH₂</p>  <p>DO NOT ALLOW $\delta+$ on C of carbocation.</p> <p>Curly arrow must come from a lone pair on Br⁻ OR from the negative sign of Br⁻ ion (then lone pair on Br⁻ ion does not need to be shown)</p>
	(ii) Electrophilic addition ✓	1	

		Answer	Mark	Guidance
(f)	(i)	H ₂ AND Ni (catalyst) ✓	1	ALLOW name or formula for each IGNORE any stated temperature and pressure
	(ii)	(Initiation) Cl ₂ → 2Cl ✓ AND UV ✓ (Propagation) C ₃ H ₇ Br + Cl → C ₃ H ₆ Br + HCl ✓ C ₃ H ₆ Br + Cl ₂ → C ₃ H ₆ BrCl + Cl ✓ (Termination) Two from the three termination equations below ✓ 2Cl → Cl ₂ C ₃ H ₆ Br + Cl → C ₃ H ₆ BrCl 2C ₃ H ₆ Br → C ₆ H ₁₂ Br ₂ names of steps initiation, propagation and termination linked to one correct equation for each step in this mechanism ✓	5	ANNOTATE ANSWER WITH TICKS AND CROSSES ETC DO NOT ALLOW any ECF in this question IGNORE references to temperature THROUGHOUT, ALLOW correct molecular formulae OR structural OR displayed OR skeletal OR mixture of the above IGNORE dots IGNORE state symbols IGNORE one incorrect termination equation
	(iii)	further substitution OR produces different termination products OR More than one termination step ✓ substitution at different positions along chain ✓	2	IGNORE mixture of organic products (<i>in question</i>) ALLOW dichloro/multichloro/dibromo/multibromo compounds formed OR an example of a further substitution product OR an example of a different termination product ALLOW more than one hydrogen (atom) can be replaced ALLOW radicals react with each other to form other products ALLOW forms different structural isomers ALLOW a hydrogen (atom) on a different carbon (atom) can be replaced
Total			25	

Question	Answer	Mark	Guidance
2 (a)	It is an electron pair donor OR can donate a lone pair ✓	1	
(b)	 <p>Dipole shown on the C-Br bond, C^{δ+} and Br^{δ-} and curly arrow from the C-Br bond to the Br atom ✓</p> <p>Curly arrow from :$\bar{\text{O}}\text{CH}_3$ to carbon atom in the C-Br bond ✓</p> <p>Correct organic product ✓</p> <p>S_N1 mechanism</p> 	3	<p>ANNOTATE ANSWER WITH TICKS AND CROSSES ETC</p> <p>IGNORE connectivity to C₃H₇ throughout</p> <p>IGNORE alkyl group in first marking point. Curly arrow must start from C-Br bond and not from C atom. Dipole must be partial charge and not full charge</p> <p>CH₃O⁻ curly arrow must come from one lone pair on O of CH₃O⁻ ion OR from negative sign on O of the CH₃O⁻ ion ALLOW arrow from lone pair on O in OCH₃⁻ Lone pair not required DO NOT ALLOW CH₃O^{δ-} DO NOT ALLOW incorrect connectivity of CH₃O group in the final product -CH₃O IGNORE Br^{δ-} as a product</p> <p>ALLOW S_N1 mechanism Dipole shown on the C-Br bond, C^{δ+} and Br^{δ-} and curly arrow from C-Br bond to the Br atom ✓ curly arrow from CH₃O⁻ to carbonium ion ✓ correct organic product ✓</p>

Question		Answer	Mark	Guidance
	(c)	1-Iodobutane increases the rate <input checked="" type="checkbox"/> AND C—I bonds are weaker (than C—Br) OR C—I bond has a lower bond enthalpy OR C—I bond needs a smaller amount of energy to break OR C—I bond is easier to break ✓	1	All statements must be comparative ALLOW ORA IGNORE C—I bond is longer IGNORE polarity and references to electronegativity
	(d)	 butyl ethanoate ✓	2	ALLOW only skeletal formula DO NOT ALLOW ECF from incorrect structure. ALLOW butylethanoate ALLOW butanyl for butyl DO NOT ALLOW butly
(e)	(i)	$(\frac{136.9}{291.1} \times 100) = 47\%$ ✓	1	ALLOW 47 up to calculator value correctly rounded. 47.0 or 47.03 or 47.029 will be correct common answers IGNORE any working shown.
(e)	(ii)	NaBr OR LiBr ✓	1	ALLOW correct name or formula DO NOT ALLOW HBr (it is an acid)
(e)	(iii)	Look at answer if 88.8% AWARD 3 marks if 88.75% AWARD 2 marks (not 3 sig. fig.) Moles of butan-1-ol = 0.08(00) ✓ Moles of 1-bromobutane = 0.071(0) ✓ % yield = 88.8% ✓	3	Answer MUST be to 3 significant figures. ALLOW ECF but do not allow a yield >100% ALLOW Mass of 1-bromobutane expected = 10.952 g
Total			12	

Question		Answer	Mark	Guidance	
3	(a)	<p>Correct polymer with side links ✓</p> <p>Balanced equation for formation of correct polymer - correct use of n in the equation and brackets ✓</p>	2	<p>Displayed formulae MUST be used to award each mark</p> <p>n on LHS can be at any height to the left of formula AND n on the RHS must be a subscript (essentially below the side link)</p>	
	(b)	(i)	$\text{CH}_2\text{CHCl} + 2\text{O}_2 \longrightarrow \text{CO} + \text{CO}_2 + \text{HCl} + \text{H}_2\text{O} \checkmark$	1	<p>ALLOW any other correctly balanced equation with the same reactants and products ALLOW $\text{C}_2\text{H}_3\text{Cl}$ for CH_2CHCl</p>
		(ii)	Sodium hydrogencarbonate neutralises HCl ✓	1	<p>Assume that 'it' refers to sodium hydrogencarbonate but DO NOT ALLOW other chemicals e.g. sodium</p> <p>ALLOW NaHCO_3 is a base ALLOW forms a salt or sodium chloride or NaCl ALLOW equation to show formation of NaCl from NaHCO_3 and HCl even if not balanced. IGNORE reacts</p>

Question		Answer	Mark	Guidance
	(c)	<p>ANY TWO from</p> <p>abundance (in atmosphere) OR amount (in atmosphere) OR (atmospheric) concentration OR percentage (in air) ✓</p> <p>OR</p> <p>ability to absorb infrared/IR (radiation)✓</p> <p>OR</p> <p>residence time ✓</p>	2	ALLOW absorption of infrared/IR
	(d) (i)	<p>Any balanced equation between a metal oxide and carbon dioxide to form a carbonate e.g $\text{CaO} + \text{CO}_2 \longrightarrow \text{CaCO}_3$ ✓</p>	1	ALLOW MO for metal oxide
	(ii)	<p>ANY ONE FROM</p> <p>deep in oceans OR in geological formations OR (deep) in rocks OR in mines OR in oil wells OR in gas fields ✓</p>	1	<p>Assume that 'it' refers to carbon dioxide but DO NOT ALLOW carbon</p> <p>DO NOT ALLOW reacted with oxides or stored as carbonates.</p>
Total			8	

Question			Answer	Marks	Guidance
4	(a)	(i)	<p>correct curly arrow from double bond to iodine atom and curly arrow from the I–Br bond to the bromine atom ✓</p> <p>correct carbonium ion OR correct carbocation ✓</p> <p>correct curly arrow from bromide ion to the (positive) carbon ✓</p>	3	<p>Curly arrow must start from bond and go to correct atom DO NOT ALLOW partial charges on carbon–carbon double bond</p> <p>DO NOT ALLOW $\delta+$ on carbon atom The positive charge must be associated with the carbon atom and not with a bond Make certain the carbonium ion includes the iodine atom</p> <p>Curly arrow must come from any lone pair or the negative sign of the bromide ion</p> <p>The lone pair on the bromide ion does not need to be shown</p>
		(ii)	Electrophilic addition ✓	1	
		(iii)		1	<p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) eg $\text{CH}_2\text{BrCHICH}_3$</p> <p>IGNORE any name given</p>

Question		Answer	Marks	Guidance
	(b) (i)	Ultraviolet OR UV ✓	1	ALLOW high temperature OR 300 °C IGNORE light/radiation DO NOT ALLOW any catalyst
	(ii)	<p>(free) radical substitution ✓</p> <p>(Initiation step) $\text{IBr} \rightarrow \text{Br} + \text{I}$ ✓</p> <p>homolytic fission ✓</p> <p>(Propagation steps) $\text{Br} + \text{CH}_4 \rightarrow \text{HBr} + \text{CH}_3$ ✓</p> <p>$\text{CH}_3 + \text{IBr} \rightarrow \text{CH}_3\text{I} + \text{Br}$ ✓</p> <p>(Termination steps) $\text{I} + \text{CH}_3 \rightarrow \text{CH}_3\text{I}$ OR $\text{Br} + \text{Br} \rightarrow \text{Br}_2$ OR $\text{I} + \text{I} \rightarrow \text{I}_2$ OR $\text{Br} + \text{CH}_3 \rightarrow \text{CH}_3\text{Br}$ OR $\text{CH}_3 + \text{CH}_3 \rightarrow \text{C}_2\text{H}_6$ OR $\text{I} + \text{Br} \rightarrow \text{IBr}$ ✓</p> <p>QWC propagation linked to correct equations $\text{Br} + \text{CH}_4 \rightarrow \text{HBr} + \text{CH}_3$ $\text{CH}_3 + \text{IBr} \rightarrow \text{CH}_3\text{I} + \text{Br}$ AND initiation linked to correct equation $\text{IBr} \rightarrow \text{Br} + \text{I}$ ✓</p>	7	<p>Use the SEEN annotation on page 11 if blank or no credit can be given</p> <p>IGNORE any state symbols in equations Radicals do NOT need a single dot</p> <p>IGNORE dots</p> <p>DO NOT ALLOW homolytical fission Heterolytic anywhere in the answer contradicts this mark</p> <p>IGNORE $\text{I} + \text{CH}_4 \rightarrow \text{HI} + \text{CH}_3$</p> <p>IGNORE $\text{CH}_3 + \text{IBr} \rightarrow \text{CH}_3\text{Br} + \text{I}$ DO NOT ALLOW equations with H OR any other incorrect equation (i.e. not one of the four propagation steps shown)</p> <p>ALLOW any other suitable termination steps DO NOT ALLOW termination steps with H</p> <p>QWC can only be given if marking points 2, 4 and 5 have been awarded</p>
Total			13	

Question		Answer	Marks	Guidance
5	(a)	N ✓	1	ALLOW CF_3CFCI_2
	(b)	(i) S ✓	1	ALLOW $\text{CH}_3\text{CHBrCH}_2\text{CHICH}_3$
		(ii) curly arrow from HO^- to carbon atom of C-Br bond ✓ Dipole shown on C-Br bond, $\text{C}^{\delta+}$ and $\text{Br}^{\delta-}$, and curly arrow from C-Br bond to the halogen atom – arrow must be very close to the bond ✓ correct products of the reaction – not ambiguous with the C_3H_7 ✓ <div style="text-align: center;"> <p style="text-align: center;"> $\text{C}_3\text{H}_7-\text{C}^{\delta+}(\text{H})_2-\text{Br}^{\delta-} + \text{:OH}^- \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2-\text{C}(\text{H})_2-\text{OH} + \text{Br}^-$ </p> </div> nucleophilic substitution ✓	4	The curly arrow must start from the oxygen atom of the OH^- , and must start either from a lone pair or from the negative charge. No need to show lone pair if curly arrow came from negative charge DO NOT ALLOW attack by KOH or K^+OH^- ALLOW $\text{S}_{\text{N}}1$ Dipole shown on C-Br bond, $\text{C}^{\delta+}$ and $\text{Br}^{\delta-}$, and curly arrow from C-Br bond to the halogen atom – arrow must be very close to the bond ✓ Correct carbocation drawn AND curly arrow from HO^- to the carbocation (the curly arrow must start from the oxygen atom of the OH^- , and must start either from a lone pair or from the negative charge. No need to show lone pair if curly arrow came from negative charge) ✓ Correct products of the reaction – not ambiguous with the C_3H_7 ✓ nucleophilic substitution ✓

Question		Answer	Marks	Guidance
	(b) (iii)	C-I bond is weaker than C-Br bond OR C-I has a lower bond enthalpy than C-Br bond OR C-I bond is longer than C-Br bond AND C-I bond is easier to break than C-Br bond OR less energy is needed to break the C-I bond ✓	1	Answer must refer to the correct bond ALLOW ora IGNORE references to electronegativity
	(c)	$\text{HCl} + \text{CH}_3\text{CHCHCH}_3 \rightarrow \text{CH}_3\text{CH}_2\text{CHC}/\text{CH}_3$ Correct structural formula of product ✓ Equation with structural formulae ✓	2	Must use structural formulae for both organic compounds in the equation ALLOW $\text{CH}_3\text{CH}=\text{CHCH}_3$ for but-2-ene ALLOW two marks for correct equation with structural formulae ALLOW one mark for correct equation with displayed formulae IGNORE any mechanisms
	(d)	HCFCs OR hydrocarbons OR HFCs ✓	1	ALLOW alkanes DO NOT ALLOW specific alkanes
Total			10	