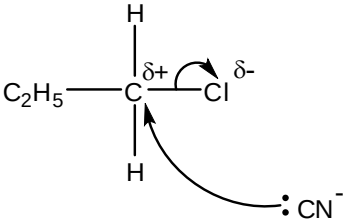
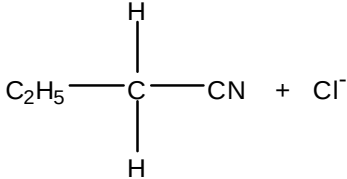
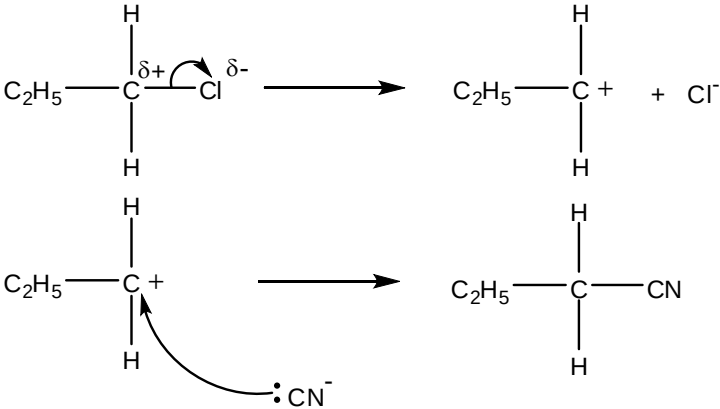
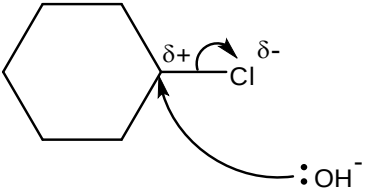
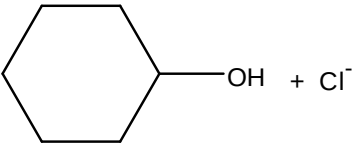
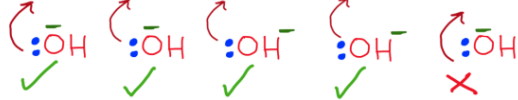
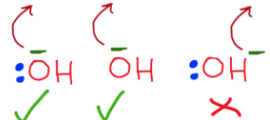
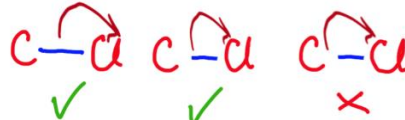


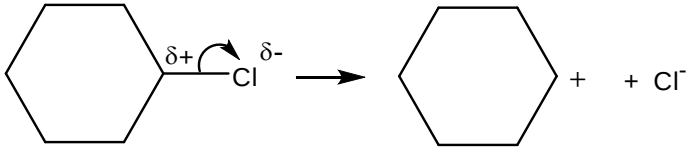
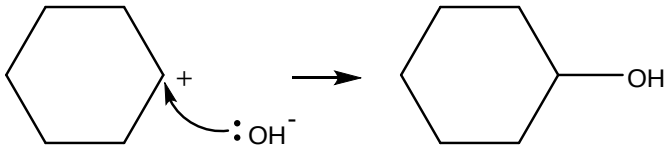
Question	Key	Marks	Guidance
1	B	1	

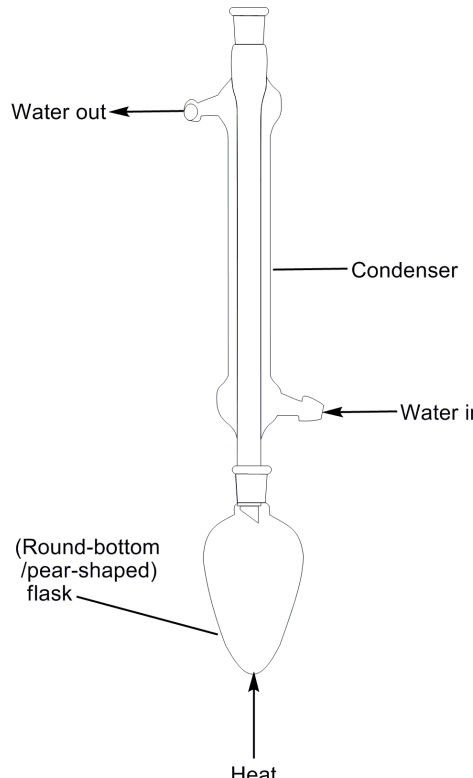
Question	Answer	Marks	Guidance
2 (a) (i)	curly arrow from CN^- to carbon atom of $\text{C}-\text{Cl}$ bond ✓ Dipole shown on $\text{C}-\text{Cl}$ bond, $\text{C}^{\delta+}$ and $\text{Cl}^{\delta-}$, AND curly arrow from $\text{C}-\text{Cl}$ bond to Cl atom ✓  ----- correct organic product AND Cl^- ✓ 	3	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) IGNORE NaCl ----- ALLOW $\text{S}_{\text{N}}1$ mechanism: Dipole shown on $\text{C}-\text{Cl}$ bond, $\text{C}^{\delta+}$ and $\text{Cl}^{\delta-}$, AND curly arrow from $\text{C}-\text{Cl}$ bond to Cl atom ✓ Correct carbocation AND curly arrow from CN^- to carbocation. 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) ✓ correct organic product AND Cl^- ✓ 

Question	Answer	Marks	Guidance
3	D	1	

Question		Answer	Marks	Guidance
4	(a)	Links rate of reaction to strength of bond/bond enthalpy ✓ e.g. the weaker the bond the faster the reaction stronger bond takes longer to break lower bond enthalpy reacts faster Correct comparison of rate of reaction for at least two C–Hal bonds e.g. C–F bond is hydrolysed slowest C–I bond is hydrolysed faster than C–Br C–Br has shorter reaction time than C–Cl OR Correct comparison of C–Hal bond strength/enthalpy of at least two of C–Hal bonds e.g. C–I bond is the weakest C–I has lower bond enthalpy than C–Br C–Br is broken more easily/readily than C–Cl C–Hal bond strength decreases down group (7) ✓	2	Each marking point must be a comparison IGNORE references to halogens as elements: <i>i.e.</i> chlorine is less reactive than bromine etc. DO NOT ALLOW chloride, bromide and iodide IGNORE references to bond length, polarity and electronegativity

Question	Answer	Marks	Guidance
(b)	Curly arrow from HO^- to carbon atom of C–Cl bond ✓ Dipole shown on C–Cl bond, $\text{C}^{\delta+}$ and $\text{Cl}^{\delta-}$ AND curly arrow from C–Cl bond to Cl atom ✓  IGNORE presence of Na^+ but OH^- needed i.e. Na^+OH^- can be allowed if criteria met Correct organic product AND Cl^- ✓  IGNORE presence of Na^+ but Cl^- needed i.e. Na^+Cl^- can be allowed BUT NaCl does NOT show Cl^-	3	ANNOTATE ANSWER TICKS AND CROSSES NOTE: curly arrows can be straight, snake-like, etc. but NOT double headed or half headed arrows 1st curly arrow must - go to the C of C–Cl AND - start from, OR be traced back to any point across width of lone pair on O of OH^-  OR start from – charge on O of OH^- ion  (Lone pair NOT needed if curly arrow shown from O^-) 2nd curly arrow must start from, OR be traced back to, any part of C–Cl bond and go to Cl 

Question			Answer	Marks	Guidance
					----- ALLOW S_N1 mechanism First mark Dipole shown on C–Cl bond, C^{δ+} and Cl^{δ-}, AND curly arrow from C–Cl bond to Cl atom ✓  Second mark 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 on O of HO⁻ ion (no need to show lone pair if curly came from negative charge) ✓ Third mark Correct organic product AND Cl⁻ ✓ -----

Question			Answer	Marks	Guidance
	(c)	(i)	Diagram Diagram showing round bottom/pear shaped flask AND upright condenser ✓  Labels (Round-bottom/pear-shaped) flask AND condenser AND water in at bottom and out at top AND heat (source) ✓	2	DO NOT ALLOW conical flask, volumetric flask, beaker in place of round bottom/pear shaped flask DO NOT ALLOW distillation DO NOT ALLOW stopper/bung on top of condenser IGNORE a thermometer in condenser IGNORE a small gap between flask and condenser ALLOW diagram of heating apparatus as an alternative to heat label

Question			Answer	Marks	Guidance
	(c)	(ii)	Precipitate G 1 mark silver bromide/AgBr AND $M = 1.88/0.01 = 188 \text{ (g mol}^{-1}\text{)}$ $188 - 107.9 = 80.1$ (so halide is Br⁻)✓ Alcohol F and Haloalkane E 2 marks E and F clearly identified F/alcohol: butan-2-ol $\begin{array}{c} \text{H} \quad \text{OH} \\ \quad \\ \text{H}_3\text{C}-\text{C}-\text{C}-\text{CH}_3 \\ \quad \\ \text{H} \quad \text{H} \end{array}$ E/haloalkane: E is haloalkane of C₄H₉X with • same halogen as G AND • same carbon chain as F ✓	3	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous Note: working is required for first mark ALLOW use of 108 as A_r of Ag Note: E and F can be identified by correct name or structure BUT IGNORE incorrect names
			Total	10	

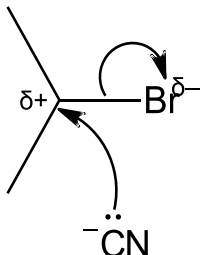
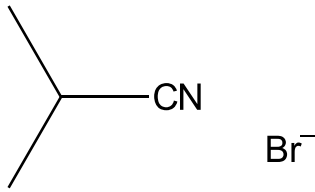
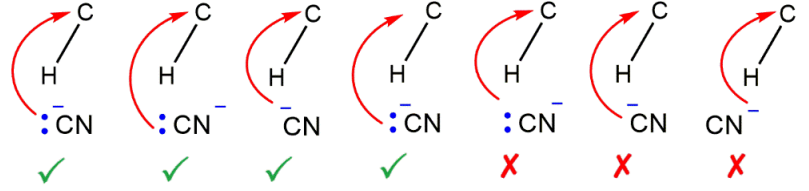
Question			Answer	Marks	AO element	Guidance
5	(a)		Formation of $\text{Cl}\cdot$ $\text{CClF}_3 \rightarrow \text{CF}_3\cdot + \text{Cl}\cdot \checkmark$ Breakdown of O_3 $\text{Cl}\cdot + \text{O}_3 \rightarrow \cdot\text{ClO} + \text{O}_2 \checkmark$ $\cdot\text{ClO} + \text{O} \rightarrow \text{Cl}\cdot + \text{O}_2 \checkmark$	3	AO2.5 AO1.1 x2	IGNORE dots for formation $\text{Cl}\cdot$, i.e. ALLOW $\text{CClF}_3 \rightarrow \text{CF}_3 + \text{Cl}$ DO NOT ALLOW ECF Dots required in this equation IGNORE $\text{O} + \text{O}_3 \rightarrow 2\text{O}_2$ ALLOW 1 mark if both equations are correct by atom but dot(s) missing or incorrect

Question	Answer	Marks	AO	Guidance
6	B	1	AO1.1	

Question	Answer	Marks	Guidance
7	D	1	

Question	Answer	Marks	Guidance
8	C	1	

Question			Answer	Marks	Guidance
9	(a)	(i)	Equation $ \begin{array}{c} \text{H} & \text{H} & \text{H} \\ & & \\ \text{H}-\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & \\ \text{H} & \text{CH}_3 & \text{H} \end{array} + \text{Br}_2 \longrightarrow \begin{array}{c} \text{H} & \text{Br} & \text{H} \\ & & \\ \text{H}-\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & \\ \text{H} & \text{CH}_3 & \text{H} \end{array} + \text{HBr} \quad \checkmark $ Name Radical substitution ✓ Bond fission homolytic (fission) ✓	3	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous IGNORE mechanism, need overall equation
18	(a)	(ii)	Further substitution/s OR Different termination products OR More than one termination step Substitution at different positions along (carbon) chain ✓	2	ALLOW dibromo/multibromo compounds formed OR example of further substitution product e.g. $\text{CH}_2\text{BrCBr}(\text{CH}_3)_2$ / $\text{C}_4\text{H}_8\text{Br}_2$ / 1,2-dibromo-2-methylpropane OR example of different organic termination product e.g. C_8H_{18} ALLOW more than one H (atom) can be replaced ALLOW radicals react with each other to form other products ALLOW a hydrogen (atom) on a different carbon (atom) can be replaced ALLOW Substitutions can occur at other carbons (along the chain) ALLOW example of substitution at different position on chain e.g. $\text{CH}_2\text{BrCH}(\text{CH}_3)_2$ / 1-bromo-2-methylpropane IGNORE references to separation of products IGNORE references to atom economy or yield

Question	Answer	Mark	Guidance
10 (a) (i)	Curly arrow from CN^- to $\text{C}^{(\delta+)}$ of $\text{C}-\text{Br}$ bond ✓ Dipole shown on $\text{C}-\text{Br}$ bond, $\text{C}^{\delta+}$ and $\text{Br}^{\delta-}$ AND curly arrow from $\text{C}-\text{Br}$ bond to Br atom ✓  Correct organic product AND Br^- ✓ 	3	ANNOTATIONS MUST BE USED ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous NOTE: curly arrows can be straight, snake-like etc., but NOT double headed or half headed arrows 1st curly arrow must: - go to C of $\text{C}-\text{Br}$ AND - start from, OR be traced back to any point across width of the lone pair on C of CN^- OR start from $-$ charge on C of CN^-  2nd curly arrow must start from, OR be traced back to, any part of $\text{C}-\text{Br}$ bond and go to Br IGNORE presence of K^+ BUT KBr does NOT show Br^- ALLOW $\text{S}_{\text{N}}1$ mechanism: - Dipole on $\text{C}-\text{Br}$ bond AND curly arrow from the $\text{C}-\text{Br}$ bond to Br ✓ - Correct carbocation AND Curly arrow from CN^- to C^+ on carbocation ✓ - Correct organic product AND Br^- ✓

Question			Answer	Mark	Guidance
10	(a)	(ii)	Nucleophilic substitution ✓	1	
19	(b)	(i)	NaBr AND H ₂ SO ₄ ✓	1	ALLOW HBr (IGNORE additional acid if given e.g HBr and H₂SO₄) ALLOW KBr instead of NaBr ALLOW H₃PO₄ OR HNO₃ in place of H₂SO₄ BUT NOT HCl ALLOW PBr₃ ALLOW names if no formulae given IGNORE conc OR dilute OR (aq) IGNORE H⁺/Acid (<i>must be clear which acid should be used</i>)

Question			Answer	Mark	Guidance
10	(b)	(ii)	Step 1 (Add to) separating funnel ✓ (Use of) bottom layer (containing 1-bromopropane / organic) ✓ Step 2 Dry with (one of the following) • an anhydrous salt • MgSO_4 /magnesium sulfate • CaCl_2 /calcium chloride ✓ Step 3 (Re)Distil (and collect the fraction) at 71°C ✓	4	ANNOTATIONS MUST BE USED Mark each step in order but then don't mark any further if response refers to purification of a solid e.g. dissolve in minimum amount of hot solvent, evaporate off water to allow solid to crystallise IGNORE use of base/carbonate (to remove excess acid) OR (saturated) NaCl ALLOW (remove) aqueous layer on the top ALLOW description that aqueous layer can be determined by adding water and seeing which layer increases in size IGNORE distillation OR filtration prior to step 1 OR step 2 ALLOW 'to remove water' instead of 'dry' IGNORE any other salt IGNORE filtration to remove anhydrous salt after step 2 ALLOW temperature range of $70 - 72^\circ\text{C}$ for distillation DO NOT ALLOW if forms a solid product