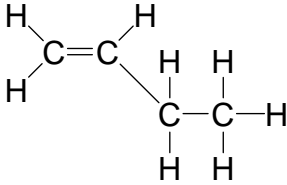
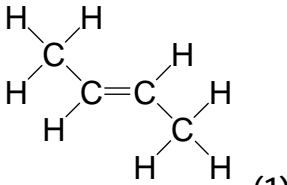
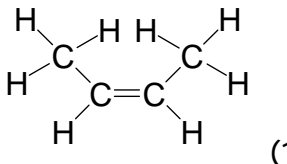


Question Number	Correct Answer	Reject	Mark
1 (a)(i)	Reaction 1 - (nucleophilic) substitution (1) Reaction 2 - elimination (1)		2

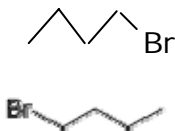

Question Number	Correct Answer	Reject	Mark
1 (a)(ii) QWC	Reaction 1 - Water can behave as a nucleophile /water can donate a lone pair (from oxygen)/water has a lone pair/water forms an OH^- ion (1) And attack (positive) carbon (originally attached to Cl)/bonds to the carbon/bonds to the carbocation (1) Reaction 2 - behaves as a base (1) and accepts a hydrogen ion/proton / donates e^- pair to H/removes a proton/removes a hydrogen ion/removes a H^+ (1) In each case a correctly drawn mechanism could get (2)	Removes a H atom	4

Question Number	Correct Answer	Reject	Mark
1 (b)(i)	Heterolytic (fission) Notes Accept phonetic/incorrect spelling as long as the word is recognisable		1

Question Number	Correct Answer	Reject	Mark
1 (b)(ii)	<p>Butyl group less electron releasing/butyl group has less of a (positive) inductive effect (1)</p> <p>so less stable (positive charge on) carbocation (1)</p> <p>OR</p> <p>1- chlorobutane is a primary halogenoalkane/the carbon only has 1 other C attached (1)</p> <p>So forms a less stable carbocation (1)</p> <p>OR</p> <p>Primary carbocation is less stable than a tertiary carbocation (2)</p> <p>OR</p> <p>Water/OH^- can attack C on 1° chloroalkane more easily (so no need to form cation) OWTTE / 1° chloroalkane reacts via SN_2 mechanism/C-O bond forms before C-Cl breaks (1)</p> <p>As the carbon attacked is not surrounded by bulky groups OWTTE (1)</p>	Negative inductive effect	2

Question Number	Correct Answer	Reject	Mark
1 (c)	<p>Hydrogen (ion) can be eliminated from C on either side (of C attached to Cl)/double bond can form between 1st and 2nd or 2nd and 3rd carbon OWTTE (1)</p> <p>OR</p> <p>double bond can't rotate (so methyl group and hydrogens can be fixed in position) to form E and Z isomers / geometric isomers/cis and trans/stereoisomers/or named in diagrams OWTTE (1)</p> <p>allow descriptions in terms of cis and trans</p> <div style="text-align: center;">  <p>(1)</p> </div> <div style="text-align: center;">  <p>(1)</p> </div> <div style="text-align: center;">  <p>(1)</p> </div> <p>Methyl and ethyl groups do not need to be fully displayed</p> <p>Structural formulae/skeletal formulae For all 3 (2) For 2 (1) For 1 (0)</p> <p>For an incorrect haloalkane structure that can form 3 isomers including cis/trans (2 max) (eg 2-chloropentane)</p>		4

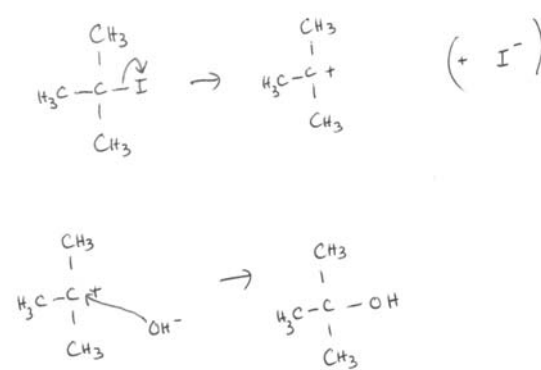
Question Number	Correct Answer	Reject	Mark
1 (d)	<p>(Slower) as C-F bond is stronger (than C-Cl)/fluorine bonds more strongly/fluorine holds the carbon more strongly</p> <p>OR</p> <p>Slower as F⁻ is a poorer leaving group (than Cl⁻) (1)</p> <p>Use sodium hydroxide /NaOH/ potassium hydroxide /KOH/ hydroxide ions (1)</p> <p>As OH⁻ is a stronger nucleophile / OH⁻ has a full negative charge/ more strongly attracted to C^{δ+} /OH⁻ has more lone pairs (than water)/ OH⁻ is more negative than water (1)</p>	<p>Alkali Hydroxide</p>	3

Question Number	Acceptable Answers	Reject	Mark
2(a)(i)	 <p>Allow the bond to Br to be before or after the zig-zag line representing the 4C atoms, and to be at any angle Ignore bonds of unequal length</p>		1

Question Number	Acceptable Answers	Reject	Mark
2(a)(ii)	<p>2-iodo-(2-)methylpropane</p> <p>Accept (2-)methyl-2-iodopropane</p> <p>Ignore punctuation (brackets, hyphens, commas)</p>	<p>2,2-iodomethylpropane</p> <p>2-iodobutane</p>	1

Question Number	Acceptable Answers	Reject	Mark
2(a)(iii)	<p>$C_4H_9Br + 2NH_3 \rightarrow C_4H_9NH_2 + NH_4Br$ OR $C_4H_9Br + NH_3 \rightarrow C_4H_9NH_2 + HBr$ OR $C_4H_9Br + NH_3 \rightarrow C_4H_9NH_3^{(+)}Br^{(-)}$ (1)</p> <p>Accept structural / skeletal formula for X and product Allow inorganic product as ions</p> <p>Butylamine / 1-aminobutane / 1-butylamine/ 1-butanamin butan-1-amine (1)</p> <p>Ignore incorrect spacing and punctuation</p> <p>OR (N) butyl ammonium bromide if third equation given (1)</p> <p>OR Answers with multiple substitutions giving (C_4H_9)₂ NH (1) dibutylamine (1) (C_4H_9)₃ N (1) tributylamine (1) (C_4H_9)₄ N⁽⁺⁾ Br⁽⁻⁾ (1) tetrabutyl ammonium bromide (1)</p> <p>No TE on naming a product in an incorrect equation except if C_4H_8 is shown in a correct or incorrect elimination equation then 1 mark for naming it but-1-ene</p>	<p>Just word equations</p> <p>Molecular formula for organic product i.e. $C_4H_{11}N$</p> <p>Equation for elimination reaction</p> <p>Aminobutane</p> <p>Butamine</p> <p>Any amide</p>	2

	If correct equation and name (e.g. 2-amino-2-methylpropane) are given using Y max 1		
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Question Number	Acceptable Answers	Reject	Mark
2 (a)(iv)	 <p>Arrow to I from within C-I bond (1) Formula of carbocation (1) Arrow from OH⁻ to C⁺ (1)</p> <p>If both arrows are shown before formation of intermediate max 2</p> <p>Charge on OH⁻ essential for third mark. Lone pair need not be shown. Ignore partial charges on C and I in Y</p> <p>Ignore arrows showing hydroxide ion formation in KOH / covalent KOH Ignore K⁺ ions combining with I⁻ / inorganic products Mechanism for X instead of Y Max 2</p> <p>Correct SN2 mechanism can score first mark and third mark for arrow from OH⁻ to C^(δ+)</p>	Half arrows, but don't penalise twice δ ⁺ charge on intermediate	3

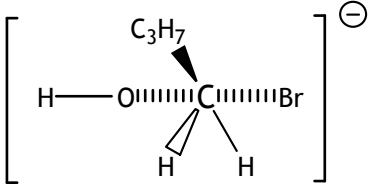
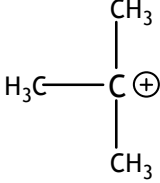
Question Number	Acceptable Answers	Reject	Mark
2(a)(v)	(Nucleophilic) elimination (reaction) (of HI)	Electrophilic elimination Nucleophilic substitution Dehydration	1

Question Number	Acceptable Answers	Reject	Mark
2(b)	<p>X Cream precipitate Allow off white / creamy white / white-cream / (very) pale yellow (1)</p> <p>Y yellow precipitate (1)</p> <p>One mark for two correct colours but not precipitates Mention of precipitate without colours doesn't score Ignore identity of precipitates even if incorrect</p>	<p>Yellow/ creamy yellow precipitate for X</p> <p>Pale yellow precipitate for Y</p>	2

Question Number	Acceptable Answers	Reject	Mark
2(c)	<p>C-Br stronger / C-I weaker with an attempt at an explanation (correct or incorrect) (1)</p> <p>as bond is shorter/ Br (atom) is smaller / as nuclei are closer</p> <p>OR reverse argument (1)</p> <p>Allow Br is more electronegative/ there is a bigger electronegativity difference / bond is more polar / $C^{\delta+}$ and $Br^{\delta-}$ attract more strongly / Br is less shielded</p> <p>Second mark depends on first</p>	<p>Br_2 is smaller</p> <p>References to Br^- implying bond is ionic.</p> <p>Br is more reactive</p>	2

Question Number	Acceptable Answers	Reject	Mark
3(a)	<p>Names OR Formulae</p> <p>A = NaOH/KOH in ethanol /alcohol (1)</p> <p>B = NaOH/KOH in water/ aqueous (1) IGNORE any reference to ethanol /alcohol /dilute</p> <p>C = NaBr/KBr & (50% or moderately conc) H₂SO₄ / P & Br₂ / PBr₃ /PBr₅/NaBr /KBr & H₃PO₄ /HBr ALLOW phosphorus bromide (1)</p> <p>IGNORE red/white (phosphorus)</p> <p>D = NH₃ (in alcohol /in a sealed tube /at high pressure) (1)</p> <p>IGNORE aqueous</p>	<p>Water + ethanol /water + alcohol For A and B OH⁻/alkali (penalise once)</p> <p>Dilute H₂SO₄</p> <p>any mention of alkali</p> <p>any mention of acid</p>	4

Question Number	Acceptable Answers	Reject	Mark
3(b)(i)	<p>A = elimination (1)</p> <p>IGNORE 'nucleophilic'</p> <p>D = (nucleophilic) substitution (1)</p>	<p>mention of dehydration in A</p> <p>mention of electrophilic in A or D</p>	2

Question Number	Acceptable Answers	Reject	Mark
<p>3(b)(ii)</p>	<p>Mark the diagrams; then mark the explanation sections together Score (1) for intermediate/ transition state wrong way round</p> <div style="text-align: center;">  </div> <p>IGNORE geometry and missing minus sign and $\delta+$/ $\delta-$ (1)</p> <div style="text-align: center;">  </div> <p>(1)</p> <p>Any two from</p> <p>Tertiary carbocation more stable (than primary carbocation) ALLOW Tertiary carbocation very stable/fairly stable/stable (1) This mark can be awarded even if structures and other explanations are incorrect or missing</p> <p>Methyl groups stabilise charge (of carbocation) (through positive inductive effect)</p> <p>Steric hindrance (by methyl groups) inhibits formation of (trigonal bipyramid) transition state/attack by nucleophile with tertiary compound</p> <p>Steric hindrance is less with the primary halogenoalkane/more with tertiary halogenoalkane</p> <p>ALLOW a description of steric hindrance e.g. blocking/less space</p>	<p>Full O—C—Br bonds</p> <p>OH—C</p> <p>+ sign</p> <p>$\delta+$</p> <p>Just 'primary carbocation unstable'</p>	<p>4</p>

Question Number	Acceptable Answers	Reject	Mark
3(b)(iii)	<p>C–I bond weaker ALLOW C–I bond easier to break</p> <p>ALLOW iodine forms weaker bonds than bromine without mention of carbon</p> <p>ALLOW reverse arguments with C–Br bond stronger</p> <p>IGNORE Explanations in terms of electronegativity or bond polarity or activation energy or shielding even if incorrect</p>	Just C–I bond longer	1

Question Number	Acceptable Answers	Reject	Mark
3(c)(i)	<p>(Boiling) absorbs heat (allow energy)/latent heat (of vaporization)/enthalpy of vaporization from the surroundings/endothermic.</p> <p>If bonds are mentioned they must be intermolecular</p>		1

Question Number	Acceptable Answers	Reject	Mark
3(c)(ii)	<p>Any two from</p> <p>Not flammable Not toxic Unreactive/inert/non-corrosive (only one of these can score) (easily) compressible does not harm the ozone layer Boiling temperature below target temperature</p> <p>ALLOW low boiling temperature high heat of vaporization high gas density high critical temperature</p> <p>IGNORE Non-polluting/ environmentally friendly/ cheap/easily manufactured/ easy to store/easy to contain /take up little space/low melting point/endothermic/ harmful</p>	<p>Does not produce CFCs Gas/solid</p> <p>stable</p>	2

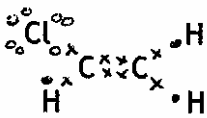
Question Number	Acceptable Answers	Reject	Mark
4(a)(i)	Reagent: chlorine/ Cl ₂ (1) Condition: uv/ sunlight (1) ALLOW light Mark independently Ignore reference to temp and pressure if given with uv light. If answers reversed/both on one line 1 out of 2	Cl Just "heat"	2

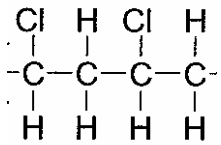
Question Number	Acceptable Answers	Reject	Mark
4(a)(ii)	(free) radical (1) Substitution (1) Mark independently		2

Question Number	Acceptable Answers	Reject	Mark
4(b)(i)	Hydrogen chloride / HCl	Hydrochloric acid Chlorine HCl (aq) Cl ₂	1

Question Number	Acceptable Answers	Reject	Mark
4(b)(ii)	<p>Curly (not half headed) arrow from C=C to H (1) Curly arrow from bond in H-Cl to Cl (1) Curly arrow from Cl⁻ to C⁺ (1)</p> <p>Partial charges on HCl not required Lone pairs on Cl⁻ not required It should be clear if arrows are to/ from a bond or an atom, but give allowance for precise position Correct intermediate without arrows (1)</p> <p>Correct addition of HBr max 2 Correct addition of HCl to propene max 2 Max 2 for addition of Cl₂ instead of HCl (forming 1,2 - dichloroethane) Max 1 for addition of Cl₂ instead of HCl forming chloroethane</p>	<p>Attack by Cl^{δ-} or Cl[·] loses 3rd mark only</p> <p>Correct free radical mechanism from ethane and chlorine scores 0</p>	3

Question Number	Acceptable Answers	Reject	Mark
4(c)	<p>Higher atom economy from ethene /by electrophilic addition Higher yield from ethene Both correct for (1)</p> <p>From ethene only one product / all atoms are used making product /no unwanted products (1)</p> <p>For ethene yield high as no di-, tri- etc substituted products form /only one product / no by-products OR no side reactions occur OR no C₄ compounds can form (1) [Or reverse argument]</p>	Not much product is lost	3

Question Number	Acceptable Answers	Reject	Mark
4(d)(i)	 <p>Double bond and electrons around C correct (1) Other electrons correct (1) Can be all dots or all crosses</p> <p>First mark can be given if C₂H₄ drawn correctly Second mark can be given if C₂H₅Cl drawn correctly Don't penalise if bonds shown as well as electrons</p>		2

Question Number	Acceptable Answers	Reject	Mark
4d)(ii)	 <p>ALLOW H and Cl below C chain; Cl on C2 and C3 or C1 and C4; formula above with brackets at each end and n outside end bracket</p> <p>End bonds should be shown, but don't penalise if these don't go through brackets H atoms should be shown</p>	<p>Formula not displayed One monomer unit shown in bracket with the number 2 outside bracket</p> <p>Cl on C1 and C2 Cl on C3 and C4</p>	1

Question Number	Acceptable Answers	Reject	Mark
4(d)(iii)	<p>QWC Any 2 Answers could consider the following factors:</p> <ul style="list-style-type: none"> • energy for manufacture • availability / abundance of raw materials • lifetime of product/ how often will it need to be replaced /metal rusts/plastic more easily punctured etc • ease of recycling /steel an excellent recyclable material • consequences of disposal / is it biodegradable? • Is it from a non-renewable resource? • Atom economy in manufacture <p>Allow answers comparing specific properties (if correct) illustrating the relevant property Examples PVC will last longer than iron due to lack of corrosion (1) PVC comes from oil which is non-renewable (1) PVC and metals come from non-renewable sources (1) Credit any two valid points</p>	<p>Ignore if other answers given: cost PVC biodegradable its carbon footprint Is it environmentally friendly?</p> <p>Pollution comments without reference to resources needed to clean up</p>	2