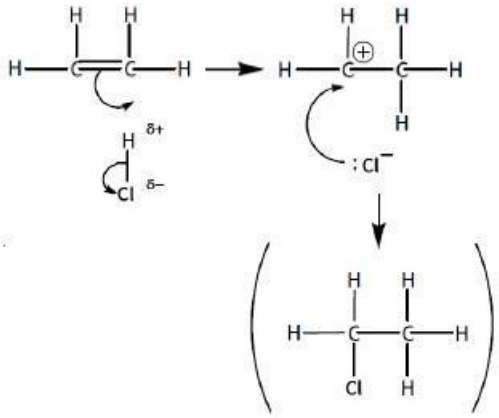
Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following point: • HCl((g)) / hydrogen chloride (gas)	Do not award hydrochloric acid / HCl(aq) / chlorine / Cl_2 / Cl If name and formula are both given, both must be correct	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following points: • dipole present on hydrogen chloride (1) • arrow from C=C **bond** to H or to where bond will be and arrow from H–Cl **bond** to, or just beyond, Cl (1) • correct carbocation intermediate (1) • arrow from **lone pair** on chloride ion to positive carbon in carbocation (to give correct product) (1)	 Allow TE for use of Cl_2 in (a)(i), but max (3) if chloroethane is formed as the product Use of the wrong alkene (e.g. propene) or the wrong hydrogen halide (e.g. HBr) cannot score M4	(4)

Q2.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following point: • Vinyl chloride is the **monomer** from which (the polymer) polyvinyl chloride is made Or the **polymer** polyvinyl chloride is made from the (monomer) vinyl chloride	Correct answers will include monomer, polymer or words describing bonding / joining / linking of the vinyl chloride Allow pvc for polyvinyl chloride throughout Allow many vinyl chloride molecules joined / bonded together to make polyvinyl chloride Allow vinyl chloride is the repeat unit in polyvinyl chloride	**(1)**

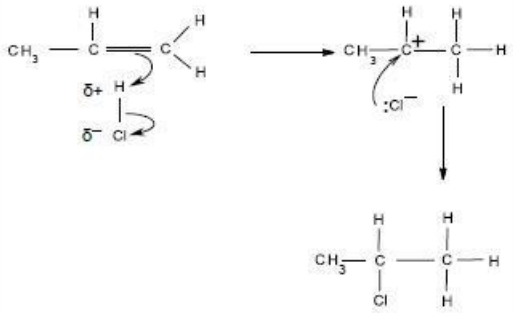
Q3.

Question Number	Answer		Additional Guidance	Mark
	An answer that makes reference to two of the following points:			**(2)**
	• recycling	**(1)**	Allow remoulding Allow made into other items / description of recycling	
	• incineration to release energy	**(1)**	Allow for burning as a fuel Ignore just 'for incineration'	
	• as a feedstock for cracking	**(1)**	Ignore just 'as a feedstock'	

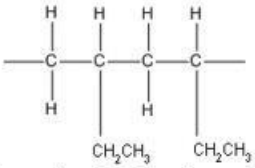
Q4.

Question Number	Acceptable Answer	Mark
(i)	**The only correct answer is B** ***A*** *is not correct because reaction is not substitution* ***C*** *is not correct because reaction is not substitution, nor nucleophilic* ***D*** *is not correct because reaction is not nucleophilic*	**(1)**

Question Number	Acceptable Answer	Mark
(ii)	**The only correct answer is C** ***A*** *is not correct because no C=C present* ***B*** *is not correct because no C=C present* ***D*** *is not correct because these are not stereoisomers*	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	An answer which shows the following: • curly arrow from double bond to H atom of HCl/space between double bond and H atom of HCl **(1)** • correct dipole on HCl molecule and curly arrow from H-Cl bond to Cl atom **(1)** • intermediate with + charge shown on correct carbon **(1)** • curly arrow from lone pair on chloride ion to correct carbon **(1)**	Example of mechanism  incorrectly drawn starting molecule loses M1, e.g. missing H or pentavalent carbon. incorrect starting molecule, e.g. butene will lose M3. if product is 1-chloropropane M3 only is lost. Other errors in end product lose M4 use of HBr in place of HCl loses M2 only use of H^+ and Cl^- loses M1 and M2	**(4)**

Q5.

Question Number	Answer	Additional Guidance	Mark
(i)	• 2 repeat units with extension bonds	Example of two repeat units  The extension bonds can be solid / dotted / dashed Allow C_2H_5 for the side chains Allow ethyl groups on carbon atoms: 1 and 3, 2 and 4, 1 and 4 or 2 and 3 Allow skeletal formula / any combination of structural or displayed formulae Ignore brackets / n Ignore connectivity of vertical CH_2CH_3 groups	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	• calculation of moles of but-1-ene **(1)** • calculation of number of molecules of but-1-ene **(1)**	Example of calculation moles of but-1-ene = $\frac{70.0}{56.0}$ = 1.25 (mol) molecules of but-1-ene = 1.25 x 6.02 x10^{23} = 7.525 x 10^{23} TE on moles but-1-ene Ignore SF except 1 SF Do not award M2 for mass x 6.02 x10^{23} Correct answer with no working scores (2)	(2)

Q6.

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td></td><td>A description that makes reference to two of the following points:

• reagent (1)

• corresponding observation (1)</td><td>Examples of reagents and observations

<table>
<tr><th>Reagent</th><th>Observation</th></tr>
<tr><td>bromine water
Allow bromine (in an organic solvent)</td><td>orange / yellow / brown solution goes colourless
Allow bromine water is decolourised</td></tr>
<tr><td>carboxylic acid and (concentrated) H_2SO_4 / HCl / H^+</td><td>characteristic smell (of an ester)</td></tr>
<tr><td>acidified potassium manganate(VII) / permanganate</td><td>purple to colourless / decolourised</td></tr>
<tr><td>alkaline potassium manganate(VII)</td><td>purple to green</td></tr>
<tr><td>(neutral) potassium manganate(VII)</td><td>purple to brown ppt</td></tr>
<tr><td>acidified (potassium) dichromate((VI)) (ions)</td><td>orange to green</td></tr>
</table>

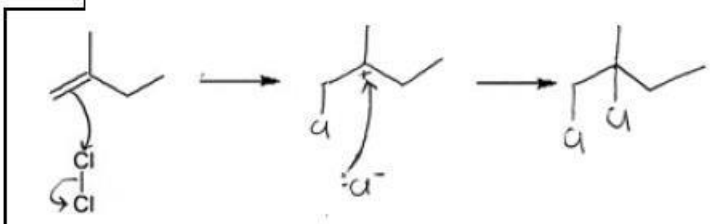
Allow names or formulae for reagents but if both are given, both must be correct

Ignore conditions e.g. heat

Do not award PCl_5 / Na

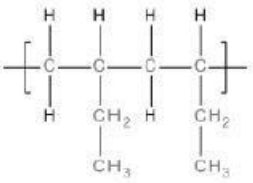
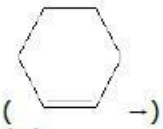
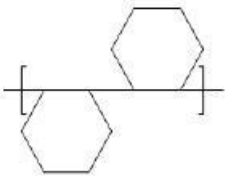
If more than one test is given, penalise any incorrect tests</td><td>(2)</td></tr>
</table>

Q7.

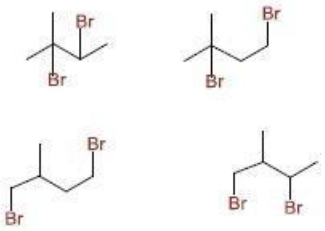
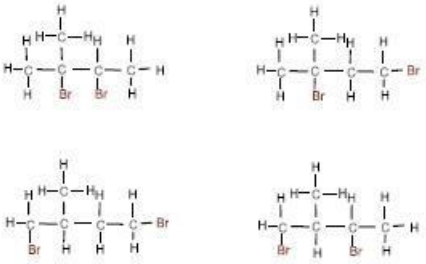
Question Number	Answer	Additional Guidance	Mark
(i)		Example of mechanism:	(3)
	• curly arrow from C=C to chlorine **and** curly arrow from Cl–Cl to 'bottom' chlorine atom(**1**)	Ignore dipoles even if incorrect	
	• structure of carbocation intermediate **and** structure of final product **(1)**	Allow correct structural/displayed formulae for intermediate and/or product	
	• chloride ion with lone pair **and** curly arrow from lone pair to C+ of carbocation **(1)**	Allow TE on incorrect primary carbocation	

Question Number	Answer	Additional Guidance	Mark
(ii)	• 1,2-dichloro-2-methylbutane	Allow name shown on mechanism Ignore missing hyphens and commas Do not allow 2-methyl-1,2-dichlorobutane TE on structure in (a)(i) Allow correct name even if incorrect structure in (i)	(1)

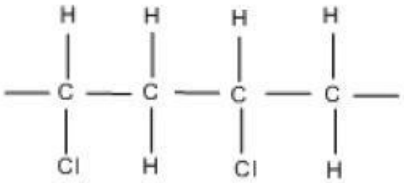
Q8.

Question Number	Answer	Additional Guidance	Mark
	($CH_2=CHCH_2CH_3-$)  **(1)**   (→) **(1)**	Accept skeletal, structural or displayed formulae or combination of which is clear, e.g. $-C_2H_5$ Brackets are not essential Ignore 'n' Ignore orientation of side chains Ignore bond length Ignore where bond goes to for the ethyl groups Penalise lack of 'end-bonds' once only Award 1 mark max if only one repeat unit given for each polymer Ignore more than 2 repeat units	**(2)**

Q9.

Question Number	Acceptable Answer	Additional Guidance	Mark
	 one mark for each structure	accept displayed/structural/skeletal formulae  Allow 2 marks for 4 different and correct monobromo isomers Allow 1 mark for 2/3 different and correct monobromo isomers Zero for 1 monobromoisomer accept correct enantiomers (provided both C=C bond react) Deduct one mark only for use of HCl Deduct one mark for (any number of) missing hydrogens	(4)

Q10.

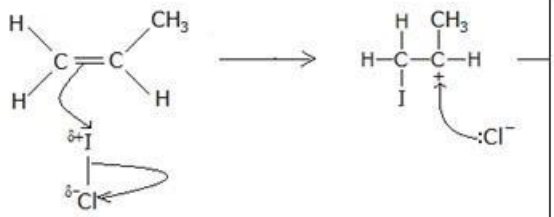
Question Number	Acceptable Answer	Additional Guidance	Mark
(i)		must show **two** repeat units fully displayed allow head to head, head to tail, tail to tail, syndiotactic and isotactic stuctures do not award any other type of formula ignore brackets and n	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following: • (incineration produces) HCl/chlorinated molecules **(1)** • which are corrosive/toxic /cause acid rain **(1)**	M2 is dependent on M1 allow chlorine ignore carbon dioxide and its consequences allow adverse effect on ozone layer	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to the following: any appropriate precautions to deal with toxic vapours/use fume cupboard etc.	allow good ventilation required allow gas mask/respirator do not award just mask ignore gloves, lab coat	**(1)**

Q11.

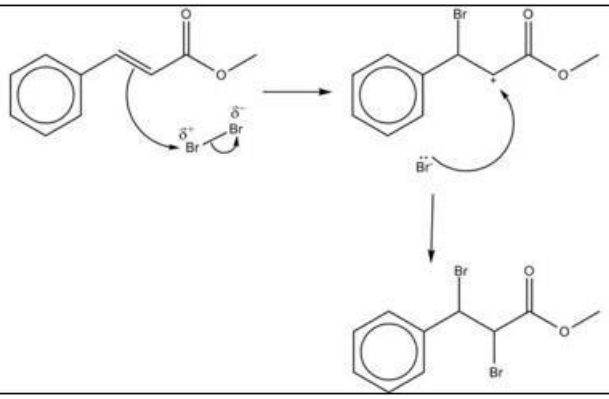
Question Number	Answer	Additional Guidance	Mark
(i)	• diagram showing bond polarity using partial charges δ+ on iodine and δ- on chlorine	$I^{\delta+}-Cl^{\delta-}$	**(1)**

	Answer		Additional Guidance	Mark
(ii)				(3)
	• arrow from double **bond** to $I^{\delta+}$ and arrow from I–Cl **bond** to $Cl^{\delta-}$	**(1)**	Award M1 if dipoles are reversed in (b)(i) and arrow to $Cl^{\delta+}$ Arrows should come from, or very close to, bonds and go to, or very close to, atoms. Allow arrow to I with no δ+ if given correctly in (i)	
	• intermediate **secondary** carbocation with positive charge on carbon in the **2** position	**(1)**	Mark is for secondary carbocation so **TE from (b)(i)** for carbocation from addition of Cl first in M1 Do not award δ+ instead of + Do not award δ- instead of –	
	• arrow from **lone pair** on Cl^- to electron deficient carbon of carbocation	**(1)**	If dipole is reversed in (i) award mark for arrow from lone pair on I^- to electron deficient carbon of carbocation Ignore missing final product Allow M1 & M3 for minor product	

Q12.

Question Number	Answer	Additional Guidance	Mark
(i)	• **M1** arrow from double bond to (δ+)Br in Br_2 (1) • **M2** arrow from bond in Br_2 to $Br^{\delta-}$ (1) • **M3** structure of carbocation (1) • **M4** arrow from **lone pair** on Br^- to C^+ in carbocation **and** final product (1)	Example of mechanism **See below** Penalise lack of dipole only once in M1 and M2 Award C^+ in intermediate on either C from the double bond Do not award M3 if four bonds are shown on carbocation Br atoms can be shown either upwards or downwards in final product Award (0) if just electrophilic substitution mechanism given. If **both** electrophilic substitution and addition shown allow 2 max Penalise errors in structure of methyl cinnamate once only in either M3 or M4	**(4)**

Example of mechanism



Question Number	Answer	Mark
(ii)	**The only correct answer is C (4)** **A** *is not correct because 2 chiral centres form in reaction, so 4 possible combinations of +/- forms* **B** *is not correct because 2 chiral centres form in reaction, so 4 possible combinations of +/- forms* **D** *is not correct because 2 chiral centres form in reaction, so 4 possible combinations of +/- forms*	**(1)**

Question Number	Answer	Mark
(iii)	**The only correct answer is D** (rotated) **A** *is not correct because diffracted is the wrong term* **B** *is not correct because reflected is the wrong term* **C** *is not correct because refracted is the wrong term*	**(1)**

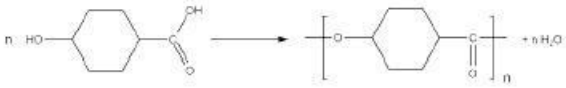
Q13.

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>*</td><td>This question assesses the student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5-4</td><td>3</td></tr>
<tr><td>3-2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
The following table shows how the marks should be awarded for structure and lines of reasoning
<table>
<tr><th></th><th>Number of marks awarded for structure of answer and sustained lines of reasoning</th></tr>
<tr><td>Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table></td><td>Guidance on how the mark scheme should be applied:
The mark for indicative content should be added to the mark for lines of reasoning.
For example, a response with four indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).
If there were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and zero marks for linkages).</td><td>(6)</td></tr>
</table>

	Indicative content • **IP1** in both cases many monomers join (by covalent bonds to form polymers) • **IP2** cyclohexene forms an addition polymer / the polymer is formed by an addition reaction • **IP3** 4-hydroxycyclohexanecarboxylic acid forms a condensation polymer / the polymer is formed by a condensation reaction • **IP4** no additional products from when cyclohexene polymerises, but water is also	Allow both polymerisations require a catalyst Allow both polymers are formed from a single type of monomer Allow unsaturated monomer forms saturated polymer	

	formed when 4-hydroxycyclohexanecarboxylic acid polymerises • **IP5** • **IP6**  	Allow 'only 1 product in addition but two products in condensation' Allow only one functional group is needed for addition polymerisation but two different functional groups are needed for condensation polymerisation Allow cyclohexene polymerisation has 100% atom economy, 4-hydroxycyclohexanecarboxylic polymerisation has less than 100% atom economy Ignore omitted or misplaced n in **IP5** and **IP6** Allow 1 IP for IP5 and IP6 if both correct repeat units shown Allow 2 oxygen atoms on RHS and none on LHS for IP6 repeat unit	

Q14.

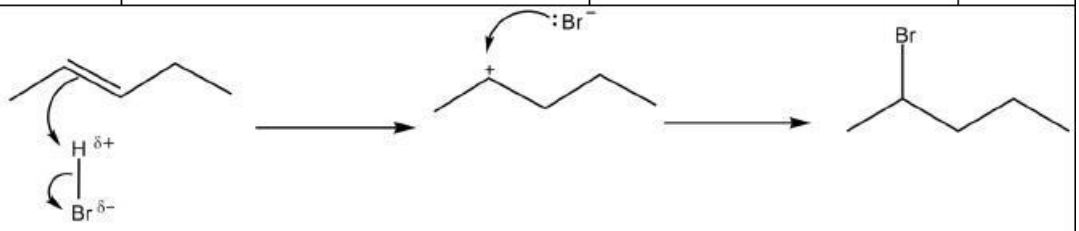
Question Number	Acceptable Answer	Additional Guidance	Mark
	2 **(1)** number of C atoms in geraniol = 10, C atoms in isoprene = 5, (10/5 = 2) **(1)**	Note: this must be a whole number Allow answers using C chain length ie isoprene = 4, geraniol = 8 Ignore number of hydrogens in both isoprene and geraniol Do not award answers using M_r	**(2)**

Q15.

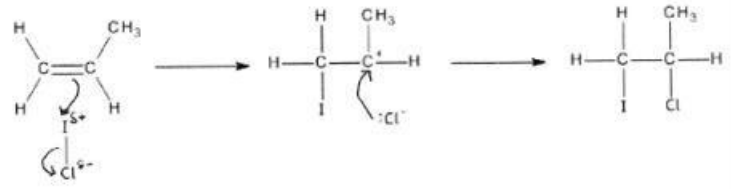
Question Number	Acceptable Answer	Mark
	The only correct answer is **B** ***A*** *is incorrect because this is an oxidising agent for alcohols not alkenes* ***C*** *is incorrect because this would not react* ***D*** *is incorrect because this would only produce an alcohol*	**(1)**

Q16.

Question Number	Answer	Additional Guidance	Mark
	• arrow from double bond to $\partial+$ H in HBr (1) • arrow from bond in HBr to $Br^{\partial-}$ (1) • structure of carbocation (1) • arrow from lone pair on Br^- to C^+ in carbocation and final products (1)	Penalise lack of dipole only once in M1 or M2 Do not award M1 if arrow from C=C to C also shown Formation of 3-bromopropane can potentially score M1, M2 and M4 as a TE	(4)



Q17.

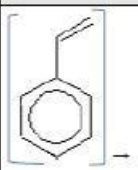
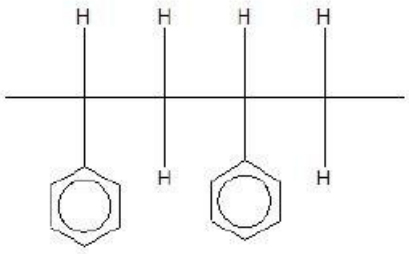
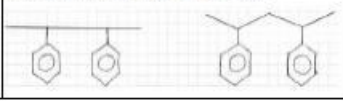
Question Number	Answer	Additional Guidance	Mark
	• dipole on I-Cl **and** correct major product **(1)** • curly arrow from C=C to I **and** curly arrow from I-Cl to, or just beyond, Cl **(1)** • intermediate **(1)** • lone pair on Cl^- **and** curly arrow from **lone pair** to C^+ **(1)**	Example of mechanism  Do not award $C^{\delta+}$ on intermediate Allow curly arrow from lone pair to $C^{\delta+}$ if penalised in M3 **Notes** If minor product formed, M2, M3 (with I on other carbon atom) and M4 can score If dipole shows $Cl^{\delta+}$ or no dipole shown and Cl joining first, M2 can score for curly arrow from C=C to Cl **and** curly arrow from Cl-I to, or just beyond, I and M4 can score for lone pair on I^- **and** curly arrow from lone pair to C^+	**(4)**

Q18.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	• hydrogen chloride / HCl((g)) / H–Cl	Do not award hydrochloric acid / HCl(aq)	**(1)**

Question Number	Answer	Mark
(ii)	**The only correct answer is A (electrophilic addition)** **B** *is not correct because the reaction involves attack by an electrophile* **C** *is not correct because the reaction is an addition not a substitution* **D** *is not correct because the reaction is an addition involving attack by an electrophile*	**(1)**

Q19.

Question Number	Acceptable Answer	Additional Guidance	Mark
	 	Accept skeletal, structural or displayed formulae Accept any orientation of benzene ring Ignore brackets Ignore 'n' / '2n' / '$^{n}/_{2}$' Allow syndiotactic and atactic forms Allow more than two units, as long as all correct. Neither of these diagrams scores Both have missing CH_2 	(1)

Q20.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	Reagent: • B is hydrogen / H_2 (gas) **(1)** Condition: • nickel/ Ni (catalyst) **(1)**	mark independently allow any other suitable transition metal catalysts eg Pt, Pd ignore additional information relating to the support for the catalyst ignore references to heating/pressure/UV	**(2)**

Question Number	Acceptable Answer	Mark
(ii)	**The only correct answer is C** **A** is not correct because water is not involved **B** is not correct because there is no increase in number of oxygen atoms **D** is not correct because no substitution has taken place	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	margarine	allow liquid coal allow butter substitute do not award just butter	(1)

Q21.

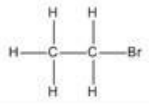
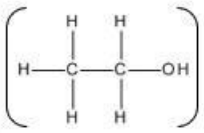
Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following point: • the hydride ion will not attack / will be repelled by regions of high electron density	Allow the reduction by $LiAlH_4$ is a nucleophilic addition / alkenes do not undergo nucleophilic reactions / H^- is a nucleophile Allow alkenes react with H^+ / $H^{\delta+}$ / H• Allow the hydride ion will not attack a pi-bond / C=C Allow like charges repel Ignore hydride ions cannot reduce alkenes Ignore hydride ions can only reduce carbonyl compounds	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following points: • hydrogen / H_2 **(1)** • nickel / Ni **or** platinum / Pt / palladium / Pd **(1)**	Mark independently Ignore reference to temperature	(2)

Question Number	Answer	Additional Guidance	Mark
(iii)	• 1-bromobutane / $CH_3CH_2CH_2CH_2Br$	If name and formula are given, both must be correct Allow Cl or I instead of Br Allow skeletal or displayed formulae	(1)

Question Number	Answer	Additional Guidance	Mark
(iv)	• hydrochloric acid / HCl / H^+	Allow any (dilute) strong acid Ignore concentration of acid Do not award any weak acid	(1)

Q22.

Question Number	Answer	Additional Guidance	Mark
	• product in Reaction **1** **(1)** • reagent in Reaction **2** **(1)** • condition in Reaction **2** **(1)**	Example of table Reaction 1: Reagent and condition: (HBr at room temperature); Product:  Reaction 2: Reagent and condition: steam / $H_2O(g)$ and acid / H^+; Product:  Allow structural / skeletal / molecular formula / name for (1-)bromoethane Allow water / H_2O **and** heat instead of steam Allow specific acid e.g. (concentrated) phosphoric acid / sulfuric acid Ignore any specific temperature and pressure Do not award acid if mention of any reagent other than steam / water e.g. acidified dichromate	(3)