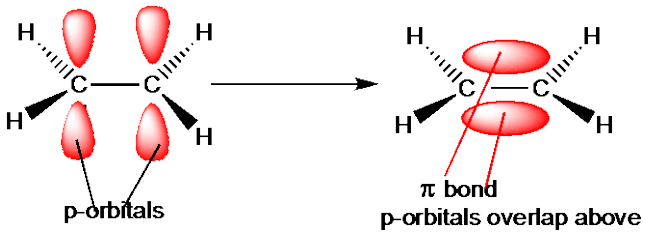
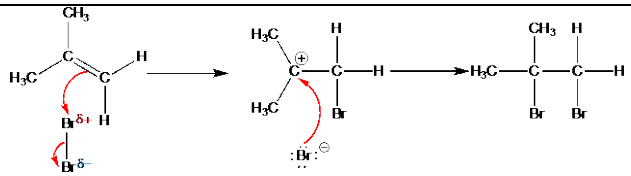
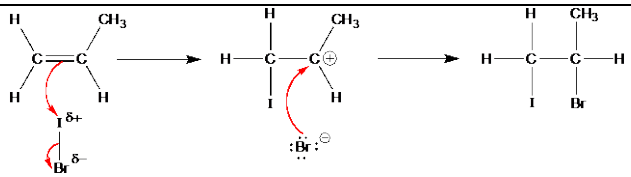
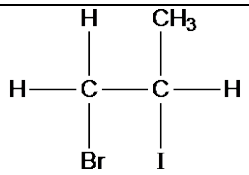
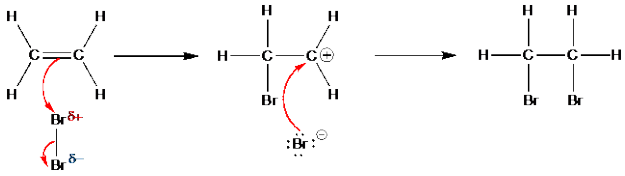
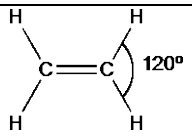
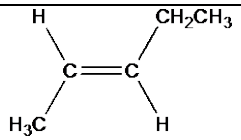
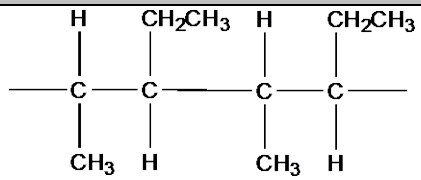
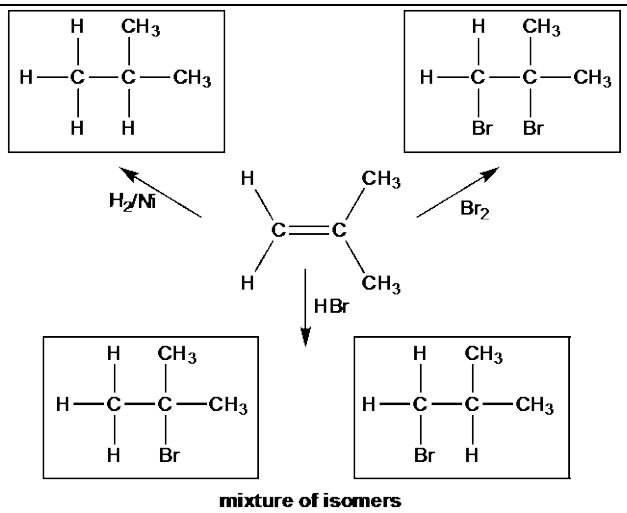
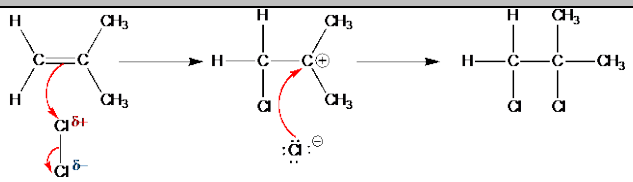
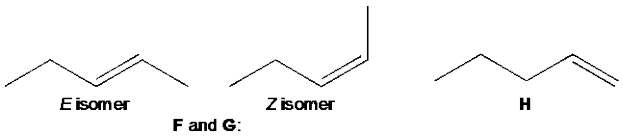
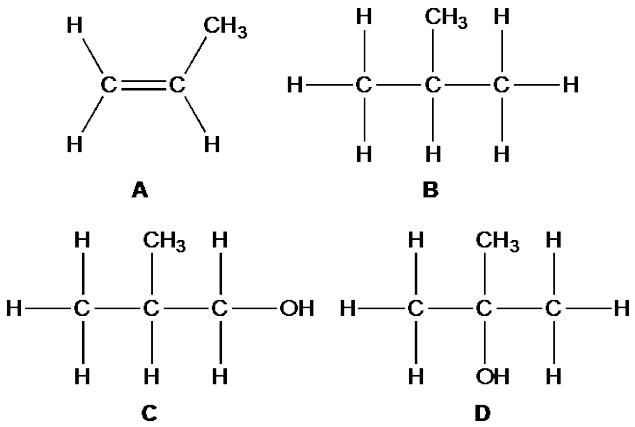
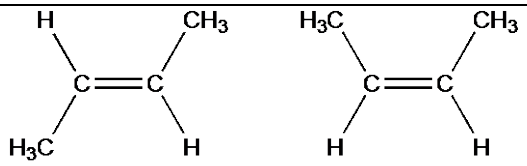
Question number	Answer	Marks	Guidance
1 (a)	An unsaturated compound contains double or triple covalent bonds. A hydrocarbon is a compound of carbon and hydrogen only	B1 B1	
1 (b)	**a**: 109.5º **b**: 120º	B1 B1	
1 (c)	 1 mark for sideways overlap of p orbitals 1 mark for diagram showing π bond	B1 x 2	
2 (a)	An electrophile is an electron pair acceptor	B1	
2 (b)	 1 mark for curly arrow from C=C to $Br^{\delta+}$ of Br_2 1 mark for curly arrow from Br–Br and correct dipole 1 mark for correct carbocation AND curly arrow from Br^- to C^+ 1 mark for product	B1 x 4	
3 (a) (i)	 1 mark for curly arrow from C=C to $I^{\delta+}$ of IBr 1 mark for curly arrow from I–Br and correct dipole 1 mark for correct carbocation AND curly arrow from Br^- to C^+	B1 x 3	Curly arrow must start from bond and go to correct atom **DO NOT ALLOW** partial charges on carbon–carbon double bond **DO NOT ALLOW** δ+ 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

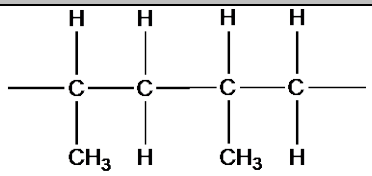
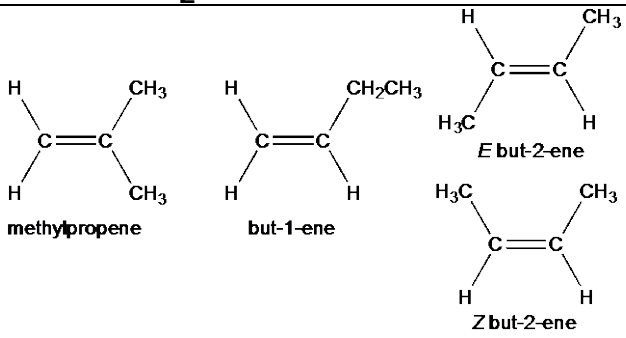
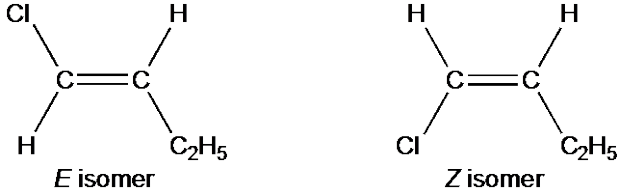
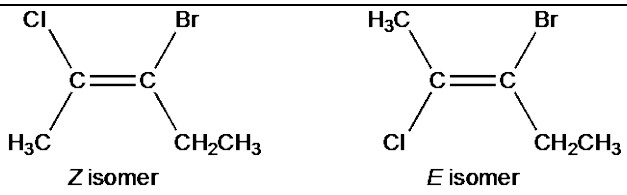
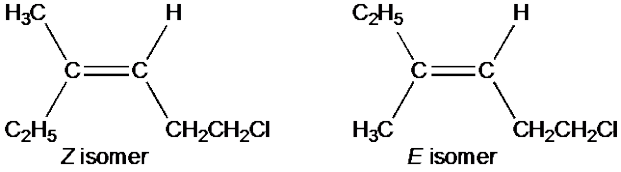
Question number	Answer	Marks	Guidance
			Curly arrow must come from any lone pair or the negative sign of the bromide ion The lone pair on the bromide ion does not need to be shown
3 (a) (ii)	Electrophilic addition	B1	
3 (a) (iii)		B1	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) eg $CH_2BrCHICH_3$ **IGNORE** any name given
4 (a)	1,2-dibromoethane: Use bromine $C_2H_4 + Br_2 \rightarrow C_2H_4Br_2$ bromoethane: Hydrogen bromide $C_2H_4 + Br_2 \rightarrow C_2H_5OH$ Ethanol: steam with an acid catalyst (e.g. conc H_2SO_4) $C_2H_4 + H_2O \rightarrow C_2H_5OH$ Name of mechanism: electrophilic addition  1 mark for curly arrow from C=C to $Br^{\delta+}$ of Br_2 1 mark for curly arrow from Br–Br and correct dipole 1 mark for correct carbocation 1 mark for curly arrow from Br^- to C^+	B1 B1 B1 B1 B1 B1 x 4	**ALLOW** reactants even from incorrect equations **ALLOW** reactants or conditions over the arrow **ALLOW** Br_2 mark from the mechanism even if the mechanism is incorrect **IGNORE** conditions unless they would lead to a different reaction with ethane **IGNORE** conditions unless they would lead to a different reaction with ethane **ALLOW** temperature range between 100–400°C if quoted **IGNORE** reference to pressure **IGNORE** hydrolysis Hydration is not sufficient but **DO NOT ALLOW** Hydrogenation **ALLOW** H_2SO_4 OR H_3PO_4 OR H^+ **DO NOT ALLOW** HCl, HBr etc. **ALLOW** two stage process e.g. react with HBr one mark followed by KOH(aq) one mark

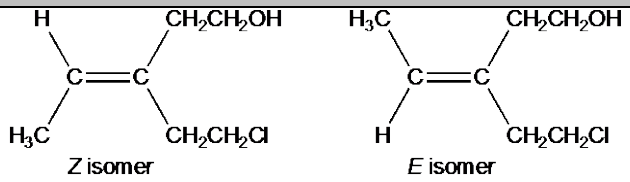
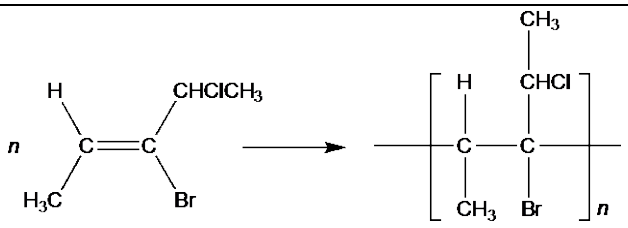
Question number	Answer	Marks	Guidance
			Curly arrow must start from the double bond and not a carbon atom and go the $Br^{\delta+}$; other curly arrow must start from Br–Br bond. **ALLOW** attack of Br–Br if dipoles not shown **DO NOT ALLOW** attack of $Br^{\delta-}$ Dipole must be partial charge and not full charge **DO NOT ALLOW** any other partial charges eg on the double bond Carbocation needs a full charge and not a partial charge (charges do not need to be surrounded by a circle) All atoms in the carbocation must be shown Br^- curly arrow must come from one lone pair on Br^- ion **OR** from minus sign on Br^- ion Lone pair does not need to be shown on Br^- ion **ALLOW** mechanism which goes via a cyclic bromonium ion instead of the carbocation
4 (b)	 3 areas of electron density surround each carbon atom and repel one another as far apart as possible Bond angle: 120°	B1 B1 B1	**IGNORE** any name of shape given **ALLOW** 115–125° **ALLOW** even if it is the C–C–H shown on a diagram. **ALLOW** three or four electron pairs repel **OR** three or four bonds repel **IGNORE** does not have any lone pairs **DO NOT ALLOW** atoms repel / electrons repel **DO NOT ALLOW** has lone pair which repels more
4 (c) (i)	 	B1	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous)

Question number	Answer	Marks	Guidance
4 (c) (ii)		B1	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) **ALLOW** CH_3 and C_2H_5 groups above or below chain **ALLOW** bond to ethyl and methyl group to any part of ethyl or methyl group **IGNORE** any brackets drawn **ALLOW two** or more repeat units but has to have a whole number of repeat units (ie does not have to be two) 'End bonds' **MUST** be shown and can be dotted **IGNORE** *n*
5 (a)	 mixture of isomers 1 mark for each product	B1 x 4	**ALLOW** skeletal formula **OR** displayed formulae **IGNORE** molecular formulae **IF** two answers given e.g. name and structure then both must be correct to be given a mark **ALLOW** methylpropane **OR** $(CH_3)_3CH$ **ALLOW** 1,2-dibromo-methylpropane **OR** $CH_2BrCBr(CH_3)_2$ **ALLOW** 1-bromo-methylpropane **OR** $CH_2BrCH(CH_3)_2$ **ALLOW** 2-bromo-methylpropane **OR** $CH_3CBr(CH_3)_2$ **ALLOW** ecf if wrong carbon skeleton is used in all of the structures mark first structure wrong and then apply ecf for the rest

Question number	Answer	Marks	Guidance
5 (b)	 1 mark for curly arrow from C=C to $Cl^{\delta+}$ of Cl_2 1 mark for curly arrow from Cl–Cl and correct dipole 1 mark for correct carbocation AND curly arrow from Cl^- to C^+	B1 x 3	Curly arrow must start from the double bond and not a carbon atom, other curly arrow must start from Cl—Cl bond **ALLOW** curly arrow from any part of chloride ion The chloride ion does not need to show a lone pair Dipole must be partial charge and not full charge Carbocation needs a full charge and not a partial charge (charges do not need to be surrounded by a circle) **ALLOW** carbocation on carbon 1 where electrophile attacks carbon 2 i.e. $^+CH2CCl(CH_3)_2$
6 (a)	Structural isomers are compounds with the same molecular formula but different structural formulae Stereoisomers have same structural formulae but different arrangements in space The double C=C bond which does not rotate The alkene needs to have two different groups attached to each carbon atom of C=C bond Evidence for molecular formula: **F**, **G** and **H** have molecular formula of C_5H_{10} as M_r is $5 \times 12 + 10 \times 1 = 70$  F and G: 1 mark for each structure of F, G and H (3 marks total) E and Z isomers identified	B1 B1 B1 B1 B1 B1 B1 B1 B1 x 4	**ALLOW** same molecular formula but different structures Second marking point is **DEPENDENT** on first mark **ALLOW** compounds with the same structure Second marking point is **DEPENDENT** on first mark This is the QWC mark **IGNORE** wrong names of F, G and H **ALLOW** structural or displayed formulae for F, G and H e.g. H is $CH_3CH_2CH_2CHCH_2$ **ALLOW** identification using *trans* and *cis* and **ALLOW** this marking point as identification of another example of identifying *E/Z* or *cis* and *trans* if not done for F and G **ALLOW** one mark if no structures drawn but correct names given for F, G and H

Question number	Answer	Marks	Guidance
			i.e *E*-pent-2-ene, *Z*-pent-2-ene and pent-1-ene **ALLOW** ecf on structures if wrong molecular formula used or consistent error or slip such as having just sticks
7	C : H = 82.8/12.0 : 17.2/1 = 6.9 : 17.2 Empirical formula = C_2H_5 Molecular formula = $C_2H_5 \times 58/29$ $= C_2H_5 \times 2 = C_4H_{10}$  **A** **B** **C** **D** 1 mark for each structure **B**: $C_4H_8 + H_2 \rightarrow C_4H_{10}$ **C** and **D**: $C_4H_8 + H_2O \rightarrow C_4H_9OH$	B1 B1 B1 B1 x 4 B1 B1	
8	 *E* isomer *Z* isomer **Q** and **R**: 2 marks for **Q** and **R** identified 1 mark for correct labelling of *E* and *Z* isomers	B1 x 3	
9 (a)	Addition polymerisation	B1	
9 (b)	Propene	B1	

Question number	Answer	Marks	Guidance
9 (c)	 **E**	B1	
10	 methylpropene; but-1-ene; *E* but-2-ene; *Z* but-2-ene 1 mark for each structure Methylpropene, but-1-ene and but-2-ene are structural isomers But-2-ene has *E* and *Z* stereoisomers	B1 x 4 B1 B1	
11 (a)	 *E* isomer; *Z* isomer 1 mark for correct E/Z assignment + stereoisomer	B1	
11 (b)	 *Z* isomer; *E* isomer 1 mark for correct E/Z assignment + stereoisomer	B1	
11 (c)	 *Z* isomer; *E* isomer 1 mark for correct E/Z assignment + stereoisomer	B1	

Question number	Answer	Marks	Guidance
11 (d)	 1 mark for correct E/Z assignment + stereoisomer	B1	
12	 1 mark for repeat unit being correct 1 mark for monomer and balancing	B1 x 2	