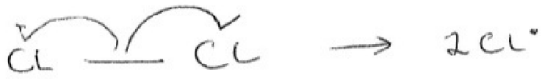
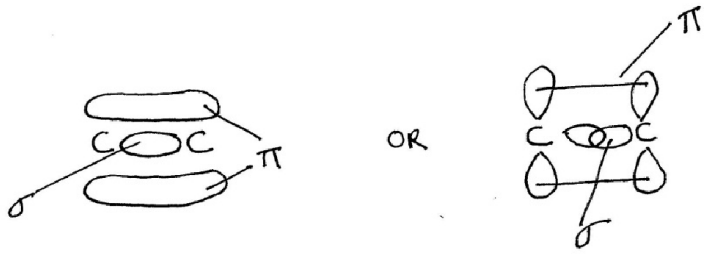
Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	Species/ atom/ molecule/ particle with an **unpaired electron** ALLOW An element with an **unpaired electron** IGNORE Reference to neutral species /lack of charge	Just "with a single electron" A lone electron Charged particle with an unpaired electron	**(1)**

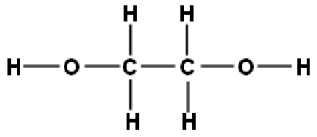
Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	 Half arrows going from bond to Cl or just beyond **and** product 2Cl• / Cl• + Cl•	Cl without •	**(1)**

Question Number	Acceptable Answers	Reject	Mark
21a(iii)	$C_2H_6 + Cl\bullet \rightarrow C_2H_5\bullet + HCl$ ALLOW Structural formulae e.g. CH_3CH_3 OR displayed IGNORE Production of C_2H_5Cl from $C_2H_5\bullet$ if first step is correct (1) Propagation (1) The second mark is independent of the first	$C_2H_5^+$	**(2)**

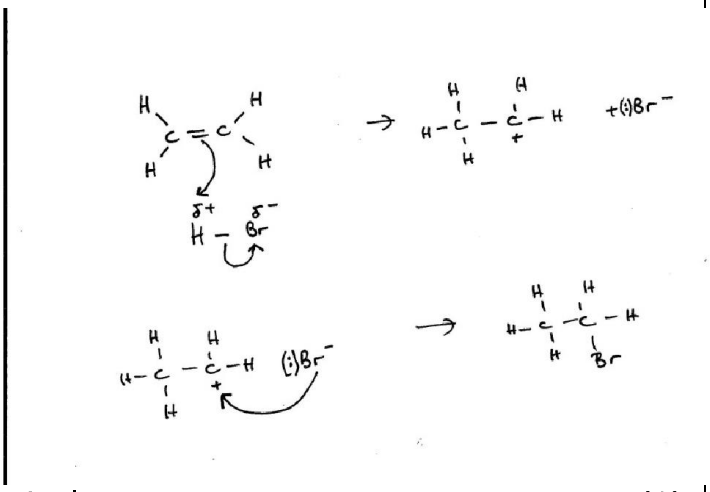
Question Number	Acceptable Answers	Reject	Mark
21a(iv)	$C_2H_5\bullet + C_2H_5\bullet \rightarrow C_4H_{10}$ ALLOW Structural formulae e.g. $CH_3CH_2\bullet$ /• CH_3CH_2 OR displayed IGNORE $Cl\bullet + Cl\bullet \rightarrow Cl_2$	Methyl or propyl radicals	**(1)**

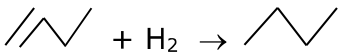
Question Number	Acceptable Answers	Reject	Mark
21b(i)	 σ bond between C atoms shown as 2 overlapping orbitals/ one electron cloud/ single bond (1) π bond above and below σ bond shown as two electron clouds/ overlapping p orbitals/ p orbitals linked by a line / a curved line above and below single bond (1) Both bonds must be labelled for 2 marks.		**(2)**

Question Number	Acceptable Answers	Reject	Mark
***21b(ii)**	**MP1** σ bond remains ALLOW The product contains σ bonds only (1) **MP2** π bonds break because they are weaker (than σ bonds) ALLOW π bonds break because σ bonds are stronger (1) **MP3** Breaking the π bond results in carbocation intermediate / positively charged carbon forming OR π orbital overlap is lateral/ sideways /between parallel orbitals (making π bonds break/ weak) OR The σ bonds are much stronger (than the π bond) because of more effective (orbital) overlap (1)		**(3)**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	From: Purple/ pink (solution) To: colourless (1)  (1) Any orientation Don't penalise undisplayed OH Don't penalise bonds going to middle of undisplayed OH	To brown Molecular/ structural/ skeletal formulae C bonded to H of OH	**(2)**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iv)	Second mark depends on use of bromine/ solution of bromine for test. EITHER Test: add bromine water / Br_2**(aq)** ALLOW Add bromine in organic solvent/ bromine dissolved in hexane/ bromine in 1,1,1-trichloroethane (1) From: brown/ red-brown/orange/ yellow To: colourless (1) OR Add bromine / Br_2 (1) From: brown/ red-brown To: colourless (1)		**(2)**

Question Number	Acceptable Answers	Reject	Mark
21(b)(v)	 Dipole on HBr (1) Curly arrow from C=C double bond to $H^{\delta+}$ of HBr **and** curly arrow from H-Br bond to Br (1) Correct intermediate with + charge (1) Curly arrow from Br^- to C^+ and formula of product ALLOW Curly arrow from anywhere on Br, including the – sign or lone pair (which is optional) (1)	Half arrows	**(4)**

Question Number	Acceptable Answers	Reject	Mark
21(c)	 (1) Suitable catalyst nickel/ platinum/ palladium (1) Ignore references to temperature, pressure, uv light	Use of H, H^+ Zeolite catalyst	**(2)**

(Total for Question 21 = 20 marks)

TOTAL FOR PAPER = 80 MARKS