Question Number	Acceptable Answers	Reject	Mark
1(a)	C_nH_{2n} ALLOW letters other than *n*		**1**

Question Number	Acceptable Answers	Reject	Mark
1(b)	A compound which contains (C=C) double bonds OR A compound that will undergo addition reactions OR Does not contain the maximum number of hydrogen atoms		**1**

Question Number	Acceptable Answers	Reject	Mark
1(c)(i)	*E*-3-ethylhex-2-ene **(2)** **(1)** mark for 3-ethylhex-2-ene **(1)** mark for '**E**' IGNORE any missing hyphens or any hyphens replaced by commas Mark independently		**2**

Question Number	Acceptable Answers	Reject	Mark
1(c)(ii)	The four atoms/four groups around the C=C double bond are different OR No two groups are the same OR There are no common groups on either side of the C=C double bond OR There are two alkyl groups on one of the carbon atoms (in the C=C double bond) OR There are three alkyl groups around the double bond OR An indication of the existence of Priority Rules (for E-Z nomenclature) OR One of the carbon atoms (of the C=C double bond) is not bonded to a hydrogen atom ALLOW 'functional groups' for 'groups'	Each side is not symmetrical	**1**

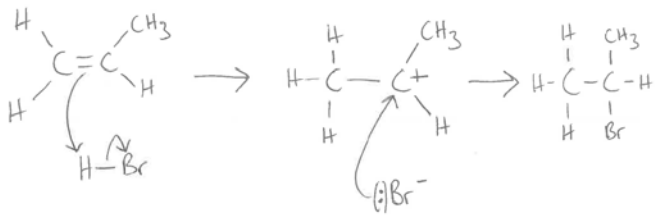
ALLOW displayed or skeletal formulae throughout 24(d)

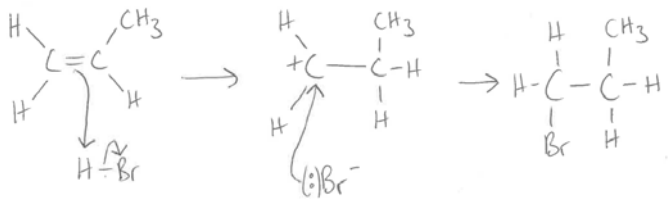
Question Number	Acceptable Answers	Reject	Mark
1(d)(i)	CH_3CH_3 ALLOW displayed or skeletal formulae throughout 24(d)	C_2H_6	**1**

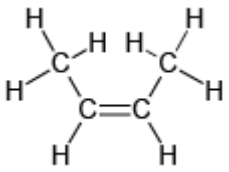
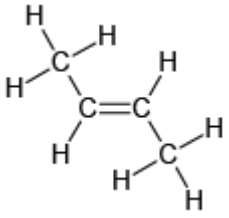
Question Number	Acceptable Answers	Reject	Mark
1(d)(ii)	$ClCH_2CH_2Cl$ / CH_2ClCH_2Cl	$_2H_4Cl_2$	**1**

Question Number	Acceptable Answers	Reject	Mark
1(d)(iii)	$HOCH_2CH_2OH$ / CH_2OHCH_2OH	$C_2H_6O_2$	**1**

Question Number	Acceptable Answers	Reject	Mark
1(d)(iv)	$HOCH_2CH_2Br$ / CH_2OHCH_2Br	$BrCH_2CH_2Br$; C_2H_5OBr; $C_2H_4Br_2$	**1**

Question Number	Acceptable Answers	Reject	Mark
1(e)	Major product route:  **First mark:** Curly arrow from C=C to the H (in H-Br) **AND** curly arrow from the bond in H—Br to the Br **(1)** **Second mark:** Structure of correct secondary carbocation **(1)** **Third mark:** Curly arrow from anywhere on the bromide ion towards the C+ on the carbocation **(1)** NOTE: The bromide ion must have a full negative charge, but the lone pair of electrons on the Br^- NEED NOT be shown **Fourth mark:** Choice of 2-bromopropane as major product **(1)** For showing the major product mechanism correctly **(4)** • both arrows **(1)** • carbocation intermediate **(1)** • attack by bromide ion **(1)** (Bromide ion must show a full negative charge. The lone pair of electrons need not be shown) • choice of 2-bromopropane as major product **(1)**		**4**

	Single-headed arrows used throughout **max (3)** Minor product route **max (3)**  If the minor product route is shown, the last mark is lost, but the first three marks can be scored consequentially as follows:- • both arrows **(1)** • carbocation intermediate **(1)** • attack of bromide ion **(1)** (NOTE: The bromide ion must show a full negative charge. The lone pair of electrons need not be shown) NOTE: If a correct mechanism for the electrophilic addition of HBr to **ethene** is shown then max **(2)** (i.e. the first and the third marks in the mechanism)		

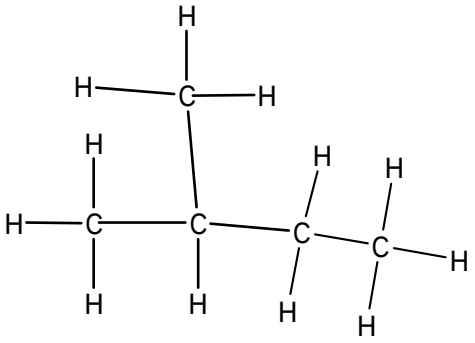
Question Number	Acceptable Answers	Reject	Mark
1(f)(i)	 **(1)**  **(1)** NOTE: CH_3 group does not have to be displayed. IGNORE if any connectivity is shown from the **H_3** in a C**H_3** group IGNORE bond angles ALLOW one mark for just but-2-ene's structural formula		**2**

Question Number	Acceptable Answers	Reject	Mark
1(f)(ii)	**ONE of:-** • No atoms lost (or gained) • No elements lost (or gained) • (Only) one product (is formed) • (Produced by) an addition reaction • Addition polymer(ization) • Polymer is a repeat of the monomer • No small molecules (formed) • No co-products • No waste products • Same C:H ratio • Same ratio of carbon:hydrogen atoms • Same ratio of each element • Same ratio of atoms	(Monomer and polymer have) '**same number** of carbon and hydrogen atoms'	**1**

Question Number	Acceptable Answers	Reject	Mark
1(f)iii	**AND** some correct justification is needed **ONE answer from:-** 100% as addition reaction 100% because all the atoms are incorporated into the polymer 100% because (only) one product is formed 100% because (only) one desired product is formed 100% because no atoms are lost 100% because no waste products 100% because no small molecules (formed) 100% as no co-products 100% as no by-products	Statements such as 'the atom economy is **almost** 100%' OR **Just** "it has a high atom economy"	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a)(i)	C_nH_{2n+2} or any symbol in place of n Ignore C_5H_{12}		**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a)(ii)	(structural / chain) isomers		**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a)(iii)	 (any orientation of this structure) Ignore non-displayed formulae	Structures in which **any** bonds or atoms are omitted Structures with CH_3 groups	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a)(iv)	2,2-dimethylpropane **(1)** Allow dimethylpropane, 2-dimethylpropane 2,2 dimethylpropane, 2 dimethylpropane Ignore hyphens, commas, spaces		**1**

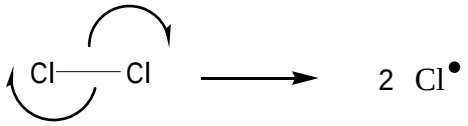
Question Number	Acceptable Answers	Reject	Mark
2 (b)(i)	$CH_4 + 1½O_2 \rightarrow CO + 2H_2O$ Formulae **(1)** balance **(1)** Or multiples Ignore state symbols No TE on **any** other species		**2**

Question Number	Acceptable Answers	Reject	Mark
2 (b)(ii)	Insufficient / not excess oxygen / air	Reactant does not react completely with oxygen Just 'methane in excess'	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (b)(iii)	**Any two from** **CO** is toxic / poisonous (allow harmful) **(1)** Less energy is produced (allow (methane) becomes a less efficient fuel) **(1)** Unburned hydrocarbons react to form compounds which are toxic / harmful **(1)** Allow sooty deposits / carbon / particulates in atmosphere (ignore reference to global dimming) **(1)** Unburned hydrocarbons are toxic / harmful **(1)** If reference to damage to ozone layer, global warming and / or acid rain then max **(1)**	Explosive Reactants wasted Air pollution	**2**

Question Number	Acceptable Answers	Reject	Mark
***2(b)(iv)**	Global warming / climate change **(1)** Due to (increase in concentration of) CO_2 in the atmosphere / CO_2 is a greenhouse gas **(1)** Traps the heat **from the earth** / IR radiation (re-radiating) **from the earth (1)** If reference to damage to ozone layer then max **(2)** Photochemical smog is formed **(0)** NO_x is produced (by reaction of nitrogen & oxygen) **(1)** and reacts with (volatile) organic compounds in sunlight **(1)** Ignore references to increase in (of concentration) of H_2O in the atmosphere Ignore references to the effects of climate change	(heat) from the sun Global dimming due to complete combustion of hydrocarbon fuels Effects (e.g. reactions of unburned hydrocarbons) due to *incomplete* combustion	**3**

Question Number	Acceptable Answers	Reject	Mark
2 (c)(i)	The arrows show the movement of electrons **(1)** Single-headed/I denotes 1 electron and Double-headed/II denotes a pair of / 2 electrons /allow lone pair **(1)** Allow Explanations just in terms of electron movement in bond fission	Just stating homolytic and heterolytic fission	**2**

Question Number	Acceptable Answers	Reject	Mark
2 (c)(ii)	 Equation **(1)** two arrows correctly showing a homolytic fission **(1)** Here and in subsequent mechanisms the covalent bonds may be shown as lines or electron pairs or both The mechanism arrows may be shown on the same side or on different sides of the bond The single electrons need not be shown		**2**

Question Number	Acceptable Answers	Reject	Mark
2 (c)(iii)	$CH_4 + Cl^{\bullet} \rightarrow CH_3^{\bullet} + HCl$ **(1)** $CH_3^{\bullet} + Cl_2 \rightarrow CH_3Cl + Cl^{\bullet}$ **(1)** Ignore state symbols and curly arrows. Ignore order of equations so these marks may be scored if an initiation step with fission of C – H bond in methane is given in c(ii)		**2**

Question Number	Acceptable Answers	Reject	Mark
2 (c)(iv)	Because a (chlorine) radical is regenerated / reformed / reproduced / recycled (by the propagation reactions each time a molecule of product is formed) **(1)** Allow methyl radical regenerated if initiation step with fission of C – H bond in methane is given in c(ii) and propagation order reversed Ignore references to chain reaction	radical is regenerated by UV light (chlorine) radical is a catalyst	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (c)(v)	$CH_3^{\bullet} + CH_3^{\bullet} \rightarrow C_2H_6$ / $2CH_3^{\bullet} \rightarrow C_2H_6$ Ignore state symbols The single electrons need not be shown		**1**

Question Number	Acceptable Answers	Reject	Mark
2 (d)	UV light does not have enough energy to (ALLOW 'cannot') break the C-H bond **(1)** So no H free radicals / atoms are formed (therefore cannot combine to form H_2) **(1)**	Just 'hydrogen' Just 'so no H_2 formed	**2**