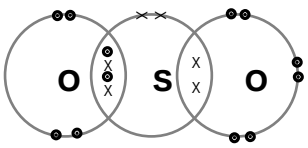
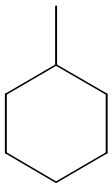
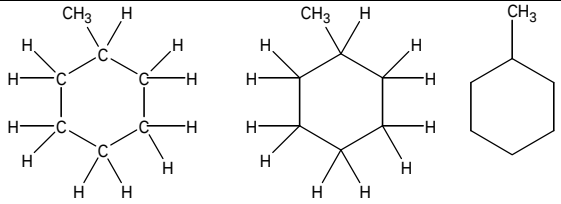
Question Number	Acceptable Answers	Reject	Mark
1(a)	C_nH_{2n+2} IGNORE 'where n=1, 2, 3 etc' or 'where n is greater than 1'		**1**

Question Number	Acceptable Answers	Reject	Mark
1(b)(i)	$C_{10}H_{22} + 10½O_2 \rightarrow 10CO + 11H_2O$ ALLOW 21 / 2 O_2 ALLOW any correct multiples IGNORE state symbols, even if incorrect	21 [O]	**1**

Question Number	Acceptable Answers	Reject	Mark
1(b)(ii)	Any statement that makes it clear there is not enough air or oxygen e. Limited supply of air / limited supply of oxygen / not enough air / not enough oxygen / lack of oxygen / little amount of oxygen/ small amount of oxygen IGNORE "it is not completely oxidized"		**1**

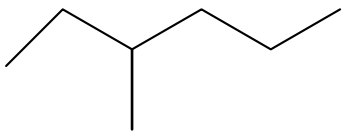
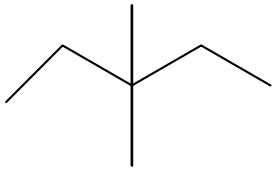
Question Number	Acceptable Answers	Reject	Mark
1(c)	**First mark** Dative pair of e^- between S and right-hand O **(1)** **Second mark** Two bond pairs between S and left-hand O **(1)** **Third mark** Two lone pairs on left-hand O, one lone pair on central S and three lone pairs on right-hand O atom **(1)** If 2 double bonds between sulfur and each oxygen then the third mark can be given for two lone pairs on both oxygens and one lone pair on central S  NOTE ALLOW dots and crosses that have been reversed Lone pair electrons can be shown as separated (rather than having to be paired up) – **it is the total number of electrons in each outer shell that matters** Stand alone marks If molecule shown as charged then 2 max		**3**

Question Number	Acceptable Answers	Reject	Mark
1(d)(i)		 benzene ring	**1**

Question Number	Acceptable Answers	Reject	Mark
1(d)(ii)	$C_7H_{16} \rightarrow C_7H_{14} + H_2$ ALLOW $C_6H_{11}CH_3$ IGNORE state symbols, even if incorrect	Formulae other than molecular formulae Any other structural or displayed formulae	**1**

Question Number	Acceptable Answers	Reject	Mark
1(d)(iii)	Any **ONE** of: (a cyclic alkane) has more efficient combustion allows smoother burning increases octane number reduces knocking / less likely to produce pre-ignition is a more efficient fuel burns better / easier to burn /combusts more easily / improves combustion IGNORE (a cyclic alkane): increases the volatility of a fuel "ignites more easily" "is a better fuel" "burns more cleanly" IGNORE (a cyclic alkane) has a lower boiling point mentions of viscosity safer fuel	Less pollution / reduce waste High atom economy Produces useful products / hydrogen Used to make polymers Produces substances in higher demand / more valuable	**1**

Question Number	Acceptable Answers	Reject	Mark
1(e)(i)	2,2-dimethylpent**ane** IGNORE missing hyphen/missing comma	2-dimethylpentane	**1**

Question Number	Acceptable Answers	Reject	Mark
1(e)(ii)	 **(1)**  **(1)** IGNORE names even if incorrect IGNORE different length bonds IGNORE direction of methyl groups		**2**

Question Number	Acceptable Answers	Reject	Mark
1(f)(i)	U.V. / U.V.light / light / sunlight ALLOW high temperature	 heat alone	**1**

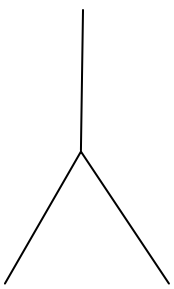
Question Number	Acceptable Answers	Reject	Mark
1(f)(ii)	$Cl_2 \rightarrow Cl\cdot + Cl\cdot$ / $Cl_2 \rightarrow 2Cl\cdot$ IGNORE any curly arrows, even if incorrect IGNORE C_4H_{10} given on both sides		**1**

Question Number	Acceptable Answers	Reject	Mark
1(f)(iii)	Homolytic (fission) IGNORE any formulae and arrows	Photolysis (fission) / free radical (fission)	**1**

Question Number	Acceptable Answers	Reject	Mark
1(f)(iv	**propagation step)** $C_4H_{10} + Cl\cdot \rightarrow C_4H_9\cdot + HCl$ **(1)** **(Second propagation step)** $C_4H_9\cdot + Cl_2 \rightarrow C_4H_9Cl + Cl\cdot$ **(1)** Formulae can be displayed 'dots' can be anywhere on free radical but no dots at all scores zero ALLOW in either order Incorrect alkane / halogenoalkane but two correct propagation steps scores 1 out of 2	Any reactions involving Hydrogen radicals scores zero Reverse of first reaction	**2**

Question Number	Acceptable Answers	Reject	Mark
1(f)(v)	Any **ONE** of: $C_4H_9\cdot + Cl\cdot \rightarrow C_4H_9Cl$ OR $Cl\cdot + Cl\cdot \rightarrow Cl_2$ OR $C_4H_9\cdot + C_4H_9\cdot \rightarrow C_8H_{18}$		**1**

Question Number	Correct Answer	Reject	Mark
2 (a)(i)	Easier to transport / easier to store / less space / less volume needed for storage / easier to handle / easier to transfer *IGNORE* references to "safety" **Accept** Denser/cheaper to transport OWTTE	Just "cost"	**1**

Question Number	Correct Answer	Reject	Mark
2 (a)(ii)	**skeletal formula (1)**  **Name**: butane **(1)** Stand alone **skeletal formula (1)**  **Name**: methylpropane **OR** 2-methylpropane **(1)** *IGNORE* incorrect punctuation [e.g. extra/missing hyphens, etc.] Stand alone *IGNORE* displayed formulae if also given with skeletal formulae if 2 correct displayed formulae are given **max** 1 out of 2 for the structures		**4**

Question Number	Correct Answer	Reject	Mark
2 (a)(iii)	(Structural) isomers		**1**

Question Number	Correct Answer	Reject	Mark
2 (b)(i)	$Cl_2 \rightarrow Cl\cdot + Cl\cdot$ / $Cl_2 \rightarrow 2Cl\cdot$ **(1)** (U.V.) light / sunlight **(1)** Must show the dots · *IGNORE* any subsequent propagation steps in (b)(i)	 heat alone	**2**

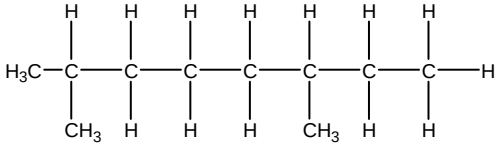
Question Number	Correct Answer	Reject	Mark
2 (b)(ii)	$C_3H_8 + Cl\cdot \rightarrow C_3H_7\cdot + HCl$ **(1)** $C_3H_7\cdot + Cl_2 \rightarrow C_3H_7Cl + Cl\cdot$ **(1)** Must show the dots ·		**2**

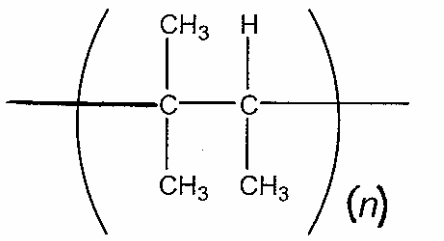
Question Number	Correct Answer	Reject	Mark
2 (b)(iii)	$C_3H_7\cdot + Cl\cdot \rightarrow C_3H_7Cl$ **OR** $Cl\cdot + Cl\cdot \rightarrow Cl_2$ **OR** $C_3H_7\cdot + C_3H_7\cdot \rightarrow C_6H_{14}$ Must show dots in termination step		**1**

Question Number	Correct Answer	Reject	Mark
2 (c)(i)	Alkene / triene **Accept** Diene Carbon-carbon double bond		**1**

Question Number	Correct Answer	Reject	Mark
2 (c)(ii)	**From:** Red / brown / orange / yellow or combinations of these colours **To:** colourless *both colours needed*	 "clear" instead of colourless	**1**

Question Number	Correct Answer	Reject	Mark
2 (c)(iii)	Electrophilic **(1)** addition **(1)**		**2**

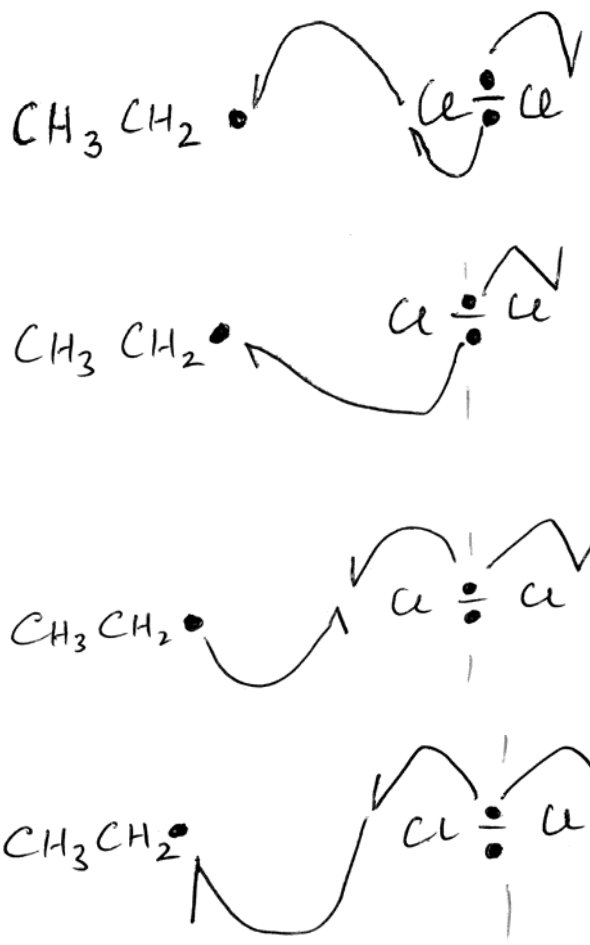
Question Number	Correct Answer	Reject	Mark
2 (c)(iv)	**Calculation:** 0.01 mol myrcene reacts with 0.03 mol H_2 **OR** 1 mol myrcene reacts with 3 mol H_2 **(1)** **Structural formula**: $(CH_3)_2CH(CH_2)_3CH(CH_3)CH_2CH_3$ **OR**  **(1)** **Accept** Fully displayed formula/skeletal formula Mark calculation and structural formula **independently**.		**2**

Question Number	Correct Answer	Reject	Mark
2 (d)	 repeat unit **(1)** continuation bonds shown (but these bonds do not have to cut through the brackets) **(1)** *n* **not essential** *IGNORE* the position of "*n*" relative to the repeat unit (e.g. can be written as a superscript)		**2**

Question Number	Acceptable Answers	Reject	Mark
3(a)	$C_2H_6(g) + 3½O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ Formulae and states **(1)** Balancing of correct entities **(1)**	Multiples	**2**

Question Number	Acceptable Answers	Reject	Mark
3(b)	Notice the first mark is for the equation and there are 3 separate additional marks for the calculation H H H H | | | | H-C-C-H + Cl-Cl → H-C-C-Cl + H-Cl | | | | H H H H **(1)** Check all bonds displayed especially Cl-Cl and H- **Calculation marks:** +413 + 243 **(1)** (−)(346 + 432) **(1)** OR 656 **(1)** (−) 778 **(1)** = −122 (kJ mol^{-1}) **(1)** Fully correct answer to calculation with no working **(3)** Extra 5x413 and 347 may be included on both sides, giving 3068 and (-)3190 Allow other same values(s) missing from both sides Bonds breaking **(1)** Bonds making **(1)** [Bonds breaking - bonds making] to give correct answer **with sign** **(1)**	Incorrect / no sign and / or incorrect units Incorrect units loses this mark	**4**

Question Number	Acceptable Answers	Reject	Mark
3 (c)(i)	Initiation **(1)** Allow homolysis / atomization / homolytic (fission) Ignore any reference to free radical substitution UV / (sun)light **(1)** Ignore reference to high temperature	Free radical substitution alone Photolysis	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (c)(ii)	$CH_3CH_2\bullet$ + Cl-Cl → CH_3CH_2Cl + Cl• OR $CH_3CH_2\bullet$ + Cl-Cl → C_2H_5Cl + Cl• Both products correct including dot (1) Two half headed arrows showing homolytic breaking of Cl-Cl bond **(1)** Half headed arrow from radical to pair with a Cl arrow OR One arrow from chlorine bond clearly to ethyl radical **(1)** Arrows must be single-headed  The two dots in the covalent bond do not have to be shown		**3**

Question Number	Acceptable Answers	Reject	Mark
3 (c)(iii)	$Cl\bullet + Cl\bullet \rightarrow Cl_2$ **(1)** $\bullet CH_2CH_3 + \bullet CH_2CH_3 \rightarrow CH_3CH_2CH_2CH_3$ / C_4H_{10} **(1)** $\bullet CH_2CH_3 + Cl\bullet \rightarrow CH_3CH_2Cl$ **(1)** Penalise missing dots once Allow $\bullet C_2H_5$ for $\bullet CH_2CH_3$ Di and tri substitution steps	C_4H_{12} $CH_3CH_2CH_3CH_2$	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (d)	$C_2H_6 \rightarrow C_2H_4 + H_2$ Allow **2**$C_2H_6 \rightarrow C_2H_4 +$ **2**CH_4		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (e)	Any two from: (It) produces (more) petrol / gasoline / diesel / jet fuel / LPG / liquid petroleum gas / fuel **(1)** Short chain alkanes / lighter fractions are more useful products **(1)** Demand is greater for shorter chain alkanes / lighter fractions / smaller molecules OR converts surplus of low demand fractions **(1)** It produces ethane / short chain alkenes for making poly(ethene) / ethane-1,2-diol / ethanol / plastics / polymers **(1)** Smaller alkanes give less pollution/burn more efficiently **(1)** Recycles waste products **(1)** As a source of hydrogen **(1)** **NB** examiners need to look carefully at the vowel in the middle of alk**a**ne / alk**e**ne / eth**a**ne / eth**e**ne if not clear do not give BOD	Points based on atom economy / renewable fuels alone Easier to transport / store Short chain alkenes / ethene more useful alone Recycles alone	2

Question Number	Acceptable Answers	Reject	Mark
4(a)(i)	$CH_3CH_3 + Cl\cdot \rightarrow CH_3CH_2\cdot + HCl$ OR $CH_3CH_2\cdot + Cl_2 \rightarrow CH_3CH_2Cl + Cl\cdot$		**1**

Question Number	Acceptable Answers	Reject	Mark
4(a)(ii)	$CH_3CH_2\cdot + Cl_2 \rightarrow CH_3CH_2Cl + Cl\cdot$ OR $CH_3CH_3 + Cl\cdot \rightarrow CH_3CH_2\cdot + HCl$ N.B. different answers for (i) and (ii) needed		**1**

Question Number	Acceptable Answers	Reject	Mark
4(a)(iii)	$2CH_3CH_2\cdot \rightarrow CH_3CH_2CH_2CH_3$ OR $CH_3CH_2\cdot + Cl\cdot \rightarrow CH_3CH_2Cl$	$Cl\cdot + Cl\cdot \rightarrow Cl_2$	**1**

Question Number	Acceptable Answers	Reject	Mark
4(a)(iv)	$CH_3CH_2\cdot + Cl\cdot \rightarrow CH_3CH_2Cl$ OR $2CH_3CH_2\cdot \rightarrow CH_3CH_2CH_2CH_3$ N.B. different answers for (iii) and (iv) needed		**1**

Question Number	Acceptable Answers	Reject	Mark
4(b)	**First mark:** Structural formula (enough to see the structure) **of any polyhalogenated ethane derivative** OR **any polyhalogenated methane derivative** ALLOW correct displayed or skeletal formula **(1)** **Second mark:** If first mark awarded the name must be consequentially correct IGNORE any missing or incorrect numbering in name (e.g. "dichloroethane" scores the mark) IGNORE missing or incorrect hyphens If first mark NOT awarded then only ALLOW correct name **of any polyhalogenated ethane or polyhalogenated methane derivative** **(1)**	Butane /C_4H_{10} / $CH_3CH_2CH_2CH_3$ / chlorobutane / hexane / chloromethane	**2**

Question Number	Acceptable Answers	Reject	Mark
4(c)(i)	**1st mark for HAZARD:** This mark is for the idea of: (substance or procedure that) can cause harm/may cause harm/has the potential to do harm/can be dangerous ALLOW references to specific hazards such as toxic/flammable /harmful/ irritant /corrosive /oxidizing/ carcinogenic for the mark **(1)** **2nd mark for RISK:** This mark is for the idea of likelihood/probability/chance that harm will result (from the use of a substance or a procedure) **(1)**	**Just** "causes harm"/**just** "is a danger"	**2**

Question Number	Acceptable Answers	Reject	Mark
4(c)(ii)	fume cupboard OR gloves OR **u.v.** goggles	**Just** 'open windows'/**Just** well-ventilated lab/**Just** 'gas mask'/**Just** "use of smaller quantities"/closed system/closed experiment	**1**