

Question Number	Acceptable Answers	Reject	Mark
<b>1(a)</b>	$C_nH_{2n}$ ALLOW letters other than $n$		<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>1(b)</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		<b>1</b>

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

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

ALLOW displayed or skeletal formulae throughout 24(d)

Question Number	Acceptable Answers	Reject	Mark
<b>1(d)(i)</b>	<p>CH<sub>3</sub>CH<sub>3</sub></p> <p>ALLOW displayed or skeletal formulae throughout 24(d)</p>	C <sub>2</sub> H <sub>6</sub>	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>1(d)(ii)</b>	ClCH <sub>2</sub> CH <sub>2</sub> Cl / CH <sub>2</sub> ClCH <sub>2</sub> Cl	<sub>2</sub> H <sub>4</sub> Cl <sub>2</sub>	<b>1</b>

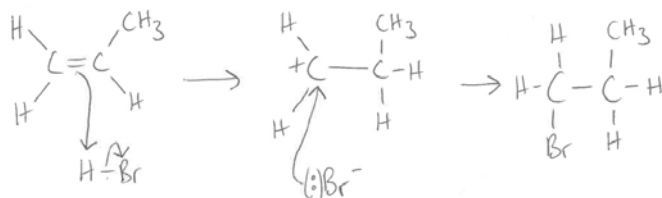
Question Number	Acceptable Answers	Reject	Mark
<b>1(d)(iii)</b>	HOCH <sub>2</sub> CH <sub>2</sub> OH / CH <sub>2</sub> OHCH <sub>2</sub> OH	C <sub>2</sub> H <sub>6</sub> O <sub>2</sub>	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>1(d)(iv)</b>	HOCH <sub>2</sub> CH <sub>2</sub> Br / CH <sub>2</sub> OHCH <sub>2</sub> Br	BrCH <sub>2</sub> CH <sub>2</sub> Br; C <sub>2</sub> H <sub>5</sub> OBr; C <sub>2</sub> H <sub>4</sub> Br <sub>2</sub>	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
1(e)	<p>Major product route:</p> <p><b>First mark:</b> Curly arrow from C=C to the H (in H-Br) <b>AND</b> curly arrow from the bond in H—Br to the Br <b>(1)</b></p> <p><b>Second mark:</b> Structure of correct secondary carbocation <b>(1)</b></p> <p><b>Third mark:</b> Curly arrow from anywhere on the bromide ion towards the C<sup>+</sup> on the carbocation <b>(1)</b></p> <p>NOTE: The bromide ion must have a full negative charge, but the lone pair of electrons on the Br<sup>-</sup> NEED NOT be shown</p> <p><b>Fourth mark:</b> Choice of 2-bromopropane as major product <b>(1)</b></p> <p>For showing the major product mechanism correctly <b>(4)</b></p> <ul style="list-style-type: none"> <li>• both arrows <b>(1)</b></li> <li>• carbocation intermediate <b>(1)</b></li> <li>• attack by bromide ion <b>(1)</b> (Bromide ion must show a full negative charge. The lone pair of electrons need not be shown)</li> <li>• choice of 2-bromopropane as major product <b>(1)</b></li> </ul>		<b>4</b>

Single-headed arrows used throughout **max (3)**

Minor product route **max (3)**

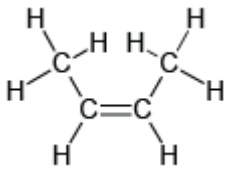
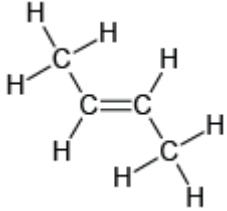


If the minor product route is shown, the last mark is lost, but the first three marks can be scored consequentially as follows: -

- 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)

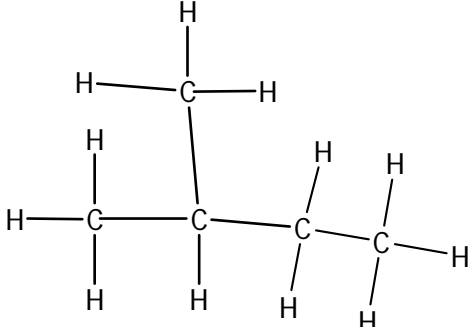
Question Number	Acceptable Answers	Reject	Mark
<b>1(f)(i)</b>	 <p style="text-align: right;"><b>(1)</b></p>  <p style="text-align: right;"><b>(1)</b></p> <p>NOTE: CH<sub>3</sub> group does not have to be displayed.</p> <p>IGNORE if any connectivity is shown from the <b>H<sub>3</sub></b> in a <b>CH<sub>3</sub></b> group</p> <p>IGNORE bond angles</p> <p>ALLOW one mark for just but-2-ene's structural formula</p>		<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>1(f)(ii)</b>	<p style="text-align: center;"><b>ONE of:-</b></p> <ul style="list-style-type: none"> <li>• No atoms lost (or gained)</li> <li>• No elements lost (or gained)</li> <li>• (Only) one product (is formed)</li> <li>• (Produced by) an addition reaction</li> <li>• Addition polymer(ization)</li> <li>• Polymer is a repeat of the monomer</li> <li>• No small molecules (formed)</li> <li>• No co-products</li> <li>• No waste products</li> <li>• Same C:H ratio</li> <li>• Same ratio of carbon:hydrogen atoms</li> <li>• Same ratio of each element</li> <li>• Same ratio of atoms</li> </ul>	(Monomer and polymer have) <b>'same number</b> of carbon and hydrogen atoms'	<b>1</b>

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

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

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

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

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

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

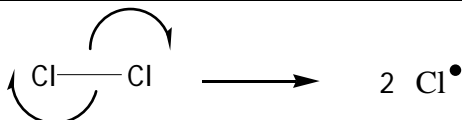
Question Number	Acceptable Answers	Reject	Mark
<b>2</b> <b>(b)( ii)</b>	Insufficient / not excess oxygen / air	Reactant does not react completely with oxygen Just 'methane in excess'	<b>1</b>

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



Question Number	Acceptable Answers	Reject	Mark
<b>*2(b)(iv)</b>	<p>Global warming / climate change <b>(1)</b></p> <p>Due to (increase in concentration of) CO<sub>2</sub> in the atmosphere / CO<sub>2</sub> is a greenhouse gas <b>(1)</b></p> <p>Traps the heat <b>from the earth</b> / IR radiation (re-radiating) <b>from the earth (1)</b></p> <p>If reference to damage to ozone layer then max <b>(2)</b></p> <p>Photochemical smog is formed <b>(0)</b></p> <p>NO<sub>x</sub> is produced (by reaction of nitrogen &amp; oxygen) <b>(1)</b> and reacts with (volatile) organic compounds in sunlight <b>(1)</b></p> <p>Ignore references to increase in (of concentration) of H<sub>2</sub>O in the atmosphere</p> <p>Ignore references to the effects of climate change</p>	<p>(heat) from the sun</p> <p>Global dimming due to complete combustion of hydrocarbon fuels</p> <p>Effects (e.g. reactions of unburned hydrocarbons) due to <i>incomplete</i> combustion</p>	<b>3</b>

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

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

Question Number	Acceptable Answers	Reject	Mark
<b>2</b> <b>(c)(iii)</b>	$\text{CH}_4 + \text{Cl}^\bullet \rightarrow \text{CH}_3^\bullet + \text{HCl} \quad \mathbf{(1)}$ $\text{CH}_3^\bullet + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{Cl}^\bullet \quad \mathbf{(1)}$ <p>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)</p>		<b>2</b>

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

Question Number	Acceptable Answers	Reject	Mark
<b>2 (c)(v)</b>	$\text{CH}_3^\bullet + \text{CH}_3^\bullet \rightarrow \text{C}_2\text{H}_6$ / $2\text{CH}_3^\bullet \rightarrow \text{C}_2\text{H}_6$ Ignore state symbols The single electrons need not be shown		<b>1</b>

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