

Alkenes & Polymers

Mark Scheme

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	The Core Principles of Chemistry
Sub Topic	Alkenes & Polymers
Booklet	Mark Scheme

Time Allowed: 84 minutes

Score: /70

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

Question Number	Correct Answer	Reject	Mark
1	A		1
	Incorrect Answers: B – The methyl groups are bonded to the same carbon C - The double bonds are still present D- The double bond has moved and results in pentavalent carbons		

Question Number	Correct Answer	Reject	Mark
2	B		1

Question Number	Correct Answer	Reject	Mark
3	A		1

Question Number	Correct Answer	Reject	Mark
4	A		1

Question Number	Correct Answer	Mark
5	C	1

Question Number	Correct Answer	Mark
6	A	1

Question Number	Correct Answer	Mark
7	B	1

Question Number	Correct Answer	Mark
8	C	1

Question Number	Correct Answer	Mark
9	A	1

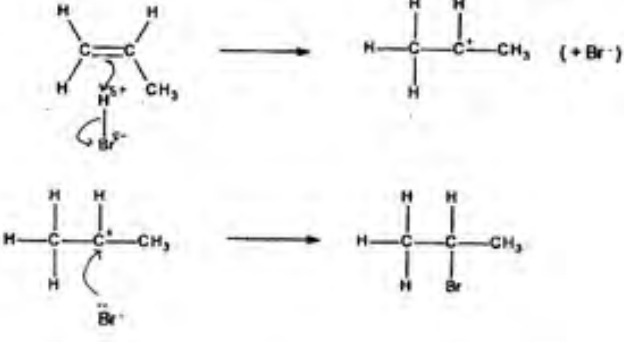
Question Number	Acceptable Answers	Reject	Mark
10(a)(i)	C ₇ H ₁₄ ALLOW H ₁₄ C ₇ IGNORE any working/ names	C ⁷ H ¹⁴	1

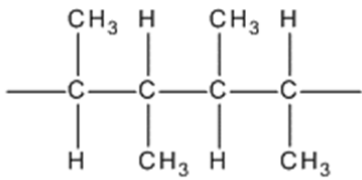
Question Number	Acceptable Answers	Reject	Mark
10(a)(ii)	<p>rst mark Restricted/barrier to rotation (around C=C/ pi bond)</p> <p>ALLOW no rotation (around C=C/ pi bond/ the double bond) (1)</p> <p>IGNORE Just 'groups/atoms attached to C=C are in fixed positions '</p> <p>Second mark (Two) different groups/atoms (with different priorities/masses) on both/each of the carbon atoms (of C=C) OR (Two) different groups on either side of C=C OR There are three different groups/atoms around the C=C bond</p> <p>ALLOW two clear diagrams/structures showing the two different groups in each isomer (1)</p>	<p>the molecule/ hydrocarbon cannot rotate</p> <p>compounds/ molecules/ branches for groups</p> <p>4 different groups/atoms</p>	2

Question Number	Acceptable Answers	Reject	Mark
10(b)(i)	bromine water/ aqueous bromine /Br ₂ (aq)	Just 'bromine/Br ₂ '/ Br ₂ (l)/ BrOH	1

Question Number	Acceptable Answers	Reject	Mark
10(b)(ii)	<p>propane-1,2-diol</p> <p>ALLOW propan-1,2-diol/ 1,2-propanediol/ 1,2-propandiol</p> <p>IGNORE missing/ additional hyphens in name</p> <p>OR</p> $ \begin{array}{ccccc} & \text{H} & & \text{H} & & \text{H} & & \\ & & & & & & & \\ \text{H} & -\text{C} & - & \text{C} & - & \text{C} & -\text{H} \\ & & & & & & & \\ & \text{OH} & & \text{OH} & & \text{H} & & \end{array} $ <p>ALLOW Structural formula, skeletal formula or a combination of these</p> <p>IGNORE Molecular formula/ C₃H₈O₂</p>	<p>1,2-dipropanol</p> <p>Correct name with incorrect formula or vice versa</p> <p>O-H-C. OH-C... OHC... ...C-H-O ... C-HO ...CHO</p>	1

Question Number	Acceptable Answers	Reject	Mark
10(b)(iii)	<p>(From) purple/ pink (to) colourless</p> <p>Both colours correct for the mark</p>		1

Question Number	Acceptable Answers	Reject	Mark
<p>10(b)(iv)</p>	 <p>Correct dipole on HBr (1)</p> <p>Curly arrow from C=C to H of HBr and curly arrow from H-Br bond to Br (1)</p> <p>Correct intermediate with + charge (1)</p> <p>(At least one) lone pair on Br⁻ and curly arrow from Br⁻ to C⁺ (1)</p> <p>ALLOW curly arrow from anywhere on Br, including the - sign</p> <p>If mechanisms are given for 1-bromopropane and 2-bromopropane, ignore the mechanism for 1-bromopropane</p> <p>If final product is 1-bromopropane only, mechanism can score marks 1, 2 and 4</p>	<p>Clearly half-headed arrows once only</p> <p>Missing H on structures once only</p> <p>δ+</p> <p>Br^{δ-}</p>	<p>4</p>

Question Number	Acceptable Answers	Reject	Mark
10(c)	 <p>ALLOW CH₃ groups above or below the chain</p> <p>ALLOW fully displayed formula</p> <p>IGNORE brackets and n/ 2</p> <p>IGNORE bond angles and bond lengths</p> <p>IGNORE working before final structure</p>		1

Question Number	Acceptable Answers	Reject	Mark
10(d)(i)	<p>Correct answer with no working scores the mark</p> $(\text{percentage atom economy}) = \frac{82.0}{100.0} \times 100$ $= 82(.0) (\%)$	<p>82.4(%) (incorrect M_rs of 84 and 102 used)</p> <p>80 (1 SF)</p>	1

Question Number	Acceptable Answers	Reject	Mark
10(d)(ii)	<p>Correct answer with no working scores both marks</p> <p>First mark</p> <p>moles of cyclohexanol $= \frac{10.2}{100.0} = 0.102$</p> <p>ALLOW TE on incorrect M_r in (i) (1)</p> <p>Second mark EITHER</p> <p>moles of cyclohexene produced $= \frac{6.15}{82.0} = 0.075$</p> <p>% yield = $\frac{0.075}{0.102} \times 100$ = 73.529/ 73.53/ 73.5/ 74 (%) (1)</p> <p>ALLOW TE on incorrect mol of cyclohexanol and cyclohexene or incorrect M_r in (i)</p> <p>OR</p> <p>theoretical mass of cyclohexene = 0.102 x 82.0 = 8.364 g</p> <p>% yield = $\frac{6.15}{8.364} \times 100$ = 73.529/ 73.53/ 73.5/ 74 (%) (1)</p> <p>ALLOW TE on mol of cyclohexanol, mass of cyclohexene or incorrect M_r</p> <p>IGNORE SF except 1 SF</p>	<p>$\frac{6.15}{10.2} \times 100$ = 60.3% scores (0)</p> <p>70 for the second mark</p>	2

(Total for Question 10 = 14 marks)

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

ALLOW: (partially) displayed or skeletal formulae throughout **Q11(b)**

IGNORE: additional incorrect non-organic products

Question Number	Acceptable Answers	Reject	Mark
11(b)(i)	CH_3CH_3	C_2H_6	1

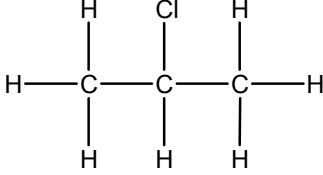
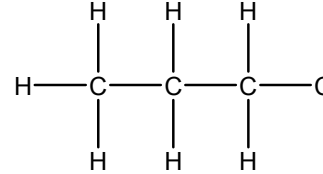
Question Number	Acceptable Answers	Reject	Mark
11(b)(ii)	$ClCH_2CH_2Cl$ / CH_2ClCH_2Cl	$C_2H_4Cl_2$	1

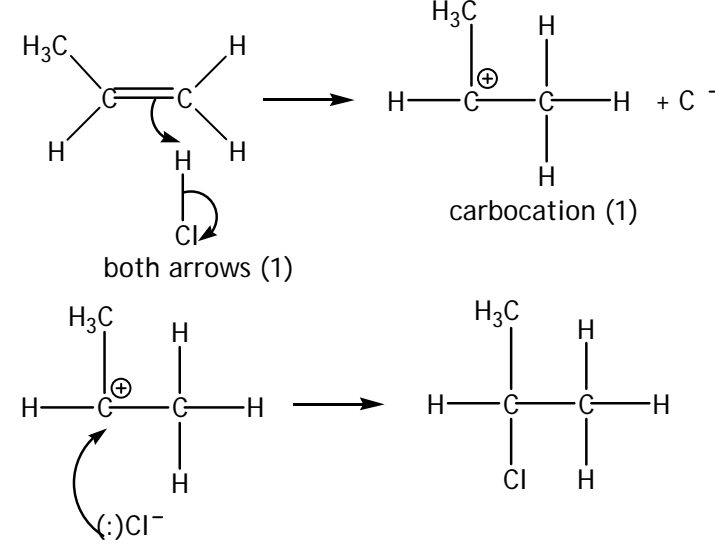
ONLY PENALISE ONCE ONLY in (b)(iii) & (b)(iv) THE CONNECTIVITY BETWEEN C and OH if CLEARLY a C to H covalent bond has been drawn

Question Number	Acceptable Answers	Reject	Mark
11(b)(iii)	CH_2CH_2OH / CH_2OHCH_2OH	$C_2H_6O_2$ / OH CH_2CH_2OH	1

Question Number	Acceptable Answers	Reject	Mark
11(b)(iv)	$HOCH_2CH_2Br$ / CH_2OHCH_2Br	$BrCH_2CH_2Br$ / C_2H_5OBr / $C_2H_4Br_2$	1

PENALISE USE OF Br instead of Cl once only in parts (c)(i) & (c)(ii)
PENALISE missing H atoms from displayed formulae once only in parts (c)(i) & (c)(ii)

Question Number	Acceptable Answers	Reject	Mark
11(c)(i)	<div style="text-align: center;">  <p>(Major product) (1)</p> </div> <div style="text-align: center;">  <p>(Minor product) (1)</p> </div> <p>Both DISPLAYED structures, with all bonds and atoms shown but in the wrong boxes scores (1)</p> <p>PENALISE CH_3 not fully displayed ONCE only So $\text{CH}_3\text{CH}(\text{Cl})\text{CH}_3$ and $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$ scores (1)</p>		2

Question Number	Acceptable Answers	Reject	Mark
11(c)(ii)	 <p>both arrows (1)</p> <p>carbocation (1)</p> <p>attack of chloride ion (1)</p> <p>1st mark: Curly arrow from C=C to H (in H—Cl) AND curly arrow from bond in H—Cl to the Cl (dipole not reqd) Curly arrows must start from the bonds NOT the atoms (1)</p> <p>2nd mark: Structure of correct secondary carbocation (1)</p> <p>3rd mark: Curly arrow from anywhere on the chloride ion (including the minus sign) towards the C+ on the carbocation (1)</p> <p>NOTE: The chloride ion must have a full negative charge, but the lone pair of electrons on the Cl⁻ need not be shown</p> <p>ALLOW: TE on major product given in (c)(i)</p> <p>Skeletal formulae can be used Mark the three points independently</p>	<p>Full + and - charges on HCl</p> <p>Incorrect polarity on HCl</p> <p>Extra / spare bond dangling from the C+ carbon</p> <p>δ- on chloride ion instead of Cl⁻</p>	3

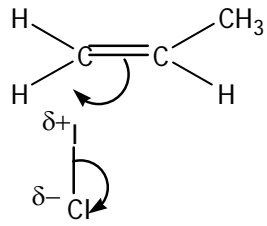
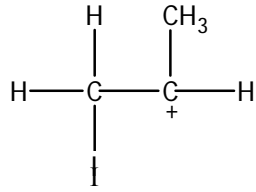
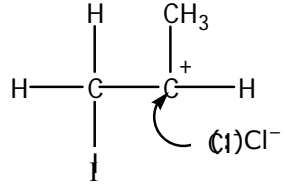
Question Number	Acceptable Answers	Reject	Mark
11(d)(i)	<div style="text-align: center;"> <p style="text-align: center;"> $n\text{C}_3\text{H}_6 \rightarrow \left[\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C} \\ \\ \text{---} \text{C} \text{---} \text{C} \text{---} \\ \quad \\ \text{H} \quad \text{H} \end{array} \right]_n$ </p> </div> <p>TWO 'n' in the equation and a correct formula (molecular or structural) for propene on the left-hand side of the equation (1)</p> <p>One correct repeating unit, with the methyl branch shown (1)</p> <p>ALLOW</p> <p>CH₃ fully displayed or just as CH₃</p> <p>BOTH continuation bonds (with or without bracket shown) (1)</p> <p>If C=C bond left in polymer on right-hand side, then max (1)</p> <p>Mark the three points independently</p>		3

Question Number	Acceptable Answers	Reject	Mark
11(d)(ii)	<p>Non-biodegradable</p> <p>IGNORE References to toxicity of poly(propene) / flammability</p> <p>IGNORE Litter / pollution / waste of resources / costs</p> <p>ALLOW People are reluctant to recycle OR Harmful to marine life / harmful to wildlife OR References to 'landfill' OR References to 'incineration' producing toxic fumes/toxic gases / CO₂ / Greenhouse gases OR References to use of energy/fuel used in transport (of waste) OR It takes a long time to degrade</p>		1

Question Number	Acceptable Answers	Reject	Mark
11(e)(i)	<p>Both arrows in the correct direction</p> <p>AND 3CO₂ and 3H₂O in lowest box</p> <p>IGNORE state symbols, even if incorrect IGNORE extra O₂ molecules in box or alongside arrows</p>		1

Question Number	Acceptable Answers	Reject	Mark
11(e)(ii)	<p>1st mark (-394 x 3) + (-286 x 3)</p> <p>OR</p> <p>= -2040 (kJ mol⁻¹) (1)</p> <p>2nd mark: ΔH_f = -2040 - (-2058) = (+)18 (kJ mol⁻¹) (1)</p> <p>NOTE: The following answers score (1) mark with or without working -18 (kJ mol⁻¹) (+)1378 (kJ mol⁻¹) (+)806 (kJ mol⁻¹) (+)590 (kJ mol⁻¹) -4098 (kJ mol⁻¹)</p> <p>IGNORE units even if incorrect</p>		2

(Total for Question 11 = 17 marks)

Question Number	Acceptable Answers	Reject	Mark
12(a)(i)	<p>Curly arrow from double bond towards iodine atom AND curly arrow from the I—Cl bond to the chlorine atom</p> <p>(1)</p>  <p>Carbocation intermediate</p> <p>(1)</p>  <p>Curly arrow from the chloride ion to the correct C⁺ in the intermediate</p> <p>(1)</p>  <p>NOTE</p> <p>Curly arrow can originate from anywhere on the Cl⁻ ion in the final step. Do not have to have a lone pair of e⁻ on the Cl⁻ ion</p>	<p>δ^+ for +</p> <p>δ^- for - on Cl⁻</p>	3

Question Number	Acceptable Answers	Reject	Mark
12(a)(ii)	Electrophilic Addition (1) (1) ALLOW answers in either order IGNORE 'heterolytic'		2

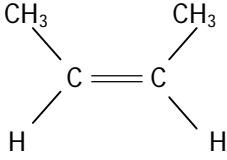
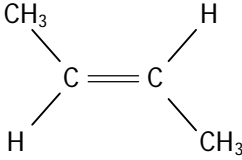
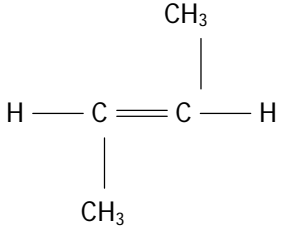
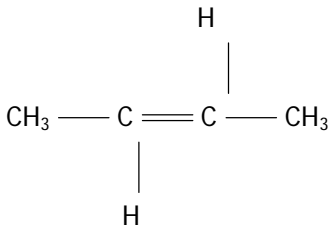
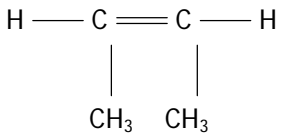
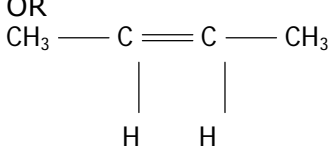
Question Number	Acceptable Answers	Reject	Mark
12(a)(iii)	$ \begin{array}{c} \text{H} \quad \text{CH}_3 \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{H} \\ \quad \\ \text{Cl} \quad \text{I} \end{array} $ ALLOW Correct structural OR displayed OR skeletal formula OR mixture of these (so long as unambiguous) Eg CH ₂ ClCHICH ₃ IGNORE Any name given, even if incorrect		1

Question Number	Acceptable Answers	Reject	Mark
12(b)(i)	Ultraviolet / UV OR Sun (light) OR Light ALLOW High temperature / 300°C (minimum) IGNORE Just heat / just radiation / rays	Mention of a 'catalyst'	1

Question Number	Acceptable Answers	Reject	Mark
12(b)*(ii)	<p>First mark:</p> <p>(Free) radical substitution (1)</p> <p>Second mark:</p> <p>Homolytic (fission) (1)</p> <p>Third mark:</p> <p>Initiation</p> <p>AND</p> <p>$\text{ICl} \rightarrow \text{I}\bullet + \text{Cl}\bullet$ (1)</p> <p>BOTH needed for the 3rd mark</p> <p>Fourth mark:</p> <p>Propagation (1)</p> <p>Fifth and sixth marks:</p> <p>$\text{CH}_4 + \text{Cl}\bullet \rightarrow \text{CH}_3\bullet + \text{HCl}$ (1)</p> <p>$\text{CH}_3\bullet + \text{ICl} \rightarrow \text{CH}_3\text{I} + \text{Cl}\bullet$ (1)</p> <p>IGNORE</p> <p>$\text{CH}_4 + \text{I}\bullet \rightarrow \text{CH}_3\bullet + \text{HI}$</p> <p>$\text{CH}_3\bullet + \text{ICl} \rightarrow \text{CH}_3\text{Cl} + \text{I}\bullet$</p> <p>Seventh mark:</p> <p>$\text{CH}_3\bullet + \text{I}\bullet \rightarrow \text{CH}_3\text{I}$</p> <p>OR</p> <p>$\text{Cl}\bullet + \text{Cl}\bullet \rightarrow \text{Cl}_2$</p> <p>OR</p> <p>$\text{CH}_3\bullet + \text{Cl}\bullet \rightarrow \text{CH}_3\text{Cl}$</p> <p>OR</p> <p>$\text{CH}_3\bullet + \text{CH}_3\bullet \rightarrow \text{C}_2\text{H}_6$</p> <p>OR</p> <p>$\text{I}\bullet + \text{Cl}\bullet \rightarrow \text{ICl}$</p> <p>ALLOW</p> <p>$\text{I}\bullet + \text{I}\bullet \rightarrow \text{I}_2$ (1)</p> <p>IGNORE</p> <p>Any INCORRECT termination step(s)</p> <p>IGNORE</p> <p>State symbols, even if incorrect</p> <p>Curly arrows / half curly arrows, even if incorrect</p>	<p>Heterolytic (fission)</p> <p>H• (the fifth and sixth marks cannot be awarded if H• appears in either propagation step)</p>	7

(Total for Question 12 = 14 marks)

Question Number	Acceptable Answers	Reject	Mark
13(a)	Any ONE of : Contains a carbon-carbon double bond / C=C OR Contains a carbon-carbon triple bond OR Does not contain the maximum number of hydrogen atoms/hydrogen(s) OR Can undergo addition reactions	Just 'carbon double bond' / Just 'contains a double bond' / 'contains a double bond between carbon molecules' 'contains more than one carbon-carbon double bond'	1

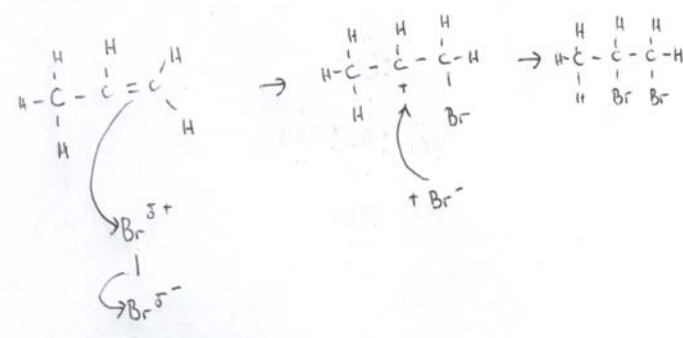
Question Number	Acceptable Answers	Reject	Mark
13(b)(i)	<div style="display: flex; justify-content: space-around; align-items: flex-start;"> <div style="text-align: center;">  <p>Z-but-2-ene</p> </div> <div style="text-align: center;">  <p>E-but-2-ene</p> </div> </div> <p>IGNORE references to <i>cis-trans</i> isomerism</p> <p>BOTH correct structures drawn (1)</p> <p><i>E</i>-isomer and <i>Z</i>-isomer correctly identified (1)</p> <p>but-2-ene written for each isomer (1) IGNORE missing hyphens Allow angles shown as right angles CH₃ does not have to be displayed in full Allow for <i>E</i>:</p> <div style="text-align: center;">  </div> <p>OR</p> <div style="text-align: center;">  </div> <p>Allow for <i>Z</i>:</p> <div style="text-align: center;">  </div> <p>OR</p> <div style="text-align: center;">  </div> <p>H atoms must be shown</p>	<p>If propene is drawn (0) overall</p>	3

Question Number	Acceptable Answers	Reject	Mark
13(b)(ii)	From purple/ (pale) pink to colourless Both needed Accept to brown	Clear for colourless/violet for purple	1

Question Number	Acceptable Answers	Reject	Mark
13(b)(iii)	$ \begin{array}{c} \text{CH}_3 \quad \text{CH}_3 \\ \quad \\ \text{HO}-\text{C}-\text{C}-\text{OH} \\ \quad \\ \text{H} \quad \text{H} \end{array} \quad \text{OR} \quad \begin{array}{c} \text{CH}_3 \quad \text{H} \\ \quad \\ \text{HO}-\text{C}-\text{C}-\text{OH} \\ \quad \\ \text{H} \quad \text{CH}_3 \end{array} $ <p>Ignore bond angles and orientation</p>		1

Question Number	Acceptable Answers	Reject	Mark
13(b)(iv)	Breaking a C-C bond/ breaking the molecule into a smaller molecule/ breaking the hydrocarbon into a smaller hydrocarbon ALLOW Any mention of 'breaking' or 'splitting' (molecule or compound or hydrocarbon) or 'large to small' IGNORE Just 'cracking to form an alkane and an alkene'	Any mention of 'breaking down into fractions' / forms branched molecules / splitting of crude oil (into smaller molecules)	1

Question Number	Acceptable Answers	Reject	Mark
13(b)(v)	$\text{C}_8\text{H}_{18} \rightarrow \text{C}_4\text{H}_8 + \text{C}_4\text{H}_{10}$ OR Equations with correct structural or displayed formulae IGNORE State symbols, even if incorrect Names, even if incorrect		1

Question Number	Acceptable Answers	Reject	Mark
13(c)	<p>Electrophilic (addition) (1)</p> <p>IGNORE 'heterolytic'</p> <p>Name of final product = 1,2-dibromopropane (1)</p> <p>No TE on naming a product shown incorrectly in equation.</p>  <p>Both curly arrows in first step (1)</p> <p>The structure of the intermediate carbocation $\text{CH}_3\text{CH}^+-\text{CH}_2\text{Br}$ (1) Allow $\text{CH}_3\text{CHBr}-\text{CH}_2^+$ as intermediate</p> <p>Curly arrow from Br^- to C^+ (1)</p> <p>Partial (δ^+ and δ^-) charges are not required Lone pair on bromide ion not required</p>	<p>If curly arrow from Br^- to a C^+ with a Br already attached to it</p>	5

Question Number	Acceptable Answers	Reject	Mark
13(d)(i)	<p>100% as only one product /</p> <p>100% as no by product(s) /</p> <p>100% as addition reaction /</p> <p>100% as no waste product (formed)</p>	<p>Just "atom economy is high" /</p> <p>no mention of 100%</p>	1

Question Number	Acceptable Answers	Reject	Mark
13(d)(ii)	$ \begin{array}{cccc} & \text{H} & & \text{H} \\ & & & \\ - & \text{CH}_2 & - \text{C} & - \text{CH}_2 & - \text{C} & - \\ & & & & \\ & & \text{CH}_3 & & \text{CH}_3 \end{array} $ <p>CH₃ groups may be on C2 and C4 OR C1 and C3</p> <p>IGNORE brackets IGNORE 'n'</p> <p>BOTH continuation bonds are essential</p>	Just repeating unit / one repeating unit drawn with an 'n' or a '2' next to it	1

Question Number	Acceptable Answers	Reject	Mark
13(d)(iii)	<p>Not sustainable as poly(propene) not made from a renewable resource /</p> <p>Not sustainable as made from non-renewable resource / not sustainable as made from crude oil.</p> <p>Not sustainable as crude oil is not renewable/</p> <p>Not sustainable as crude oil finite resource</p> <p>ALLOW Is sustainable if linked to recycling</p> <p>IGNORE References to non-biodegradability / long-lasting in use</p>		1

Total for Question 13 = 16 marks