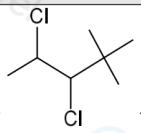
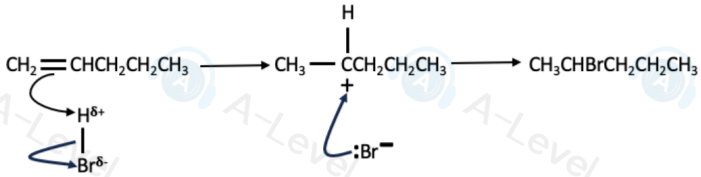
| Question Number | Answer | Mark |
|---|---|---|
| 16 |  <br>**The only correct answer is A** ( )<br><br>***B*** *is not correct because this is 2,4-dichloro-2,3-dimethylpentane*<br>***C*** *is not correct because this is 2,3-dichloro-2,4-dimethylpentane*<br>***D*** *is not correct because this is 2,2-dichloro-3,4-dimethylpentane* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| 15 | **The only correct answer is D** ($C_{13}H_{28}$)<br><br>***A*** *is incorrect because* $2(C_2H_4)+2(C_3H_6)+(C_3H_8) \neq C_8H_{18}$<br><br>***B*** *is incorrect because* $2(C_2H_4)+2(C_3H_6)+(C_3H_8) \neq C_{10}H_{22}$<br><br>***C*** *is incorrect because* $2(C_2H_4)+2(C_3H_6)+(C_3H_8) \neq C_{11}H_{24}$ | **(1)** |

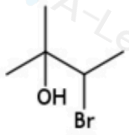
| Question Number | Answer | Mark |
|---|---|---|
| 19 | **The only correct answer is B**<br><br>  <br><br>***A*** *is incorrect because the arrow goes from the carbocation to the bromide ion*<br><br>***C*** *is incorrect because the arrow goes from* $H^{\delta+}$ *to the double bond*<br><br>***D*** *is incorrect because the bromide ion has a partial negative charge* | **(1)**<br><br>**Computer** |

| Question Number | Answer | Mark |
|---|---|---|
| 13 | **The only correct answer is C** (green solution and effervescence)<br><br>***A*** *is not correct because the solution is not colourless and effervescence is not included*<br>***B*** *is not correct because a colourless solution is not formed*<br>***D*** *is not correct because effervescence is not included* | **(1)**<br><br>**Computer** |

| Question Number | Answer | Mark |
|---|---|---|
| 15 | **The only correct answer is B** (3,4-dimethyldecane)<br><br>***A*** *is incorrect because the longest chain has 10 carbons so it is a decane*<br><br>***C*** *is incorrect because the longest chain has 10 carbons so it is a decane*<br><br>***D*** *is incorrect because the numbering of the substituents must give the lowest numbers* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| 17 | **The only correct answer is A** (*E*-1-bromo-2-methylbut-1-ene)<br><br>***B*** *is incorrect because the highest priority groups are on opposite sides of the double bond*<br><br>***C*** *is incorrect because the longest carbon chain has four atoms*<br><br>***D*** *is incorrect because the longest carbon chain has four atoms and the highest priority groups are on opposite sides of the double bond* | **(1)**<br><br>**Computer** |

| Question Number | Answer | Mark |
|---|---|---|
| 4 | **The only correct answer is B** (a compound containing of carbon and hydrogen only)<br><br>***A*** *is not correct because hydrocarbons do not contain oxygen*<br>***C*** *is not correct because not all hydrocarbons have only single carbon to carbon bonds*<br>***D*** *is not correct because it does not suggest that the hydrogen and carbon atoms are bonded together* | **(1)**<br><br>**Computer** |

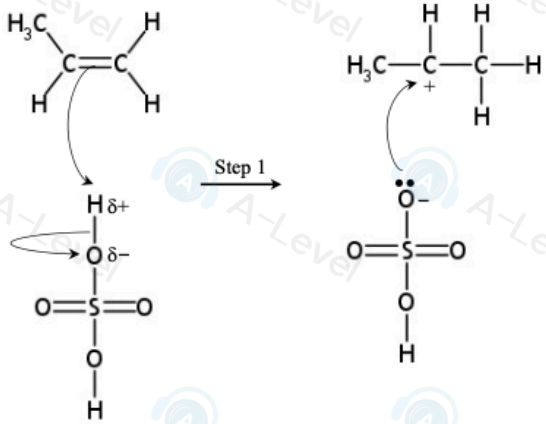
| Question Number | Answer | Mark |
|---|---|---|
| 17 | **The only correct answer is A (**  **)**<br><br>***B*** *is incorrect because this is the minor product of the addition of BrOH to 2-methylbut-2-ene*<br><br>***C*** *is incorrect because this is the major product of the addition of BrOH to 2-methylbut-1-ene*<br><br>***D*** *is incorrect because this is the minor product of the addition of BrOH to 2-methylbut-1-ene* | **(1)** |



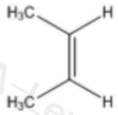
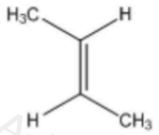
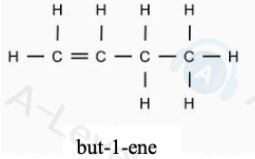
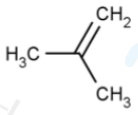
| Question Number | Answer | Mark |
|---|---|---|
| 16 | **The only correct answer is A** (butene, pentane and propene)<br><br>***B*** *is not correct because there are too many hydrogen atoms in the products*<br><br>***C*** *is not correct because there are too few carbon atoms in the products*<br><br>***D*** *is not correct because there are too many carbon atoms in the products* | **(1)** |

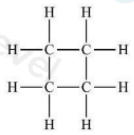
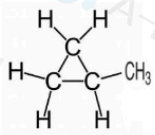
| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| 19(a)(i) | An answer that makes reference to the following point:<br>• electrophilic addition | Do not award substitution | (1) |

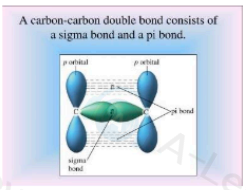
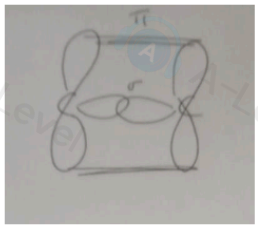
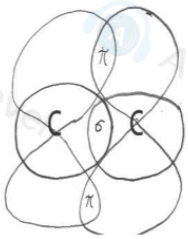
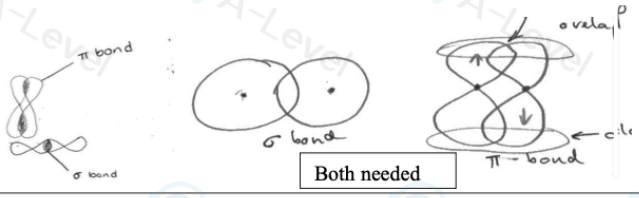
| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| 19(a)(ii) | An explanation that makes reference to the following points:<br>• (because) the formation of 2-chloropropane / the major product proceeds via a secondary **carbocation** **(1)**<br>• (but) the reaction / the formation of 1-chloropropane / the formation of the minor product proceeds via a primary **carbocation** **(1)**<br>• (and) secondary carbocations are more stable than primary carbocations **(1)** | Do not award 2-chloropropane is a secondary carbocation<br>Do not award 1-chloropropane is a primary carbocation<br>Allow TE on incorrect type of carbocations used in M1 and M2 but must be in the correct order of stability (3° more stable than 2° more stable than 1°) | (3) |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| 19(b) | All 9 points scores (4)<br>7 or 8 points scores (3)<br>5 or 6 points scores (2)<br>3 or 4 points scores (1)<br>• dipole on O–H bond<br>• arrow from double bond to correct H or just in front of H<br>• arrow from O–H bond to O<br>• structure of intermediate carbocation ignoring any charge<br>• positive charge on intermediate carbocation<br>• structure of intermediate anion<br>• single negative charge on intermediate anion<br>• lone pair of electrons on relevant O<br>• arrow from lone pair of electrons to correct carbon | Example of diagram:<br>  <br><br>Allow charge on the anion anywhere on the ion including outside a bracket | (4) |

**(Total for Question 19 = 8 marks)**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| 18(a) | An answer that makes reference to the following points:<br>• **A**<br>  <br>*cis-* / *Z-* but-2-ene **(1)**<br>• **B**<br>  <br>*trans-* /*E-* but-2-ene **(1)**<br>• **C**<br>  <br>but-1-ene<br>  <br>methylprop-1-ene **(1)** | Allow structural/skeletal/displayed or any combination.<br><br>Both name and structure required for each mark<br><br>A and B can be swapped over<br><br>If both A and B structures are correct but names wrong score 1(and vice versa)<br><br>Ignore lack of hyphens<br><br>Either structure allowed<br>Allow $C_2H_5CHCH_2$<br><br>Allow 2-methylprop-1-ene, methylpropene | **(4)** |

| | | | |
|---|---|---|---|
| | • **D**<br>  <br>cyclobutane<br>  <br>methylcyclopropane **(1)** | Either structure allowed<br>If both C and D structures are correct but names wrong score 1(and vice versa)<br><br>Only penalise missing Hs once if displayed or structural given<br>Allow cyclicbutane<br><br>If no other mark is awarded score 1 mark for any 2 correct structures or names in correct position | |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| 18(b) | An answer that makes reference to the following points:<br>  <br>• diagram showing electron density of σ bond (1)<br>• diagram showing electron density of π bond (1)<br>  <br>  <br>  <br>  <br>Both needed | Only one pi bond needs to be labelled<br>Can be shown by 2 separate diagrams<br>All the examples on the left score M1 and M2<br>If both diagrams are correct but names reversed score 1<br>Do not award electron rings, single lines or contour lines | (4) |

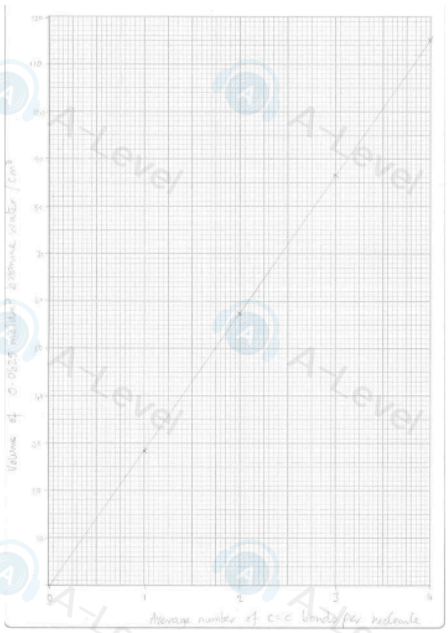
| | | | |
|---|---|---|---|
| | • σ bond head/end on overlap of *(p)* orbitals (1)<br>• π bond sideways overlap of *(p)* orbitals (1) | Allow overlap along the axis between the atoms/ nuclei<br>Allow axial overlap<br>Allow parallel overlap<br>Allow lateral overlap<br>Ignore above and below/horizontal | |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| 18(c) | An answer that makes reference to the following points:<br>• restricted/ no rotation about the double bond/C=C (1)<br>• (two) different groups on each carbon (of the double bond)/the carbons (of the double bond) (1) | Allow no or restricted free rotation<br>Ignore lack of twisting/bending/movement<br>Allow different elements/atoms/functional groups<br>Allow an explanation or diagram of the positions of the $CH_3$ and H.<br>Ignore just the position of the $CH_3$<br>Do not award different compounds/molecules | (2) |

**(Total for Question 18 = 10 marks)**

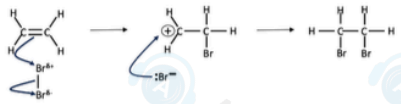
| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| 19(a) | An answer that makes reference to the following point:<br>• presence of (at least one) carbon to carbon double bond / C = C | Allow C ≡ C bond<br>Ignore just having a double bond<br>Ignore Hydrocarbon | (1) |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| 19(b) (i) | An answer that makes reference to the following point:<br>• addition (reaction) **(1)** | Ignore electrophilic, bromination, hydration, halogenation<br><br>Do not award nucleophilic, substitution | (1) |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| 19(b)(ii)<br><br>Clip with (b)(iii) and (b)(iv) | An answer that makes reference to the following points:<br><br>• x-axis labelled (average) number of C=C (bonds per molecule) **(1)**<br><br>**and**<br><br>y-axis labelled **volume** (of 0.0625 mol $dm^{-3}$ bromine water) **/$cm^3$**<br><br>• 4 **points** in the table plotted correctly to within half a small square **(1)**<br><br>**and**<br><br>plots to cover ½ the grid in both directions with linear scales<br><br>• straight line of best fit (through all 4 points) **(1)** |  <br>Ignore extrapolation of straight line | **(3)** |
| **Question** | **Answer** | **Additional Guidance** | **Mark** |

| Number | | | |
|---|---|---|---|
| 19(b) (iii)<br><br>Clip with (b)(ii) and (b)(iv) | • calculation of the mean to 3SF | Example of calculation:<br><br>$\frac{36.9 + 34.1 + 39.3 + 32.5}{4} = 35.7\ (cm^3)$ | **(1)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| 19(b) (iv)<br><br>Clip with (b)(ii) and (b)(iii) | • average number of C=C bonds derived from their graph<br><br>**and**<br><br>given to 2SF | Average number of C=C bonds per molecule<br>1.25<br>=1.2 or 1.3<br>Allow TE from an incorrect line of best fit | **(1)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| 19(c) (i) | An answer that makes reference to the following points:<br>• dipole on Br−Br<br>• arrow from double bond to delta + bromine<br>• arrow from bromine bond to delta - bromine<br>• carbocation on correct intermediate<br>• lone pair on bromide<br>• negative charge on bromide ion<br>• arrow from lone pair on bromide ion to carbocation<br>• correct formula of final product (1,2-dibromoethane)<br><br>all 8 points 4 marks, 6 or 7 points 3 marks, 4 or 5 points 2 marks, 2 or 3 points 1 mark |  <br><br>Point 1 if H-Br used penalise here only<br>Point 4 carbocation intermediate based on any alkene<br>Point 7 given for the arrow from lone pair if given, or anywhere if lone pair not given. | (4) |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| 19(c) (ii) | An answer that makes reference to the following point:<br><br>(E- / trans-) 4-methylhex-2-ene | Do not award hexa | (1) |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| 19(d) | An answer that makes reference to the following points:<br>• correct skeletal formula (1)<br>• trans means that the (alkyl) groups (methyl or R) are on either side of the double bond (1) |  <br><br>Allow (alkyl) groups point in opposite directions<br>M2 is dependent on the presence of a double bond in M1 or text of M2<br><br>Ignore planes as this does not differentiate sufficiently between cis and trans<br>Do not award species or molecules instead of groups | (2) |

**(Total for Question 19 = 14 marks)**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **21(a)(i)** | An answer that makes reference to the following points:<br>• $C_8H_{18}$ **(1)**<br>• 2,2,4–**tri**methylpentane **(1)** | Allow incorrect dashes / commas / spaces | **(2)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **21(a)(ii)** | • reforming | Allow reformation<br>Allow isomerisation | **(1)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **21(b)(i)** | • correct equation **(1)**<br>• state symbols **(1)** | Example of equation<br>$C_7H_{16}(l) + 11O_2(g) \rightarrow 7CO_2(g) + 8H_2O(l)$<br>Accept water as a gas<br>M2 is dependent on M1, or a near miss e.g. lack of balancing or balanced for the incorrect hydrocarbon.<br>No M2 possible for hydrocarbons as products | **(2)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **21(b)(ii)** | • carbon monoxide / CO / soot / C / (carbon) particulates / unburnt heptane | Do not award carbon dioxide / $CO_2$ / nitrogen oxides / $NO_x$ / sulfur oxides / $SO_x$ / any other hydrocarbon<br>Ignore water / $H_2O$<br>If name and formula are given, both need to be correct | **(1)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **21(c)** | An answer that makes reference to two of the following points:<br>• (electric cars) do not emit **carbon dioxide** **and** (carbon dioxide) causes climate change / causes global warming / is a greenhouse gas)<br>OR<br>(electric cars) can be powered by **electricity** from renewable sources (which do not contribute to climate change / global warming / greenhouse effect) **(1)**<br>• do not emit substances which cause (local) pollution / acid rain **(1)**<br>• they are much quieter so reduce noise pollution **(1)** | Ignore references to carbon monoxide as a greenhouse gas<br>Ignore any references to the ozone layer, even if incorrect<br>Allow examples of renewable sources e.g. solar<br>Allow examples of substances e.g. nitrogen oxides / carbon particulates / carbon monoxide<br>Ignore "less air pollution" and "pollutants" alone<br>Ignore "acid rain" alone<br>Ignore reduce non-renewable fuel use / refineries<br>Ignore catalytic converters<br>Ignore "more carbon neutral" | **(2)** |

**(Total for Question 21 = 8 marks)**