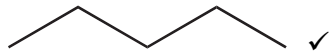


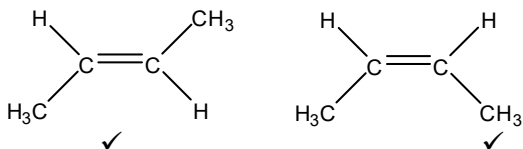
Question			Answer	Mark	Guidance
1	(a)	(i)	(compounds or molecules having the) same molecular formula but different structural formulae ✓	1	ALLOW different structure OR different displayed formula OR different skeletal formula for structure DO NOT ALLOW any reference to spatial/space Same formula is not sufficient (<i>no reference to molecular</i>) Different arrangement of atoms is not sufficient (<i>no reference to structure/structural</i>)
		(ii)	2,2,3-trimethylbutane ✓	1	ALLOW trimethylbutane as the ONLY alternative response
	(b)		 ✓	1	DO NOT ALLOW molecular formulae OR structural formula OR displayed formula OR mixture of the above
	(c)		C ₁₂ H ₂₅ ✓	1	IGNORE C ₂₄ H ₅₀
	(d)	(i)	C ₈ H ₁₈ + 12½O ₂ → 8CO ₂ + 9H ₂ O ✓	1	ALLOW multiples e.g. 2C ₈ H ₁₈ + 25O ₂ → 16CO ₂ + 18H ₂ O IGNORE state symbols

Question	Answer	Mark	Guidance
(ii)	$(n(\text{C}_8\text{H}_{18}) \text{ burned}) = 0.32 \text{ (mol)} \checkmark$ $(n(\text{CO}_2) \text{ from complete combustion}) = 2.56 \text{ or } 2.6 \text{ mol}$ OR $(\text{ratio } n\text{CO}_2/n\text{C}_8\text{H}_{18}) = 7.8(125)$ OR $(n \text{ C}_8\text{H}_{18} \text{ produce } 2.5 \text{ mol CO}_2) = 0.31(25) \checkmark$	2	<p>DO NOT ALLOW ECF from an incorrect moles of octane</p> <p>DO NOT ALLOW ECF from incorrect ratio from equation in (i)</p> <p>ALLOW the following alternate methods</p> <p>-----</p> <p>Method 1</p> <p>$(\text{mass CO}_2 \text{ produced}) = 110 \text{ g} \checkmark$</p> <p>$(\text{mass CO}_2 \text{ from complete combustion})$ $= 8 \times 0.32 \times 44 = 112.64 \text{ or } 112.6 \text{ or } 113 \text{ g} \checkmark$</p> <p>-----</p> <p>Method 2</p> <p>$(n \text{ C}_8\text{H}_{18} \text{ to produce } 2.5 \text{ mol CO}_2) = 0.31(25) \checkmark$</p> <p>$(\text{mass of octane required to produce } 2.50 \text{ mol CO}_2)$ $= 35.6 \text{ OR } 35.63 \text{ OR } 35.625 \text{ g} \checkmark$</p>



Question		Answer	Mark	Guidance	
	(e)	(i)	Fractional distillation AND cracking ✓	1	ALLOW either order
		(ii)	Correct equation showing cracking of an alkane to form ethene ✓	1	<p>ALLOW any correct equation with correct formulae to show cracking forming C₂H₄ of the type: alkane → shorter alkane(s) + alkene, e.g. C₁₀H₂₂ → C₈H₁₈ + C₂H₄ C₁₀H₂₂ → C₆H₁₄ + 2C₂H₄</p> <p>ALLOW C₂H₆ → C₂H₄ + H₂</p> <p>ALLOW correct molecular formulae OR structural OR displayed OR skeletal OR mixture of the above.</p> <p>IGNORE state symbols</p>
			Total	9	

Question			Answer	Mark	Guidance
2	(a)	(i)	(series of compounds with the) same functional group OR same/similar chemical properties OR same/similar chemical reactions ✓ each successive/subsequent member differing by CH ₂ ✓	2	IGNORE references to physical properties IGNORE has same general formula (in question) DO NOT ALLOW have the same empirical formula OR have the same molecular formula
		(ii)	C _n H _{2n} ✓	1	
		(iii)	More carbons (in ring) OR more (surface area of) contact AND more van der Waals forces OR stronger van der Waals forces ✓ More energy needed to break the intermolecular forces ✓	2	Both answers need to be comparisons ALLOW ORA throughout ALLOW has more electrons OR larger (carbon) ring OR higher molecular mass IGNORE bigger molecule IGNORE chain instead of ring DO NOT ALLOW 'more contact between atoms' ALLOW 'VDW' for van der Waals 'More intermolecular forces' is not sufficient ALLOW it is harder to overcome the intermolecular forces ALLOW intermolecular bonds / van der Waals bonds ALLOW more energy is needed to separate molecules IGNORE more energy is needed to break bonds

Question		Answer	Mark	Guidance
(b)		tetrahedral ✓ four bonding pairs repel OR four bonds repel ✓	2	Mark each point independently IGNORE surrounded by four atoms IGNORE four areas of electron charge repel IGNORE four electron pairs repel (<i>one could be lp</i>) DO NOT ALLOW atoms repel
(c)		$\begin{array}{ccccccc} & \text{H} & & \text{H} & & \text{H} & \\ & & & & & & \\ \text{Br} & - \text{C} & - & \text{C} & - & \text{C} & - \text{Br} \\ & & & & & & \\ & \text{H} & & \text{H} & & \text{H} & \end{array}$ ✓	1	ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) ALLOW structure of 1,2-isomer $\begin{array}{ccccccc} & \text{H} & & \text{H} & & \text{H} & \\ & & & & & & \\ \text{Br} & - \text{C} & - & \text{C} & - & \text{C} & - \text{H} \\ & & & & & & \\ & \text{H} & & \text{Br} & & \text{H} & \end{array}$ IGNORE molecular formula DO NOT ALLOW , structure of 1,1-isomer OR 2,2-isomer $\begin{array}{ccccccc} & \text{H} & & \text{H} & & \text{H} & \\ & & & & & & \\ \text{Br} & - \text{C} & - & \text{C} & - & \text{C} & - \text{H} \\ & & & & & & \\ & \text{Br} & & \text{H} & & \text{H} & \end{array} \quad \text{H} - \begin{array}{ccc} & \text{H} & \\ & & \\ & \text{H} & \end{array} - \begin{array}{ccc} & \text{Br} & \\ & & \\ & \text{Br} & \end{array} - \begin{array}{ccc} & \text{H} & \\ & & \\ & \text{H} & \end{array} - \text{H}$
(d)	(i)	$\text{C}_6\text{H}_{14} \rightarrow \text{C}_6\text{H}_{12} + \text{H}_2$ ✓	1	ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) ALLOW any correct multiple IGNORE state symbols

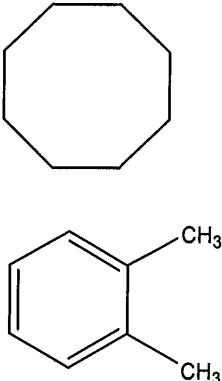
Question		Answer	Mark	Guidance
	(ii)	Cyclohexane will burn more efficiently ✓	1	<p>KEY IDEA IS COMBUSTION OR BURNING</p> <p>Assume 'it' refers to cyclohexane ALLOW ORA for hexane</p> <p>ALLOW cyclohexane allows smoother burning OR promotes more efficient combustion OR increases octane number OR reduces knocking OR less likely to produce pre-ignition OR burns better OR easier to burn OR combusts more easily OR improves combustion OR burns more cleanly DO NOT ALLOW cyclohexane ignites more easily IGNORE cyclohexane increase volatility of fuel IGNORE reference to boiling points IGNORE cyclohexane gives a better fuel</p>
(e)	(i)	(Compounds with the) same structural formula but a different arrangement (of atoms) in space ✓	1	<p>ALLOW different spatial arrangement of atoms. DO NOT ALLOW different displayed formula.</p>
	(ii)		2	<p>ALLOW displayed OR skeletal formula OR mixture of the above. ALLOW structures in either order IGNORE molecular formula IGNORE structural formula IGNORE names IGNORE E/Z and cis/trans labels ALLOW 1 mark for a pair of E/Z isomers of an incorrect hydrocarbon structure with four C atoms e.g. C, or CH or CH₂ instead of CH₃ groups.</p>

Question		Answer	Mark	Guidance								
	(f) (i)	<table border="1"> <thead> <tr> <th>Step</th> <th>Equation</th> </tr> </thead> <tbody> <tr> <td>Initiation (1 mark)</td> <td>$\text{Br}_2 \rightarrow 2\text{Br}\cdot \checkmark$</td> </tr> <tr> <td>Propagation (2 marks)</td> <td>$\text{C}_6\text{H}_{12} + \text{Br}\cdot \rightarrow \text{C}_6\text{H}_{11}\cdot + \text{HBr} \checkmark$ $\text{C}_6\text{H}_{11}\cdot + \text{Br}_2 \rightarrow \text{C}_6\text{H}_{11}\text{Br} + \text{Br}\cdot \checkmark$</td> </tr> <tr> <td>Termination (2 marks)</td> <td>$\text{C}_6\text{H}_{11}\cdot + \text{Br}\cdot \rightarrow \text{C}_6\text{H}_{11}\text{Br}$ $\text{C}_6\text{H}_{11}\cdot + \text{C}_6\text{H}_{11}\cdot \rightarrow \text{C}_{12}\text{H}_{22}$ $\text{Br}\cdot + \text{Br}\cdot \rightarrow \text{Br}_2$ Two correct \checkmark All three correct $\checkmark\checkmark$</td> </tr> </tbody> </table>	Step	Equation	Initiation (1 mark)	$\text{Br}_2 \rightarrow 2\text{Br}\cdot \checkmark$	Propagation (2 marks)	$\text{C}_6\text{H}_{12} + \text{Br}\cdot \rightarrow \text{C}_6\text{H}_{11}\cdot + \text{HBr} \checkmark$ $\text{C}_6\text{H}_{11}\cdot + \text{Br}_2 \rightarrow \text{C}_6\text{H}_{11}\text{Br} + \text{Br}\cdot \checkmark$	Termination (2 marks)	$\text{C}_6\text{H}_{11}\cdot + \text{Br}\cdot \rightarrow \text{C}_6\text{H}_{11}\text{Br}$ $\text{C}_6\text{H}_{11}\cdot + \text{C}_6\text{H}_{11}\cdot \rightarrow \text{C}_{12}\text{H}_{22}$ $\text{Br}\cdot + \text{Br}\cdot \rightarrow \text{Br}_2$ Two correct \checkmark All three correct $\checkmark\checkmark$	5	<p>IGNORE state symbols</p> <p>IGNORE dots</p> <p>If an incorrect hydrocarbon with six C atoms is used: DO NOT ALLOW any marks for the propagation steps but ALLOW ECF for termination steps (<i>i.e.</i> 3 max)</p>
Step	Equation											
Initiation (1 mark)	$\text{Br}_2 \rightarrow 2\text{Br}\cdot \checkmark$											
Propagation (2 marks)	$\text{C}_6\text{H}_{12} + \text{Br}\cdot \rightarrow \text{C}_6\text{H}_{11}\cdot + \text{HBr} \checkmark$ $\text{C}_6\text{H}_{11}\cdot + \text{Br}_2 \rightarrow \text{C}_6\text{H}_{11}\text{Br} + \text{Br}\cdot \checkmark$											
Termination (2 marks)	$\text{C}_6\text{H}_{11}\cdot + \text{Br}\cdot \rightarrow \text{C}_6\text{H}_{11}\text{Br}$ $\text{C}_6\text{H}_{11}\cdot + \text{C}_6\text{H}_{11}\cdot \rightarrow \text{C}_{12}\text{H}_{22}$ $\text{Br}\cdot + \text{Br}\cdot \rightarrow \text{Br}_2$ Two correct \checkmark All three correct $\checkmark\checkmark$											
	(ii)	The breaking of a (Br-Br) bond AND forms (two) radicals OR the breaking of a (Br-Br) bond AND one electron (from the bond pair) goes to each atom/bromine \checkmark	1	<p>ALLOW 'the breaking of a covalent bond'</p> <p>ALLOW the splitting of the bond in bromine</p> <p>ALLOW the breaking of a covalent bond where each atom keeps one of the bonding electrons</p> <p>IGNORE particle for atom</p> <p>ALLOW one electron goes to each product / species</p> <p>DO NOT ALLOW molecule or compound for atom</p> <p>IGNORE homolytic fission equations</p>								
	(g) (i)	$\text{C}_6\text{H}_{12} + 2\text{Br}_2 \rightarrow \text{C}_6\text{H}_{10}\text{Br}_2 + 2\text{HBr} \checkmark$	1	ALLOW molecular formula only.								
	(ii)	1,1-dibromocyclohexane OR 1,2-dibromocyclohexane OR 1,3-dibromocyclohexane OR 1,4-dibromocyclohexane \checkmark	1	Locant numbers MUST lowest possible e.g. DO NOT ALLOW 2,4-dibromocyclohexane etc. IGNORE structures								
Total			21									

Question			Answer	Marks	Guidance
3	(a)	(i)	C ₁₀ H ₂₂ ✓	1	IGNORE the name decane
		(ii)	Correct skeletal formula ✓ Correct name for structure drawn providing the structure is a branched chain isomer of C ₁₀ H ₂₂ ✓	2	<p>DO NOT ALLOW structural formula OR displayed formula</p> <p>Examples of skeletal formulae:</p> <div style="display: flex; justify-content: space-around; align-items: flex-end;"> <div style="text-align: center;">  <p>2-methylnonane</p> </div> <div style="text-align: center;">  <p>3-methylnonane</p> </div> </div> <p>ALLOW name even if structural or displayed formula drawn</p> <p>DO NOT ALLOW incorrect nomenclature eg 2-ethyloctane, 6-methylnonane, 2-methnonane, 2-methylnonan, 2-methynonane</p> <p>There are many more isomers that can be drawn</p>

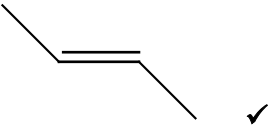
Question	Answer	Marks	Guidance
(a) (iii)	<p>B has less surface (area of) contact OR ORA AND B has fewer van der Waals' forces OR B has weaker van der Waals' forces OR ORA ✓</p> <p>So less energy needed to break the intermolecular forces in B OR ORA ✓</p>	2	<p>Both answers need to be comparisons Assume 'it' refers to B</p> <p>ALLOW B has less points of contact AND fewer VDW</p> <p>DO NOT ALLOW less points of contact between atoms</p> <p>Reference to just surface area or closeness of molecules is not sufficient. IGNORE if not qualified</p> <p>IGNORE B more compact OR B has a shorter chain</p> <p>DO NOT ALLOW B is a smaller molecule DO NOT ALLOW B has fewer electrons</p> <p>Intermolecular forces is not sufficient for the first marking point must refer to van der Waals'</p> <p>ALLOW ORA throughout in terms of A if specified</p> <p>ALLOW in B it takes less energy to overcome the intermolecular forces</p> <p>ALLOW it is easier to overcome the intermolecular forces</p> <p>DO NOT ALLOW so less energy is needed to break bonds</p> <p>DO NOT ALLOW intermolecular bonds</p>

Question		Answer	Marks	Guidance
	(b) (i)	Correct equation for the cracking of C ₁₅ H ₃₂ ✓ eg C ₁₅ H ₃₂ → C ₁₃ H ₂₈ + C ₂ H ₄	1	<p>ALLOW molecular formula OR correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous)</p> <p>ALLOW any correct equation that has an alkane and alkene(s) (and hydrogen) as products OR has alkenes and hydrogen as products e.g. C₁₅H₃₂ → C₁₁H₂₄ + 2C₂H₄ C₁₅H₃₂ → C₆H₁₂ + C₉H₁₈ + H₂</p> <p>IGNORE state symbols</p>
	(ii)	(idea that) any carbon–carbon bond (in the chain) can break ✓	1	<p>ALLOW carbon chain can break in many different places</p> <p>ALLOW the position of breakdown of the carbon chain is random</p> <p>ALLOW the carbon chain can break in many different places</p> <p>ALLOW carbon chain can split in many different places</p> <p>Carbon chain is cracked in many places is not sufficient</p> <p>Molecule can break anywhere is not sufficient / cannot control where the molecule breaks is not sufficient</p> <p>Molecule can form many different chain lengths is not sufficient</p>

Question		Answer	Marks	Guidance
(c)	(i)	<p>Any cyclic hydrocarbon with eight carbon atoms in all ✓ eg</p>  <p>The image shows two chemical structures. The first is a regular octagon representing cyclooctane. The second is a benzene ring with two methyl groups (CH₃) attached to adjacent carbons, representing 1,2-dimethylbenzene (o-xylene).</p>	1	<p>ALLOW correct structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous)</p> <p>ALLOW equation with the correct product</p> <p>DO NOT ALLOW if any other extra structure is included which is incorrect</p> <p>DO NOT ALLOW 'aromatic cyclooctatetraene' but ALLOW this as a normal structural formula</p> <p>IGNORE hydrogen as an extra product</p> <p>IGNORE any name given</p>

Question		Answer	Marks	Guidance
(c)	(ii)	Cyclic hydrocarbons promote efficient combustion ✓	1	<p>The answer must relate to combustion or burning</p> <p>ALLOW cyclic hydrocarbons allow smoother burning OR cyclic hydrocarbons increase octane number OR cyclic hydrocarbons reduce knocking OR cyclic hydrocarbons are less likely to produce pre-ignition OR cyclic hydrocarbons are more efficient fuels OR cyclic hydrocarbons burn better OR easier to burn OR cyclic hydrocarbon combust more easily OR improves combustion DO NOT ALLOW cyclic hydrocarbons ignite more easily</p> <p>ALLOW ora for straight chain hydrocarbons</p> <p>IGNORE cyclic hydrocarbons increase volatility of fuel IGNORE cyclic hydrocarbons have a lower boiling point</p> <p>Cyclic hydrocarbons are a better fuel on their own is NOT sufficient Cyclic hydrocarbons burn more cleanly on their own is NOT sufficient</p>
Total			9	

Question		Answer	Marks	Guidance
4	(a)	alkene ✓ ester ✓	2	ALLOW carbon-carbon double bond OR a C-C <u>double</u> bond A double bonded carbon is not sufficient C=C is not sufficient Carbon-carbon multiple bond is not sufficient Ketone / carbonyl / aldehyde / carboxylic acid contradicts the ester mark
	(b)	contains a C=C bond ✓	1	Contains a double bond is not sufficient Carbon-carbon multiple bond is not sufficient DO NOT ALLOW contains a C=O bond
	(c)	(from) orange (to) colourless ✓	1	ALLOW shades of orange OR yellow OR brown ALLOW orange to decolourised DO NOT ALLOW red alone DO NOT ALLOW any response that includes precipitate OR solid, irrespective of colour DO NOT ALLOW clear for colourless
	(d) (i)	Same structural formula AND different arrangement (of atoms) in space OR different spatial arrangement ✓	1	ALLOW have the same structure/displayed formula/skeletal formula DO NOT ALLOW same empirical formula OR same general formula Stereoisomers have the same formula or molecular formula is not sufficient Different three dimensional arrangement is not sufficient Reference to <i>E/Z</i> isomerism or optical isomerism is not sufficient

Question		Answer	Marks	Guidance
	(d) (ii)		1	<p>Any writing must not contradict the diagram</p> <p>IGNORE any other feature of the structure drawn</p> <p>ALLOW the J will be the <i>E</i> isomer and I is the <i>Z</i> isomer</p> <p>ALLOW the J will be the <i>trans</i> isomer and I is the <i>cis</i> isomer</p> <p>ALLOW a description, eg the other isomer will have (carbon) chains diagonally arranged across the C=C or the other isomer will have hydrogen atoms diagonally arranged across the C=C bond</p> <p>DO NOT ALLOW draw <i>trans</i> but label as <i>cis</i></p>
	(e) (i)	<p>(Enthalpy change that occurs) when one mole of a substance ✓</p> <p>completely combusts OR reacts fully with oxygen ✓</p>	2	<p>ALLOW energy required OR energy released</p> <p>ALLOW (energy change) when one mole of an element / compound / molecule / reactant</p> <p>DO NOT ALLOW one mole of reactants / product / substances / fuel / atoms</p> <p>ALLOW combusts in excess oxygen</p> <p>ALLOW burns in excess oxygen</p> <p>DO NOT ALLOW combust in excess air</p> <p>IGNORE fully oxidised</p> <p>IGNORE any conditions stated</p>

Question		Answer	Marks	Guidance
(e)	(ii)	<p>FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = 7.06(42), award 2 marks. IF answer = 7.1, award 1 mark.</p> <p>$q = 50.0 \times 4.18 \times 33.8$ OR 7064.2 (J) ✓ = 7.06(42) (kJ) ✓</p>	2	<p>ALLOW 7.06 up to calculator value of 7.0642 correctly rounded</p> <p>DO NOT ALLOW ECF from marking point 1 IGNORE negative sign in answer</p>
	(iii)	<p>FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = 0.005(00), award 2 marks.</p> <p>$M_r = 268.0$ ✓</p> <p>amount used = 0.005(00) (mol) ✓</p>	2	<p>IF there is an alternative answer, check to see if there is any ECF credit possible using working below</p> <p>ALLOW 268</p> <p>ALLOW 5×10^{-3} ALLOW ECF from incorrect M_r IGNORE trailing zeros</p>
	(iv)	<p>FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = -1413, award 3 marks. IF answer = 1413, award 2 marks.</p> <p>$\Delta H = \frac{\text{answer to (ii)}}{\text{answer to (iii)}} \text{ OR } \frac{7.0642}{0.005}$ ✓</p> <p>1413 ✓</p> <p>minus sign (this is an independent mark) ✓</p>	3	<p>IF there is an alternative answer, check to see if there is any ECF credit possible using working below</p> <p>ALLOW ECF from (ii) and (iii)</p> <p>ALLOW 1410 up to calculator value of 1412.84 correctly rounded ALLOW answers in standard form 1.41×10^3 up to calculator value of 1.41284×10^3 correctly rounded</p> <p>Answer must be at least three significant figures</p> <p>ALLOW 1412 if answer to (ii) is 7.06 ALLOW 1420 if answer to (ii) is 7.1</p>

Question		Answer	Marks	Guidance
	(e) (v)	incomplete combustion OR not sufficient oxygen available AND carbon is formed ✓	1	IGNORE soot is formed, carbon monoxide is formed or carbon dioxide is formed
	(f)	$\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 2\text{CO}_2 + 2\text{C}_2\text{H}_5\text{OH} \checkmark$ use of yeast OR zymase ✓ anaerobic OR absence of oxygen OR any temperature between 20 and 45 °C OR water OR aqueous ✓	3	ALLOW correct molecular OR structural OR displayed OR skeletal formula OR mixture of the above (as long as unambiguous) IGNORE state symbols Enzyme is not sufficient DO NOT ALLOW acid catalyst If there is a contradiction or an incorrect answer in any condition given then do not award this mark. ALLOW room temperature Temperature quoted must include unit ALLOW conditions shown in the equation IGNORE warm temperature IGNORE heat / warm Body temperature is not sufficient A limited supply of oxygen is not sufficient IGNORE low pressure OR atmospheric pressure DO NOT ALLOW high pressure OR a pressure above 2 atmospheres
			Total	19