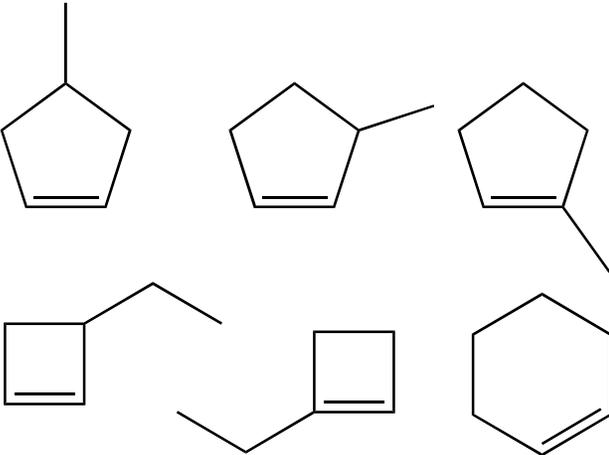
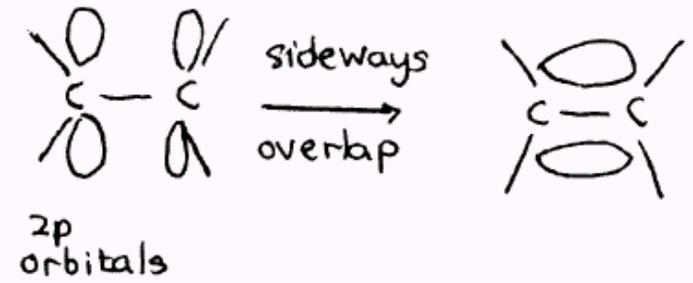


Question			Expected Answers	Marks	Additional Guidance
1	a	i	Series having same functional group and a general formula ✓	1	ALLOW same functional group and members vary by CH ₂ ALLOW organic compounds with the same functional group that differ in length of their hydrocarbon chain
		ii	More surface contact OR bigger molecules ✓ More van der Waals' forces ✓	2	BOTH answers need to be comparisons ALLOW higher relative formula mass OR has more electrons OR longer chain length OR more carbon atoms IGNORE surface area / bigger compounds ALLOW stronger van der Waals' forces / stronger induced dipoles VDW forces is not sufficient More intermolecular forces is not sufficient DO NOT ALLOW breaking bonds within the chain / breaking covalent bonds IGNORE reference to bonds if not linked to covalent bonds
	b	i	Pent-1-yne OR pent-2-yne ✓	1	ALLOW pentyne Look for answer in the table if not on answer line but answer line takes precedence
		ii	C _n H _{2n-2} ✓	1	ALLOW C _n H _{2(n-1)}

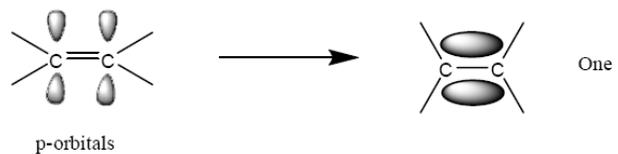
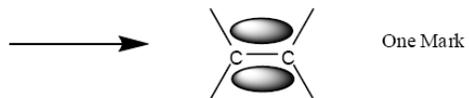
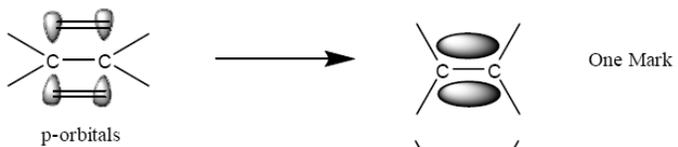
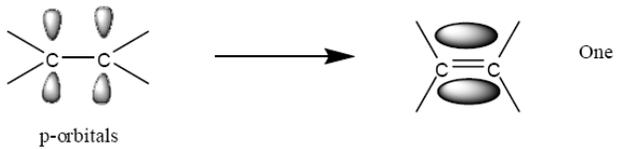
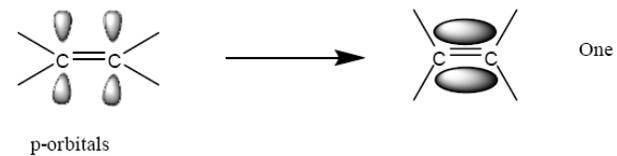
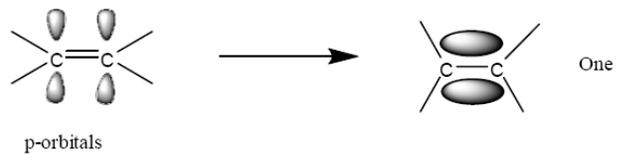
Question			Expected Answers	Marks	Additional Guidance
1	b	iii	Correct displayed formula ✓	1	$ \begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{C}\equiv\text{C}-\text{H} \\ \\ \text{H} \end{array} $
		iv	Correct skeletal formula of cyclic hydrocarbon with formula C_6H_{10} ✓	1	<p>Examples of correct skeletal formulae include</p> 
	c		<p>Energy required to break bonds = (+) 2912 ✓</p> <p>Energy released to make bonds = (-)4148 ✓</p> <p>Enthalpy of combustion = -1236 ✓</p>	3	<p>ALLOW full marks for correct answer with no working out</p> <p>ALLOW $(2 \times 415) + (837) + (2.5 \times 498)$</p> <p>ALLOW $(4 \times -805) + (2 \times -464)$</p> <p>OR $(4 \times 805) + (2 \times 464)$</p> <p>ALLOW ECF for calculation of enthalpy of combustion</p> <p>ALLOW 2 marks for +1236 with no working out</p>

Question			Expected Answers	Marks	Additional Guidance
1	d	i	(Enthalpy change) when one mole of a compound ✓ is made from its elements (in their standard states) ✓ (Standard conditions are) 298 K and 100 kPa ✓	3	IGNORE energy required / energy released ALLOW (energy change) when one mole of a substance DO NOT ALLOW enthalpy change for one mole of products ALLOW 1 atmosphere pressure / 101 kPa / 10^5 Pa / $1.01 \times 10^5 \text{ Nm}^{-2}$ / 1000 millibars / 25 °C / any stated temperature in words IGNORE 1 mol dm^{-3} for solutions
		ii	From energy cycle Enthalpy change to get elements = $-(-60) - (2 \times -286) / (+) 632$ ✓ Enthalpy change from elements = $-987 + (+227) / (-)760$ ✓ Enthalpy change = -128 ✓	3	ALLOW full marks for -128 with no working out ALLOW ECF from errors in calculation ALLOW two marks for answer of $-414 / +128 / -1392 / +1392$ ALLOW one mark for answer of $+414$
	e	i	$\frac{26.0}{100.1} \times 100$ 100.1 ✓ 26.0% ✓	2	First mark for 100.1 OR $(64.1 + 36.0)$ OR $(74.1 + 26.0)$ at bottom of fraction with or without $\times 100$ ALLOW full marks for 26.0 or 26% with no working out ALLOW from two significant figures up to calculator value ALLOW 25.97 / 26% NO ECF for this part from incorrect numbers in first expression

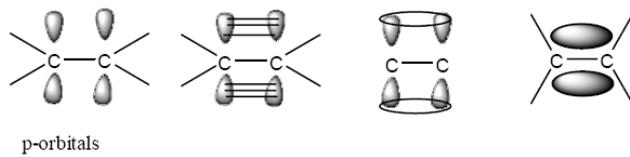
Question			Expected Answers	Marks	Additional Guidance
1	e	ii	1.56×10^4 OR 15600 OR 15601 ✓	1	ALLOW calculator value of 15600.62402 and any rounded value to a minimum of three significant figures
		iii	1.5×10^4 OR 15000 ✓	1	ALLOW 1.50×10^4 etc.
		iv	96.2 ✓	1	ALLOW ECF from (iii) ÷ (ii) ALLOW calculator value 96.1538461 and any rounded value to a minimum of two significant figures ALLOW 96.14768284 if 15601 is used ALLOW any value between 88 to 89 if answer to (iii) was calculated by dividing by 26
		v	Any two from: Low atom economy gives a poor sustainability OR low atom economy means lots of waste ✓ A use for the aqueous calcium hydroxide needs to be developed to increase atom economy ✓ Alternative process needs to be developed with high atom economy ✓	2	ANNOTATE WITH TICKS AND CROSSES IGNORE comments about percentage yield ALLOW ECF from (i) e.g. high atom economy will have good sustainability ALLOW find a use for the waste to increase atom economy
			Total	23	

Question		Expected Answers	Marks	Additional Guidance
2	a	<p>Sideways overlap of two p orbitals on each carbon atom ✓</p> <p>forms π-orbital or π-bond above and below plane of molecule ✓</p>	2	<p>Answers can be awarded from a labelled diagram see additional page with typical diagrams you might see</p>  <p>Drawings with a double bond drawn can score a maximum of one mark</p> <p>Drawing above with no labels scores one mark</p>

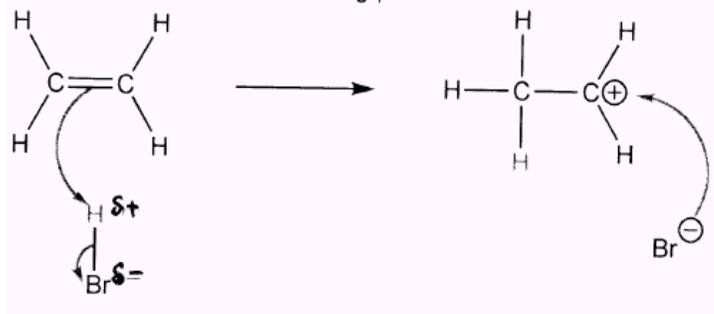
Each of the following diagrams is worth one mark. The words p-orbitals must be present to score the mark



Each of the diagrams on its own scores no mark



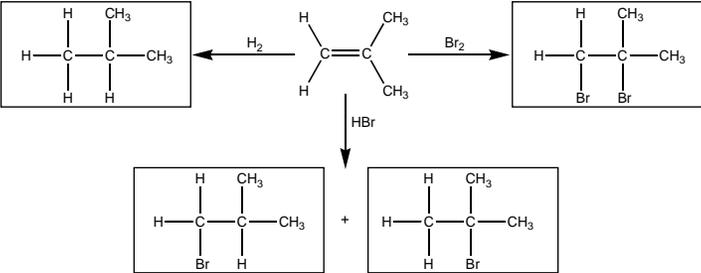
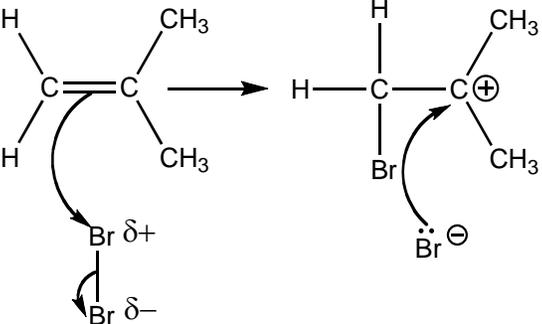
Question			Expected Answers	Marks	Additional Guidance
2	b	i	Double bond does not rotate / restricted rotation of the double bond ✓ Each carbon atom of double bond is bonded to (two) different groups ✓	2	ALLOW π bond does not rotate ALLOW each carbon atom of double bond is bonded to (two) different atoms / each end of the π -bond is bonded to different groups or atoms ✓
		ii	C and E ✓	1	

Question		Expected Answers	Marks	Additional Guidance
	c	CH ₃ CH ₂ OH / ethanol ✓	1	IGNORE alcohol
	d	<p>C₄H₈ + HBr → C₄H₉Br ✓ C₂H₄ + HBr → C₂H₅Br ✓</p> <p>B makes CH₃CH₂CH₂CH₂Br ✓ CH₃CHBrCH₂CH₃ ✓</p> <p>QWC – number of products is linked to structure of alkene e.g. because D is symmetrical OR B is not symmetrical ✓</p> <p>Movement of electron pair from double bond to attack hydrogen of H–Br and breaking of H–Br bond ✓</p> <p>Correct dipole shown on H–Br ✓</p> <p>Correct carbonium ion drawn ✓</p> <p>Curly arrow from Br[–] to the carbonium ion ✓</p>	9	<p>ANNOTATE WITH TICKS AND CROSSES QWC mark and 8 other marking points</p> <p>The equation must be the overall equation not a series of steps as in a mechanism</p> <p>ALLOW skeletal or displayed formulae ALLOW B makes 1-bromobutane and 2-bromo butane ✓ if marks for the structures not awarded</p>  <p>ALLOW curly arrow from lone pair or minus sign of bromide ion</p> <p>ALLOW marks for the mechanism even if the wrong alkene is used e.g. for alkene B If two mechanisms are drawn mark the one for alkene D</p>

Question		Expected Answers	Marks	Additional Guidance
e	i	$ \begin{array}{cccc} \text{H} & \text{C}_2\text{H}_5 & \text{H} & \text{C}_2\text{H}_5 \\ & & & \\ \text{---C---} & \text{C---} & \text{C---} & \text{C---} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array} $ <p style="text-align: right;">✓</p>	1	Must have at least two repeat units and the free bonds at the end All carbon-carbon bonds in the polymer chain must be shown ALLOW bond to ethyl group to any part of ethyl group IGNORE any brackets drawn
	ii	Poly(but-1-ene) ✓	1	ALLOW polybut-1-ene n.b. the bracket is part of the answer DO NOT ALLOW polybutene
f	i	(Lots of) OH group present ✓ Can form hydrogen bonds with water ✓	2	ALLOW hydroxyl group present / hydroxy group Alcohol group is not sufficient
	ii	Any two from: Incineration to produce energy OR combustion to produce energy ✓ Sorting and recycling OR sorting and remoulding ✓ Cracked (to give monomers) OR as an organic feedstock ✓	2	Used as a fuel is not sufficient IGNORE use photodegradable or biodegradable polymers
Total			21	

Question		Expected Answers	Marks	Additional Guidance
3	(a)	C_nH_{2n+2} ✓	1	ALLOW $C_nH_{2(n+1)}$ ✓ IGNORE size of subscripts
	(b) (i)	$C_8H_{18} + 8\frac{1}{2}O_2 \rightarrow 8CO + 9H_2O$ ✓	1	ALLOW any correct multiples IGNORE state symbols
	(ii)	limited supply of air OR not enough O_2 ✓	1	ALLOW use of air or oxygen IGNORE it is not completely oxidised
	(c) (i)	$2CO + 2NO \rightarrow 2CO_2 + N_2$ ✓	1	ALLOW any correct multiples including fractions IGNORE state symbols
	(c) (ii)	CO and NO are adsorbed (onto surface) OR reactants are adsorbed (onto surface) ✓ weakening of bonds OR lowers activation energy ✓ CO_2 and N_2 desorbs (from the surface) OR products desorbs (from the surface) ✓	3	ALLOW CO and NO stick onto surface OR CO and NO form weak attractions to the surface OR gases are adsorbed onto surface NOT absorb but allow ecf for deabsorb later on IGNORE alternative pathway Requires less energy is not sufficient ALLOW products leave the surface OR products diffuse away from surface OR weak attraction to surface is broken ALLOW deadsorb
	(d)	skeletal formula of a branched isomer of C_8H_{18} ✓ skeletal formula of a cyclic hydrocarbon OR skeletal formula of substituted arene of C_8H_{10} ✓	2	ALLOW any ring between C_3 and C_8 with 8 carbon atoms per molecule IGNORE wrong names If two correct structural or displayed formulae drawn award one mark

Question		Expected Answers	Marks	Additional Guidance
	(e)	<p>Any TWO from: atmospheric concentration ✓ ability to absorb infrared radiation ✓ residence time ✓</p>	2	<p>ALLOW the amount of the gas OR abundance of gas ALLOW how much IR it absorbs OR ability to absorb heat IGNORE global warming potential / heat reflected / how much is produced ALLOW how long it stays in the atmosphere</p>
		<p>Any TWO from: deep in the oceans OR on the sea-bed ✓ storage in geological formations OR under the sea-bed ✓ by reaction (with metal oxides) to form carbonates ✓</p>	2	<p>ALLOW piped into disused or partially filled oil wells ALLOW stored as a carbonate OR equation to show formation of suitable carbonate from an oxide IGNORE mineral storage IGNORE reforestation</p>
		Total	13	

Question	Expected Answers	Marks	Rationale
4 (a)	 <p>one mark for each correct structure ✓ ✓ ✓ ✓</p>	4	<p>ALLOW skeletal formula OR displayed formulae IGNORE molecular formulae IF two answers given e.g. name and structure then both must be correct to be given a mark</p> <p>ALLOW methylpropane OR $(\text{CH}_3)_3\text{CH}$ ✓</p> <p>ALLOW 1,2-dibromo-methylpropane OR $\text{CH}_2\text{BrCBr}(\text{CH}_3)_2$ ✓</p> <p>ALLOW 1-bromo-methylpropane OR $\text{CH}_2\text{BrCH}(\text{CH}_3)_2$ ✓</p> <p>ALLOW 2-bromo-methylpropane OR $\text{CH}_3\text{CBr}(\text{CH}_3)_2$ ✓</p> <p>ALLOW ecf if wrong carbon skeleton is used in all of the structures mark first structure wrong and then apply ecf for the rest</p>
(b)	<p>curly arrow from double bond to $\text{Br}^{\delta+}$ and curly arrow from $\text{Br}-\text{Br}$ bond pair to $\text{Br}^{\delta-}$ in 1st step ✓</p> <p>curly arrow in 2nd step from bromide ion ✓</p> <p>correct dipole shown on Br_2 ✓</p> <p>correct carbocation shown ✓</p> 	4	<p>Curly arrow must start from the double bond and not a carbon atom, other curly arrow must start from $\text{Br}-\text{Br}$ bond</p> <p>ALLOW curly arrow from any part of bromide ion The bromide ion does not need to show a lone pair</p> <p>Dipole must be partial charge and not full charge Carbocation needs a full charge and not a partial charge (charges do not need to be surrounded by a circle)</p> <p>ALLOW carbocation on carbon 1 where electrophile attacks carbon 2 i.e. $^+\text{CH}_2\text{CBr}(\text{CH}_3)_2$</p>

Question		Expected Answers	Marks	Rationale	
	(c)	(i)	C_6H_{10} ✓	1	
		(ii)	$M_r(\text{cyclohexanol}) = 100$ ✓ amount of cyclohexanol = 0.0765 mol ✓ percentage yield = 35.0% ✓	3	ALLOW full marks for correct answer with no or limited working out ALLOW ecf from wrong molar mass i.e. $7.65 \div \text{molar mass}$ ALLOW ecf from wrong amount in moles i.e. $[0.0268 \div \text{moles}] \times 100$ ALLOW 35% ALLOW two marks for 0.35% If M_r of 82 is used then % yield will be 28.7 or 29 and this is worth two marks
	(d)	(i)	(sum of) the molecular masses of the desired product ÷ sum of molecular masses of all products × 100 ✓	1	ALLOW (sum of) the molecular masses of the desired product ÷ sum of molecular masses of all reactants × 100 ✓
		(ii)	this preparation is addition OR has 100% atom economy OR there is only one product ✓ preparation from cyclohexanol has less than 100% atom economy OR H_2O is produced as well OR calculated atom economy = 82% ✓	2	ALLOW no by products formed ALLOW other substances formed OR cyclohexene is not the only product
			Total	15	