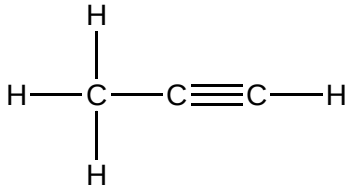
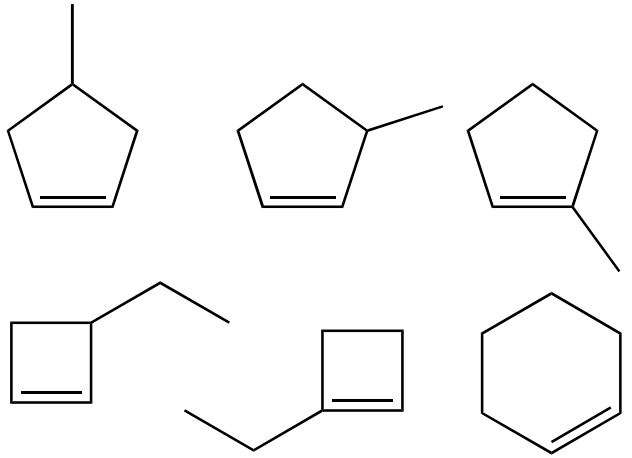
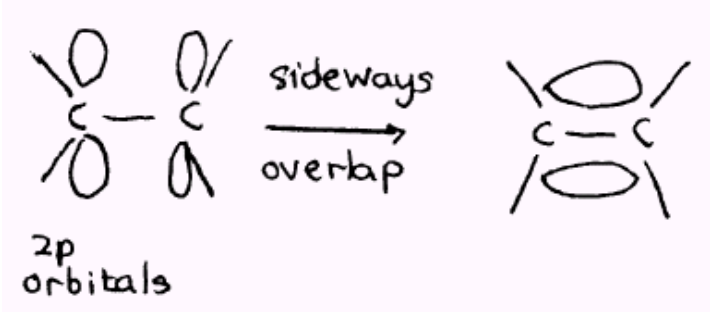
Question			Expected Answers	Marks	Additional Guidance
1	a	i	Series having same functional group and a general formula ✓	1	**ALLOW** same functional group and members vary by CH_2 **ALLOW** organic compounds with the same functional group that differ in length of their hydrocarbon chain
		ii	More surface 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_nH_{2n-2} ✓	1	**ALLOW** $C_nH_{2(n-1)}$

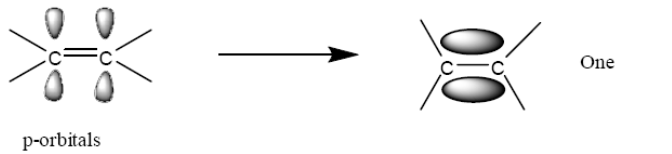
Question			Expected Answers	Marks	Additional Guidance
1	b	iii	Correct displayed formula ✓	1	
		iv	Correct skeletal formula of cyclic hydrocarbon with formula C_6H_{10} ✓	1	Examples of correct skeletal formulae include 
	c		Energy required to break bonds = (+) 2912 ✓ Energy released to make bonds = (–)4148 ✓ Enthalpy of combustion = –1236 ✓	3	**ALLOW** full marks for correct answer with no working out **ALLOW** (2 × 415) + (837) + (2.5 × 498) **ALLOW** (4 × –805) + (2 × –464) **OR** (4 × 805) + (2 × 464) **ALLOW** ECF for calculation of enthalpy of combustion **ALLOW** 2 marks for +1236 with no working out

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 / 1.01×10^5 Nm^{-2} / 1000 millibars / 25 ^oC / any stated temperature in words **IGNORE** 1 mol dm^{-3} for solutions
		ii	From energy cycle Enthalpy change to get elements = −(−60) – (2 −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	$\frac{26.0}{100.1} \times 100$ ✓ 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 × 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**	

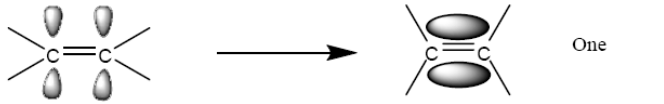
Question			Expected Answers	Marks	Additional Guidance
2	**a**		**Sideways** overlap of two p orbitals on each carbon atom ✓ forms π-orbital or π-bond above and below plane of molecule ✓	2	Answers can be awarded from a labelled diagram see additional page with typical diagrams you might see  Drawings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

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



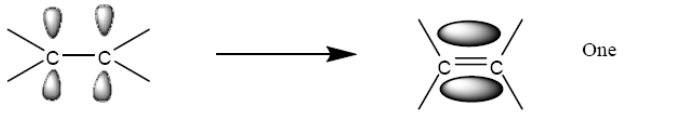
p-orbitals

One



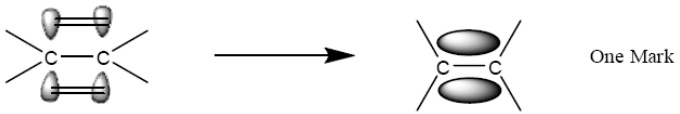
p-orbitals

One



p-orbitals

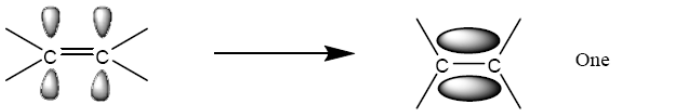
One



p-orbitals

One Mark

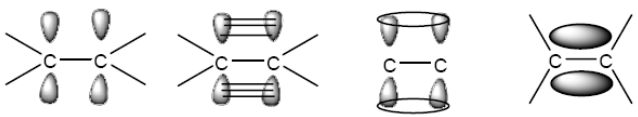
One Mark



p-orbitals

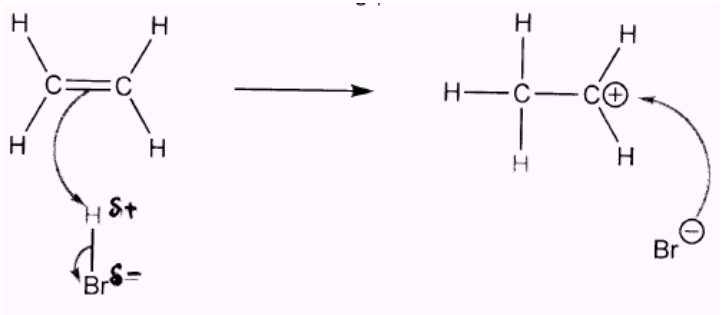
One

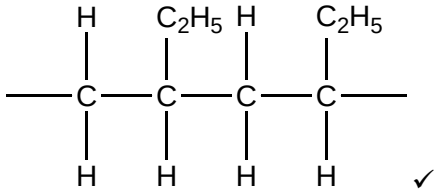
Each of the diagrams on its own scores no mark



p-orbitals

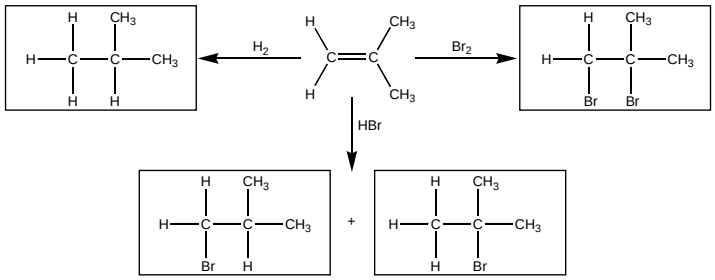
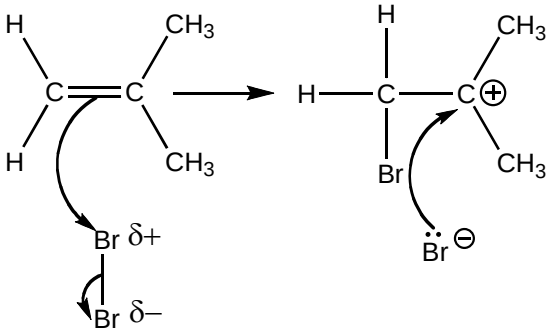
Question			Expected Answers	Marks	Additional Guidance
2	**b**	**i**	Double bond does not rotate / restricted rotation of the double bond ✓ Each carbon atom of double bond is bonded to (two) different groups ✓	2	**ALLOW** π bond does not rotate **ALLOW** each carbon atom of double bond is bonded to (two) 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_3CH_2OH / ethanol ✓	1	**IGNORE** alcohol
	d		C_4H_8 + HBr → C_4H_9Br ✓ C_2H_4 + HBr → C_2H_5Br ✓ **B** makes $CH_3CH_2CH_2CH_2Br$ ✓ $CH_3CHBrCH_2CH_3$ ✓ QWC – number of products is linked to structure of alkene e.g. because **D** is symmetrical **OR B** is not symmetrical ✓ Movement of electron pair from double bond to attack hydrogen of H–Br and breaking of H–Br bond ✓ Correct dipole shown on H–Br ✓ Correct carbonium ion drawn ✓ Curly arrow from Br^- to the carbonium ion ✓	9	**ANNOTATE WITH TICKS AND CROSSES** **QWC** mark and **8 other** marking points The equation must be the overall equation not a series of steps as in a mechanism **ALLOW** skeletal or displayed formulae **ALLOW B** makes 1-bromobutane and 2-bromo butane ✓ if marks for the structures not awarded  **ALLOW** curly arrow from lone pair or minus sign of bromide ion **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**

Question			Expected Answers	Marks	Additional Guidance
	e	**i**	 ✓	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)	$C_8H_{18} + 8½O_2 \rightarrow 8CO + 9H_2O$ ✓	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)		**Any TWO from:** atmospheric concentration ✓ ability to absorb infrared radiation ✓ residence time ✓	**2**	 **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
			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 ✓	**2**	 **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
			Total	**13**	

Question			Expected Answers	Marks	Rationale
4	(a)		 one mark for each correct structure ✓ ✓ ✓ ✓	4	**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 **ALLOW** methylpropane **OR** $(CH_3)_3CH$ ✓ **ALLOW** 1,2-dibromo-methylpropane **OR** $CH_2BrCBr(CH_3)_2$ ✓ **ALLOW** 1-bromo-methylpropane **OR** $CH_2BrCH(CH_3)_2$ ✓ **ALLOW** 2-bromo-methylpropane **OR** $CH_3CBr(CH_3)_2$ ✓ **ALLOW** ecf if wrong carbon skeleton is used in all of the structures mark first structure wrong and then apply ecf for the rest
	(b)		curly arrow from double bond to $Br^{\delta+}$ and curly arrow from Br—Br bond pair to $Br^{\delta-}$ in 1st step ✓ curly arrow in 2nd step from bromide ion ✓ correct dipole shown on Br_2 ✓ correct carbocation shown ✓ 	4	Curly arrow must start from the double bond and not a carbon atom, other curly arrow must start from Br—Br bond **ALLOW** curly arrow from any part of bromide ion The bromide ion does not need to show a lone pair 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) **ALLOW** carbocation on carbon 1 where electrophile attacks carbon 2 i.e. $^{+}CH_2CBr(CH_3)_2$

Question			Expected Answers	Marks	Rationale
	(c)	**(i)**	C_6H_{10} ✓	**1**	
		(ii)	M_r(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 ÷ molar mass **ALLOW** ecf from wrong amount in moles i.e. [0.0268 ÷ moles] × 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 than100% 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**	