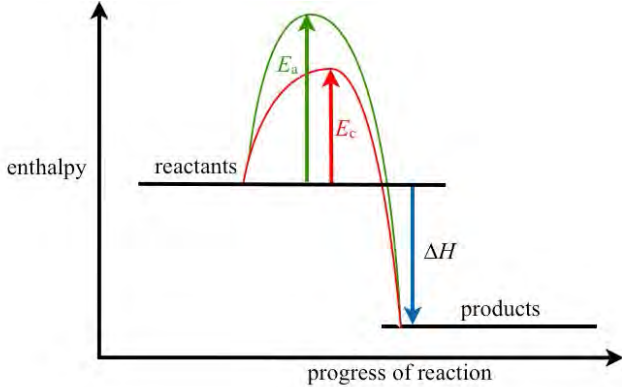


Question		Expected Answers	Marks	Additional Guidance
1	(a)	C_nH_{2n+2} ✓	1	ALLOW $C_nH_{2(n+1)}$ ✓ IGNORE size of subscripts
	(b) (i)	$C_8H_{18} + 8\frac{1}{2}O_2 \rightarrow 8CO + 9H_2O$ ✓	1	ALLOW any correct multiples IGNORE state symbols
	(ii)	limited supply of air OR not enough O_2 ✓	1	ALLOW use 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			Answer	Mark	Guidance
2	(a)	(i)	$\text{Cl} + \text{O}_3 \rightarrow \text{ClO} + \text{O}_2 \checkmark$ $\text{ClO} + \text{O} \rightarrow \text{Cl} + \text{O}_2 \checkmark$	2	ALLOW any correct multiples ALLOW $\text{ClO} + \text{O}_3 \rightarrow 2\text{O}_2 + \text{Cl}$ IGNORE state symbols and dots
		(ii)	$\text{O}_3 + \text{O} \rightarrow 2\text{O}_2 \checkmark$	1	ALLOW any correct multiple ALLOW $2\text{O}_3 \rightarrow 3\text{O}_2$ IGNORE state symbols and dots
	(b)		Adsorption of reactants OR NO and CO attached to surface \checkmark Bonds weaken in reactants \checkmark Chemical reaction OR rearrangement of electrons \checkmark Desorption \checkmark	4	ANNOTATE WITH TICKS AND CROSSES ALLOW CO and NO (weakly) bonded to surface OR reactants bond to surface OR CO and NO form temporary bonds with the catalyst DO NOT ALLOW absorption ALLOW bonds weaken in NO OR bonds weaken in CO OR activation energy is lowered ALLOW bonds break and new bonds made in product OR N_2 and CO_2 made ALLOW products leave the surface OR N_2 and CO_2 no longer bonded to surface ALLOW desorption ALLOW deabsorption if absorption given at start of answer

Question	Answer	Mark	Guidance
(c)	<p>one activation energy labelled on enthalpy profile diagram ✓</p> <p>idea that activation energy is lowered ✓</p> <p>catalyst has a different reaction pathway OR different reaction mechanism OR two curves drawn on profile ✓</p> <p>QWC – correct diagram of reaction profile for endothermic or exothermic reaction with products and reactants at different heights – y axis labelled as energy or enthalpy ✓</p>		<p>ANNOTATE WITH TICKS AND CROSSES</p> <p>ALLOW double headed arrows on the activation energy label ALLOW vertical line with no arrows DO NOT ALLOW arrow just pointing downwards Be generous with respect to the position of the line and the maximum of the curve</p> <p>marks can be awarded via, reaction profile, in words or from Boltzmann</p> <p>IGNORE any enthalpy change label drawn</p>  <p>IGNORE missing progress of reaction</p>

Question	Answer	Mark	Guidance
(d)	<p>ANY FOUR FROM</p> <p>Enable reactions to occur with less waste OR enable reactions to take place with higher atom economy OR fewer undesired products ✓</p> <p>Enable reactions to happen with less toxic solvents/reactants OR enable reactions to produce less toxic waste/side products ✓</p> <p>Reactions can happen at room temperature OR reactions can happen at atmospheric pressure OR reactions can happen at a lower pressure OR reactions can happen at a lower temperature ✓</p> <p>Saves energy (costs) ✓</p> <p>Reduce carbon dioxide emissions OR reduces amount of fuel burnt OR reduces greenhouse gas emissions ✓</p> <p>Enable reactions to occur with more specificity OR enable reactions to produce correct stereoisomer ✓</p>	4	<p>ANNOTATE WITH TICKS AND CROSSES</p> <p>ALLOW make less hazardous waste ALLOW corrosive, poisonous, harmful, hazardous as alternative to toxic DO NOT ALLOW does not harm the environment IGNORE dangerous</p> <p>IGNORE less expensive IGNORE reduces activation energy</p> <p>IGNORE less pollution</p>
Total		18	

Question		Answer	Mark	Guidance
3	(a)	<p>ANY THREE FROM</p> <p>$C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_5OH$ ✓</p> <p>Use of yeast/zymase at 25–45 °C OR warm with yeast/zymase ✓</p> <p>Anaerobic OR lack of oxygen ✓</p> <p>(Separate bioethanol) by (fractional) distillation ✓</p>	3	<p>IGNORE state symbols</p> <p>ALLOW correct multiples</p> <p>DO NOT ALLOW yeast/zymase and heat DO NOT ALLOW yeast/zymase and reflux</p>
	(b) (i)	<p>$C_{15}H_{30}O_2 + 21\frac{1}{2}O_2 \rightarrow 15CO_2 + 15H_2O$ ✓✓</p>	2	<p>ALLOW $\frac{43}{2}$ for 21½</p> <p>DO NOT ALLOW [O]</p> <p>ALLOW one mark for correct products if equation is wrong</p>
	(ii)	<p>(Energy needed) for processing biofuel makes carbon dioxide ✓</p>	1	<p>ALLOW (energy needed) for transport makes carbon dioxide</p>
	(c)	<p>ANY THREE FROM</p> <p>Fossil fuels are finite resources OR biofuels are renewable ✓</p> <p>Allows fossil fuels to be used as a feedstock for organic compounds ✓</p> <p>Less food crops may be grown OR Land not used to grow food crops ✓</p> <p>(rain) forests have to be cut down to provide land OR deforestation ✓</p> <p>Shortage of fertile soils OR reduces fertility of soils ✓</p> <p>No risk of large scale pollution from exploitation of fossil fuels ✓</p>	3	<p>ANNOTATE WITH TICKS AND CROSSES</p> <p>ALLOW fossil fuels are non-renewable OR plants are a renewable resource OR bio-fuels is (more) sustainable OR fossil fuels are not sustainable</p> <p>ALLOW decrease the need for fossil fuels</p> <p>Destroys habitats is NOT sufficient</p> <p>IGNORE comments about availability / fertilisers / pesticides</p>

Question		Answer	Mark	Guidance
	(d)	React with hydrogen OR hydrogenation ✓ Nickel catalyst ✓	2	IGNORE reference to pressure and temperature
	(e)	(i)	1	Diagram must show a minimum of four carbon atoms and two hydrogen atoms and the correct orientation of the C=C double bond ALLOW minor slips with rest of structure eg missing atoms, bonds and subscripts
		(ii)	2	ALLOW π /pi bond does not rotate IGNORE 'bond does not move' ALLOW each carbon atom of double bond is bonded to (two) different atoms OR each carbon atom of double bond is bonded to a hydrogen and a carbon/different group OR each end of the π /pi-bond is bonded to different groups or atoms
Total			12	

Question		Expected Answers	Marks	Additional Guidance
4	(a)	Cracking ✓	1	ALLOW catalytic or thermal cracking ✓
	(b)	(i) Acid ✓	1	ALLOW correct formula if no name given: e.g. H ₃ PO ₄ OR H ₂ SO ₄ OR H ⁺ ✓ ALLOW correct name of acid even if an incorrect formula is used IGNORE heterogeneous OR homogeneous
		(ii) The position of equilibrium will shift so as to minimise the effect of any change in conditions ✓	1	DO NOT ALLOW 'reaction shifts' The idea of a shift in equilibrium is essential
		(iii) Low temperature AND high pressure ✓ Low temperature because the (forward) reaction is exothermic ✓ High pressure because there are fewer moles (of gas) on the right hand side ✓	3	One mark for conditions. This mark is independent of the reasons for conditions One mark for reason for the chosen temperature One mark for reason for the chosen pressure ALLOW fewer moles of products
		(iv) (60 atmosphere pressure is a) high pressure may be too expensive OR may cause safety problems ✓ (300 °C is sufficiently high) to give a fast rate of reaction ✓ without shifting equilibrium to the left OR compromising equilibrium yield ✓	3	
	(c)	Propene ✓	1	ALLOW prop-1-ene ✓ DO NOT ALLOW prop-2-ene
	(d)	(i) —CH ₂ CHCl— + 2½O ₂ → 2CO ₂ + H ₂ O + HCl ✓	1	
		(ii) Alkali OR base OR carbonate ✓	1	ALLOW correct formula of or named carbonate OR alkali OR base Correct name and wrong formula does not score

Question		Expected Answers	Marks	Additional Guidance
	(e)	<p>Any two marks from the following:</p> <p>Develop photodegradable polymers ✓</p> <p>Develop biodegradable polymers OR develop compostable polymers ✓</p> <p>Develop techniques for cracking polymers OR develop use as a chemical feedstock ✓</p> <p>Develop ways of making polymers from plant-based substances OR reduce the need to use finite raw materials such as crude oil ✓</p> <p>Designing processes with high atom economy OR reduce waste products during manufacture ✓</p> <p>Develop ways of sorting AND recycling polymers ✓</p>	2	
		Total	14	