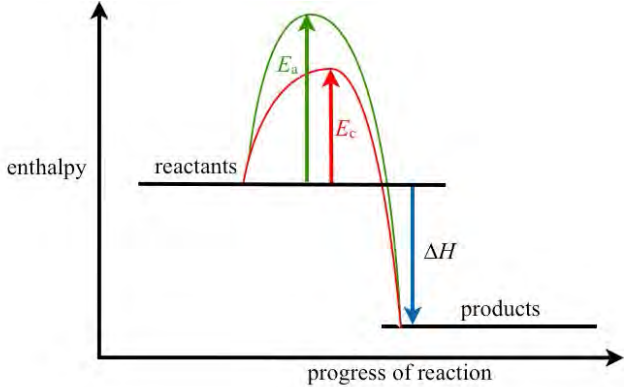
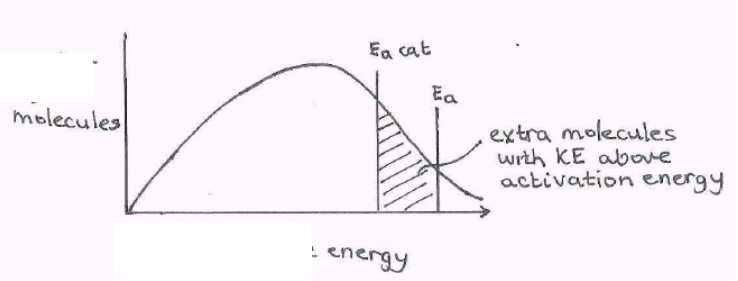


Question		Expected Answers	Marks	Additional Guidance
1	(a)	$C_nH_{2n+2}$ ✓	1	<b>ALLOW</b> $C_nH_{2(n+1)}$ ✓ <b>IGNORE</b> size of subscripts
	(b) (i)	$C_8H_{18} + 8\frac{1}{2}O_2 \rightarrow 8CO + 9H_2O$ ✓	1	<b>ALLOW</b> any correct multiples <b>IGNORE</b> state symbols
	(ii)	limited supply of air <b>OR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

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

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	<b>ALLOW</b> any correct multiples <b>ALLOW</b> $\text{ClO} + \text{O}_3 \rightarrow 2\text{O}_2 + \text{Cl}$ <b>IGNORE</b> state symbols and dots
		(ii)	$\text{O}_3 + \text{O} \rightarrow 2\text{O}_2 \checkmark$	1	<b>ALLOW</b> any correct multiple <b>ALLOW</b> $2\text{O}_3 \rightarrow 3\text{O}_2$ <b>IGNORE</b> state symbols and dots
	(b)		Adsorption of reactants <b>OR</b> NO and CO attached to surface $\checkmark$  Bonds weaken in reactants $\checkmark$  Chemical reaction <b>OR</b> rearrangement of electrons $\checkmark$  Desorption $\checkmark$	4	<b>ANNOTATE WITH TICKS AND CROSSES</b>  <b>ALLOW</b> CO and NO (weakly) bonded to surface <b>OR</b> reactants bond to surface <b>OR</b> CO and NO form temporary bonds with the catalyst <b>DO NOT ALLOW</b> absorption  <b>ALLOW</b> bonds weaken in NO <b>OR</b> bonds weaken in CO <b>OR</b> activation energy is lowered  <b>ALLOW</b> bonds break and new bonds made in product <b>OR</b> $\text{N}_2$ and $\text{CO}_2$ made  <b>ALLOW</b> products leave the surface <b>OR</b> $\text{N}_2$ and $\text{CO}_2$ no longer bonded to surface <b>ALLOW</b> desorption <b>ALLOW</b> 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  <b>OR</b> different reaction mechanism  <b>OR</b> two curves drawn on profile ✓</p> <p><b>QWC</b> – 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><b>ANNOTATE WITH TICKS AND CROSSES</b></p> <p><b>ALLOW</b> double headed arrows on the activation energy label  <b>ALLOW</b> vertical line with no arrows  <b>DO NOT ALLOW</b> 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><b>IGNORE</b> any enthalpy change label drawn</p>  <p><b>IGNORE</b> missing progress of reaction</p>

Question	Answer	Mark	Guidance
(c)	<p>Drawing of Boltzmann distribution <b>AND</b> axes labelled (number of) molecules and energy ✓</p> <p>More molecules with energy above activation energy with a catalyst <b>OR</b>            More molecules that overcome the activation energy ✓</p> <p>More effective collisions <b>OR</b> more successful collisions ✓</p>	7	<p>Boltzmann distribution - must start at origin and must not end up at 0 on y-axis ie must not touch x-axis.  <b>DO NOT ALLOW</b> Boltzmann mark if two distributions are drawn one for non-catalysed and one for catalysed</p> <p><b>ALLOW</b> particles instead of molecules</p> <p><b>DO NOT ALLOW</b> atoms instead of particles</p>  <p><b>DO NOT ALLOW</b> more molecules have sufficient energy to react</p>

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

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

Question		Answer	Mark	Guidance
	(d)	React with hydrogen <b>OR</b> hydrogenation ✓  Nickel catalyst ✓	2	<b>IGNORE</b> 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  <b>ALLOW</b> minor slips with rest of structure eg missing atoms, bonds and subscripts
		(ii)	2	<b>ALLOW</b> $\pi$ /pi bond does not rotate <b>IGNORE</b> 'bond does not move'  <b>ALLOW</b> each carbon atom of double bond is bonded to (two) different atoms <b>OR</b> each carbon atom of double bond is bonded to a hydrogen and a carbon/different group <b>OR</b> each end of the $\pi$ /pi-bond is bonded to different groups or atoms
<b>Total</b>			<b>12</b>	



Question		Expected Answers	Marks	Additional Guidance
4	(a)	Cracking ✓	1	<b>ALLOW</b> catalytic or thermal cracking ✓
	(b)	(i)	1	<b>ALLOW</b> correct formula if no name given: e.g. H <sub>3</sub> PO <sub>4</sub> <b>OR</b> H <sub>2</sub> SO <sub>4</sub> <b>OR</b> H <sup>+</sup> ✓  <b>ALLOW</b> correct name of acid even if an incorrect formula is used  <b>IGNORE</b> heterogeneous <b>OR</b> homogeneous
		(ii)	1	<b>DO NOT ALLOW</b> 'reaction shifts' The idea of a shift in equilibrium is essential
		(iii)	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 <b>ALLOW</b> fewer moles of products
		(iv)	3	
	(c)	Propene ✓	1	<b>ALLOW</b> prop-1-ene ✓ <b>DO NOT ALLOW</b> prop-2-ene
	(d)	(i)	1	
		(ii)	1	<b>ALLOW</b> correct formula of or named carbonate <b>OR</b> alkali <b>OR</b> base Correct name and wrong formula does <b>not</b> score

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