OCR
RECOGNISING ACHIEVEMENT

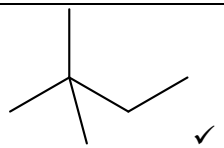
GCE

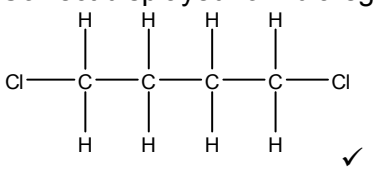
Chemistry A

Advanced Subsidiary GCE

Unit **F322:** Chains, Energy and Resources

Mark Scheme for January 2013

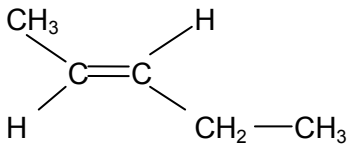
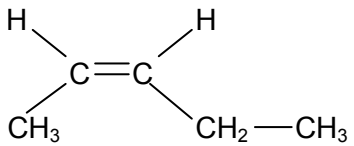
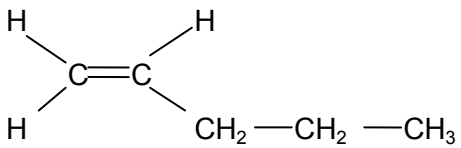
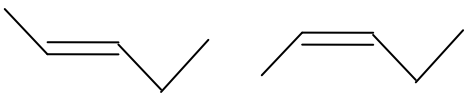
Question			Answer	Marks	Guidance
1	(a)		C_3H_7 ✓	1	**ALLOW** H_7C_3
	(b)		***Saturated*** **Only** has (carbon to carbon) single bonds ✓ ***Hydrocarbon*** Contains (the elements) hydrogen and carbon **only** ✓	2	**ALLOW** does not contain any (carbon to carbon) double bonds **ALLOW** all of the carbon atoms are bonded to four other atoms **DO NOT ALLOW** contains hydrogen and carbon **DO NOT ALLOW** a mixture of carbon and hydrogen only **DO NOT ALLOW** hydrogen and carbon molecules only
	(c)		 ✓	1	
	(d)		as branching increases the boiling point decreases **OR** the more branched the isomers of hexane are the lower the boiling point ✓ branched isomers have less surface (area) of contact **OR** branched fewer points of contact (than unbranched) ✓ (the more branched the) **fewer** van der Waals' forces **OR** (the more branched) has **weaker** van der Waals' forces **OR** Less energy required to break van der Waal's forces ✓	3	**ALLOW** ORA throughout *First marking point must compare boiling point **and** branching for **all** three isomers* Reference to just surface area / closeness of molecules is **not** sufficient **ALLOW** vdw forces **OR** VDW forces (and any combination of upper and lower cases) **DO NOT ALLOW** VDW mark if answer states that these are between atoms or answer implies that these are bonds
	(e)		$C_{10}H_{22} \rightarrow C_6H_{14} + C_4H_8$ **OR** $C_{10}H_{22} \rightarrow C_6H_{14} + 2C_2H_4$ ✓	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) **IGNORE** state symbols

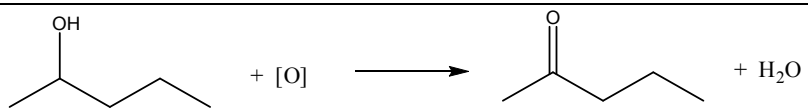
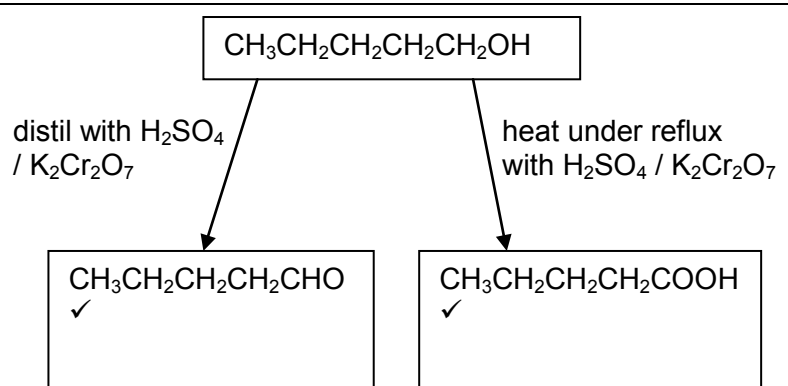
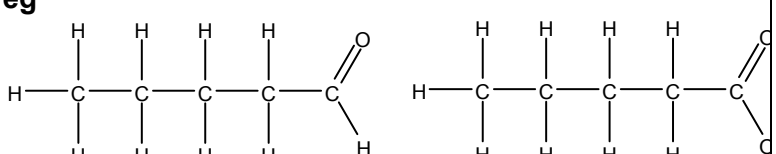
Question			Answer	Marks	Guidance
1	(f)	(i)	$C_4H_{10} + 2Cl_2 \rightarrow C_4H_8Cl_2 + 2HCl$ ✓	1	**IGNORE** state symbols
		(ii)	<table><tr><th>Isomer 1</th><th>Isomer 2</th></tr><tr><td></td><td>1,3-dichlorobutane ✓</td></tr><tr><td>Correct displayed formula eg:  ✓</td><td></td></tr></table>	2	**Must be a displayed formula** **ALLOW** absence of hyphens 1 and 3 must be clearly separated: **ALLOW** full stops: 1.3 **OR** spaces: 1 3 **DO NOT ALLOW** 13
	(g)	(i)	covalent bond breaking ✓ one electron (from the bond pair) goes to each atom **OR** makes (two) radicals ✓	2	**ALLOW** covalent bond is split **IGNORE** particle for atom **DO NOT ALLOW** molecule or compound for atom **DO NOT ALLOW** to each molecule or to each reactant **ALLOW** one electron goes to each product / species **IGNORE** homolytic fission equations
		(ii)	$Cl + C_4H_9Cl \rightarrow C_4H_8Cl + HCl$ ✓ $C_4H_8Cl + Cl_2 \rightarrow C_4H_8Cl_2 + Cl$ ✓	2	**IGNORE** dots even if incorrect
	(h)		$C_4H_{10} + 4½O_2 \rightarrow 4CO + 5H_2O$ **OR** $C_4H_{10} + 2½O_2 \rightarrow 4C + 5H_2O$ ✓	1	**ALLOW** any correct multiples for these equations eg $2C_4H_{10} + 9O_2 \rightarrow 8CO + 10\ H_2O$ **IGNORE** state symbols **ALLOW** equations for incomplete combustion that give CO_2 with CO and/or C eg $C_4H_{10} + 4O_2 \rightarrow 3CO + C + 5H_2O$
			Total	**16**	

Question			Answer	Marks	Guidance
2	(a)		(enthalpy change for the) formation of one mole (of P_4O_{10}) ✓ from (constituent) elements **OR** from P_4/phosphorus and O_2/oxygen ✓	2	**ALLOW** energy required **OR** energy released **ALLOW** makes one mole of product/substance/molecule/ compound **ALLOW** made from P and O_2 **OR** made from two elements **IGNORE** comments related to standard conditions
	(b)		**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer = –368 (kJ mol^{-1}) award 3 marks** (+)2984 +(+)6 × 286 **OR** (+)2984 +(+)1716 **OR** (+)4700 ✓ (−)1267 × 4 **OR** (–)5068 ✓ −368 ✓	3	**IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below. **See list below for marking of answers from common errors.** **IGNORE** sign **IGNORE** sign **ALLOW ECF** for enthalpy change of products – enthalpy change of reactants **ALLOW for 2 marks:** +368 cycle wrong way around **OR** −1798 no × 6 **OR** (+)3433 no x 4 **OR** −3352 missing 2984 **OR** (+) 9768 product the wrong sign around **OR** (−) 9768 reactants the wrong sign **ALLOW for 1 mark:** (+)1798 no x 6 and cycle wrong way around **OR** –3433 cycle wrong way around and not × 4 **OR** (+)3352 missing 2984 and cycle wrong way around **OR** (+)2003 no x 6 or x 4 **OR** (+)449 missing 2984 and x 4 **OR** −4782 missing 2984 and x 6 **Note:** There may be other possibilities.

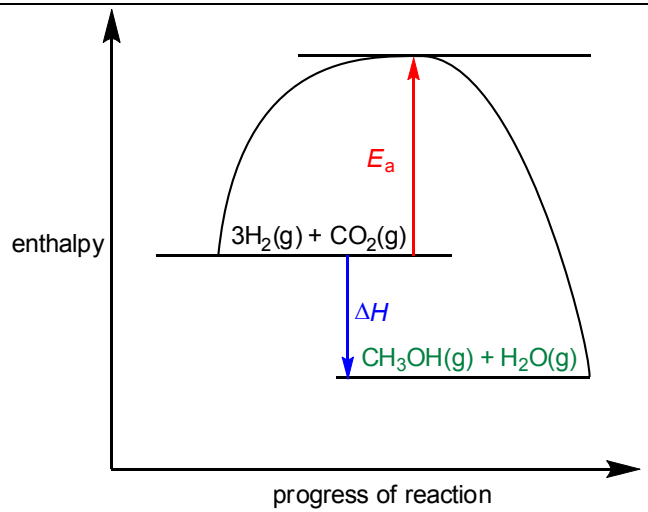
Question			Answer	Marks	Guidance
	(c)		$P_4 + 5O_2 + 6H_2O \rightarrow 4H_3PO_4$ ✓ Only the **desired product** is made ✓ **Second marking point can only be awarded if the equation is correct.**	2	**ALLOW** there are no waste products **OR** there are no by-products **OR** there is only one product. **DO NOT ALLOW** it is an addition reaction
			Total	**7**	

Question			Answer	Marks	Guidance
3	(a)	(i)	acid ✓	1	**ALLOW** named mineral acid or correct formula eg phosphoric acid, H_3PO_4, sulfuric acid, H_2SO_4 or H^+ **DO NOT ALLOW** any carboxylic acids
		(ii)	$C_5H_{12}O \rightarrow C_5H_{10} + H_2O$ ✓	1	**DO NOT ALLOW** use of $C_5H_{11}OH$
		(iii)	***structural isomerism*** have the same molecular formula ✓ but different structural formulae ✓ ***stereoisomerism*** have the same structural formula ✓ but different arrangement (of atoms) in space ✓	4	Same formula is **not** sufficient **ALLOW** different structure **OR** different displayed formula **OR** different skeletal formula Different formula or different arrangement of atoms is **not** sufficient **ALLOW** different **structural** arrangement (of atoms) **ALLOW** have the same structure Stereoisomers have the same formula or molecular formula is **not** sufficient **ALLOW** different spatial arrangements (of atoms)

Question			Answer	Marks	Guidance
3	(a)	(iv)	 **A**  **B**  **C** Correct structure for **A** ✓ Correct structure for **B** ✓ Correct structure for **C** ✓	3	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above **A** and **B** must clearly show cis and trans configuration **eg**  **A** ***B*** **Answers to A and B are interchangeable** **C:** $CH_2CHCH_2CH_2CH_3$ **ALLOW** $-C_2H_5$ group in A or B or $-CH_2C_2H_5$ in C **DO NOT ALLOW** $-C_3H_7$ group in C

Question			Answer	Marks	Guidance
3	(a)	(v)	carbon–carbon double bond ✓ **Each** carbon atom in the double bond is attached to (two) different groups/atoms ✓	2	**IGNORE** comments about rotation **ALLOW** carbon double bond **ALLOW Each** carbon atom of the double bond is attached to a H and an alkyl group **DO NOT ALLOW** functional groups for groups **DO NOT ALLOW** the carbon atoms are attached to different groups "**Each** carbon atom in the double bond" implies a carbon–carbon double bond for the first marking point
	(b)		 Correct **skeletal** structure of product ✓ Balanced equation ✓	2	Balancing mark can only be awarded if the equation has a correct **skeletal** formula for the product
	(c)			2	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) **eg**  **ALLOW** CO_2H for the carboxylic acid **DO NOT ALLOW** COH for aldehyde **IGNORE** names
			Total	**15**	

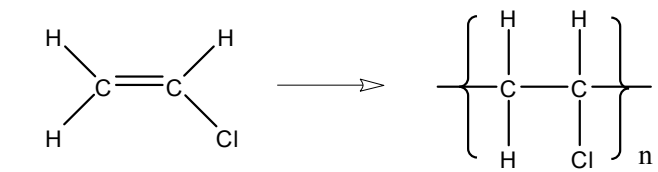
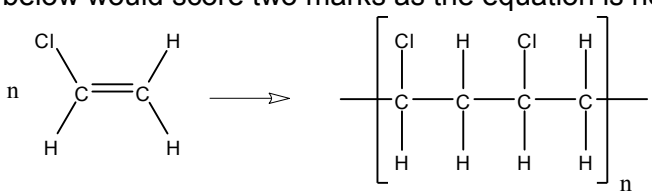
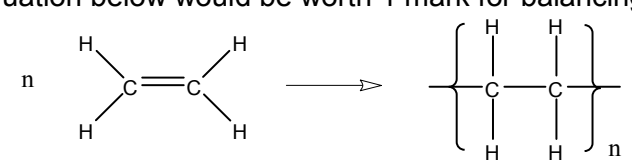
Question			Answer	Marks	Guidance
4	(a)		**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer = 681 (kJ) award 3 marks**	3	**IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below.
			Evidence of dividing 1000 by 24		**ALLOW** 41.7 up to calculator value 41.6666667 correctly rounded. **ALLOW** $\frac{1000}{24}$ for first marking point if not calculated
			Evidence of dividing by 3 and multiplying by 49 in the calculation		**ALLOW** energy released per mole = 16.3 ✓
			energy released = 681 (kJ) ✓ **(MUST BE TO 3 SIG FIGS)**		**IGNORE (–) sign in the answer**
			--- **Alternative Working**		**Common Incorrect answers** **0.392** scores 2 marks **392000** scores 2 marks
			3 moles = 72 dm^3 ✓ So $\frac{1000}{72}$ or 13.9 ✓		
			Energy released = 13.9 × 49 = 681 (kJ)		

Question	Answer	Marks	Guidance
4 (b)		3	**IGNORE** state symbols for the products
	CH_3OH and H_2O added as product **AND** shown below the reactants ✓		
	ΔH labelled with arrow pointing towards products or the product line if no products stated ✓		**IF** there is **no ΔH labelled** then **ALLOW** –49 only as an alternative label for ΔH **IF ΔH is labelled** then **IGNORE** any numerical value **DO NOT ALLOW** $-\Delta H$ **ALLOW** this arrow even if it has a small gap at the top and bottom i.e. does not quite reach reactant or product line
	E_a labelled correctly **AND** above reactants ✓		**ALLOW** (+) 225 only as an alternative label for E_a **ALLOW** arrows at both ends of activation energy line The E_a line must point to maximum (or near to the maximum) on the curve **ALLOW** this line even if it has a small gap at the top and bottom ie does not quite reach the maximum or reactant line **ALLOW** A_E or E_a for activation energy

Question	Answer	Marks	Guidance
(c)	(+)49 ✓	1	**DO NOT ALLOW** –49
(d)	(+)274 ✓	1	**DO NOT ALLOW –**274 **ALLOW** answer to **(c)** + 225 as **ECF**
(e)	(equilibrium position shifts) to the left ✓ (Forward) reaction is exothermic **OR** reaction gives out heat **OR** reverse reaction is endothermic **OR** reverse reaction takes in heat ✓ **The explanation mark is dependent on the correct shift of the equilibrium**	2	**ALLOW** 'favours the left', as alternative for 'shifts equilibrium to left' **Note: ALLOW** suitable alternatives for 'to left', eg: towards CO_2 / H_2 **OR** towards reactants **OR** in backward direction **OR** in reverse direction **OR** decreases yield of CH_3OH /products **IGNORE** responses in terms of rate
(f)	(equilibrium position) shifts to the left ✓ Right-hand side has fewer (gaseous) moles/molecules ✓ **ORA** **The explanation mark is dependent on the correct shift of the equilibrium**	2	**ALLOW** 'favours the left', as alternative for 'shifts equilibrium to left' **Note: ALLOW** suitable alternatives for 'to left', eg: towards CO_2 / H_2 **OR** towards reactants **OR** in backward direction **OR** in reverse direction **OR** decreases yield of CH_3OH /products **IGNORE** responses in terms of rate **ALLOW** four moles on the left and two moles on the right **ALLOW** more moles of reactants or fewer moles of products **ASSUME** "goes the side with more gas molecules" implies from equation that more molecules on the left **OR** "goes to side with fewer gas molecules" implies from equation that fewer molecules are on the right

Question			Answer	Marks	Guidance
	(g)		Adsorption of reactants **OR** adsorption of gases **OR** H_2 and CO_2 attached to surface ✓	3	**ALLOW** CO_2 and H_2 (weakly) bonded to surface **OR** reactants bond to surface **OR** CO_2 and H_2 form temporary bonds with the catalyst **DO NOT ALLOW** absorption
			Bonds weaken in reactants **OR** chemical reaction **OR** activation energy decreases ✓		**ALLOW** bonds weaken in H_2 **OR** bonds weaken in CO_2 **OR** C=O bonds weaken **OR** bonds break and new bonds made in product **OR** H_2O and CH_3OH made
			Desorption of products **OR** desorption of H_2O and CH_3OH ✓		**ALLOW** products leave the surface/catalyst **OR** H_2O and CH_3OH no longer bonded to surface/catalyst **ALLOW** deadsorption **OR** adsorb from for desorption **ALLOW** diffuse away for desorption
			Total	**15**	

Question			Answer	Marks	Guidance
5	(a)		**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer = 90% award 3 marks** amount of dichloroethane $= \frac{19800000}{99.0}$ **OR** 200000 (mol) **OR** 2×10^5 (mol) ✓ amount of chloroethene $= \frac{11250000}{62.5}$ **OR** 180000 (mol) **OR** 1.8×10^5 (mol) ✓ Calculates percentage yield $= \frac{180000}{200000} \times 100 = 90\ \%$ ✓	3	**IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below. ***ALLOW approach based on mass for 2nd and 3rd marks*** Theoretical mass of chloroethene = 200000 × 62.5 **OR** 12500000 (g) **OR** 1.25×10^7 (g) ✓ Calculates percentage yield $= \frac{11250000}{12500000} \times 100 = 90\ \%$ ✓ --- ***ALLOW approach based on grams rather than tonnes:*** n(dichloroethane) $= \frac{19.80}{99.0}$ **OR** 0.2 (mol) ✓ n(chloroethane) $= \frac{11.25}{62.5}$ **OR** 0.18 (mol) **OR** theoretical mass chloroethane = 0.2 × 62.5 **OR** 12.5 g ✓ % yield $= \frac{0.18}{0.20} \times 100 = 90\ \%$ **OR** $\frac{11.25}{12.5} \times 100 = 90\ \%$ ✓ --- **ALLOW ECF** throughout from wrong M_r value(s) with final % yield to 2 or more significant figures **DO NOT ALLOW** final mark for an answer above 100% --- **Note**: If this is the only working seen award no marks ie $\frac{11.25 \times 10^6}{19.80 \times 10^6} \times 100 = 56.81\%$

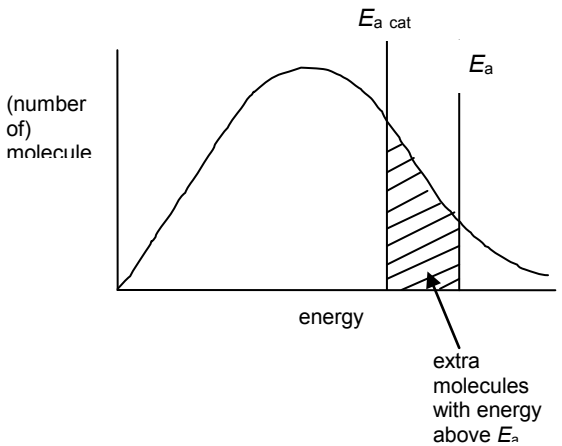
Question			Answer	Marks	Guidance
5	(b)		**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer = (+)62 award 3 marks** ΔH for bonds broken = 2691 (kJ mol^{-1}) ✓ ΔH for bond formed = 2629 (kJ mol^{-1}) ✓ ΔH = (+)62 (kJ mol^{-1}) ✓	3	**IF** there is an alternative answer, check to see if there is any **ECF** credit possible. **IGNORE** sign **ALLOW** 1106 (C–Cl, C–C and C–H bonds) **IGNORE** sign **ALLOW** 1044 (H–Cl and C=C bonds) **ECF** based on bonds broken – bonds formed **ALLOW** 2 marks for –62
	(c)		Displayed formulae of monomer and polymer required for the marks.  Only chloroethene on left hand side ✓ Only the correct polymer on right hand side ✓ A correctly balanced equation using displayed formulae for any monomer and matching polymer including the correct use of *n* ✓	3	Polymer must have **side** links (do not have to cut through bracket and can be dotted lines) **ALLOW** a correct section of the polymer with side links as below would score two marks as the equation is not balanced  **DO NOT ALLOW ECF** from wrong monomer *n* on LHS can be at any height to the left of formula **AND** *n* on the RHS must be a subscript (essentially below the side link) The equation below would be worth 1 mark for balancing 

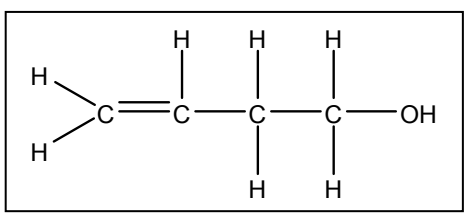
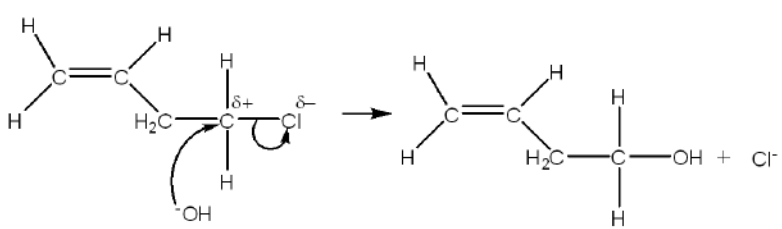
Question			Answer	Marks	Guidance
	(d)	(i)	React with an alkali **OR** react with a base/carbonate **OR** Bubble through water (to make HCl(aq)) **OR** dissolve in water ✓	1	**ALLOW** react with a named alkali or base eg calcium carbonate, calcium hydroxide, magnesium oxide, ammonia **ALLOW** an appropriate chemical formula **IGNORE** use of gas scrubbers
		(ii)	Sort and recycle ✓ Organic feedstock **OR** cracked ✓	2	**ALLOW** separate and recycle or sorting and remoulding **ALLOW** use for the production organic compounds **OR** synthesis gas **ALLOW** the production of plastics or monomers or new polymers
		(iii)	(Bio) degradable (polymers) **OR** compostable (polymers) **OR** soluble (polymers) **OR** photodegradable (polymers) ✓	1	**IGNORE** a named polymer if degradable **DO NOT ALLOW** any addition polymer eg PTFE
			Total	**13**	

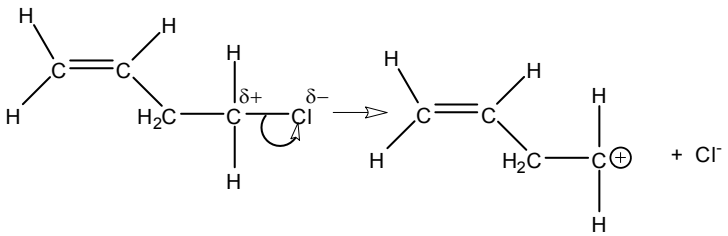
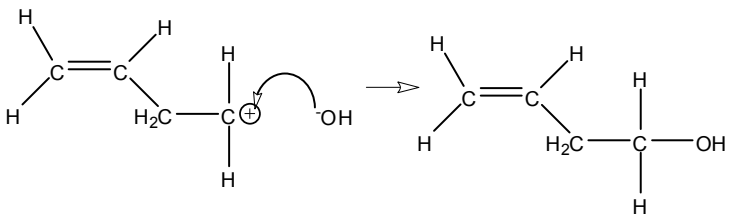
Question			Answer	Marks	Guidance
6	(a)		Bond breaking absorbs energy **AND** bond forming releases energy ✓ More energy released than absorbed ✓ The second marking point is **dependent** on the correct identification of the energy changes during bond breaking and bond making	2	**ALLOW** bond breaking is endothermic **AND** bond forming is exothermic **DO NOT ALLOW** bond forming requires energy **ALLOW** more energy is released when the bond in the products are formed than is required to break the bonds in the reactants **ALLOW** exothermic change transfers more energy than endothermic change **OR** bond forming transfers more energy than bond breaking **OR** '(the sum of the) bond enthalpies in the products is greater than the (sum of the) bond enthalpies in the reactants' **OR** '(the sum of the) bond enthalpies of the bonds made is greater than (the sum of) the bond enthalpies of the bonds broken' **OR** more energy associated with bond making than with bond breaking **IGNORE** reference to strong and weak bonds **IGNORE** reference to number of bonds broken or made **IGNORE** enthalpy of products is less than enthalpy of reactants
	(b)	(i)	(C=O) **bond** vibrates (more) **OR bond** bends (more) **OR bond** stretches (more) ✓	1	**IGNORE** molecule vibrates/rotates "It" refers to the molecule and is insufficient **DO NOT ALLOW** any reference to bond breaking. **DO NOT ALLOW** a stated bond if **not** present in CO_2 eg C–O, C–H

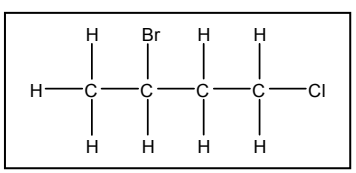
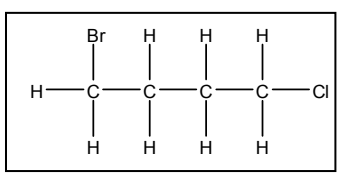
Question			Answer	Marks	Guidance
		(ii)	***Any two from:*** (injected) **deep** into the oceans / sea ✓ (Stored) in geological formations **OR** (stored) deep in rocks **OR** (stored) in old mines **OR** (stored) in old oil wells **OR** old gas fields ✓ (Stored) by reaction with metal oxides **OR** reaction to form (solid) carbonates **OR** (stored) as a carbonate **OR** equation to show formation of metal carbonate ✓	2	**DO NOT ALLOW** reference to carbon being stored – the answer must either refer to carbon dioxide or not mention the name of the stored substance. Assume "it" refers to CO_2 **DO NOT ALLOW** dumping waste at the bottom of the sea **ALLOW on** the **sea-bed** **DO NOT ALLOW** dissolve CO_2 in the sea **OR** (stored) in ocean **DO NOT ALLOW** geographical formations **ALLOW** stored **under** the sea (bed) **ALLOW** pumped into oil wells to force last bit of oil out **DO NOT ALLOW** buried underground **DO NOT ALLOW** react with **metals** to form carbonates **IGNORE** mineral storage

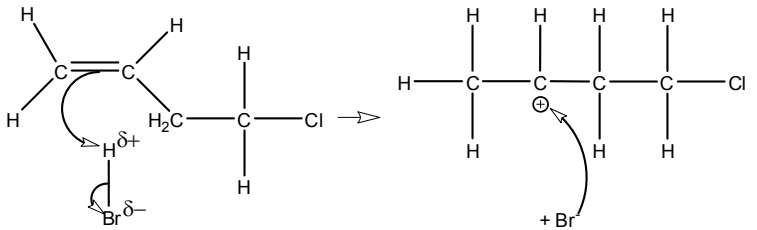
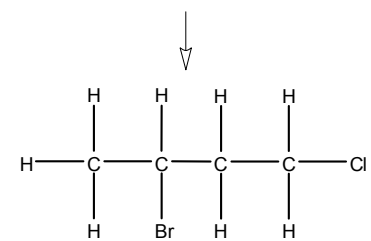
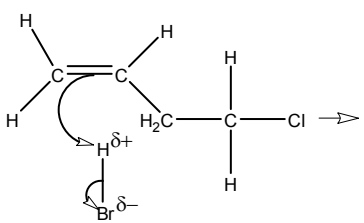
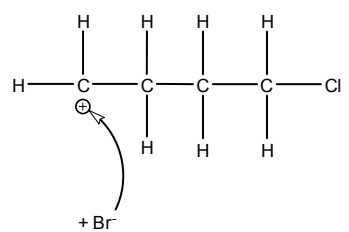
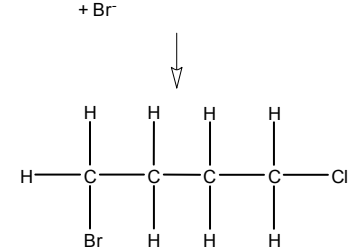
Question	Answer	Marks	Guidance
(c)	***Any two from:***	2	
	Energy demand Low(er) temperature (can be used) **OR** reduces CO_2 emissions (from burning fossil fuels) ✓		**ALLOW** 'allows use of room temperature' **OR** 'allows use of a lower pressure' **OR** uses less fuel **IGNORE** lower energy demand **OR** lower activation energy **IGNORE** cheaper **IGNORE** less greenhouse gases **OR** reduces global warming
	Specificity enzymes have a great deal of specificity ✓		**ALLOW** making specific isomers / enantiomers **ALLOW** for making pure products **ALLOW** generating specified products
	Atom economy greater atom economy **OR** less waste ✓		**ALLOW** increases atom economy
	Toxicity can reduce use of toxic solvents **OR** reduces use of toxic catalysts **OR** reduces the use of toxic reactants ✓		**ALLOW** reduce use of hazardous/toxic/harmful/poisonous chemicals **ALLOW** enzymes are non toxic **IGNORE** can be reused

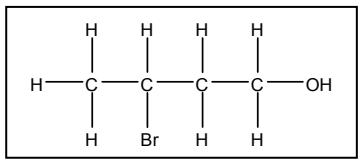
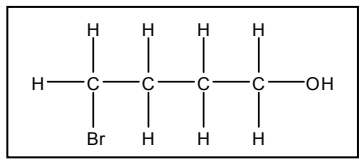
Question	Answer	Marks	Guidance
(d)	Catalyst lowers the activation energy (because of a different reaction pathway) ✓	5	Can be scored from the diagram by correctly labelling $E_{a\ cat}$ closer to the origin than E_a
	Diagram of Boltzmann distribution ✓		Boltzmann distribution must start at origin **AND** must not touch *x*-axis at high energy
	axes labelled (number of) molecules and energy ✓		**DO NOT ALLOW** Boltzmann distribution mark if **two** curves drawn
			**DO NOT ALLOW Boltzmann distribution** curve bending upwards at higher energy **ALLOW** particles instead of molecules **DO NOT ALLOW** the first use of atoms but credit atoms if used in a subsequent marking point **DO NOT ALLOW** enthalpy on x-axis instead of energy
	Greater proportion of molecules with energy above activation energy with catalyst ✓		**ALLOW** more molecules with energy above activation energy (with a catalyst) **OR** more molecules overcome the activation energy (with a catalyst) **OR** more molecules have enough energy to react (with a catalyst) **OR** more molecules are able to react at lower energies
	more **effective** collisions **OR** more **successful** collisions **OR** increased frequency of **successful** collisions ✓		More collisions **OR** more frequent collisions are **not** sufficient
	Total	**12**	

Question			Answer	Marks	Guidance
7			**Nucleophilic substitution reaction** **correct equation for the reaction** ✓ $CH_2CHCH_2CH_2Cl$ + KOH → $CH_2CHCH_2CH_2OH$ + KCl **OR** C_4H_7Cl + KOH → C_4H_7OH + KCl **correct product of the reaction** ✓  **Mechanism**  dipole shown on C—Cl bond: $C^{\delta+}$ and $Cl^{\delta-}$ in the correct chloroalkene ✓ curly arrow from HO^- to carbon atom of C–Cl bond **AND** curly arrow from C–Cl bond to chlorine atom ✓ formation of Cl^- ✓	5	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** **ALLOW** $CH_2CHCH_2CH_2Cl + OH^- \rightarrow CH_2CHCH_2CH_2OH + Cl^-$ **ALLOW** $C_4H_7Cl + OH^- \rightarrow C_4H_7OH + Cl^-$ **ALLOW** correct molecular **OR** structural **OR** displayed **OR** skeletal formula **OR** mixture of the above **For structure of the product** **ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) if seen **ONCE** in equation, mechanism or drawn out eg $CH_2CHCH_2CH_2OH$ curly arrow must start from one lone pair on O atom of ^-OH ion **OR** from negative charge on the O atom of the ^-OH ion Lone pair does **not** need to be shown on ^-OH ion

Question	Answer	Marks	Guidance
	Nucleophilic substitution continued (S_N1) **Step 1:**  **Step 2:**  		**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** **ALLOW S_N1 mechanism** dipole shown on C–Cl bond, $C^{\delta+}$ and $Cl^{\delta-}$ in correct chloroalkene ✓ curly arrow from C–Cl bond to halogen atom and Cl^- ✓ curly arrow from ^-OH to **correct** carbocation ✓ curly arrow must start from one lone pair on O atom of ^-OH ion **OR** from negative charge on the O atom of the ^-OH ion Lone pair does **not** need to be shown on ^-OH ion

Question			Answer	Marks	Guidance
7			**Electrophilic addition** **correct equation for the reaction** ✓ $CH_2CHCH_2CH_2Cl + HBr \longrightarrow CH_3CHBrCH_2CH_2Cl$ **OR** $CH_2CHCH_2CH_2Cl + HBr \longrightarrow CH_2BrCH_2CH_2CH_2Cl$ Indication that there are two possible addition products ✓ **Correct product** ✓  **OR**  **Mechanism** Curly arrow from C=C of correct chloroalkene to attack the H atom in HBr ✓ Correct dipole on H–Br: $H^{\delta+}$ and $Br^{\delta-}$ **AND** curly arrow from H–Br bond to Br ✓ Correct carbocation / carbonium ion with the **full** positive charge shown: C^+ **AND** correct curly arrow from lone pair of Br^- to correct carbon atom **OR** correct curly arrow from negative charge of Br^- to correct carbon atom ✓	6	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** **ALLOW** correct molecular **OR** structural **OR** displayed **OR** skeletal formula **OR** mixture of the above. **eg** $C_4H_7Cl + HBr \rightarrow C_4H_8BrCl$ For the structure of the product **ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) if seen **ONCE** in equation, mechanism or drawn out eg $CH_2BrCH_2CH_2CH_2Cl$ or $CH_3CHBrCH_2CH_2Cl$ curly arrow must start from covalent bonds and not atoms Lone pair does **not** need to be shown on ion or used in mechanism **DO NOT ALLOW** any other partial charges eg shown on double bond **DO NOT ALLOW** $C^{\delta+}$ for charge on carbonium ion. Curly arrow from Br^- can start from the negative charge or the lone pair **DO NOT ALLOW** delta negative, i.e. $Br^{\delta-}$

Question			Answer	Marks	Guidance
7			**Electrophilic addition continued**   **OR**   		
			heterolytic fission for **both** mechanisms and **not** contradicted ✓	1	

Question			Answer	Marks	Guidance
			ALTERNATIVE APPROACH **The Candidate who reacts with KOH followed by HBr** • Award all marks for the nucleophilic substitution mechanism as per the marking scheme • You can award all marks for the electrophilic addition mechanism; however the product will be one of the following:  **OR**  • The mechanism will be the same except the –C*l* will now be replaced by –OH at every stage		
			Total	**12**	

Question			Answer	Marks	Guidance
8			**IR spectrum** (absorbance between) 3200–3550 cm^{-1} indicates –OH **AND** X is an alcohol ✓	1	**LOOK ON THE SPECTRUM** for labelled absorbance which can be given credit **ALLOW** an absorbance within the range 3100 to 3700cm^{-1} from the spectrum. Answer must give –OH and alcohol for the mark. **IGNORE** phenol **DO NOT ALLOW** carboxylic acid (there is no carbonyl group present in the spectrum)
			Formula **mole ratio C : H : O** $\frac{0.600}{12} : \frac{0.133}{1.0} : \frac{0.267}{16}$ **OR** 0.0500 :0.133 : 0.0167 ✓ $\frac{0.05}{0.0167} : \frac{0.133}{0.0167} : \frac{0.0167}{0.0167}$ **OR** 3 : 8 : 1 **OR** C_3H_8O ✓ Candidate links $\mathbf{C_3H_8O}$ to 60 such as $\mathbf{C_3H_8O}$ has M_r 60 **OR** $\mathbf{C_3H_8O}$ has m/z = 60 ✓	3	Must be a clear link between the **formula** and the M_r **OR** m/z **ALLOW** evidence of M_r , eg (12 x 3) + (8 x 1) + 16; 36 + 8 + 16 = 60 **ALLOW** alternative approach for empirical formula and evidence that 60 is equal to C_3H_8O M_r = 60 Carbon $60 \times \frac{60}{100} = 36$ Hydrogen $60 \times \frac{13.3}{100} = 8$ 36/12 = 3 C 8/1 = 8H 36 + 8 = 44 60 – 44 = 16 so 1 O C_3H_8O

Question			Answer	Marks	Guidance
8			**Identification and equation**	6	
			X is $CH_3CH_2CH_2OH$ **OR** $CH_3CHOHCH_3$ **OR** either $CH_3CH_2CH_2OH$ or $CH_3CHOHCH_3$ ✓		**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) **IGNORE** names
			QWC Stated in words that **Y** must be an ester because it is made from the reaction of a **carboxylic acid** **AND X (propan-1-ol OR propan-2-ol OR** an **alcohol**) ✓		**ALLOW** a carboxylic acid reacts with an alcohol to give an ester. **IGNORE** ethanoic acid (as this is stated in the question)
			Y is $CH_3COOCH_2CH_2CH_3$ **OR** $CH_3COOCH(CH_3)_2$ **OR** either $CH_3COOCH_2CH_2CH_3$ or $CH_3COOCH(CH_3)_2$ ✓ Must be consistent with a structure of alcohol **X**		**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) If no structure of **X** is provided one mark can be awarded for a correct structure of $CH_3COOCH_2CH_2CH_3$ **OR** $CH_3COOCH(CH_3)_2$
			m/*z* = 31 is CH_2OH^+ ✓		**DO NOT ALLOW** CH_3O^+
			QWC *m*/*z* = 31 or CH_2OH indicates that X must be $CH_3CH_2CH_2OH$ **OR** cannot be $CH_3CH(OH)CH_3$ **OR** shows that X is the primary alcohol ✓		**QWC** must link the evidence to the structure of propan-1-ol.
			$C_3H_8O + C_2H_4O_2 \rightarrow C_5H_{10}O_2 + H_2O$ ✓		In equation **ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above
			Total	**10**	