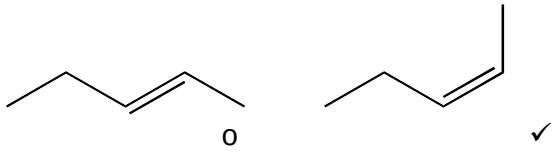
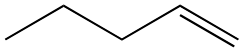
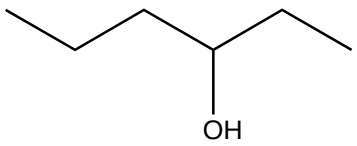
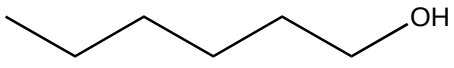
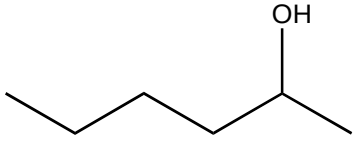
Question			Expected Answers	Marks	Additional Guidance
1	(a)		**Structural isomer** compounds with the same molecular formula ✓ but with different structural formulae ✓ **Stereoisomer** compounds with the same structural formula ✓ but with different arrangements in space ✓ **Evidence** of using M_r of 70 to **calculate** molecular formula of C_5H_{10} ✓ **F** and **G** are  o ✓ Correct identification of the *E* and *Z* isomers ✓ **H is**  ✓ ***E/Z* happens because** double bonds restricts rotation ✓ different groups on each carbon of the double bond ✓	**11**	**ALLOW** same molecular formula ✓ but different structures✓ Second marking point is **DEPENDENT** on first mark **ALLOW** compounds with the same structure Second marking point is **DEPENDENT** on first mark This is the QWC mark **IGNORE** wrong names of **F**, **G** and **H** **ALLOW** structural or displayed formulae for **F**, **G** and **H** e.g. **H is** $CH_3CH_2CH_2CHCH_2$ **ALLOW** identification using *trans* and *cis* and **ALLOW** this marking point as identification of another example of identifying *E/Z* or *cis* and *trans* if not done for **F** and **G** **ALLOW** one mark if no structures drawn but correct names given for **F**, **G** and **H** i.e *E*-pent-2-ene, *Z*-pent-2-ene and pent-1-ene **ALLOW** ecf on structures if wrong molecular formula used or consistent error or slip such as having just sticks

Question			Expected Answers	Marks	Additional Guidance
	(b)		from IR absorption, **J** contains O–H **OR** from IR **J** is an alcohol✓ C : H : O = $\frac{70.59}{12.0}$: $\frac{13.72}{1.0}$: $\frac{15.69}{16.0}$ **OR** 5.8825 : 13.72 : 0.9806 ✓ empirical formula = $C_6H_{14}O$ ✓ (from mass spectrum), M_r = 102 ✓ evidence that it has been shown that the empirical formula is the molecular formulae e.g. M_r of $C_6H_{14}O$ = 102 so empirical formula is molecular formula ✓    One mark for each correct structure ✓ ✓ ✓	**8**	This is a QWC mark **ALLOW two** marks for correct empirical formula with no working out This is a QWC mark **ALLOW** structural or displayed formulae **IGNORE** incorrect names **ALLOW** one minor slip in drawing structures e.g. one missing hydrogen but **ALLOW** ecf for bigger slips such as showing just sticks and no hydrogen atoms **ALLOW** bond to H in OH **ALLOW one** mark for three isomers of $C_6H_{13}OH$ whether branched or unbranched as a catch mark if no other mark has been awarded for the structures If more than three isomers of $C_6H_{13}OH$ drawn • 1 branched and 3 unbranched award **two** marks • any other combination award **one** mark **ALLOW** one mark for hexan-1-ol, hexan-2-ol and hexan-3-ol if structures not drawn
			Total	**19**	

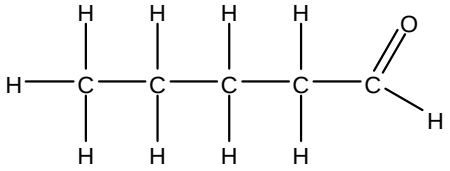
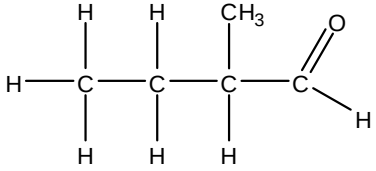
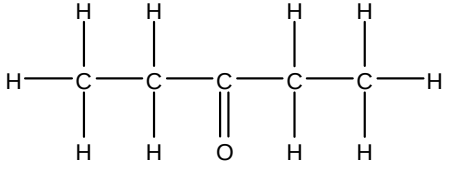
Question			er	Marks	Guidance
2	(a)		(a compound) with no double bond (or triple bond) ✓ containing hydrogen and carbon **only** ✓	2	**ALLOW** contains single bonds only **ALLOW** it contains just carbon and hydrogen **DO NOT ALLOW** a mixture of carbon and hydrogen **OR** only carbon and hydrogen molecules
	(b)		CH_2 ✓	1	**ALLOW** H_2C
	(c)		**D** and **I** **OR** **F** and **G** **OR** **F** and **H** ✓	1	**DO NOT ALLOW G** and **H**
	(d)	(i)	Cyclic hydrocarbons have more efficient combustion ✓	1	**The answer must relate to combustion or burning** **Assume 'they' refers to the cyclic hydrocarbons** **ALLOW** cyclic hydrocarbons allow smoother burning **OR** cyclic hydrocarbons increase octane number **OR** cyclic hydrocarbons reduce knocking **OR** cyclic hydrocarbons are less likely to produce pre-ignition **OR** cyclic hydrocarbons are more efficient fuels **OR** cyclic hydrocarbons burn better **OR** easier to burn **OR** cyclic hydrocarbon combust more easily **OR** improves combustion **DO NOT ALLOW** cyclic hydrocarbons ignite more easily **ALLOW** ora for straight chain hydrocarbons **IGNORE** cyclic hydrocarbons increase volatility of fuel **IGNORE** cyclic hydrocarbons have a lower boiling point cyclic hydrocarbons are a better fuel on their own is **NOT** sufficient cyclic hydrocarbons burn more cleanly on their own is **NOT** sufficient

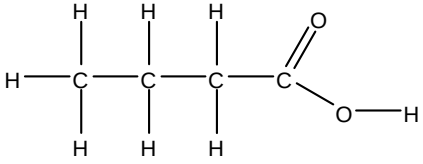
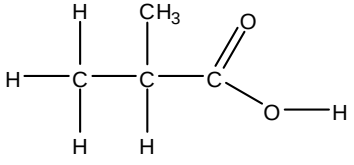
Question			Answer	Marks	Guidance
	(d)	(ii)	$C_7H_{16} \rightarrow C_7H_{14} + H_2$ ✓	1	**ALLOW** molecular formulae **OR** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) **DO NOT ALLOW** cycloheptane structure in equation
	(e)		**D** has more surface (area of) contact **OR D** is a bigger molecule ✓ **D** has more van der Waals' forces **OR C** have fewer van der Waals' forces ✓	2	**Both answers need to be comparisons** Assume 'it' refers to **D** **ALLOW** has more electrons **OR** longer (carbon) chain **OR** higher molecular mass **IGNORE** surface area **ALLOW** ORA **ALLOW D** has stronger van der Waals' forces / larger VDW / greater VDW **OR C** has weaker van der Waals' forces **OR C** has smaller VDW **ALLOW** more VDW forces More intermolecular forces is **not** sufficient **DO NOT ALLOW** reference to bonds breaking or more bonds present unless it is clear that that the bonds are VDW
	(f)		Same structural formula ✓ Different arrangement of groups around a double bond **OR** different arrangement (of atoms) in space ✓	2	**ALLOW** have the same structure / displayed formula / skeletal formula Stereoisomers have the same formula or molecular formula is **not** sufficient **ALLOW** different three dimensional arrangement

Question			er	Marks	Guidance
	(g)		$C_7H_{16} + 11O_2 \rightarrow 7CO_2 + 8H_2O$ Correct reactants and products ✓ Balancing ✓	2	**ALLOW** molecular formulae **OR** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) **ALLOW** any correct multiple **IGNORE** state symbols Balancing is **dependent** on correct formulae
	(h)		$C_{16}H_{34} \rightarrow C_8H_{18} + 2C_4H_8$ ✓	1	**ALLOW** molecular formulae **OR** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) **ALLOW** any correct multiple **ALLOW** structural **OR** displayed **OR** skeletal formulae in equation **ALLOW** but-1-ene **IGNORE** state symbols
	(i)	(	Group of atoms (in a molecule or compound) that is responsible for the reactions ✓	1	**ALLOW** the 'part' (of the molecule or compound) that reacts **ALLOW** the group of atoms that gives the chemical properties **ALLOW** group of atoms which indicates the homologous series
		(ii)	8 ✓	1	
		(iii)	has an unpaired electron ✓	1	**ALLOW** plural i.e. unpaired electrons has a lone **OR** single **OR** free electron is **not** sufficient
			Total	**16**	

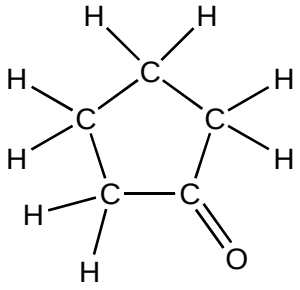
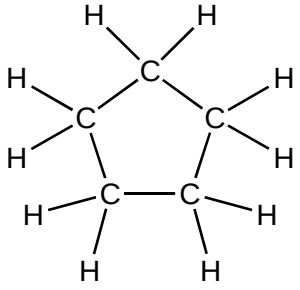
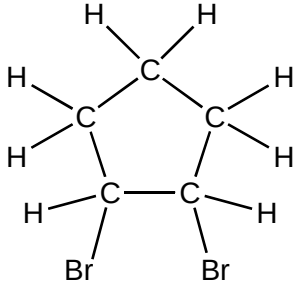
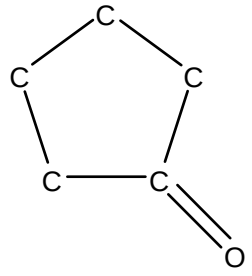
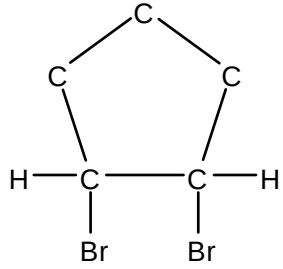
Question			Answer	Marks	Guidance
3	(a)		***Any three from:***	3	Assume it refers to **Process 1**
			Process 1 has a high atom economy **OR** has 100% atom economy **OR** a greater atom economy **OR** makes only the desired product ✓		**ALLOW** process **1** has no waste **OR** process **1** has no co-products **OR** process **1** needs less separation **OR** process **1** has fewer other products **OR** gives only one product **ALLOW** ORA if process **2** is specified
			Process 1 has a very efficient conversion of reactants to products **OR** not much waste of **starting material** ✓		**ALLOW** ORA if process **2** is specified high percentage yield is **not** sufficient **DO NOT ALLOW** if percentage yield is explicitly linked to more waste (products) e.g. process **1** has a high percentage yield so makes little waste (product) scores **0 marks** but process **1** makes no waste (product) and it has a high percentage yield scores **1 mark**
			Process 1 uses a low**er** pressure ✓		**ALLOW** ORA if process **2** is specified
			Process 1 uses up **toxic** carbon monoxide ✓		
			Process 1 uses methanol which can be produced from biomass ✓		**IGNORE** process **2** comes from crude oil a non-renewable source **ALLOW** process **1** starts from a renewable source if the source is specified e.g. wood, municipal waste or sewage **IGNORE** reference to catalyst and rate of reaction

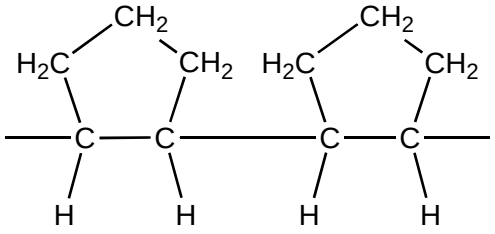
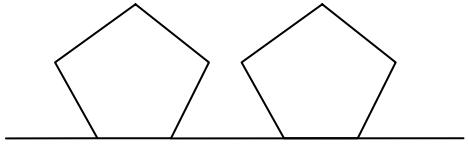
Question			er	Marks	Guidance
	(b)	(		5	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC**
			Contains C=O bond because of absorption between 1700 and 1740 cm^{-1} (from the spectrum) ✓		**ALLOW** contains a carbonyl group because of absorption within range 1640–1750 cm^{-1} **OR** contains an aldehyde, ketone or carboxylic acid because of absorption within range 1640–1750 cm^{-1} ✓ Mention of only an aldehyde or a ketone is not sufficient it needs reference to the wavenumber **LOOK FOR THIS MARK ON THE SPECTRUM**
			does not contain an O–H bond ✓		**ALLOW** not a carboxylic acid ✓ **ALLOW** does not have any other characteristic absorbance due to other functional groups
			(So was a) ketone **OR** aldehyde ✓		**ALLOW (**so was a) carbonyl compound **ALLOW** this mark if a structure of an aldehyde or a ketone is given even if the structure has an incorrect number of carbon atoms
			M_r = 86 ✓		
			Correct structure ✓		**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) LOOK FOR AN **ALDEHYDE** or **KETONE** with **FIVE** carbon atoms **OR** a **DIALDEHYDE**, **DIONE OR** an **OXOALDEHYDE** with **FOUR** carbon atoms – a comprehensive list of correct structures is shown on page 34 **IGNORE** incorrect name **DO NOT ALLOW** COH for an aldehyde

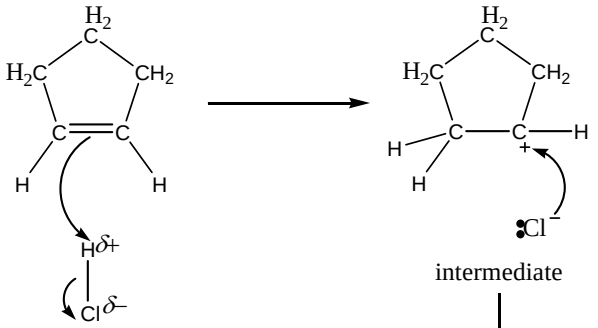
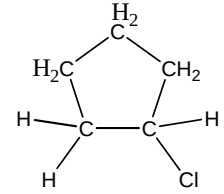
Question			er	Marks	Guidance
			 pentanal **OR**  2-methylbutanal **OR**  pentan-3-one		**ALLOW** as a slip one stick with no H on in a displayed formula

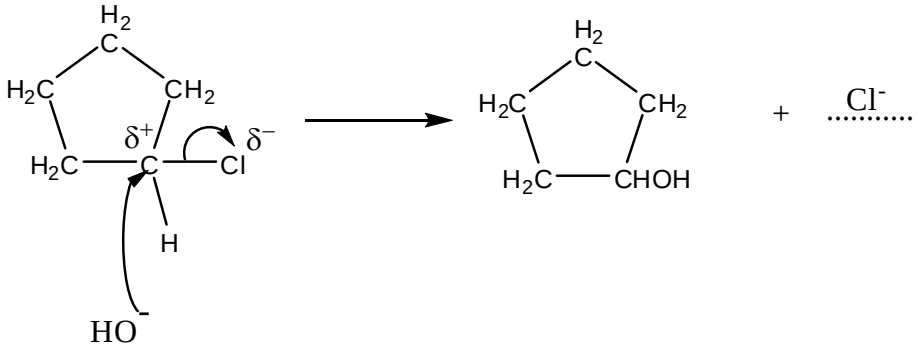
Question			er	Marks	Guidance
	(b)	(i	Correct structure ✓ Name of the structure drawn ✓  butanoic acid **OR**  2-methylpropanoic acid	2	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) All bonds and all hydrogen atoms must be shown in a displayed formula within this question Name must correspond to the correct structure for two marks **ALLOW** butanoic acid or 2-methylpropanoic acid if the structure drawn is incorrect There is **no** ECF in this question **ALLOW** $CH_3CH_2CH_2COOH$ **ALLOW** $(CH_3)_2CHCOOH$ **ALLOW** methylpropanoic acid

Question			er	Marks	Guidance
	(c)		Use of propan-1-ol ✓	4	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) **ALLOW** from the equation propanol **OR** C_3H_7OH is **not** sufficient
			$CH_3COOH + C_3H_7OH \rightarrow CH_3COOCH_2CH_2CH_3 + H_2O$		**ALLOW** molecular formula **OR** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above **ALLOW** propan-2-ol in the equation
			Correct formulae for the ester ✓ Correctly balanced equation ✓		
			Add H_2SO_4 **OR** acid catalyst **OR** H^+ ✓		**ALLOW** conditions mark over the arrow in the equation
			Total	**14**	

Question			er	Marks	Guidance
4	(a)		 **compound P ✓**  **compound Q ✓**  **compound R ✓**	3	**ALLOW** structures with missing hydrogen atoms on the carbon atoms that do not take part in the reaction. i.e. all hydrogen atoms must be shown in **Q** but not in **P** and **R** For example for the structures of **P** and **R**  

Question			er	Marks	Guidance
	(b)		Orange **OR** brown to colourless ✓	1	**ALLOW** shades of orange **OR** yellow **OR** brown **DO NOT ALLOW** red alone **DO NOT ALLOW** any response that includes precipitate **OR** solid, irrespective of colour
	(c)		Two or more repeat units ✓  	1	**ALLOW** correct structural **OR** displayed **OR** skeletal formula **OR** mixture of the above (as long as unambiguous) Must have at least two repeat units and the free bonds at the end **ALLOW** free bonds with dotted lines All carbon–carbon bonds in the polymer chain must be shown **IGNORE** any brackets drawn **IGNORE** any missing hydrogen atoms on the CH_2 groups **ALLOW** skeletal formula 

Question			er	Marks	Guidance
	(d)		Curly arrow from double bond to attack hydrogen of H–C*l* and breaking of H–C*l* bond ✓ Correct dipole shown on H–Cl ✓ Correct carbonium ion drawn ✓ Curly arrow from Cl^- to the carbonium ion ✓  intermediate  product Correct product ✓	5	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** Curly arrow must start from the double bond and not a carbon atom; other curly arrow must start from H–C*l* bond **DO NOT ALLOW** dipoles on double bond 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 in a circle) C*l*$^-$ curly arrow must come from one lone pair on C*l*$^-$ ion **OR** from minus sign on C*l*$^-$ ion Lone pair does not need to be shown on C*l*$^-$ ion **ALLOW** structures with missing hydrogen atoms on the CH_2 groups

Question			er	Marks	Guidance
	(e)			5	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC**
			Nucleophilic substitution ✓		
			Heterolytic (fission) spelt correctly ✓		
			dipole shown on C—C*l* bond, $C^{\delta+}$ and $Cl^{\delta-}$✓		Dipole must be partial charge and not full charge
			curly arrow from HO^- to carbon atom of C—C*l* bond ✓		HO^- curly arrow must come from one lone pair on O of HO^- ion **OR** from minus sign on HO^- ion
			curly arrow from C—C*l* bond to the chlorine atom **and** formation of Cl^- ✓		curly arrow must start from C–C*l* bond and not from C atom
					**ALLOW** structures with missing hydrogen atoms on the CH_2 groups
					ALLOW S_N1 mechanism dipole shown on C—C*l* bond, $C^{\delta+}$ and $Cl^{\delta-}$ ✓ curly arrow from C—C*l* bond to the Cl atom and Cl^- shown✓ curly arrow from HO^- to correct carbonium ion ✓
			Total		