OCR
RECOGNISING ACHIEVEMENT

GCE

Chemistry A

Mark Scheme

Mark Scheme

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** $C_nH_{2(n-1)}$

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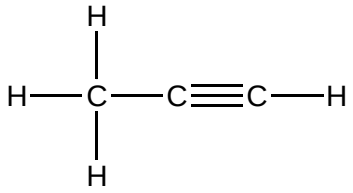
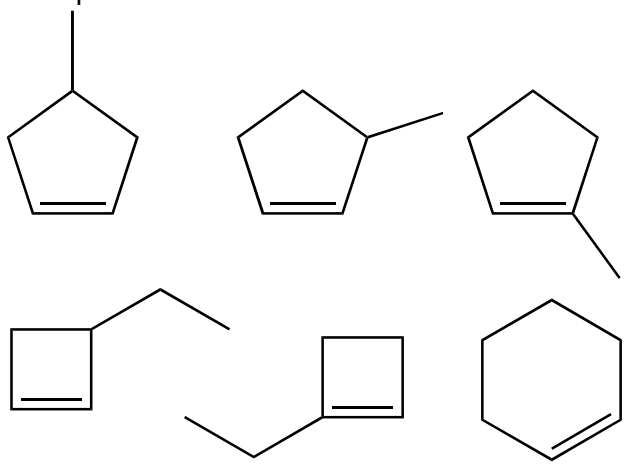
1	**b**	**iii**	Correct displayed formula ✓	1	
		iv	Correct skeletal formula of cyclic hydrocarbon with formula C_6H_{10} ✓	1	Examples of correct skeletal formulae include 
	c		Energy required to break bonds = (+) 2912 ✓ Energy released to make bonds = (–)4148 ✓ Enthalpy of combustion = –1236 ✓	3	**ALLOW** 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

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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

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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**	

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2	**a**	**i**	Branched chain alkane of formula C_5H_{12} to C_9H_{20} e.g. 2-methylpentane, 3-methyloctane ✓	1	Must have position number **but ALLOW** methylbutane **DO NOT ALLOW** 1-methylpentane or 2-ethylpentane etc **DO NOT ALLOW** incorrect nomenclature e.g. 2-**methy**pentane etc
	b	**i**	Vibrate (more) ✓	1	**ALLOW** bend / stretch / oscillate **IGNORE** rotate **NOT** break / molecules vibrate
		ii	Incomplete combustion ✓	1	**ALLOW** not enough oxygen
		iii	NO for photochemical smog **OR low level** ozone ✓ CO is toxic ✓	2	**ALLOW** NO can (eventually) cause acid rain **OR** can result in respiratory irritation **OR** can (eventually) depletes high level ozone **OR** depletes ozone layer **IGNORE** greenhouse gas **ALLOW** poisonous **OR** kills **OR** lethal **ALLOW** CO reduces the capacity of blood to carry oxygen Oxygen combines with haemoglobin is insufficient **IGNORE** CO is harmful / suffocates / greenhouse gas
	c	**i**	Makes nitrogen **AND** carbon dioxide ✓ $2CO + 2NO \rightarrow N_2 + 2CO_2$ ✓	2	 **ALLOW** any correct multiples **IGNORE** state symbols

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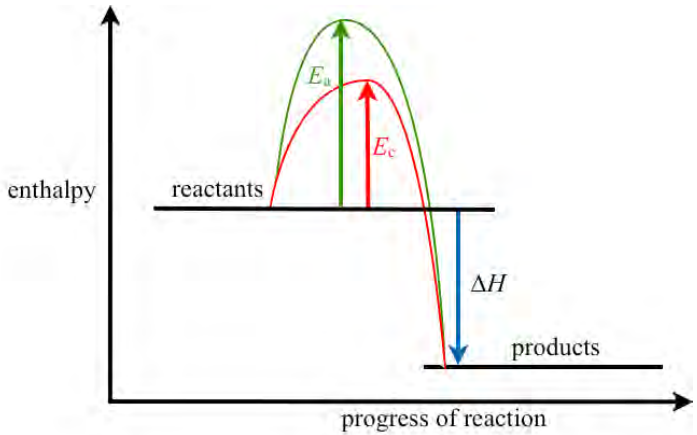
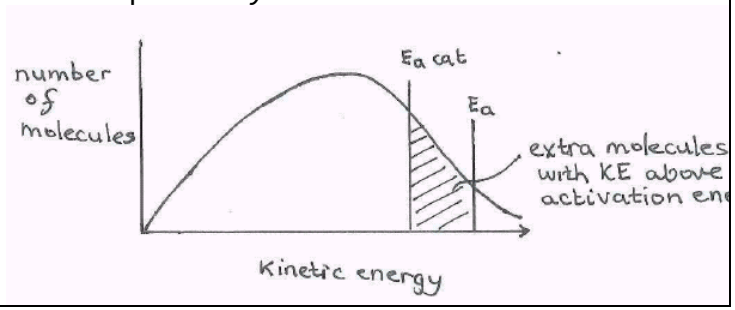
2	c	ii	One activation energy correctly labelled on enthalpy profile diagram ✓ Idea that activation energy is lowered ✓ Catalyst has a different reaction pathway **OR** different reaction mechanism **OR** two curves drawn on profile ✓ Correct diagram of reaction profile for exothermic reaction with product below reactants with y axis as enthalpy or energy and ΔH label – arrow should go down. Ignore a small gap between at either end of ΔH line ✓ Drawing of Boltzmann distribution – axes labelled number of molecules and energy ✓ More molecules with energy above activation energy with a catalyst ✓ More effective collisions **OR** more successful collisions ✓	7	**ANNOTATE WITH TICKS AND CROSSES** With the line/arrow no more than 1 mm from top of curve or reactant line – arrow can be double headed for activation energy **ALLOW** vertical line with no arrows **DO NOT ALLOW** arrow just pointing downwards Marks can be awarded via, reaction profile, in words or from Boltzmann  Boltzmann distribution – must start at origin and must not end up at 0 on *y*-axis i.e. must not touch *x*-axis 

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2	**d**		**Any two benefits from**: Save crude oil **OR** no risk of large scale pollution from exploitation of crude oil ✓ Biodiesel is renewable **OR** diesel is non-renewable ✓ Use of biodiesel is (more) carbon-neutral **OR** plants take up the carbon dioxide released during combustion ✓ **and one disadvantage** Land not used to grow food crops **OR** (rain)forests have to be cut down to provide land **OR** food prices may rise because less is grown ✓	3	**ANNOTATE WITH TICKS AND CROSSES** **ALLOW** decrease the need for fossil fuels **ALLOW** plants are a renewable resource / crude oil non-renewable resource / biodiesel is more sustainable / diesel is not sustainable **ALLOW** lower carbon footprint **IGNORE** can be used by diesel powered cars with or without any conversion **IGNORE** comments about availability / fertilisers / pesticides Destroys habitats is not sufficient
			Total	**17**	

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Question			Expected Answers	Marks	Additional Guidance
3	**a**		Answers clockwise from top left $CH_3CH_2CH_2COOH$ ✓ $CH_3CH_2CHCH_2$ ✓ $CH_3COOCH_2CH_2CH_2CH_3$ ✓ $CH_3CH_2CH_2CHO$ ✓	4	**ALLOW** skeletal formula **ALLOW** butanoic acid **ALLOW** but-1-ene **ALLOW** butyl ethanoate **ALLOW** butanal If name and structure given both must be correct If C_3H_7 used instead of $CH_3CH_2CH_2$ penalise once and then apply ECF If wrong carbon skeleton used then penalise once then apply ECF If a hydrogen is missing then penalise once

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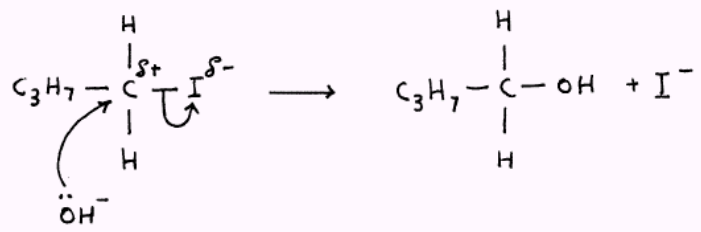
Question			Expected Answers	Marks	Additional Guidance
3	b	i	Nucleophilic substitution ✓ Heterolytic ✓ Dipole shown on C–I bond, $C^{\delta+}$ and $I^{\delta-}$ ✓ Curly arrow from OH^- to carbon atom of C–I bond ✓ Curly arrow from C–I bond to the iodine atom ✓	5	**ANNOTATE WITH TICKS AND CROSSES** **DO NOT ALLOW** fish hooks No need to show lone pair on OH^- or I^- Curly arrow must come from the negative sign or lone pair on the oxygen of the hydroxide ion  **ALLOW S_N1 mechanism** dipole shown on C–I bond, $C^{\delta+}$ and $I^{\delta-}$ ✓ curly arrow from C–I bond to the iodine atom ✓ curly arrow from OH^- to correct carbonium ion ✓
		ii	Use reflux **OR** heat for more than 20 minutes ✓ C–C*l* stronger bond (than C–I bond) **OR** C–C*l* shorter bond (than C–I bond) **OR** C–C*l* bond is harder to break **OR** needs more energy to break C–C*l* bond **OR** ora ✓	2	**ALLOW** heat stronger **OR** heat for longer **OR** heat at a higher temperature **OR** more heat Answer must refer to the C–C*l* bond or C–I bonds
			Total	**11**	

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Question			Expected Answers	Marks	Additional Guidance
4	**a**	**i**	**Any two from:** Any value between 1000–1300 ✓ Any value between 2850–3100 ✓ Any value between 3200–3550 ✓	2	
		ii	Orange to green or blue ✓	1	
		iii	$CH_3CH_2OH + [O] \rightarrow CH_3CHO + H_2O$ **OR** $CH_3CH_2OH + 2[O] \rightarrow CH_3COOH + H_2O$ Correct organic product ✓ Balanced equation ✓	2	**IGNORE** any state symbols **ALLOW** CH_3COH in equation but not for the structure **ALLOW** equations with molecular formulae but not the product mark
	b	**i**	Absorption around 2850–3100 (cm^{-1}) so contains C—H bonds ✓ No other **important** absorptions present / no other **characteristic** absorptions ✓	2	Answer must have a reference to infrared spectrum i.e. use of cm^{-1} or data from the infrared spectrum 'Has no other peaks so no functional groups present' is **not** sufficient **BUT** There are no peaks due to functional groups is sufficient **ALLOW** peaks instead of absorption **ALLOW** no absorption due to C=O and O–H / no absorption due to carbonyl and hydroxyl
		ii	Peak furthest to right hand side is 58 / molecular ion peak is 58 / peak at highest mass ✓	1	**ALLOW** peak at *m/z* 58 marked on the mass spectrum / M peak is 58 / peak at 58 linked to the molecular mass **DO NOT ALLOW** highest peak but **ALLOW** 58 is the highest peak

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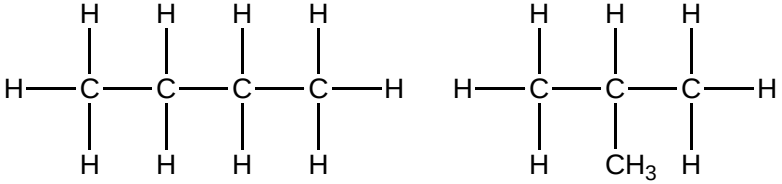
4	**b**	**iii**	 **BOTH** isomers correct ✓	1	If three structures are drawn then do not award mark **ALLOW** skeletal formulae / structural formulae **IGNORE** incorrect names
		iv	CH_3^+ ✓ $C_2H_5^+$ ✓ $C_3H_7^+$ / $CH_3CH_2CH_2^+$ / $(CH_3)_2CH^+$ ✓	3	Essentially marks are allocated as positive ions ✓ Formula of two fragments correct (ignore charge) ✓ **BUT** formulae of all three fragments correct (ignore charge) ✓✓
		v	$CH_3CH_2CH_2CH_3$ because there is a peak at m/z = 29 ✓	1	**ALLOW** name, displayed or skeletal structure **ALLOW** butane because there is a C_2H_5 fragment **ALLOW** butane because it gives all three fragments listed in **(iv)**
			Total	**13**	

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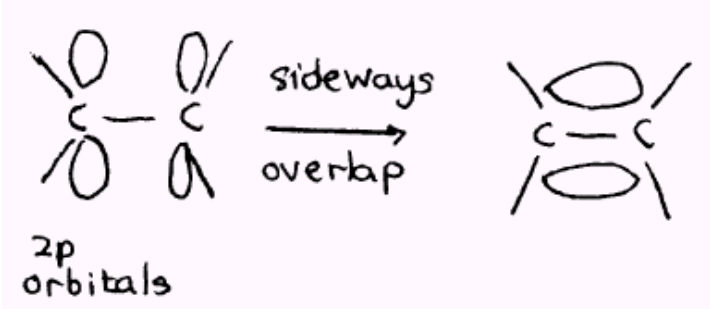
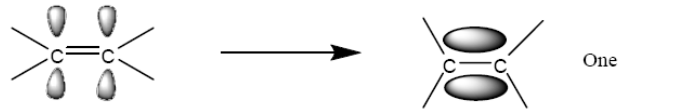
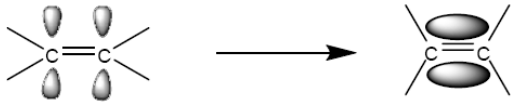
Question			Expected Answers	Marks	Additional Guidance
5	**a**		**Sideways** overlap of two p orbitals on each carbon atom ✓ forms π-orbital or π-bond above and below plane of molecule ✓	2	Answers can be awarded from a labelled diagram see additional page with typical diagrams you might see  Drawings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

Mark Scheme

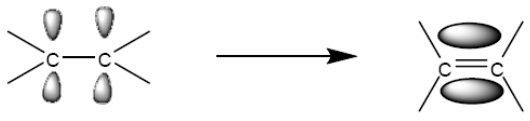
Each of the following diagrams is worth one mark. The words p-orbitals must be present to score the mark



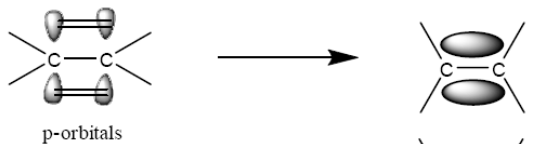
One



One

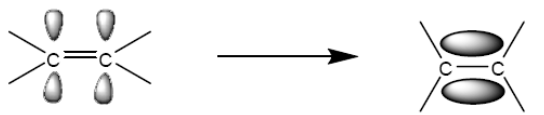


One



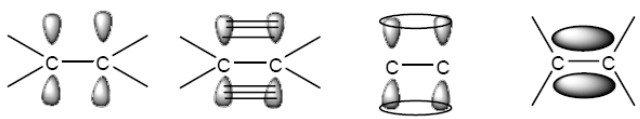
One Mark

One Mark



One

Each of the diagrams on its own scores no mark



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Question			Expected Answers	Marks	Additional Guidance
5	**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	

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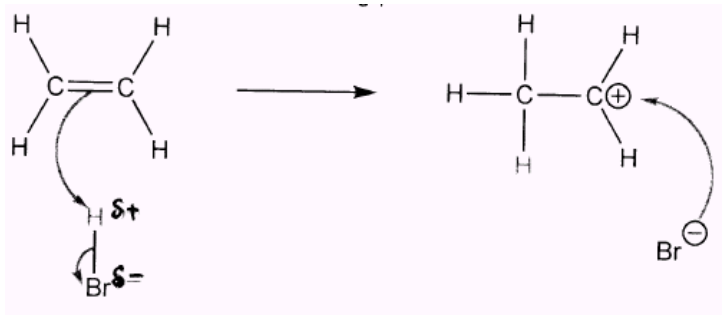
Question			Expected Answers	Marks	Additional Guidance
5	c		CH_3CH_2OH / ethanol ✓	1	**IGNORE** alcohol
	d			9	**ANNOTATE WITH TICKS AND CROSSES** **QWC** mark and **8 other** marking points
			C_4H_8 + HBr → C_4H_9Br ✓ C_2H_4 + HBr → C_2H_5Br ✓		The equation must be the overall equation not a series of steps as in a mechanism
			B makes $CH_3CH_2CH_2CH_2Br$ ✓ $CH_3CHBrCH_2CH_3$ ✓		**ALLOW** skeletal or displayed formulae **ALLOW B** makes 1-bromobutane and 2-bromo butane ✓ if marks for the structures not awarded
			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 ✓		 **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**

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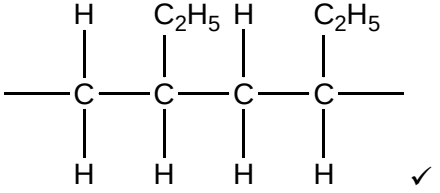
Question			Expected Answers	Marks	Additional Guidance
5	**e**	**i**	 ✓	1	Must have at least two repeat units and the free bonds at the end All carbon–carbon bonds in the polymer chain must be shown **ALLOW** bond to ethyl group to any part of ethyl group **IGNORE** any brackets drawn
		ii	Poly(but-1-ene) ✓	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**	

Mark Scheme

Question			Expected Answers	Marks	Additional Guidance
6	**a**		Low pressure because more (gas) molecules on right hand side of equation **OR** low pressure because ΔV = positive ✓ Low temperature because the (forward) reaction is exothermic ✓	2	**ALLOW** low pressure because more (gas) moles on right hand side of equation
	b		Increased pressure speeds up reaction / ora ✓ 900 ^{o}C increases the rate **OR** increased temperature speeds up reaction / ora ✓ Idea that high enough temperature without compromising yield **OR** idea that high enough pressure without compromising yield ✓	3	**ANNOTATE WITH TICKS AND CROSSES** **ALLOW** 'pushes gases through system'
	c	**i**	5.68×10^7 / 5.7×10^7 ✓	1	**ALLOW** two or more significant figures Calculator answer is 5.6812500×10^7
		ii	Used to heat the incoming gases ✓	1	**ALLOW** used to heat rest of factory **OR** sold to the national grid Provide energy to create conditions is not sufficient because one condition is pressure
			Total	**7**	

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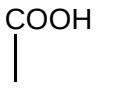
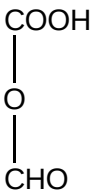
7	**Infrared** QWC – 1720 cm^{-1} indicates carbonyl group ✓ QWC – broad 2900 cm^{-1} indicates O–H bond in **carboxylic acid** ✓ QWC – 1080 cm^{-1} indicates C–O bond ✓ **Percentage composition** Mole ratio C : H : O = 2.23 : 2.22 : 4.44 ✓ Empirical formula is CHO_2 ✓ (mass of one mole is 90 g) so M_r is 90 ✓ QWC – molecular formula is $C_2H_2O_4$ with working out from M_r ✓ Structure is  ✓	8	**ANNOTATE WITH TICKS AND CROSSES** ✎ **QWC** –Structure linked to information at least once **ALLOW** 1720 indicates presence of aldehydes, ketones, esters, carboxylic acid, amides **ALLOW** 2900 indicates carboxylic acid **ALLOW** 1080 indicates alcohol, esters, carboxylic acids **ALLOW** 26.7/12.0. 2.22/1.0 and 71.1/16.0 **ALLOW** COOH **ALLOW two** marks for correct empirical formula with no working out **ALLOW** 0.0945/0.00105 = 90 **ALLOW** 
	Total	**8**	