OCR
RECOGNISING ACHIEVEMENT

GCE

Chemistry A

Advanced Subsidiary GCE

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

Mark Scheme for June 2011

Oxford Cambridge and RSA Examinations

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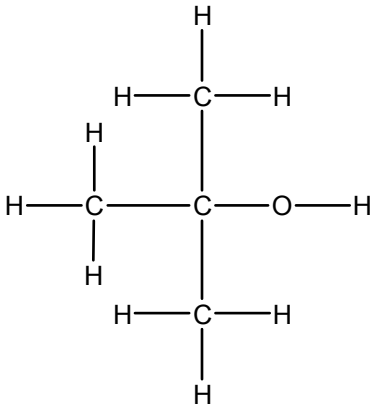
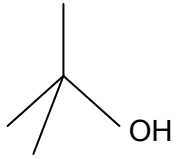
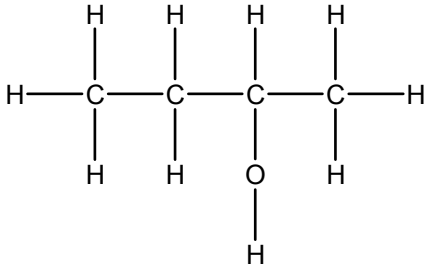
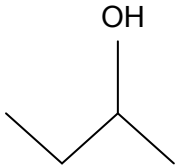
Question			Answer	Mark	Guidance
1	(a)	(i)	$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ ✓	1	**IGNORE** state symbols
		(ii)	Bond breaking absorbs energy **AND** bond forming releases energy ✓ More energy released than absorbed ✓	2	**ALLOW** bond breaking is endothermic **AND** bond forming is exothermic **DO NOT ALLOW** bond forming requires energy The second marking point is **dependent** on the correct identification of the energy changes during bond breaking and bond making **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' **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)	(Enthalpy change) when one mole of a substance ✓ is completely combusted **OR** burns in excess oxygen ✓	2	**ALLOW** energy released **DO NOT ALLOW** energy required **ALLOW** element **OR** compound **OR** molecule **DO NOT ALLOW** one mole of atoms **ALLOW** reacts fully with oxygen
		(ii)	Would make carbon dioxide and water instead **OR** activation energy (too) high **OR** rate is (too) slow **OR** do not react together ✓	1	**ALLOW** will make other compounds (containing carbon and hydrogen or carbon, oxygen and hydrogen) **ALLOW** reaction cannot be carried out experimentally **IGNORE** heat is lost to the surroundings

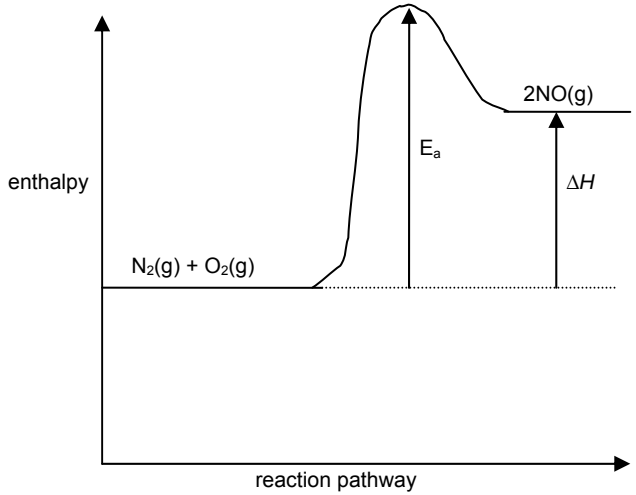
Question			Answer	Mark	Guidance
1	(b)	(iii)	(+)2801 ✓ + (−)394 × 6 + (−)286 × 6 **OR** (–)4080 ✓ −1279 ✓	3	**IGNORE** sign **IGNORE** sign **ALLOW** full marks for −1279 with no working out ✓✓✓ Unit **not** needed **ALLOW** ECF enthalpy change of combustion of carbon dioxide and water – enthalpy of combustion of glucose **ALLOW for 2 marks:** +1279 cycle wrong way around **OR** +151 **OR** +691 one value not × 6 **OR** –6881 **OR** +6881 wrong sign for 2801 or 4080 **OR** +2121 ✓✓ correct cycle but not × 6 **ALLOW for 1 mark:** –151 **OR** –691 cycle wrong way around and one value not × 6 **OR** –2121 cycle wrong way around and not × 6 **OR** –3481 **OR** +3481 ✓ wrong sign and not × 6 **Note:** There may be other possibilities
			Total	9	

Question			Answer	Mark	Guidance
2	(a)	(i)	$C_nH_{2n+1}OH$ ✓	1	**ALLOW** $C_nH_{2n+2}O$
		(ii)	$C_{13}H_{28}O$ ✓	1	**ALLOW** $C_{13}H_{27}OH$
	(b)		group of atoms **OR** part of a molecule ✓ that give a compound its (characteristic set of) reactions ✓	2	**ALLOW** part of an alcohol **IGNORE** part of a compound **ALLOW** that determines its **chemical** properties **OR** that gives the compound its reaction **ALLOW** that determines its homologous series
	(c)	(i)	Alkanes have van der Waals' intermolecular forces ✓ Alcohols have hydrogen bonds (and van der Waals' forces) ✓ Hydrogen bonds are stronger (than van der Waals' forces) **OR** ORA ✓	3	**ANNOTATE ANSWER WITH TICKS AND CROSSES** **ALLOW** reference to specific compounds e.g. comparing methane and methanol vdW force is **not** sufficient here Third marking point is dependent on the correct intermolecular forces being described **BUT ALLOW** hydrogen bonds are stronger than intermolecular forces in alkanes
		(ii)	Methylpropan-1-ol has weaker van der Waals' forces (than butan-1-ol) **OR** ORA ✓ Methylpropan-1-ol has less surface contact (than butan-1-ol) **OR** ORA **OR** Methylpropan-1-ol has more branching (than butan-1-ol) **OR** ORA ✓	2	**ALLOW** methylpropan-1-ol has fewer van der Waals' forces (than butan-1-ol) **IGNORE** reference to more surface area / molecules are closer **ALLOW** methylpropan-1-ol is branched and butan-1-ol is not **IGNORE** 'methylpropan-1-ol is branched' with no comparison

Question			Answer	Mark	Guidance
2	(d)	(i)	$CH_3OH + 1½O_2 \rightarrow CO_2 + 2H_2O$ ✓ $CH_3OH + O_2 \rightarrow CO + 2H_2O$ ✓	2	**ALLOW** CH_4O for incomplete combustion **ALLOW** $CH_3OH + ½O_2 \rightarrow C + 2H_2O$ **ALLOW** $2CH_3OH + 1½O_2 \rightarrow C + CO + 4H_2O$ **ALLOW** correct multiples of these equations **IGNORE** state symbols
		(ii)	insufficient supply of oxygen **OR** limited amount of air **OR** poorly ventilated ✓	1	
		(iii)	Feedstock (in manufacture of organic compounds) **OR** manufacture of biodiesel **OR** manufacture of esters. ✓	1	**ALLOW** manufacture of a named organic compound that can be made from methanol **ALLOW** antifreeze, screenwash
	(e)		$CH_3CH_2CH_2COOH$ ✓ **BUT** $C_4H_9OH + 2[O] \rightarrow CH_3CH_2CH_2COOH + H_2O$ ✓✓	2	One mark is for the correct structure of the product One mark is for the equation **ALLOW** $CH_3CH_2CH_2CO_2H$ **DO NOT ALLOW** $C_4H_8O_2$, C_3H_7COOH, C_4H_7OOH for the structure mark but **ALLOW** for the equation mark Give credit for the correct structure in the equation e.g. $C_4H_9OH + 2[O] \rightarrow CH_3CH_2CH_2COOH + H_2O$ scores two marks **but** $C_4H_9OH + [O] \rightarrow CH_3CH_2CH_2COOH + H_2$ scores one mark $C_4H_{10}O + 2[O] \rightarrow C_4H_8O_2 + H_2O$ scores one mark **ALLOW** one mark for: $C_4H_9OH + [O] \rightarrow CH_3CH_2CH_2CHO + H_2O$

Question			Answer	Mark	Guidance
2	(f)	(i)	methylpropan-2-ol **OR** 2-methylpropan-2-ol ✓  ✓	2	**DO NOT ALLOW** methylprop-2-ol **ALLOW** $(CH_3)_3COH$ **ALLOW** vertical 'bond' to any part of the OH group **DO NOT ALLOW** horizontal –HO in the formula **ALLOW** 
		(ii)	 ✓	1	**ALLOW** $CH_3CHOHCH_2CH_3$ **ALLOW**  **ALLOW** vertical 'bond' to any part of the OH group **DO NOT ALLOW** horizontal –HO in the formula **IGNORE** an incorrect name
			Total	**18**	

Question			Answer	Mark	Guidance
3	(a)	(i)	Reaction in which energy enters the system (from the surroundings) ✓	1	**ALLOW** reaction that absorbs energy **ALLOW** takes energy in (from the surroundings) **ALLOW** enthalpy of products have higher enthalpy than enthalpy of reactants **ALLOW** heat instead of energy **ALLOW** correct reference in terms of bond breaking and bond making **IGNORE** incorrect reference to bond breaking or bond making
		(ii)	+33 ✓	1	+ sign is **not** required **DO NOT ALLOW** –33

Question			Answer	Mark	Guidance
3	(b)	(i)	2NO added for product ✓ Δ*H* labelled with product above reactant **AND** arrow upwards ✓ E_a labelled correctly **AND** above products ✓  	3	**ANNOTATE ANSWER WITH TICKS AND CROSSES** **IGNORE** State symbol **ALLOW** product line above or below reactants line **ALLOW** (+)66 **ALLOW** line that has a small gap at the top and bottom **IGNORE** arrows at both ends of activation energy line The E_a line must go to maximum (or near to the maximum) on the curve **ALLOW** if the line clearly shows an activation energy and is not an enthalpy change **ALLOW** line that has a small gap at the top and bottom
		(ii)	Activation energy is the **minimum** amount of energy needed for the reactants to react ✓	1	**ALLOW** compounds **OR** elements **OR** molecules **OR** chemicals instead of reactants **ALLOW** minimum energy needed to start a reaction

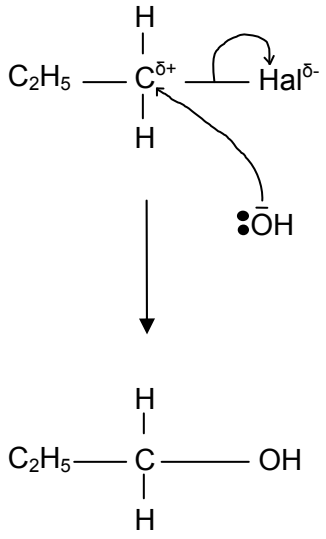
Question			Answer	Mark	Guidance
3	(c)	(i)	Rate of forward reaction slows down and rate of backward reaction speeds up ✓ (Until) rate of forward reaction is the same as the rate of the backward reaction ✓	2	**ALLOW** at start rate of forward reaction is fast but rate of backward reaction is slow **DO NOT ALLOW** forward reaction is the same as backward reaction
		(ii)	 Reaction is faster ✓ Increasing pressure mean more particles per unit volume **OR** increasing pressure gives more crowded particles **OR** increasing pressure gives more concentrated (particles) ✓ So more collisions per second **OR** higher collision frequency **OR** collisions more often ✓ (Changes of pressure) do not change the (position of) equilibrium ✓ Both sides of equation have same number of moles (of gas) ✓	5	**ANNOTATE ANSWER WITH TICKS AND CROSSES** **ALLOW** particles are closer together **DO NOT ALLOW** 'area' instead of 'volume' **ALLOW** increased rate of collision **OR** collisions are more likely **OR** there is a greater chance of collisions 'More collisions' or 'more successful collision' are **not** sufficient **DO NOT ALLOW** composition of equilibrium is the same (in question) **ALLOW** both sides of equation have same number of molecules (of gas)
		(iii)	Not a closed system ✓	1	**ALLOW** gases can escape **OR** gases are continuously entering **OR** it is an open system
	(d)		has an unpaired electron ✓	1	**ALLOW** plural: unpaired electrons has a lone electron is **not** sufficient
	(e)	(i)	$2NO + O_2 \rightarrow 2NO_2$ ✓	1	**ALLOW** any correct multiple including fractions **IGNORE** state symbols

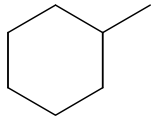
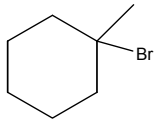
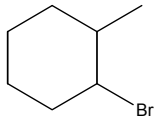
Question			Answer	Mark	Guidance
3	(e)	(ii)	NO is not consumed **OR** overall reaction is $O_3 + O \rightarrow 2O_2$ ✓ $NO + O_3 \rightarrow NO_2 + O_2$ ✓ $NO_2 + O \rightarrow NO + O_2$ ✓	3	**ANNOTATE ANSWER WITH TICKS AND CROSSES** **ALLOW** $2O_3 \rightarrow 3O_2$ **OR** It is a chain reaction **OR** NO is reformed **OR** mechanism of ozone depletion is changed **OR** NO made can react with more ozone **IGNORE dots** **ALLOW** $NO_2 + O_3 \rightarrow NO + 2O_2$
		(iii)	**ANY TWO FROM:** To identify the functional groups (in pollutants) **OR** to identify the bonds (in pollutants) ✓ Match spectrum to known pollutants **OR** each pollutant will have a different spectrum ✓ Idea that you can measure the concentration or abundance of pollutant ✓	2	 **ALLOW** a named bond **IGNORE** any specific wavenumber or range of wavenumbers **ALLOW** match spectrum to database or datasheet
			Total	21	

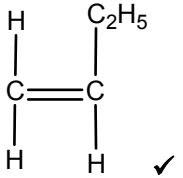
Question			Answer	Mark	Guidance
4	(a)		Atom economy = $\frac{\text{sum of (all) } M_r \text{ of desired product(s)}}{\text{sum of (all) } M_r \text{ of (all) products}}$ ✓	1	**ALLOW** Atom economy = $\frac{\text{sum of (all) } M_r \text{ of desired product(s)}}{\text{sum of (all) } M_r \text{ of (all) reactants}}$ **ALLOW** for the numerator: 'sum of' to be crossed out and replaced by 'molecular mass of the desired product(s)' **ALLOW** for the denominator: 'sum of molecular masses of all products'
	(b)	(i)	Process **5** ✓	1	**ALLOW** $C_8H_{18} \rightarrow C_2H_4 + C_6H_{14}$
		(ii)	Process **1** ✓	1	**ALLOW** $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3 \rightarrow (CH_3)_2CHCH_2CH_2CH(CH_3)_2$
		(iii)	Process **2** ✓ water is a waste product ✓	2	**ALLOW** $CH_3CH_2OH + CH_3COOH \rightarrow CH_3COOCH_2CH_3 + H_2O$ **ALLOW** it is a condensation reaction **ALLOW** water is a by-product / water is a non-desirable product **ALLOW** process 2 has an 83% atom economy **IGNORE** it forms more than one product / it forms a waste product
	(c)	(i)	Less waste products **OR** better sustainability **OR** get 100% atom economy ✓ (Stops) greenhouse gas emitted **OR** (stops) gas that (may) cause global warming ✓	2	**ALLOW** no waste products / there is no longer a waste product **ALLOW** increase atom economy

Question			Answer	Mark	Guidance
4	(c)	(ii)	High percentage yield with a simple reason e.g. because the aim is to manufacture ethanol; to reduce waste; increases sustainability ✓ **BUT** High percentage yield because there is very efficient conversion from **reactant** to product **OR** to reduce the waste of **starting** materials ✓✓ **OR** High atom economy with a simple reason e.g. because it is cheaper or makes less harmful products; to reduces waste; increases sustainability ✓ **BUT** High atom economy to reduce the amount of waste **products** **OR** less **by products** **OR** more desired **product** ✓✓	**2**	No marks for just percentage yield or for atom economy. Marks are for the quality of the explanation Marks are awarded as follows **One** mark – a simple reason that is not fully correct whether a choice has been made or not **Two** marks – a choice must be made and the reason must be correct
			Total	**9**	

Question			Answer	Mark	Guidance
5	(a)		Compound of hydrogen and carbon only ✓	1	**ALLOW** contains hydrogen and carbon only **DO NOT ALLOW** 'it contains hydrogen and carbon' **DO NOT ALLOW** a mixture of hydrogen and carbon only
	(b)		**F** ✓	1	**ALLOW** cyclobutane
	(c)		$C_5H_{10}O$ ✓	1	**ALLOW** any order **IGNORE** structural or displayed formula
	(d)		**D** and **E** **OR** **F** and **G** ✓	1	**ALLOW** pentanal and pentan(-3-)one **ALLOW** cyclobutane and but(-2-)ene Award mark if both pairs are given
	(e)	(i)	Tetrahedral ✓ Four (single) bonds (around carbon atom) **OR** four (single) bond pairs (around carbon atom) **OR** (carbon) bonded to four groups ✓	2	**IGNORE** incorrect bond angle If shape is not given, explanation mark **can** be credited If shape is incorrect, explanation mark **cannot** be credited
		(ii)	Trigonal planar ✓	1	**ALLOW** planar triangle **IGNORE** if incorrect bond angle is stated
	(f)	(i)	**G** ✓	1	**ALLOW** but-2-ene
		(ii)	Non rotating (carbon–carbon) double bond ✓ Each carbon atom of the double bond attached to (two) different groups/atoms ✓	2	

Question	Answer	Mark	Guidance
5 (g)	**Equation** $C_3H_7X + KOH \rightarrow C_3H_7OH + KX$ **OR** $C_3H_7X + OH^- \rightarrow C_3H_7OH + X^-$ ✓ **Structure of product** $CH_3CH_2CH_2OH$ ✓ **Reaction mechanism** QWC - nucleophilic substitution ✓ dipole shown on C–Hal bond, $C^{\delta+}$ and $Hal^{\delta-}$ ✓ curly arrow from HO^- to carbon atom of C–Hal bond ✓ curly arrow from C–Hal bond to the halogen atom ✓	10	**ANNOTATE ANSWER WITH TICKS AND CROSSES** X = Br or C*l* **ALLOW** molecular, structural, displayed or skeletal formula in equation **ALLOW** $C_3H_7X + H_2O \rightarrow C_3H_7OH + HX$ **ALLOW** equation from the mechanism **IGNORE** incorrect equations **ALLOW** structural, displayed or skeletal formula of product if seen **ONCE** in equation, mechanism or drawn out **If two mechanism shown award marks from the mechanism that gives the higher mark**  The curly arrow must start from the oxygen lone pair or the negative charge on the oxygen of ^-OH ion No need to show lone pair on the oxygen atom

Question			Answer	Mark	Guidance
5	(g)		**Type of bond fission** QWC - heterolytic ✓ **Reasons for the difference in rate of hydrolysis** 1-bromopropane reacts faster (than 1-chloropropane) **OR B** reacts faster (than **C**) **OR** C–Br reacts faster ✓ Because the C–Br bond is weaker **OR** C–Br has a lower bond enthalpy **OR** C–Br bond is longer ✓ C–Br is more easy to break ✓		**ALLOW S_N1 mechanism** dipole shown on C–Hal bond, $C^{\delta+}$ and $Hal^{\delta-}$ ✓ curly arrow from C–Hal bond to the halogen atom ✓ curly arrow from OH^- to correct carbocation ✓ **IGNORE** bromine reacts faster than chlorine **ALLOW** ora **ALLOW** less energy to break C–Br **ALLOW** ora **ALLOW** ora
	(h)		With H_2  ✓ With HBr  ✓  ✓	**3**	**ALLOW** methylcyclohexane **ALLOW** 1-bromo-1-methylcyclohexane **ALLOW** 1-bromo-2-methylcyclohexane **ALLOW** 2-bromo-1-methylcyclohexane
			Total	**23**	

Question			Answer	Mark	Guidance
6	(a)	(i)	But-1-ene ✓  ✓	2	**ALLOW** displayed formula **ALLOW** $C_2H_5CH=CH_2$
		(ii)	Poly(ethenol) has (many) O–H group(s) ✓ Poly(ethenol) forms hydrogen bonds with water ✓	2	**ALLOW** poly(ethenol) has hydroxyl group **OR** hydroxy group **OR** is an alcohol **DO NOT ALLOW** hydroxide **DO NOT ALLOW** 'it forms hydrogen bonds'
	(b)		CO is a poisonous gas ✓ HC*l* is acidic/forms acid rain **OR** corrosive **OR** HC*l* will react with metalwork **OR** HC*l* will react with marble/limestone buildings ✓ **ANY TWO METHODS FROM:** **Method 1** Remove HC*l* by reacting with a base **OR** remove HC*l* by use of a gas scrubber ✓ **Method 2** Develop ways of ensuring all CO is oxidised to CO_2 **OR** ensure complete combustion to avoid making CO ✓ **Method 3** Remove CO_2 by CCS ✓ **Method 4** (Use methods to remove the need for incineration such as) separation **AND** recycling of the plastics/polymers ✓ **Method 5** (Use methods to remove the need for incineration such as) developing biodegradable/compostable plastics/polymers ✓	4	**ANNOTATE ANSWER WITH TICKS AND CROSSES** **ALLOW** CO reduces amount of oxygen transported in blood Forming carboxyhaemoglobin/binds with haemoglobin is **not** sufficient **IGNORE** HC*l* is toxic **IGNORE** references to ozone layer and greenhouse effect **Methods 1 to 3 must be linked to a gas** **IGNORE** reference to catalytic converter **ALLOW** specific examples of CCS e.g. CO_2 stored as a metal carbonate / CO_2 stored deep under sea / CO_2 stored in rock **ALLOW** (Use methods to remove the need for incineration such as) use of plastics/polymers as a feedstock for making other chemicals

Question			Answer	Mark	Guidance
6	(c)		**ANY TWO FROM:** Idea that all countries contribute towards pollution ✓ Idea that atmospheric pollution (from incineration travels) across borders **OR** waste plastics travel across borders / waste plastics travel across the sea ✓ Cooperation means that scientists can share ideas **OR** scientists can warn governments of risk **OR** world-wide legislation can be introduced **OR** allows monitoring of pollution in different countries **OR** richer countries can help poorer countries introduce pollution controls ✓ One country cannot control pollution unless all countries do ✓	**2**	**ALLOW** some countries produce more pollution than others. **ALLOW** reference to protocols
			Total	**10**	

Question			Answer	Mark	Guidance
7				7	**ANNOTATE ANSWER WITH TICKS AND CROSSES** PLEASE ENSURE YOU LOOK AT THE DATA AND SPECTRA ON PAGE 20 IN CASE THEY INCLUDE COMMENTS THAT ARE WORTHY OF CREDIT. MARK THIS PAGE WITH AN OMISSION MARK, ^ , IF BLANK QWC: mark is integrated into the chemistry marks. These marks need to link evidence with an explanation
			ANY SEVEN FROM: **Compound X** QWC: **X** contains C=O because of absorption at 1720 cm^{-1} **AND** contains O–H because of (broad) absorption between 2500 to 3300 cm^{-1} ✓ So **X** is a carboxylic acid ✓ Molar ratio (C:H:O) of **X** is 4.05 : 8.1 : 2.7 **OR** $\frac{48.65}{12.0} : \frac{8.11}{1.0} : \frac{43.24}{16.0}$ ✓ (Empirical formula) is $C_3H_6O_2$ ✓ M_r is 74.0 so **X** is $C_3H_6O_2$ ✓		**ALLOW X** contains C=O and O–H because of absorptions at 1720 cm^{-1} and 2500 to 3300 cm^{-1} **ALLOW X** contains carboxylic acid/COOH because of absorption at 1720 cm^{-1} and (broad) absorption between 2500 to 3300 cm^{-1} ✓✓ **ALLOW** alternative approach to molecular formula M_r is 74.0 ✓ $74 \times \frac{48.65}{100} : 74 \times \frac{8.11}{100} : 74 \times \frac{43.24}{100}$ = 36 : 6 : 32 ✓ $C_3H_6O_2$ ✓ This mark is for some evidence of using M_r to deduce the molecular or structural formula **ALLOW** M_r is 74.0 so **X** is CH_3CH_2COOH ✓ **DO NOT ALLOW** ECF from the empirical formula with the wrong molar ratio

Question			Answer	Mark	Guidance
7			**Compound Y** QWC **Y** contains O–H because of absorption between 3100 and 3500 cm^{-1} ✓ QWC Mass spec of **Y** has molecular ion, *m*/*z* = 46 so M_r is 46 ✓ Correct identification of one fragment from a *m*/*z* value e.g. *m/z* = 31 is CH_2OH^+; *m/z* = 29 is $C_2H_5^+$; *m/z* = 15 is CH_3^+ ✓		**ANNOTATE ANSWER WITH TICKS AND CROSSES** **ALLOW Y** is an alcohol (or phenol) because of absorption between 3200 and 3550 cm^{-1} **ALLOW Y** contains C–O, C–H and O–H bonds because of absorptions at approximately 1030, 2950 and 3350 cm^{-1} **ALLOW** *m/z* = 46 so M_r is 46 **OR** mass spectrum has a peak at 46 which is the M_r **OR** M_r is 46 because of *m/z* peak shown on the actual spectra M_r = 46 on its own is **not** sufficient *m*/*z* = 46 on its own is not sufficient **ALLOW** *m/z* = 31 shows CH_2OH (fragment); *m/z* = 29 shows C_2H_5 (fragment); *m/z* = 15 is CH_3 (fragment)
			Identification of compounds So **X** must be CH_3CH_2COOH **OR** propanoic acid ✓ So **Y** is ethanol **OR** C_2H_5OH **OR** CH_3CH_2OH ✓ **Z** is $CH_3CH_2COOC_2H_5$ **OR** ethyl propanoate ✓	**3**	**Note**: an incorrect name CONs a correct structure **ALLOW** skeletal **OR** displayed formula throughout **DO NOT ALLOW** propanoic acid with wrong structure or incorrect molecular formula **DO NOT ALLOW** ethanol with wrong structure or incorrect molecular formula **DO NOT ALLOW** ethyl propanoate with wrong structure or incorrect molecular formula **ALLOW** ECF for identification of **Z** from incorrect **X** and **Y**. **DO NOT ALLOW** this ECF if name and structures of **X** or **Y** do **not** match
			Total	**10**	

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

14 – 19 Qualifications (General)
Telephone: 01223 553998
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