

Chemistry A

Advanced Subsidiary GCE **F322**

Chains, Energy and Resources

Mark Scheme for June 2010

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by Examiners. It does not indicate the details of the discussions which took place at an Examiners' meeting before marking commenced.

All Examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the Report on the Examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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Any enquiries about publications should be addressed to:

OCR Publications
PO Box 5050
Annesley
NOTTINGHAM
NG15 0DL

Telephone: 0870 770 6622
Facsimile: 01223 552610
E-mail: publications@ocr.org.uk

General advice to Assistant Examiners on the procedures to be used

YOU WILL BE REQUIRED TO UNDERTAKE 10 PRACTICE AND 10 STANDARDISATION SCRIPTS BEFORE STARTING TO MARK LIVE SCRIPTS.

- 1 The schedule of dates for the marking of this paper is very important. It is vital that you meet these requirements. If you experience problems then you must contact your Team Leader (Supervisor) without delay.
- 2 An element of professional judgement is required in the marking of any written paper. Candidates often do not use the exact words which appear in the detailed sheets which follow. If the science is correct and also answers the question then the mark(s) should normally be credited. If you are in doubt about the validity of any answer then consult your Team Leader (Supervisor) by phone, the messaging system within SCORIS or e-mail.
- 3 Correct answers to calculations always gain full credit even if no working is shown. (The 'Show your working' is to help candidates, who may then gain partial credit even if their final answer is not correct.)
- 4 Some questions may have a 'Level of Response' mark scheme. Any details about these will be in the Additional Guidance.
- 5 If an answer has been crossed out and no alternative answer has been written then mark the answer crossed out.
- 6 In addition to the award of 0 marks, there is a NR (No Response) option on SCORIS.

Award 0 marks

- if there is any attempt that earns no credit (including copying out the question or some crossed out working)

Award NR (No Response)

- if there is nothing written at all in the answer space
OR
- if there is any comment which does not in any way relate to the question being asked (e.g. 'can't do', 'don't know')
OR
- if there is any sort of mark which is not an attempt at the question (e.g. a dash, a question mark)

- 7 Abbreviations, annotations and conventions used in the detailed Mark Scheme.

/	= alternative and acceptable answers for the same marking point
not	= answers which are not worthy of credit
reject	= answers which are not worthy of credit
ignore	= statements which are irrelevant
allow	= answers that can be accepted
()	= words which are not essential to gain credit
<u> </u>	= underlined words must be present in answer to score a mark
ECF	= error carried forward
AW	= alternative wording
ora	= or reverse argument

8 Annotations: the following annotations are available on SCORIS.

✓	= correct response
×	= incorrect response
bod	= benefit of the doubt
nbod	= benefit of the doubt not given
ECF	= error carried forward
^	= information omitted
I	= ignore
R	= reject

Highlighting is also available to highlight any particular points on the script.

The following questions should be annotated with ticks to show where marks have been awarded in the body of the text:
2(c)(ii), 3(b)(i), 5(d), 6(b) and 7

9 The Comments box

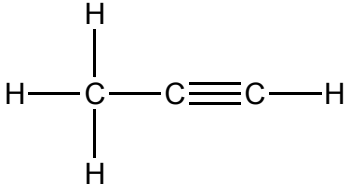
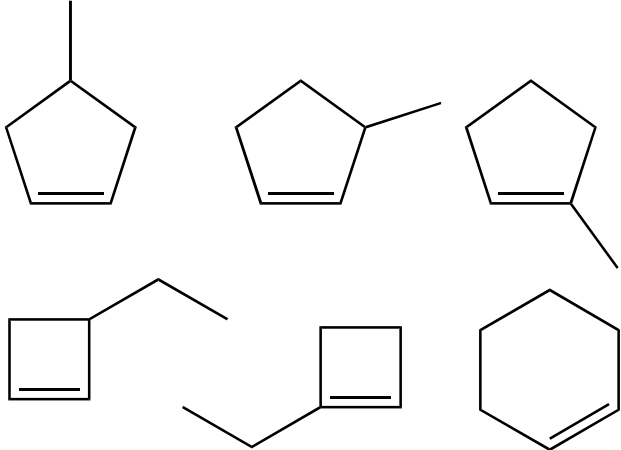
The comments box will be used by your PE to explain their marking of the practice scripts for your information. Please refer to these comments when checking your practice scripts. You should only type in the comments box yourself when you have an additional object of the type described in Appendix B of the Handbook for Assistant Examiners and Subject Markers.

Please do not use the comments box for any other reason.

Any questions or comments you have for your Team Leader should be communicated by phone, SCORIS messaging system or e-mail.

10 Please send a brief report on the performance of the candidates to your Team Leader (Supervisor) by the end of the marking period. The Assistant Examiner's Report Form (AERF) can be found on the Cambridge Assessment Support Portal. This should contain notes on particular strengths displayed, as well as common errors or weaknesses. Constructive criticisms of the question paper/mark scheme are also appreciated.

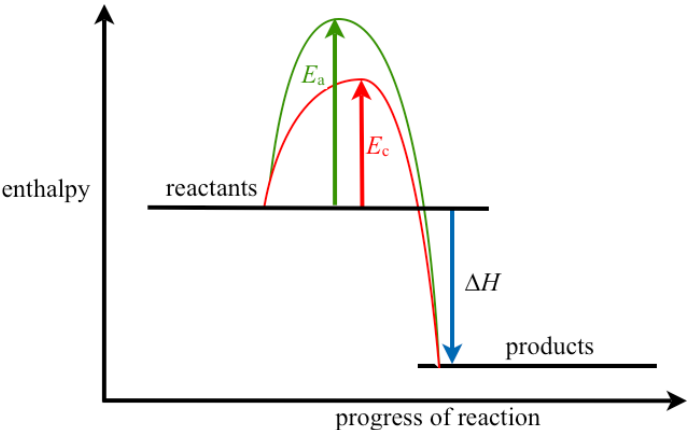
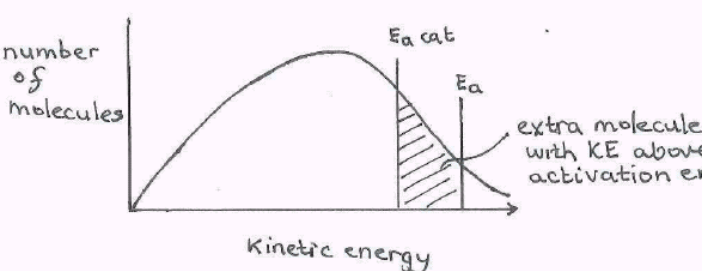
Question			Expected Answers	Marks	Additional Guidance
1	a	i	Series having same functional group and a general formula ✓	1	ALLOW same functional group and members vary by CH ₂ ALLOW organic compounds with the same functional group that differ in length of their hydrocarbon chain
		ii	More surface contact 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 _n H _{2n-2} ✓	1	ALLOW C _n H _{2(n-1)}

Question			Expected Answers	Marks	Additional Guidance
1	b	iii	Correct displayed formula ✓	1	
		iv	Correct skeletal formula of cyclic hydrocarbon with formula C_6H_{10} ✓	1	<p>Examples of correct skeletal formulae include</p> 
	c		<p>Energy required to break bonds = (+) 2912 ✓</p> <p>Energy released to make bonds = (-)4148 ✓</p> <p>Enthalpy of combustion = -1236 ✓</p>	3	<p>ALLOW full marks for correct answer with no working out</p> <p>ALLOW $(2 \times 415) + (837) + (2.5 \times 498)$</p> <p>ALLOW $(4 \times -805) + (2 \times -464)$</p> <p>OR $(4 \times 805) + (2 \times 464)$</p> <p>ALLOW ECF for calculation of enthalpy of combustion</p> <p>ALLOW 2 marks for +1236 with no working out</p>

Question			Expected Answers	Marks	Additional Guidance
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 / $1.01 \times 10^5 \text{ Nm}^{-2}$ / 1000 millibars / 25 °C / any stated temperature in words IGNORE 1 mol dm^{-3} for solutions
		ii	From energy cycle Enthalpy change to get elements = $-(-60) - (2 \times -286) / (+) 632$ ✓ 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	$\frac{26.0}{100.1} \times 100$ 100.1 ✓ 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 $\times 100$ 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

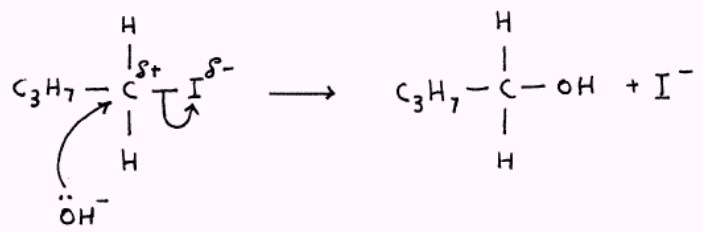
Question			Expected Answers	Marks	Additional Guidance
1	e	ii	1.56×10^4 OR 15600 OR 15601 ✓	1	ALLOW calculator value of 15600.62402 and any rounded value to a minimum of three significant figures
		iii	1.5×10^4 OR 15000 ✓	1	ALLOW 1.50×10^4 etc.
		iv	96.2 ✓	1	ALLOW ECF from (iii) ÷ (ii) ALLOW calculator 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	

Question			Expected Answers	Marks	Additional Guidance
2	a	i	Branched chain alkane of formula C ₅ H ₁₂ to C ₉ H 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-methypentane 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 ✓ $2\text{CO} + 2\text{NO} \rightarrow \text{N}_2 + 2\text{CO}_2$ ✓	2	ALLOW any correct multiples IGNORE state symbols

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

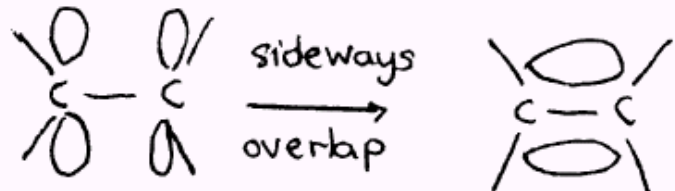
Question		Expected Answers	Marks	Additional Guidance
2	d	<p>Any two benefits from:</p> <p>Save crude oil OR no risk of large scale pollution from exploitation of crude oil ✓</p> <p>Biodiesel is renewable OR diesel is non-renewable ✓</p> <p>Use of biodiesel is (more) carbon-neutral OR plants take up the carbon dioxide released during combustion ✓</p> <p>and one disadvantage</p> <p>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 ✓</p>	3	<p>ANNOTATE WITH TICKS AND CROSSES</p> <p>ALLOW decrease the need for fossil fuels</p> <p>ALLOW plants are a renewable resource / crude oil non-renewable resource / biodiesel is more sustainable / diesel is not sustainable</p> <p>ALLOW lower carbon footprint IGNORE can be used by diesel powered cars with or without any conversion</p> <p>IGNORE comments about availability / fertilisers / pesticides</p> <p>Destroys habitats is not sufficient</p>
Total			17	

Question		Expected Answers	Marks	Additional Guidance
3	a	<p>Answers clockwise from top left</p> <p>$\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$ ✓</p> <p>$\text{CH}_3\text{CH}_2\text{CHCH}_2$ ✓</p> <p>$\text{CH}_3\text{COOCH}_2\text{CH}_2\text{CH}_2\text{CH}_3$ ✓</p> <p>$\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$ ✓</p>	4	<p>ALLOW skeletal formula</p> <p>ALLOW butanoic acid</p> <p>ALLOW but-1-ene</p> <p>ALLOW butyl ethanoate</p> <p>ALLOW butanal</p> <p>If name and structure given both must be correct</p> <p>If C_3H_7 used instead of $\text{CH}_3\text{CH}_2\text{CH}_2$ penalise once and then apply ECF</p> <p>If wrong carbon skeleton used then penalise once then apply ECF</p> <p>If a hydrogen is missing then penalise once</p>

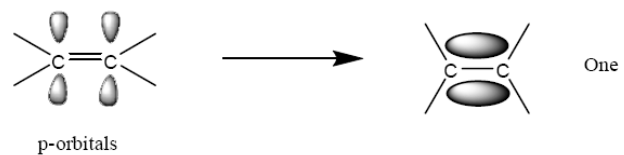
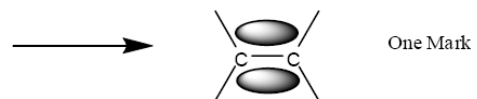
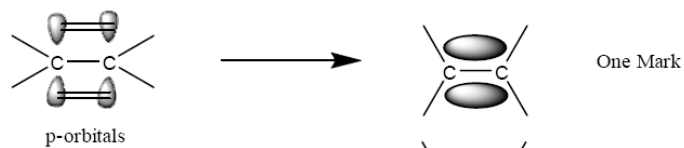
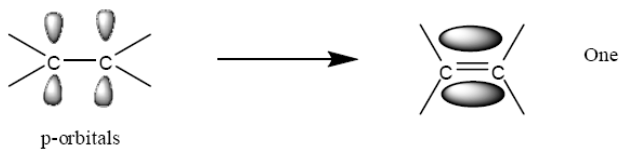
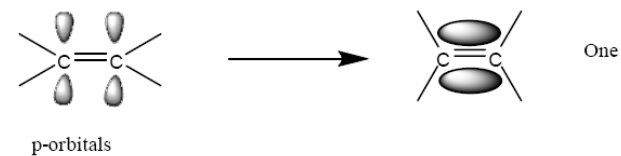
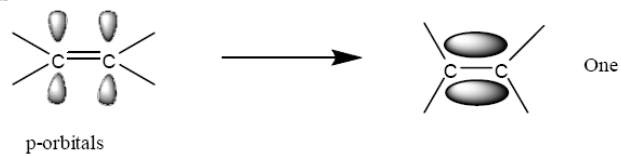
Question			Expected Answers	Marks	Additional Guidance
3	b	i	Nucleophilic substitution ✓ Heterolytic ✓ Dipole shown on C–I bond, C ^{δ+} and I ^{δ-} ✓ Curly arrow from OH ⁻ to carbon atom of C–I bond ✓ Curly arrow from C–I bond to the iodine atom ✓	5	ANNOTATE WITH TICKS AND CROSSES DO NOT ALLOW fish hooks 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 ^{δ+} and I ^{δ-} ✓ 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–Cl stronger bond (than C–I bond) OR C–Cl shorter bond (than C–I bond) OR C–Cl bond is harder to break OR needs more energy to break C–Cl 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–Cl bond or C–I bonds
			Total	11	

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	$\text{CH}_3\text{CH}_2\text{OH} + [\text{O}] \rightarrow \text{CH}_3\text{CHO} + \text{H}_2\text{O}$ OR $\text{CH}_3\text{CH}_2\text{OH} + 2[\text{O}] \rightarrow \text{CH}_3\text{COOH} + \text{H}_2\text{O}$ 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

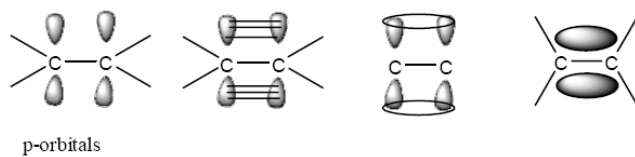
Question			Expected Answers	Marks	Additional Guidance
4	b	iii	$ \begin{array}{cccc} \text{H} & \text{H} & \text{H} & \text{H} \\ & & & \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array} \quad \begin{array}{ccc} \text{H} & \text{H} & \text{H} \\ & & \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{H} \\ & & \\ \text{H} & \text{CH}_3 & \text{H} \end{array} $ <p>BOTH isomers correct ✓</p>	1	<p>If three structures are drawn then do not award mark</p> <p>ALLOW skeletal formulae / structural formulae</p> <p>IGNORE incorrect names</p>
		iv	CH_3^+ ✓ C_2H_5^+ ✓ C_3H_7^+ / $\text{CH}_3\text{CH}_2\text{CH}_2^+$ / $(\text{CH}_3)_2\text{CH}^+$ ✓	3	<p>Essentially marks are allocated as positive ions ✓</p> <p>Formula of two fragments correct (ignore charge) ✓</p> <p>BUT</p> <p>formulae of all three fragments correct (ignore charge) ✓✓</p>
		v	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$ because there is a peak at $m/z = 29$ ✓	1	<p>ALLOW name, displayed or skeletal structure</p> <p>ALLOW butane because there is a C_2H_5 fragment</p> <p>ALLOW butane because it gives all three fragments listed in (iv)</p>
Total				13	

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

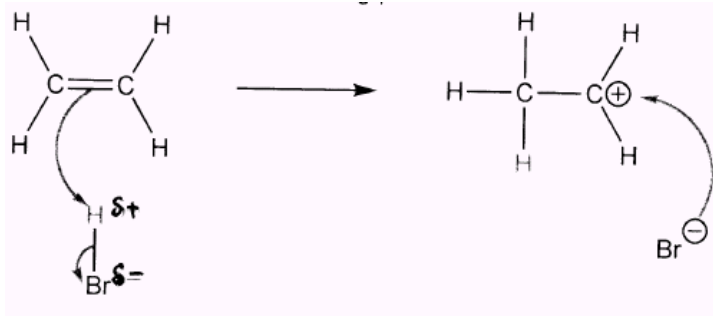
Each of the following diagrams is worth one mark. The words p-orbitals must be present to score the mark



Each of the diagrams on its own scores no mark




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	

Question		Expected Answers	Marks	Additional Guidance
5	c	CH ₃ CH ₂ OH / ethanol ✓	1	IGNORE alcohol
	d	<p>C₄H₈ + HBr → C₄H₉Br ✓ C₂H₄ + HBr → C₂H₅Br ✓</p> <p>B makes CH₃CH₂CH₂CH₂Br ✓ CH₃CHBrCH₂CH₃ ✓</p> <p>QWC – number of products is linked to structure of alkene e.g. because D is symmetrical OR B is not symmetrical ✓</p> <p>Movement of electron pair from double bond to attack hydrogen of H–Br and breaking of H–Br bond ✓</p> <p>Correct dipole shown on H–Br ✓</p> <p>Correct carbonium ion drawn ✓</p> <p>Curly arrow from Br[–] to the carbonium ion ✓</p>	9	<p>ANNOTATE WITH TICKS AND CROSSES QWC mark and 8 other marking points</p> <p>The equation must be the overall equation not a series of steps as in a mechanism</p> <p>ALLOW skeletal or displayed formulae ALLOW B makes 1-bromobutane and 2-bromo butane ✓ if marks for the structures not awarded</p>  <p>ALLOW curly arrow from lone pair or minus sign of bromide ion</p> <p>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</p>

Question			Expected Answers	Marks	Additional Guidance
5	e	i	$ \begin{array}{cccc} \text{H} & \text{C}_2\text{H}_5 & \text{H} & \text{C}_2\text{H}_5 \\ & & & \\ \text{---C---} & \text{C---} & \text{C---} & \text{C---} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array} $ ✓	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	

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

Question	Expected Answers	Marks	Additional Guidance
7	<p>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 ✓</p> <p>Percentage composition Mole ratio C : H : O = 2.23 : 2.22 : 4.44 ✓ Empirical formula is CHO_2 ✓</p> <p>(mass of one mole is 90 g) so M_r is 90 ✓</p> <p>QWC – molecular formula is $\text{C}_2\text{H}_2\text{O}_4$ with working out from M_r ✓</p> <p style="text-align: center;"> $\begin{array}{c} \text{COOH} \\ \\ \text{COOH} \end{array}$ Structure is ✓ </p>	8	<p>ANNOTATE WITH TICKS AND CROSSES  QWC –Structure linked to information at least once</p> <p>ALLOW 1720 indicates presence of aldehydes, ketones, esters, carboxylic acid, amides ALLOW 2900 indicates carboxylic acid</p> <p>ALLOW 1080 indicates alcohol, esters, carboxylic acids</p> <p>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</p> <p>ALLOW $0.0945/0.00105 = 90$</p> <p style="text-align: center;"> $\begin{array}{c} \text{COOH} \\ \\ \text{O} \\ \\ \text{CHO} \end{array}$ ALLOW CHO </p>
	Total	8	

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