

GCE

Chemistry A

Unit **H032/02**: Depth in chemistry

Advanced Subsidiary GCE

Mark Scheme for June 2018

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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.

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Annotations

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
ALLOW	Answers that can be accepted
()	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
AW	Alternative wording
ORA	Or reverse argument
	Correct response
	Incorrect response
	Omission mark
	Benefit of doubt given
	Contradiction
	Rounding error

SF	Error in number of significant figures
ECF	Error carried forward
L1	Level 1
L2	Level 2
L3	Level 3
NBOD	Benefit of doubt not given
SEEN	Noted but no credit given
I	Ignore

Subject-specific Marking Instructions**INTRODUCTION**

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

Question			Answer	Marks	Guidance												
1	(a)		A solution of known concentration ✓	1	ALLOW description of concentration												
1	(b)		Releases OH⁻ (ions in aqueous solution) ✓	1	ALLOW containing OH⁻ ions IGNORE mention of pH												
1	(c)	(i)	<table border="1"><tr><td>Final reading/cm³</td><td>27.30</td><td>27.00</td><td>27.75</td></tr><tr><td>Initial reading/cm³</td><td>0.45</td><td>0.60</td><td>1.25</td></tr><tr><td>Titre/cm³</td><td>26.85</td><td>26.40</td><td>26.50</td></tr></table> Initial and final readings All burette readings (×6) correct ✓ Titres recorded to two decimal places with the last figure either 0 or 5 Correct subtractions to obtain final titre values ✓ Mean titre calculated from concordant results Correct mean titre = 26.45 (cm³) ✓ Mean titre recorded to accuracy of burette Final answer recorded to two decimal places with the last figure either 0 or 5 ✓	Final reading/cm ³	27.30	27.00	27.75	Initial reading/cm ³	0.45	0.60	1.25	Titre/cm ³	26.85	26.40	26.50	4	ANNOTATE ANSWER WITH TICKS AND CROSSES ETC ALLOW missing zeroes for burette readings i.e. 0.6 for 0.60 27 OR 27.0 for 27.00 ALLOW ECF from incorrect burette readings IF MEAN IS CALCULATED FROM ECF, IT MUST BE FROM CLOSEST TITRES ALLOW ecf from incorrect mean DO NOT ALLOW 26.5 cm ³ <i>Question asks for nearest 0.05 cm³</i>
Final reading/cm ³	27.30	27.00	27.75														
Initial reading/cm ³	0.45	0.60	1.25														
Titre/cm ³	26.85	26.40	26.50														
1	(c)	(ii)	$\frac{2 \times 0.05}{26.85} \times 100 = 0.37(2) \text{ (\%)} \checkmark$	1	ALLOW 0.4 up to full calculation display of 0.372439478 ALLOW ECF FOR CORRECT CALCULATION FROM 1 (c) (i) OR USE OF ANY TITRE												

Question			Answer	Marks	Guidance
1	(c)	(iii)	Use a (250 cm ³) volumetric flask (instead of a beaker) ✓	1	IGNORE graduated flask
1	(d)	(i)	FIRST CHECK ANSWER ON ANSWER LINE If answer = 118 (g mol⁻¹) award 4 marks If answer = 108 (g mol⁻¹) award 3 marks ----- $n(\text{NaOH})$ $= 0.112 \times \frac{25.0}{1000} = 0.00280 \text{ (mol) } \checkmark$ $n(\text{A})$ in 25.0 cm³ $= \frac{0.00280}{2} = 0.00140 \text{ (mol) } \checkmark$ $n(\text{A})$ in 250 cm³ $= 0.00140 \times \frac{250.0}{27.30} = 0.0128 \text{ (mol) } \checkmark$ Molar mass, $M(\text{A})$ to nearest whole number. $= \frac{1.513}{0.0128} = 118 \text{ (g mol}^{-1}\text{) } \checkmark$	4	ANNOTATE ANSWER WITH TICKS AND CROSSES ETC Throughout: IGNORE trailing zeroes in intermediate working, e.g. For $n(\text{NaOH})$ ALLOW 0.0028 for 0.00280 ALLOW ECF from incorrect $n(\text{NaOH})$ ALLOW ECF from incorrect $n(\text{A})$ OR $n(\text{NaOH})$ ALLOW 3 sig fig up to full calculator display correctly rounded (0.012820512) ALLOW ECF from incorrect $n(\text{NaOH})$ ----- Possible ECFs for 3 marks $1.513 \div (0.00140 \times 250/25) = \mathbf{108}$ $1.513 \div 0.00140 = \mathbf{1081}$ No $\div 2$ for $n(\text{A})$ • Molar mass A = 59 (g mol⁻¹) Using mean titre of 26.45 cm³ from 1c(i) • Molar mass A = 114 (g mol⁻¹) Using 27.3×0.112 in M1 and then 25.0 in M3 • Molar mass A = 99 (g mol⁻¹)

Question			Answer	Marks	Guidance
1	(d)	(ii)	Structure of dicarboxylic acid HOOCCH ₂ CH ₂ COOH OR HOOCCH(CH ₃)COOH ✓ STRUCTURE MUST MATCH M_r from answer to 1 d) i) (within 10 AMU)	1	ALLOW correct structural OR skeletal OR displayed formulae OR a combination ALLOW incorrect connectivity e.g –HO ALLOW ECF from incorrect molar mass in (d)(i) but only if 2 × COOH possible and M_r is a close match to (d) (i) within 10 AMU
			Total	13	

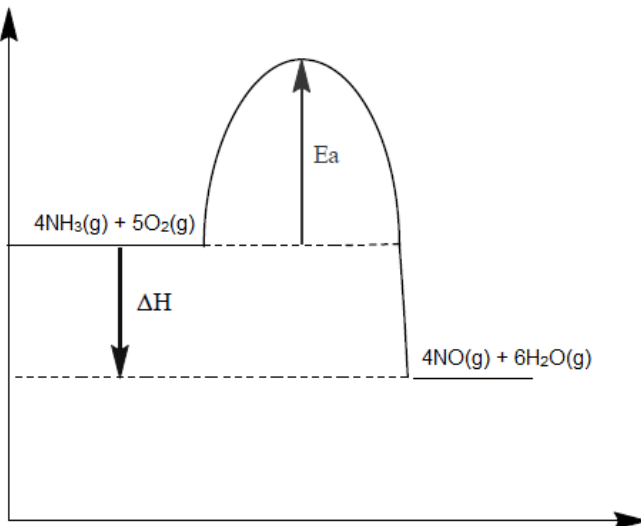
Question			Answer	Marks	Guidance																				
2	(a)		Na Na x S x Na shown with either 0 or 8 electrons AND S shown with 8 electrons with 6 dots and 2 crosses (or vice versa) ✓ Correct charges ✓	2	ALLOW 2[Na]⁺ ALLOW [Na]⁺₂ Brackets not required For first mark, if eight electrons are shown around Na, the ‘extra’ electrons around S must match the symbol chosen for the electrons for Na. IGNORE inner shells Circles not required																				
2	(b)		<table><tr><td></td><td>Na₂S</td><td>Na</td><td>S</td></tr><tr><td>Melting point / °C</td><td>1180</td><td>98</td><td>113</td></tr><tr><td>Type of structure</td><td>giant</td><td>giant</td><td>simple</td></tr><tr><td>Conductivity of solid</td><td>poor</td><td>good</td><td>poor</td></tr><tr><td>Conductivity of liquid</td><td>good</td><td>good</td><td>poor</td></tr></table> ✓ ✓ ✓ One mark for each correct column		Na ₂ S	Na	S	Melting point / °C	1180	98	113	Type of structure	giant	giant	simple	Conductivity of solid	poor	good	poor	Conductivity of liquid	good	good	poor	3	Mark by COLUMN
	Na ₂ S	Na	S																						
Melting point / °C	1180	98	113																						
Type of structure	giant	giant	simple																						
Conductivity of solid	poor	good	poor																						
Conductivity of liquid	good	good	poor																						

Question			Answer	Marks	Guidance
2	(c)	(i)	$(1s^2) 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^4$ ✓ Look carefully at $(1s^2) 2s^2 2p^6 3s^2 3p^6$ – there may be a mistake	1	ALLOW subscripts ALLOW in any order i.e. $3d^{10}$ after $4s^2$ or after $4p^4$ ALLOW upper case D, etc and subscripts, e.g.3S ₂ 3P ₆ DO NOT ALLOW [Ar] as shorthand for $1s^2 2s^2 2p^6 3s^2 3p^6$
2	(c)	(ii)	Gas B H_2Se / Hydrogen selenide / Selenium hydride ✓ Equation $Na_2Se + 2HCl \rightarrow 2NaCl + H_2Se$ All formulae and balancing ✓	2	ALLOW SeH_2 ALLOW correct multiples IGNORE STATE SYMBOLS DO NOT ALLOW H_2S for gas B BUT ALLOW ECF from H_2S for equation: $Na_2S + 2HCl \rightarrow 2NaCl + H_2S$
			Total	8	

Question			Answer	Marks	Guidance
3	(a)	(i)	$\text{Br}_2 + 2\text{I}^- \rightarrow \text{I}_2 + 2\text{Br}^-$ ✓	1	ALLOW multiples IGNORE state symbols
		(ii)	Iodine has a larger atomic radius ✓ Iodine has greater shielding / more shells ✓ Iodine has weaker / less nuclear attraction (on electron gained than bromine) ✓	3	ORA ALLOW iodine is larger / bromine is smaller ALLOW electron added to a shell further from the nucleus ALLOW bromine has greater nuclear attraction IGNORE 'gained less easily' for 'weaker attraction' IGNORE references to ionisation energy DO NOT ALLOW mention of losing electrons for M3 ALLOW 'pull' for 'attraction' IGNORE just 'greater attraction' OR greater force

Question			Answer	Marks	Guidance
3	(b)	(i)	Disproportionation Oxidation AND reduction of same element/iodine OR Iodine has been oxidised and Iodine has been reduced ✓ Oxidation from 0 to +1 in HIO ✓ Reduction from 0 to -1 in HI ✓	3	ALLOW I or I ₂ for iodine IGNORE numbers around equation for oxidation states ALLOW 1- for -1 AND 1+ for +1 NOTE (for iodine/I ₂) from 0 only needs to be seen once, does not need to be stated twice ALLOW 1 mark for 3 ox nos correct but no mention of words oxidation/reduction : 0 in I ₂ AND -1 in HI AND +1 in HIO ALLOW 1 mark for species missing: Iodine oxidised (from 0) to +1 AND iodine reduced (from 0) to -1
3		(ii)	Chlorine is toxic/poisonous OR forms halogenated hydrocarbons OR forms carcinogens/toxic compounds ✓	1	ALLOW (reacts with hydrocarbons to) form carcinogens/toxic compounds IGNORE - chlorine causes cancer - harmful/dangerous - chlorine causes breathing problems
3	(c)		FIRST CHECK ON ANSWER LINE If answer = (+) 431.5 (kJ mol⁻¹) award 2 marks If answer = -431.5 (kJ mol⁻¹) award 1 mark (wrong sign) ----- 2 × H-Cl bond enthalpy correctly calculated = +436 +243 +184 = +863 (kJ mol ⁻¹) ✓ H-Cl bond enthalpy correctly calculated	2	ALLOW to 3 SF i.e. 432

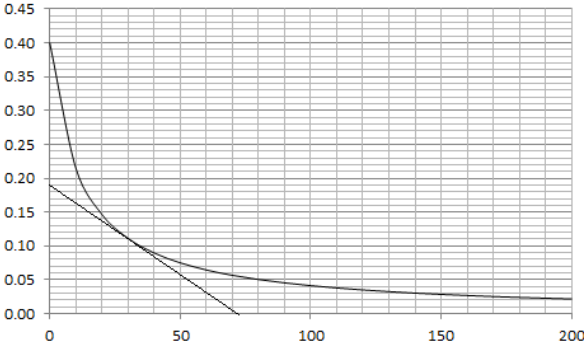
Question			Answer	Marks	Guidance
			$+863/2 = (+)431.5 \text{ (kJ mol}^{-1}\text{)} \checkmark$		ALLOW 1 mark for (+)247.5 / 248 (wrong expression) i.e. (436+243–184)/2
	(d)	(i)	$\text{Br}_2(\text{l}) \rightarrow \text{Br}_2(\text{g}) \checkmark$	1	
		(ii)	Endothermic AND Energy required to overcome induced dipole–dipole forces/London forces $\checkmark$	1	Mark independently of 3 (d) (i) ALLOW endo to break intermolecular forces/bonds ALLOW bonds between molecules DO NOT ALLOW van der Waals' forces
			Total	12	

4	Question	(a) (i)	Answer	Marks	Guidance
			 Reactants, products and E_a Reactants on LHS $4\text{NH}_{3(g)} + 5\text{O}_{2(g)}$ AND Products on RHS $4\text{NO}_{(g)} + 6\text{H}_2\text{O}_{(g)}$ AND Activation energy correctly labelled / E_a ✓ ΔH ΔH labelled with product below reactant AND Arrow downwards ✓	2	ANNOTATE ANSWER WITH TICKS AND CROSSES ETC IGNORE state symbols ALLOW 1 mark for a correctly labelled endothermic diagram E_a ALLOW no arrowhead or arrowheads at both end of E_a line. E_a line must reach maximum (or near to maximum) on curve For E_a, ALLOW AE OR A_E ΔH DO NOT ALLOW $-\Delta H$ DO NOT ALLOW double headed arrow on ΔH ALLOW ΔH arrow even with small gap at the top and bottom, i.e. line does not quite reach reactant or product line. ALLOW -905 for ΔH

Question	Answer	Marks	Guidance
(ii)	FIRST CHECK ON ANSWER LINE If answer = 6.79×10^7 (kJ) award 4 marks If answer = 2.72×10^8 (kJ) award 3 marks (no $\div 4$) ----- $n(\text{NH}_3)$ $= \frac{5.1 \times 10^6}{17} = 3.00 \times 10^5 \text{ (mol) } \checkmark$ Stoichiometry and ΔH 1 mol NH_3 releases $\frac{905}{4}$ OR 226.25 (kJ) $\checkmark$ Energy released $(3.00 \times 10^5) \times \frac{905}{4}$ OR 67875000 (kJ) $\checkmark$ Final answer to 3SF AND standard form $= 6.79 \times 10^7 \text{ (kJ) } \checkmark$ <i>standard form AND 3 SF required</i>	4	IGNORE (-) SIGN Throughout: IGNORE trailing zeroes in intermediate working, e.g. For $n(\text{NH}_3)$ ALLOW 3×10^5 for 3.00×10^5 ----- ALLOW ECF from incorrect $n(\text{NH}_3)$ OR 905/4 ALLOW 3 SF up to calc value correctly rounded. Value will depend on intermediate rounding Common Errors 1.09×10^9 (x 4 instead of $\div 4$) 3 marks 2.72×10^8 (no $\div 4$) 3 marks 6.79×10^1 (no tonnes $\rightarrow$ g) 3 marks
(b)	$(K_c =) \frac{[\text{NO(g)}]^4 [\text{H}_2\text{O(g)}]^6}{[\text{NH}_3\text{(g)}]^4 [\text{O}_2\text{(g)}]^5} \checkmark$	1	Square brackets required IGNORE state symbols

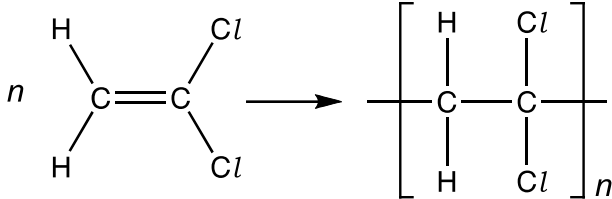
Question		Answer	Marks	Guidance
4	(c)	EQUILIBRIUM CONDITIONS Temperature: 1 mark (Forward) reaction is exothermic/ΔH is negative OR (Forward) reaction gives out heat ✓ Pressure: 1 mark Left-hand side has fewer (gaseous) moles OR 9 (gaseous) moles form 10 (gaseous) moles ✓ OPTIMUM EQUILIBRIUM CONDITIONS: 1 mark (for maximum yield of NO) Low temperature AND low pressure ✓ RATE: 1 mark Low temperature/pressure gives a slow rate/slower reaction so high temperatures / higher pressure needed to increase rate OR frequency of collisions ✓ INDUSTRIAL CONDITIONS / OPERATIONAL FACTORS: 1 mark High pressure provides a safety risk OR Higher temperatures increase energy costs / reduce yield / shift equilibrium to left OR (High) pressure is expensive (to generate) / uses a lot of energy ✓	5	ANNOTATE ANSWER WITH TICKS AND CROSSES ETC ALLOW reverse arguments Answer MUST relate temp/pressure to rate / frequency of collisions ALLOW Temperature / pressure not too high because yield reduced IGNORE stated temperatures and pressures IGNORE catalyst
		Total	12	

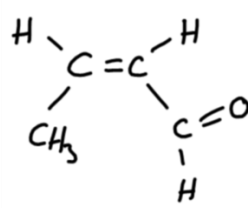
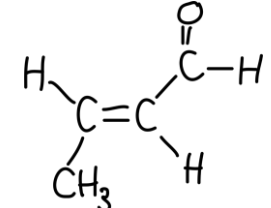
Question	Answer	Marks	Guidance
5 (a) (i)*	Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) Correctly labelled diagram of reflux apparatus that works, with no safety problems AND An appreciation of most of the purification steps required to gain a pure sample <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Labelled diagram of apparatus (either reflux or distillation) but with safety/procedural problems OR clear diagram of reflux apparatus without labelling AND Some details of further purification steps <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) Diagram of apparatus (reflux OR separation OR distillation) drawn with no labelling OR labelled diagram with significant safety/procedural AND / OR Few or imprecise details about further purification stages <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks No response or no response worthy of credit.	6	Indicative scientific points may include: Apparatus set up for reflux: • round-bottom/pear shaped flask • heat source • condenser <i>Detail: water flow in condenser bottom to top; open system.</i> Purification • Use of a separating funnel to separate organic and aqueous layers <i>Detail: Collect lower organic layer density greater</i> • Drying with an anhydrous salt, <i>Detail: e.g. MgSO_4, CaCl_2, etc.</i> • Redistillation <i>Detail: Collect fraction distilling at 102°C.</i>

Question			Answer	Marks	Guidance
5	(a)	(ii)	FIRST, CHECK THE ANSWER ON ANSWER LINE IF answer = 12.6 (g) award 2 marks $n(1\text{-bromobutane}) = 0.150 \times \frac{61.4}{100} = 0.0921 \text{ (mol)} \checkmark$ - Mass 1-bromobutane = $0.0921 \times 136.9 = 12.6 \text{ (g)} \checkmark$ 3 SF required	2	Common errors: 33.4 ($0.150 \times 100/61.4 = 0.244 \times 136.9$) 1 mark ALLOW ECF for incorrect moles or incorrect M_r of 1-bromobutane (provided answer is to 3 SF) DO NOT ALLOW 6.82 (using M_r of butan-1-ol) ALLOW calculation using masses, e.g. - Theoretical = $0.150 \times 136.9 = 20.535 \text{ (g)} \checkmark$ <i>(ALLOW 20.535 rounded back to 20.5)</i> - Actual mass = $20.535 \times \frac{61.4}{100} = 12.6 \text{ (g)} \checkmark$ <i>(20.5 also gives 12.6)</i>
	(b)		Tangent on graph drawn at approximately $t = 30 \text{ min}$ ($\pm 10 \text{ mins}$) $\checkmark$ Calculation of rate = Gradient (y/x) of tangent drawn e.g. $\frac{0.19}{72} = 2.64 \times 10^{-3} / 0.00264 \text{ (mol dm}^{-3}\text{min}^{-1}) \checkmark$ 	2	DO NOT ALLOW interpolation (taking a direct reading from graph), answer must be derived from taking a gradient ALLOW ecf from incorrectly drawn tangent Tolerance: Readings from y axis should be $\pm 0.01 \text{ mol dm}^{-3}$ (i.e. within 1 square) Readings from x axis should be $\pm 5 \text{ minutes}$ (i.e. within 0.5 of a square) IGNORE units IGNORE sign
			Total	10	

Question			Answer	Marks	
6	(a)		steam AND Acid/H ⁺ (catalyst) ✓	1	
	(b)	(i)	1,2-dibromo-1,1-dichloroethane ✓	1	

Question	Answer	Marks	Guidance
6 (b) (ii)	1st curly arrow (from ANY alkene) Curly arrow from double bond to Br of Br–Br ✓ DO NOT ALLOW partial charge on C=C 2nd curly arrow Correct dipole on Br–Br AND curly arrow for breaking of Br–Br bond ✓ 3rd curly arrow Correct carbocation with + charge on C with 3 bonds AND curly arrow from Br[–] to C⁺ of carbocation ✓ DO NOT ALLOW δ+ on C of carbocation OR <i>i.e. ALLOW carbonium + on either C atom</i> DO NOT ALLOW half headed or double headed arrows but allow ECF if seen more than once	3	ANNOTATE ANSWER WITH TICKS AND CROSSES ETC For curly arrows, ALLOW straight or snake-like arrows and small gaps (see examples): 1st curly arrow must - go to a Br atom of Br–Br AND - start from, OR be traced back to any point across width of C=C 2nd curly arrow must - start from, OR be traced back to, any part of δ⁺Br–Br^{δ–} bond AND go to Br^{δ–} 3rd curly arrow must - go to the C⁺ of carbocation AND - start from, OR be traced back to any point across width of lone pair on :Br[–] OR start from – charge on Br[–] ion (Lone pair NOT needed if curly arrow shown from – charge on Br[–])

Question	Answer	Marks	Guidance
6 (c) (i)	 Correct polymer with side links and brackets ✓ Equation balanced with n ✓ TAKE CARE of 'n' position on both sides of equation.	2	For repeat unit, - displayed formula required 'side bonds' required on either side of repeat unit from C atoms ALLOW section containing more than one repeat unit DO NOT ALLOW ECF from incorrect repeat unit n on LHS at any height to the left of the formula n on RHS must be subscript
(c) (ii)	Advantage (1 mark) Energy production / (energy) used to produce electricity ✓ Disadvantage (1 mark) Formation of HCl/products of combustion cause acid rain OR Formation of CO₂/gases that cause global warming / greenhouse gases OR Formation of CO ✓	2	ALLOW reduced use of fossil fuels ALLOW less landfill / less harm to wildlife ALLOW chlorine/Cl OR Cl₂ ALLOW toxic/poisonous waste products
	Total	9	

Question	Answer	Marks	Guidance																				
7*	Please refer to the marking instructions on page 5 of the mark scheme for guidance on how to mark this question. Level 3 (5-6 marks) A comprehensive description including most of the evidence to justify the correct structure of F (accept <i>cis</i> or <i>trans</i>). <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) The candidate attempts all three scientific points, but explanations are incomplete. OR Explains two scientific points thoroughly with few omissions. AND an attempt at a feasible structure based on deduction from correct molecular formula <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) The correct empirical formula AND a simple description based on at least one of the main scientific points. OR The candidate explains one scientific point thoroughly with few omissions. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks No response or no response worthy of credit.	6	LOOK AT THE SPECTRA for labelled peaks Indicative scientific points may include: Empirical formula - empirical formula = C₄H₆O <table><tr><th>element</th><th>% mass</th><th>Ar</th><th>moles</th><th>ratio</th></tr><tr><td>C</td><td>68.6</td><td>12</td><td>5.72</td><td>4</td></tr><tr><td>H</td><td>8.6</td><td>1</td><td>8.60</td><td>6</td></tr><tr><td>O</td><td>22.8</td><td>16</td><td>1.43</td><td>1</td></tr></table> IR and spectra and molecular formula - infrared absorption; 1630–1820 cm^{–1}, due to C=O (aldehyde/ketone/carbonyl group) - molar mass = 70 g mol^{–1} (mass spectrum molecular ion peak <i>m/z</i> = 70) - molecular formula = C₄H₆O Functional groups, structure and stereochemistry - alkene / C=C - aldehyde / –CHO (C₃H₅⁺ fragment) - mass spectrum; peak at 41 due to C₃H₅⁺ (loss of CHO) <i>E/Z</i> or <i>cis-trans</i> isomer: <i>E/Z</i> or <i>cis-trans</i> isomer:  <i>cis</i>  <i>trans (correct structure)</i>	element	% mass	Ar	moles	ratio	C	68.6	12	5.72	4	H	8.6	1	8.60	6	O	22.8	16	1.43	1
element	% mass	Ar	moles	ratio																			
C	68.6	12	5.72	4																			
H	8.6	1	8.60	6																			
O	22.8	16	1.43	1																			
	Total	6																					

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