

GCE

Chemistry A

Unit **H432A/03**: Unified chemistry

Advanced GCE

Mark Scheme for June 2017

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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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Annotations available in RM Assessor

Annotation	Meaning
	Correct response
	Incorrect response
	Omission mark
	Benefit of doubt given
	Contradiction
	Rounding error
	Error in number of significant figures
	Error carried forward
	Level 1
	Level 2
	Level 3
	Benefit of doubt not given
	Noted but no credit given
	Ignore

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
✓	Separates marking points
DO NOT ALLOW	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
—	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

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)	Throughout <ul style="list-style-type: none"> • ALLOW bonding regions for bonded pairs • ALLOW diagrams for communicating two bonds, two lone pairs and hydrogen bonding in ice • IGNORE responses about open lattice/tetrahedral structure in ice 		
	Ice Ice has hydrogen bonds/bonding ✓ H₂O(g) 2 bonded pairs AND 2 lone pairs ✓ Repulsion Lone pairs repel more (than bonded pairs) ✓	3	ALLOW more hydrogen bonding/H bonds For H ₂ O(g), <ul style="list-style-type: none"> • ALLOW water • IGNORE hydrogen bonding
(b)	It increases/causes/contributes to global warming OR C–H bonds vibrate OR absorb IR ✓	1	ALLOW it is a greenhouse gas/increases temp IGNORE ozone, radicals OR acid rain
(c)	FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = CH ₄ •5.74 H ₂ O OR 5.74 award 2 marks ----- Mole ratio $n(\text{CH}_4) : n(\text{H}_2\text{O}) = \frac{13.4}{16.0} : \frac{86.6}{18.0}$ OR 0.8375 : 4.811 ✓ Formula CH ₄ •5.74 H ₂ O OR 5.74 ✓	2	Working to at least 3 SF but IGNORE 'trailing zeroes', e.g. ALLOW 16 for 16.0 ----- ALLOW algebraic approach, e.g. $\frac{13.4}{16.0} = \frac{100}{16.0 + 18x}$ $x = 5.74$ ALLOW ECF from incorrect mole ratio ----- For 1 mark, ALLOW x with < 2 DP: <ul style="list-style-type: none"> • x = 5.7 • x = 6 • x = 5.73 from 0.8375 and 4.8 • x = 5.71 from 0.84 and 4.811 • x = 5.71 from 0.84 and 4.8
(d)	FIRST CHECK THE ANSWER ON THE ANSWER LINE	4	

Question	Answer	Marks	Guidance
	<p>IF answer = 188 (dm³) AND use of ideal gas equation Award 4 marks for calculation</p> <p>-----</p> <p><i>n(CH₄) in 1 kg</i> $n(\text{CH}_4) = \frac{1 \times 10^3}{16.0} \times \frac{13.4}{100} = 8.375 \text{ OR } 8.38 \text{ (mol) } \checkmark$</p> <p><i>Rearranging ideal gas equation</i> $V = \frac{nRT}{p} \checkmark$</p> <p><i>Substitution of values into $V = \frac{nRT}{p}$:</i></p> <ul style="list-style-type: none"> • Calculated value of <i>n(CH₄)</i> (Use ECF) • <i>R</i> = 8.314 OR 8.31 • <i>T</i> in K: 273 K • <i>p</i> in Pa OR kPa 101 OR 101 × 10³ OR 1.01 × 10⁵ <p>e.g. $\frac{8.375 \times 8.314 \times 273}{(101 \times 10^3)}$ OR $\frac{8.375 \times 8.314 \times 273}{101} \checkmark$</p> <p><i>Final volume in dm³ to 3 SF</i> $V = 188 \text{ (dm}^3\text{)} \checkmark$</p>		<p>ALLOW use of <i>M</i>(answer to (c) OR 119.32 <i>Examples</i> From <i>n(CH₄•5.74 H₂O)</i> $\frac{1 \times 10^3}{119.32} = 8.38(1) \rightarrow 188 \text{ (dm}^3\text{)}$</p> <p>From <i>n(CH₄•5.7 H₂O)</i> $\frac{1 \times 10^3}{118.6} = 8.43(2) \rightarrow 189 \text{ (dm}^3\text{)}$</p> <p>From <i>n(CH₄•6 H₂O)</i> $\frac{1 \times 10^3}{124.0} = 8.06 \text{ (mol)} \rightarrow 181 \text{ (dm}^3\text{)}$</p> <p>-----</p> <p>IF $V = \frac{nRT}{p}$ is omitted, ALLOW when values are substituted into rearranged ideal gas equation.</p>
	<p>COMMON ERRORS</p> <p>Use of 298 K ALLOW ECF 3 marks max</p> <p><i>Example</i> $n(\text{CH}_4 \cdot 5.74 \text{ H}_2\text{O}) = 8.375 \checkmark$ $V = \frac{8.375 \times 8.314 \times 298}{101 \times 10^3} \rightarrow 205 \text{ (dm}^3\text{)} \checkmark \checkmark$</p> <p>Use of 24.0 dm³ OR 22.4 dm³ ALLOW ECF from <i>n(CH₄)</i> 2 marks max for <i>n(CH₄)</i> and <i>V</i> in dm³</p> <p>24.0 dm³ $n(\text{CH}_4 \cdot 5.74 \text{ H}_2\text{O}) = 8.375 \checkmark$ $V = 8.375 \times 24.0 = 201 \text{ (dm}^3\text{)} \checkmark$</p> <p>22.4 dm³ $n(\text{CH}_4 \cdot 5.74 \text{ H}_2\text{O}) = 8.375 \checkmark$ $V = 8.375 \times 22.4 = 188 \text{ (dm}^3\text{)} \checkmark$</p> <p>13.4% (13.4/100) omitted 3 marks</p> <p>$n = \frac{1 \times 10^3}{16} = 62.5 \text{ (mol)} \times$ $V = \frac{62.5 \times 8.314 \times 273}{101 \times 10^3} \rightarrow 1400 \text{ (dm}^3\text{)} \checkmark \checkmark \checkmark$</p>		
(e)	For fuel OR energy \checkmark	1	ALLOW responses linked with energy. e.g. <ul style="list-style-type: none"> • to generate electricity

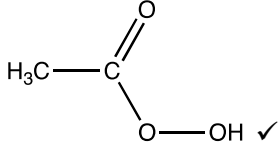
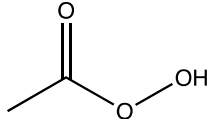
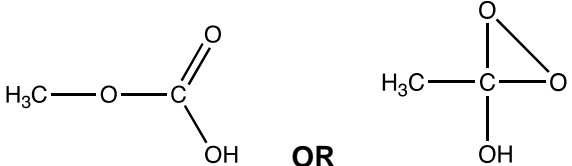
Question			Answer	Marks	Guidance
					<ul style="list-style-type: none">• for burning/heat <p>ALLOW (chemical) feedstock</p> <p>IGNORE cooking</p>
			Total	11	

Question	Answer	Marks	Guidance
2 (a)	<p><i>Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.</i></p> <p>Level 3 (5–6 marks) A comprehensive conclusion, using all quantitative data, to calculate the energy change and ΔH values for reactions 3.1 and 3.2 AND linking ΔH data using Hess' Law</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The working throughout is clearly shown. All values calculated with reasonable numbers of SF and correct signs mostly shown, allowing for ECF.</i></p> <p>Level 2 (3–4 marks) Attempts to describe all three scientific points but explanations may be incomplete. OR Explains two scientific points thoroughly with few omissions.</p> <p><i>There is a line of reasoning with some logical structure. There may be minor errors in energy change and errors in the calculations of ΔH for reaction 3.1 or reaction 3.2.</i></p> <p>Level 1 (1–2 marks) Processes raw mass and temperature data and obtains a calculated value for the energy change using $mc\Delta T$ OR attempts to obtain values for two scientific points but explanations may be incomplete</p> <p><i>There is an attempt at a logical structure with a line of reasoning to obtain a value for energy change. There may be minor errors in calculation of energy change.</i></p> <p>0 marks – No response or no response worthy of credit.</p>	6	<p>Indicative scientific points may include:</p> <p>1. Masses and ΔT from raw results</p> <ul style="list-style-type: none"> $m(\text{Na}_2\text{O}) = 1.24 \text{ (g)}$ $m(\text{solution}) = 25.75 \text{ (g)}$ $\Delta T = 35.0 \text{ (}^\circ\text{C)}$ <p>Energy change from $mc\Delta T$</p> <ul style="list-style-type: none"> energy released in J OR kJ $= 25.75 \times 4.18 \times 35.0$ $= 3767 \text{ (J)}$ OR 3.767 (kJ) <i>(3.767225 unrounded)</i> <p>-----</p> <p>2. $\Delta_r H$ for reaction 3.2</p> <ul style="list-style-type: none"> $n(\text{Na}_2\text{O}) = \frac{1.24}{62.0} = 0.0200 \text{ (mol)}$ $\Delta_r H \text{ value} = \frac{3767}{0.0200} = -188 \text{ (kJ mol}^{-1}\text{)}$ <i>(-188.36125 unrounded)</i> <p>-----</p> <p>3. $\Delta_r H$ for reaction 3.1</p> <ul style="list-style-type: none"> ΔH value for reaction 3.1 clearly linked to ΔH for reaction 3.2 and reaction 3.3 in energy cycle or an expression: $\Delta H(\mathbf{3.1}) = \Delta H(\mathbf{3.2}) + 2\Delta H(\mathbf{3.3})$ $\Delta H(\mathbf{3.1}) = -188 + (2 \times -57.6)$ $= -188 - 115.2 = -303(.2) \text{ (kJ mol}^{-1}\text{)}$ <i>(-303.56125 unrounded)</i> <p>Note Throughout, ALLOW ECF from previous value ALLOW omission of trailing zeroes</p> <p>-----</p>

Question	Answer	Marks	Guidance
(b)	<p>% uncertainties to at least 1 SF, rounded or truncated</p> <p>-----</p> <p>ONE correct % uncertainty ✓</p> <p>BOTH correct % uncertainties ✓</p> <p>-----</p> <p>mass: $\frac{0.005 \times 2}{1.24} \times 100 = 0.8/0.81$ OR 0.80 (truncated)</p> <p>$\Delta T:$ $\frac{0.1 \times 2}{35.0} \times 100 = 0.6 / 0.57$ (%) ✓</p> <p><i>Calculator values:</i></p> <p>mass: 0.8064516129</p> <p>$\Delta T:$ 0.5714285714</p>	2	<p>ALLOW error for uncertainty</p> <p>-----</p> <p>ALLOW ECF from mass and ΔT in 2(a)</p> <p>IGNORE % uncertainty of mass of solution</p> <p>-----</p> <p>ALLOW one mark for:</p> <ul style="list-style-type: none"> • 2 calculations with both $\times 2$ factors missing i.e. mass 0.3% AND ΔT 0.4% • Not converting to %s using $\times 2$ factors i.e. 0.008 AND 0.006
(c)	<p>ALLOW uncertainty OR error throughout</p> <p>Greater mass of Na₂O OR more Na₂O ✓</p> <p>For mass, ALLOW amount/moles/quantity</p> <p>larger ΔT</p> <p>OR reduces % uncertainty in ΔT ✓</p>	2	<p>ALLOW up to 2 marks based on a single mass measurement:</p> <p>one mass measurement</p> <p>OR measure mass directly ✓</p> <p><i>e.g. tare balance</i></p> <p>% uncertainty reduced by half ✓</p> <p>-----</p> <p>IGNORE</p> <ul style="list-style-type: none"> • repeat and take average • read to more figures (<i>same apparatus</i>) • increase volume (<i>reduces mass error but increases ΔT error</i>) • use a cooling curve • use a lid

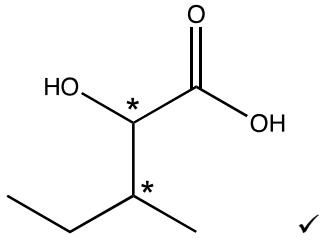
Question		Answer	Marks	Guidance
(d)	(i)	sodium nitrate(III)	1	ALLOW sodium nitrite OR sodium nitrite(III)
(d)	(ii)	Sodium/Na oxidised from 0 to +1 ✓ Nitrogen/N reduced from +3 to 0 ✓	2	ALLOW 1+ for +1 and 3+ for +3 ALLOW N ₂ for nitrogen ALLOW 1 mark for elements AND all oxidation numbers correct, but N on oxidised line and Na on reduced line '+' is required in +3 and +1 oxidation numbers
(d)	(iii)	$2\text{NaNO}_2 + 6\text{Na} \rightarrow 4\text{Na}_2\text{O} + \text{N}_2$ ✓ IGNORE state symbols	1	ALLOW multiples, e.g. $\text{NaNO}_2 + 3\text{Na} \rightarrow 2\text{Na}_2\text{O} + \frac{1}{2}\text{N}_2$
Total			14	

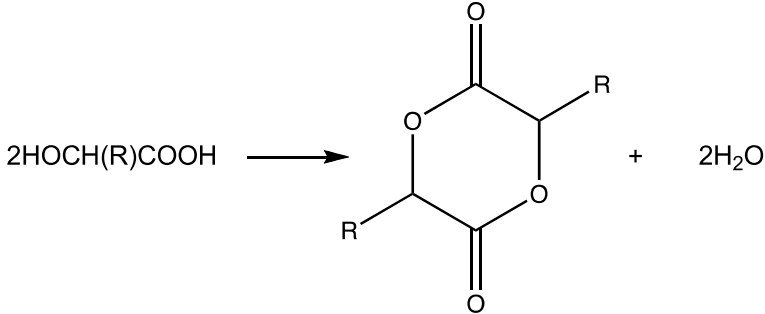
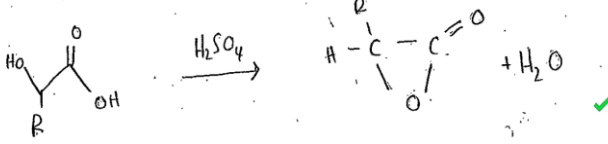
Question			Answer	Marks	Guidance
3	(a)	(i)	<p>(rate =) $k [\text{H}_2\text{O}_2] [\text{I}^-] \checkmark$</p> $k = \frac{\text{rate}}{[\text{H}_2\text{O}_2] [\text{I}^-]} = \frac{2.00 \times 10^{-6}}{0.0100 \times 0.0100} = 0.02(00) \checkmark$ <p>units: $\text{dm}^3 \text{mol}^{-1} \text{s}^{-1} \checkmark$</p>	3	<p>Square brackets required IGNORE any state symbols</p> <p>IGNORE $[\text{H}^+]^0$</p> <p>ALLOW ECF from incorrect rate equation BUT units must fit with rate equation used</p> <p>ALLOW $\text{mol}^{-1} \text{dm}^3 \text{s}^{-1}$ OR in any order</p> <p>NOTE K_c expression with calculation and units 0 marks</p>
	(a)	(ii)	<p>Plot graph using $\ln k$ AND $1/T \checkmark$</p> <p>(Measure) gradient \checkmark Independent mark</p> <p>$E_a = (-)R \times \text{gradient}$ OR $(-)8.314 \times \text{gradient} \checkmark$</p> <ul style="list-style-type: none"> • Independent mark, even if variables for graph are incorrect • Subsumes 'gradient' mark 	3	<p>Unless otherwise stated, assume, that $\ln k$ is on y axis and $1/T$ is on x axis</p> <p>IGNORE intercept</p> <p>ALLOW gradient = $(-)\frac{E_a}{R}$</p> <p>-----</p> <p>NOTE: ALLOW 'Inverse graph' (special case)</p> <p>Plot graph of $1/T$ against $\ln k \checkmark$</p> <p>(Measure) gradient \checkmark Independent mark</p> <p>$E_a = (-)\frac{R}{\text{gradient}}$ OR $(-)\frac{8.314}{\text{gradient}}$</p> <p>OR gradient = $(-)\frac{R}{E_a} \checkmark$</p> <p>Subsumes 'gradient' mark</p>

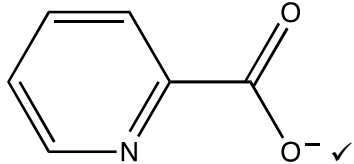
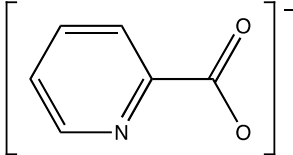
Question	Answer	Marks	Guidance
(b)	<p>ALLOW equilibrium sign in equations provided reactants on left</p> <p>Reaction of H₂O₂ with MnO₂: $\text{H}_2\text{O}_2 + \text{MnO}_2 + 2\text{H}^+ \rightarrow \text{O}_2 + \text{Mn}^{2+} + 2\text{H}_2\text{O} \checkmark$</p> <p>Reaction of H₂O₂ with Mn²⁺: $\text{H}_2\text{O}_2 + \text{Mn}^{2+} \rightarrow \text{MnO}_2 + 2\text{H}^+ \checkmark$</p> <p>Use of E data Use of E data to support equation(s) above or half direction of provided half equations (one including MnO₂) ✓ <i>Also look for evidence around half equations</i></p> <p>MnO₂ regenerated/reformed ✓ <i>Must be linked to an equation showing MnO₂ as reactant and an equation showing MnO₂ as product</i></p>	4	<p>ALLOW correct multiples IGNORE state symbols</p> <p>-----</p> <p>ALLOW uncanceled H₂O and H⁺ $\text{H}_2\text{O}_2 + \text{MnO}_2 + 4\text{H}^+ \rightarrow \text{O}_2 + \text{Mn}^{2+} + 2\text{H}_2\text{O} + 2\text{H}^+$</p> <p>$\text{H}_2\text{O}_2 + \text{Mn}^{2+} + 2\text{H}_2\text{O} + 2\text{H}^+ \rightarrow \text{MnO}_2 + 4\text{H}^+ + 2\text{H}_2\text{O}$</p> <p>Examples</p> <ul style="list-style-type: none"> • More negative E moves to left ORA • Reduction half equation to the right ORA • Most positive E is reduced ORA • Calculated E cell = +0.81 V (from top 2) OR +0.27 V (from bottom 2) <p>ALLOW combining of equations above to show that MnO₂ is used and reformed</p>
(c) (i)	 <p>ALLOW skeletal OR displayed formula OR mixture of the above as long as non-ambiguous, e.g.</p> 	1	<p>ALLOW</p>  <p>Structure must include OH as part of COOH group</p> <p>ALLOW -O⁻H⁺ in structure</p>

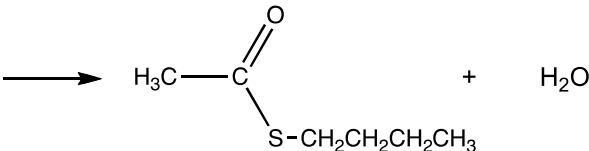
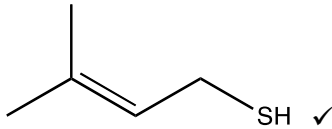
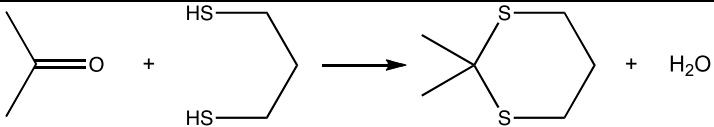
Question		Answer	Marks	Guidance
(c)	(ii)	<p>FIRST CHECK THE ANSWER ON THE ANSWER LINE IF answer = 0.023(125) (mol) award 3 marks for calculation</p> <hr/> <p>K_c expression $(K_c =) \frac{[\text{CH}_3\text{COOOH}]}{[\text{H}_2\text{O}_2][\text{CH}_3\text{COOH}]}$ ✓</p> <p>$[\text{CH}_3\text{COOOH}]$ $= 0.37 \times 0.500 \times 0.500 = 0.0925 \text{ (mol dm}^{-3}\text{)}$ ✓ <i>Subsumes K_c expression</i></p> <p>$n(\text{CH}_3\text{COOOH})$ $= 0.0925 \times \frac{250}{1000} = 0.023(125) \text{ (mol)}$ ✓</p>	3	<p>If there is an alternative answer, check for any ECF credit</p> <hr/> <p>ALLOW $0.37 = \frac{[\text{CH}_3\text{COOOH}]}{0.500 \times 0.500}$</p> <p>ALLOW ECF but ONLY if 0.37 AND 0.5×0.5 have been used</p> <p>Common errors</p> <p>0.076 2 marks <i>Use of $[\text{CH}_3\text{COOOH}]^2$</i></p> <p>0.675 2 marks <i>Use of 0.5 for $[\text{H}_2\text{O}]$ on K_c</i></p> <p>0.169 2 marks <i>Inverted K_c</i></p> <p>0.338 1 mark <i>Inverted K_c AND 0.5 for $[\text{H}_2\text{O}]$</i></p> <p>5.78×10^{-3} 2 marks <i>$\times \frac{250}{1000}$ before $[\text{CH}_3\text{COOOH}]$</i></p>
		Total	14	

Question			Answer	Marks	Guidance														
4	(a)	(i)	<p>Burette readings</p> <table border="1"> <tr> <td>Final (reading)/cm³</td> <td>23.15</td> <td>45.95</td> <td>32.45</td> <td rowspan="2">✓</td> </tr> <tr> <td>Initial (reading)/cm³</td> <td>0.60</td> <td>23.15</td> <td>10.00</td> </tr> </table> <ul style="list-style-type: none"> Correct titration results recorded with initial and final readings, clearly labeled AND all readings recorded to two decimal places with last figure either 0 or 5 <p>Titres</p> <table border="1"> <tr> <td>Titre/cm³</td> <td>22.55</td> <td>22.80</td> <td>22.45</td> <td>✓</td> </tr> </table> <ul style="list-style-type: none"> Correct subtractions to obtain final titres to 2 DP <p>Units</p> <ul style="list-style-type: none"> Units of cm³ for initial, final and titres ✓ <p>Mean titre</p> <ul style="list-style-type: none"> mean titre = $\frac{22.55 + 22.45}{2} = 22.50$ OR 22.5 cm³ ✓ <i>i.e. using concordant (consistent) titres</i> 	Final (reading)/cm ³	23.15	45.95	32.45	✓	Initial (reading)/cm ³	0.60	23.15	10.00	Titre/cm ³	22.55	22.80	22.45	✓	4	<p>Table not required</p> <p>ALLOW initial reading before final reading</p> <p>ALLOW ECF</p> <p>ALLOW units with each value ALLOW brackets for units, i.e. (cm³)</p> <p>ALLOW ECF from incorrect concordant titres</p>
Final (reading)/cm ³	23.15	45.95	32.45	✓															
Initial (reading)/cm ³	0.60	23.15	10.00																
Titre/cm ³	22.55	22.80	22.45	✓															

Question	Answer	Marks	Guidance
(a) (ii)	<p>ALLOW 3SF or more throughout IGNORE trailing zeroes, e.g. ALLOW 0.084 for 0.0840</p> <hr/> $n(\text{NaOH}) = 0.0840 \times \frac{22.50}{1000} = 1.89 \times 10^{-3} \text{ (mol) } \checkmark$ $n(\text{A}) \text{ in } 250 \text{ cm}^3 = 10 \times 1.89 \times 10^{-3} = 1.89 \times 10^{-2} \text{ (mol) } \checkmark$ $M(\text{A}) = \frac{2.495}{1.89 \times 10^{-2}} = 132 \text{ (g mol}^{-1}\text{)} \checkmark$ $M(\text{alkyl group}) (= 132 - 75) = 57 \checkmark$ $\text{R} = \text{C}_4\text{H}_9 \checkmark$ <p>ALLOW alkyl group in drawn structure with straight chain or branch(es) in wrong position, e.g. for R = C₄H₉, CH₃CH₂CH₂CH₂ OR (CH₃)₃C</p> <p>Structure with chiral carbon atoms identified (see * below)</p> 	6	<p>ALLOW ECF from incorrect mean titre in 4a(i) e.g. From 22.60 cm³ (mean of all 3 titres in (i)), $n(\text{NaOH}) = 1.8984 \times 10^{-3} \text{ (mol)}$</p> <p>ALLOW ECF from incorrect $n(\text{NaOH})$</p> <p>ALLOW ECF from incorrect $n(\text{A})$</p> <p>ALLOW ECF from incorrect $M(\text{A}) - 75$</p> <p>ALLOW ECF for alkyl group closest to calculated $M(\text{alkyl group})$, e.g. for $M = 45$, ALLOW C₃H₇ (43)</p> <p>ALLOW correct structural OR skeletal OR displayed formula OR mixture of the above as long as non-ambiguous</p> <p>IGNORE poor connectivity to OH groups <i>Given in question</i></p> <hr/> <p>Common error for 4 marks max 25.00 instead of 22.50 and scaling by $\times 10$ $2.10 \times 10^{-3} \times \rightarrow 2.10 \times 10^{-2} \checkmark$ $\rightarrow 118.81 \checkmark \rightarrow 43.81 \checkmark \rightarrow \text{C}_3\text{H}_7 \checkmark$</p> <p>25.00 instead of 22.50 and scaling by $\times \frac{250}{22.50}$ $2.10 \times 10^{-3} \times \rightarrow 2.33 \times 10^{-2} \checkmark$ $\rightarrow 106.93 \checkmark \rightarrow 31.93 \checkmark \rightarrow \text{C}_2\text{H}_5 \checkmark$ No structure with 2 chiral centres possible \times</p>

Question		Answer	Marks	Guidance
(b)	(i)	<p>Equation</p> $2\text{HOCH(R)COOH} + \text{Mg} \rightarrow (\text{HOCH(R)COO})_2\text{Mg} + \text{H}_2$ <p>Organic product ✓</p> <p>Balance ✓</p> <p>Type of reaction Redox ✓</p>	3	<p>ALLOW correct structural OR skeletal OR displayed formula OR mixture of the above as long as non-ambiguous</p> <p>ALLOW $2\text{HOCH(R)COOH} + \text{Mg} \rightarrow 2\text{HOCH(R)COO}^- + \text{Mg}^{2+} + \text{H}_2$</p> <p>ALLOW multiples</p> <p>IGNORE poor connectivity to OH groups <i>Given in question</i></p>
(b)	(ii)	<p>Equation</p> $2\text{HOCH(R)COOH} \longrightarrow \text{Cyclic product} + 2\text{H}_2\text{O}$  <p>Organic product ✓</p> <p>Balance ✓</p> <p>Type of reaction Condensation OR esterification ✓</p>	3	<p>ALLOW correct structural OR skeletal OR displayed formula OR mixture of the above as long as non-ambiguous</p> <p>ALLOW 1 mark of the 2 equation marks for formation of '3 ring' with balanced equation:</p>  <p>ALLOW condensation polymerisation ALLOW addition-elimination</p> <p>IGNORE elimination IGNORE dehydration</p>

Question		Answer	Marks	Guidance
(c)	(i)		1	<p>ALLOW brackets around structure with negative charge outside, i.e.</p>  <p>ALLOW ring (Kekulé structure)</p>
(c)	(ii)	<p>FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 1.61×10^{-3} award 2 marks</p> <p>$M = 418(.0) \text{ (g mol}^{-1}\text{) OR } n(\text{Cr}) = 3.85 \times 10^{-6} \text{ (mol) } \checkmark$</p> <p>$\text{Mass} = 3.85 \times 10^{-6} \times 418.0 = 1.61 \times 10^{-3} \text{ g } \checkmark$</p>	2	<p>Note: $\frac{200 \times 10^{-6}}{52.0} = 3.85 \times 10^{-6}$ (at least 3 SF)</p> <p>ALLOW ECF from incorrect M OR $n(\text{Cr})$</p> <p>ALLOW 3 SF up to calculator value correctly rounded</p>
Total			19	

Question			Answer	Marks	Guidance
			For 5a(i)–(iv) IGNORE poor connectivity to SH groups	<i>Given in question</i>	
5	(a)	(i)	$K_a = \frac{[H^+][C_4H_9S^-]}{[C_4H_9SH]}$ ✓ Square brackets required	1	ALLOW correct structural OR skeletal OR displayed formula OR mixture of the above as long as non-ambiguous
	(a)	(ii)	$CH_3CH_2CH_2CH_2SH + H_3C-C(=O)OH$  Structure of thioester ✓ Complete equation ✓	2	ALLOW correct skeletal OR displayed formula OR mixture of the above as long as non-ambiguous ALLOW C ₄ H ₉ SH ALLOW CH ₃ COOH Thioester functional group must be fully displayed, OR as a skeletal formula but allow SC ₄ H ₉ in thioester
	(a)	(iii)	 ✓	1	IF correct skeletal formula is shown, IGNORE displayed formula in a second structure
	(a)	(iv)	 Reactants ✓ Products AND balanced equation ✓	2	ALLOW correct structural OR skeletal OR displayed formula OR mixture of the above as long as non-ambiguous

Question	Answer	Marks	Guidance																																			
(b)*	<p>Refer to the marking instructions on page 5 of the mark scheme for guidance on marking this question.</p> <p>Level 3 (5–6 marks) Develops a plan that identifies all compounds by a process of elimination AND includes essential detail for all required tests and observations <i>There is a well-developed line of reasoning which is clear and logically structured</i></p> <p>Level 2 (3–4 marks) Develops a plan that identifies at least half of the compounds OR identifies the functional groups in most of the compounds AND includes detail of the required tests and observations <i>There is a line of reasoning with some structure. The information is mostly relevant and supported by some evidence.</i></p> <p>Level 1 (1–2 marks) Develops a plan that attempts to identify the compounds OR functional groups AND includes detail of the required tests and observations <i>There is a line of reasoning using information that is mostly relevant.</i></p> <p>0 marks – No response or no response worthy of credit with no compounds identified</p>	6	<p>Indicative scientific points may include:</p> <p>Functional groups</p> <ul style="list-style-type: none"> • B alkene and tertiary alcohol • C alkene and aldehyde • D alkene and primary alcohol • E ketone • F secondary alcohol • G alkene and ketone <p>Tests</p> <ul style="list-style-type: none"> • B, C, D and G → Bromine decolourises • C, D and F → $(H^+)/Cr_2O_7^{2-}$ green • C, E and G → 2,4-DNP orange precipitate • C → Tollens silver mirror <p>For Tollens' ALLOW alternative: Fehling's solution produces a 'brown/brick red/orange precipitate</p> <p>For 2,4-DNP, ALLOW 2,4-DNPH and Brady's</p> <table border="1" data-bbox="1384 935 2018 1169"> <thead> <tr> <th></th> <th>B</th> <th>C</th> <th>D</th> <th>E</th> <th>F</th> <th>G</th> </tr> </thead> <tbody> <tr> <td>Bromine</td> <td>✓</td> <td>✓</td> <td>✓</td> <td></td> <td></td> <td>✓</td> </tr> <tr> <td>$(H^+)/Cr_2O_7^{2-}$</td> <td></td> <td>✓</td> <td>✓</td> <td></td> <td>✓</td> <td></td> </tr> <tr> <td>2,4-DNP</td> <td></td> <td>✓</td> <td></td> <td>✓</td> <td></td> <td>✓</td> </tr> <tr> <td>Tollens'</td> <td></td> <td>✓</td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p>No credit for tests on products of tests, melting points, spectra, etc. For other tests seen, contact TL for advice</p>		B	C	D	E	F	G	Bromine	✓	✓	✓			✓	$(H^+)/Cr_2O_7^{2-}$		✓	✓		✓		2,4-DNP		✓		✓		✓	Tollens'		✓				
	B	C	D	E	F	G																																
Bromine	✓	✓	✓			✓																																
$(H^+)/Cr_2O_7^{2-}$		✓	✓		✓																																	
2,4-DNP		✓		✓		✓																																
Tollens'		✓																																				
	Total	12																																				

Appendix for Q5b Level of Response

Results of tests

	B	C	D	E	F	G
Bromine	✓	✓	✓			✓
(H⁺)/Cr₂O₇²⁻		✓	✓		✓	
2,4-DNP		✓		✓		✓
Tollens		✓				

Possible processes of elimination (not inclusive)

BCDEFG with 2,4 DNP **CEG** orange ppt
CEG with Tollens **C** silver mirror
EG with bromine **G** decolourises **E** no change

BDF with (H⁺)/Cr₂O₇²⁻ **DF** green
DF with bromine **B** no colour change
D decolourises **F** no change

BCDEFG with (H⁺)/Cr₂O₇²⁻ **CDF** green
CDF with Tollens/2,4DNP **C** silver mirror/orange ppt
DF with bromine **D** decolourises **F** no change

BEG with 2,4 DNP **EG** orange ppt
EG with bromine **B** no change
G decolourises **E** no change

BCDEFG with bromine **BCDG** decolourise
EF with 2,4-DNP/(H⁺)/Cr₂O₇²⁻ **EF** no change
BCDG with Tollens' **E** orange ppt/**F** green
BDG with H⁺/Cr₂O₇²⁻ **C** silver mirror **BDG** no change
BG with 2,4-DNP **D** green **BG** no change
 G orange ppt **B** no change

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