



**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).

<b>Annotation</b>	<b>Meaning</b>
/	alternative and acceptable answers for the same marking point
✓	Separates marking points
<b>DO NOT ALLOW</b>	Answers which are not worthy of credit
<b>IGNORE</b>	Statements which are irrelevant
<b>ALLOW</b>	Answers that can be accepted
( )	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
<b>ECF</b>	Error carried forward
<b>AW</b>	Alternative wording
<b>ORA</b>	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"> <li>• <b>ALLOW</b> bonding regions for bonded pairs</li> <li>• <b>ALLOW</b> diagrams for communicating <b>two</b> bonds, <b>two</b> lone pairs and hydrogen bonding in ice</li> <li>• <b>IGNORE</b> responses about open lattice/tetrahedral structure in ice</li> </ul>		
	<b>Ice</b> Ice has hydrogen bonds/bonding ✓  <b>H<sub>2</sub>O(g)</b> 2 bonded pairs <b>AND</b> 2 lone pairs ✓  <b>Repulsion</b> Lone pairs repel more (than bonded pairs) ✓	3	<b>ALLOW</b> more hydrogen bonding/H bonds  For H <sub>2</sub> O(g), <ul style="list-style-type: none"> <li>• <b>ALLOW</b> water</li> <li>• <b>IGNORE</b> hydrogen bonding</li> </ul>
(b)	It increases/causes/contributes to global warming <b>OR</b> C–H bonds vibrate <b>OR</b> absorb IR ✓	1	<b>ALLOW</b> it is a greenhouse gas/increases temp  <b>IGNORE</b> ozone, radicals <b>OR</b> acid rain
(c)	<b>FIRST CHECK THE ANSWER ON THE ANSWER LINE</b> <b>IF answer = CH<sub>4</sub>•5.74 H<sub>2</sub>O OR 5.74 award 2 marks</b> ----- <b>Mole ratio</b> $n(\text{CH}_4) : n(\text{H}_2\text{O}) = \frac{13.4}{16.0} : \frac{86.6}{18.0}$ <b>OR</b> 0.8375 : 4.811 ✓  <b>Formula</b> CH <sub>4</sub> •5.74 H <sub>2</sub> O <b>OR</b> 5.74 ✓	2	Working to at least 3 SF but <b>IGNORE</b> 'trailing zeroes', e.g. <b>ALLOW</b> 16 for 16.0 ----- <b>ALLOW</b> algebraic approach, e.g. $\frac{n(\text{CH}_4)}{16.0} = \frac{n(\text{CH}_4 \cdot x \text{H}_2\text{O})}{16.0 + 18x}$ $\frac{13.4}{16.0} = \frac{100}{16.0 + 18x}$ $x = 5.74$  <b>ALLOW ECF</b> from incorrect mole ratio ----- For 1 mark, <b>ALLOW</b> x with < 2 DP: <ul style="list-style-type: none"> <li>• x = 5.7</li> <li>• x = 6</li> <li>• x = 5.73 from 0.8375 and 4.8 from 0.84 and 4.811</li> <li>• x = 5.71 from 0.84 and 4.8</li> </ul>
(d)	<b>FIRST CHECK THE ANSWER ON THE ANSWER LINE</b>	4	



Question	Answer	Marks	Guidance
	<p><b>IF</b> answer = 188 (dm<sup>3</sup>) <b>AND</b> use of ideal gas equation Award <b>4 marks</b> for calculation</p> <p>-----</p> <p><b><i>n(CH<sub>4</sub>) in 1 kg</i></b>  <math display="block">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</math></p> <p><b><i>Rearranging ideal gas equation</i></b>  <math display="block">V = \frac{nRT}{p} \checkmark</math></p> <p><b><i>Substitution of values into <math>V = \frac{nRT}{p}</math>:</i></b></p> <ul style="list-style-type: none"> <li>• Calculated value of <math>n(\text{CH}_4)</math> (Use <b>ECF</b>)</li> <li>• <math>R = 8.314 \text{ OR } 8.31</math></li> <li>• <math>T</math> in K: 273 K</li> <li>• <math>p</math> in Pa <b>OR</b> kPa 101 <b>OR</b> <math>101 \times 10^3</math> <b>OR</b> <math>1.01 \times 10^5</math></li> </ul> <p>e.g. <math>\frac{8.375 \times 8.314 \times 273}{(101 \times 10^3)}</math> <b>OR</b> <math>\frac{8.375 \times 8.314 \times 273}{101} \checkmark</math></p> <p><b><i>Final volume in dm<sup>3</sup> to 3 SF</i></b>  <math>V = 188 \text{ (dm}^3\text{)} \checkmark</math></p>		<p><b>ALLOW</b> use of <math>M</math>(answer to (c) <b>OR</b> 119.32 <i>Examples</i></p> <p>From <math>n(\text{CH}_4 \cdot 5.74 \text{ H}_2\text{O})</math>  <math display="block">\frac{1 \times 10^3}{119.32} = 8.38(1) \rightarrow 188 \text{ (dm}^3\text{)}</math></p> <p>From <math>n(\text{CH}_4 \cdot 5.7 \text{ H}_2\text{O})</math>  <math display="block">\frac{1 \times 10^3}{118.6} = 8.43(2) \rightarrow 189 \text{ (dm}^3\text{)}</math></p> <p>From <math>n(\text{CH}_4 \cdot 6 \text{ H}_2\text{O})</math>  <math display="block">\frac{1 \times 10^3}{124.0} = 8.06 \text{ (mol)} \rightarrow 181 \text{ (dm}^3\text{)}</math></p> <p>-----</p> <p><b>IF</b> <math>V = \frac{nRT}{p}</math> is omitted, <b>ALLOW</b> when values are substituted into rearranged ideal gas equation.</p>
	<p><b>COMMON ERRORS</b></p> <p><b>Use of 298 K</b> <b>ALLOW ECF</b>  <i>Example</i> <math>n(\text{CH}_4 \cdot 5.74 \text{ H}_2\text{O}) = 8.375 \checkmark</math> <math>V = \frac{8.375 \times 8.314 \times 298}{101 \times 10^3} \rightarrow 205 \text{ (dm}^3\text{)} \checkmark \checkmark</math> <b>3 marks max</b></p> <p><b>Use of 24.0 dm<sup>3</sup> OR 22.4 dm<sup>3</sup></b> <b>ALLOW ECF</b> from <math>n(\text{CH}_4)</math> <b>2 marks max for <math>n(\text{CH}_4)</math> and <math>V</math> in dm<sup>3</sup></b>  24.0 dm<sup>3</sup> <math>n(\text{CH}_4 \cdot 5.74 \text{ H}_2\text{O}) = 8.375 \checkmark</math> <math>V = 8.375 \times 24.0 = 201 \text{ (dm}^3\text{)} \checkmark</math>  22.4 dm<sup>3</sup> <math>n(\text{CH}_4 \cdot 5.74 \text{ H}_2\text{O}) = 8.375 \checkmark</math> <math>V = 8.375 \times 22.4 = 188 \text{ (dm}^3\text{)} \checkmark</math></p> <p><b>13.4% (13.4/100) omitted</b> <b>3 marks</b>  <math>n = \frac{1 \times 10^3}{16} = 62.5 \text{ (mol)} \times</math> <math>V = \frac{62.5 \times 8.314 \times 273}{101 \times 10^3} \rightarrow 1400 \text{ (dm}^3\text{)} \checkmark \checkmark \checkmark</math></p>		
(e)	For fuel <b>OR</b> energy $\checkmark$	1	<b>ALLOW</b> responses linked with energy. e.g. • to generate electricity



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



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><b>Level 3 (5–6 marks)</b> A comprehensive conclusion, using all quantitative data, to calculate the energy change and <math>\Delta H</math> values for reactions 3.1 and 3.2 <b>AND</b> linking <math>\Delta H</math> 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><b>Level 2 (3–4 marks)</b> Attempts to describe all three scientific points but explanations may be incomplete. <b>OR</b> 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 <math>\Delta H</math> for reaction 3.1 or reaction 3.2.</i></p> <p><b>Level 1 (1–2 marks)</b> Processes raw mass and temperature data and obtains a calculated value for the energy change using <math>mc\Delta T</math> <b>OR</b> 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><b>0 marks – No response or no response worthy of credit.</b></p>	6	<p><b>Indicative scientific points may include:</b></p> <p><b>1. Masses and <math>\Delta T</math> from raw results</b></p> <ul style="list-style-type: none"> <li><math>m(\text{Na}_2\text{O}) = 1.24 \text{ (g)}</math></li> <li><math>m(\text{solution}) = 25.75 \text{ (g)}</math></li> <li><math>\Delta T = 35.0 \text{ (}^\circ\text{C)}</math></li> </ul> <p><b>Energy change from <math>mc\Delta T</math></b></p> <ul style="list-style-type: none"> <li>energy released in J <b>OR</b> kJ  <math>= 25.75 \times 4.18 \times 35.0</math>  <math>= 3767 \text{ (J)}</math> <b>OR</b> <math>3.767 \text{ (kJ)}</math>  <i>(3.767225 unrounded)</i></li> </ul> <p>-----</p> <p><b>2. <math>\Delta_r H</math> for reaction 3.2</b></p> <ul style="list-style-type: none"> <li><math>n(\text{Na}_2\text{O}) = \frac{1.24}{62.0} = 0.0200 \text{ (mol)}</math></li> <li><math>\Delta_r H \text{ value} = \frac{-3767}{0.0200} = -188 \text{ (kJ mol}^{-1}\text{)}</math>  <i>(-188.36125 unrounded)</i></li> </ul> <p>-----</p> <p><b>3. <math>\Delta_r H</math> for reaction 3.1</b></p> <ul style="list-style-type: none"> <li><math>\Delta H</math> value for <b>reaction 3.1</b> clearly linked to <math>\Delta H</math> for <b>reaction 3.2</b> and <b>reaction 3.3</b> in energy cycle or an expression:  <math>\Delta H(\mathbf{3.1}) = \Delta H(\mathbf{3.2}) + 2\Delta H(\mathbf{3.3})</math></li> <li><math>\Delta H(\mathbf{3.1}) = -188 + (2 \times -57.6)</math>  <math>= -188 - 115.2 = -303(.2) \text{ (kJ mol}^{-1}\text{)}</math>  <i>(-303.56125 unrounded)</i></li> </ul> <p><b>Note</b> Throughout, <b>ALLOW ECF</b> from previous value <b>ALLOW</b> 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><b>ONE</b> correct % uncertainty ✓</p> <p><b>BOTH</b> correct % uncertainties ✓</p> <p>-----</p> <p><b>mass:</b> <math>\frac{0.005 \times 2}{1.24} \times 100 = 0.8/0.81</math> <b>OR</b> 0.80 (truncated)</p> <p><b><math>\Delta T</math>:</b> <math>\frac{0.1 \times 2}{35.0} \times 100 = 0.6 / 0.57</math> (%) ✓</p> <p>Calculator values:</p> <p>mass: 0.8064516129</p> <p><math>\Delta T</math>: 0.5714285714</p>	2	<p><b>ALLOW</b> error for uncertainty</p> <p>-----</p> <p><b>ALLOW ECF</b> from mass and <math>\Delta T</math> in 2(a)</p> <p><b>IGNORE</b> % uncertainty of mass of solution</p> <p>-----</p> <p><b>ALLOW one</b> mark for:</p> <ul style="list-style-type: none"> <li>• 2 calculations with both <math>\times 2</math> factors missing i.e. mass 0.3% <b>AND</b> <math>\Delta T</math> 0.4%</li> <li>• Not converting to %s using <math>\times 2</math> factors i.e. 0.008 <b>AND</b> 0.006</li> </ul>
(c)	<p><b>ALLOW</b> uncertainty <b>OR</b> error throughout</p> <p>Greater mass of Na<sub>2</sub>O <b>OR</b> more Na<sub>2</sub>O ✓</p> <p>For mass, <b>ALLOW</b> amount/moles/quantity</p> <p>larger <math>\Delta T</math></p> <p><b>OR</b> reduces % uncertainty in <math>\Delta T</math> ✓</p>	2	<p><b>ALLOW</b> up to 2 marks based on a single mass measurement:</p> <p>one mass measurement</p> <p><b>OR</b> measure mass directly ✓</p> <p><i>e.g. tare balance</i></p> <p>% uncertainty reduced by <b>half</b> ✓</p> <p>-----</p> <p><b>IGNORE</b></p> <ul style="list-style-type: none"> <li>• repeat and take average</li> <li>• read to more figures (<i>same apparatus</i>)</li> <li>• increase volume (<i>reduces mass error but increases <math>\Delta T</math> error</i>)</li> <li>• use a cooling curve</li> <li>• use a lid</li> </ul>

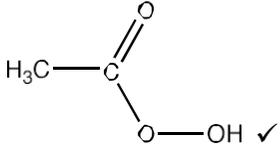
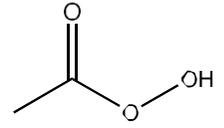
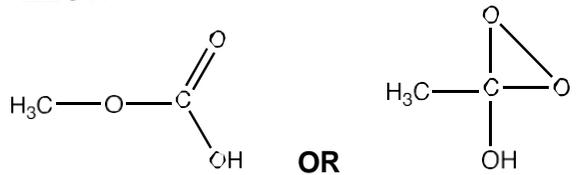


Question		Answer	Marks	Guidance
(d)	(i)	sodium nitrate(III)	1	<b>ALLOW</b> sodium nitrite <b>OR</b> sodium nitrite(III)
(d)	(ii)	Sodium/Na oxidised from 0 to +1 ✓ Nitrogen/N reduced from +3 to 0 ✓	2	<b>ALLOW</b> 1+ for +1 and 3+ for +3 <b>ALLOW</b> N <sub>2</sub> for nitrogen <b>ALLOW</b> 1 mark for elements <b>AND</b> all oxidation numbers correct, but N on oxidised line and Na on reduced line '+' is required in +3 and +1 oxidation numbers
(d)	(iii)	2NaNO <sub>2</sub> + 6Na → 4Na <sub>2</sub> O + N <sub>2</sub> ✓ <b>IGNORE</b> state symbols	1	<b>ALLOW</b> multiples, e.g. NaNO <sub>2</sub> + 3Na → 2Na <sub>2</sub> O + ½N <sub>2</sub>
<b>Total</b>			<b>14</b>	



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



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

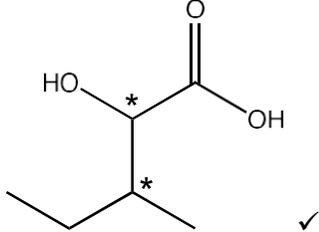


Question		Answer	Marks	Guidance
(c)	(ii)	<p><b>FIRST CHECK THE ANSWER ON THE ANSWER LINE</b>  <b>IF</b> answer = 0.023(125) (mol) award 3 marks for calculation</p> <p>-----</p> <p><b><i>K<sub>c</sub> expression</i></b>  <math>(K_c =) \frac{[\text{CH}_3\text{COOOH}]}{[\text{H}_2\text{O}_2][\text{CH}_3\text{COOH}]}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

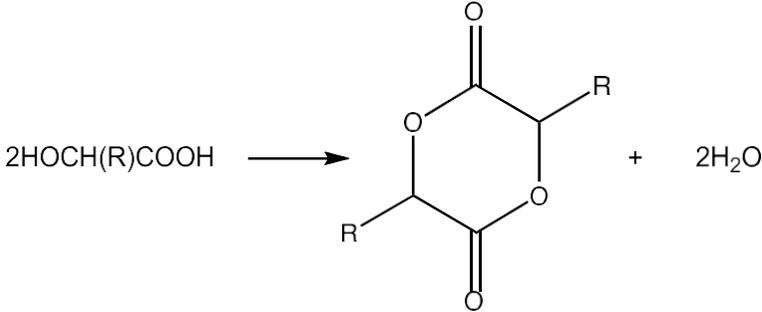
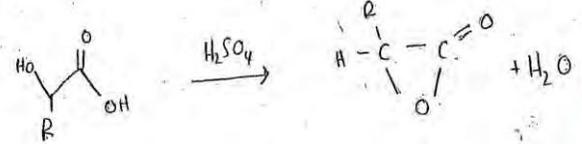


Question			Answer					Marks	Guidance														
4	(a)	(i)	<p><b>Burette readings</b></p> <table border="1"> <tr> <td>Final (reading)/cm<sup>3</sup></td> <td>23.15</td> <td>45.95</td> <td>32.45</td> <td rowspan="2">✓</td> </tr> <tr> <td>Initial (reading)/cm<sup>3</sup></td> <td>0.60</td> <td>23.15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



Question	Answer	Marks	Guidance
(a) (ii)	<p><b>ALLOW 3SF</b> or more throughout  <b>IGNORE</b> trailing zeroes, e.g. <b>ALLOW</b> 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><b>ALLOW</b> alkyl group in drawn structure with straight chain or branch(es) in wrong position, e.g. for R = C<sub>4</sub>H<sub>9</sub>, CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub> <b>OR</b> (CH<sub>3</sub>)<sub>3</sub>C</p> <p>Structure with chiral carbon atoms identified (see * below)</p> 	6	<p><b>ALLOW ECF</b> from incorrect mean titre in <b>4a(i)</b>  e.g. From 22.60 cm<sup>3</sup> (mean of all 3 titres in <b>(i)</b>),  <math>n(\text{NaOH}) = 1.8984 \times 10^{-3} \text{ (mol)}</math></p> <p><b>ALLOW ECF</b> from incorrect <math>n(\text{NaOH})</math></p> <p><b>ALLOW ECF</b> from incorrect <math>n(\text{A})</math></p> <p><b>ALLOW ECF</b> from incorrect <math>M(\text{A}) - 75</math></p> <p><b>ALLOW ECF</b> for alkyl group closest to calculated <math>M(\text{alkyl group})</math>, e.g. for <math>M = 45</math>, <b>ALLOW</b> C<sub>3</sub>H<sub>7</sub> (43)</p> <p><b>ALLOW</b> correct structural <b>OR</b> skeletal <b>OR</b> displayed formula <b>OR</b> mixture of the above as long as non-ambiguous</p> <p><b>IGNORE</b> poor connectivity to OH groups  <i>Given in question</i></p> <hr/> <p><b>Common error for 4 marks max</b>  25.00 instead of 22.50 and scaling by <math>\times 10</math>  <math>2.10 \times 10^{-3} \times \rightarrow 2.10 \times 10^{-2} \checkmark</math>  <math>\rightarrow 118.81 \checkmark \rightarrow 43.81 \checkmark \rightarrow \text{C}_3\text{H}_7 \checkmark</math></p> <p>25.00 instead of 22.50 and scaling by <math>\times \frac{250}{22.50}</math>  <math>2.10 \times 10^{-3} \times \rightarrow 2.33 \times 10^{-2} \checkmark</math>  <math>\rightarrow 106.93 \checkmark \rightarrow 31.93 \checkmark \rightarrow \text{C}_2\text{H}_5 \checkmark</math>  No structure with 2 chiral centres possible <math>\times</math></p>



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



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



Question			Answer	Marks	Guidance
			<b>For 5a(i)–(iv) IGNORE</b> 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	<b>ALLOW</b> correct structural <b>OR</b> skeletal <b>OR</b> displayed formula <b>OR</b> 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	<b>ALLOW</b> correct skeletal <b>OR</b> displayed formula <b>OR</b> mixture of the above as long as non-ambiguous  <b>ALLOW</b> C <sub>4</sub> H <sub>9</sub> SH  <b>ALLOW</b> CH <sub>3</sub> COOH  Thioester functional group <b>must</b> be fully displayed, <b>OR</b> as a skeletal formula but allow SC <sub>4</sub> H <sub>9</sub> in thioester
	(a)	(iii)	 ✓	1	<b>IF</b> correct <b>skeletal</b> formula is shown, <b>IGNORE</b> displayed formula in a second structure
	(a)	(iv)	 Reactants ✓ Products <b>AND</b> balanced equation ✓	2	<b>ALLOW</b> correct structural <b>OR</b> skeletal <b>OR</b> displayed formula <b>OR</b> 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><b>Level 3 (5–6 marks)</b> Develops a plan that identifies <b>all</b> compounds by a process of elimination <b>AND</b> 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><b>Level 2 (3–4 marks)</b> Develops a plan that identifies at least half of the compounds <b>OR</b> identifies the functional groups in most of the compounds <b>AND</b> 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><b>Level 1 (1–2 marks)</b> Develops a plan that attempts to identify the compounds <b>OR</b> functional groups <b>AND</b> includes detail of the required tests and observations <i>There is a line of reasoning using information that is mostly relevant.</i></p> <p><b>0 marks</b> – No response or no response worthy of credit with no compounds identified</p>	6	<p><b>Indicative scientific points may include:</b></p> <p><b>Functional groups</b></p> <ul style="list-style-type: none"> <li>• <b>B</b> alkene and tertiary alcohol</li> <li>• <b>C</b> alkene and aldehyde</li> <li>• <b>D</b> alkene and primary alcohol</li> <li>• <b>E</b> ketone</li> <li>• <b>F</b> secondary alcohol</li> <li>• <b>G</b> alkene and ketone</li> </ul> <p><b>Tests</b></p> <ul style="list-style-type: none"> <li>• <b>B, C, D</b> and <b>G</b> → <b>Bromine</b> decolourises</li> <li>• <b>C, D</b> and <b>F</b> → <math>(\text{H}^+)/\text{Cr}_2\text{O}_7^{2-}</math> green</li> <li>• <b>C, E</b> and <b>G</b> → <b>2,4-DNP</b> orange precipitate</li> <li>• <b>C</b> → <b>Tollens</b> silver mirror</li> </ul> <p>For Tollens' <b>ALLOW</b> alternative: Fehling's solution produces a 'brown/brick red/orange precipitate' For 2,4-DNP, <b>ALLOW</b> 2,4-DNPH and Brady's</p> <table border="1"> <thead> <tr> <th></th> <th><b>B</b></th> <th><b>C</b></th> <th><b>D</b></th> <th><b>E</b></th> <th><b>F</b></th> <th><b>G</b></th> </tr> </thead> <tbody> <tr> <td><b>Bromine</b></td> <td>✓</td> <td>✓</td> <td>✓</td> <td></td> <td></td> <td>✓</td> </tr> <tr> <td><math>(\text{H}^+)/\text{Cr}_2\text{O}_7^{2-}</math></td> <td></td> <td>✓</td> <td>✓</td> <td></td> <td>✓</td> <td></td> </tr> <tr> <td><b>2,4-DNP</b></td> <td></td> <td>✓</td> <td></td> <td>✓</td> <td></td> <td>✓</td> </tr> <tr> <td><b>Tollens'</b></td> <td></td> <td>✓</td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table> <p><b>No credit for tests on products of tests, melting points, spectra, etc.</b> <b>For other tests seen, contact TL for advice</b></p>		<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>F</b>	<b>G</b>	<b>Bromine</b>	✓	✓	✓			✓	$(\text{H}^+)/\text{Cr}_2\text{O}_7^{2-}$		✓	✓		✓		<b>2,4-DNP</b>		✓		✓		✓	<b>Tollens'</b>		✓				
	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>F</b>	<b>G</b>																																
<b>Bromine</b>	✓	✓	✓			✓																																
$(\text{H}^+)/\text{Cr}_2\text{O}_7^{2-}$		✓	✓		✓																																	
<b>2,4-DNP</b>		✓		✓		✓																																
<b>Tollens'</b>		✓																																				
	<b>Total</b>	<b>12</b>																																				



## Appendix for Q5b Level of Response

### Results of tests

	B	C	D	E	F	G
Bromine	✓	✓	✓			✓
(H <sup>+</sup> )/Cr <sub>2</sub> O <sub>7</sub> <sup>2-</sup>		✓	✓		✓	
2,4-DNP		✓		✓		✓
Tollens		✓				

### Possible processes of elimination (not inclusive)

BCDEFG with 2,4 DNP

CEG orange ppt  
CEG with Tollens  
EG with bromine

C silver mirror  
G decolourises E no change

BDF with (H<sup>+</sup>)/Cr<sub>2</sub>O<sub>7</sub><sup>2-</sup>

DF green  
DF with bromine

B no colour change  
D decolourises F no change

BCDEFG with (H<sup>+</sup>)/Cr<sub>2</sub>O<sub>7</sub><sup>2-</sup>

CDF green  
CDF with Tollens/2,4DNP  
DF with bromine

C silver mirror/orange ppt  
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<sup>+</sup>)/Cr<sub>2</sub>O<sub>7</sub><sup>2-</sup>  
BCDG with Tollens'  
BDG with H<sup>+</sup>/Cr<sub>2</sub>O<sub>7</sub><sup>2-</sup>  
BG with 2,4-DNP

EF no change  
E orange ppt/F green  
C silver mirror BDG no change  
D green BG no change  
G orange ppt B no change

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