



Mark Scheme (Results)

Summer 2015

IAL Chemistry (WCH04)

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Summer 2015

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## General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:
  - i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  - ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  - iii) organise information clearly and coherently, using specialist vocabulary when appropriate

**Section A (multiple choice)**

Question Number	Correct Answer	Mark
<b>1</b>	A	1

Question Number	Correct Answer	Mark
<b>2</b>	C	1

Question Number	Correct Answer	Mark
<b>3</b>	A	1

Question Number	Correct Answer	Mark
<b>4</b>	C	1

Question Number	Correct Answer	Mark
<b>5</b>	C	1

Question Number	Correct Answer	Mark
<b>6(a)</b>	D	1

Question Number	Correct Answer	Mark
<b>6(b)</b>	B	1

Question Number	Correct Answer	Mark
<b>7</b>	B	1

Question Number	Correct Answer	Mark
<b>8(a)</b>	D	1

Question Number	Correct Answer	Mark
<b>8(b)</b>	C	1

Question Number	Correct Answer	Mark
<b>9</b>	B	1

Question Number	Correct Answer	Mark
<b>10(a)</b>	C	1

Question Number	Correct Answer	Mark
<b>10(b)</b>	A	1

Question Number	Correct Answer	Mark
<b>10(c)</b>	D	1

Question Number	Correct Answer	Mark
<b>11(a)</b>	D	1

Question Number	Correct Answer	Mark
<b>11(b)</b>	C	1

Question Number	Correct Answer	Mark
<b>11(c)</b>	A	1

Question Number	Correct Answer	Mark
<b>12(a)</b>	B	1

Question Number	Correct Answer	Mark
<b>12(b)</b>	A	1

Question Number	Correct Answer	Mark
<b>12(c)</b>	B	1

**Total for Section A = 20 marks**

## Section B

Question Number	Acceptable Answers	Reject	Mark
<p><b>13(a)</b> <b>(i)</b></p>	<p><b>1<sup>st</sup> mark: Identification of buffer</b></p> <p>Any mention of buffer solution / buffering (region) <b>(1)</b></p> <p><b>2<sup>nd</sup> mark: Identification of species responsible for buffering action</b></p> <p>ammonia/NH<sub>3</sub> <b>and</b> ammonium ions /NH<sub>4</sub><sup>+</sup> present (in significant concentrations) <b>OR</b> ammonia/NH<sub>3</sub> <b>and</b> ammonium chloride /NH<sub>4</sub>Cl present (in significant concentrations) <b>OR</b> weak base <b>and</b> salt/conjugate acid present (in significant concentrations) <b>OR</b> B <b>and</b> BH<sup>+</sup> present (in significant concentrations) <b>Can be awarded from a correct equation</b> <b>(1)</b></p> <p><b>3<sup>rd</sup> mark: For mention of how this buffer works on addition of small amounts of H<sup>+</sup> ions</b></p> <p>(relatively large concentration/reservoir of) ammonia molecules react with added hydrogen ions/ H<sup>+</sup> /(hydrochloric) acid <b>OR</b> (relatively large concentration /reservoir of weak) base reacts with added hydrogen ions / H<sup>+</sup> /(hydrochloric) acid <b>OR</b> H<sup>+</sup> + NH<sub>3</sub>→NH<sub>4</sub><sup>+</sup> <b>Allow</b> reversible arrow <b>OR</b> Adding (hydrochloric) acid/H<sup>+</sup> /hydrogen ions has negligible effect on ratio [NH<sub>3</sub>]: [NH<sub>4</sub><sup>+</sup>] <b>(1)</b></p> <p><b>Ignore</b> references to buffering action on addition of OH<sup>-</sup> (not relevant here)</p> <p><b>Ignore</b> general descriptions of buffer solution eg resists change in pH when small amounts of acid or alkali added</p>	<p>Acidic buffer</p> <p>Weak acid and its conjugate base HA and A<sup>-</sup></p>	<p><b>3</b></p>

Question Number	Acceptable Answers	Mark
<b>13(a)</b> <b>(ii)</b>	<p><b>Note</b> – the equations  <math>\text{NH}_4^+ + \text{H}_2\text{O} \rightarrow \text{NH}_3 + \text{H}_3\text{O}^+</math>  <math>\text{NH}_4^+ + \text{H}_2\text{O} \rightarrow \text{NH}_4\text{OH} + \text{H}^+</math>  score <b>all three marks</b></p> <p><b>Note</b> –the equation  <math>\text{NH}_4^+ \rightarrow \text{NH}_3 + \text{H}^+</math>  scores 2 marks, but if (aq) state symbols are given,  scores 3 marks</p> <p><b>1<sup>st</sup> mark:</b>  Ammonium ions /<math>\text{NH}_4^+</math> present (at equivalence point)  <b>OR</b>  ammonium chloride/ammonium salt <b>(1)</b></p> <p><b>2<sup>nd</sup> mark</b>  Ammonium (ions) / <math>\text{NH}_4^+</math> react with water /hydrolysed  by water /dissociate in water  <b>Ignore</b> ammonium chloride reacts with water <b>(1)</b></p> <p><b>3<sup>rd</sup> mark</b>  <math>\text{NH}_4^+ \rightarrow \text{NH}_3 + \text{H}^+</math>  <b>OR</b>  <math>\text{NH}_4^+ + \text{H}_2\text{O} \rightarrow \text{NH}_3 + \text{H}_3\text{O}^+</math>  <b>Allow</b>  <math>\text{NH}_4^+ + \text{H}_2\text{O} \rightarrow \text{NH}_4\text{OH} + \text{H}^+</math> <b>(1)</b></p> <p><b>Note if no other mark awarded</b>  Just 'strong acid – weak base (titration)' /  ammonium chloride is the salt of a strong acid and a  weak base scores <b>(1)</b> only</p>	<b>3</b>

Question Number	Acceptable Answers	Mark
<b>13(a) (iii)</b>	<p><b>If final answer is 1.6(2), with correct working or without working, award 4 marks</b></p> <p>Mol of ammonia used = <math>(25/1000 \times 0.024)</math>  <math>= 6 \times 10^{-4}</math> mol</p> <p><b>and</b></p> <p>Mol of acid added = <math>(40/1000 \times 0.054)</math>  <math>= 2.16 \times 10^{-3}</math> (1)</p> <p>Mol of excess acid = <math>2.16 \times 10^{-3} - 6 \times 10^{-4}</math>  <math>= 1.56 \times 10^{-3}</math> mol (1)</p> <p><math>[H^+] = 1.56 \times 10^{-3} / (65/1000) = 0.024 \text{ mol dm}^{-3}</math> (1)</p> <p><math>\text{pH} = -\log [H^+] = 1.6(2)</math> (1)</p> <p><b>Ignore</b> SF except 1 SF  <b>Allow</b> TE for 2<sup>nd</sup>, 3<sup>rd</sup> marks  <b>Allow</b> TE for 4<sup>th</sup> mark provided pH is less than 7 and it is based on some use of data in question</p> <p><b>Alternative method for 1<sup>st</sup> and 2<sup>nd</sup> marks</b></p> <p>Mol of ammonia used = <math>(25/1000 \times 0.024)</math>  <math>= 6 \times 10^{-4}</math> mol</p> <p><b>and</b></p> <p>Volume of acid used = <math>\frac{6 \times 10^{-4} \times 1000}{0.054}</math>  <math>= 11.111 \text{ cm}^3</math> (1)</p> <p>Volume of acid left = <math>40 - 11.111</math>  <math>= 28.889 \text{ cm}^3</math></p> <p>Mol of excess acid = <math>\frac{28.889 \times 0.054}{1000}</math>  <math>= 1.56 \times 10^{-3}</math> mol (1)</p>	<b>4</b>

Question Number	Acceptable Answers	Reject	Mark
<b>13(b)(i)</b>	<p><b>EITHER</b></p> <p><math>[H^+]^2 = 5.5 \times 10^{-13}</math> or <math>[H^+] = \sqrt{5.5 \times 10^{-13} / 7.416 \times 10^{-7}}</math>  <math>(\text{mol dm}^{-3})</math> (1)</p> <p><math>\text{pH} = -\log \sqrt{5.5 \times 10^{-13}} (= 6.12982 / 6.13)</math> (1)</p> <p><b>OR</b></p> <p><math>\text{pK}_w = 12.26</math> (1)</p> <p><math>\text{pH} = \frac{1}{2} \text{pK}_w (= 6.130)</math> (1)</p>	6.13 with no working	<b>2</b>



Question Number	Acceptable Answers	Reject	Mark
<b>13(b)</b> <b>(ii)</b>	Neutral (1)  [H <sup>+</sup> ] = [OH <sup>-</sup> ] /equal amounts of H <sup>+</sup> and OH <sup>-</sup> ions <b>OR</b> <b>Both</b> [H <sup>+</sup> ] and [OH <sup>-</sup> ] have increased by the same amount (1)	Acidic or alkaline for both marks	<b>2</b>

**Total for Question 13 = 14 marks**

Question Number	Acceptable Answers	Reject	Mark
14(a)	<p><b>The first two marks can be scored from a diagram or a written account</b></p> <p>Suitable reaction vessel e.g. side arm conical flask / flask with delivery tubing attached via bung / side arm boiling/test tube / boiling/test tube with delivery tubing attached via bung (1)</p> <p>Method of gas collection e.g. gas syringe / upturned measuring cylinder/burette over water <b>Allow</b> this as a label on a poorly drawn diagram (1)</p> <p>Measure volume collected at time intervals / time taken to collect fixed volume <b>Allow</b> mention of volume and time <b>Allow</b> amount of gas and time <b>Ignore</b> measure time taken for reaction to go to completion (1)</p> <p><b>OR</b> A suitable open reaction vessel (but plugged with cotton wool) (1)</p> <p>Use of balance (1)</p> <p>Measure the mass at various time intervals / at a fixed time on a balance <b>Allow</b> mention of mass (loss) and time (1)</p> <p><b>Ignore</b> heating</p>	<p>Diagram of apparatus that will not work eg delivery tube starting in solution or apparatus not sealed for first mark only</p> <p>Measure rate at which gas is produced</p>	3

Question Number	Acceptable Answers	Mark
<b>14(b)(i)</b>	<p>Any linked pair of responses. In each pair, the 2<sup>nd</sup> mark is dependent on the 1<sup>st</sup> mark being awarded.</p> <p><b>EITHER</b>            Reaction is endothermic /energy taken in / temperature <b>falls</b>  <b>Allow</b> just "lower temperature"  <b>Ignore</b> room temperature falls (1)</p> <p>Decreases rate of reaction (1)</p> <p><b>OR</b>            There is loss of product/gas before the apparatus is sealed (1)</p> <p>This is <b>greater</b> because the reaction is at a higher concentration (of A) (1)</p> <p><b>OR</b>            Active sites/surface (area) on catalyst full/blocked/saturated (1)</p> <p>Because the reaction is at a higher concentration (of A)/ decreases rate of reaction (1)</p> <p><b>Ignore</b> references to experimental error</p> <p><b>Ignore</b> comparisons of concentrations of A and B</p> <p><b>Ignore</b> any reference to side-reactions</p>	<b>2</b>

Question Number	Acceptable Answers	Mark
<b>14(b)(ii)</b>	<p>0 order <span style="float: right;"><b>(1)</b></span></p> <p>As increase/change in concentration does not affect the rate /rate is independent of [A]</p> <p><b>Allow</b> graph is a horizontal line / has zero gradient <b>(1)</b></p> <p><b>Ignore</b> graph is a straight line</p> <p><b>Ignore</b> just 'there is no change in the rate' / 'rate is constant' / gradient remains constant</p>	<b>2</b>

Question Number	Acceptable Answers	Mark
<b>14(c)(i)</b>	<p><b>EITHER</b></p> <p>increases reliability improves validity (of the data obtained) /</p> <p>confirms the initial result /</p> <p>to check for anomalous results</p> <p><b>Ignore</b></p> <p>References to average/precision/accuracy</p> <p><b>OR</b></p> <p>to determine order w.r.t B and/or X /</p> <p>to determine order w.r.t reactants / substances /</p> <p>to find overall order /</p> <p>to see the effect of B and/or X on the rate/</p> <p>to see the effect of reactants/ substances on the rate/</p> <p>to determine rate equation /</p> <p>to calculate <math>k</math></p> <p><b>Allow</b> to find out which species are in the rate determining step</p>	<b>1</b>

Question Number	Acceptable Answers	Mark
<b>14(c)(ii)</b>	<p>2nd order w.r.t B (1)</p> <p>(Compare expt 1 &amp; 2 when [X] is constant), as [B] triples so rate increases by a factor of 9 (1)</p> <p>First order w.r.t X (1)</p> <p><b>EITHER (using experiments 1 and 3 or 1 and 4)</b> as [B] quadruples so rate should increase by a factor of 16 but increases by a factor of 32 / additional increase of x 2 due to doubling of [X] (hence first order w.r.t X)</p> <p><b>OR (using experiments 2 and 3 or 2 and 4)</b> as [B] x4/3 (1.333) so rate should increase by a factor of 16/9 (1.778) but increases by 3.556 / additional increase of x2 due to doubling of [X] (hence first order w.r.t X)</p> <p><b>Allow</b> these explanations shown as equations</p> <p>If C used instead of X, allow both marks for order and explanation (1)</p> <p><b>Allow</b> TE on order w.r.t A and B</p>	<b>4</b>

Question Number	Acceptable Answers	Mark
<b>14(c)(iii)</b>	<p>Rate = <math>k[B]^2[X]</math> / Rate = <math>k[A]^0[B]^2[X]</math></p> <p><b>Allow</b> r/R for rate and K for k</p> <p><b>Allow</b> TE from b(ii) and c(ii)</p>	<b>1</b>

Question Number	Acceptable Answers	Mark
<b>14(c)(iv)</b>	<p><math>k = \text{rate}/[B]^2[X] = 0.08/(0.1 \times 0.1 \times 0.2)</math> = 40 (1)</p> <p><math>\text{dm}^6\text{mol}^{-2}\text{s}^{-1}</math></p> <p><b>Allow</b> units in any order (1)</p> <p><b>Allow</b> use of data from experiments 1, 2 &amp; 4</p> <p><b>Allow</b> TE from c(iii)</p>	<b>2</b>

Question Number	Acceptable Answers	Mark
<b>14(d)</b>	<p><b>Correct feature – two from</b></p> <p>Mechanism does involve (formation of) a transition state  <b>Allow</b> mechanism does involve the (formation of) an intermediate  <b>Allow</b> transition/intermediate step (1)</p> <p>Second order overall / <math>S_N2</math> / both halogenoalkane and hydroxide ions involves in slow step/rds/1<sup>st</sup> Step (1)</p> <p>Correct curly arrow from C-Br bond to Br (1)</p> <p>Transition state has a negative charge / correct charge  Or  Charges on all species are correct (1)</p> <p><b>Ignore</b> references to stereochemistry  <b>Ignore</b> references to final product correct/ lone pairs correct</p> <p><b>Incorrect features – two from</b></p> <p>Curly arrow should go from <math>OH^-</math> to carbon (attached to Br as it represents movement of a lone pair of electrons) / <math>OH^-</math> should give electrons rather than accept them  <b>Allow</b> the arrow between C and O should be in the opposite direction (1)</p> <p>Bonds to OH and Br should be partial bonds /dotted lines (in transition state as insufficient electrons for (five) complete bonds) / carbon can only form four full bonds (1)</p> <p><b>Allow</b>  Dipole/partial charges on C-Br not shown (1)</p> <p><b>Ignore</b>  Mechanism should be 1 step not 2 steps for <math>S_N2</math>  <b>Ignore</b> there should be a curly arrow from C-Br bond to Br in the transition state</p>	<b>4</b>

**Total for Question 14 = 19 marks**

Question Number	Acceptable Answers	Reject	Mark
<b>15(a)</b>	ethyl dodecanoate  <b>Allow</b> ethyldodecanoate ethyl dodecan-1-oate	ethyl decanoate / ethyl dodecanal/ ethyl dodecate / ethanoyl dodecanoate	<b>1</b>

Question Number	Acceptable Answers	Mark
<b>15(b)</b>	Reducing (agent)  <b>Allow</b> (source of) nucleophile  <b>Ignore</b> source of hydride ions	<b>1</b>

Question Number	Acceptable Answers	Mark
<b>15(c)</b>	Prevent further reduction / reduction of the aldehyde (to an alcohol)  <b>Allow</b> to prevent further reaction of dodecanal /aldehyde  <b>Ignore</b> reference to rates  <b>Ignore</b> higher yield/ prevent side reactions  <b>Ignore</b> exothermic / optimum temperature  <b>Ignore</b> volatility	<b>1</b>

Question Number	Acceptable Answers	Mark
<b>15(d)</b>	<p><b>If final answer is 3.74 (g), with or without working, award 3 marks</b></p> <p>Moles ester = <math>5.26 / 228 = 0.02307</math> mol  <b>NOTE:</b> Do not allow this rounded to 0.02 (1)</p> <p><b>EITHER</b>            So mass of aldehyde at 100%                = <math>0.02307 \times 184</math>                = 4.2449 (g) (1)</p> <p>But yield is 88%, so actual mass                = <math>4.245 \times 0.88</math>                = 3.7355 / 3.74 (g)            Allow 3.73 g if 4.24 g of aldehyde used (1)</p> <p><b>OR</b>            But yield is 88%, so actual moles                = <math>0.02307 \times 0.88</math>                = 0.02(03) (1)</p> <p>So mass of aldehyde formed                = <math>0.0203 \times 184</math>                = 3.7355 / 3.74 / 3.7 (g) (1)</p> <p><b>Allow</b> TE for 2<sup>nd</sup> and 3<sup>rd</sup> marks</p> <p>Ignore SF in final answer except 1SF</p>	<b>3</b>

**Total for Question 15 = 6 marks**



Question Number	Acceptable Answers	Reject	Mark
<b>16(a)(i)</b>	(fractional) distillation / steam distillation / solvent extraction  <b>Ignore</b> filtration / use of separating funnel	recrystallisation	<b>1</b>

Question Number	Acceptable Answers	Mark
<b>16(a)(ii)</b>	$3\text{C}_{15}\text{H}_{31}\text{COOCH}_3 + \begin{array}{c} \text{CH}_2\text{OH} \\   \\ \text{CHOH} \\   \\ \text{CH}_2\text{OH} \end{array}$ <p>3 C<sub>15</sub>H<sub>31</sub>COOCH<sub>3</sub>  <b>Allow</b>  3 CH<sub>3</sub>OOCC<sub>15</sub>H<sub>31</sub>  <b>Allow</b> the correct formulae written three times <b>(1)</b>  Correct formula for propane-1,2,3-triol <b>(1)</b>  Mark independently</p>	<b>2</b>

Question Number	Acceptable Answers	Mark
<b>16(a)(iii)</b>	Sodium hydroxide / potassium hydroxide / NaOH / KOH / OH <sup>-</sup>  <b>Allow</b> sulfuric acid / H <sub>2</sub> SO <sub>4</sub> or other named strong acids or strong alkalis / HCl / just 'acid' / just 'base' / just 'alkali' / just H <sup>+</sup>  <b>Ignore</b> concentrations of reagents, incorrect or missing state symbols	<b>1</b>

Question Number	Acceptable Answers	Mark
16(b)	<p><b>Do not award any marks for processing the plants or seeds into bio-diesel as the question is about growing</b></p> <p><b>Award (1) mark for any statement in the following headings:</b></p> <p>GREEN e.g. samphire / non-edible seeds / both are renewable / (produce bio-diesel that is) carbon neutral Ignore just "green / sustainable"</p> <p>LAND e.g. samphire uses land unlikely to be used for growing other food crops / no need to cut down trees to provide land / non-edible seed take up land otherwise used to grow crops</p> <p>WASTE e.g. non-edible seeds have no other use / would be thrown away / can only be used for oil production</p> <p>FOOD e.g. using samphire for bio-diesel <b>reduces availability</b> as a food source</p> <p>FOOD CHAIN e.g. using samphire disrupts the food chain for (marine) organisms</p> <p>GROWING e.g. samphire doesn't need to be irrigated / can take water or nutrients from the marshland Ignore just 'easier to grow' Ignore does not need specific conditions</p> <p>WEATHER e.g. samphire growing is subject to coastal weather</p> <p>TECHNOLOGY e.g. using samphire needs new / improved technology OR machines to farm coastal areas OR higher transport costs (from marshland to production plant) Ignore technology for processing plants or seeds</p> <p>WILL IT WORK? e.g. samphire gives unknown yield / use may need more research</p> <p><b>To score the maximum of 4 marks, the response must include a decision about which is greener but there is no separate mark for this.</b></p>	4

**Total for Question 16 = 8 marks**

## Section C

Question Number	Acceptable Answers	Mark															
<b>17(a)(i)</b>	<table border="1"> <thead> <tr> <th></th> <th>CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>3</sub></th> <th>O<sub>2</sub></th> <th>CH<sub>3</sub>CO<sub>2</sub>H</th> <th>H<sub>2</sub>O</th> </tr> </thead> <tbody> <tr> <td><math>\Delta H_f^\ominus</math> / kJ mol<sup>-1</sup></td> <td><b>-126.5</b></td> <td>0</td> <td><b>-484.5</b></td> <td><b>-285.8</b></td> </tr> <tr> <td><math>S^\ominus</math> / J mol<sup>-1</sup> K<sup>-1</sup></td> <td><b>310.1</b></td> <td>205</td> <td><b>159.8</b></td> <td><b>69.9</b></td> </tr> </tbody> </table> <p>6 values correct 3 marks</p> <p>4 / 5 values correct 2 marks</p> <p>2/3 values correct 1 mark</p> <p>0/1 values correct 0 marks</p> <p><b>Ignore</b> values multiplied by balancing numbers in addition to correct values eg for water 2 x -285.8 (=571.6)</p>		CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>3</sub>	O <sub>2</sub>	CH <sub>3</sub> CO <sub>2</sub> H	H <sub>2</sub> O	$\Delta H_f^\ominus$ / kJ mol <sup>-1</sup>	<b>-126.5</b>	0	<b>-484.5</b>	<b>-285.8</b>	$S^\ominus$ / J mol <sup>-1</sup> K <sup>-1</sup>	<b>310.1</b>	205	<b>159.8</b>	<b>69.9</b>	<b>3</b>
	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>3</sub>	O <sub>2</sub>	CH <sub>3</sub> CO <sub>2</sub> H	H <sub>2</sub> O													
$\Delta H_f^\ominus$ / kJ mol <sup>-1</sup>	<b>-126.5</b>	0	<b>-484.5</b>	<b>-285.8</b>													
$S^\ominus$ / J mol <sup>-1</sup> K <sup>-1</sup>	<b>310.1</b>	205	<b>159.8</b>	<b>69.9</b>													

Question Number	Acceptable Answers	Mark
<b>17(a)(ii)</b>	<p><b>If answer is - 2256.6 / - 2257 (kJ mol<sup>-1</sup>), award 2 marks</b></p> <p>[(2 x -285.8) + (4 x -484.5)] - (2 x -126.5) <span style="float: right;"><b>(1)</b></span></p> <p>= - 2256.6 / - 2257 (kJ mol<sup>-1</sup>) <span style="float: right;"><b>(1)</b></span></p> <p><b>Allow</b> answer converted to J mol<sup>-1</sup></p> <p><b>Allow</b> TE from incorrect data in table in (a)(i)</p> <p><b>Allow</b> (1) for cycle wrong way round eg (+) 2256.6 / (+)2257 (kJ mol<sup>-1</sup>)</p> <p><b>Allow</b> (1) for using correct values but not multiplied by balancing numbers eg -643.8 (kJ mol<sup>-1</sup>)</p> <p><b>Ignore</b> SF except 1SF</p>	<b>2</b>

Question Number	Acceptable Answers	Mark
<b>17(a) (iii)</b>	<p><b>If answer is <math>-866.2 \text{ (J mol}^{-1}\text{K}^{-1}\text{)}</math>, award 2 marks</b></p> $\frac{[(2 \times 69.9) + (4 \times 159.8)] - [(2 \times 310.1) + (5 \times 205)]}{-866.2 \text{ (J mol}^{-1}\text{K}^{-1})}$ <p><b>(1)</b></p> <p><b>(1)</b></p> <p><b>Allow</b> answer converted to <math>\text{kJ mol}^{-1}\text{K}^{-1}</math></p> <p><b>Allow</b> TE from incorrect data in table in (a)(i)</p> <p><b>Allow</b> (1) for cycle wrong way round eg (+) <math>866.2 \text{ (J mol}^{-1}\text{K}^{-1}\text{)}</math></p> <p><b>Allow</b> (1) for using correct values but error(s) in balancing numbers eg <math>-285.4 \text{ (J mol}^{-1}\text{K}^{-1}\text{)}</math></p> <p><b>Ignore</b> SF except 1SF</p>	<b>2</b>

Question Number	Acceptable Answers	Mark
<b>17(a) (iv)</b>	<p><b>If answer is (+) <math>6706.3 \text{ J mol}^{-1} \text{ K}^{-1}</math> or (+) <math>6.7063 \text{ kJ mol}^{-1} \text{ K}^{-1}</math>, award 3 marks</b></p> $\Delta S_{\text{surr}} \text{ at } 298 \text{ K} = -\Delta H/T$ $= -(-2256.6 \times 1000) / 298$ <p><b>(1)</b></p> $= 7572.483... \text{ (J mol}^{-1}\text{K}^{-1}\text{)}$ <p><b>Allow</b> rounding to 3SF or more <b>(1)</b></p> <p><b>Allow</b> correct answers given in <math>\text{kJ mol}^{-1} \text{ K}^{-1}</math> eg <math>7.5725 \text{ kJ mol}^{-1} \text{ K}^{-1}</math></p> $\Delta S_{\text{tot}} = \Delta S_{\text{surr}} + \Delta S_{\text{sys}} / \Delta S_{\text{tot}} = -866.2 + 7572.5 / \Delta S_{\text{tot}} = (+)6706.3 \text{ J mol}^{-1} \text{ K}^{-1}$ <p><b>OR</b></p> $-0.8662 + 7.5725 / \Delta S_{\text{tot}} = (+)6.7063 \text{ kJ mol}^{-1} \text{ K}^{-1}$ <p><b>(1)</b></p> <p><b>Allow</b> TE from (a)(ii) and (a)(iii)</p> <p><b>Ignore</b> SF except 1SF in final answer</p>	<b>3</b>

Question Number	Acceptable Answers	Mark
<b>17(a)(v)</b>	<p><b>1st mark: consideration of <math>\Delta S_{\text{system}}</math></b>  <math>\Delta S_{\text{sys}}</math> is not (significantly) changed /is unchanged /remains (approximately) constant <b>(1)</b></p> <p><b>2nd mark: consideration of <math>\Delta S_{\text{surr}}</math></b>  (Higher temperature makes) <math>\Delta S_{\text{surr}} / -\Delta H/T</math> is smaller / decreases / less positive  Comment  <b>Allow</b> more negative <b>(1)</b>  <b>No TE</b> if <math>\Delta S_{\text{surr}}</math> is -ve in (a)(iv)</p> <p><b>3rd mark: consideration of <math>\Delta S_{\text{total}}</math></b>  <b>EITHER</b>  reduces <math>\Delta S_{\text{tot}}</math> / makes <math>\Delta S_{\text{tot}}</math> less positive / makes <math>\Delta S_{\text{tot}}</math> closer to zero (so would not produce a greater yield)</p> <p><b>OR</b>  <math>\Delta S_{\text{tot}}</math> is very large (so <math>K</math> is very large) so the effect of change in temperature is negligible <b>(1)</b></p> <p><b>NOTE</b>  if <math>\Delta S_{\text{surr}}</math> is -ve in (iv), then allow increases <math>\Delta S_{\text{tot}}</math> / makes <math>\Delta S_{\text{tot}}</math> more positive / makes <math>\Delta S_{\text{tot}}</math> closer to zero (so would produce a greater yield).</p> <p><b>NOTE</b>  IF no reference / an incorrect reference made to <math>\Delta S_{\text{system}}</math>, then only the 2nd and 3rd marks can be awarded</p>	<b>3</b>

Question Number	Acceptable Answers	Mark
<b>17(b)</b>	<p><b>Note:</b> All we are looking for are the correct ranges, exactly as given below (i.e. the bonds do not have to be stated, as they follow from the correct ranges)</p> <p>Peak between <b>1725 – 1700</b> (<math>\text{cm}^{-1}</math>) (would appear due to C=O group (in alkyl carboxylic acid))</p> <p><b>Allow</b> peak between <b>3300 – 2500</b> (<math>\text{cm}^{-1}</math>) (due to OH group (in carboxylic acid))</p>	<b>1</b>

Question Number	Acceptable Answers	Mark
<b>17(c)</b>	<p>increase sourness / sharpness of flavour</p> <p><b>OR</b> preservative / prevents growth of microbes / prevents food decay / prevents food decomposition /kills microbes</p> <p><b>OR</b> acidity regulator / buffer</p> <p><b>Allow</b> improves flavouring</p> <p><b>Ignore</b> reduce pH/ make (slightly) acidic/just 'flavouring'</p>	<b>1</b>

Question Number	Acceptable Answers	Mark
<b>17(d)(i)</b>	<p><b>Working must be shown</b></p> <p><b>EITHER</b></p> <p>% of oxygen = 40% (1)</p> <p>Amount of C = <math>52.5/12 = 4.375</math> (mol)            Amount of H = <math>7.5/1 = 7.5</math> (mol)            Amount of O = <math>40/16 = 2.5</math> (mol) (1)</p> <p>Ratio 1.75 C : 3 H : 1 O  <math>\equiv 7</math> C : 12 H : 4 O  <b>Ignore</b> SF in mol and ratios (1)</p> <p><b>OR</b></p> <p>% of C in <math>C_7H_{12}O_4 = \frac{84}{160} \times 100 = 52.5\%</math> (1)            % of H in <math>C_7H_{12}O_4 = \frac{12}{160} \times 100 = 7.5\%</math> (1)            % of O in <math>C_7H_{12}O_4 = \frac{64}{160} \times 100 = 40\%</math> (1)</p> <p><b>OR</b></p> <p>No C atoms = <math>\frac{52.5 \times 160}{100 \times 12} = 7</math> (1)            No H atoms = <math>\frac{7.5 \times 160}{100 \times 1} = 12</math> (1)            No O atoms = <math>\frac{40 \times 160}{100 \times 16} = 4</math> (1)</p>	<b>3</b>

Question Number	Acceptable Answers	Reject	Mark
<b>17(d)(ii)</b>	<p>Largest/highest m/e or m/z value (is 160)  <b>OR</b>            Mass (/charge ratio) or m/e or m/z of molecular/parent ion/ <math>C_7H_{12}O_4^+</math> (=160(=<math>M_r</math>))</p> <p><b>Allow</b> last peak / peak on rhs (is at 160)  <b>Allow</b> peak before last (is at 160 due to <math>M+1</math> peak at 161)</p>	<p>Highest peak</p> <p>Just 'there is a peak at 160'</p>	<b>1</b>

Question Number	Acceptable Answers	Mark																
17(d) (iii)	<p data-bbox="418 289 1174 384"><b>For 'chemical shift' column, allow any range or any single value within range and allow range in the opposite order eg 3.0-1.8</b></p> <table border="1" data-bbox="418 415 1096 894"> <thead> <tr> <th data-bbox="418 415 581 573">Feature of compound X</th> <th data-bbox="581 415 751 573">Chemical shift / ppm for TMS</th> <th data-bbox="751 415 971 573">Splitting patterns</th> <th data-bbox="971 415 1096 573">Relative area below peak</th> </tr> </thead> <tbody> <tr> <td data-bbox="418 573 581 642">CH<sub>3</sub></td> <td data-bbox="581 573 751 642">0.1 – 1.9</td> <td data-bbox="751 573 971 642">doublet</td> <td data-bbox="971 573 1096 642"><b>3 (1)</b></td> </tr> <tr> <td data-bbox="418 642 581 800">CH</td> <td data-bbox="581 642 751 800"><b>1.8 – 3.0 (1)</b></td> <td data-bbox="751 642 971 800"><b>septuplet / heptuplet / splits into 7 / 7 splits (1)</b></td> <td data-bbox="971 642 1096 800">1</td> </tr> <tr> <td data-bbox="418 800 581 894">COOH</td> <td data-bbox="581 800 751 894"><b>10 – 12.0 (1)</b></td> <td data-bbox="751 800 971 894">singlet</td> <td data-bbox="971 800 1096 894">1</td> </tr> </tbody> </table> <p data-bbox="418 930 1182 991"><b>Allow</b> heptet / septet / sevenlet and similar words that indicate 7</p>	Feature of compound X	Chemical shift / ppm for TMS	Splitting patterns	Relative area below peak	CH <sub>3</sub>	0.1 – 1.9	doublet	<b>3 (1)</b>	CH	<b>1.8 – 3.0 (1)</b>	<b>septuplet / heptuplet / splits into 7 / 7 splits (1)</b>	1	COOH	<b>10 – 12.0 (1)</b>	singlet	1	<b>4</b>
Feature of compound X	Chemical shift / ppm for TMS	Splitting patterns	Relative area below peak															
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CH	<b>1.8 – 3.0 (1)</b>	<b>septuplet / heptuplet / splits into 7 / 7 splits (1)</b>	1															
COOH	<b>10 – 12.0 (1)</b>	singlet	1															

**Total for Question 17 = 23 marks**



