

# Mark Scheme (Results)

Summer 2013

GCE Chemistry 6CH04/01  
General Principles of Chemistry I

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Summer 2013

Publications Code UA035570

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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

## Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:

- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.

( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.

ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

### Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.

Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

## Section A (multiple choice)

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

Question Number	Correct Answer	Reject	Mark
<b>2</b>	B		<b>1</b>

Question Number	Correct Answer	Reject	Mark
<b>3</b>	C		<b>1</b>

Question Number	Correct Answer	Reject	Mark
<b>4(a)</b>	B		<b>1</b>
<b>(b)</b>	D		<b>1</b>

Question Number	Correct Answer	Reject	Mark
<b>5(a)</b>	B		<b>1</b>
<b>(b)</b>	C		<b>1</b>
<b>(c)</b>	B		<b>1</b>

Question Number	Correct Answer	Reject	Mark
<b>6</b>	A		<b>1</b>

Question Number	Correct Answer	Reject	Mark
<b>7</b>	A		<b>1</b>

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

Question Number	Correct Answer	Reject	Mark
<b>9</b>	A		<b>1</b>

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

Question Number	Correct Answer	Reject	Mark
<b>11</b>	D		<b>1</b>

Question Number	Correct Answer	Reject	Mark
<b>12</b>	B		<b>1</b>

Question Number	Correct Answer	Reject	Mark
<b>13</b>	B		<b>1</b>

Question Number	Correct Answer	Reject	Mark
<b>14</b>	C		<b>1</b>

Question Number	Correct Answer	Reject	Mark
<b>15</b>	D		<b>1</b>

Question Number	Correct Answer	Reject	Mark
<b>16</b>	D		<b>1</b>

**Total for Section A = 20 Marks**

## Section B

Question Number	Acceptable Answers	Reject	Mark
<b>17(a)</b>	<p>Units are not required in (a) or (c) but if used should be correct.                      Penalise incorrect units in (a), (b) &amp; (c) once only                      IGNORE                      case of J and K                      order of units</p> <p><b>First mark:</b>                      65.3/ 130.6 <b>and</b> 69.9 (J mol<sup>-1</sup> K<sup>-1</sup>)      <b>(1)</b></p> <p><b>Second mark:</b>  <math>\Delta S = 69.9 - (130.6 + 102.5)</math>      <b>(1)</b></p> <p><b>Third mark:</b>  <math>\Delta S = -163.2 = -163</math> (J mol<sup>-1</sup> K<sup>-1</sup>)      <b>(1)</b></p> <p>Correct answer with no working scores 3                      Ignore SF except 1 SF                      TE at each stage                      If 65.3 used instead of 130.6 penalize once                      (answer is then <math>\Delta S = -97.9</math> (J mol<sup>-1</sup> K<sup>-1</sup>))</p>	+163 or any positive answer	<b>3</b>

Question Number	Acceptable Answers	Reject	Mark
<b>17(b)</b>	<p><math>\Delta S_{\text{surroundings}} = -\Delta H / T</math> or just numbers      <b>(1)</b>  <math>= +285800/298</math>  <math>= +959.06 = +959</math> J mol<sup>-1</sup> K<sup>-1</sup> /  <math>+0.959</math> kJ mol<sup>-1</sup> K<sup>-1</sup></p> <p>Correct value to 3SF      <b>(1)</b></p> <p>Correct units and positive sign      <b>(1)</b></p> <p>Correct answer with no working scores 3</p>	answer with no sign	<b>3</b>

Question Number	Acceptable Answers	Reject	Mark
<b>17(c)</b>	$\Delta S_{\text{total}} = \Delta S_{\text{system}} + \Delta S_{\text{surroundings}}$ <b>(1)</b> Allow $\Delta S_{\text{reaction}}$ for $\Delta S_{\text{system}}$ $\Delta S_{\text{total}} = \text{answer (a)} + \text{answer (b)}$ $= -163.2 + 959$ $= (+)795.8 = (+)796 \text{ (J mol}^{-1} \text{ K}^{-1}\text{)}$  If $\Delta S_{\text{surroundings}} = +959.06$ then $\Delta S_{\text{total}} = +795.9$ <b>(1)</b>  Correct answer with no working scores 2  Ignore SF except 1 SF  TE on values in (a) & (b) no TE on incorrect equation  If answer to (a) = $-97.9 \text{ (J mol}^{-1} \text{ K}^{-1}\text{)}$ $\Delta S_{\text{total}} = (+)861.1 \text{ (J mol}^{-1} \text{ K}^{-1}\text{)}$		<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>17(d)</b>	A mixture of hydrogen and oxygen is <b>thermodynamically unstable because</b> $\Delta S_{\text{total}}$ is positive  OR  Reaction between hydrogen and oxygen is <b>thermodynamically feasible because</b> $\Delta S_{\text{total}}$ is positive  ALLOW $\Delta S$ for $\Delta S_{\text{total}}$ <b>(1)</b>  No TE on negative $\Delta S_{\text{total}}$ from (c)  The mixture is kinetically inert /stable or reaction is (very) slow <b>because</b> the activation energy is (very) high <b>(1)</b>  Mixture / reaction is <b>kinetically</b> inert / stable but <b>thermodynamically</b> unstable / feasible scores 1 mark  IGNORE References to spark / flame providing the (activation) energy for reaction	Reference to the stability of individual elements	<b>2</b>

**Total for Question 17 = 10 Marks**



Question Number	Acceptable Answers	Reject	Mark
<b>18(a)(i)</b>	$\text{HC}_2\text{O}_4^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{C}_2\text{O}_4^{2-}(\text{aq}) + \text{H}_3\text{O}^+(\text{aq})$ (or $\rightarrow$ ) ALLOW $\text{H}_2\text{O}(\text{aq})$ Equation <b>(1)</b> states <b>(1)</b> ALLOW for 1 mark $\text{HC}_2\text{O}_4^-(\text{aq}) \rightleftharpoons \text{C}_2\text{O}_4^{2-}(\text{aq}) + \text{H}^+(\text{aq})$ States mark is not stand alone but can be awarded if the equation has a minor error e.g. an incorrect charge		<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>18(a)(ii)</b>	$K_a = [\text{C}_2\text{O}_4^{2-}] [\text{H}_3\text{O}^+] / [\text{HC}_2\text{O}_4^-]$ OR $K_a = [\text{C}_2\text{O}_4^{2-}] [\text{H}^+] / [\text{HC}_2\text{O}_4^-]$ No TE on incorrect equation in (a)(i) Penalise incorrect charges in (i) and (ii) once only	$K_a =$ $\frac{[\text{H}^+]^2}{[\text{HC}_2\text{O}_4^-]}$ $\frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]}$	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>18(a)(iii)</b>	No TE on (a)(ii) $K_a = 10^{-4.28} \quad \text{OR} \quad 5.24807 \times 10^{-5} \text{ (mol dm}^{-3}\text{)} \quad \textbf{(1)}$ $K_a = \frac{[\text{H}^+]^2}{[\text{HC}_2\text{O}_4^-]}$ $K_a = \frac{[\text{H}^+]^2}{0.050}$ $[\text{H}^+] = \sqrt{(0.05 \times 10^{-4.28})} = 1.61988 \times 10^{-3} \text{ (mol dm}^{-3}\text{)} \quad \textbf{(1)}$ TE on incorrect $K_a$ value $\text{pH} = -\log 1.61988 \times 10^{-3} = 2.7905 = 2.8 \quad \textbf{(1)}$ For final mark TE on algebraic / arithmetical errors providing $\text{pH} \geq 1.3$ Correct answer with no working scores 3 Ignore SF except 1 SF		<b>3</b>

Question Number	Acceptable Answers	Reject	Mark
<b>18(b)(i)</b>	<p>IGNORE explanations</p> <p><b>First mark:</b>  <math>\text{HC}_2\text{O}_4^-</math>/hydrogenethanedioate ion ionization negligible  ALLOW  Acid for <math>\text{HC}_2\text{O}_4^-</math>  Slight / partial / incomplete / does not dissociate for negligible</p> <p>OR</p> <p><math>[\text{HC}_2\text{O}_4^-]_{\text{equilibrium}} = [\text{HC}_2\text{O}_4^-]_{\text{initial}} / 0.050 \text{ (mol dm}^{-3}\text{)}</math> <b>(1)</b></p> <p><b>Second mark:</b>  <math>[\text{H}^+]</math> due to ionization of water negligible  OR  auto ionization of water negligible</p> <p>OR</p> <p><math>[\text{H}^+]</math> only due to ionization of <math>\text{HC}_2\text{O}_4^-</math>/acid  OR  <math>[\text{C}_2\text{O}_4^{2-}] = [\text{H}^+]</math> <b>(1)</b></p> <p>IGNORE references to temperature and to HA and <math>\text{A}^-</math>  Penalize omission of [ ] in discussion once only</p>	<p>Use of <math>\text{NaHC}_2\text{O}_4</math> for <math>\text{HC}_2\text{O}_4^-</math>  OR  sodium hydrogenethanedioate for hydrogenethanedioate ion throughout this item</p>	<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>18(b)(ii)</b>	<p>Ethanedioic acid is a (much) stronger acid (than hydrogenethanedioate ion / sodium hydrogenethanedioate)</p> <p>OR</p> <p>Ethanedioic acid has a (much) smaller <math>pK_a</math> (than hydrogenethanedioate)</p> <p>OR</p> <p>Ionization / dissociation of ethanedioic acid is (much) greater (than hydrogenethanedioate)</p> <p>OR</p> <p>Reverse arguments <b>(1)</b></p> <p>IGNORE</p> <p><math>\text{NaHC}_2\text{O}_4</math> ionization negligible</p> <p>Approximation of negligible ionization invalid / incorrect</p> <p>OR</p> <p><math>[\text{H}_2\text{C}_2\text{O}_4]_{\text{equilibrium}}</math> not equal to <math>[\text{H}_2\text{C}_2\text{O}_4]_{\text{initial}}</math> <b>(1)</b></p> <p>No TE on 18(a)(iii)</p> <p>IGNORE</p> <p>Second ionization occurs</p>	<p>Ethanedioic acid is a strong acid / fully dissociated</p> <p>Just 'approximation invalid'</p>	<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>18(c)(i)</b>	<p>Start pH at 2.8</p> <p>ALLOW</p> <p>2—4 <b>(1)</b></p> <p>Vertical section at <math>25 \text{ cm}^3</math> within pH range 6-11 and 2.5-4 units long <b>(1)</b></p> <p>end pH (approaching) value in range 12-13 (asymptotically) <b>(1)</b></p>	<p>deviation from vertical</p> <p>maximum before final pH</p>	<b>3</b>

Question Number	Acceptable Answers	Reject	Mark
<b>18(c)(ii)</b>	<p><b>First mark:</b>  Methyl yellow range = 2.9–4  and the phenolphthalein range = 8.2–10  ALLOW  <math>pK_{in}</math> (methyl yellow) = 3.5  and <math>pK_{in}</math> (phenolphthalein) = 9.3 <b>(1)</b></p> <p><b>Second mark:</b>  (The volumes are different) because ethanedioic acid is dibasic / diprotic / has two <b>replaceable/acidic</b> hydrogen atoms  ALLOW dicarboxylic (acid)  (therefore there are two stages to the neutralization)</p> <p>OR</p> <p>Methyl yellow range coincides with neutralization of first proton and phenolphthalein range coincides with neutralization of second proton <b>(1)</b></p>		<b>2</b>

**Total for Question 18 = 15 Marks**

Question Number	Acceptable Answers	Reject	Mark
<b>19(a)(i)</b>	<p>A chiral molecule is non-superimposable on its mirror image / 3D molecule with no plane of symmetry <b>(1)</b></p> <p>2-hydroxypropanoic acid has a carbon atom which is asymmetric / has <b>four</b> different groups attached <b>(1)</b></p> <p><b>Middle</b> carbon labelled in any clear way <b>(1)</b> e.g.</p> $  \begin{array}{ccccccc}  & & \text{H} & & \text{OH} & & \text{O} \\  & &   & &   & &    \\  \text{H} & - & \text{C} & - & \text{C} & - & \text{C} & - & \text{OH} \\  & &   & &   & & & & \\  & & \text{H} & & \text{H} & & & &   \end{array}  $ <p>ALLOW asymmetric C described but not labelled</p> <p>IGNORE references to rotation of plane polarized light</p>	<p>just 'non-superimposable'</p> <p>just 'no plane of symmetry'</p> <p>Molecules for groups</p>	<b>3</b>

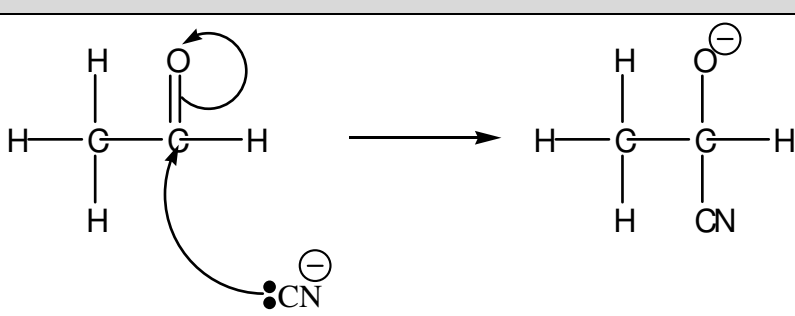
Question Number	Acceptable Answers	Reject	Mark
<b>19(a)(ii)</b>	<p>2-hydroxypropanoic acid formed in muscles is a single (allow pure) enantiomer /(optical) isomer ALLOW Unequal mixture of enantiomers /(optical) isomers <b>(1)</b></p> <p>2-hydroxypropanoic acid formed in milk is a racemic mixture / equimolar mixture of the two enantiomers / racemate <b>(1)</b></p> <p>If milk and muscles are reversed but the rest is correct, one mark is awarded</p>	<p>Just "not a racemic mixture"</p> <p>Just 'a mixture of enantiomers'</p>	<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>19(b)(i)</b>	<p><b>First step</b> NaOH(aq) / KOH(aq) or names <b>(1)</b></p> <p>Second mark dependent on first being correct</p> <p><b>Second step</b> HCl(aq) / hydrochloric acid / H<sub>2</sub>SO<sub>4</sub>(aq) / sulfuric acid</p> <p>ALLOW HNO<sub>3</sub> / nitric acid /dil HCl /((dil) H<sub>2</sub>SO<sub>4</sub> /((dil) HNO<sub>3</sub> or any strong acid (name or formula) including HBr((aq)) and HI((aq)) <b>(1)</b></p> <p>IGNORE Omission of (aq) and references to temperature Ethanolic /alcoholic solutions</p> <p>ALLOW One mark for correct two reagents in the wrong order One mark for 'alkali / OH<sup>-</sup> followed by acid / H<sup>+</sup> /H<sub>3</sub>O<sup>+</sup>'</p>	<p>OH<sup>-</sup> / alkali</p> <p>H<sup>+</sup> / H<sub>3</sub>O<sup>+</sup> /acid</p>	<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>19(b)(ii)</b>	<p><b>First mark</b> (Stand alone) A racemic mixture is not formed</p> <p>OR</p> <p>More of one enantiomer /(optical) isomer is formed</p> <p>OR</p> <p>Only one enantiomer /(optical) isomer is formed <b>(1)</b></p> <p><b>Second mark</b> (Stand alone)</p> <p>(Some of the) reaction is S<sub>N</sub>2 <b>(1)</b></p> <p><b>Third mark</b> (Stand alone) Nucleophile / OH<sup>-</sup> only attacks from one side of the molecule / from the opposite side to leaving group <b>(1)</b></p> <p>ALLOW Use of 'intermediate' for 'transition state' in description of S<sub>N</sub>2 Reverse argument based on S<sub>N</sub>1 forming a racemic mixture</p>	<p>Carbocation (for molecule)</p>	<b>3</b>

Question Number	Acceptable Answers	Reject	Mark
<b>19(c)(i)</b>	Nucleophilic <b>(1)</b>		<b>2</b>
	Addition <b>(1)</b>	$S_N1/S_N2$	

Question Number	Acceptable Answers	Reject	Mark
<b>19(c)(ii)</b>	Cyanide (ion) / $CN^-$ / $C\equiv N^-$ / $:C\equiv N^-$ / $^-CN$	$HCN$ / $C\equiv N$	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>19(c)(iii)</b>	 <p>Both curly arrows <b>(1)</b></p> <p>Intermediate <b>(1)</b></p> <p>ALLOW</p> <p>Omission of lone pair</p> <p>Curly arrow from anywhere on nucleophile including from charge or nitrogen</p> <p>Formation of charged canonical form followed by attack of cyanide ion</p> <p>IGNORE <math>\delta^+/\delta^-</math> even if unbalanced</p>	<p>Omission of charges (penalise once only)</p> <p>Full charges on ethanal</p> <p><math>-C-NC</math> in intermediate</p>	<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>19 (c) (iv)</b>	<p>Racemic mixture / equal amounts of the two enantiomers / racemate formed <b>(1)</b></p> <p>Stand alone mark</p> <p>CHO / aldehyde group is (trigonal) planar <b>(1)</b></p> <p>ALLOW ethanal / molecule is (trigonal) planar</p> <p>Cyanide (ion) / <math>\text{CN}^-</math> / nucleophile attacks (equally) from above or below / either side (of the molecule) <b>(1)</b></p> <p>Penalise use of intermediate / ion for aldehyde group <b>once</b> only</p> <p>Third mark cannot be awarded if the reaction is described as a nucleophilic substitution</p>	<p>Intermediate / carbonyl group / <math>\text{C}_=\text{O}</math> is planar</p> <p>two positions Intermediate</p>	<b>3</b>

Question Number	Acceptable Answers	Reject	Mark
<b>19(d)(i)</b>	<p>Any value /range within the range <math>3750\text{--}2500\text{ cm}^{-1}</math> due to <math>\text{O--H}</math> / <math>\text{OH}</math> / <math>\text{--OH}</math></p> <p>IGNORE <math>\text{COOH}</math> / <math>\text{CO}_2\text{H}</math> / carboxylic acid</p>	<p>Wavenumbers alone</p> <p><math>\text{OH}</math> in alcohol</p>	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>19(d)(ii)</b>	<p>These three marks are stand alone</p> <p>Q is due to <math>\text{C}=\text{O}</math> <b>(1)</b></p> <p>The (<math>\text{C}=\text{O}</math>) aldehyde range is <math>1740\text{--}1720\text{ cm}^{-1}</math> <b>and</b></p> <p>(<math>\text{C}=\text{O}</math>) carboxylic acid range is <math>1725\text{--}1700\text{ cm}^{-1}</math> <b>(1)</b></p> <p>So the peaks / absorptions cannot be used to distinguish these two compounds because they overlap.</p> <p>OR</p> <p>The (broad) absorption Q covers both the aldehyde and the carboxylic acid ranges <b>(1)</b></p> <p>ALLOW 'too close'/'quite similar' for 'overlap'</p>	<p>Carboxylic acid / <math>\text{COOH}</math> group</p> <p>Just 'cannot be used to distinguish the compounds'</p>	<b>3</b>



Question Number	Acceptable Answers	Reject	Mark																						
<b>19(e)</b>	<p>If reagent incorrect, observation mark can only be awarded for a near miss</p> <p>Test positive for ethanal</p> <table border="1"> <thead> <tr> <th>Reagent (1)</th> <th>Observation (1)</th> </tr> </thead> <tbody> <tr> <td>Tollens'</td> <td>Silver mirror / black / grey <b>ppt</b></td> </tr> <tr> <td>Fehling's / Benedict's</td> <td>Red-brown <b>ppt</b></td> </tr> <tr> <td>2,4-DNP(H) / Brady's reagent</td> <td>Orange / red / yellow <b>ppt</b> ALLOW brick-red <b>ppt</b></td> </tr> </tbody> </table> <p>Test positive for 2-hydroxypropanoic acid</p> <table border="1"> <thead> <tr> <th>Reagent (1)</th> <th>Observation (1)</th> </tr> </thead> <tbody> <tr> <td>PCl<sub>5</sub> / Phosphorus (V)chloride / phosphorus pentachloride</td> <td>Steamy fumes* ALLOW gas evolved turns (blue) litmus / UI red</td> </tr> <tr> <td>Named metal carbonate (solution)</td> <td>Effervescence ALLOW <b>gas / CO<sub>2</sub></b> evolved turns lime water cloudy</td> </tr> <tr> <td>Sodium hydrogencarbonate (solution)</td> <td>Effervescence ALLOW <b>gas / CO<sub>2</sub></b> evolved turns lime water cloudy</td> </tr> <tr> <td>Magnesium (&amp; water)</td> <td>Effervescence</td> </tr> <tr> <td>Ethanol &amp; H<sub>2</sub>SO<sub>4</sub>/named strong acid</td> <td>Sweet / fruity / pear drops / glue smell</td> </tr> <tr> <td>Ethanoic acid &amp; H<sub>2</sub>SO<sub>4</sub>/named strong acid</td> <td>Sweet / fruity / pear drops / glue smell</td> </tr> </tbody> </table> <p>ALLOW Na and effervescence / gas evolved pops with a lighted splint for 2-hydroxypropanoic acid (2)</p> <p>ALLOW fizzing / bubbling for effervescence</p> <p>IGNORE names of product</p> <p>IF two tests given for one substance both must be correct for full marks</p> <p>*misty fumes / white fumes / gas for fumes</p>	Reagent (1)	Observation (1)	Tollens'	Silver mirror / black / grey <b>ppt</b>	Fehling's / Benedict's	Red-brown <b>ppt</b>	2,4-DNP(H) / Brady's reagent	Orange / red / yellow <b>ppt</b> ALLOW brick-red <b>ppt</b>	Reagent (1)	Observation (1)	PCl <sub>5</sub> / Phosphorus (V)chloride / phosphorus pentachloride	Steamy fumes* ALLOW gas evolved turns (blue) litmus / UI red	Named metal carbonate (solution)	Effervescence ALLOW <b>gas / CO<sub>2</sub></b> evolved turns lime water cloudy	Sodium hydrogencarbonate (solution)	Effervescence ALLOW <b>gas / CO<sub>2</sub></b> evolved turns lime water cloudy	Magnesium (& water)	Effervescence	Ethanol & H <sub>2</sub> SO <sub>4</sub> /named strong acid	Sweet / fruity / pear drops / glue smell	Ethanoic acid & H <sub>2</sub> SO <sub>4</sub> /named strong acid	Sweet / fruity / pear drops / glue smell	<p>Iodine in alkali / iodoform test Acidified potassium dichromate</p> <p>Smoke Just 'fumes'</p> <p>Any indicator as sole test</p> <p>incorrect formulae of reagents</p>	<b>4</b>
Reagent (1)	Observation (1)																								
Tollens'	Silver mirror / black / grey <b>ppt</b>																								
Fehling's / Benedict's	Red-brown <b>ppt</b>																								
2,4-DNP(H) / Brady's reagent	Orange / red / yellow <b>ppt</b> ALLOW brick-red <b>ppt</b>																								
Reagent (1)	Observation (1)																								
PCl <sub>5</sub> / Phosphorus (V)chloride / phosphorus pentachloride	Steamy fumes* ALLOW gas evolved turns (blue) litmus / UI red																								
Named metal carbonate (solution)	Effervescence ALLOW <b>gas / CO<sub>2</sub></b> evolved turns lime water cloudy																								
Sodium hydrogencarbonate (solution)	Effervescence ALLOW <b>gas / CO<sub>2</sub></b> evolved turns lime water cloudy																								
Magnesium (& water)	Effervescence																								
Ethanol & H <sub>2</sub> SO <sub>4</sub> /named strong acid	Sweet / fruity / pear drops / glue smell																								
Ethanoic acid & H <sub>2</sub> SO <sub>4</sub> /named strong acid	Sweet / fruity / pear drops / glue smell																								

**Total for Question 19 = 26 Marks**

**Total for Section B = 51 Marks**

## Section C

Question Number	Acceptable Answers	Reject	Mark
<b>20(a)(i)</b>	<p>(Sodium thiosulfate) (rapidly) reacts with / reduces the iodine (as it is formed) <b>(1)</b></p> <p>So prevents the starch-iodine colour appearing until a fixed amount of reaction has occurred</p> <p>ALLOW (for second mark) So prevents the starch-iodine colour appearing until all the thiosulfate has reacted</p> <p>OR</p> <p>Moles of iodine reacted / thiosulfate <math>\div</math> time is (approximately) proportional to the (initial) rate of reaction <b>(1)</b></p> <p>ALLOW Use of 'thio' for thiosulfate</p>	iodide / $I^-$	<b>2</b>

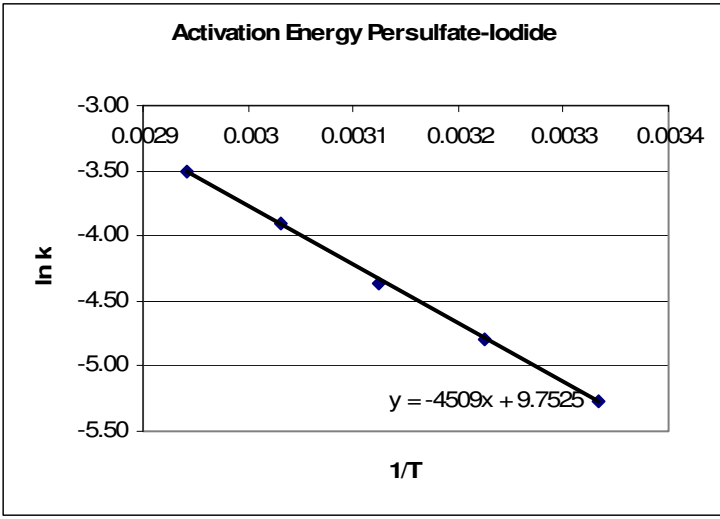
Question Number	Acceptable Answers	Reject	Mark
<b>20(a)(ii)</b>	<p>(From 2 to 1) <b><math>[S_2O_8^{2-}]</math></b> doubles (<math>[I^-]</math> unchanged) and rate doubles / time halves so order wrt <b><math>S_2O_8^{2-} = 1</math></b> <b>(1)</b></p> <p>(From 3 to 1) <b><math>[I^-]</math></b> doubles (<b><math>[S_2O_8^{2-}]</math></b> unchanged) and rate doubles / time halves so order <b>wrt <math>I^- = 1</math></b> OR (if first mark awarded) (From 3 to 2) <b><math>[I^-]</math></b> doubles (<b><math>[S_2O_8^{2-}]</math></b> halved) and rate unchanged so order <b>wrt <math>I^- = 1</math></b> <b>(1)</b></p> <p>Penalise omission of concentration/square brackets once only</p> <p>Rate = <math>k[S_2O_8^{2-}][I^-]</math> <b>(1)</b></p> <p>Third mark stand alone if no working &amp; TE on incorrect orders</p> <p>IGNORE case of k</p>	Rate equation =	<b>3</b>

Question Number	Acceptable Answers	Reject	Mark
<b>20(b)(i)</b>	<p><b>First mark</b> Colorimetry /Use a colorimeter <b>(1)</b></p> <p><b>Second mark</b> Measure transmittance / absorbance (at various times) <b>(1)</b></p> <p><b>Third mark</b> (Use a calibration curve to) convert transmittance / absorbance into concentration. OR transmittance / absorbance proportional to concentration</p> <p>ALLOW Colorimetry may be used because iodine (solution) is coloured (and other reagents are colourless) / to measure intensity of the iodine colour <b>(1)</b></p> <p>ALLOW (for the same three marks) Electrical conductivity</p> <p>Measured at various times / (use a calibration curve to) convert conductivity into concentration.</p> <p>Conductivity reduces as reaction proceeds because 3 mol ions converted to 2 mol ions / fewer ions on right hand side</p>	<p>Sampling methods colorimeter</p> <p>pH meter</p> <p>Just conductivity changes</p>	<b>3</b>

Question Number	Acceptable Answers	Reject	Mark
<b>20(b)(ii)</b>	<p><math>[(\text{NH}_4)_2\text{S}_2\text{O}_8]</math> / <math>[\text{S}_2\text{O}_8^{2-}]</math> / [peroxodisulfate] / [persulfate] remains (approximately) unchanged during the reaction.</p> <p>OR</p> <p><math>[\text{KI}]</math> / <math>[\text{I}^-]</math> is the only variable</p>	<p><math>(\text{NH}_4)_2\text{S}_2\text{O}_8</math> in excess. <math>[(\text{NH}_4)_2\text{S}_2\text{O}_8]</math> etc does not affect the rate</p> <p>Only <math>[\text{KI}]</math> / <math>[\text{I}^-]</math> affects the rate</p>	<b>1</b>

Question Number	Acceptable Answers	Reject	Mark
<b>20(b)(iii)</b>	<p>Plot a graph of concentration (of iodine/<math>\text{I}_2</math>) (on the y axis) against time <b>(1)</b></p> <p>Measure the initial gradient / gradient at <math>t=0</math> <b>(1)</b></p> <p>'Plot a graph and measure the initial gradient / gradient at <math>t=0</math>' alone scores second mark</p>		<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>20(b)(iv)</b>	<p>TE on 20(a)(ii) on numerical answer and appropriate units</p> $8.75 \times 10^{-5} = k \times 2.0 \times 0.025$ $k = 8.75 \times 10^{-5} / (2.0 \times 0.025)$ $= 1.75 \times 10^{-3}$ $\text{dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$ <p style="text-align: right;"><b>(1)</b> <b>(1)</b></p> <p>ALLOW units in any order</p> <p>Correct answer including units with no working scores 2</p>	1 SF	<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>20(c)(i)</b>	<div style="text-align: center;">  <p style="text-align: center;">Use the overlay to mark the graph</p> <p>At least 4 points within the circles on the overlay <b>(1)</b></p> <p>Best fit line on points given <b>(1)</b></p> </div>		<b>2</b>

Question Number	Acceptable Answers	Reject	Mark
<b>20(c)(ii)</b>	<p>Gradient = <math>-(-3.50 - -5.27) / (0.00333 - 0.00294)</math>  <math>= (-)4538 = (-)4500</math></p> <p>ALLOW  values from <math>(-)4300</math> to <math>(-)4700</math> <b>(1)</b></p> <p>gradient value negative <b>(1)</b></p> <p><math>E_a = -\text{gradient} \times R = --4538 \times 8.31</math>  <math>= (+)37700 \text{ J mol}^{-1} (= (+)38 \text{ kJ mol}^{-1})</math> <b>(1)</b></p> <p>TE on value of gradient even if it is positive</p> <p><math>-4300</math> gives 35.7; <math>-4700</math> gives 39.1</p> <p>Correct units <b>(1)</b></p> <p>Correct answer from the gradient calculation with units scores final 2 marks</p> <p><b>BUT</b> correct answer with units but no gradient calculation scores units mark only</p>		<b>4</b>

**Total for Section C = 19 Marks**

**Total for Paper = 90 Marks**

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Summer 2013

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