

## **MARK SCHEME for the October/November 2013 series**

### **9701 CHEMISTRY**

**9701/31**

Paper 3 (Advanced Practical Skills) maximum raw mark 40

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

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| Question | Sections      | Indicative material                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Mark | Total |
|----------|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------|
| 1 (a)    | PDO Layout    | <p><b>I</b> The following data must be given</p> <ul style="list-style-type: none"> <li>• mass of solid used (<b>or</b> both weighings)</li> <li>• volume for rough titre (<b>or</b> both readings)</li> <li>• initial <b>and</b> final readings for two (or more) accurate titrations.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                    | 1    |       |
|          | PDO Recording | <p><b>II</b> Appropriate headings for <b>all</b> data given in weighing <b>and</b> accurate titration tables <b>and</b> g and cm<sup>3</sup> units.</p> <ul style="list-style-type: none"> <li>• mass/weight (of) beaker (empty)</li> <li>• mass/weight (of) beaker + <b>FA 1</b>/solid</li> <li>• initial/start (burette) reading/volume</li> <li>• final/end (burette) reading/volume</li> <li>• titre <b>or</b> volume/<b>FA 2</b> used/added</li> <li>• unit: /cm<sup>3</sup> <b>or</b> (cm<sup>3</sup>) <b>or</b> in cm<sup>3</sup> <b>or</b> cm<sup>3</sup> for <b>each</b> volume</li> </ul> <p><i>If g and/or cm<sup>3</sup> units are not given in the heading, every entry in the table must have the correct unit.</i></p> | 1    |       |
|          | PDO Recording | <p><b>III</b> All <b>accurate</b> burette readings (including 0.00) are to the nearest 0.05 cm<sup>3</sup>.<br/> <i>The need to record to 0.05 applies only to the burette readings and <b>not</b> to the recorded titres. Do <b>not</b> award this mark if:</i></p> <ul style="list-style-type: none"> <li>• 50.(00) is used as an initial burette reading <b>or</b></li> <li>• more than one final burette reading is 50.(00) <b>or</b></li> <li>• any burette reading is greater than 50.(00).</li> </ul>                                                                                                                                                                                                                          | 1    |       |
|          | MMO Decision  | <p><b>IV</b> There are two uncorrected <b>accurate</b> titres within 0.10 cm<sup>3</sup>.<br/> <i>Do <b>not</b> include a reading if it is labelled “rough”. Do <b>not</b> award this mark if, having performed two titres within 0.1 cm<sup>3</sup>, a further titration is performed which is more than 0.10 cm<sup>3</sup> from the closer of the initial <b>two</b> titres, <b>unless</b> a further titration, within 0.1 cm<sup>3</sup> of any other, has also been carried out.</i><br/> <i>Do <b>not</b> award the mark if any ‘accurate’ burette readings (apart from initial 0) are given to <b>zero</b> dp.</i></p>                                                                                                         | 1    |       |

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| Question        | Sections              | Indicative material                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Mark        | Total |
|-----------------|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------|
| (a)<br>(cont)   | MMO<br>Quality        | <p>Award <b>V, VI</b> and <b>VII</b> if <math>\delta \leq 0.03</math> (cm<sup>3</sup> g<sup>-1</sup>) <i>i.e. three Q marks.</i></p> <p>Award <b>V</b> and <b>VI</b> if <math>0.03 &lt; \delta \leq 0.06</math> <i>i.e. two Q marks.</i></p> <p>Award <b>V</b>, only, if <math>0.06 &lt; \delta \leq 0.10</math> <i>i.e. one Q mark.</i></p> <p><b>Spread penalty:</b> if the two “best” (corrected) titres used by the Examiner were <math>\geq 0.50</math> cm<sup>3</sup> apart, cancel <b>one</b> Q mark.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 1<br>1<br>1 | [7]   |
| (b)             | MMO<br>Decision       | <p>Check mean titre is correctly calculated from clearly selected values (ticks or working).</p> <ul style="list-style-type: none"> <li>• Candidate must average two (or more) titres where the <b>total</b> spread is <math>\leq 0.20</math> cm<sup>3</sup>.</li> <li>• Working must be shown or ticks must be put next to the two (or more) accurate readings selected.</li> <li>• The mean should normally be quoted to 2 dp rounded to the nearest 0.01.<br/>[e.g. 26.667 must be rounded to 26.67]</li> </ul> <p>Two special cases where the mean may not be to 2 dp:<br/>allow mean to 3 dp only for 0.025 or 0.075 e.g. 26.325;<br/>allow mean to 1 dp if <b>all</b> accurate burette readings were given to 1 dp (<i>ignoring initial given as 0</i>) and the mean is exactly correct.<br/>[e.g. 26.0 and 26.2 = 26.1 is correct<br/>but 26.0 and 26.1 = 26.1 is incorrect.]</p> <p>Do <b>not</b> award this mark if:</p> <ul style="list-style-type: none"> <li>• the rough titre was used to calculate the mean;</li> <li>• candidate carried out only 1 accurate titration;</li> <li>• burette readings were incorrectly subtracted to obtain any of the accurate titre values;</li> <li>• <b>all</b> burette readings (resulting in titre values used in calculation of mean) are integers.</li> </ul> | 1           | [1]   |
| (c) (i)         | ACE<br>Interpretation | <b>I</b> Correctly calculates<br>No. of moles of KMnO <sub>4</sub> = $0.0200 \times \frac{(b)}{1000}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 1           |       |
| (ii)            | ACE<br>Conclusion     | <b>II</b> $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + \text{e}^- / 5\text{Fe}^{2+} \rightarrow 5\text{Fe}^{3+} + 5\text{e}^-$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 1           |       |
| (iii)<br>+ (iv) | PDO<br>Display        | <b>III</b> Correct working shown in (iii) and (iv).<br>The answer to (i) should be multiplied by 5 to give (iii).<br>The answer to (iii) should be multiplied by 10 to give (iv).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 1           |       |
| (v)             | ACE<br>Interpretation | <b>IV</b> Correct calculation of relative formula mass.<br>$M_r = \frac{\text{correct mass of FA 1 used}}{\text{answer to (iv)}}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 1           |       |

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| Question                                                                                                                                                                                                                                                                                                                    | Sections              | Indicative material                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Mark | Total |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------|
| (v)<br>(cont)                                                                                                                                                                                                                                                                                                               | PDO<br>Display        | <b>V</b> All answers are quoted to 3 or 4 significant figures.<br>A minimum of three answers is needed to qualify.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 1    | [5]   |
| (d) (i)                                                                                                                                                                                                                                                                                                                     | ACE<br>Interpretation | % error for pipette = $\frac{0.06}{25} \times 100 = 0.24\%$ (or 0.240%)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1    |       |
| (ii)<br>+ (iii)                                                                                                                                                                                                                                                                                                             | ACE<br>Interpretation | <i>If balance displays to 1 decimal place:<br/>error in balance reading is <math>\pm 0.05\text{g}</math> or <math>\pm 0.1(0)\text{g}</math>.<br/>If balance displays to 2 decimal places:<br/>error in balance reading is <math>\pm 0.005\text{g}</math> or <math>\pm 0.01\text{g}</math>.<br/>If balance displays to 3 decimal places:<br/>error in balance reading is <math>\pm 0.0005\text{g}</math> or <math>\pm 0.001\text{g}</math>.<br/>% error = <math>2 \times \frac{\text{balance error (above)}}{\text{mass of FA 1 used}} \times 100</math><br/>Correct answer is <b>not</b> required, but if the “<math>\times 100</math>” factor was omitted, a correctly calculated % error answer scores the mark.</i> | 1    | [2]   |
| <b>[Total: 15]</b>                                                                                                                                                                                                                                                                                                          |                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |      |       |
| <b>2 (a)</b>                                                                                                                                                                                                                                                                                                                | MMO<br>Collection     | <b>I</b> The masses of <b>FA 5</b> used by the candidate were between 2.0–2.4 g (expt 1) and 1.5–1.9 g (expt 2).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 1    |       |
|                                                                                                                                                                                                                                                                                                                             | PDO<br>Display        | <b>II</b> Suitable headings for a table or list, shown completely for at least one experiment carried out. If 2 experiments, all headings must be correct. <ul style="list-style-type: none"> <li>(mass of) empty crucible</li> <li>(mass of) crucible + <b>FA 5</b></li> <li>(mass of) crucible + residue / <b>FA 5</b> after heating</li> <li>(mass of) residue (<i>owtte</i>)</li> <li>mass lost <b>or</b> (mass of) water lost.</li> </ul> <b>and</b> unit was given “covering” every weighing;<br><i>Unit: /g or (g) or in grams or g following each weighing</i>                                                                                                                                                 | 1    |       |
|                                                                                                                                                                                                                                                                                                                             | PDO<br>Recording      | <b>III</b> Records <b>all</b> weighings <b>consistently</b> to at least 1 dp.<br><i>A minimum of <b>three</b> weighings are needed.</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1    |       |
| <b>Accuracy (Q) marks for gravimetric experiment – 3 marks available</b><br>Examiner checks working for mass of residue <b>and</b> mass of water and expresses the ratio $\frac{\text{mass of hydrated solid}}{\text{mass of water}}$ to 2 dp for <b>each</b> experiment.<br>The expected ratio = $\frac{244}{36} = 6.78$ . |                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |      |       |

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| Question                                                                                                                                                                                                                                              | Sections              | Indicative material                                                                                                                                                                                                                                                                                                                      | Mark        | Total |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------|
| (a)<br>(cont)                                                                                                                                                                                                                                         | MMO<br>Quality        | Award <b>IV</b> if the ratio in expt <b>1</b> is between 6.30 and 7.25.<br>Award <b>V</b> If the ratio in expt <b>2</b> is between 6.30 and 7.25.<br>Award <b>VI</b> If the ratio in <b>both</b> of experiments <b>1</b> and <b>2</b> is between 5.90 and 7.65, inclusive.                                                               | 1<br>1<br>1 | [6]   |
| (b) (i)                                                                                                                                                                                                                                               | MMO<br>Display        | Correct expression for the number of moles of water lost (from mass as recorded) <b>or</b> correct answer.                                                                                                                                                                                                                               | 1           |       |
| (ii)                                                                                                                                                                                                                                                  | ACE<br>Interpretation | Correct expression for the number of moles of residue with <b>correct</b> masses of anhydrous salt <b>and</b> 208 <b>and</b> answer expressed to 2–4 sf<br><b>or</b> correct answer <b>and</b> 2–4 sf<br>If only <b>one</b> expt carried out then<br><b>correct calculation</b> for number of moles of residue expressed to 2–4 sig fig. | 1           |       |
| (iii)                                                                                                                                                                                                                                                 | ACE<br>Interpretation | Correct calculation of (i) ÷ (ii) to give answer as an integer.<br>(should be <b>x</b> = 2)                                                                                                                                                                                                                                              | 1           | [3]   |
| (c) (i)                                                                                                                                                                                                                                               | ACE<br>Improvements   | Heat to constant <b>mass</b> (owtte)                                                                                                                                                                                                                                                                                                     | 1           |       |
| (ii)                                                                                                                                                                                                                                                  | ACE<br>Interpretation | An <b>attempt</b> to “ <b>scale</b> ” mass loss to the mass of <b>FA 5</b> used<br><b>or</b> to calculate <b>x</b> separately for the two experiments.                                                                                                                                                                                   | 1           |       |
|                                                                                                                                                                                                                                                       | ACE<br>Conclusion     | Uses calculated values to comment sensibly on the consistency the results.                                                                                                                                                                                                                                                               | 1           | [3]   |
| <b>[Total: 12]</b>                                                                                                                                                                                                                                    |                       |                                                                                                                                                                                                                                                                                                                                          |             |       |
| <b>FA 6</b> is (NH <sub>4</sub> ) <sub>2</sub> Fe(SO <sub>4</sub> ) <sub>2</sub> (s); <b>FA 7</b> is Na <sub>2</sub> CO <sub>3</sub> (aq); <b>FA 8</b> is Pb(NO <sub>3</sub> ) <sub>2</sub> (aq); <b>FA 9</b> is K <sub>2</sub> CrO <sub>4</sub> (aq) |                       |                                                                                                                                                                                                                                                                                                                                          |             |       |
| <b>3 (a) (i)</b>                                                                                                                                                                                                                                      | MMO<br>Collection     | Green precipitate <b>and</b> ppt insoluble in excess NaOH/ppt turning brown (in air / on standing).                                                                                                                                                                                                                                      | 1           |       |
|                                                                                                                                                                                                                                                       | MMO<br>Decision       | (When heated with NaOH) <b>gas</b> / NH <sub>3</sub> turns red litmus to blue.                                                                                                                                                                                                                                                           | 1           |       |
|                                                                                                                                                                                                                                                       | MMO<br>Collection     | (With BaCl <sub>2</sub> ), white precipitate forms <b>and</b> insoluble in HCl.                                                                                                                                                                                                                                                          | 1           |       |
| (ii)                                                                                                                                                                                                                                                  | ACE<br>Conclusion     | <b>FA 6</b> contains ammonium ions <b>and</b> sulfate ions.<br>(correct evidence needed for each ion in the observations table).                                                                                                                                                                                                         | 1           |       |
| (iii)                                                                                                                                                                                                                                                 | ACE<br>conclusion     | Fe <sup>2+</sup> + 2OH <sup>-</sup> → Fe(OH) <sub>2</sub>                                                                                                                                                                                                                                                                                | 1           |       |

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| Question | Sections           | Indicative material                                                                                                                                                                                                                                                                     | Mark   | Total |
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| (iv)     | MMO collection     | <b>Any two</b> of <ul style="list-style-type: none"><li>Solid goes paler / loses green colour (at first) <b>and then</b> becomes brown (on strong heating)</li><li>Condensation / water vapour / steam produced</li><li>(Gas/<math>\text{NH}_3</math>) turns red litmus blue.</li></ul> | 1<br>1 | [7]   |
| (b)      | MMO collection     | <b>FA 7 + FA 3 :</b><br>Fizzing/effervescence <b>and</b> limewater goes milky.                                                                                                                                                                                                          | 1      |       |
|          |                    | <b>FA 8 + FA 3</b> and <b>FA 8 + FA 7 :</b><br>white precipitate obtained in <b>both</b> cases                                                                                                                                                                                          | 1      |       |
|          |                    | <b>FA 9 + FA 3:</b> (solution) turns orange<br><b>FA 9 + FA 7:</b> statement of no change/yellow solution<br><b>FA 9 + FA 8:</b> (bright) yellow precipitate/solid (formed).<br><i>All three observations in the third column must be correct.</i>                                      | 1      |       |
|          | ACE Conclusion     | <b>FA 7</b> contains carbonate ions (evidence needed) / $\text{CO}_3^{2-}$                                                                                                                                                                                                              | 1      |       |
|          |                    | <b>FA 8</b> contains lead ions <b>or</b> barium ions ( <b>or</b> both) (evidence needed) / $\text{Pb}^{2+}$ / $\text{Ba}^{2+}$                                                                                                                                                          | 1      |       |
|          |                    | <b>FA 9</b> contains chromate(VI) ions / $\text{CrO}_4^{2-}$                                                                                                                                                                                                                            | 1      | [6]   |
|          | <b>[Total: 13]</b> |                                                                                                                                                                                                                                                                                         |        |       |

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| Question | Sections      | Indicative material                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Mark | Total |
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|          | PDO Recording | <p><b>II</b> Appropriate headings for <b>all</b> data given in weighing <b>and</b> accurate titration tables <b>and</b> g and cm<sup>3</sup> units.</p> <ul style="list-style-type: none"> <li>• mass/weight (of) beaker (empty)</li> <li>• mass/weight (of) beaker + <b>FA 1</b>/solid</li> <li>• initial/start (burette) reading/volume</li> <li>• final/end (burette) reading/volume</li> <li>• titre <b>or</b> volume/<b>FA 2</b> used/added</li> <li>• unit: /cm<sup>3</sup> <b>or</b> (cm<sup>3</sup>) <b>or</b> in cm<sup>3</sup> <b>or</b> cm<sup>3</sup> for <b>each</b> volume</li> </ul> <p><i>If g and/or cm<sup>3</sup> units are not given in the heading, every entry in the table must have the correct unit.</i></p> | 1    |       |
|          | PDO Recording | <p><b>III</b> All <b>accurate</b> burette readings (including 0.00) are to the nearest 0.05 cm<sup>3</sup>.<br/> <i>The need to record to 0.05 applies only to the burette readings and <b>not</b> to the recorded titres. Do <b>not</b> award this mark if:</i></p> <ul style="list-style-type: none"> <li>• 50.(00) is used as an initial burette reading <b>or</b></li> <li>• more than one final burette reading is 50.(00) <b>or</b></li> <li>• any burette reading is greater than 50.(00).</li> </ul>                                                                                                                                                                                                                          | 1    |       |
|          | MMO Decision  | <p><b>IV</b> There are two uncorrected <b>accurate</b> titres within 0.10 cm<sup>3</sup>.<br/> <i>Do <b>not</b> include a reading if it is labelled “rough”. Do <b>not</b> award this mark if, having performed two titres within 0.1 cm<sup>3</sup>, a further titration is performed which is more than 0.10 cm<sup>3</sup> from the closer of the initial <b>two</b> titres, <b>unless</b> a further titration, within 0.1 cm<sup>3</sup> of any other, has also been carried out.</i><br/> <i>Do <b>not</b> award the mark if any ‘accurate’ burette readings (apart from initial 0) are given to <b>zero</b> dp.</i></p>                                                                                                         | 1    |       |

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| (b)             | MMO<br>Decision       | <p>Check mean titre is correctly calculated from clearly selected values (ticks or working).</p> <ul style="list-style-type: none"> <li>• Candidate must average two (or more) titres where the <b>total</b> spread is <math>\leq 0.20</math> cm<sup>3</sup>.</li> <li>• Working must be shown or ticks must be put next to the two (or more) accurate readings selected.</li> <li>• The mean should normally be quoted to 2 dp rounded to the nearest 0.01.<br/>[e.g. 26.667 must be rounded to 26.67]</li> </ul> <p>Two special cases where the mean may not be to 2 dp:<br/>allow mean to 3 dp only for 0.025 or 0.075 e.g. 26.325;<br/>allow mean to 1 dp if <b>all</b> accurate burette readings were given to 1 dp (<i>ignoring initial given as 0</i>) and the mean is exactly correct.<br/>[e.g. 26.0 and 26.2 = 26.1 is correct<br/>but 26.0 and 26.1 = 26.1 is incorrect.]</p> <p>Do <b>not</b> award this mark if:</p> <ul style="list-style-type: none"> <li>• the rough titre was used to calculate the mean;</li> <li>• candidate carried out only 1 accurate titration;</li> <li>• burette readings were incorrectly subtracted to obtain any of the accurate titre values;</li> <li>• <b>all</b> burette readings (resulting in titre values used in calculation of mean) are integers.</li> </ul> | 1                          | [1]   |
| (c) (i)         | ACE<br>Interpretation | <b>I</b> Correctly calculates<br>No. of moles of KMnO <sub>4</sub> = $0.0200 \times \frac{(b)}{1000}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 1                          |       |
| (ii)            | ACE<br>Conclusion     | <b>II</b> $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + \text{e}^- / 5\text{Fe}^{2+} \rightarrow 5\text{Fe}^{3+} + 5\text{e}^-$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 1                          |       |
| (iii)<br>+ (iv) | PDO<br>Display        | <b>III</b> Correct working shown in (iii) and (iv).<br>The answer to (i) should be multiplied by 5 to give (iii).<br>The answer to (iii) should be multiplied by 10 to give (iv).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 1                          |       |
| (v)             | ACE<br>Interpretation | <b>IV</b> Correct calculation of relative formula mass.<br>$M_r = \frac{\text{correct mass of FA 1 used}}{\text{answer to (iv)}}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 1                          |       |

|        |                                     |          |       |
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| Question                                                                                                                                                                                                                                                                                                                    | Sections              | Indicative material                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Mark | Total |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------|
| (v)<br>(cont)                                                                                                                                                                                                                                                                                                               | PDO<br>Display        | <b>V</b> All answers are quoted to 3 or 4 significant figures.<br>A minimum of three answers is needed to qualify.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 1    | [5]   |
| (d) (i)                                                                                                                                                                                                                                                                                                                     | ACE<br>Interpretation | % error for pipette = $\frac{0.06}{25} \times 100 = 0.24\%$ (or 0.240%)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1    |       |
| (ii)<br>+ (iii)                                                                                                                                                                                                                                                                                                             | ACE<br>Interpretation | <i>If balance displays to 1 decimal place:<br/>error in balance reading is <math>\pm 0.05\text{g}</math> or <math>\pm 0.1(0)\text{g}</math>.<br/>If balance displays to 2 decimal places:<br/>error in balance reading is <math>\pm 0.005\text{g}</math> or <math>\pm 0.01\text{g}</math>.<br/>If balance displays to 3 decimal places:<br/>error in balance reading is <math>\pm 0.0005\text{g}</math> or <math>\pm 0.001\text{g}</math>.<br/>% error = <math>2 \times \frac{\text{balance error (above)}}{\text{mass of FA 1 used}} \times 100</math><br/>Correct answer is <b>not</b> required, but if the “<math>\times 100</math>” factor was omitted, a correctly calculated % error answer scores the mark.</i> | 1    | [2]   |
| <b>[Total: 15]</b>                                                                                                                                                                                                                                                                                                          |                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |      |       |
| <b>2 (a)</b>                                                                                                                                                                                                                                                                                                                | MMO<br>Collection     | <b>I</b> The masses of <b>FA 5</b> used by the candidate were between 2.0–2.4 g (expt 1) and 1.5–1.9 g (expt 2).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 1    |       |
|                                                                                                                                                                                                                                                                                                                             | PDO<br>Display        | <b>II</b> Suitable headings for a table or list, shown completely for at least one experiment carried out. If 2 experiments, all headings must be correct. <ul style="list-style-type: none"> <li>(mass of) empty crucible</li> <li>(mass of) crucible + <b>FA 5</b></li> <li>(mass of) crucible + residue / <b>FA 5</b> after heating</li> <li>(mass of) residue (<i>owtte</i>)</li> <li>mass lost <b>or</b> (mass of) water lost.</li> </ul> <b>and</b> unit was given “covering” every weighing;<br><i>Unit: /g or (g) or in grams or g following each weighing</i>                                                                                                                                                 | 1    |       |
|                                                                                                                                                                                                                                                                                                                             | PDO<br>Recording      | <b>III</b> Records <b>all</b> weighings <b>consistently</b> to at least 1 dp.<br><i>A minimum of <b>three</b> weighings are needed.</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1    |       |
| <b>Accuracy (Q) marks for gravimetric experiment – 3 marks available</b><br>Examiner checks working for mass of residue <b>and</b> mass of water and expresses the ratio $\frac{\text{mass of hydrated solid}}{\text{mass of water}}$ to 2 dp for <b>each</b> experiment.<br>The expected ratio = $\frac{244}{36} = 6.78$ . |                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |      |       |

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| Question                                                                                                                                                                                                                                              | Sections              | Indicative material                                                                                                                                                                                                                                                                                                                      | Mark        | Total |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------|
| (a)<br>(cont)                                                                                                                                                                                                                                         | MMO<br>Quality        | Award <b>IV</b> if the ratio in expt <b>1</b> is between 6.30 and 7.25.<br>Award <b>V</b> If the ratio in expt <b>2</b> is between 6.30 and 7.25.<br>Award <b>VI</b> If the ratio in <b>both</b> of experiments <b>1</b> and <b>2</b> is between 5.90 and 7.65, inclusive.                                                               | 1<br>1<br>1 | [6]   |
| (b) (i)                                                                                                                                                                                                                                               | MMO<br>Display        | Correct expression for the number of moles of water lost (from mass as recorded) <b>or</b> correct answer.                                                                                                                                                                                                                               | 1           |       |
| (ii)                                                                                                                                                                                                                                                  | ACE<br>Interpretation | Correct expression for the number of moles of residue with <b>correct</b> masses of anhydrous salt <b>and</b> 208 <b>and</b> answer expressed to 2–4 sf<br><b>or</b> correct answer <b>and</b> 2–4 sf<br>If only <b>one</b> expt carried out then<br><b>correct calculation</b> for number of moles of residue expressed to 2–4 sig fig. | 1           |       |
| (iii)                                                                                                                                                                                                                                                 | ACE<br>Interpretation | Correct calculation of (i) ÷ (ii) to give answer as an integer.<br>(should be <b>x</b> = 2)                                                                                                                                                                                                                                              | 1           | [3]   |
| (c) (i)                                                                                                                                                                                                                                               | ACE<br>Improvements   | Heat to constant <b>mass</b> (owtte)                                                                                                                                                                                                                                                                                                     | 1           |       |
| (ii)                                                                                                                                                                                                                                                  | ACE<br>Interpretation | An <b>attempt</b> to “ <b>scale</b> ” mass loss to the mass of <b>FA 5</b> used<br><b>or</b> to calculate <b>x</b> separately for the two experiments.                                                                                                                                                                                   | 1           |       |
|                                                                                                                                                                                                                                                       | ACE<br>Conclusion     | Uses calculated values to comment sensibly on the consistency the results.                                                                                                                                                                                                                                                               | 1           | [3]   |
| <b>[Total: 12]</b>                                                                                                                                                                                                                                    |                       |                                                                                                                                                                                                                                                                                                                                          |             |       |
| <b>FA 6</b> is (NH <sub>4</sub> ) <sub>2</sub> Fe(SO <sub>4</sub> ) <sub>2</sub> (s); <b>FA 7</b> is Na <sub>2</sub> CO <sub>3</sub> (aq); <b>FA 8</b> is Pb(NO <sub>3</sub> ) <sub>2</sub> (aq); <b>FA 9</b> is K <sub>2</sub> CrO <sub>4</sub> (aq) |                       |                                                                                                                                                                                                                                                                                                                                          |             |       |
| <b>3 (a) (i)</b>                                                                                                                                                                                                                                      | MMO<br>Collection     | Green precipitate <b>and</b> ppt insoluble in excess NaOH/ppt turning brown (in air / on standing).                                                                                                                                                                                                                                      | 1           |       |
|                                                                                                                                                                                                                                                       | MMO<br>Decision       | (When heated with NaOH) <b>gas</b> / NH <sub>3</sub> turns red litmus to blue.                                                                                                                                                                                                                                                           | 1           |       |
|                                                                                                                                                                                                                                                       | MMO<br>Collection     | (With BaCl <sub>2</sub> ), white precipitate forms <b>and</b> insoluble in HCl.                                                                                                                                                                                                                                                          | 1           |       |
| (ii)                                                                                                                                                                                                                                                  | ACE<br>Conclusion     | <b>FA 6</b> contains ammonium ions <b>and</b> sulfate ions.<br>(correct evidence needed for each ion in the observations table).                                                                                                                                                                                                         | 1           |       |
| (iii)                                                                                                                                                                                                                                                 | ACE<br>conclusion     | Fe <sup>2+</sup> + 2OH <sup>-</sup> → Fe(OH) <sub>2</sub>                                                                                                                                                                                                                                                                                | 1           |       |

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| Question | Sections           | Indicative material                                                                                                                                                                                                                                                                           | Mark   | Total |
|----------|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------|
| (iv)     | MMO collection     | <b>Any two of</b> <ul style="list-style-type: none"><li>• Solid goes paler / loses green colour (at first) <b>and then</b> becomes brown (on strong heating)</li><li>• Condensation / water vapour / steam produced</li><li>• (Gas/<math>\text{NH}_3</math>) turns red litmus blue.</li></ul> | 1<br>1 | [7]   |
| (b)      | MMO collection     | <b>FA 7 + FA 3 :</b><br>Fizzing/effervescence <b>and</b> limewater goes milky.                                                                                                                                                                                                                | 1      |       |
|          |                    | <b>FA 8 + FA 3</b> and <b>FA 8 + FA 7 :</b><br>white precipitate obtained in <b>both</b> cases                                                                                                                                                                                                | 1      |       |
|          |                    | <b>FA 9 + FA 3:</b> (solution) turns orange<br><b>FA 9 + FA 7:</b> statement of no change/yellow solution<br><b>FA 9 + FA 8:</b> (bright) yellow precipitate/solid (formed).<br><i>All three observations in the third column must be correct.</i>                                            | 1      |       |
|          | ACE Conclusion     | <b>FA 7</b> contains carbonate ions (evidence needed) / $\text{CO}_3^{2-}$                                                                                                                                                                                                                    | 1      |       |
|          |                    | <b>FA 8</b> contains lead ions <b>or</b> barium ions ( <b>or</b> both) (evidence needed) / $\text{Pb}^{2+}$ / $\text{Ba}^{2+}$                                                                                                                                                                | 1      |       |
|          |                    | <b>FA 9</b> contains chromate(VI) ions / $\text{CrO}_4^{2-}$                                                                                                                                                                                                                                  | 1      | [6]   |
|          | <b>[Total: 13]</b> |                                                                                                                                                                                                                                                                                               |        |       |

## **MARK SCHEME for the October/November 2013 series**

### **9701 CHEMISTRY**

**9701/34**

Paper 3 (Advanced Practical Skills 2),  
maximum raw mark 40

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the October/November 2013 series for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level components and some Ordinary Level components.

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| Question | Sections          | Indicative material                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Mark | Total |
|----------|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------|
| 1 (a)    | MMO<br>Collection | I Initial and final readings and titre value given for rough titre<br><b>and</b><br>initial and final readings for two (or more) accurate titrations ( <i>minimum of 2 × 2 box</i> )                                                                                                                                                                                                                                                                                                                                                                                                                      | 1    |       |
|          | PDO<br>Layout     | II Appropriate headings and units for all accurate data<br><b>and</b><br>volume <b>FB 1</b> added recorded for each accurate titre.<br><i>Headings should match readings.</i> <ul style="list-style-type: none"> <li>initial/start (burette) reading/volume</li> <li>final/end (burette) reading/volume</li> <li>titre <b>or</b> volume/<b>FB 1</b> used/added (<i>but not “difference”</i>)</li> <li>unit: /cm<sup>3</sup> <b>or</b> (cm<sup>3</sup>) <b>or</b> in cm<sup>3</sup> <b>or</b> cm<sup>3</sup> for <b>each</b> entry</li> </ul>                                                              | 1    |       |
|          | PDO<br>Recording  | III <b>All</b> accurate burette readings recorded to 0.05 cm <sup>3</sup> .<br><i>The need to record to 0.05 applies only to the burette readings and <b>not</b> to the recorded titres.</i><br><i>Do <b>not</b> award this mark if:</i> <ul style="list-style-type: none"> <li>50(.00) is used as an initial burette reading</li> <li>more than one final burette reading is 50.(00)</li> <li>any burette reading is greater than 50.(00).</li> </ul>                                                                                                                                                    | 1    |       |
|          | MMO<br>Decisions  | IV Has two uncorrected accurate titres within 0.1 cm <sup>3</sup> .<br><i>Do <b>not</b> include a reading if it is labelled “rough”.</i><br><i>Do <b>not</b> award this mark if, having performed two titres within 0.1 cm<sup>3</sup>, a further titration is performed which is more than 0.10 cm<sup>3</sup> from the closer of the initial <b>two</b> titres, <b>unless</b> a further titration, within 0.1 cm<sup>3</sup> of any other, has also been carried out.</i><br><i>Do <b>not</b> award the mark if any ‘accurate’ burette readings (apart from initial 0) are given to <b>zero</b> dp.</i> | 1    |       |

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| Question        | Sections      | Indicative material                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Mark | Total |
|-----------------|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------|
| 1 (a)<br>(cont) |               | <p><b>For assessment of accuracy (Q) marks</b>, an Examiner rounds any burette readings to the nearest <math>0.05 \text{ cm}^3</math>, checks subtractions and then selects the <b>“best” titres</b> using the hierarchy:</p> <ul style="list-style-type: none"> <li>two (or more) accurate identical titres (ignoring any that are labelled “rough”), <i>then</i></li> <li>two (or more) accurate titres within <math>0.05 \text{ cm}^3</math>, <i>then</i></li> <li>two (or more) accurate titres within <math>0.10 \text{ cm}^3</math>, <i>etc.</i></li> </ul> <p>These best titres are used to calculate the mean titre, to nearest <math>0.01 \text{ cm}^3</math>.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |      |       |
|                 | MMO Quality   | <p>Award <b>V</b>, <b>VI</b> and <b>VII</b> for <math>\delta \leq 0.20 \text{ cm}^3</math><br/> Award <b>V</b> and <b>VI</b> for <math>0.20 &lt; \delta \leq 0.30 \text{ cm}^3</math><br/> Award <b>V</b> for <math>0.30 &lt; \delta \leq 0.50 \text{ cm}^3</math><br/> Spread penalty: if the two ‘best’ titres used by the Examiner are <math>\geq 0.50 \text{ cm}^3</math> apart, cancel one Q mark.<br/> If Supervisor titre <math>\leq 15 \text{ cm}^3</math> then tolerances are <math>0.10</math>, <math>0.20</math> and <math>0.30 \text{ cm}^3</math>.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 3    | [7]   |
| 1 (b)           | MMO Decisions | <p>Check mean titre is correctly calculated from clearly selected values (ticks or working).</p> <ul style="list-style-type: none"> <li>Candidate must average two (or more) titres where the <b>total</b> spread is <math>\leq 0.20 \text{ cm}^3</math>.</li> <li>Working must be shown or ticks must be put next to the two (or more) accurate readings selected.</li> <li>The mean should normally be quoted to 2 dp rounded to the nearest 0.01.<br/> [e.g. <math>26.667</math> must be rounded to <math>26.67</math>]</li> </ul> <p>Two special cases where the mean may not be to 2 dp: allow mean to 3 dp only for <math>0.025</math> or <math>0.075</math> eg <math>26.325</math>; allow mean to 1 dp if <b>all</b> accurate burette readings were given to 1 dp (ignoring initial given as 0) and the mean is exactly correct.<br/> [e.g. <math>26.0</math> and <math>26.2 = 26.1</math> is correct<br/> but <math>26.0</math> and <math>26.1 = 26.1</math> is incorrect.]</p> <p>Do <b>not</b> award this mark if:</p> <ul style="list-style-type: none"> <li>the rough titre was used to calculate the mean;</li> <li>candidate carried out only 1 accurate titration;</li> <li>burette readings were incorrectly subtracted to obtain any of the accurate titre values;</li> <li><b>all</b> burette readings (resulting in titre values used in calculation of mean) are integers.</li> </ul> | 1    | [1]   |

|               |                                            |                 |              |
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| Question       | Sections           | Indicative material                                                                                                                                            | Mark | Total |
|----------------|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------|
| 1 (c) (i) (ii) | ACE Interpretation | <b>I</b> Correctly calculates answer to $\frac{(b) \times 0.125}{1000}$ in (i)<br><b>and</b><br>$\frac{23.25 \times 0.125}{1000} = 0.002906$ (0.00291) in (ii) | 1    | [6]   |
| (iii)          |                    | <b>II</b> Correctly calculates answer to (iii) (ignore sf).<br>If (i) < (ii) then answer must be negative.                                                     | 1    |       |
| (iv) (v)       | PDO Display        | <b>III</b> Shows use of (iii) × 106 in (iv)<br><b>and</b><br>× 2 in (v). ( <i>This should be (iii) × 2 but allow (iv) × 2.</i> )                               | 1    |       |
| (vi)           | ACE Interpretation | <b>IV</b> Correct method [(i) – (v)] × 40 in (vi)                                                                                                              | 1    |       |
| (vii)          |                    | <b>V</b> Correct expression: $\frac{(iv)}{[(iv) + (vi)]} \times 100$ in (vii)<br><b>or</b> correct answer                                                      | 1    |       |
|                | PDO Display        | <b>VI</b> All quoted answers given to 3 or 4 significant figures except in (iii). ( <i>Minimum of 4 answers needed.</i> )                                      | 1    |       |
|                | [Total 14]         |                                                                                                                                                                |      |       |

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| Question | Sections           | Indicative material                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Mark | Total |
|----------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------|
| 2 (a)    | PDO Layout         | <b>I</b> Presents data in list/form in the space provided.<br>Must have all four required weighings <b>and</b> attempt at mass of solid/ <b>FB 4</b> <b>or</b> attempt at mass of carbon dioxide.                                                                                                                                                                                                                                                                                               | 1    |       |
|          | PDO Recording      | <b>II</b> Gives all appropriate headings and units <ul style="list-style-type: none"> <li>• mass/weight of flask + acid</li> <li>• mass of tube + <b>FB 4</b></li> <li>• mass of flask + contents (owtte)</li> <li>• mass of tube + residue/mass of tube</li> <li>• mass of <b>FB 4</b></li> <li>• mass of CO<sub>2</sub>/mass lost</li> </ul> <i>(minimum of four required pieces of information)</i><br>Units: /g or (g) or in g or g by <b>each</b> entry<br><i>(Ignore irrelevant data)</i> | 1    |       |
|          |                    | <b>II</b> <b>All</b> recorded balance readings consistent to at least 1 decimal place.<br><i>(minimum of <b>three</b> balance readings)</i>                                                                                                                                                                                                                                                                                                                                                     | 1    |       |
|          | ACE Interpretation | <b>IV</b> Correctly calculates the mass of <b>FB 4</b> added and the mass of carbon dioxide evolved.                                                                                                                                                                                                                                                                                                                                                                                            | 1    |       |
|          | MMO Quality        | <b>V and VI</b><br>Calculate $\frac{\text{mass FB 4}}{\text{mass of carbon dioxide}}$<br>to 3 significant figures and compare with Supervisor.                                                                                                                                                                                                                                                                                                                                                  |      |       |
|          |                    | Award <b>V</b> and <b>VI</b> for a difference $\leq 0.20$<br>Award <b>V</b> for a difference of $0.20 < \delta \leq 0.50$                                                                                                                                                                                                                                                                                                                                                                       | 2    | [6]   |

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| Question  | Sections           | Indicative material                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Mark | Total |
|-----------|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------|
| 2 (b)     | ACE Interpretation | (i) Correctly calculates<br>$\frac{\text{mass CO}_2 \text{ from (a)} \times 106}{44}$ to 2 – 4 sf                                                                                                                                                                                                                                                                                                                                                                     | 1    | [2]   |
|           |                    | (ii) Correct expression<br>$\frac{(\text{b})(\text{i}) \times 100}{\text{mass FB 4 from (a)}}$ <b>or</b> correct answer<br>to 2–4 sf ( <i>Do not penalise sf twice.</i> )                                                                                                                                                                                                                                                                                             | 1    |       |
| 2 (c) (i) | ACE Interpretation | Suggests a suitable significant source of error: <ul style="list-style-type: none"> <li>• CO<sub>2</sub> remains dissolved in acid</li> <li>• Impossible to prevent all acid spray</li> <li>• Reaction does not go to completion/ CO<sub>2</sub> not diffused (owtte) from flask</li> <li>• Some <b>FB 4</b> sticks to the wall of the flask.</li> </ul>                                                                                                              | 1    |       |
| (ii)      | ACE Conclusions    | Would lower %/decrease since less mass lost/CO <sub>2</sub> lost/ given out/evolved.<br>Would raise %/increase since more mass lost.<br>Would lower % since less mass lost/CO <sub>2</sub> produced.<br>Would lower % since less mass lost/used or less CO <sub>2</sub> produced<br>Explanation <b>must</b> follow source of error.<br><b>If</b> using 1dp balance then allow cannot tell whether the answer should be greater or smaller/% error could be either way | 1    |       |

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| Question   | Sections           | Indicative material                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Mark | Total |
|------------|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------|
| 2 (c)(iii) | ACE<br>Improvement | <p>Improvement suggested must be linked to the error (<i>even if imprecisely expressed</i>) identified in (i).</p> <p><b>Dissolved CO<sub>2</sub></b><br/>           Saturate the solution with CO<sub>2</sub> before experiment<br/> <b>or</b> use warm acid<br/> <b>or</b> use less acid.</p> <p><b>Acid spray</b><br/>           Use taller container<br/> <b>or</b> cotton wool plug or bung with hole<br/> <b>or</b> collect gas in syringe<br/> <b>or</b> use less concentrated acid.</p> <p><b>Going to completion</b><br/>           Keep weighing until mass does not go down further<br/> <b>or</b> leave for longer<br/> <b>or</b> swirl for longer<br/> <b>or</b> warm flask and contents<br/> <b>or</b> use more concentrated acid.</p> <p><b>Sticks to side</b><br/>           Use beaker<br/> <b>or</b> wider-necked flask.<br/> <b>If</b> 1dp balance used then allow use balance to 2 or 3 dp.</p> | 1    | [3]   |
|            | [Total 11]         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |      |       |

|        |                                     |          |       |
|--------|-------------------------------------|----------|-------|
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| Question                                                                                                                                  | Sections       | Indicative material                                                                                                                                             | Mark | Total |
|-------------------------------------------------------------------------------------------------------------------------------------------|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------|
| <b>FB 5</b> is $\text{CuCO}_3(\text{s})$ ; <b>FB 6</b> is $\text{Pb}(\text{NO}_3)_2(\text{s})$ ; <b>FB 7</b> is ethanedioic (oxalic) acid |                |                                                                                                                                                                 |      |       |
| <b>3 (a) (i)</b>                                                                                                                          | MMO Collection | Blue solution with <b>FB 5</b><br><b>and</b><br>colourless solution with <b>FB 6</b><br><b>and</b><br>(rapid) fizzing/bubbling/effervescence with <b>FB 5</b> . | 1    |       |
|                                                                                                                                           | MMO Decisions  | Describes the test on gas from <b>FB 5</b> with limewater with positive outcome<br><b>or</b><br>gas pops with lighted splint in <b>(b)(i)</b> .                 | 1    |       |

expected observations for **3(a)(ii)**

| test            | <b>FB 5</b>                                                                                                      | <b>FB 6</b>                      |
|-----------------|------------------------------------------------------------------------------------------------------------------|----------------------------------|
| + NaOH          | (pale) blue ppt<br>insoluble in excess                                                                           | white ppt<br>soluble in excess   |
| + $\text{NH}_3$ | (pale) blue ppt<br>(soluble in excess) forming<br>deep/dark blue solution                                        | white ppt<br>insoluble in excess |
| + KI            | brown (yellow-brown/orange-brown,<br>red-brown) ppt/solid/mixture<br><b>or</b> off-white ppt with brown solution | yellow ppt                       |

| Question         | Sections        | Indicative material                                                                                                                                                                                                                                                                                                                                                                      | Mark | Total |
|------------------|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------|
| <b>3 (a)(ii)</b> | MMO Collection  | <b>FB 5</b> correct observations with NaOH                                                                                                                                                                                                                                                                                                                                               | 1    | [9]   |
|                  |                 | <b>FB 5</b> correct observations with $\text{NH}_3$                                                                                                                                                                                                                                                                                                                                      | 1    |       |
|                  |                 | <b>FB 6</b> correct observations with NaOH <b>and</b> ammonia                                                                                                                                                                                                                                                                                                                            | 1    |       |
|                  |                 | KI correct observations with <b>FB 5 and FB 6</b>                                                                                                                                                                                                                                                                                                                                        | 1    |       |
| <b>(iii)</b>     | ACE Conclusions | <b>FB 5</b> contains $\text{Cu}^{2+}$                                                                                                                                                                                                                                                                                                                                                    | 1    |       |
|                  |                 | <b>FB 6</b> contains $\text{Pb}^{2+}$ (with some evidence)                                                                                                                                                                                                                                                                                                                               | 1    |       |
| <b>(iv)</b>      |                 | $\text{CO}_3^{2-}$ is anion in <b>FB 5</b> as fizzing / positive limewater test<br><b>or</b><br>some valid statement about the anion in <b>FB 6</b><br>e.g. could not be carbonate/sulfite as no fizz / could be nitrate as lead nitrate soluble/ not halide/sulfate/sulfite as lead halide/ $\text{PbSO}_4$ insoluble<br><b>or</b> no anion tests carried out so no conclusion possible | 1    |       |

|               |                                            |                 |              |
|---------------|--------------------------------------------|-----------------|--------------|
| <b>Page 9</b> | <b>Mark Scheme</b>                         | <b>Syllabus</b> | <b>Paper</b> |
|               | <b>GCE A LEVEL – October/November 2013</b> | <b>9701</b>     | <b>34</b>    |

|         |                    |                                                                                                                                                                                                                                                                     |        |     |
|---------|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----|
| (b) (i) | MMO<br>Collection  | effervescence between solution and Mg ribbon<br>manganate(VII) decolourised                                                                                                                                                                                         | 1<br>1 | [6] |
|         | ACE<br>Conclusions | <b>FB 7</b> is an acid<br><b>and</b><br>a reducing agent.                                                                                                                                                                                                           | 1      |     |
| (ii)    | MMO<br>Collection  | (ii) <b>Any two of</b> <ul style="list-style-type: none"><li>condensation near mouth of tube <b>or</b> steam produced</li><li>liquid at bottom of tube/solid melts/solid dissolves/gives colourless solution</li><li>charring in the solid/turning black.</li></ul> | 1<br>1 |     |
| (iii)   | ACE<br>Conclusions | (iii) <b>FB 7</b> is organic<br><b>or</b> simple covalent/molecular<br><b>or FB 7</b> is hydrated/has water of crystallisation<br><b>or</b> undergoes thermal decomposition.                                                                                        | 1      |     |
|         | [Total 15]         |                                                                                                                                                                                                                                                                     |        |     |

## **MARK SCHEME for the October/November 2013 series**

### **9701 CHEMISTRY**

**9701/35**

Paper 3 (Advanced Practical Skills 1),  
maximum raw mark 40

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the October/November 2013 series for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level components and some Ordinary Level components.

|        |                                     |          |       |
|--------|-------------------------------------|----------|-------|
| Page 2 | Mark Scheme                         | Syllabus | Paper |
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| Question | Sections                 | Indicative material                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Mark |  |
|----------|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|--|
| 1 (a)    | PDO<br><i>Layout</i>     | <b>I</b> Volume given for rough titre<br><b>and</b><br>accurate burette readings tabulated.<br>(min of 2 × 2 box)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 1    |  |
|          | MMO<br><i>Collection</i> | <b>II</b> Initial and final burette readings recorded for rough titre<br><b>and</b><br>volume of <b>FA 2</b> added recorded for each accurate titre<br><b>and</b><br>acceptable headings and units in the accurate section.<br><i>Acceptable headings are initial (burette) reading / initial volume / first reading / start reading<br/>Final (burette) reading / final volume / 2<sup>nd</sup> reading / end reading<br/>Titre / volume used / volume added / FA 2 added. (not difference or change in)<br/>Acceptable units are /cm<sup>3</sup> / in cm<sup>3</sup> / (cm<sup>3</sup>) / cm<sup>3</sup> by each reading.</i> | 1    |  |
|          | PDO<br><i>Recording</i>  | <b>III</b> <b>All</b> accurate burette readings recorded to nearest 0.05 cm <sup>3</sup> .<br><i>Do not award this mark if:</i> <ul style="list-style-type: none"> <li>• 50 (.00) is used as an initial burette reading</li> <li>• More than one final burette reading is 50 (.00)</li> <li>• Any burette reading is greater than 50. (00)</li> </ul>                                                                                                                                                                                                                                                                           | 1    |  |
|          | MMO<br><i>Decisions</i>  | <b>IV</b> Has two uncorrected, accurate titres within 0.1 cm <sup>3</sup> .<br><i>Do not include a reading labelled 'rough'.<br/>Do not award this mark if, having performed 2 titres within 0.1 cm<sup>3</sup>, a further titration is carried out which is &gt; 0.1 cm<sup>3</sup> from the closer of the 2 initial titres unless further titrations, within 0.1 of any others, have also been carried out.<br/>Do not award the mark if any accurate burette readings (apart from initial zero) are given as integer.</i>                                                                                                    | 1    |  |

| Page 3 | Mark Scheme                         | Syllabus | Paper |
|--------|-------------------------------------|----------|-------|
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|     |                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   |     |
|-----|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|-----|
|     | MMO<br>Quality        | <p><b>V, VI and VII</b></p> <p>All burette readings should be rounded to the nearest <math>0.05\text{ cm}^3</math>. Subtractions should be checked. Examiner then selects the 'best' titre using the hierarchy: two identical, titres within <math>0.05\text{ cm}^3</math> etc.</p> <p>These best titres should be used to calculate the mean titre to the nearest <math>0.01\text{ cm}^3</math>.</p> <p>Award <b>V, VI and VII</b> for a difference from Supervisor <math>\leq 0.2\text{ cm}^3</math>.</p> <p>Award <b>V and VI</b> for a difference from Supervisor <math>0.2 &lt; \delta \leq 0.3\text{ cm}^3</math>.</p> <p>Award <b>V</b> for a difference from Supervisor <math>0.3 &lt; \delta \leq 0.5\text{ cm}^3</math>.</p> <p><i>Spread penalty: if the two 'best' titres used by the Examiner are <math>\geq 0.50\text{ cm}^3</math> apart, cancel 1 Q mark.</i></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 3 | [7] |
| (b) | ACE<br>Interpretation | <p>Candidate calculates the mean correctly.</p> <p>Candidate must take the average of two (or more) titres where the total spread is <math>\leq 0.2\text{ cm}^3</math>.</p> <p>Working must be shown or ticks must be placed next to the accurate titres selected.</p> <p>The mean should normally be shown to <b>2 dp</b>, rounded to the nearest <math>0.01\text{ cm}^3</math>. Example 26.667 must be rounded to 26.67 and not 26.65 and 26.675 must be rounded to 26.68 and not 26.70.</p> <p>Two special cases where the mean may not be to 2 dp:<br/>Allow mean to 3dp only for 0.025 or 0.075 (e.g. 26.325)<br/>Allow mean to 1 dp if all accurate burette readings were given to 1 dp and the mean is exactly correct (e.g. 26.0 and <math>26.2 = 26.1</math> is correct but 26.0 and <math>26.1 = 26.1</math> is incorrect – should be 26.05)</p> <p><i>Do not award this mark if:</i><br/> <i>The rough titre was used to calculate the mean.</i><br/> <i>The candidate performed only one accurate titration.</i><br/> <i>Burette readings were incorrectly subtracted to obtain any of the accurate titre values.</i><br/> <i>All burette readings (resulting in titre values used in calculation of mean) are integers.</i></p> <p><i>Note: the candidate's mean will sometimes be marked correct even if it is different from the mean calculated by the Examiner for the purpose of assessing accuracy.</i></p> | 1 | [1] |

|        |                                     |          |       |
|--------|-------------------------------------|----------|-------|
| Page 4 | Mark Scheme                         | Syllabus | Paper |
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|             |                              |     |                                                                                                                                                                                         |   |     |
|-------------|------------------------------|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|-----|
| (c)         | ACE<br><i>Interpretation</i> | I   | Correctly calculates moles of NaOH = $\frac{(b) \times 0.1}{1000}$ in (i)<br><b>and</b><br>$\frac{(i) \times 1000}{25.0}$ in (ii)                                                       | 1 |     |
|             |                              | II  | $1.85 \times 4 = 7.40 \text{ (g dm}^{-3}\text{)}$<br><b>and</b><br>(iii) in (iv)<br>(ii)                                                                                                | 1 |     |
|             | PDO<br><i>Display</i>        | III | All answers to 3 or 4 sf (minimum of 3 answers)                                                                                                                                         | 1 |     |
|             | ACE<br><i>Conclusions</i>    | IV  | Acid with nearest $M_r$ .<br>Conclusion must correspond to $M_r$ .                                                                                                                      | 1 |     |
|             | MMO<br><i>Decisions</i>      | V   | Test – (aqueous) bromine/ <b>acidified</b> $\text{KMnO}_4$ /<br><b>alkaline</b> $\text{KMnO}_4$ .<br>Expected result – decolorises / (goes) colourless) /<br>decolorised / turns green. | 1 |     |
|             |                              |     |                                                                                                                                                                                         |   | [5] |
| [Total: 13] |                              |     |                                                                                                                                                                                         |   |     |

|        |                                     |          |       |
|--------|-------------------------------------|----------|-------|
| Page 5 | Mark Scheme                         | Syllabus | Paper |
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| Question | Sections                     | Indicative material                                                                                                                                                                                                                                          | Mark |     |
|----------|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-----|
| 2 (a)    | PDO<br><i>Layout</i>         | I Records at least four different balance readings (including 2 after heating) in the correct space.                                                                                                                                                         | 1    | [6] |
|          | PDO<br><i>Recording</i>      | II Gives all appropriate headings and units for all weighings.                                                                                                                                                                                               | 1    |     |
|          |                              | III All recorded <b>balance</b> readings consistent to at least 1 decimal place.                                                                                                                                                                             | 1    |     |
|          | MMO<br><i>Quality</i>        | IV Evidence of reheating to constant mass.<br>For balances reading to 1 dp two masses must be identical.<br>For 2 or 3 dp balances, two masses must be within 0.05g.                                                                                         | 1    |     |
|          |                              | V and VI<br>Examiner calculates $\frac{\text{mass residue}}{\text{mass of water}}$ to 3 significant figures.<br><br>Award <b>V</b> and <b>VI</b> for a difference from Supervisor up to 0.10.<br>Award <b>V</b> for a difference $0.10 < \delta \leq 0.30$ . | 2    |     |
| (b) (i)  | ACE<br><i>Interpretation</i> | I Calculation of mass of water and iron(II) sulfate                                                                                                                                                                                                          | 1    | [3] |
|          |                              | II $M_r$ s of 18 and 151.9 / sum of $A_r$ s if correctly used                                                                                                                                                                                                | 1    |     |
|          | (ii) PDO<br><i>Display</i>   | III Calculation $x = \frac{\text{mass water} \times 151.9}{\text{mass FeSO}_4 \times 18}$<br>(or 8.439 / ratio used for Q)<br><b>and</b><br>final answer to nearest integer.                                                                                 | 1    |     |
|          | ACE<br><i>Interpretation</i> |                                                                                                                                                                                                                                                              |      |     |

|        |                                     |          |       |
|--------|-------------------------------------|----------|-------|
| Page 6 | Mark Scheme                         | Syllabus | Paper |
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|                                                                                                                                                                         |                              |                                                                                                                                                                                                                                |   |     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|-----|
| (c)                                                                                                                                                                     | ACE<br><i>Interpretation</i> | Spitting / decomposition of anhydrous salt / stirring                                                                                                                                                                          | 1 | [3] |
|                                                                                                                                                                         | ACE<br><i>Improvements</i>   | If value of x is too high, the final mass of solid must be too low / some solid sticks to stirrer / crucible was wet and this water lost on heating / any statement that says that too much water is lost (free standing mark) | 1 |     |
|                                                                                                                                                                         |                              | Spitting – lid / larger container / heat <b>more</b> gently.                                                                                                                                                                   | 1 |     |
|                                                                                                                                                                         |                              | Decomposition – practical suggestion to control temperature.                                                                                                                                                                   |   |     |
|                                                                                                                                                                         |                              | No improvement possible for stirring losses (max 2)                                                                                                                                                                            |   |     |
| <b>[Total: 12]</b>                                                                                                                                                      |                              |                                                                                                                                                                                                                                |   |     |
| <b>FA 5</b> = Pb(NO <sub>3</sub> ) <sub>2</sub> ; <b>FA 6</b> = CaCl <sub>2</sub> ; <b>FA 7</b> is Al(NO <sub>3</sub> ) <sub>3</sub> ; <b>FA 8</b> is ZnSO <sub>4</sub> |                              |                                                                                                                                                                                                                                |   |     |
| 3 (a) (i)                                                                                                                                                               | MMO<br><i>Collection</i>     | Sublimes / OWTTE / white smoke / white gas                                                                                                                                                                                     | 1 |     |
|                                                                                                                                                                         |                              | Litmus paper to blue <b>and</b> ammonia evolved.                                                                                                                                                                               | 1 |     |
| (ii)                                                                                                                                                                    | MMO<br><i>Collection</i>     | Fizzing / bubbles / <b>gas</b> turns limewater milky                                                                                                                                                                           | 1 |     |
| (iii)                                                                                                                                                                   | MMO<br><i>Collection</i>     | Sodium hydroxide – no reaction.                                                                                                                                                                                                | 1 |     |
|                                                                                                                                                                         |                              | Silver nitrate – white precipitate<br><b>and</b><br>dissolves partly in nitric acid / does not dissolve in nitric acid / bubbles                                                                                               | 1 |     |
| (iv)                                                                                                                                                                    | ACE<br><i>Conclusions</i>    | Anions – CO <sub>3</sub> <sup>2-</sup> and Cl <sup>-</sup>                                                                                                                                                                     | 1 |     |
|                                                                                                                                                                         |                              | Cation – NH <sub>4</sub> <sup>+</sup>                                                                                                                                                                                          | 1 |     |
| (v)                                                                                                                                                                     | MMO<br><i>Decisions</i>      | (Aqueous) sodium hydroxide gives ammonia on heating                                                                                                                                                                            | 1 |     |
| (vi)                                                                                                                                                                    | MMO<br><i>Collection</i>     | White (precipitate) <b>and</b> barium carbonate.<br>(ecf of barium sulfite if sulfite in (iv))                                                                                                                                 | 1 | [9] |

|               |                                            |                 |              |
|---------------|--------------------------------------------|-----------------|--------------|
| <b>Page 7</b> | <b>Mark Scheme</b>                         | <b>Syllabus</b> | <b>Paper</b> |
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|             |                    |                                                                                                                                                                     |               |             |               |               |     |
|-------------|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-------------|---------------|---------------|-----|
| (b)         | MMO<br>Collection  | test                                                                                                                                                                | observations  |             |               |               |     |
|             |                    | FA 5                                                                                                                                                                | FA 6          | FA 7        | FA 8          |               |     |
|             |                    | sodium hydroxide                                                                                                                                                    | white ppt     | white ppt   | white ppt     | white ppt     |     |
|             |                    | excess                                                                                                                                                              | ppt dissolves | ppt remains | ppt dissolves | ppt dissolves |     |
|             |                    | ammonia                                                                                                                                                             | white ppt     | no reaction | white ppt     | white ppt     |     |
|             |                    | excess                                                                                                                                                              | ppt remains   |             | ppt remains   | ppt dissolves |     |
|             |                    | KI                                                                                                                                                                  | yellow ppt    | no reaction | no reaction   | no reaction   |     |
| (i)         |                    | 1 mark for each correct vertical column<br>or<br>1 mark for each horizontal row (max 3 marks)                                                                       |               |             |               | 4             |     |
| (ii)        | ACE<br>Conclusions | FA 5 is Pb <sup>2+</sup> , FA 6 is Ca <sup>2+</sup> , FA 7 is Al <sup>3+</sup> , FA 8 is Zn <sup>2+</sup> .<br>All correct scores 2 marks, 2 correct scores 1 mark. |               |             |               | 2             | [6] |
| [Total: 15] |                    |                                                                                                                                                                     |               |             |               |               |     |

## **MARK SCHEME for the October/November 2013 series**

### **9701 CHEMISTRY**

**9701/36**

Paper 3 (Advanced Practical Skills 2),  
maximum raw mark 40

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

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| Question | Sections      | Indicative material                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Mark        | Total |
|----------|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------|
| 1 (a)    | PDO layout    | I The following data are given <ul style="list-style-type: none"> <li>mass of solid used (or both weighings)</li> <li>volume used in rough titre (or both readings)</li> <li>initial <b>and</b> final readings for <b>two</b> (or more) accurate titrations</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 1           |       |
|          | PDO recording | II Acceptable/appropriate headings for <b>all</b> data given in weighing <b>and</b> accurate titration tables <b>and</b> g and cm <sup>3</sup> units. <ul style="list-style-type: none"> <li>mass/weight of beaker (empty)</li> <li>mass of beaker + <b>FB 1</b>/solid</li> <li>mass solid/<b>FB1</b></li> <li>initial/start/first (burette) reading/volume</li> <li>final/end/second (burette) reading/volume</li> <li>titre <b>or</b> volume used/added/<b>FB 5</b> added (<i>but not difference or change in volume</i>)</li> <li>unit:/cm<sup>3</sup> <b>or</b> (cm<sup>3</sup>) <b>or</b> in cm<sup>3</sup> <b>or</b> cm<sup>3</sup></li> </ul> <p><i>If g/cm<sup>3</sup> units are not given in the heading, every entry in the table must have the correct unit.</i></p> | 1           |       |
|          | PDO recording | III All <b>accurate</b> burette readings are to the nearest 0.05 cm <sup>3</sup> .<br><i>The need to record to 0.05 only applies to the burette readings, including 0.00 cm<sup>3</sup> (if this was the initial reading), but it does <b>not</b> apply to the titre.</i><br><i>Do <b>not</b> award this mark if:</i> <ul style="list-style-type: none"> <li>50(.00) is used as an initial burette reading</li> <li>more than one final burette reading is 50.(00)</li> <li>any burette reading is greater than 50.(00).</li> </ul>                                                                                                                                                                                                                                             | 1           |       |
|          | MMO decision  | IV There are two uncorrected accurate titres within 0.10 cm <sup>3</sup> .<br><i>Do not include a reading if it is labelled “rough”.</i><br><i>Do not award this mark if, having performed two titres within 0.1 cm<sup>3</sup>, a further titration is performed which is more than 0.10 cm<sup>3</sup> from the closer of the initial two titres, unless further titrations, within 0.1 cm<sup>3</sup> of any other, has also been carried out.</i><br><i>Do not award the mark if any accurate burette readings (apart from initial zero) are given as integers.</i>                                                                                                                                                                                                         | 1           |       |
|          | MMO quality   | Examiner calculates mean titre × mass <b>FB 1</b> for candidate and Supervisor.<br>Award <b>V</b> , <b>VI</b> and <b>VII</b> if $\delta \leq 2$ (g cm <sup>3</sup> )<br>Award <b>V</b> and <b>VI</b> if $2 < \delta \leq 3$<br>Award <b>V</b> , only, if $3 < \delta \leq 5$ .<br><i>Spread penalty: if two best titres used by the Examiner are <math>\geq 0.50</math> cm<sup>3</sup> apart, cancel one Q mark.</i>                                                                                                                                                                                                                                                                                                                                                            | 1<br>1<br>1 | [7]   |

| Page 3 | Mark Scheme                         | Syllabus | Paper |
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|       |              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |   |     |
|-------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|-----|
| 1 (b) | MMO decision | <p>Candidate calculates the mean correctly.</p> <p>Candidate must take the average two (or more) titres where the total spread is <math>\leq 0.2 \text{ cm}^3</math>.</p> <p>Working must be shown <b>or</b> ticks must be put next to the accurate titres selected.</p> <p>The mean should normally be quoted to <b>2 dp</b>, rounded to nearest <math>0.01 \text{ cm}^3</math>. Example <math>26.667 \text{ cm}^3</math> must be rounded to <b>26.67 not</b> <math>26.65 \text{ cm}^3</math>, <math>26.675 \text{ cm}^3</math> must be rounded to <b>26.68 not</b> <math>26.70 \text{ cm}^3</math>.</p> <p>Two special cases, where the mean may not be to 2 dp: Allow mean expressed to 3 dp, only for 0.025 or 0.075. Allow mean if expressed to 1 dp if all accurate burette readings were given to 1 dp (ignoring initial given as 0) and the mean is exactly correct e.g. <math>26.0</math> and <math>26.2 = 26.1</math> is correct but <math>26.0</math> and <math>26.1 = 26.1</math> is wrong – should be <math>26.05</math>.</p> <p><i>Do not award this mark if:</i></p> <ul style="list-style-type: none"> <li>The rough titre was used to calculate the mean.</li> <li>The candidate did only one accurate titration.</li> <li>Burette readings were incorrectly subtracted to obtain any of the accurate titre values.</li> <li>All burette readings (resulting in titre values used in calculation of mean) are integers.</li> </ul> <p><b>Note:</b> the candidate's mean will sometimes be marked correct even if it is different from the mean calculated by the Examiner for the purpose of assessing accuracy.</p> | 1 | [1] |
|       |              | I Correctly calculates moles of $\text{Na}_2\text{S}_2\text{O}_3$ weighed in (i) = <u>mass of FB1 used</u><br>248.2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 1 |     |
|       |              | II Correct expression for moles of $\text{Na}_2\text{S}_2\text{O}_3$ used in (ii) = <u>answer (i) <math>\times</math> mean titre</u><br>250                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 1 |     |
|       |              | III Correct calculations/expression in (iii) and (iv) (iii) : no moles of $\text{I}_2 = 0.5 \times$ (ii)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 1 |     |
|       | PDO display  | IV Correct expression in (v)<br>Mass = answer (iv) $\times 40 \times 158(.0)$ ( $\times 40$ may be shown as $\times 1000/25$ )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 1 | [5] |
|       | PDO display  | V All quoted answers are given to 3 or 4 significant figures. (minimum of three answers)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 1 |     |

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|                    |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |             |     |
|--------------------|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-----|
| 1 (d)              | ACE interpretation | error = 0.05 cm <sup>3</sup> in (i)<br><b>and</b><br>% error in volume of <b>FB 5</b> = $\frac{2 \times 0.05}{\text{vol of FB 5 used}} \times 100$ in (ii)                                                                                                                                                                                                                                                                                                                                                | 1           | [1] |
| <b>[Total: 14]</b> |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |             |     |
| 2 (a)              | MMO collection     | I The masses of <b>FB 6</b> used by the candidate were between 2.0 – 2.4 g (expt 1) <b>and</b> 2.5 – 2.9 g (expt 2).                                                                                                                                                                                                                                                                                                                                                                                      | 1           |     |
|                    | PDO display        | II Suitable headings for a table or list, shown completely for at least one experiment. If 2 experiments, all headings must be correct.<br><ul style="list-style-type: none"> <li>• (mass of) empty crucible</li> <li>• (mass of) crucible + <b>FB 6</b></li> <li>• (mass of) crucible + residue/<b>FB 6</b> after heating</li> <li>• mass (water) lost or mass anhydrous remaining</li> </ul> <b>and</b> unit covering every weighing.<br><i>Unit/g or (g) or in grams or g following each weighing.</i> | 1           |     |
|                    | PDO recording      | III Records <b>all</b> balance readings consistently to at least 1 dp<br><i>A minimum of <b>three</b> weighings are needed.</i>                                                                                                                                                                                                                                                                                                                                                                           | 1           |     |
|                    | MMO quality        | Examiner calculates $\frac{\text{mass of hydrated salt}}{\text{mass of water}}$ for each experiment.<br>Award <b>IV</b> if the ratio in expt 1 is between 0.95 and 1.15.<br>Award <b>V</b> If the ratio in expt 2 is between 0.95 and 1.15.<br>Award <b>VI</b> If the ratio in <b>both</b> of experiments 1 and 2 is between 0.85 and 1.25.                                                                                                                                                               | 1<br>1<br>1 | [6] |
| 2 (b)              | MMO quality        | (i) An appropriate choice of the more accurate experiment, <b>and</b> justification of choice. Three possibilities: <ul style="list-style-type: none"> <li>• <i>Experiment 2 uses a larger mass and has a greater <b>percentage</b> accuracy.</i></li> <li>• <i>A reference to either experiment “spitting” or “frothing” during heating is a valid reason for nominating the other experiment.</i></li> <li>• <i>Experiment 1 as smaller mass takes less heating.</i></li> </ul>                         | 1           |     |
|                    | ACE interpretation | (ii) Correctly calculates number of moles of water = $\frac{\text{mass of water lost}}{18}$<br><i>Ans to 2–4 sf</i><br><i>Candidate must use the mass loss for the experiment thought to be more accurate. (If no choice is expressed in (i), this should be expt 2.)</i>                                                                                                                                                                                                                                 | 1           |     |
|                    | ACE conclusion     | (iii) <b>MSO<sub>4</sub>·7H<sub>2</sub>O(s) → MSO<sub>4</sub>(s) + 7H<sub>2</sub>O(g)</b><br><i>Allow (l) for water.</i>                                                                                                                                                                                                                                                                                                                                                                                  | 1           |     |

|               |                                            |                 |              |
|---------------|--------------------------------------------|-----------------|--------------|
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|              |                    |                                                                                                                                                                                                                                |   |                    |
|--------------|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|--------------------|
|              | ACE interpretation | <b>(iv) Correct answer calculated</b><br>$n(\text{MSO}_4) = \frac{n(\text{water})}{7}$<br>i.e. answer (ii) divided by 7<br><i>Ans to 2–4 sf</i>                                                                                | 1 |                    |
|              | ACE interpretation | <b>(v) Method mark showing the numbers for the expression</b><br>Relative formula mass = $\frac{\text{mass of residue}}{\text{no of moles}}$<br><i>Mass of residue from same expt as mass of water</i><br><i>Ans to 2–4 sf</i> | 1 |                    |
|              | ACE interpretation | <b>(vi) Correct answer calculated</b><br>$A_r = M_r - 96.1$ .<br>Candidates are allowed to use 126.3 as the $M_r$ .<br>In this case, the $A_r = 30.2$ .<br><i>Ans 2–4 sf</i><br><i>Penalise sf once only within (b)</i>        | 1 |                    |
|              | ACE conclusion     | <b>(vii) Correct identification of M as magnesium and explanation that this <math>A_r</math> is closest to value calculated.</b><br><i>Allow alternative identity of metal as ecf from <math>A_r</math> value.</i>             | 1 |                    |
|              | ACE conclusion     | <b>(viii) (M is divalent but) Al and Cr are both trivalent or (M forms 2+ ion whereas) Al and Cr are 3+ or sulfates of Cr/Al are not <math>\text{CrSO}_4</math> and <math>\text{AlSO}_4</math> (ora) ref to both needed</b>    | 1 | [8]                |
| <b>2 (c)</b> | ACE Improvements   | Cool in a desiccator<br><b>or</b> cool in closed container with a (named) drying agent                                                                                                                                         | 1 | [1]                |
|              |                    |                                                                                                                                                                                                                                |   | <b>[Total: 15]</b> |

|        |                                     |          |       |
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**FB 6** = MgSO<sub>4</sub>; **FB 7** is H<sub>2</sub>SO<sub>4</sub>; **FB 8** is Pb(NO<sub>3</sub>)<sub>2</sub>; **FB 9** = KI

|                |                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                               |     |            |                                                                                                   |                                            |             |      |    |                                                                                                   |                                            |             |      |  |           |             |      |  |  |            |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|------------|---------------------------------------------------------------------------------------------------|--------------------------------------------|-------------|------|----|---------------------------------------------------------------------------------------------------|--------------------------------------------|-------------|------|--|-----------|-------------|------|--|--|------------|
| 3 (a)          | MMO collection                                                                                                                                             | (i) White precipitate, insoluble in excess for <b>both</b> NaOH <b>and</b> NH <sub>3</sub>                                                                                                                                                                                                                                                                                                                    | 1   |            |                                                                                                   |                                            |             |      |    |                                                                                                   |                                            |             |      |  |           |             |      |  |  |            |
|                | MMO decision                                                                                                                                               | (ii) Use barium chloride/nitrate <b>and</b> hydrochloric/nitric acid<br><br>White precipitate formed, insoluble in acid.                                                                                                                                                                                                                                                                                      | 1   |            |                                                                                                   |                                            |             |      |    |                                                                                                   |                                            |             |      |  |           |             |      |  |  |            |
|                | MMO collection                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                               | 1   |            |                                                                                                   |                                            |             |      |    |                                                                                                   |                                            |             |      |  |           |             |      |  |  |            |
|                | ACE conclusion                                                                                                                                             | (iii) Ba <sup>2+</sup> + SO <sub>4</sub> <sup>2-</sup> → BaSO <sub>4</sub>                                                                                                                                                                                                                                                                                                                                    | 1   | [4]        |                                                                                                   |                                            |             |      |    |                                                                                                   |                                            |             |      |  |           |             |      |  |  |            |
| 3 (b)          | MMO collection                                                                                                                                             | (i) One mark for each column                                                                                                                                                                                                                                                                                                                                                                                  | 1   |            |                                                                                                   |                                            |             |      |    |                                                                                                   |                                            |             |      |  |           |             |      |  |  |            |
|                |                                                                                                                                                            | <table><tr><td></td><td>FB 7</td><td>FB 8</td><td>FB 9</td></tr><tr><td>Mg</td><td>Fizzing or tube gets hot/heat given out or Mg dissolves <b>and</b> (gas) pops with lighted splint</td><td>Black solid/ppt formed/Mg strip turns dark</td><td>No reaction</td></tr><tr><td>FB 7</td><td></td><td>White ppt</td><td>No reaction</td></tr><tr><td>FB 8</td><td></td><td></td><td>Yellow ppt</td></tr></table> |     |            |                                                                                                   | FB 7                                       | FB 8        | FB 9 | Mg | Fizzing or tube gets hot/heat given out or Mg dissolves <b>and</b> (gas) pops with lighted splint | Black solid/ppt formed/Mg strip turns dark | No reaction | FB 7 |  | White ppt | No reaction | FB 8 |  |  | Yellow ppt |
|                |                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                               |     |            | FB 7                                                                                              | FB 8                                       | FB 9        |      |    |                                                                                                   |                                            |             |      |  |           |             |      |  |  |            |
|                |                                                                                                                                                            | Mg                                                                                                                                                                                                                                                                                                                                                                                                            |     |            | Fizzing or tube gets hot/heat given out or Mg dissolves <b>and</b> (gas) pops with lighted splint | Black solid/ppt formed/Mg strip turns dark | No reaction |      |    |                                                                                                   |                                            |             |      |  |           |             |      |  |  |            |
|                |                                                                                                                                                            | FB 7                                                                                                                                                                                                                                                                                                                                                                                                          |     |            |                                                                                                   | White ppt                                  | No reaction |      |    |                                                                                                   |                                            |             |      |  |           |             |      |  |  |            |
|                | FB 8                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                               |     | Yellow ppt |                                                                                                   |                                            |             |      |    |                                                                                                   |                                            |             |      |  |           |             |      |  |  |            |
|                |                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                               |     |            |                                                                                                   |                                            |             |      |    |                                                                                                   |                                            |             |      |  |           |             |      |  |  |            |
|                |                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                               |     |            |                                                                                                   |                                            |             |      |    |                                                                                                   |                                            |             |      |  |           |             |      |  |  |            |
|                |                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                               |     |            |                                                                                                   |                                            |             |      |    |                                                                                                   |                                            |             |      |  |           |             |      |  |  |            |
| ACE conclusion | (ii) <b>FB 7</b> is sulfuric acid <b>and</b> it is acidic ( <b>or</b> H <sup>+</sup> ions are present) because it fizzes/hydrogen produced with magnesium. | 1                                                                                                                                                                                                                                                                                                                                                                                                             |     |            |                                                                                                   |                                            |             |      |    |                                                                                                   |                                            |             |      |  |           |             |      |  |  |            |
| MMO collection | (iii) Red-brown/brown/orange-brown/yellow-brown colour with KI (not red or orange or yellow) <b>and</b> blue or black colour with starch                   | 1                                                                                                                                                                                                                                                                                                                                                                                                             |     |            |                                                                                                   |                                            |             |      |    |                                                                                                   |                                            |             |      |  |           |             |      |  |  |            |
| ACE conclusion | Iodine produced <b>and</b> the anion in <b>FB 9</b> is iodide.                                                                                             | 1                                                                                                                                                                                                                                                                                                                                                                                                             |     |            |                                                                                                   |                                            |             |      |    |                                                                                                   |                                            |             |      |  |           |             |      |  |  |            |
| ACE conclusion | (iv) PbI <sub>2</sub> or AgI (or both)<br><i>Ecf possible for CrO<sub>4</sub><sup>2-</sup> in (iii) with Ba<sup>2+</sup> or Pb<sup>2+</sup></i>            | 1                                                                                                                                                                                                                                                                                                                                                                                                             | [7] |            |                                                                                                   |                                            |             |      |    |                                                                                                   |                                            |             |      |  |           |             |      |  |  |            |
| [Total: 11]    |                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                               |     |            |                                                                                                   |                                            |             |      |    |                                                                                                   |                                            |             |      |  |           |             |      |  |  |            |