

**UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS**

**GCE Advanced Subsidiary Level and GCE Advanced Level**

**MARK SCHEME for the May/June 2009 question paper  
for the guidance of teachers**

**9701 CHEMISTRY**

**9701/31**

Paper 31 (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.

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### Supervisor's Report

Calculate, correct to 2 dp, the titre if the Supervisor had diluted 47.25 cm<sup>3</sup> of **FA 2**.

This is given by the expression  $\frac{47.25}{\text{volume diluted}} \times \text{Examiner selected titre}$

### Candidate scripts

Calculate the scaled titre for 47.25 cm<sup>3</sup> of **FA 2**.

Record the value against the titration table and calculate the difference to Supervisor.

| Question | Sections              | Indicative material  | Mark |     |
|----------|-----------------------|--|------|-----|
| 1 (a)    | PDO<br>Layout         | (i) Tabulates initial and final burette readings and volume added in each of the tables.<br><i>Do <b>not</b> award this mark if any final and initial burette readings are inverted or 50 is used as the initial burette reading.</i>  | 1    | [6] |
|          | PDO<br>Recording      | (ii) Both burette readings in the dilution table and <u>final and initial</u> burette readings for all accurate titres in the titration table recorded to the nearest 0.05 cm <sup>3</sup> .   | 1    |     |
|          | MMO<br>Collection     | (iii) Follows instructions:<br>dilutes 47.00 cm <sup>3</sup> to 47.50 cm <sup>3</sup><br><b>and</b><br>has any two titres within 0.20 cm <sup>3</sup>  | 1    |     |
|          | MMO<br>Decisions      | (iv) Has at least two uncorrected "accurate" titres within 0.1 cm <sup>3</sup><br><i>Do <b>not</b> include any titre labelled "rough"/"trial" unless the candidate has ticked that value or used it in an expression when calculating the average in (b).</i>  | 1    |     |
|          | MMO<br>Quality        | <b>Accuracy (v) and (vi)</b><br>Give (v) and (vi) if difference to Supervisor is <b>0.3</b> or less<br>Give (vi) <b>only</b> for a difference of <b>0.3+ to 0.5</b><br>Give <b>neither mark</b> for a difference greater than <b>0.5</b> .   | 2    |     |
| (b)      | ACE<br>Interpretation | Candidate selects/calculates appropriate "average" from any uncorrected titre values within 0.20 cm <sup>3</sup> .<br><i>Candidate is permitted to use a titre labelled "rough" or "trial".</i><br><i>Titres to be used <b>must be shown</b>.</i><br><br>Where <b>all</b> titres are given to 1 decimal place the average should be calculated correct to 1 or 2 decimal places.<br>Where any titre is recorded to 2 decimal places, the average should be calculated to 2 decimal places or rounded to the nearest 0.05 cm <sup>3</sup> . | 1    | [1] |

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|                    |                    |  |   |     |
|--------------------|--------------------|--|---|-----|
| (c)                | ACE Interpretation | <p><b>(i), (ii) and (iii)</b><br/>Award three marks if all steps are chemically correct. Withhold 1 mark for each chemical error – no negative marks. Count non-completed steps as chemical errors.</p> <p>step 1 <math>\frac{\text{titre}}{1000} \times 0.15</math></p> <p>step 2 <math>\times \frac{1}{2}</math></p> <p>step 3 <math>\times 2</math></p> <p>step 4 <math>\times \frac{1000}{25}</math></p> <p>step 5 <math>\times \frac{250}{\text{volume diluted}}</math></p> <p>step 6 <math>\times 249.6</math></p> | 3 |     |
|                    | PDO Display        | <b>(iv)</b> Working shown in at least three of the 5 steps   | 1 |     |
|                    |                    | <b>(v)</b> Answers to 3 or 4 significant figures in final answer to each step attempted ( <b>minimum of three steps required</b> )   | 1 |     |
|                    |                    |  |   | [5] |
| (d)                | ACE Interpretation | Explains that the maximum error is given by + 0.05 cm <sup>3</sup> on one burette reading and –0.05 cm <sup>3</sup> on the other burette reading,<br><b>or</b><br>Individual errors are in opposite directions.  | 1 |     |
|                    |                    |  |   | [1] |
| (e)                | ACE Interpretation | Calculates $\frac{0.1}{\text{titre}} \times 100 \%$<br>Answer must be correct to 2 or 3 decimal places.  | 1 |     |
|                    |                    |  |   | [1] |
| <b>[Total: 14]</b> |                    |  |   |     |

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### Supervisor's Report

From the Supervisor's experimental results **round times to the nearest second** and calculate the average of (volume of sodium thiosulfate x time) for 50 cm<sup>3</sup> and for 25 cm<sup>3</sup> of sodium thiosulfate.

### Candidate's scripts

From the candidate's experimental results **round times to the nearest second** and calculate (volume of sodium thiosulfate x time) as above.

Record values of (V x t) on script and use in assessing accuracy marks.

| Question | Sections          | Indicative material   | Mark |  |
|----------|-------------------|---|------|--|
| 2 (a)    | PDO<br>Layout     | (i) Tabulates all experimental readings: volumes of sodium thiosulfate and water, time and rate ( $1/t$ )   | 1    |  |
|          | PDO<br>Recording  | (ii) Single table covering all three experiments<br><i>A single table has no repetition of column headings.</i>   | 1    |  |
|          |                   | (iii) Table has correct labels and units: e.g. /cm <sup>3</sup> , /cubic centimetres, <b>or</b> (cm <sup>3</sup> ), (cubic centimetres) <b>or</b> volume in cubic centimetres;<br><b>Similarly</b> for time (s or seconds but <b>not</b> sec) <b>and</b> rate (s <sup>-1</sup> , rate (in) per second; $1/s$ etc.)<br><b>At least two different units are required.</b><br><i>Where units have not been included in the column or row header there should be the appropriate unit for <u>each entry</u> in the table.</i> | 1    |  |
|          | MMO<br>Collection | (iv) All times of reaction are recorded to the nearest second ( <b>no</b> decimal places).  | 1    |  |
|          | MMO<br>Quality    | (v) and (vi)<br>Give (v) and (vi) if difference between candidate's (V x t) values ( <b>50 &amp; 25 cm<sup>3</sup> FA 1</b> ), is within 5% of the larger value.<br>Give (vi) <b>only</b> if the difference is > 5% but ≤10% of the larger value.   | 2    |  |
|          |                   | (vii) and (viii)<br>Compare the closer of the candidate's (V x t) values with the Supervisor's average Vt.<br>Give (vii) and (viii) if difference is within 10% of the <u>Supervisor's value</u> .<br>Give (viii) <b>only</b> if the difference is > 10% but ≤20% of the <u>Supervisor's value</u> .  | 2    |  |
|          | MMO<br>Decisions  | (ix) Selects (10–15) <b>or</b> (35–40) cm <sup>3</sup> sodium thiosulfate and an appropriate volume of water to give a total volume of 50 cm <sup>3</sup> (or 55 cm <sup>3</sup> if the volume of acid is tabulated).   | 1    |  |

[9]

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|                    |                    |   |   |     |
|--------------------|--------------------|---|---|-----|
| (b)                | ACE Interpretation | Candidate shows by calculation or by mathematical expression that $[\text{Na}_2\text{S}_2\text{O}_3] \propto \text{volume of Na}_2\text{S}_2\text{O}_3(\text{aq})$ in 50/55 $\text{cm}^3$ of solution.<br><i>Reference to (<math>^{50}/_{50}</math> or <math>^{50}/_{55}</math>) and (<math>^{25}/_{50}</math> or <math>^{25}/_{55}</math>)</i> | 1 | [1] |
| (c)                | ACE Conclusions    | Explains that rate is given by the inverse of time <b>or</b> is inversely proportional to time; <b>or</b><br>Rate $\propto \frac{1}{\text{time}}$<br><i>Allow Rate = <math>\frac{1}{\text{time}}</math></i>   | 1 | [1] |
| (d)                | ACE Interpretation | (i) <b>Correctly</b> evaluates all $Vt$ values (using times given by candidate, including decimal places where appropriate –<br><b>or</b><br>(ii) gives an appropriate qualitative statement relating (rate or time) and concentration.<br><i>Award this mark if <b>either</b> is correct.</i>  | 1 | [2] |
|                    | ACE Conclusions    | Gives a quantitative description of relationship.<br><i><math>Vt</math> values are required but do not have to be correctly evaluated.<br/>Where no pattern is obvious accept an appropriate statement to that effect.</i>  | 1 |     |
| (e)                | ACE Improvements   | Explains that volumes of reactants or concentration (of thiosulfate and acid) must be kept constant <b>and</b> describes <u>how</u> the temperature will be varied.   | 1 | [1] |
| <b>[Total: 14]</b> |                    |   |   |     |

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| Question  | Sections          | Indicative material   | Mark |     |
|---|-------------------|---|------|-----|
| <b>FA 5 is K<sub>2</sub>CrO<sub>4</sub>(aq); FA 6 is NaNO<sub>2</sub>(aq); FA 7 is Pb(NO<sub>3</sub>)<sub>2</sub>(aq), FA 8 is MgSO<sub>4</sub>(aq)</b> |                   |   |      |     |
| <b>3 (a)</b>  | MMO<br>Collection | (i) Records no reaction, no change or no precipitate on adding NaOH and NH <sub>3</sub> (aq) to <b>FA 5</b> and <b>FA 6</b> .   | 1    | [4] |
|   |                   | (ii) Records white ppt soluble (in excess NaOH) and white ppt insoluble (in excess NH <sub>3</sub> ) with <b>FA 7</b>   | 1    |     |
|   |                   | (iii) Records white ppt insoluble (in excess for both NaOH and NH <sub>3</sub> ) with <b>FA 8</b>   | 1    |     |
|   | ACE<br>Conclusion | (iv) Conclusion is marked <b>consequentially</b> from the observations for a single cation and a pair of cations.<br><i>Mg<sup>2+</sup>/magnesium from white ppt insoluble in an excess of NaOH(aq) and in an excess of NH<sub>3</sub>(aq)</i><br><br><i>Ca<sup>2+</sup>/calcium from white ppt insoluble in an excess of NaOH(aq) no ppt in NH<sub>3</sub>(aq)</i><br><br><i>Pb<sup>2+</sup>/Al<sup>3+</sup> from white ppt soluble in an excess of NaOH(aq) and insoluble in an excess of NH<sub>3</sub>(aq)</i><br><br><i>Ba<sup>2+</sup>/NH<sub>4</sub><sup>+</sup> from no ppt with NaOH(aq) or NH<sub>3</sub>(aq)</i><br><b>FA 6 only</b>   | 1    |     |
| <b>(b)</b>  | MMO<br>Decisions  | (Warms) with NaOH and Al(s) and records appropriate test for ammonia. <b>Gas</b> must be tested in at least one test. <i>This is a mark for the method not the observation.</i>   | 1    | [2] |
|   | ACE<br>Conclusion | Must have indication that the test has been performed with <b>FA 6, FA 7</b> and <b>FA 8</b> .<br><br>In awarding the conclusion mark, assume, <b>in this section only</b> , that a blank box indicates no reaction (no ammonia detected).<br><br>Award this mark for any of the following:<br>(i) a conclusion, from correct observations, that <b>FA 6</b> and <b>FA 7</b> contain nitrate or nitrite<br>(ii) correct observations for NH <sub>3</sub> – only with <b>FA 6</b> and <b>FA 7</b> , but no conclusion given<br>(iii) a statement that NH <sub>3</sub> is evolved – only with <b>FA 6</b> and <b>FA 7</b><br>(iv) observation that red litmus turns blue (gas not needed) – only with <b>FA 6</b> and <b>FA 7</b> | 1    |     |

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|-----|--------------------|---|--------------------|--|
| (c) | MMO<br>Collection  | (i) Observes a change in colour (from yellow) to yellow/orange or orange (solution), <b>no ppt</b> , with <b>FA 5 and</b><br>a white ppt with <b>FA 7</b> .   | 1                  |  |
|     | ACE<br>Conclusions | (ii) Observes a brown gas formed with only <b>FA 6</b> .<br><b>Mark (iii) and (iv) consequentially to observations</b><br>(iii) Give this mark for <b>one</b> conclusion providing it is supported by an acceptable explanation.<br>(iv) Give this mark for <b>two</b> further conclusions supported by acceptable explanations.<br><br>Minimum acceptable supporting evidence:<br>CrO <sub>4</sub> <sup>2-</sup> from yellow soln <b>or</b> soln turning orange in acid<br>NO <sub>2</sub> <sup>-</sup> from brown gas<br><b>or</b><br>from effervescence/fizzing/bubbling with acid, <b>if</b> named soln has yielded ammonia or an alkaline gas in <b>(b)</b><br>NO <sub>3</sub> <sup>-</sup> no brown gas etc with acid, but ammonia evolved in <b>(b)</b><br>Pb <sup>2+</sup> white ppt with HCl if Pb <sup>2+</sup> in <b>(a) (iv)</b><br>Al <sup>3+</sup> no white ppt with HCl if Al <sup>3+</sup> in <b>(a) (iv)</b> | 1<br><br>2         |  |
| (d) | MMO<br>Collection  | Mixes <b>FA 5</b> and <b>FA 7</b> and observes a yellow ppt.<br><br>If this section has not been attempted, the correct <u>observation</u> on mixing <b>FA 5</b> and <b>FA 7</b> can be carried forward from the conclusions in <b>(c)</b> .  | 1                  |  |
|     | ACE<br>Conclusions | Concludes that <b>FA 5</b> contains CrO <sub>4</sub> <sup>2-</sup> and <b>FA 7</b> contains Pb <sup>2+</sup> providing the ions have been previously mentioned in <b>(a)</b> or <b>(c)</b> .  | 1                  |  |
|     |                    |   | <b>[Total: 12]</b> |  |