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**CHEMISTRY**

**9701/51**

Paper 5 Planning, Analysis and Evaluation

**October/November 2019**

MARK SCHEME

Maximum Mark: 30

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**Published**

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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This document consists of **7** printed pages.



**Cambridge Assessment**  
International Education

**Generic Marking Principles**

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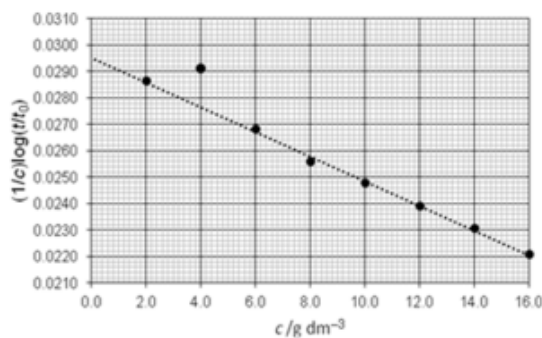
**GENERIC MARKING PRINCIPLE 6:**

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## PUBLISHED

| Question  | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Marks |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 1(a)(i)   | <p><b>M1:</b> moles of <math>Y_2O_3</math> = <math>0.750 \div (2 \times 88.9 + 3 \times 16.0)</math><br/> = <math>0.750 \div 225.8</math><br/> = <math>3.32 \times 10^{-3}</math> (mol) <math>3.3215235 \times 10^{-3}</math></p> <p><b>M2:</b> mass of <math>BaCO_3</math> = <math>4 \times 3.32 \times 10^{-3} \times (137.3 + 12.0 + 3 \times 16.0)</math><br/> = <math>4 \times 3.32 \times 10^{-3} \times 197.3</math><br/> = 2.62 (g) 2.6213463</p> <p><b>M3:</b> mass of <math>CuO</math> = <math>6 \times 3.32 \times 10^{-3} \times (63.5 + 16.0)</math><br/> = <math>6 \times 3.32 \times 10^{-3} \times 79.5</math><br/> = 1.58 (g) 1.5813667</p> | 3     |
| 1(a)(ii)  | heat solid again (and allow to cool) <b>AND</b> (to) constant mass                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 1     |
| 1(b)(i)   | (Prevents) reaction of $Cu^{2+}$ with $I^-$ <b>OR</b> (prevents) formation of $CuI$ / $Cu^+$ / copper(I) <b>OR</b> (prevents) oxidation of $I^-$ (to $I_2$ ) by $Cu^{2+}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 1     |
| 1(b)(ii)  | $I^-$ is oxidised (to $I_2$ ) in acidic solution                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 1     |
| 1(b)(iii) | 2A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 1     |
| 1(c)(i)   | $1.0 \times 250.0 / 1000 \times 294.0 = 73.5$ (g)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 1     |
| 1(c)(ii)  | <p><b>M1:</b> Dissolve / make a solution in (beaker) in (small volume of distilled water)</p> <p><b>M2:</b> Add / transfer solution to a <u>250 cm<sup>3</sup> volumetric flask</u></p> <p><b>M3:</b> Make to mark of (volumetric) flask with distilled water and the washings</p>                                                                                                                                                                                                                                                                                                                                                                           | 3     |
| 1(d)      | <p><b>M1:</b> titres are not concordant</p> <p><b>M2:</b> repeat titration <b>until concordant titres are obtained</b> OR improved valid experimental technique</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 2     |

| Question | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Marks |                 |                      |                                  |                      |                                  |      |               |     |      |              |               |      |               |     |      |              |               |      |               |     |      |              |               |      |              |     |      |              |               |     |              |     |      |              |               |     |              |     |      |              |                                |     |              |     |      |              |               |     |              |    |      |               |               |   |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-----------------|----------------------|----------------------------------|----------------------|----------------------------------|------|---------------|-----|------|--------------|---------------|------|---------------|-----|------|--------------|---------------|------|---------------|-----|------|--------------|---------------|------|--------------|-----|------|--------------|---------------|-----|--------------|-----|------|--------------|---------------|-----|--------------|-----|------|--------------|--------------------------------|-----|--------------|-----|------|--------------|---------------|-----|--------------|----|------|---------------|---------------|---|
| 2(a)     | <p><b>M1:</b> to remove (remaining) hydrochloric and nitric acid</p> <p><b>M2:</b> to remove water / dry the tube</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 2     |                 |                      |                                  |                      |                                  |      |               |     |      |              |               |      |               |     |      |              |               |      |               |     |      |              |               |      |              |     |      |              |               |     |              |     |      |              |               |     |              |     |      |              |                                |     |              |     |      |              |               |     |              |    |      |               |               |   |
| 2(b)     | <table><tr><th>c</th><th><math>\frac{1}{c}</math></th><th>t</th><th><math>\frac{t}{t_0}</math></th><th><math>\log \frac{t}{t_0}</math></th><th><math>\frac{1}{c} \log \frac{t}{t_0}</math></th></tr><tr><td>16.0</td><td><b>0.0625</b></td><td>176</td><td>2.26</td><td><b>0.354</b></td><td><b>0.0221</b></td></tr><tr><td>14.0</td><td><b>0.0714</b></td><td>164</td><td>2.10</td><td><b>0.322</b></td><td><b>0.0230</b></td></tr><tr><td>12.0</td><td><b>0.0833</b></td><td>151</td><td>1.94</td><td><b>0.288</b></td><td><b>0.0240</b></td></tr><tr><td>10.0</td><td><b>0.100</b></td><td>138</td><td>1.77</td><td><b>0.248</b></td><td><b>0.0248</b></td></tr><tr><td>8.0</td><td><b>0.125</b></td><td>125</td><td>1.60</td><td><b>0.204</b></td><td><b>0.0255</b></td></tr><tr><td>6.0</td><td><b>0.167</b></td><td>113</td><td>1.45</td><td><b>0.161</b></td><td><b>0.0269</b><br/><b>0.0268</b></td></tr><tr><td>4.0</td><td><b>0.250</b></td><td>102</td><td>1.31</td><td><b>0.117</b></td><td><b>0.0293</b></td></tr><tr><td>2.0</td><td><b>0.500</b></td><td>89</td><td>1.14</td><td><b>0.0569</b></td><td><b>0.0285</b></td></tr></table> <p><b>M1:</b> for column 2, <math>\frac{1}{c}</math>, to 3 SF</p> <p><b>M2:</b> for column 5, <math>\log \frac{t}{t_0}</math>, to 3 SF</p> <p><b>M3:</b> for column 6, <math>\frac{1}{c} \log \frac{t}{t_0}</math>, to 3 SF</p> | c     | $\frac{1}{c}$   | t                    | $\frac{t}{t_0}$                  | $\log \frac{t}{t_0}$ | $\frac{1}{c} \log \frac{t}{t_0}$ | 16.0 | <b>0.0625</b> | 176 | 2.26 | <b>0.354</b> | <b>0.0221</b> | 14.0 | <b>0.0714</b> | 164 | 2.10 | <b>0.322</b> | <b>0.0230</b> | 12.0 | <b>0.0833</b> | 151 | 1.94 | <b>0.288</b> | <b>0.0240</b> | 10.0 | <b>0.100</b> | 138 | 1.77 | <b>0.248</b> | <b>0.0248</b> | 8.0 | <b>0.125</b> | 125 | 1.60 | <b>0.204</b> | <b>0.0255</b> | 6.0 | <b>0.167</b> | 113 | 1.45 | <b>0.161</b> | <b>0.0269</b><br><b>0.0268</b> | 4.0 | <b>0.250</b> | 102 | 1.31 | <b>0.117</b> | <b>0.0293</b> | 2.0 | <b>0.500</b> | 89 | 1.14 | <b>0.0569</b> | <b>0.0285</b> | 3 |
| c        | $\frac{1}{c}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | t     | $\frac{t}{t_0}$ | $\log \frac{t}{t_0}$ | $\frac{1}{c} \log \frac{t}{t_0}$ |                      |                                  |      |               |     |      |              |               |      |               |     |      |              |               |      |               |     |      |              |               |      |              |     |      |              |               |     |              |     |      |              |               |     |              |     |      |              |                                |     |              |     |      |              |               |     |              |    |      |               |               |   |
| 16.0     | <b>0.0625</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 176   | 2.26            | <b>0.354</b>         | <b>0.0221</b>                    |                      |                                  |      |               |     |      |              |               |      |               |     |      |              |               |      |               |     |      |              |               |      |              |     |      |              |               |     |              |     |      |              |               |     |              |     |      |              |                                |     |              |     |      |              |               |     |              |    |      |               |               |   |
| 14.0     | <b>0.0714</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 164   | 2.10            | <b>0.322</b>         | <b>0.0230</b>                    |                      |                                  |      |               |     |      |              |               |      |               |     |      |              |               |      |               |     |      |              |               |      |              |     |      |              |               |     |              |     |      |              |               |     |              |     |      |              |                                |     |              |     |      |              |               |     |              |    |      |               |               |   |
| 12.0     | <b>0.0833</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 151   | 1.94            | <b>0.288</b>         | <b>0.0240</b>                    |                      |                                  |      |               |     |      |              |               |      |               |     |      |              |               |      |               |     |      |              |               |      |              |     |      |              |               |     |              |     |      |              |               |     |              |     |      |              |                                |     |              |     |      |              |               |     |              |    |      |               |               |   |
| 10.0     | <b>0.100</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 138   | 1.77            | <b>0.248</b>         | <b>0.0248</b>                    |                      |                                  |      |               |     |      |              |               |      |               |     |      |              |               |      |               |     |      |              |               |      |              |     |      |              |               |     |              |     |      |              |               |     |              |     |      |              |                                |     |              |     |      |              |               |     |              |    |      |               |               |   |
| 8.0      | <b>0.125</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 125   | 1.60            | <b>0.204</b>         | <b>0.0255</b>                    |                      |                                  |      |               |     |      |              |               |      |               |     |      |              |               |      |               |     |      |              |               |      |              |     |      |              |               |     |              |     |      |              |               |     |              |     |      |              |                                |     |              |     |      |              |               |     |              |    |      |               |               |   |
| 6.0      | <b>0.167</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 113   | 1.45            | <b>0.161</b>         | <b>0.0269</b><br><b>0.0268</b>   |                      |                                  |      |               |     |      |              |               |      |               |     |      |              |               |      |               |     |      |              |               |      |              |     |      |              |               |     |              |     |      |              |               |     |              |     |      |              |                                |     |              |     |      |              |               |     |              |    |      |               |               |   |
| 4.0      | <b>0.250</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 102   | 1.31            | <b>0.117</b>         | <b>0.0293</b>                    |                      |                                  |      |               |     |      |              |               |      |               |     |      |              |               |      |               |     |      |              |               |      |              |     |      |              |               |     |              |     |      |              |               |     |              |     |      |              |                                |     |              |     |      |              |               |     |              |    |      |               |               |   |
| 2.0      | <b>0.500</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 89    | 1.14            | <b>0.0569</b>        | <b>0.0285</b>                    |                      |                                  |      |               |     |      |              |               |      |               |     |      |              |               |      |               |     |      |              |               |      |              |     |      |              |               |     |              |     |      |              |               |     |              |     |      |              |                                |     |              |     |      |              |               |     |              |    |      |               |               |   |

| Question  | Answer                                                                                                                                                                                       | Marks  |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|
| 2(c)      |  <p><b>M1:</b> all eight points plotted correctly</p> <p><b>M2:</b> best-fit <b>straight</b> line drawn</p> | 2      |
| 2(d)(i)   | <p><b>M1:</b> time will be greater / longer / flows more slowly (at a lower temperature)</p> <p><b>M2:</b> solution is more viscous</p>                                                      | 1<br>1 |
| 2(d)(ii)  | use a <b>controlled</b> water bath (at 25 °C)                                                                                                                                                | 1      |
| 2(e)      | point at (4.0, 0.0286) circled <b>AND</b> timer / (initial) time started too early / timer (final) time stopped too late                                                                     | 1      |
| 2(f)(i)   | correctly extrapolates best-fit line to vertical intercept <b>AND</b> $\eta = \text{intercept} \times 2.30$                                                                                  | 1      |
| 2(f)(ii)  | <p><b>M1:</b> <math>\log M_r = 1.59 \log \eta + 7.03</math></p> <p><b>M2:</b> <math>M_r = 1.48 \times 10^5</math></p>                                                                        | 2      |
| 2(f)(iii) | <p><math>M_r \div 104.0</math></p> <p><math>x = 1422</math></p>                                                                                                                              | 1      |

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| Question | Answer                                                                                                                                                                                                                                                                           | Marks    |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 2(g)     | <b>M1:</b> a will be higher<br><br><b>M2:</b> poly(ethanol) and water form stronger / greater intermolecular forces (than between poly(phenylethene) with methyl benzene)<br><b>OR</b><br>poly(ethanol) and water form strong(er) hydrogen bonds (which were not present before) | <b>2</b> |

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| Question  | Answer                                                                                                                                                                                 | Marks |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 1(a)(i)   | arrow pointing inwards at bottom condenser inlet                                                                                                                                       | 1     |
| 1(a)(ii)  | Solution <b>A</b> / alkali must be added dropwise                                                                                                                                      | 1     |
| 1(a)(iii) | to prevent vapour loss / escape of vapour                                                                                                                                              | 1     |
| 1(a)(iv)  | (incorrect)<br><br>heating causes gases to expand<br><b>OR</b><br>Pressure would build up (causing apparatus to pop apart)                                                             | 1     |
| 1(b)(i)   | <b>M1:</b> Condenser <b>sloping</b> in the 'distillation' position able to accept distillate vapours<br><br><b>M2:</b> Condenser with (delivery) end open and rest of apparatus sealed | 2     |
| 1(b)(ii)  | CH <sub>3</sub> CH <sub>2</sub> OH <b>AND</b> lowest boiling point.                                                                                                                    | 1     |
| 1(b)(iii) | <b>M1:</b> Cool (the solution) (until crystals form)<br><br><b>M2:</b> Filter <b>AND</b> rinse (the crystals) [with (cold) water].                                                     | 2     |
| 1(c)      | <b>M1:</b> mass obtained would be less<br><br><b>M2:</b> because of H <sub>2</sub> O loss / formation / production                                                                     | 2     |
| 1(d)      | <b>M1:</b> (only) CH <sub>3</sub> I is a liquid at room temperature<br><br><b>M2:</b> (C—I) bond weakest / easiest to break                                                            | 2     |

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| Question | Answer                                                                                                                                                      |            |       |      |      |                  |         |         |         | Marks |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|-------|------|------|------------------|---------|---------|---------|-------|
| 2(a)(i)  | mass = 0.100 × (10 × 12.0 + 8 × 1.0) = 12.8(0)                                                                                                              |            |       |      |      |                  |         |         |         | 1     |
| 2(a)(ii) | Mol                                                                                                                                                         | Y          |       |      | temp | 1/T <sub>m</sub> | Log Y   |         |         | 3     |
|          | 0.00                                                                                                                                                        | 1.00...    | 1.00  | 1.00 | 353  | 2.83             | 0.00    | 0.00    | 0.00    |       |
|          | 0.00888                                                                                                                                                     | 0.91844... | 0.918 | 0.92 | 349  | 2.87             | -0.0369 | -0.0372 | -0.0362 |       |
|          | 0.0178                                                                                                                                                      | 0.84889... | 0.849 | 0.85 | 345  | 2.90             | -0.0711 | -0.0711 | -0.0706 |       |
|          | 0.0266                                                                                                                                                      | 0.78988... | 0.790 | 0.79 | 341  | 2.93             | -0.102  | -0.102  | -0.102  |       |
|          | 0.0355                                                                                                                                                      | 0.73800... | 0.738 | 0.74 | 338  | 2.96             | -0.132  | -0.132  | -0.131  |       |
|          | 0.0444                                                                                                                                                      | 0.69252... | 0.693 | 0.69 | 334  | 2.99             | -0.160  | -0.159  | -0.161  |       |
|          | 0.0533                                                                                                                                                      | 0.65231... | 0.652 | 0.65 | 331  | 3.02             | -0.186  | -0.186  | -0.187  |       |
|          | 0.0621                                                                                                                                                      | 0.61690... | 0.617 | 0.62 | 329  | 3.04             | -0.210  | -0.210  | -0.208  |       |
|          | 0.0769                                                                                                                                                      | 0.56529... | 0.565 | 0.57 | 325  | 3.08             | -0.248  | -0.248  | -0.244  |       |
|          | <p><b>M1:</b> for column 4, (<math>\frac{1}{T_m}</math>)</p> <p><b>M2:</b> for column 5 (log Y)</p> <p><b>M3:</b> All values in columns 4 and 5 to 3 SF</p> |            |       |      |      |                  |         |         |         |       |
| 2(b)     | <p><b>M1:</b> nine points plotted correctly including 2.83, 0.00.</p> <p><b>M2:</b> best-fit <b>straight</b> line drawn</p>                                 |            |       |      |      |                  |         |         |         | 2     |
| 2(c)(i)  | <p><b>M1:</b> coordinates read &amp; recorded correctly</p> <p><b>M2:</b> gradient determined</p>                                                           |            |       |      |      |                  |         |         |         | 2     |

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| Question | Answer                                                                                                                                                                                                                                                                                                                                                                                                                             | Marks |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 2(c)(ii) | $\frac{-\Delta H_{\text{fusion}}}{2.30 \times R} \Delta H_{\text{fusion}} = (-2(c)(i) \times 2.30 \times 8.31) / 1000$                                                                                                                                                                                                                                                                                                             | 1     |
| 2(d)(i)  | <p>Yes, (the data is reliable because)<br/> <b>AND</b></p> <p>there are no anomalous points<br/> <b>OR</b><br/> only 1, 2 or 3 anomalous points<br/> <b>OR</b><br/> only a few points are not on/near the line<br/> <b>OR</b><br/> most points on the line<br/> <b>OR</b><br/> all the points are on the line<br/> <b>OR</b></p> <p>No <b>AND</b> one or more anomalous points <b>OR</b> one or more points away from the line</p> | 1     |
| 2(d)(ii) | <p><b>M1:</b> <i>literature values</i>: lower limit = <math>1.45 \div (10.00/128.0) = 18.56 \text{ (kJ mol}^{-1}\text{)}</math><br/> <b>AND</b> upper limit = <math>1.47 \div (10.00/128.0) = 18.82 / 18.816 \text{ (kJ mol}^{-1}\text{)}</math></p> <p><b>M2:</b> experiment is not (very) accurate because experimental <math>\Delta H_{\text{fusion}}</math> is outside literature range</p>                                    | 2     |
| 2(e)     | <p><b>M1:</b> (on mixing) <math>\Delta H_1</math> would be more positive</p> <p><b>M2:</b> <math>\Delta H_{\text{mixing}}</math> is positive / <math>&gt;0</math> <b>OR</b> <math>\Delta H_1 = \Delta H_{\text{fusion}} + \Delta H_{\text{mixing}}</math></p>                                                                                                                                                                      | 2     |
| 2(f)(i)  | Y is smaller <b>AND</b> because $n_D$ is larger (and $Y = \frac{n_N}{n_N + n_D}$ )                                                                                                                                                                                                                                                                                                                                                 | 1     |

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| Question | Answer                                                                                                                                                                                                                                                                                                                                                                                                                              | Marks    |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 2(f)(ii) | <p>If Y is <b>smaller</b> in 2(f)(i)<br/><b>M1:</b> <math>\Delta H_{\text{fusion}}</math> will be more positive (than actual value)<br/><b>M2:</b> log Y is more negative <b>OR</b> Gradient is more negative</p> <p>If Y is <b>greater</b> in 2(f)(i)<br/><b>M1:</b> <math>\Delta H_{\text{fusion}}</math> will be less positive (than actual value)<br/><b>M2:</b> log Y is less negative <b>OR</b> Gradient is less negative</p> | <b>2</b> |

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**CHEMISTRY**

**9701/53**

Paper 5 Planning, Analysis and Evaluation

**October/November 2019**

MARK SCHEME

Maximum Mark: 30

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**Published**

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 International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the October/November 2019 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

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This document consists of **7** printed pages.



**Cambridge Assessment**  
International Education

**PUBLISHED****Generic Marking Principles**

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

**GENERIC MARKING PRINCIPLE 1:**

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

**GENERIC MARKING PRINCIPLE 2:**

Marks awarded are always **whole marks** (not half marks, or other fractions).

**GENERIC MARKING PRINCIPLE 3:**

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

**GENERIC MARKING PRINCIPLE 4:**

Rules must be applied consistently e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

**PUBLISHED****GENERIC MARKING PRINCIPLE 5:**

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

**GENERIC MARKING PRINCIPLE 6:**

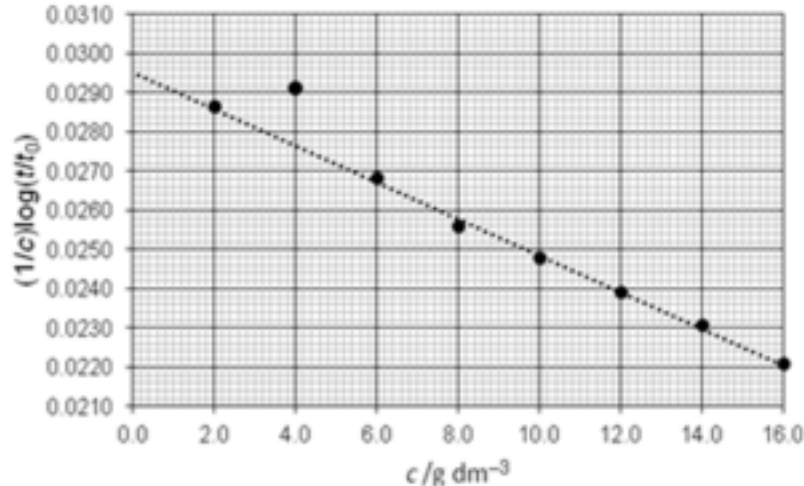
Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

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| Question  | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Marks    |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 1(a)(i)   | <p><b>M1:</b> moles of <math>\text{Y}_2\text{O}_3</math> = <math>0.750 \div (2 \times 88.9 + 3 \times 16.0)</math><br/> = <math>0.750 \div 225.8</math><br/> = <math>3.32 \times 10^{-3} \text{ (mol)}</math> <math>3.3215235 \times 10^{-3}</math></p> <p><b>M2:</b> mass of <math>\text{BaCO}_3</math> = <math>4 \times 3.32 \times 10^{-3} \times (137.3 + 12.0 + 3 \times 16.0)</math><br/> = <math>4 \times 3.32 \times 10^{-3} \times 197.3</math><br/> = 2.62 (g) 2.6213463</p> <p><b>M3:</b> mass of <math>\text{CuO}</math> = <math>6 \times 3.32 \times 10^{-3} \times (63.5 + 16.0)</math><br/> = <math>6 \times 3.32 \times 10^{-3} \times 79.5</math><br/> = 1.58 (g) 1.5813667</p> | <b>3</b> |
| 1(a)(ii)  | <b>heat</b> solid again (and allow to cool) <b>AND</b> (to) constant mass                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>1</b> |
| 1(b)(i)   | (Prevents) reaction of $\text{Cu}^{2+}$ with $\text{I}^-$ <b>OR</b> (prevents) formation of $\text{CuI}$ / $\text{Cu}^+$ / copper(I) <b>OR</b> (prevents) oxidation of $\text{I}^-$ (to $\text{I}_2$ ) by $\text{Cu}^{2+}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>1</b> |
| 1(b)(ii)  | $\text{I}^-$ is oxidised (to $\text{I}_2$ ) in acidic solution                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>1</b> |
| 1(b)(iii) | 2A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>1</b> |
| 1(c)(i)   | $1.0 \times 250.0 / 1000 \times 294.0 = 73.5 \text{ (g)}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>1</b> |
| 1(c)(ii)  | <p><b>M1:</b> Dissolve / make a solution in (beaker) in (small volume of distilled water)</p> <p><b>M2:</b> <b>Add / transfer solution</b> to a <u>250 cm<sup>3</sup> volumetric flask</u></p> <p><b>M3:</b> Make to mark of (volumetric) flask with distilled water and the washings</p>                                                                                                                                                                                                                                                                                                                                                                                                        | <b>3</b> |
| 1(d)      | <p><b>M1:</b> titres are not concordant</p> <p><b>M2:</b> repeat titration <b>until concordant titres are obtained</b> OR improved valid experimental technique</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>2</b> |

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| Question | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |     |                 |                      |                                  |  | Marks |               |   |                 |                      |                                  |      |        |     |      |       |        |      |        |     |      |       |        |      |        |     |      |       |        |      |       |     |      |       |        |     |       |     |      |       |        |     |       |     |      |       |                  |     |       |     |      |       |        |     |       |    |      |        |        |   |
|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----------------|----------------------|----------------------------------|--|-------|---------------|---|-----------------|----------------------|----------------------------------|------|--------|-----|------|-------|--------|------|--------|-----|------|-------|--------|------|--------|-----|------|-------|--------|------|-------|-----|------|-------|--------|-----|-------|-----|------|-------|--------|-----|-------|-----|------|-------|------------------|-----|-------|-----|------|-------|--------|-----|-------|----|------|--------|--------|---|
| 2(a)     | <b>M1:</b> to remove (remaining) hydrochloric and nitric acid<br><b>M2:</b> to remove water / dry the tube                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |     |                 |                      |                                  |  | 2     |               |   |                 |                      |                                  |      |        |     |      |       |        |      |        |     |      |       |        |      |        |     |      |       |        |      |       |     |      |       |        |     |       |     |      |       |        |     |       |     |      |       |                  |     |       |     |      |       |        |     |       |    |      |        |        |   |
| 2(b)     | <table><tr><th>c</th><th><math>\frac{1}{c}</math></th><th>t</th><th><math>\frac{t}{t_0}</math></th><th><math>\log \frac{t}{t_0}</math></th><th><math>\frac{1}{c} \log \frac{t}{t_0}</math></th></tr><tr><td>16.0</td><td>0.0625</td><td>176</td><td>2.26</td><td>0.354</td><td>0.0221</td></tr><tr><td>14.0</td><td>0.0714</td><td>164</td><td>2.10</td><td>0.322</td><td>0.0230</td></tr><tr><td>12.0</td><td>0.0833</td><td>151</td><td>1.94</td><td>0.288</td><td>0.0240</td></tr><tr><td>10.0</td><td>0.100</td><td>138</td><td>1.77</td><td>0.248</td><td>0.0248</td></tr><tr><td>8.0</td><td>0.125</td><td>125</td><td>1.60</td><td>0.204</td><td>0.0255</td></tr><tr><td>6.0</td><td>0.167</td><td>113</td><td>1.45</td><td>0.161</td><td>0.0269<br/>0.0268</td></tr><tr><td>4.0</td><td>0.250</td><td>102</td><td>1.31</td><td>0.117</td><td>0.0293</td></tr><tr><td>2.0</td><td>0.500</td><td>89</td><td>1.14</td><td>0.0569</td><td>0.0285</td></tr></table> <p><b>M1:</b> for column 2, <math>\frac{1}{c}</math>, to 3 SF</p> <p><b>M2:</b> for column 5, <math>\log \frac{t}{t_0}</math>, to 3 SF</p> <p><b>M3:</b> for column 6, <math>\frac{1}{c} \log \frac{t}{t_0}</math>, to 3 SF</p> |     |                 |                      |                                  |  | c     | $\frac{1}{c}$ | t | $\frac{t}{t_0}$ | $\log \frac{t}{t_0}$ | $\frac{1}{c} \log \frac{t}{t_0}$ | 16.0 | 0.0625 | 176 | 2.26 | 0.354 | 0.0221 | 14.0 | 0.0714 | 164 | 2.10 | 0.322 | 0.0230 | 12.0 | 0.0833 | 151 | 1.94 | 0.288 | 0.0240 | 10.0 | 0.100 | 138 | 1.77 | 0.248 | 0.0248 | 8.0 | 0.125 | 125 | 1.60 | 0.204 | 0.0255 | 6.0 | 0.167 | 113 | 1.45 | 0.161 | 0.0269<br>0.0268 | 4.0 | 0.250 | 102 | 1.31 | 0.117 | 0.0293 | 2.0 | 0.500 | 89 | 1.14 | 0.0569 | 0.0285 | 3 |
| c        | $\frac{1}{c}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | t   | $\frac{t}{t_0}$ | $\log \frac{t}{t_0}$ | $\frac{1}{c} \log \frac{t}{t_0}$ |  |       |               |   |                 |                      |                                  |      |        |     |      |       |        |      |        |     |      |       |        |      |        |     |      |       |        |      |       |     |      |       |        |     |       |     |      |       |        |     |       |     |      |       |                  |     |       |     |      |       |        |     |       |    |      |        |        |   |
| 16.0     | 0.0625                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 176 | 2.26            | 0.354                | 0.0221                           |  |       |               |   |                 |                      |                                  |      |        |     |      |       |        |      |        |     |      |       |        |      |        |     |      |       |        |      |       |     |      |       |        |     |       |     |      |       |        |     |       |     |      |       |                  |     |       |     |      |       |        |     |       |    |      |        |        |   |
| 14.0     | 0.0714                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 164 | 2.10            | 0.322                | 0.0230                           |  |       |               |   |                 |                      |                                  |      |        |     |      |       |        |      |        |     |      |       |        |      |        |     |      |       |        |      |       |     |      |       |        |     |       |     |      |       |        |     |       |     |      |       |                  |     |       |     |      |       |        |     |       |    |      |        |        |   |
| 12.0     | 0.0833                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 151 | 1.94            | 0.288                | 0.0240                           |  |       |               |   |                 |                      |                                  |      |        |     |      |       |        |      |        |     |      |       |        |      |        |     |      |       |        |      |       |     |      |       |        |     |       |     |      |       |        |     |       |     |      |       |                  |     |       |     |      |       |        |     |       |    |      |        |        |   |
| 10.0     | 0.100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 138 | 1.77            | 0.248                | 0.0248                           |  |       |               |   |                 |                      |                                  |      |        |     |      |       |        |      |        |     |      |       |        |      |        |     |      |       |        |      |       |     |      |       |        |     |       |     |      |       |        |     |       |     |      |       |                  |     |       |     |      |       |        |     |       |    |      |        |        |   |
| 8.0      | 0.125                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 125 | 1.60            | 0.204                | 0.0255                           |  |       |               |   |                 |                      |                                  |      |        |     |      |       |        |      |        |     |      |       |        |      |        |     |      |       |        |      |       |     |      |       |        |     |       |     |      |       |        |     |       |     |      |       |                  |     |       |     |      |       |        |     |       |    |      |        |        |   |
| 6.0      | 0.167                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 113 | 1.45            | 0.161                | 0.0269<br>0.0268                 |  |       |               |   |                 |                      |                                  |      |        |     |      |       |        |      |        |     |      |       |        |      |        |     |      |       |        |      |       |     |      |       |        |     |       |     |      |       |        |     |       |     |      |       |                  |     |       |     |      |       |        |     |       |    |      |        |        |   |
| 4.0      | 0.250                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 102 | 1.31            | 0.117                | 0.0293                           |  |       |               |   |                 |                      |                                  |      |        |     |      |       |        |      |        |     |      |       |        |      |        |     |      |       |        |      |       |     |      |       |        |     |       |     |      |       |        |     |       |     |      |       |                  |     |       |     |      |       |        |     |       |    |      |        |        |   |
| 2.0      | 0.500                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 89  | 1.14            | 0.0569               | 0.0285                           |  |       |               |   |                 |                      |                                  |      |        |     |      |       |        |      |        |     |      |       |        |      |        |     |      |       |        |      |       |     |      |       |        |     |       |     |      |       |        |     |       |     |      |       |                  |     |       |     |      |       |        |     |       |    |      |        |        |   |

| Question  | Answer                                                                                                                                                                                        | Marks  |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|
| 2(c)      |  <p><b>M1:</b> all eight points plotted correctly</p> <p><b>M2:</b> best-fit <b>straight</b> line drawn</p> | 2      |
| 2(d)(i)   | <p><b>M1:</b> time will be greater / longer / flows more slowly (at a lower temperature)</p> <p><b>M2:</b> solution is more viscous</p>                                                       | 1<br>1 |
| 2(d)(ii)  | use a <b>controlled</b> water bath (at 25 °C)                                                                                                                                                 | 1      |
| 2(e)      | point at (4.0, 0.0286) circled <b>AND</b> timer / (initial) time started too early / timer (final) time stopped too late                                                                      | 1      |
| 2(f)(i)   | correctly extrapolates best-fit line to vertical intercept <b>AND</b> $\eta = \text{intercept} \times 2.30$                                                                                   | 1      |
| 2(f)(ii)  | <p><b>M1:</b> <math>\log M_r = 1.59 \log \eta + 7.03</math></p> <p><b>M2:</b> <math>M_r = 1.48 \times 10^5</math></p>                                                                         | 2      |
| 2(f)(iii) | <p><math>M_r \div 104.0</math></p> <p><math>x = 1422</math></p>                                                                                                                               | 1      |

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| Question | Answer                                                                                                                                                                                                                                                                                  | Marks    |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 2(g)     | <b>M1:</b> <i>a</i> will be higher<br><br><b>M2:</b> poly(ethenol) and water form stronger / greater intermolecular forces (than between poly(phenylethene) with methyl benzene)<br><b>OR</b><br>poly(ethenol) and water form strong(er) hydrogen bonds (which were not present before) | <b>2</b> |