

Mark Scheme (Results)

Summer 2015

IAL Chemistry (WCH06/01)

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Summer 2015

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## General Marking Guidance

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

Question Number	Acceptable Answers	Reject	Mark
<b>1(a)(i)</b>	SO <sub>4</sub> <sup>2-</sup>  OR  SO <sub>4</sub> <sup>-2</sup>	Sulfate HSO <sub>4</sub> <sup>-</sup>	1

Question Number	Acceptable Answers	Reject	Mark
<b>1(a)(ii)</b>	(Dilute) hydrochloric (acid)/ HCl(aq) / nitric (acid) / HNO <sub>3</sub> (aq)  ALLOW HCl / HNO <sub>3</sub> Ignore concentrated/conc	Sulfuric acid H <sup>+</sup> / H <sub>3</sub> O <sup>+</sup> Carboxylic acid Hydrogen chloride	1

Question Number	Acceptable Answers	Reject	Mark
<b>1(b)(i)</b>	Water and hydroxide can be in either order  If name and formula are given, both must be correct  Copper( <b>II</b> ) hydroxide / Cu(OH) <sub>2</sub> / Cu(H <sub>2</sub> O) <sub>4</sub> (OH) <sub>2</sub>  ALLOW  Cu(H <sub>2</sub> O) <sub>2</sub> (OH) <sub>2</sub>  IGNORE  Copper hydroxide  Square brackets in formula wherever they are	Any other numbers	1

Question Number	Acceptable Answers	Reject	Mark
<b>1 (b) (ii)</b>	<p>Water and ammonia can be in either order</p> <p>If name and formula are given, both must be correct</p> <p><math>[\text{Cu}(\text{NH}_3)_4]^{2+}</math></p> <p>OR</p> <p><math>[\text{Cu}(\text{H}_2\text{O})_2(\text{NH}_3)_4]^{2+}</math></p> <p>Charge must be included</p> <p>Outer brackets not required</p> <p>IGNORE order of ligands, but numbers must be correct</p>	<p>Any other numbers e.g. <math>[\text{Cu}(\text{NH}_3)_6]^{2+}</math></p>	1

Question Number	Acceptable Answers	Reject	Mark
<b>1 (c)</b>	<p><math>\text{Cu}(\text{H}_2\text{O})_6^{2+}</math></p> <p>OR</p> <p><math>\text{Cu}(\text{H}_2\text{O})_4^{2+}</math></p> <p>IGNORE Square brackets wherever they are</p>	<p><math>\text{Cu}^{2+}</math> <math>\text{Cu}^{2+}(\text{aq})</math></p>	1

Question Number	Acceptable Answers	Reject	Mark
<b>1 (d)</b>	<p><math>\text{CuSO}_4 / \text{Cu}^{2+}\text{SO}_4^{2-}</math></p> <p>If charges given both must be given correctly</p>	$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$	1

Question Number	Acceptable Answers	Reject	Mark
1(e)	<p>Mark independently</p> <p><b>First mark</b></p> <p>The (3)d sub-shell(s) / (3)d-orbital(s) cannot be split</p> <p>OR</p> <p>No d-d splitting</p> <p>OR</p> <p>No d-d transitions (1)</p> <p><b>Second mark</b></p> <p>No colour as no ligands present</p> <p>ALLOW</p> <p>No water (of crystallization) present</p> <p>OR</p> <p>Not hydrated / Anhydrous salt</p> <p>IGNORE</p> <p>Use of copper rather than copper ions (1)</p> <p>Reverse arguments involving the addition of water acceptable</p>		2

(Total for Question 1 = 8 marks)

Question Number	Acceptable Answers	Reject	Mark
<b>2(a)</b>	Na <sup>+</sup> OR Na <sup>+1</sup> OR Na <sup>1+</sup> IGNORE sodium or sodium ion	Na Any charge other than +1	1

Question Number	Acceptable Answers	Reject	Mark
<b>2(b)(i)</b>	Measure pH/Use of alkaline buffer solution (1) and acidic buffer solution (1) ALLOW Measure pH of a (alkaline) buffer solution... (1) with known pH (1) <b>ALLOW</b> Use of acid /alkali / (de-ionized/ distilled / pure) water / <b>specified</b> neutral solution (e.g. NaCl(aq)) (1) of known pH (1) <b>OR</b> Several solutions of known pH (1) Plot graph of meter reading against (known) pH (to give a calibration curve) (1)	Neutral for pH=7	2

Question Number	Acceptable Answers	Reject	Mark																																																																																
2(b)(ii)	<p>Universal / full range indicator (paper / solution) (1)</p> <p>Colour changes to (dark) green / blue</p> <p>IGNORE</p> <p>Initial colour (1)</p> <p><b>Comment</b></p> <p><b>ALLOW for 1 mark</b></p> <p>Any named indicator from list below <b>and</b> its colour in alkali</p> <table border="1"> <thead> <tr> <th></th> <th><math>pK_{in}(298\text{ K})</math></th> <th colspan="2">pH range</th> </tr> <tr> <th></th> <th></th> <th><i>acid</i></th> <th><i>alkaline</i></th> </tr> </thead> <tbody> <tr> <td>Methyl violet</td> <td>0.8</td> <td>yellow</td> <td>0.0–1.6 blue</td> </tr> <tr> <td>Malachite green</td> <td>1.0</td> <td>yellow</td> <td>0.2–1.8 blue/green</td> </tr> <tr> <td>Thymol blue (acid)</td> <td>1.7</td> <td>red</td> <td>1.2–2.8 yellow</td> </tr> <tr> <td>Methyl yellow (in ethanol)</td> <td>3.5</td> <td>red</td> <td>2.9–4.0 yellow</td> </tr> <tr> <td>Methyl orange–xylene cyanole soln.</td> <td>3.7</td> <td>purple</td> <td>3.2–4.2 green</td> </tr> <tr> <td>Methyl orange</td> <td>3.7</td> <td>red</td> <td>3.2–4.4 yellow</td> </tr> <tr> <td>Bromophenol blue</td> <td>4.0</td> <td>yellow</td> <td>2.8–4.6 blue</td> </tr> <tr> <td>Congo red</td> <td>4.0</td> <td>violet</td> <td>3.0–5.0 red</td> </tr> <tr> <td>Bromocresol green</td> <td>4.7</td> <td>yellow</td> <td>3.8–5.4 blue</td> </tr> <tr> <td>Methyl red</td> <td>5.1</td> <td>red</td> <td>4.2–6.3 yellow</td> </tr> <tr> <td>Azolitmin (litmus)</td> <td></td> <td>red</td> <td>5.0–8.0 blue</td> </tr> <tr> <td>Bromocresol purple</td> <td>6.3</td> <td>yellow</td> <td>5.2–6.8 purple</td> </tr> <tr> <td>Bromothymol blue</td> <td>7.0</td> <td>yellow</td> <td>6.0–7.6 blue</td> </tr> <tr> <td>Phenol red</td> <td>7.9</td> <td>yellow</td> <td>6.8–8.4 red</td> </tr> <tr> <td>Thymol blue (base)</td> <td>8.9</td> <td>yellow</td> <td>8.0–9.6 blue</td> </tr> <tr> <td>Phenolphthalein (in ethanol)</td> <td>9.3</td> <td>colourless</td> <td>8.2–10.0 red</td> </tr> <tr> <td>Thymolphthalein</td> <td>9.7</td> <td>colourless</td> <td>8.3–10.6 blue</td> </tr> <tr> <td>Alizarin yellow R</td> <td>12.5</td> <td>yellow</td> <td>10.1–13.0 orange/red</td> </tr> </tbody> </table>		$pK_{in}(298\text{ K})$	pH range				<i>acid</i>	<i>alkaline</i>	Methyl violet	0.8	yellow	0.0–1.6 blue	Malachite green	1.0	yellow	0.2–1.8 blue/green	Thymol blue (acid)	1.7	red	1.2–2.8 yellow	Methyl yellow (in ethanol)	3.5	red	2.9–4.0 yellow	Methyl orange–xylene cyanole soln.	3.7	purple	3.2–4.2 green	Methyl orange	3.7	red	3.2–4.4 yellow	Bromophenol blue	4.0	yellow	2.8–4.6 blue	Congo red	4.0	violet	3.0–5.0 red	Bromocresol green	4.7	yellow	3.8–5.4 blue	Methyl red	5.1	red	4.2–6.3 yellow	Azolitmin (litmus)		red	5.0–8.0 blue	Bromocresol purple	6.3	yellow	5.2–6.8 purple	Bromothymol blue	7.0	yellow	6.0–7.6 blue	Phenol red	7.9	yellow	6.8–8.4 red	Thymol blue (base)	8.9	yellow	8.0–9.6 blue	Phenolphthalein (in ethanol)	9.3	colourless	8.2–10.0 red	Thymolphthalein	9.7	colourless	8.3–10.6 blue	Alizarin yellow R	12.5	yellow	10.1–13.0 orange/red		2
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Question Number	Acceptable Answers	Reject	Mark
<b>2(b)(iii)</b>	<p>A pH meter because...  ... difficult to match colour of indicator to pH</p> <p>OR</p> <p>...the colour of universal indicator covers a range of pH</p> <p>ALLOW  pH meters measure to at least one decimal place (after calibration)</p> <p>OR</p> <p>pH meter with any reasonable attempt at an explanation  e.g.  indicators cover a range  pH meters give exact values</p>	<p>pH meter alone</p>          <p>Any untrue statement about pH meters or indicators</p>	1

Question Number	Acceptable Answers	Reject	Mark
<b>2(c)(i)</b>	<p><b>First mark - Observation</b></p> <p>Effervescence / bubbles (of gas)  (1)</p>  <p>IGNORE  Test for carbon dioxide  Gas evolved  (Solid) sodium carbonate dissolves</p> <p><b>Second mark - Explanation</b></p> <p>because the sodium carbonate reacts with / neutralises <b>acid(s)</b> present (to form carbon dioxide)</p> <p>ALLOW</p> <p>carbon dioxide is formed  (1)</p>	<p>Incorrect observations e.g.  Solid/precipitate forms</p>   <p>Negates first mark</p>	2

Question Number	Acceptable Answers	Reject	Mark
<b>2(c)(ii)</b>	Ester  OR  Methyl ester  IGNORE  compound (of carboxylic acid and alcohol)		1

Question Number	Acceptable Answers	Reject	Mark
<b>2(d)</b>	<b>S</b> CH <sub>3</sub> COOCH <sub>3</sub> (1)  <b>R</b> CH <sub>3</sub> COOH (1)  <b>P</b> CH <sub>3</sub> COO <sup>(-)</sup> Na <sup>(+)</sup> (1)  ALLOW displayed/skeletal formulae  ALLOW TE as below:  TE from 2(a)  TE for <b>R</b> and <b>P</b> based on their formula for <b>S</b>  TE for <b>P</b> based on their formula for <b>R</b>  Ignore names even if incorrect	CH <sub>3</sub> COO—Na	3

(Total for Question 2 = 12 marks)

Question Number	Acceptable Answers	Reject	Mark
<b>3(a)</b>	<p>Sulfuric acid reacts very exothermically with water</p> <p>ALLOW</p> <p>The reaction with acid is exothermic</p> <p>OR</p> <p>(Sulfuric) acid will shoot out of container</p> <p>OR</p> <p>The reaction of water with (sulphuric) acid is vigorous/splashes</p> <p>OR</p> <p>Prevent splashing of acid</p>	<p>nitric acid</p> <p>Prevent splash alone</p>	1

Question Number	Acceptable Answers	Reject	Mark
<b>3(b)</b>	(Pale/straw-coloured) yellow / brown / red-brown	Red/purple/blue/black/blue-black/orange	1

Question Number	Acceptable Answers	Reject	Mark
<b>3(c) (i)</b>	(Freshly prepared) starch (solution)		1

Question Number	Acceptable Answers	Reject	Mark
<b>3(c) (ii)</b>	<p>(If starch is added too early) starch iodine complex formed (doesn't re-dissolve)</p> <p>ALLOW</p> <p>Iodide for iodine</p> <p>ALLOW</p> <p>(Black) solid/precipitate / complex forms</p> <p>OR</p> <p>Insoluble compound forms</p>		1

Question Number	Acceptable Answers	Reject	Mark
<b>3(c)(iii)</b>	From blue-black to colourless  ALLOW  From blue / black/ dark blue/ deep blue to colourless	...to clear	1

Question Number	Acceptable Answers	Reject	Mark
<b>3(d)(i)</b>	24.1(0) 23.8(0) 23.55 23.45 (cm <sup>3</sup> )		1

Question Number	Acceptable Answers	Reject	Mark
<b>3(d)(ii)</b>	The third and fourth / 23.55 and 23.45 (cm <sup>3</sup> )  <b>and</b>  They are concordant  OR  Within $\pm 0.2/0.1$ (cm <sup>3</sup> )  IGNORE Anomalous		1

Question Number	Acceptable Answers	Reject	Mark
<b>3(d)(iii)</b>	23.5(0) (cm <sup>3</sup> )  ALLOW  TE including second titre value, mean = 23.6(0) (cm <sup>3</sup> )		1

Question Number	Acceptable Answers	Reject	Mark
<b>3(d)(iv)</b>	<p>Correct answer 74.6% / 75%</p> <p>OR 74.9% (TE from 23.60 average titre)</p> <p>Ignore SF except 1SF</p> <p>With no working <b>(5)</b></p> <p>Number of mol of thiosulfate  <math display="block">= \frac{23.50 \times 0.200}{1000} \quad (1)</math> <math display="block">= 4.70 \times 10^{-3} / 0.00470</math> <b>Second mark</b>  EITHER  Number of mol of iodine  <math display="block">= \frac{4.70 \times 10^{-3}}{2}</math> <math display="block">= 2.35 \times 10^{-3} / 0.00235</math> <b>AND</b>  Number of moles of copper ion  <math display="block">= 2 \times 2.35 \times 10^{-3} \quad (1)</math> <math display="block">= 4.70 \times 10^{-3} / 0.00470 \text{ in } 10 \text{ cm}^3</math> OR  From equations amount of iodine is half amount of thiosulfate and amount of copper is twice amount of iodine, so amount of copper equals amount of thiosulfate for this mark  Number of moles of copper in solid</p>		5

	$= 10 \times 4.70 \times 10^{-3} \quad (1)$ $= 4.70 \times 10^{-2}/0.0470$		
	<p>Mass of copper in solid</p> $= 4.70 \times 10^{-2} \times 63.5 \text{ (g)}$ $= 2.9845 \quad (1)$		
	<p>Percentage copper</p> $= \frac{2.9845 \times 100}{4.00}$ $= 74.6125$ $= 74.6\% \quad (1)$		
	<p>Using 23.60 by averaging titres 2, 3 and 4</p> $4.72 \times 10^{-3}/0.00472 \quad (1)$ $2.36 \times 10^{-3}/0.00236$		
	<p>AND</p> $4.72 \times 10^{-3}/0.00470 \quad (1)$ $4.72 \times 10^{-2}/0.0470 \quad (1)$ $2.9972 \quad (1)$ $74.9\% \quad (1)$		
	<p>Answers greater than 100% max 3</p>		

Question Number	Acceptable Answers	Reject	Mark
3(d)(v)	<p><b>First Mark</b></p> <p>Uncertainty in titre value:</p> $\frac{2 \times 0.05}{23.55} \times 100 =$ $(\pm)0.42/0.425/0.4246\% (1)$ <p><b>Second Mark</b></p> <p>Uncertainty in the mass measurement:</p> $\frac{2 \times 0.005 \times 100}{4.0} = (\pm)0.25\%$ <p><b>OR</b></p> $\frac{1 \times 0.005 \times 100}{4.0} = (\pm)0.125\%$ <p>so it would / would not be worth using a 3 dp balance (1)</p> <p>Ignore SF including 1 SF</p>		2

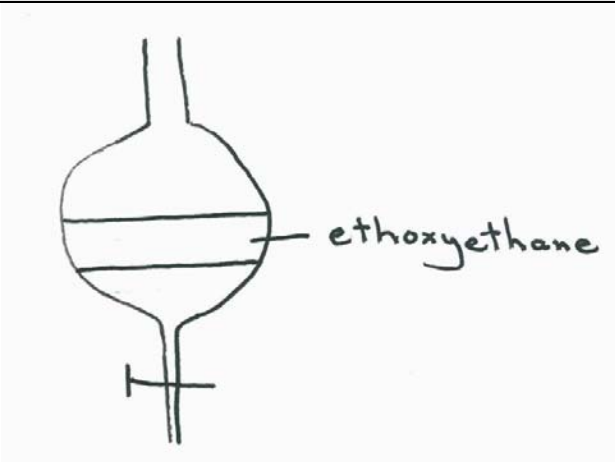
(Total for Question 3 = 15 marks)

Question Number	Acceptable Answers	Reject	Mark
4(a)	<p>Mass of bromine = <math>6.0 \times 3.1</math> (1) (= 18.6 (g))</p> <p>Number of moles of bromine = <math>\frac{6.0 \times 3.1}{2 \times 79.9}</math> = 0.116(40) = 0.12 (1)</p> <p>ALLOW Number of moles of bromine = <math>\frac{18.6}{2 \times 80}</math> = 0.11625 = 0.12</p> <p>Correct answer no working scores (2)</p> <p>IGNORE</p> <p>SF except 1 SF</p>	$\frac{6.0 \times 3.1}{1000}$	2

Question Number	Acceptable Answers	Reject	Mark
4(b)	<p>Mark Independently</p> <p><math>2\text{Fe} + 3\text{Br}_2 \rightarrow 2\text{FeBr}_3</math></p> <p>OR multiples (1)</p> <p><math>\text{Br}_2 + \text{FeBr}_3 \rightarrow \text{Br}^{\delta+} \dots \text{Br}^{\delta-} \text{FeBr}_3</math> Allow any attachment between the centre bromine atom and the iron and / or the other bromine atom. e.g. <math>\text{Br}^{\delta+} - \text{Br}^{\delta-}</math> <math>\cdot \text{FeBr}_3</math></p> <p>OR</p> <p><math>\text{Br}_2 + \text{FeBr}_3 \rightarrow \text{Br}^+ + \text{FeBr}_4^-</math> (1)</p> <p>Ignore states even if incorrect</p>	$\rightarrow \text{Br}^- + \text{FeBr}_4^+$	2



Question Number	Acceptable Answers	Reject	Mark
4(c)	To neutralize / react with HBr (formed)  ALLOW  To neutralize / react with acid  OR  To remove / react with bromine	To neutralize (the solution)	1

Question Number	Acceptable Answers	Reject	Mark
4(d)	 <p>Separating funnel which must have narrower neck than the container (capable of taking a stopper) <b>and</b> a tap (1)</p> <p>Upper layer ethoxyethane (1)</p>	Burette Filter funnel	2

Question Number	Acceptable Answers	Reject	Mark
<b>4(e)</b>	(Concentrated) nitric acid/ HNO <sub>3</sub>  <b>and</b>  (concentrated) sulfuric acid/ H <sub>2</sub> SO <sub>4</sub>	<b>Dilute</b> sulfuric acid  Any additional chemicals like Ammonia/NH <sub>3</sub> Bromine/Br <sub>2</sub> Sodium hydroxide/NaOH	1

Question Number	Acceptable Answers	Reject	Mark
<b>4(f)</b>	(0.75 x 0.70 x 0.70 x100 =) 36.75 / 36.8 / 37 (%)  Correct answer with no working	Any other answers e.g. 36.7 / 37.0 / 40	1

Question Number	Acceptable Answers	Reject	Mark
<b>4(g) (i)</b>	(While rotating the tube) heat one end of the tube in a Bunsen flame (until the glass starts to melt)  ALLOW  Heat in a flame  OR  Heat (one end of the) tube		1

Question Number	Acceptable Answers	Reject	Mark
<b>4(g)(ii)</b>	<p>By gently tapping or dropping the tube / rubbing the open end with a milled coin</p> <p>ALLOW</p> <p>Hit / flick tube with finger</p> <p>OR</p> <p>Use (very small) dry crystals</p> <p>IGNORE</p> <p>Shaking / use of wire / sticks / pins / needles</p>	Heat	1

Question Number	Acceptable Answers	Reject	Mark
<b>4(g)(iii)</b>	<p><b>Any two from</b></p> <p>High boiling temperature/ point (compared with sample melting temperature) OR not volatile</p> <p>Does not decompose / oxidize (at high temperature)</p> <p>Mobile / non-viscous / non-sticky</p> <p>IGNORE</p> <p>Any reference to thermal conductivity and heat capacity</p> <p><b>ALLOW</b></p> <p>Clear liquid (ignore colourless)</p> <p>High ignition temperature/non-(in)flammable</p> <p>Non-toxic</p> <p>IGNORE</p> <p>Unreactive alone / safety aspects</p>	<p>High melting temperature</p> <p>Just 'does not react with the crystals'</p>	2

Question Number	Acceptable Answers	Reject	Mark
4(g)(iv)	<p><b>Before recrystallization</b></p> <p>185 – 201°C</p> <p>A range of at least 5°C</p> <p>ALLOW 180 - 205 °C</p> <p>A range of at least 5°C (1)</p> <p><b>After recrystallization</b></p> <p>199 – 201°C</p> <p>ALLOW 197 - 203°C</p> <p>A range of no more than 4°C (1)</p>	<p>Single temperature</p> <p>Single temperature</p>	2

(Total for Question 4 = 15 marks)

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