

# Mark Scheme (Results)

Summer 2015

IAL Chemistry (WCH03/01)

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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>	Sodium (ion)/ Na <sup>+</sup>  If name AND formula are given BOTH must be correct	Na	1

Question Number	Acceptable Answers	Reject	Mark
<b>1(a)(ii)</b>	Carbonate (ion)/ CO <sub>3</sub> <sup>2-</sup> OR CO <sub>3</sub> <sup>-2</sup> / CO <sub>3</sub> <sup>--</sup>  OR Hydrogencarbonate (ion)/ HCO <sub>3</sub> <sup>-</sup>  ALLOW Hydrogen carbonate (ion)  If name AND and formula are given BOTH must be correct		1

Question Number	Acceptable Answers	Reject	Mark
<b>1(a)(iii)</b>	Ca(OH) <sub>2</sub> (aq) + CO <sub>2</sub> (g) → CaCO <sub>3</sub> (s)+H <sub>2</sub> O(l)  Reactants with state symbols (1) Products and state symbols (1)  Allow All formulae correct but one or more errors in state symbols (1)  All formulae and state symbols correct but incorrect balancing numbers included (1)  Ca <sup>2+</sup> (aq) + 2OH <sup>-</sup> (aq) for Ca(OH) <sub>2</sub> (aq)  Ignore multiples if equation is balanced	H <sub>2</sub> O(aq) Ca(OH) <sub>2</sub> (l)  Ca <sup>2+</sup> (aq) + CO <sub>3</sub> <sup>2-</sup> (aq) → CaCO <sub>3</sub> (s)	2

Question Number	Acceptable Answers	Reject	Mark
<b>1(b)(i)</b>	Crimson/red/ dark red/bright red / persistent red/scarlet (coloured flame)	Orange Brick red Carmine	1

Question Number	Acceptable Answers	Reject	Mark
1 (b) (ii)	White precipitate  ALLOW White solid/crystals ppt/ppte for precipitate   Ignore comments about getting darker/turning purple on standing	Cream ppt Yellow ppt Off-white ppt  Additional incorrect observations eg white ppt and effervescence or steamy fumes  Change on standing to cream or yellow	1

Question Number	Acceptable Answers	Reject	Mark
1(b)(iii)	<p>TEST Add <b>dilute</b> (aqueous) ammonia (solution) / <math>\text{NH}_3</math> / <math>\text{NH}_3</math> (aq) ALLOW Dilute <math>\text{NH}_4\text{OH}</math> / ammonium hydroxide</p> <p>IGNORE Additional test with concentrated <math>\text{NH}_3</math> (1)</p> <p>RESULT Precipitate dissolves / (colourless) solution forms ALLOW mixture dissolves / precipitate disappears/ solid dissolves / precipitate is soluble (1)</p> <p>Second mark depends on use of ammonia in first, even concentrated.</p> <p>ALLOW TEST add <b>concentrated</b> sulfuric acid to <b>ppt</b> (1)</p> <p>RESULT Steamy fumes (only)/ no brown <b>AND</b> no purple fumes ALLOW White fumes (1)</p> <p>Second mark depends on use of sulfuric acid.</p>	<p>Just "ammonia / <math>\text{NH}_3</math>" Use of ammonia on glass rod</p> <p>Incorrectly identified precipitate dissolves e.g. strontium chloride dissolves</p> <p>White smoke</p>	2

Question Number	Acceptable Answers	Reject	Mark
<b>1(b)(iv)</b>	(goes) dark / purple / grey  ALLOW Black / lilac (1)  Silver / Ag (forms) (1)	Goes blue-black  Silver colour/ mirror  Ag <sup>+</sup> / silver ions	2

Question Number	Acceptable Answers	Reject	Mark
<b>1(c)</b>	$\text{Sr}^{2+} + \text{CO}_3^{2-} \rightarrow \text{SrCO}_3$  Ignore state symbols, even if incorrect Ignore full equation, written as "rough" work and mark ionic equation only.		1

**Total for Question 1 = 11 marks**

Question Number	Acceptable Answers	Reject	Mark
2(a)	<p><b>TEST</b> Add <math>\text{PCl}_5</math> / phosphorus(V) chloride / phosphorus pentachloride / <math>\text{SOCl}_2</math> / thionyl chloride / sulphur dichloride oxide (1)</p> <p><b>RESULT</b> Mark depends on correct reagent, but allow <math>\text{PCl}_5</math> (aq)</p> <p>Steamy / misty / white fumes ALLOW Gas for fumes (1)</p> <p>Ignore incorrect identification of fumes</p> <p><b>OR</b></p> <p><b>TEST</b> Add sodium / Na (1)</p> <p><b>RESULT</b> Mark depends on correct reagent</p> <p>Effervescence / bubbling / fizzing</p> <p>Ignore incorrect identification of fumes and tests for products</p> <p>white solid (forms) / sodium dissolves</p> <p>mixture gets hot (1)</p>	<p>Acidified <math>\text{PCl}_5</math> / <math>\text{PCl}_5</math> (aq)</p> <p>Acidified dichromate(VI) <math>\text{PCl}_3</math></p> <p>Test to form an ester</p> <p>Any smoke Just "HCl fumes" Just "gas turns litmus red"</p> <p>Just "hydrogen"</p>	2



Question Number	Acceptable Answers	Reject	Mark
2(b)	(primary / secondary / tertiary) Alcohol <b>and</b> carboxylic acid  ALLOW ROH <b>and</b> RCOOH R <sub>2</sub> CHOH/ R <sub>3</sub> COH for ROH C <sub>n</sub> H <sub>2n+1</sub> OH for ROH RCO <sub>2</sub> H for RCOOH Phenol(s) (as one alternative) Fatty acid / alkanolic acid for carboxylic acid	diol carboxyl cyclic alcohol specific alcohol eg ethanol	1

Question Number	Acceptable Answers	Reject	Mark
2(c)	Z identified as tertiary alcohol (1)  <b>Justification:</b> Any one from  Test with litmus Not (carboxylic) acid because there is no change (in (blue) litmus paper)  It's an alcohol because there is no change (in (red / blue) litmus paper)  It is neutral /not an acid or an alkali because there is no change (in (red / blue) litmus paper)  Test with dichromate It is a tertiary alcohol because it can't be oxidized (by acidified dichromate(VI))/ doesn't react with acidified dichromate(VI)  It is not a primary or secondary alcohol because it can't be oxidized (by acidified dichromate(VI))/ doesn't react with acidified dichromate(VI)  IGNORE Not an amine (1)  If more than one justification is given, both must be correct		2



Question Number	Acceptable Answers	Reject	Mark
<b>2(e)(i)</b>	<p>Molecular ions have same <math>m/e</math></p> <p>ALLOW            same molecular ion            isomers have same molar mass / molecular mass            molecular ion with same mass            same maximum <math>m/e</math> value            same peak furthest to right            same last peak            Parent ion / <math>M^+</math> for molecular ion</p> <p>IGNORE            Reference to peak heights</p>	<p>Same fragments            Same <math>m/e</math> value for highest peak</p> <p>Similar for "same"</p>	1

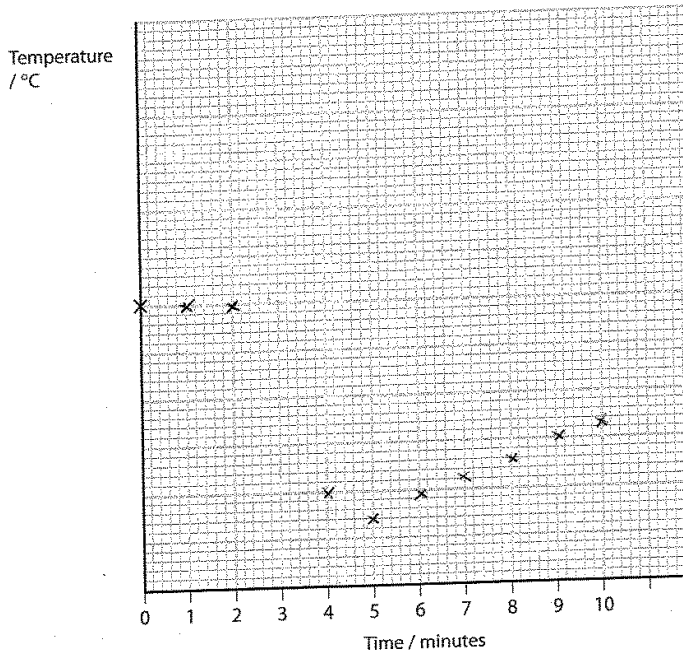
Question Number	Acceptable Answers	Reject	Mark
<b>2(e)(ii)</b>	<p>They both have an (absorption) peak for (wavenumber of) alcohol / hydroxyl group / O-H</p> <p>ALLOW            both have peak for -OH / OH            frequency / wavelength for wavenumber</p> <p>IGNORE            wavenumber values            have peak with specific shape for OH</p>	Absorption for C-OH	1

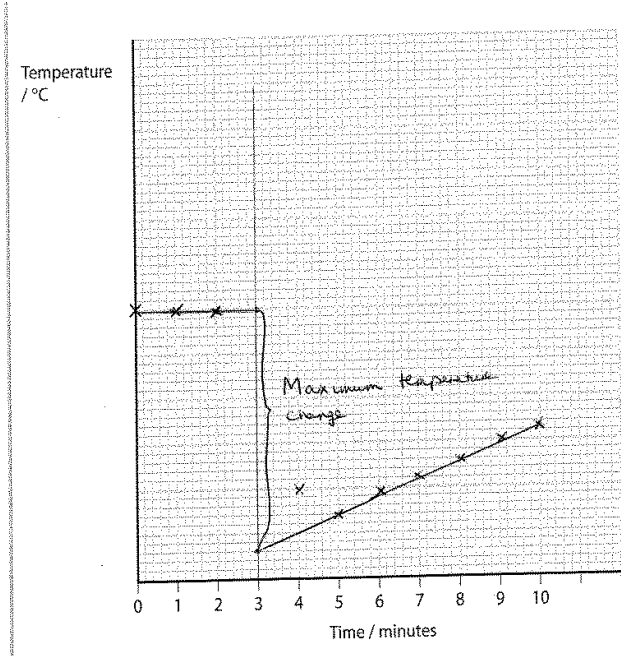
**Total for Question 2 = 10 marks**

Question Number	Acceptable Answers	Reject	Mark
3(a)(i)	<p><b>Correct final answer with + sign, 3 sf and units scores 3</b></p> <p><math>(25 \times 4.18 \times 10.5) = 1097.25 \text{ (J)} / 1.097 \text{ kJ}</math> Ignore sign if given (1)</p> <p>Mol <math>\text{NH}_4\text{Cl} = (5.00/53.5) = 0.09346/0.0935</math> (1)</p> <p><math>\Delta H_{\text{solution}} = (+1.097/0.09346)</math> <math>(= +11.7376 / +11.7406)</math> <b><math>= +11.7 \text{ kJ mol}^{-1}</math></b> OR <b><math>+11700 \text{ J mol}^{-1}</math></b> Sign, unit and sf must be correct for third mark Use of 2sf earlier may lead to an inaccurate answer (1)</p> <p>ALLOW Final answer = <math>+11.8 \text{ kJ mol}^{-1}</math> from rounding of MP1 and/or MP2 (3)</p> <p>TE from each step to the next</p> <p>If mass used is 30 g Energy transferred = 1316.7 J <math>\Delta H_{\text{solution}} = +14.1 \text{ kJ mol}^{-1}</math> max (2)</p> <p>If mass used is 5 g Energy transferred = 219.45 J <math>\Delta H_{\text{solution}} = +2.35 \text{ kJ mol}^{-1}</math> max (2)</p>	Answers not to 3 sf No sign or negative sign	3

Question Number	Acceptable Answers	Reject	Mark
<b>3(a)(ii)</b>	<p>First mark is for calculation of error. Second mark is for comparison of temperature error to mass error.</p> <p>Uncertainty in mass =  <math>(0.005 \times 100 \times 2/5.00) = (\pm)0.2\%</math> (1)</p> <p>Uncertainty / error in mass measurement (much) smaller than uncertainty in temperature reading (1)</p> <p>Second mark depends on first being correct, but allow second mark if mass error is 0.1% (as 0.005 not doubled)</p>	Just "0.2% is negligible / very small"	2

Question Number	Acceptable Answers	Reject	Mark
3(b)(i)	<p>Points (close to the) horizontal from starting temperature at 0, 1 and 2 (and 3) minutes (1)</p> <p>Points (on a line) rising from a minimum up to 10 minutes (at least 2 points needed at the warming up stage for extrapolation.) The minimum can be at 4, 5, 6, 7 or 8 minutes. (1)</p>	<p>Large change of temperature at 3 minutes</p> <p>Cooling curve instead of warming curve</p>	2



Question Number	Acceptable Answers	Reject	Mark
3(b)(ii)	<p>Line through temperature points where warming occurs extrapolated back to 3 minutes.</p> <p>ALLOW</p> <p>Line at minimum temperature shown as staying horizontal and extrapolated back (1)</p> <p>Max temperature change indicated as vertical difference between starting temperature and extrapolated line at 3 minute (1)</p> <p>TE if cooling curve drawn in 3(b)(i) for both marks.</p> 		2

Question Number	Acceptable Answers	Reject	Mark
<b>3(b)(iii)</b>	<p>To check water temperature is steady / constant OR To deduce temperature at 3 mins / at start by extrapolation of line</p> <p>ALLOW to allow water temperature to equilibrate with surroundings/ to reach temperature of surroundings/ to acclimatise</p> <p>IGNORE to get initial temperature accurate</p>	<p>Water temperature may change</p> <p>Minerals in water may affect result</p>	1

Question Number	Acceptable Answers	Reject	Mark
<b>3(c)(i)</b>	<p>Heat must be supplied (and cannot be measured)</p> <p>ALLOW impossible to tell when/if reaction is complete reaction goes to equilibrium/ is reversible</p> <p>IGNORE reference to gases escaping / products are gases / hazards</p>	<p>Just " because it is endothermic"</p> <p>Needs high temperature</p>	1



Question Number	Acceptable Answers	Reject	Mark
3(c)(ii)	<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="border: 1px solid black; padding: 5px; text-align: center;">NH<sub>4</sub>Cl(s)</div> <div style="text-align: center;">→ ΔH<sub>reaction</sub></div> <div style="border: 1px solid black; padding: 5px; text-align: center;">NH<sub>3</sub>(g) + HCl(g)</div> </div> <div style="display: flex; justify-content: space-around; align-items: center; margin-top: 10px;"> <div style="text-align: center;">ΔH<sub>1</sub> ↓</div> <div style="text-align: center;">ΔH<sub>2</sub> + ΔH<sub>3</sub> ↓</div> </div> <div style="display: flex; justify-content: space-around; align-items: center; margin-top: 10px;"> <div style="border: 1px solid black; padding: 5px; text-align: center;">NH<sub>4</sub>Cl(aq)</div> <div style="text-align: center;">← ΔH<sub>4</sub></div> <div style="border: 1px solid black; padding: 5px; text-align: center;">NH<sub>3</sub>(aq) + HCl (aq)</div> </div> <p>OR 2 separate parallel arrows for ΔH<sub>2</sub> + ΔH<sub>3</sub> OR ΔH<sub>2</sub> ΔH<sub>3</sub> next to one arrow without being separated by +</p> <p>ALLOW Arrows reversed if signs of enthalpy changes are reversed.</p> <p>IGNORE Any water molecules added/ aq signs / other reactant species Arrow size</p>		1

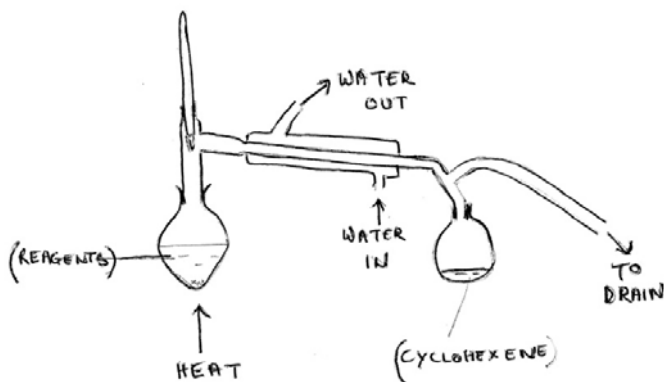
Question Number	Acceptable Answers	Reject	Mark
3(c)(iii)	$\Delta H_{\text{reaction}} = \Delta H_1 - \Delta H_2 - \Delta H_3 - \Delta H_4$ <p>ALLOW any order of terms with correct signs Any correct use of brackets</p> <p>No TE on incorrect cycle</p>		1

**Total for Question 3 = 13 marks**

Question Number	Acceptable Answers	Reject	Mark
<b>4(a)</b>	Two different hazards must be given to score 2 marks.  Phosphoric acid corrosive  ALLOW burns skin/ damages skin (1)  Cyclohexanol / cyclohexene (in)flammable  ALLOW Irritant (1)  IGNORE Comments on glass wool, calcium chloride Cyclohexene / cyclohexanol is volatile	Additional hazards e.g. irritant harms skin carcinogenic  Additional hazards e.g. explosive carcinogenic	2

Question Number	Acceptable Answers	Reject	Mark
<b>4(b)</b>	<b>Correct final answer scores (2)</b>  Mass of 12 cm <sup>3</sup> C <sub>6</sub> H <sub>11</sub> OH = 12 x 0.962 (1) = 11.544 / 11.54 / 11.5 (g)  Number of moles = (11.544 / 100 = 0.11544) = 0.115 / 0.12 (mol)  ALLOW TE from incorrect mass (1)  Ignore sf except 1 sf	0.11	2

Question Number	Acceptable Answers	Reject	Mark
4(c)	<p>Flask with heat source AND stillhead AND a closed system to the left hand side of the outlet to the condenser.</p> <p>Heat source can be electrical heater, water bath ALLOW bunsen or just arrow</p> <p>ALLOW appropriate tubing or flask with long neck as alternative to stillhead (1)</p> <p>Bulb of thermometer opposite opening to condenser (1)</p> <p>Water condenser sloping downwards AND direction of water (1)</p> <p>Connected to receiver with a vent OR delivery tube to an open <b>narrow</b> necked flask (1)</p> <p>Ignore fractionating column if included.</p> <p>Drawing showing reflux distillation scores max 1 for water direction in condenser.</p>	<p>Conical flask</p> <p>Sealed receiver, beaker</p>	4

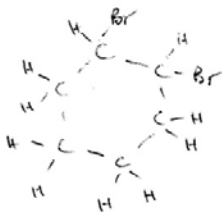


Question Number	Acceptable Answers	Reject	Mark
4(d)	<p><b>Dehydrating agent</b> removes water in a (chemical) reaction OR causes two H and one O atoms to be lost (in a reaction) OR removes the elements of water (from reactant molecules) OR removes water from molecules of a compound</p> <p>ALLOW answers indicating a reaction occurs eg <math>H^+</math> protonates OH in alcohol forming water removes water causing bonds to break reference to elimination reactions (1)</p> <p><b>Drying agent</b> removes water mixed with other materials OR removes water from a mixture OR removes water in a physical change</p> <p>ALLOW Absorbs water (1)</p> <p>"A dehydrating agent removes water in a reaction but there is no reaction when a drying agent removes water" scores 1</p>	Reference to removal of solvents other than water	2

Question Number	Acceptable Answers	Reject	Mark
<b>4(e)</b>	Glass wool less absorbent OR No cyclohexene left on wool OR filtration is faster through glass wool OR filter paper absorbs liquids/ product/ mixture  IGNORE yield is higher with glass wool/ lower with filter paper more efficient filtration		1

Question Number	Acceptable Answers	Reject	Mark
4(f)	<p><b>Look at final answer. If correct award 3 marks.</b></p> <p>There are several correct methods. All involve calculating a number of moles of cyclohexene, a mass of cyclohexanol and the use of the 75% but these stages can be done in different orders.</p> <p>EITHER</p> <p>Need theoretical yield of <math>(10.0 \times 100/75) = 13.3333 / 13.33 / 13.3 \text{ g}</math> (1)</p> <p><math>13.3333 \text{ g} = (13.3333/82) = 0.1626 / 0.163 \text{ mol cyclohexene}</math> (1)</p> <p><math>0.1626 \text{ mol cyclohexanol} = \mathbf{16.26 / 16.3 / 16 \text{ g}}</math> (1)</p> <p>OR</p> <p>Mol of cyclohexene = <math>(10/82) = 0.12195</math> (1)</p> <p>Mol of cyclohexanol = <math>(0.12195 \times 100/75) = 0.1626</math> (1)</p> <p>Mass of cyclohexanol = <math>(0.1626 \times 100) = \mathbf{16.26 / 16.3 / 16 \text{ g}}</math> (1)</p> <p>OR</p> <p>Mol of cyclohexene = <math>(10/82) = 0.12195</math> (1)</p> <p>Theoretical mass of cyclohexanol = <math>(0.12195 \times 100) = 12.195/12.2 \text{ g}</math> (1)</p> <p>Mass of cyclohexanol = <math>(12.2 \times 100/75) = \mathbf{16.26 / 16.3 / 16 \text{ g}}</math> (1)</p> <p>ALLOW</p> <p><b>16.2 (g)</b> in all methods from rounding  <b>9.146 (g)</b> from incorrect use of 75% scores <b>(2)</b></p> <p>Ignore SF in final answer except 1 SF</p>	<p>Theoretical yield = <math>(10.0 \times 75/100) = 7.5 \text{ g}</math></p> <p><math>(0.12195 \times 75/100) = 0.09146</math></p>	3

Question Number	Acceptable Answers	Reject	Mark
4(g)(i)	Brown / red-brown / orange / yellow / yellow-brown to colourless  ALLOW Brown / red-brown / orange / yellow is decolorised.  IGNORE Clear for colourless	Red to colourless	1

Question Number	Acceptable Answers	Reject	Mark
4(g)(ii)	  ALLOW Rings with CH <sub>2</sub> and/or CHBr  IGNORE Angles in ring Placing of H and Br inside or outside ring	Benzene ring  Just skeletal formula / molecular formula  Bromoalcohols  Non-adjacent Br atoms	1

Total for Question 4 = 16 marks

