

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 |
|-----------------|---|--------|------|
| 1(a)(i) | Sodium (ion)/ Na ⁺ If name AND formula are given BOTH must be correct | Na | 1 |

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

| Question Number | Acceptable Answers | Reject | Mark |
|------------------|--|---|------|
| 1(a)(iii) | Ca(OH) ₂ (aq) + CO ₂ (g) → CaCO ₃ (s)+H ₂ 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 ²⁺ (aq) + 2OH ⁻ (aq) for Ca(OH) ₂ (aq) Ignore multiples if equation is balanced | H ₂ O(aq) Ca(OH) ₂ (l) Ca ²⁺ (aq) + CO ₃ ²⁻ (aq) → CaCO ₃ (s) | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|--|--------------------------------|------|
| 1(b)(i) | 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 dilute (aqueous) ammonia (solution) / NH₃ / NH₃ (aq) ALLOW Dilute NH₄OH /ammonium hydroxide</p> <p>IGNORE Additional test with concentrated NH₃ (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 concentrated sulfuric acid to ppt (1)</p> <p>RESULT Steamy fumes (only)/ no brown AND no purple fumes ALLOW White fumes (1)</p> <p>Second mark depends on use of sulfuric acid.</p> | <p>Just "ammonia / NH₃" 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 |
|-----------------|--|--|------|
| 1(b)(iv) | (goes) dark / purple / grey ALLOW Black / lilac (1) Silver / Ag (forms) (1) | Goes blue-black Silver colour/ mirror Ag ⁺ / silver ions | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--------|------|
| 1(c) | $\text{Sr}^{2+} + \text{CO}_3^{2-} \rightarrow \text{SrCO}_3$ 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>TEST Add PCl_5 / phosphorus(V) chloride / phosphorus pentachloride / SOCl_2 / thionyl chloride / sulphur dichloride oxide (1)</p> <p>RESULT Mark depends on correct reagent, but allow PCl_5 (aq)</p> <p>Steamy / misty / white fumes ALLOW Gas for fumes (1)</p> <p>Ignore incorrect identification of fumes</p> <p>OR</p> <p>TEST Add sodium / Na (1)</p> <p>RESULT 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 PCl_5 / PCl_5 (aq)</p> <p>Acidified dichromate(VI) PCl_3</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 and carboxylic acid ALLOW ROH and RCOOH R ₂ CHOH/ R ₃ COH for ROH C _n H _{2n+1} OH for ROH RCO ₂ 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) Justification: 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 |
|-----------------|--|--|------|
| 2(e)(i) | <p>Molecular ions have same m/e</p> <p>ALLOW</p> <p>same molecular ion isomers have same molar mass / molecular mass molecular ion with same mass same maximum m/e value same peak furthest to right same last peak Parent ion / M^+ for molecular ion</p> <p>IGNORE</p> <p>Reference to peak heights</p> | <p>Same fragments Same m/e value for highest peak</p> <p>Similar for "same"</p> | 1 |

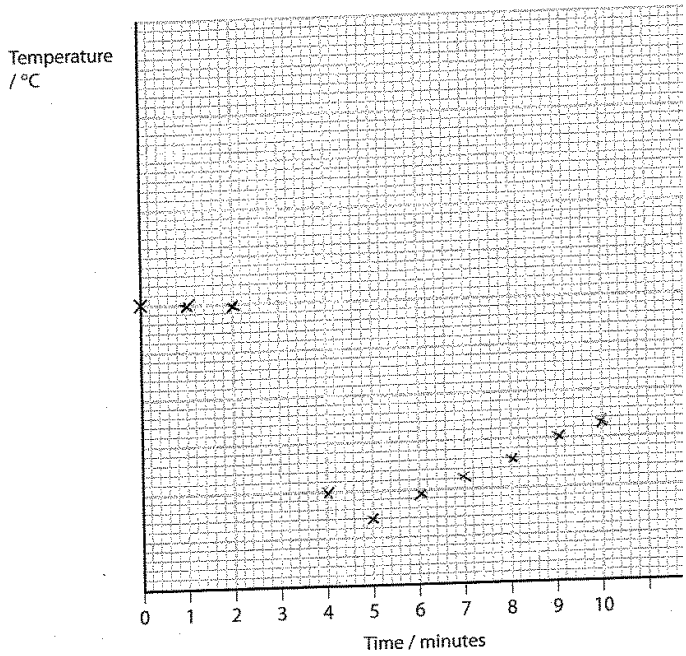
| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|---------------------|------|
| 2(e)(ii) | <p>They both have an (absorption) peak for (wavenumber of) alcohol / hydroxyl group / O-H</p> <p>ALLOW</p> <p>both have peak for -OH / OH frequency / wavelength for wavenumber</p>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

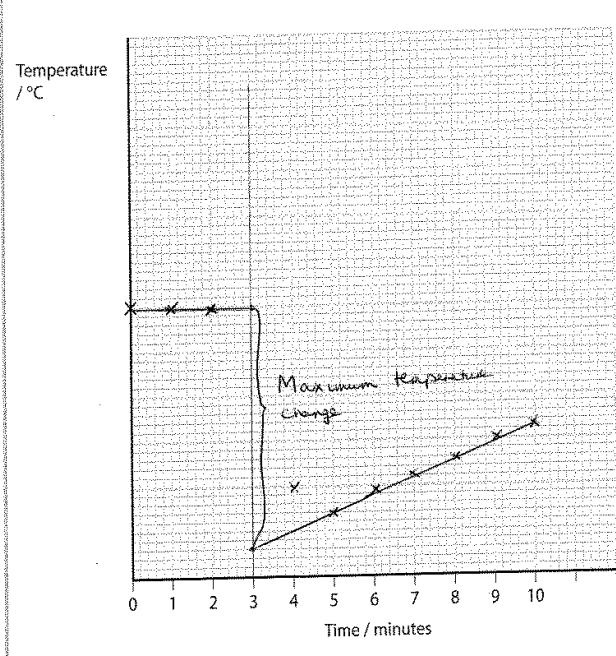
Total for Question 2 = 10 marks

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|---|------|
| 3(a)(i) | <p>Correct final answer with + sign, 3 sf and units scores 3</p> <p>$(25 \times 4.18 \times 10.5) = 1097.25 \text{ (J)} / 1.097 \text{ kJ}$ Ignore sign if given (1)</p> <p>Mol $\text{NH}_4\text{Cl} = (5.00/53.5) = 0.09346/0.0935$ (1)</p> <p>$\Delta H_{\text{solution}} = (+1.097/0.09346)$ $(= +11.7376 / +11.7406)$ = +11.7 kJ mol⁻¹ OR +11700 J mol⁻¹ 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 = +11.8 kJ mol⁻¹ 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 $\Delta H_{\text{solution}} = +14.1 \text{ kJ mol}^{-1}$ max (2)</p> <p>If mass used is 5 g Energy transferred = 219.45 J $\Delta H_{\text{solution}} = +2.35 \text{ kJ mol}^{-1}$ max (2)</p> | <p>Answers not to 3 sf No sign or negative sign</p> | 3 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|---|------|
| 3(a)(ii) | <p>First mark is for calculation of error. Second mark is for comparison of temperature error to mass error.</p> <p>Uncertainty in mass = $(0.005 \times 100 \times 2/5.00) = (\pm)0.2\%$ (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> | <p>Just "0.2% is negligible / very small"</p> | 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 |
|------------------|--|--|------|
| 3(b)(iii) | <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 |
|-----------------|---|--|------|
| 3(c)(i) | <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;"> $\text{NH}_4\text{Cl(s)}$ </div> <div style="text-align: center;"> $\xrightarrow{\Delta H_{\text{reaction}}}$ </div> <div style="border: 1px solid black; padding: 5px; text-align: center;"> $\text{NH}_3\text{(g)} + \text{HCl(g)}$ </div> </div> <div style="display: flex; justify-content: space-around; align-items: center; margin-top: 10px;"> <div style="text-align: center;"> $\Delta H_1 \downarrow$ </div> <div style="text-align: center;"> $\Delta H_2 + \Delta H_3 \downarrow$ </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;"> $\text{NH}_4\text{Cl(aq)}$ </div> <div style="text-align: center;"> $\xleftarrow{\Delta H_4}$ </div> <div style="border: 1px solid black; padding: 5px; text-align: center;"> $\text{NH}_3\text{(aq)} + \text{HCl(aq)}$ </div> </div> <p>OR 2 separate parallel arrows for $\Delta H_2 + \Delta H_3$ OR $\Delta H_2 \Delta H_3$ 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 |

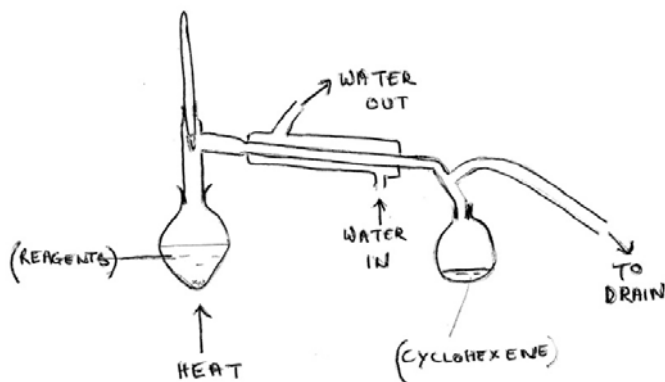
| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--------|------|
| 3(c)(iii) | $\Delta H_{\text{reaction}} = \Delta H_1 - \Delta H_2 - \Delta H_3 - \Delta H_4$ <p>ALLOW any order of terms with correct signs Any correct use of brackets</p> <p>No TE on incorrect cycle</p>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

Total for Question 3 = 13 marks

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|--|---|------|
| 4(a) | 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 |
|-----------------|--|--------|------|
| 4(b) | Correct final answer scores (2) Mass of 12 cm ³ C ₆ H ₁₁ 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 narrow 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 |

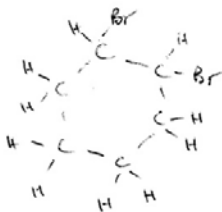


| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|--|---|------|
| 4(d) | <p>Dehydrating agent removes water in a (chemical) reaction OR causes two H and one O atoms to be lost (in a reaction) OR removes the elements of water (from reactant molecules) OR removes water from molecules of a compound</p> <p>ALLOW answers indicating a reaction occurs eg H⁺ protonates OH in alcohol forming water removes water causing bonds to break reference to elimination reactions (1)</p> <p>Drying agent 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 |
|-----------------|--|--------|------|
| 4(e) | 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>Look at final answer. If correct award 3 marks.</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 $(10.0 \times 100/75) = 13.3333 / 13.33 / 13.3 \text{ g}$ (1)</p> <p>$13.3333 \text{ g} = (13.3333/82) = 0.1626 / 0.163 \text{ mol cyclohexene}$ (1)</p> <p>$0.1626 \text{ mol cyclohexanol} = \mathbf{16.26} / \mathbf{16.3} / \mathbf{16 \text{ g}}$ (1)</p> <p>OR</p> <p>Mol of cyclohexene = $(10/82) = 0.12195$ (1)</p> <p>Mol of cyclohexanol = $(0.12195 \times 100/75) = 0.1626$ (1)</p> <p>Mass of cyclohexanol = $(0.1626 \times 100) = \mathbf{16.26} / \mathbf{16.3} / \mathbf{16 \text{ g}}$ (1)</p> <p>OR</p> <p>Mol of cyclohexene = $(10/82) = 0.12195$ (1)</p> <p>Theoretical mass of cyclohexanol = $(0.12195 \times 100) = 12.195/12.2 \text{ g}$ (1)</p> <p>Mass of cyclohexanol = $(12.2 \times 100/75) = \mathbf{16.26} / \mathbf{16.3} / \mathbf{16 \text{ g}}$ (1)</p> <p>ALLOW</p> <p>16.2 (g) in all methods from rounding 9.146 (g) from incorrect use of 75% scores (2)</p> <p>Ignore SF in final answer except 1 SF</p> | <p>Theoretical yield = $(10.0 \times 75/100) = 7.5 \text{ g}$</p> <p>$(0.12195 \times 75/100) = 0.09146$</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 ₂ 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

