



Mark Scheme (Results)

Summer 2015

IAL Chemistry (WCH02/01)

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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

**Section A (multiple choice)**

Question Number	Correct Answer	Reject	Mark
<b>1</b>	C		1

Question Number	Correct Answer	Reject	Mark
<b>2</b>	D		1

Question Number	Correct Answer	Reject	Mark
<b>3</b>	B		1

Question Number	Correct Answer	Reject	Mark
<b>4</b>	A		1

Question Number	Correct Answer	Reject	Mark
<b>5</b>	C		1

Question Number	Correct Answer	Reject	Mark
<b>6</b>	C		1

Question Number	Correct Answer	Reject	Mark
<b>7</b>	D		1

Question Number	Correct Answer	Reject	Mark
<b>8</b>	A		1

Question Number	Correct Answer	Reject	Mark
<b>9</b>	B		1

Question Number	Correct Answer	Reject	Mark
<b>10</b>	D		1

Question Number	Correct Answer	Reject	Mark
<b>11</b>	B		1

Question Number	Correct Answer	Reject	Mark
<b>12</b>	A		1

Question Number	Correct Answer	Reject	Mark
<b>13</b>	B		1

Question Number	Correct Answer	Reject	Mark
<b>14</b>	C		1

Question Number	Correct Answer	Reject	Mark
<b>15</b>	B		1

Question Number	Correct Answer	Reject	Mark
<b>16</b>	D		1

Question Number	Correct Answer	Reject	Mark
<b>17</b>	B		1

Question Number	Correct Answer	Reject	Mark
<b>18</b>	C		1

Question Number	Correct Answer	Reject	Mark
<b>19</b>	A		1

Question Number	Correct Answer	Reject	Mark
<b>20</b>	C		1

**(TOTAL FOR SECTION A = 20 MARKS)**

**Section B**

Question Number	Acceptable Answers	Reject	Mark
<b>21(a)(i)</b>	$(n = 0.05 \times 0.00450 =)$ $2.25 \times 10^{-4} / 0.000225 \text{ (mol)}$ IGNORE SF except 1SF		1

Question Number	Acceptable Answers	Reject	Mark
<b>21(a)(ii)</b>	$(n = 2.25 \times 10^{-4} \times 2 =)$ $4.50 \times 10^{-4} / 0.000450 \text{ (mol)}$ TE ans to (a)(i) $\times 2$ IGNORE SF except 1SF		1

Question Number	Acceptable Answers	Reject	Mark
<b>21(a)(iii)</b>	$(c = 4.50 \times 10^{-4} \div 0.025 =)$ $1.8 \times 10^{-2} / 0.018 / 1.80 \times 10^{-2} / 0.0180 \text{ (mol dm}^{-3}\text{)}$ TE ans to (a)(ii) $\div 0.025$ IGNORE SF except 1SF		1



Question Number	Acceptable Answers	Reject	Mark
<b>21(a)(v)</b>	<p>Correct final answer (181/182) to 3SF with or without working scores (2)</p> <p><b>Answer to (iv)</b> x 45 OR x 56.1 (1)</p> <p><math>n = 7.18 \times 10^{-2} \times 45 = (3.231) \text{ (mol)}</math></p> <p><math>m = 3.231 \times 56.1 = (181.359 / 181.4)</math></p> <p>OR 181.2591 / 181.3</p> <p>= 181 (g)</p> <p>NOTE ALLOW USE OF 56 (1)</p> <p><b>Alternative method</b></p> <p><b>Answer to (ii)</b> x <math>\frac{45000}{25}</math> OR x 56/56.1 (1)</p> <p>Amount = 0.81 (mol)</p> <p>Mass of KOH left <math>0.81 \times 56.1/56</math></p> <p>= 45.441/45.36 (g)</p> <p>Mass used = <math>226.8 - 45.441/45.36</math></p> <p>= 181 (g) (1)</p>		2

**Some TE values:**

Part	Answer	Mark	Answer	Mark
(i)	$\frac{25 \times 0.05}{1000}$ = $1.25 \times 10^{-3}$	0	$\frac{25 \times 4.5}{1000}$ = 0.1125	0
(ii)	$2.5 \times 10^{-3}$	1	0.225	1
(iii)	0.1	1	9	1
(iv)	$0.089 - 0.1$ = -0.0102	2	$0.089 - 9$ = -8.91	2
(v)	0.459 (mol) and 25.7 (g)	2	400.95 (mol) and 22 500 (g)	2

Question Number	Acceptable Answers	Reject	Mark
<b>21(b)(i)</b>	(From) (pale/bright) pink/red (1)  (To) colourless (1)  ALLOW  one mark for 'colourless to pink/red (1)  Second mark dependant on shade of pink/red/purple for first colour	purple  ...clear	2

Question Number	Acceptable Answers	Reject	Mark
<b>21(b)(ii)</b>	<b>Red/brown/colour</b> (from the hair/skin likely to have) leached out/dissolved/ solution formed  ALLOW  <b>Red/brown/colour</b> from the hair/skin makes the (colour) change/end point difficult to judge/see		1

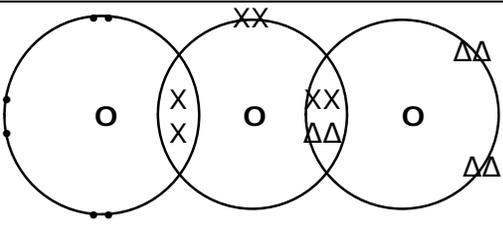
Question Number	Acceptable Answers	Reject	Mark
<b>21(b)(iii)</b>	No Only a few drops of indicator used  OR  Adding to an aqueous solution  OR  Ethanol mixes with water (in all proportions)  ALLOW  Ethanol is in solution  IGNORE  Any other reasons	Yes...	1

Question Number	Acceptable Answers	Reject	Mark
<b>21(c)(i)</b>	(Titre error) $\frac{(0.05 \times 2 \times 100=)}{4.50} \pm 2.2(2) (\%) \quad (1)$ (Sample error) $\frac{(0.06 \times 100=)}{25} \pm 0.24 (\%) \quad (1)$		2

Question Number	Acceptable Answers	Reject	Mark
<b>21(c)(ii)</b>	<p><b>Mark each point independently</b></p> <p><b>Any two from:</b></p> <p>Reduce the concentration of the sulfuric acid (1)</p> <p>Use a larger (initial) sample/R/KOH volume (1)</p> <p>Use HCl(aq) (of same concentration as sulfuric acid which would have a larger titre) (1)</p> <p>Use greater (initial) concentration/mass of KOH (1)</p> <p>Use less skin (1)</p> <p>IGNORE</p> <p>(Just) use larger titre</p> <p>Repeat the titration</p> <p>Just changing the concentration</p>	Use more skin	2

Question Number	Acceptable Answers	Reject	Mark
<b>21(c)(iii)</b>	When it is concordant/the same  OR  Within $\pm 0.1$ (cm <sup>3</sup> ) of the (mean of) other titres  ALLOW  Within $\pm 0.2$ (cm <sup>3</sup> ) of the other titres ( <b>comment</b> this is as per the User guide)  IGNORE  Close/similar/almost the same as other titres		1

**TOTAL FOR QUESTION 21 = 17 MARKS**

Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	 <p>Eight electrons around each end oxygen of which six must be of the same symbol (1)</p> <p>Rest of electrons correct (1)</p> <p>Triangles and dots can be drawn the other way round</p> <p>Non-bonding electrons can be as pairs or separate</p>		2

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	<p>There are three areas of electron density/regions of negative charge/groups of electrons (and not two) around (the central oxygen)</p> <p>OR</p> <p>Non-bonding/lone pair (of electrons) on the <b>central / middle / centre oxygen atom</b></p> <p>ALLOW</p> <p>There are more than two areas of electron density/regions of negative charge/groups of electrons on the <b>central/middle / centre oxygen atom</b></p>	<p>Mention of other atoms</p> <p>Lone pairs</p>	1

Question Number	Acceptable Answers	Reject	Mark
<b>22(a)(iii)</b>	(Increased risk of) malignant melanoma/ basal cell carcinoma(s) / (Increased risk of) <b>skin</b> cancer/DNA breakdown/mutation  Retinal/eye damage/snow blindness  IGNORE references to sunburn  IGNORE just cancer	Reference to global warming	1

Question Number	Acceptable Answers	Reject	Mark
<b>22(a)(iv)</b>	(UV) is high(er) energy /high(er) frequency /short(er) wavelength  OR (UV) breaks covalent bonds  OR produces free radicals/ions  OR Reverse answers for IR  IGNORE more penetrating	Long(er) wavelength  Low(er)energy/frequency	1

Question Number	Acceptable Answers	Reject	Mark
<b>22(a)(v)</b>	Species / molecule / atom/particles with an unpaired electron	unpaired electrons  Just 'single electron' 'lone electron' 'free electron' 'one electron'	1

Question Number	Acceptable Answers	Reject	Mark
<b>22(a)(vi)</b>	<p><b>Mark independently</b></p> <p>Dots must be shown on either second NO or on one of the NO<sub>2</sub> molecules</p> <p><b>First mark</b></p> $(\text{NO}\cdot + \text{O}_3 \rightarrow) \text{NO}_2\cdot + \text{O}_2 \quad (1)$ <p><b>Second mark</b></p> $\text{NO}_2\cdot + \text{O}_3 \rightarrow \text{NO}\cdot + 2\text{O}_2$ <p>OR BOTH</p> $\text{O}_3 \rightarrow \text{O}\cdot + \text{O}_2$ <p>AND</p> $\text{NO}_2\cdot + \text{O}\cdot \rightarrow \text{NO}\cdot + \text{O}_2 \quad (1)$ <p><b>Third mark</b></p> $2\text{O}_3 \rightarrow 3\text{O}_2 \quad (1)$ <p>Allow multiples</p>		3

Question Number	Acceptable Answers	Reject	Mark
<b>22(a)(vii)</b>	<p><b>Catalyst</b></p> <p>IGNORE anything else including catalytic converter</p> <p><b>Comment</b></p> <p>The word catalyst can be awarded the mark if shown in a(vi)</p>		1

Question Number	Acceptable Answers	Reject	Mark
<b>22(a)(viii)</b>	<p>They breakdown/react/dissolves</p> <p>(in the lower atmosphere before they rise to the ozone layer)</p>	Reference to catalytic converter	1



Question Number	Acceptable Answers	Reject	Mark
<b>22(b)(iv)</b>	(CFCs) No longer being released in the atmosphere/ less used/concentration decreasing/ amount reduced  OR  Banned from use/production  OR  CFCs replaced by HCFCs / HFCs/ Propane / Butane  IGNORE  More carbon dioxide	...Methane	1

Question Number	Acceptable Answers	Reject	Mark
<b>22(b)(v)</b>	<b>Any two from</b>  Anthropogenic change is man-made (1)  Water vapour is always present naturally OR Water vapour present from natural sources OR Water vapour due to the water cycle/ named processes (1)  The levels of water vapour have kept relatively constant (over the recent centuries) (1)  Can't control natural water vapour emissions (1)  COMMENT Do not penalise 'water vapour has less effect on global warming' in this question Do not penalise 'water vapour is not produced by humans' in this question		2

Question Number	Acceptable Answers	Reject	Mark
<b>22(b)(vi)</b>	<p><b>MP1</b> Carbon neutrality is where the CO<sub>2</sub> released on combustion is equal to the CO<sub>2</sub> absorbed on formation of the fuel/plant</p> <p>ALLOW</p> <p>Amount of carbon dioxide taken/reacted in equals amount given out/produced</p> <p>OR</p> <p>No net increase in atmospheric carbon dioxide (1)</p> <p><b>MP2</b> CO<sub>2</sub> (from fossil fuels) is likely to be released from transport/production of biofuel/production of fertiliser/processing of the biofuel</p> <p>ALLOW</p> <p>Biofuels are a blend including fossil fuels (1)</p> <p>IGNORE Reference to 'waste'</p>	Just 'carbon'	2

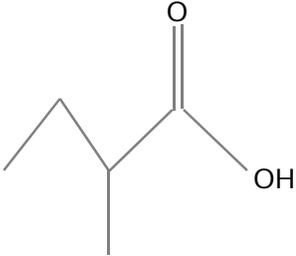
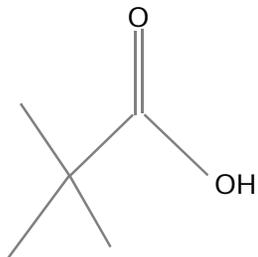
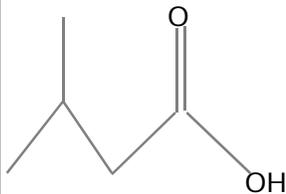
Question Number	Acceptable Answers	Reject	Mark
<b>22(b)(vii)</b>	<p><b>Any two from:</b></p> <p>Use catalysts/enzymes (to reduce energy consumption) (1)</p> <p>Use microwave energy (which is more efficient) (1)</p> <p>Improve thermal insulation (1)</p> <p>Use heat exchangers/heat recovery (1)</p> <p>Reduce waste/recycle (bi-)products (1)</p> <p>Use renewable resources in its processes (1)</p> <p>Use high atom economy processes (1)</p> <p>Use nuclear power/renewable energy sources/use wind power/use solar power/use fuel cells (1)</p> <p>Use carbon capture and storage methods (1)</p> <p><b>Note</b> Credit two different storage/capture methods separately for both marks</p> <p>eg sending carbon dioxide back to replace north sea gas under the sea (1)</p> <p>neutralising with scrubbers, absorbing with alkali/limestone etc (1)</p> <p><b>Comment</b> Send any unexpected well-reasoned points to your TL</p> <p>IGNORE Use reactions needing lower temperatures</p> <p>Plant more trees</p> <p>Reduce car use</p> <p>Use of hydrogen as a fuel</p>	High pressure	2

**TOTAL FOR QUESTION 22 = 22 MARKS**  
**TOTAL FOR SECTION B = 39 MARKS**

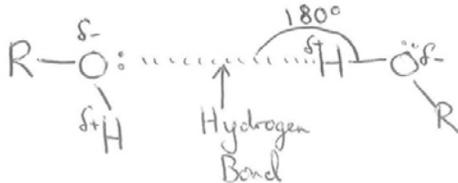
## Section C

Question Number	Acceptable Answers	Reject	Mark
<b>23(a)</b>	<b>3(-)methylbutanoic acid</b>  ALLOW <b>3(-)methylbutyric acid</b>	<b>2-methylbutanoic acid</b>	1

Question Number	Acceptable Answers	Reject	Mark
<b>23(b)</b>	$C_5H_{10}O_2$  ALLOW atoms in any order if numbers are correct for each atom  eg $H_{10}O_2C_5$ / $C_5O_2H_{10}$ / $H_{10}O_2C_5$ / $O_2C_5H_{10}$  ALLOW  Additional formulae as well as correct answer	Just ' $C_4H_9COOH$ '	1

Question Number	Acceptable Answers	Reject	Mark
<b>23(c)</b>	 <p>(1)</p> <p>Bonds may go in other directions eg methyl group upwards</p>  <p>(1)</p>		2

Question Number	Acceptable Answers	Reject	Mark
<b>23* (d)</b>	<p><b>MP1</b> Equal/specified volumes/masses/amounts of solvent (1)</p> <p><b>MP2</b> Equal volumes of valeric acid <b>and</b> shake/stir/ mix (and allow to stand) OR Add valeric acid a drop at a time/from a burette to the solvents (1)</p> <p><b>MP3</b> (Two) layers with water <b>and</b> a (single) layer with ethanol OR Immiscible with water mixes with ethanol OR Cloudy with water <b>and</b> clear with ethanol OR Measure depth of mixture/smaller rise for ethanol (1)</p>	precipitate	3

Question Number	Acceptable Answers	Reject	Mark
<b>23(e)</b>	<p>Drawing of hydrogen bond between correct atoms and in a straight line</p> <p>Ignore extra molecules Ignore dipoles and omission of lone pair of electrons Ignore R-OH bond angle</p> <p>ALLOW</p> <p>Any alcohol (1)</p> <hr/>  <p>Bond angle 180° around the correct H atom and consequential on MP1 (1)</p> <p>NOTE</p> <p>If two water molecules/R-OH and a water molecule are correctly drawn with a linear hydrogen bond and 180° correctly labelled then award (1)</p>		2

Question Number	Acceptable Answers	Reject	Mark
<b>23(f) * (i)</b>	<p>Instantaneous dipole OR temporary asymmetric electron distribution (1)</p> <p>Induced dipole/charge in adjacent/another molecule/atom/particle (1)</p>		2

Question Number	Acceptable Answers	Reject	Mark
<b>23(f)(ii)</b>	<p><b>MP1</b></p> <p>(Boiling temperature will be) lower/ <b>straight chain</b> is higher (1)</p> <p>Remaining marks are dependent on <b>MP1</b></p> <p><b>MP2 and MP3</b></p> <p>Branching reduces/ less(ens)/weakens the London/dispersion/ Van der Waals'/vdW forces (1)</p> <p>(because it has) less surface area (in contact)/ molecules can't align/molecules can't get as close (1)</p> <p>OR</p> <p>Straight chain stronger/ more/ increases London/etc forces (1)</p> <p>(because it has) greater surface area (in contact) /molecules can align better/molecules can get as closer/pack more closely (1)</p> <p>IGNORE</p> <p>References to energy</p>		3

Question Number	Acceptable Answers	Reject	Mark
<b>23(g)(i)</b>	<p>(The alcohol) can <b>only</b> be oxidized to the ketone</p> <p>OR</p> <p>cannot be further oxidized</p> <p>OR</p> <p>cannot be oxidized to a carboxylic acid</p> <p>OR</p> <p>Further oxidation would have to break a C-C bond</p> <p>IGNORE</p> <p>It's a secondary alcohol/It's not a primary alcohol/ Same product formed</p>		1

Question Number	Acceptable Answers	Reject	Mark
<b>23(g)(ii)</b>	Alkene/carbon-carbon double bond  ALLOW  C=C (1)  (Type of molecule) (1,2-) diol  ALLOW  (1,2-) dialcohol (1)	Just 'double bond'       Alcohol	2

Question Number	Acceptable Answers	Reject	Mark
<b>23(h)</b>	<b>Up to 2 marks for IR points</b> <b>Penalise the omission of bonds once only</b>	3095-3010	4
	<b>IR MP1</b>		
	3300-2500 (cm <sup>-1</sup> ) O—H/OH (stretch in a carboxylic acid) (1)	3750-3200	
	<b>IR MP2</b>		
	1725-1700 (cm <sup>-1</sup> ) C=O (stretch in a carboxylic acid) (1)	1700-1680	
	<b>Ignore</b>		
	2962 – 2853 (cm <sup>-1</sup> ) C-H (stretch in an alkane)		
	<b>Up to 3 marks for Mass Spec points</b>		
	Only penalise negative charges or lack of positive charge once		
	Molecular ion/parent ion peak /C <sub>5</sub> H <sub>10</sub> O <sub>2</sub> <sup>+</sup> at 102 (1)		
C <sub>5</sub> H <sub>9</sub> O <sub>2</sub> <sup>+</sup> at 101 (1)			
COOH <sup>+</sup> at 45 (1)			
C <sub>4</sub> H <sub>9</sub> <sup>+</sup> /CH <sub>3</sub> CH(CH <sub>3</sub> )CH <sub>2</sub> <sup>+</sup> at 57 (1)			
C <sub>4</sub> H <sub>7</sub> O <sub>2</sub> <sup>+</sup> /CH <sub>3</sub> CHCH <sub>2</sub> CO <sub>2</sub> H <sup>+</sup> at 87 (1)			
OH <sup>+</sup> at 17 (1)			
CH <sub>3</sub> <sup>+</sup> at 15 (1)			

**TOTAL FOR SECTION C (QUESTION 23) = 21 MARKS**

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**TOTAL FOR PAPER = 80 MARKS**

