



## Mark Scheme (Results)

January 2022

Pearson Edexcel International Advanced Level  
In Chemistry (WCH16)  
Paper 01: Practical Skills in Chemistry II

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January 2022

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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.

## Using the mark scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:

- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit. ( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer. ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Question Number	Answer	Additional guidance	Mark
1(a)	<ul style="list-style-type: none"> <li><math>[\text{Cr}(\text{H}_2\text{O})_6]^{2+}</math></li> </ul>	Allow $[\text{CrCl}(\text{H}_2\text{O})_5]^+$ / $[\text{CrCl}_3(\text{H}_2\text{O})_3]^-$ / $[\text{CrCl}_4(\text{H}_2\text{O})_2]^{2-}$ / $[\text{CrCl}_5(\text{H}_2\text{O})]^{3-}$ / $\text{CrCl}_2(\text{H}_2\text{O})_4$ Allow $[\text{CrCl}_3]^-$ / $[\text{CrCl}_4]^{2-}$ Allow ligands in any order Allow omission of square brackets Ignore name, even if incorrect Ignore $\text{Cr}^{2+}(\text{aq})$ Do not award incorrect charge Do not award omission of charge Do not award $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ or any other metal ion	1

Question Number	Answer	Additional guidance	Mark
1(b)	<ul style="list-style-type: none"> <li><math>\text{Cr}(\text{H}_2\text{O})_3(\text{OH})_3</math></li> </ul>	Allow $\text{Cr}(\text{OH})_3$ Ignore square brackets Ignore name, even if incorrect Do not award any species containing $\text{NH}_3$  If no other mark is scored in Q1 any correct transition metal hydroxide formula scores (1)	1

Question Number	Answer	Additional guidance	Mark
1(c)	<ul style="list-style-type: none"> <li>hydrogen peroxide / <math>\text{H}_2\text{O}_2</math></li> </ul>	Ignore alkali / sodium hydroxide / $\text{NaOH}$ Do not award any other additional reagents	1

Question Number	Answer	Additional guidance	Mark
1(d)	<ul style="list-style-type: none"> <li>barium chromate((VI)) / <math>\text{BaCrO}_4</math></li> </ul>	If oxidation state is given it must be correct	1

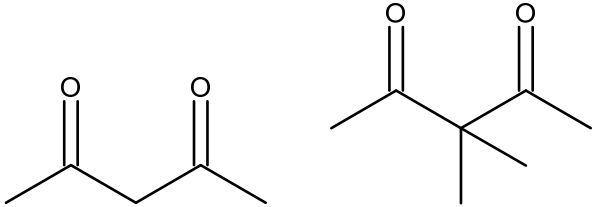
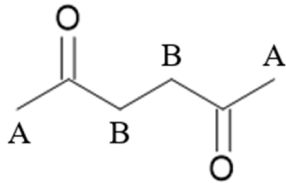
Question Number	Answer	Additional guidance	Mark
1(e)	<ul style="list-style-type: none"> <li>orange</li> </ul>	Do not award any other answer	1

Question Number	Answer	Additional guidance	Mark
1(f)	<ul style="list-style-type: none"> <li>green</li> </ul>	Allow blue-green / blue Do not award violet	1

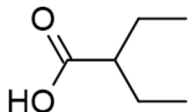
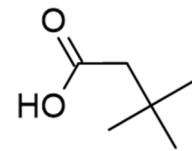
**(Total for Question 1 = 6 marks)**

Question Number	Answer	Additional guidance	Mark
2(a)	<ul style="list-style-type: none"> <li>C<sub>6</sub>H<sub>10</sub>O<sub>2</sub></li> </ul>	Allow elements in any order Do not award any other answer	1

Question Number	Answer	Additional guidance	Mark
2(b)	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>Test 1 shows that <b>X</b> is an aldehyde /RCHO or ketone / RCOR (1)</li> <li>Test 2 shows that <b>X</b> cannot be oxidised / is not an aldehyde (1)</li> <li>Test 3 shows that <b>X</b> contains a methyl ketone (1)</li> </ul>	<p>Accept carbonyl Ignore C=O</p> <p>Accept it is a ketone Ignore 'not an alcohol'</p> <p>Accept methyl carbonyl / CH<sub>3</sub>CO / 2-one / CH<sub>3</sub>COR Do not award aldehyde Do not award methyl alcohol group / 2-ol / CH<sub>3</sub>CHOH</p> <p>If the results are not clearly linked to the tests or in the order given max (2)</p>	3

Question Number	Answer	Additional guidance	Mark
2(c)	<ul style="list-style-type: none"> <li>• structure of hexane-2,5-dione (1)</li> <li>• identification of the two proton environments (1)</li> </ul> <div style="border: 1px solid black; padding: 10px; margin-top: 20px;"> <p>M2 may be awarded if an incorrect formula is given that has two CH<sub>3</sub>CO groups <b>and</b> only two proton environments with <b>both</b> labelled e.g</p> <div style="display: flex; justify-content: space-around; align-items: center;">  </div> <p>either (with proton environments labelled) scores M2</p> </div>	<p>Examples of correct structure:</p> <p style="text-align: center;">A      B   B    A CH<sub>3</sub>COCH<sub>2</sub>CH<sub>2</sub>COCH<sub>3</sub></p> <div style="text-align: center;">  </div> <p>Allow A      B CH<sub>3</sub>COCH<sub>2</sub>COCH<sub>2</sub>CH<sub>3</sub> (which has two singlets but also a triplet and a quartet) for M1 and M2</p> <p>Accept any clear method of identifying the two proton environments Allow any type of structure or combination of structures Penalise omission of H atoms in displayed structures once only throughout Q2</p> <p>Ignore name, even if incorrect</p>	2

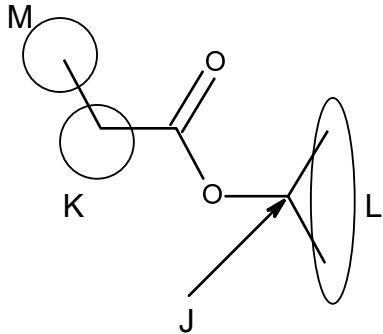
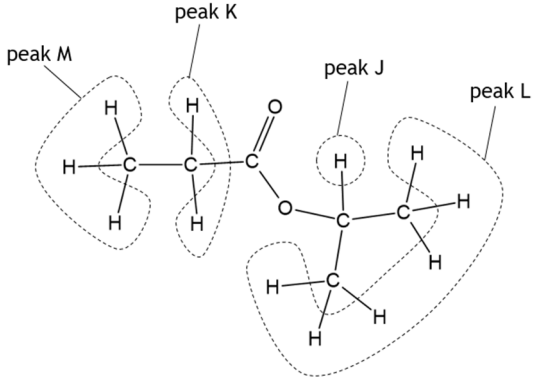
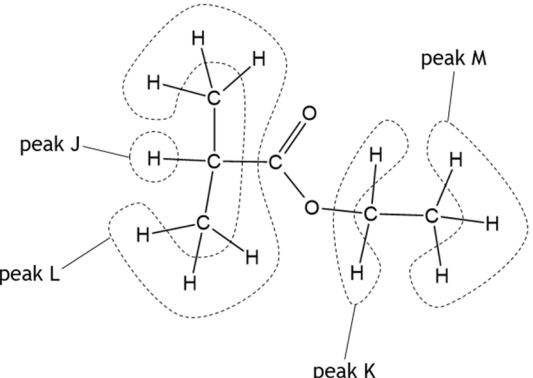
Question Number	Answer	Additional guidance	Mark
2(d)(i)	<ul style="list-style-type: none"> <li>(Y is) carboxylic acid / COOH / CO<sub>2</sub>H</li> </ul>	Do not award just 'acid' Accept RCOOH Allow carboxyl / carboxylic group if COOH shown in the structures in (d)(ii)	1

Question Number	Answer	Additional guidance	Mark
2(d)(ii)	An answer that makes reference to the following points: <ul style="list-style-type: none"> <li>structure of 2-ethylbutanoic acid (1)</li> <li>structure of 3,3-dimethylbutanoic acid (1)</li> </ul>	Example of correct structures: <div style="text-align: center;">    <math>(C_2H_5)_2CHCOOH</math>      <math>(CH_3)_3CCH_2COOH</math> </div> <p>Accept structures in either order            Allow any type of structure</p> <p>Ignore names, even if incorrect            Ignore any reference to the number of carbon/proton environments, even if incorrect</p> <p>If no other mark awarded, two carboxylic acid structures with molecular formula C<sub>6</sub>H<sub>12</sub>O<sub>2</sub> scores (1)</p>	2



Question Number	Answer	Additional guidance	Mark
2(d)(iii)	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>• (Structure 1) 2-ethylbutanoic acid has four peaks (1)</li> <li>• (Structure 2) 3,3-dimethylbutanoic acid has three peaks (1)</li> </ul>	<p>Accept correct peak areas</p> <p>Allow structure 1 has peak area ratio 6:4:1:1 and structure 2 peak area ratio is 9:2:1(2) OR Allow structure 1 has only one singlet (plus other peaks) and structure 2 has three singlets (only) OR Allow structure 1 has highest peak showing 6 protons and structure 2 has highest peak showing 9 protons</p> <p>Allow any unambiguous reference to Structure 1 and Structure 2 from (d)(ii)</p> <p>Ignore just structures have different numbers of peaks Ignore any references to chemical shift and to splitting patterns</p> <p>TE on (d)(ii) for any carboxylic acids with six carbon atoms</p>	2

Question Number	Answer	Additional guidance	Mark
2(e)(i)	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>• fruity smell indicates that <b>Z</b> is an ester (1)</li> <li>• (IR spectrum shows peak at) 1750-1735 (<math>\text{cm}^{-1}</math>) <b>and</b> (due to C=O) ester (1)</li> </ul>	<p>Allow RCOOR / RCO<sub>2</sub>R / COO Do not award just CO<sub>2</sub></p> <p>Allow peak in the range 1750-1735 (<math>\text{cm}^{-1}</math>) could be ester or aldehyde</p> <p>Ignore (C=O) peak around 1735 (<math>\text{cm}^{-1}</math>) is too high to be a ketone or carboxylic acid</p> <p>Ignore identification of C–H alkane peak Ignore references to the fingerprint region</p> <p>Do not award identification of C–H alkene Do not award identification of C–H aldehyde Do not award identification of O–H</p>	2

Question Number	Answer	Additional guidance	Mark
2(e)(ii)	<p>An answer that makes reference to the following points:</p> <ul style="list-style-type: none"> <li>• correct structure of 2-propyl propanoate (1)</li> <li>• correct indication of proton environments M and K (1)</li> <li>• correct indication of proton environments J and L (1)</li> </ul> <p>Allow skeletal formulae e.g.</p> 	<p>Example of correct structure:</p>  <p>Allow any type of formula Ignore name, even if incorrect</p> <p>Allow any unambiguous identification of proton environments</p> <p>TE on M2 and M3 for ethyl 2-methylpropanoate:</p>  <p>TE for the splitting pattern on incorrect structures with an ester group attached to an ethyl group (M2) or a methylethyl (isopropyl) group (M3)</p>	3

(Total for Question 2 = 16 marks)

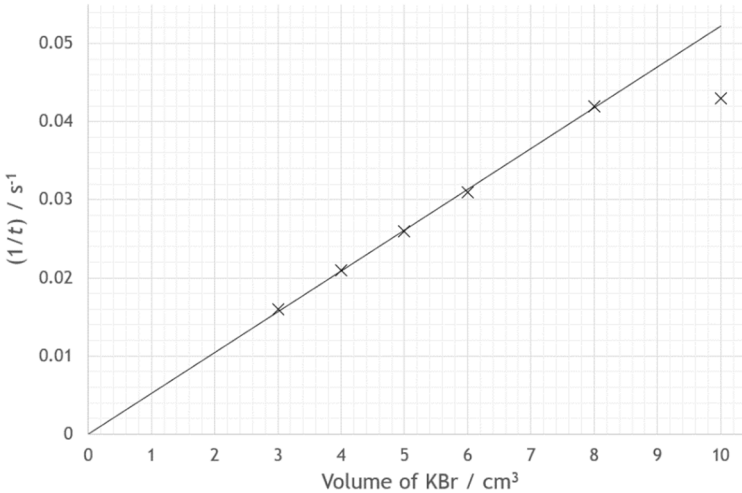
Question Number	Answer	Additional guidance	Mark
3(a)	<ul style="list-style-type: none"> <li>(to ensure the) reactants are (well) mixed</li> </ul>	Accept (to ensure a) uniform / homogeneous solution Ignore to make sure that no reactants remain in beaker Q Do not award to make sure that all the reactants react Do not award other explanations	1

Question Number	Answer	Additional guidance	Mark
3(b)(i)	An explanation that makes reference to the following points: <ul style="list-style-type: none"> <li>to react with bromine/Br<sub>2</sub> (1)</li> <li>to delay the colour change (1)</li> </ul>	Ignore reference to white precipitate (of 2,4,6-tribromophenol) Ignore any reference to the concentration/amount of phenol  Allow to remove the bromine/Br <sub>2</sub> Do not award as a solvent Do not award to provide H <sup>+</sup>  Allow to prevent an immediate colour change/bleaching of methyl orange Allow the methyl orange is bleached when all the phenol is used up	2

Question Number	Answer	Additional guidance	Mark
3(b)(ii)	<ul style="list-style-type: none"> <li>pink</li> </ul>	Accept red	1

Question Number	Answer	Additional guidance	Mark
3(b)(iii)	An answer that makes reference to the following point: <ul style="list-style-type: none"> <li>temperature also affects rate</li> </ul>	Allow temperature also affects rate constant Allow temperature is a control variable Allow the temperature must be constant Ignore to ensure a fair test Ignore reference to thermicity of the reaction	1

Question Number	Answer	Additional guidance	Mark																												
3(c)(i)	<ul style="list-style-type: none"> <li>table complete with both <math>1/t</math> values to 2 SF</li> </ul>	<p>Example of completed table:</p> <table border="1"> <tbody> <tr> <td>Volume of KBr / cm<sup>3</sup></td> <td>10.0</td> <td>8.0</td> <td>6.0</td> <td>5.0</td> <td>4.0</td> <td>3.0</td> </tr> <tr> <td>Time, <math>t</math> / s</td> <td>23</td> <td>24</td> <td>32</td> <td>39</td> <td>48</td> <td>64</td> </tr> <tr> <td><math>(1/t)</math> / s<sup>-1</sup></td> <td>0.043</td> <td>0.042</td> <td>0.031</td> <td>0.026</td> <td><u>0.021</u></td> <td><u>0.016</u></td> </tr> <tr> <td>Temperature / °C</td> <td>18</td> <td>22</td> <td>22</td> <td>22</td> <td>22</td> <td>22</td> </tr> </tbody> </table>	Volume of KBr / cm <sup>3</sup>	10.0	8.0	6.0	5.0	4.0	3.0	Time, $t$ / s	23	24	32	39	48	64	$(1/t)$ / s <sup>-1</sup>	0.043	0.042	0.031	0.026	<u>0.021</u>	<u>0.016</u>	Temperature / °C	18	22	22	22	22	22	<b>1</b>
Volume of KBr / cm <sup>3</sup>	10.0	8.0	6.0	5.0	4.0	3.0																									
Time, $t$ / s	23	24	32	39	48	64																									
$(1/t)$ / s <sup>-1</sup>	0.043	0.042	0.031	0.026	<u>0.021</u>	<u>0.016</u>																									
Temperature / °C	18	22	22	22	22	22																									

Question Number	Answer	Additional guidance	Mark
3(c)(ii)	<ul style="list-style-type: none"> <li>• axes labelled correctly with units and suitable scale (1)</li> <li>• all points plotted correctly (1)</li> <li>• straight line of best fit passing through the origin <b>and</b> missing anomalous point at 10 cm<sup>3</sup> KBr (1)</li> </ul>	<p>Example of graph:</p>  <p>Do not award M1 if variables plotted the wrong way round</p> <p>Points plotted must cover at least 50% of the graph in both directions</p> <p>Allow error margin of <math>\pm</math> one small square TE on <math>1/t</math> values from (c)(i)</p> <p>Allow BFL which would pass through the origin if extrapolated Do not award M3 if axes do not start at 0,0</p> <p>TE on points plotted provided line goes through the origin</p>	3

Question Number	Answer	Additional guidance	Mark
3(c)(iii)	<ul style="list-style-type: none"> <li>(Because) the (total) volume (of liquid / solution in the reaction flask) remains the same (for each run)</li> </ul>	Allow 40 cm <sup>3</sup> or 10 cm <sup>3</sup> for same Allow as volume of KBr is the only variable Ignore as moles is proportional to volume Do not award concentration is proportional to volume	1

Question Number	Answer	Additional guidance	Mark
3(c)(iv)	<ul style="list-style-type: none"> <li>first order</li> </ul>	Allow 1 <sup>st</sup> /1 for first No TE on (c)(ii) Ignore explanations	1

Question Number	Answer	Additional guidance	Mark
3(d)	<ul style="list-style-type: none"> <li>rate = <math>k[\text{Br}^-]^{(1)}[\text{BrO}_3^-]^{(1)}[\text{H}^+]^2</math></li> </ul>	Allow r for Rate Allow KBr for Br <sup>-</sup> and KBrO <sub>3</sub> for BrO <sub>3</sub> <sup>-</sup> TE on (c)(iv) Ignore units given for <i>k</i> , even if incorrect Ignore state symbols even if incorrect Do not award () for [] Do not award omission of 'Rate =' Do not award omission of <i>k</i>	1

(Total for Question 3 = 12 marks)

Question Number	Answer	Additional guidance	Mark
4(a)	An answer which makes reference to the following points: <ul style="list-style-type: none"> <li>concentrated hydrochloric acid is corrosive</li> <li>nitrobenzene is toxic (by skin absorption)</li> </ul>	(1) Allow just acid is corrosive Ignore hydrochloric acid is toxic / harmful Ignore any reference to granulated tin and / or glass  (1) Do not award nitrobenzene is toxic by inhalation Do not award nitrobenzene is corrosive Do not award phenylamine is toxic	2

Question Number	Answer	Additional guidance	Mark
4(b)(i)	An answer which makes reference to the following points: <ul style="list-style-type: none"> <li>(tin is a) reducing agent / reductant</li> </ul>	Do not award catalyst Do not award oxidising agent	1

Question Number	Answer	Additional guidance	Mark
4(b)(ii)	An answer which makes reference to the following point: <ul style="list-style-type: none"> <li>(initial precipitate is) tin(IV) hydroxide / Sn(OH)<sub>4</sub></li> <li>or</li> <li>(initial precipitate is) tin(II) hydroxide / Sn(OH)<sub>2</sub></li> </ul>	Allow just tin hydroxide Do not award SnOH Do not award tin(III) hydroxide / Sn(OH) <sub>3</sub> If name and formula are given both must be correct	1



Question Number	Answer	Additional guidance	Mark
4(c)	<p>An answer which makes reference to the following point:</p> <ul style="list-style-type: none"> <li>the water contains phenylamine</li> </ul>	<p>Allow any indication that phenylamine and water are partially miscible</p> <p>Allow the phenylamine contains water  Allow distillate is an emulsion  phenylamine is slightly soluble in water</p> <p>Ignore water just is present  Ignore just 'organic compound and water'</p> <p>Do not award phenylamine is insoluble in water  Do not award phenylamine is immiscible in water  Do not award distillate is insoluble in aqueous layer  Do not award phenylamine is soluble in water</p> <p>Do not award any other substances  Do not award phenylamine cannot H-bond with water</p>	1

Question Number	Answer	Additional guidance	Mark
4(d)	<p>An answer which makes reference to the following point:</p> <ul style="list-style-type: none"> <li>to aid separation (of the layers)</li> </ul>	<p>Accept to decrease the solubility of phenylamine (in the aqueous layer)  Allow to salt out the phenylamine  Allow to increase the density of the aqueous layer  Allow to increase polarity of solution</p> <p>Do not award drying agent / remove water  Do not award to neutralise acidity  Do not award to make the liquid clear  Do not award to remove impurities  Do not award to make the solution saturated</p>	<b>1</b>



Question Number	Answer	Additional guidance	Mark
4(e)(ii)	An answer which makes reference to the following point: <ul style="list-style-type: none"> <li>method for releasing pressure</li> </ul>	Invert (the funnel) <b>and</b> open the tap Allow remove the stopper	1

Question Number	Answer	Additional guidance	Mark
4(f)	An answer which makes reference to the following point: <ul style="list-style-type: none"> <li>drying agent</li> </ul>	Allow absorbs water Ignore neutralisation reactions Do not award to react with ether / nitrobenzene Do not award dehydration	1

Question Number	Answer	Additional guidance	Mark
4(g)	An answer which makes reference to the following points: <ul style="list-style-type: none"> <li>suitable heating method</li> <li>ether is highly flammable</li> </ul>	(1) Accept hot water bath / electrical heater Do not award Bunsen burner  (1) Allow ether will catch fire Allow 'it' is highly flammable Do not award reference to the flammability of any other compound  If neither mark is scored, heat to 30-50°C <b>and</b> because ether will evaporate (and phenylamine will remain) scores (1) Ignore 'distilled off' Do not award steam distil	2

Question Number	Answer	Additional guidance	Mark
4(h)	<p>A calculation including:</p> <ul style="list-style-type: none"> <li>• mass of nitrobenzene (1)</li> <li>• moles of nitrobenzene (1)</li> </ul> <p>then:</p> <ul style="list-style-type: none"> <li>• moles of phenylamine for 43% yield (1)</li> <li>• experimental mass of phenylamine (1)</li> </ul> <p>or</p> <ul style="list-style-type: none"> <li>• mass of phenylamine for 100% yield (1)</li> <li>• experimental mass of phenylamine (1)</li> </ul> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin-top: 10px;"> <p>Allow any valid calculation sequence</p> </div>	<p>Example of calculation:</p> <p>mass = <math>1.20 \times 2.1 = 2.52</math> (g)</p> <p>moles = <math>2.52 \div 123.0 = 0.020488 / 2.0488 \times 10^{-2}</math>(mols) TE on M1</p> <p>moles = <math>0.020488 \times 0.43 = 0.0088098 / 8.8098 \times 10^{-3}</math> (mols) TE on M2</p> <p>yield = <math>0.0088098 \times 93.0 = 0.8193 / 0.819 / 0.82 / 0.8</math> (g) TE on M3</p> <p>mass = <math>0.020488 \times 93.0 = 1.9054</math> (g) TE on M2</p> <p>yield = <math>1.9054 \times 0.43 = 0.8193 / 0.819 / 0.82 / 0.8</math> (g) TE on M3</p> <p>Ignore SF in the final answer</p> <p>1.9054 (g) scores M1, M2 and M3  <math>8.8098 \times 10^{-3}</math> (mol) scores M1, M2 and M3            Do not penalise correct intermediate rounding</p>	4

(Total for Question 4 = 16 marks)  
**TOTAL FOR PAPER = 50 MARKS**

