

OCR

Oxford Cambridge and RSA

...day June 20XX – Morning/Afternoon

A Level Chemistry A

H432/02 Synthesis and analytical techniques

SAMPLE MARK SCHEME

Duration: 2 hours 15 minutes

MAXIMUM MARK 100

This document consists of 24 pages

MARKING INSTRUCTIONS**PREPARATION FOR MARKING****SCORIS**

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *scoris assessor Online Training*; *OCR Essential Guide to Marking*.
2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal <http://www.rm.com/support/ca>
3. Log-in to scoris and mark the **required number** of practice responses (“scripts”) and the **required number** of standardisation responses.

YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

MARKING

1. Mark strictly to the mark scheme.
2. Marks awarded must relate directly to the marking criteria.
3. The schedule of dates is very important. It is essential that you meet the scoris 50% and 100% (traditional 50% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.
4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the scoris messaging system.

5. Work crossed out:
- where a candidate crosses out an answer and provides an alternative response, the crossed out response is not marked and gains no marks
 - if a candidate crosses out an answer to a whole question and makes no second attempt, and if the inclusion of the answer does not cause a rubric infringement, the assessor should attempt to mark the crossed out answer and award marks appropriately.
6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen.
7. There is a NR (No Response) option. Award NR (No Response)
- if there is nothing written at all in the answer space
 - OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
 - OR if there is a mark (e.g. a dash, a question mark) which isn't an attempt at the question.
- Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).
8. The scoris **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**
- If you have any questions or comments for your Team Leader, use the phone, the scoris messaging system, or email.
9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by levels of response:

Read through the whole answer from start to finish, concentrating on features that make it a stronger or weaker answer using the indicative scientific content as guidance. The indicative scientific content indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance.

Using a 'best-fit' approach based on the science content of the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, **best** describes the overall quality of the answer using the guidelines described in the level descriptors in the mark scheme.

Once the level is located, award the higher or lower mark.

The higher mark should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met.

The lower mark should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing.

In summary:

- **The science content determines the level.**
- **The communication statement determines the mark within a level.**

Level of response questions on this paper are **20(a)** and **21**.

11. Annotations

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
()	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

12. Subject-specific Marking Instructions

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

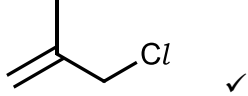
You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

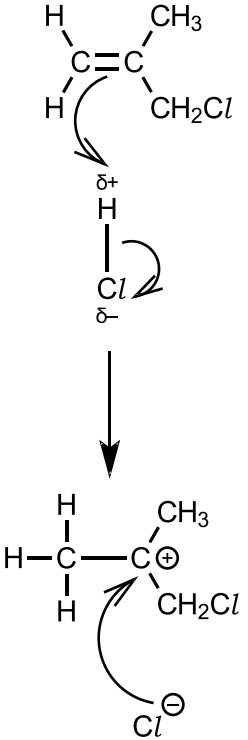
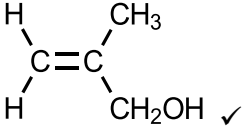
Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

SECTION A

Question	Key	Marks	Guidance
1	B	1	
2	B	1	
3	B	1	
4	D	1	
5	A	1	
6	B	1	
7	B	1	
8	B	1	
9	C	1	
10	B	1	
11	D	1	
12	C	1	
13	A	1	
14	D	1	
15	A	1	
	Total	15	

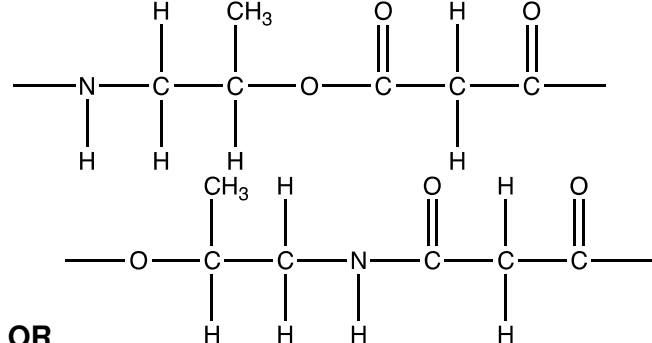
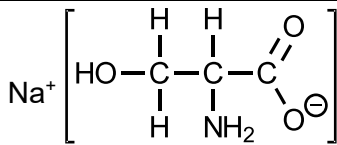
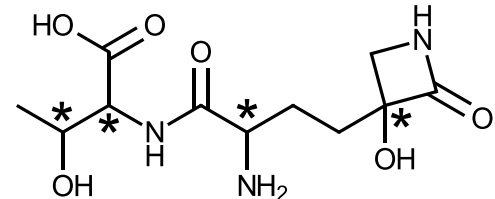
SECTION B

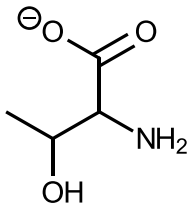
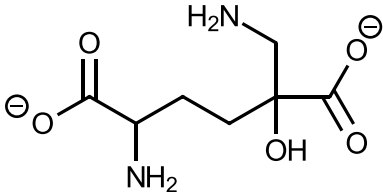
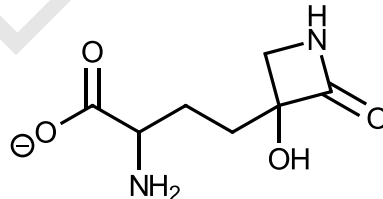
Question		Answer	Marks	Guidance
16	(a) (i)	C_4H_7Cl ✓	1	
	(ii)	 ✓	1	DO NOT ALLOW non-skeletal formulae
	(iii)	(compounds with) the same (molecular) formula AND different structures / structural formulae / arrangement of atoms / displayed formulae ✓	1	ALLOW same number of atoms of each element ALLOW different carbon backbone DO NOT ALLOW different spatial arrangement (of atoms)
	(b)	$n = \frac{pV}{RT} = \frac{(100 \times 10^3) \times (1.053 \times 10^{-3})}{8.314 \times 350}$ ✓ $n = 0.0362 \text{ mol}$ ✓ $M = \frac{m}{n} = \frac{1.321}{0.0362} = 36.5 \text{ (g mol}^{-1}\text{)}$ ✓ <i>Identity</i> HCl ✓	4	
	(c) (i)	From Reaction 1 = $\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{CH}_3 \\ \quad \\ \text{H} \quad \text{CH}_2\text{Cl} \end{array}$ ✓ compound B = $\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{Cl}-\text{C}-\text{C}-\text{CH}_3 \\ \quad \\ \text{H} \quad \text{CH}_2\text{Cl} \end{array}$ ✓	2	ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous

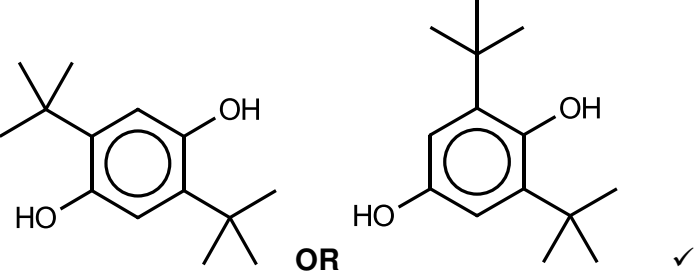
Question	Answer	Marks	Guidance
(ii)	 <p>Curly arrow from C=C to attack the H atom ✓</p> <p>Correct dipole on H—Cl AND curly arrow from bond to Cl ✓</p> <p>Correct carbocation/carbonium ion with full positive charge shown AND correct curly arrow from negative charge of Cl⁻ to correct carbon atom OR correct curly arrow from lone pair of Cl⁻ to correct carbon atom ✓</p>	3	<p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous Curly arrow must start from covalent bonds and not atoms</p> <p>DO NOT ALLOW any other partial charges e.g. shown on double bond</p> <p>DO NOT ALLOW C^{δ+} for charge on carbonium ion. Curly arrow from Cl⁻ can start from the negative charge or the lone pair DO NOT ALLOW delta negative, i.e. Cl^{δ-}</p>
(iii)	<p>because the <u>intermediate/carbocation</u> in the formation of compound B is <u>less stable</u> (than the intermediate in the formation of compound A) ✓</p>	1	
(iv)	 <p>(Formation of) <u>white</u> precipitate/solid/suspension AND (ppt is) silver chloride/AgCl ✓</p>	2	<p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous</p>

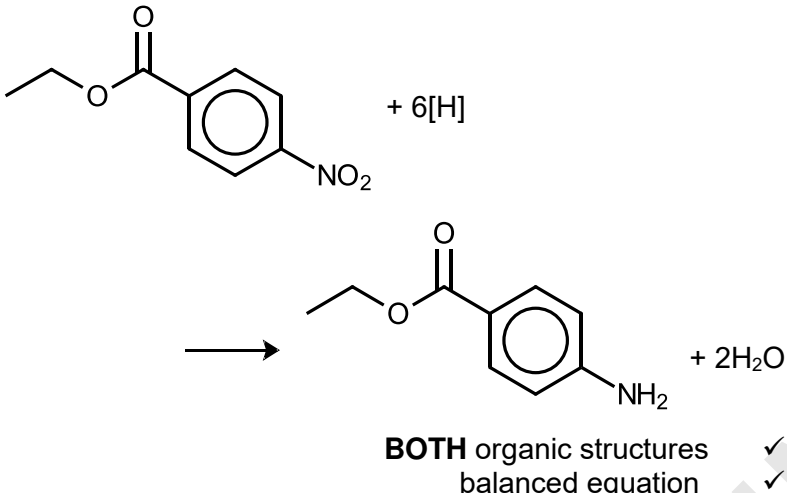
Question	Answer	Marks	Guidance																
(d)	<p>Use of elemental analysis data</p> <table border="1" data-bbox="365 279 904 421"> <thead> <tr> <th></th> <th>C</th> <th>H</th> <th>O</th> </tr> </thead> <tbody> <tr> <td>%</td> <td>46.1</td> <td>7.7</td> <td>46.2</td> </tr> <tr> <td>mol</td> <td>3.84</td> <td>7.7</td> <td>2.89</td> </tr> <tr> <td>ratio</td> <td>1.33</td> <td>2.66</td> <td>1</td> </tr> </tbody> </table> <p>atom ratio with calculation ✓ empirical formula = C₄H₈O₃ ✓</p> <p>IR spectrum (very) <u>broad</u> absorption 2500–3300 cm⁻¹ (COOH) AND absorption 1640–1750 cm⁻¹ (C=O) ✓ absorption 3450 cm⁻¹ (alcohol -OH) ✓</p> <p>Identification</p> <p>conclusion from data: compound contains –COOH and –OH (empirical formula confirms no other C=O than in COOH) in place of the previous chlorine-containing groups</p> $ \begin{array}{c} \text{H} \quad \text{OH} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{CH}_3 \\ \quad \\ \text{H} \quad \text{COOH} \quad \checkmark \end{array} $		C	H	O	%	46.1	7.7	46.2	mol	3.84	7.7	2.89	ratio	1.33	2.66	1	5	<p>ALLOW any values given within ranges given on Data Sheet</p> <p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous</p>
	C	H	O																
%	46.1	7.7	46.2																
mol	3.84	7.7	2.89																
ratio	1.33	2.66	1																
	Total	20																	

Question		Answer	Marks	Guidance
17	(a) (i)	<p>Step 1: add HCN OR H₂SO₄/KCN ✓</p> $\text{CH}_3\text{CHO} + \text{HCN} \rightarrow \text{CH}_3\text{CH}(\text{OH})\text{CN} \quad \checkmark$ <p>Step 2: react with H₂/Ni ✓</p> $\text{CH}_3\text{CH}(\text{OH})\text{CN} + 2\text{H}_2 \rightarrow \text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{NH}_2 \quad \checkmark$	4	<p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous</p> <p>first mark can be implicit from equation</p> <p>third mark can be implicit from equation if Ni shown as catalyst (<i>e.g.</i> above the reaction arrow)</p> <p>ALLOW</p> $\text{CH}_3\text{CH}(\text{OH})\text{CN} + 4[\text{H}] \rightarrow \text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{NH}_2$
	(ii)	<p>because (compound D) forms hydrogen bonds form with water ✓</p> <p>demonstrated through diagram showing:</p> <ul style="list-style-type: none"> - dashed line between —OH and (:)OH₂ ✓ - dashed line between —NH₂ and (:)OH₂ ✓ 	3	<p>dipole and lone pair are not required</p> <p>IGNORE bond angles</p> <p>Diagram does not need to show all of Compound D (and IGNORE if wrong)</p>

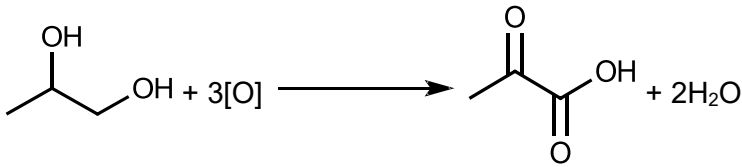
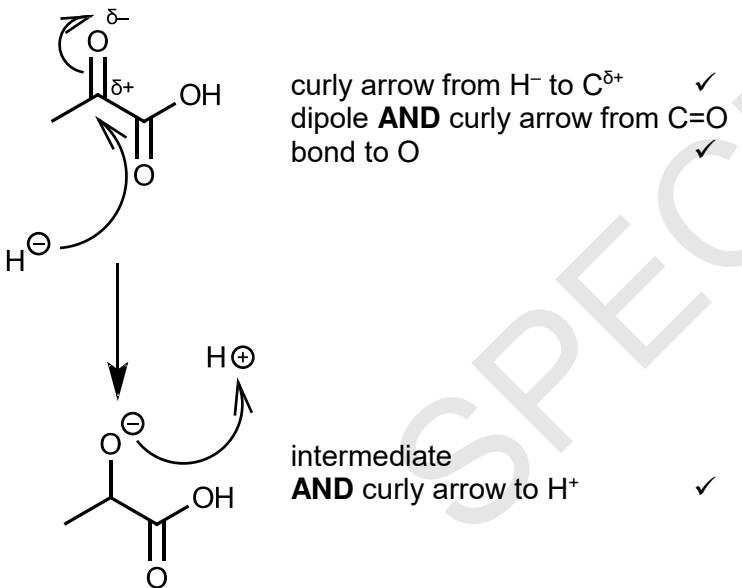
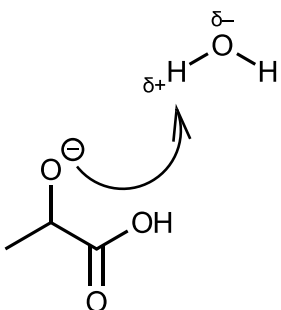
Question	Answer	Marks	Guidance
	<p>(iii)</p>  <p>OR</p> <p>ester AND amide link ✓ rest of structure ✓</p>	2	<p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous 'End bonds' MUST be shown (solid or dotted) IGNORE brackets and/or <i>n</i></p>
(b)	<p>(i)</p> <p>Atom A: 3 bonding pairs AND 1 lone pair ✓ (therefore) pyramidal AND 107° ✓</p> <p>Atom B: 3 bonding centres (and 0 lone pairs) ✓ (therefore) trigonal planar AND 120° ✓</p>	4	<p>ALLOW 106–108°</p> <p>ALLOW 4 bonding pairs but with 1 double/π-bond (therefore 3 bonding centres)</p>
	<p>(ii)</p>  <p>filter solution ✓ recrystallise ✓</p>	3	<p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous</p>
(c)	<p>(i)</p>  <p>✓ for all four</p>	1	

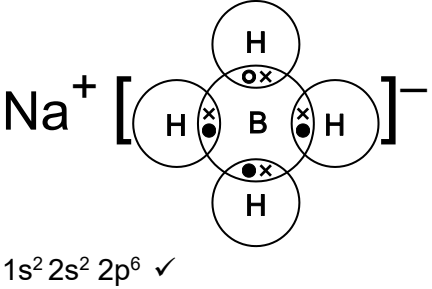
Question	Answer	Marks	Guidance
(ii)	<p>Left-hand fragment</p>  <p>OR structure with COOH rather than COO⁻ ✓</p> <p>Right-hand fragment</p>  <p>OR structure with COOH rather than COO⁻ ✓✓</p> <p>Two OR three COO⁻ shown ✓</p>	4	<p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous</p> <p>ALLOW 1 mark for structure with right-hand ring still intact</p> 
	Total	21	

Question		Answer	Marks	Guidance
18	(a) (i)		1	<p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous</p> <p>ALLOW disubstituted compound with <i>tert</i>-butyl groups adjacent</p>
	(ii)	<p>(The student's friend is correct because)</p> <p>the lone pair of electrons on the oxygen atom(s) ✓</p> <p>is donated to/partially delocalised into the π system ✓</p> <p>making quinol more susceptible to electrophilic attack ✓</p>	3	<p>ALLOW "the oxygen p-orbital overlaps with..."</p> <p>ALLOW diagrammatic answer for 1st and 2nd marks:</p> <p>1st mark: π system OR 6×p orbitals shown</p> <p>2nd mark: O lone pair OR O p-orbital AND interaction</p> <p>ALLOW undergoes electrophilic substitution more easily</p> <p>if 1st and 2nd marks achieved through diagram, conclusion must refer to diagram for 3rd mark</p>
	(b) (i)	step 1 = (conc.) H ₂ SO ₄ AND CH ₃ CH ₂ OH ✓	1	<p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous</p>

Question	Answer	Marks	Guidance
(ii)	 <p>BOTH organic structures ✓ balanced equation ✓</p>	2	ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous
	Total	7	

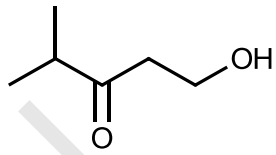
Question	Answer	Marks	Guidance
19 (a) (i)	<p>Product from reaction 1:</p> $\begin{array}{c} \text{H} \\ \\ \text{CH}_3(\text{CH}_2)_2 - \text{C} - \text{COOH} \\ \\ \text{CH}_3\text{COO} \end{array}$ <p style="text-align: right;">✓</p> <p>Product from reaction 2:</p> $\begin{array}{c} \text{Br} \\ \\ \text{CH}_3(\text{CH}_2)_2 - \text{C} - \text{COOH} \\ \\ \text{H} \end{array}$ <p style="text-align: right;">✓</p>	2	<p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous</p>
	(ii) (<i>E</i>)-pent-2-enoic acid ✓	1	ALLOW “ <i>E</i> ” with or without brackets
	<p>(iii)</p> <p>compound H =</p> $\begin{array}{c} \text{CH}_3\text{CH}_2 \quad \text{COOH} \\ \diagdown \quad / \\ \text{C} = \text{C} \\ / \quad \diagdown \\ \text{H} \quad \text{H} \end{array}$ <p style="text-align: right;">✓</p> <p>addition polymer =</p> $\begin{array}{c} \text{CH}_3\text{CH}_2 \quad \text{H} \\ \quad \\ - \text{C} - \text{C} - \\ \quad \\ \text{H} \quad \text{COOH} \end{array}$ <p style="text-align: right;">✓</p>	2	<p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous</p> <p>‘End bonds’ MUST be shown (solid or dotted) IGNORE brackets and/or <i>n</i></p>
	(iv) combustion for energy production ✓ use as an organic feedstock for the production of plastics and other organic chemicals ✓	2	

Question	Answer	Marks	Guidance
(b) (i)	<p>Oxidising agent = acidified (potassium/sodium) dichromate(VI) ✓</p> <p>(Oxidation) equation</p>  <p>(Reduction) mechanism</p>  <p>curly arrow from H⁻ to C^{δ+} ✓ dipole AND curly arrow from C=O ✓ bond to O ✓</p> <p>intermediate AND curly arrow to H⁺ ✓</p>	5	<p>ALLOW Cr₂O₇²⁻ OR K₂Cr₂O₇ OR Na₂Cr₂O₇ for dichromate ALLOW H⁺ OR (conc.) sulfuric acid for “acidified”</p> <p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous</p> <p>ALLOW correct structural OR displayed OR skeletal formulae OR a combination of above as long as unambiguous</p>  <p>ALLOW for second stage IF H₂O is used it MUST show the curly arrow from the intermediate to H^{δ+} in H₂O AND from the O—H bond to the O IGNORE product IGNORE stereochemistry of intermediate</p>

Question	Answer	Marks	Guidance
(ii)	 <p>$1s^2 2s^2 2p^6$ ✓</p>	2	<p>IGNORE inner electron shells for both ions</p> <p>Three different symbols required to identify electrons from different elements</p> <p>DO NOT ALLOW [Ne] OR [He] $2s^2 2p^6$</p>
(c)	<p>$n(\text{NaOH})$ used in titration = $0.150 \times 18.80/1000$ = 0.00282 (mol) ✓</p> <p>$n(\text{H}^+/\text{COOH})$ in 25.0 cm^3 = 0.00282 (mol) AND $n(\text{H}^+/\text{COOH})$ in 250 cm^3 = 0.0282 (mol) ✓</p> <p>'Molar' mass of K = $1.89/0.0282$ = 67.0 g mol^{-1} ✓</p> <p>K must be diprotic ✓</p> <p>K is malic acid/$\text{HOOCCH}_2\text{CHOHCOOH}$ ✓</p>	5	<p>Determined through realisation that none of the compounds listed have $M = 67.0 \text{ g mol}^{-1}$</p>
	Total	19	

Question	Answer	Marks	Guidance
20 (a)*	<p><i>Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.</i></p> <p>Level 3 (5–6 marks) Correctly labelled diagram of apparatus that works, with no safety problems AND Full appreciation of further two steps required to gain pure sample</p> <p><i>There is a well-developed diagram which is clear and structured. The information on further purification is detailed and relevant.</i></p> <p>Level 2 (3–4 marks) Labelled diagram of apparatus but with safety/procedural problems OR clear diagram of functional apparatus without labelling AND Some details of further purification steps</p> <p><i>The diagram presents apparatus that is in the most-part relevant with some correct labelling, and supported by some details of further purification steps.</i></p> <p>Level 1 (1–2 marks) Diagram of apparatus drawn with no labelling OR labelled diagram with significant safety/procedural problems AND Few or imprecise details about further purification stages</p> <p><i>The diagram is basic and unstructured. Any mention of purification steps is limited to generic term, e.g. 'drying', without relevant detail.</i></p>	6	<p>Indicative scientific points may include:</p> <p>Diagram <u>Includes following components:</u> distillation flask heat source thermometer at outlet (bulb level with outlet) still-head water condenser (correct direction of water flow) receiving vessel open system.</p> <p>Further purification Shake and leave to settle in a separating funnel Separate layers by tapping off Add (a small amount of) anhydrous magnesium sulfate/anhydrous calcium chloride to organic layer (in a dry conical flask) (Re)distil the organic layer Collect fraction distilling at (between 150 °C and) 156 °C.</p>

Question		Answer	Marks	Guidance
		<p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks No response or no response worthy of credit.</p>		
	(b)	Lack of (further) effervescence ✓	1	ALLOW fizzing/bubbling stops
	(c)	Take samples from reaction mixture at regular intervals ✓ Spot/run on a TLC plate, alongside cyclohexanol (and cyclohexanone) controls ✓	2	ALLOW "frequent" for "regular" ALLOW measure/compare R_f value to cyclohexanol IGNORE reference to solvent or visualising chemicals/UV
	(d)	React (sample of distillate) with 2,4-dinitrophenylhydrazine ✓ recrystallise AND determine the melting point ✓ Compare melting point to known/library value for cyclohexanone (derivative) ✓	3	ALLOW (2,4-)DNPH/Brady's reagent
		Total	12	

Question	Answer	Marks	Guidance										
21*	<p><i>Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.</i></p> <p>Level 3 (5–6 marks) Structure correct AND Analysed all ^1H NMR signals with at least two supporting statements made.</p> <p><i>The analysis is clear and logically structured. The supporting statements are relevant to the correct structure drawn.</i></p> <p>Level 2 (3–4 marks) Structure has correct molecular formula AND C=O AND OH but in incorrect positions AND Analysed at least three ^1H NMR signals with one or two supporting statements made</p> <p><i>The analysis is presented with some structure. The supporting statements are in the most-part relevant to the structure drawn.</i></p> <p>Level 1 (1–2 marks) Structure has correct molecular formula AND C=O OR OH but in incorrect positions AND Analysed at least two ^1H NMR signals with no or one supporting statements made</p> <p><i>The analysis is basic and communicated in an unstructured way. The relationship of the supporting evidence to the structure may not be clear.</i></p>	6	<p>Indicative scientific points may be included:</p> <p>Structure</p>  <p>L =</p> <p>^1H NMR spectrum</p> <table border="0"> <tr> <td>$\delta = 3.8$ ppm, triplet, 2H</td> <td>$\text{CH}_2\text{—CH}_2\text{—O}$</td> </tr> <tr> <td>$\delta = 3.7$ ppm, singlet, 1H</td> <td>O—H</td> </tr> <tr> <td>$\delta = 3.1$ ppm, triplet, 2H</td> <td>$\text{CH}_2\text{—CH}_2\text{C=O}$</td> </tr> <tr> <td>$\delta = 2.7$ ppm, septet, 1H</td> <td>$(\text{CH}_3)_2\text{CHC=O}$</td> </tr> <tr> <td>$\delta = 1.0$ ppm, doublet, 6H</td> <td>$(\text{CH}_3)_2\text{CH}$</td> </tr> </table> <p>Supporting statements</p> <p>$\delta = 3.7$ ppm lost after D_2O, indicating —OH</p> <p>$\delta = 213$ ppm in ^{13}C NMR but no $\delta = 9\text{--}10$ ppm in ^1H NMR so ketone, not aldehyde</p> <p>$M_r(\text{C}_3\text{H}_6\text{O}) = 58 \quad 116/58 = 2 \rightarrow \text{C}_6\text{H}_{12}\text{O}_2$</p>	$\delta = 3.8$ ppm, triplet, 2H	$\text{CH}_2\text{—CH}_2\text{—O}$	$\delta = 3.7$ ppm, singlet, 1H	O—H	$\delta = 3.1$ ppm, triplet, 2H	$\text{CH}_2\text{—CH}_2\text{C=O}$	$\delta = 2.7$ ppm, septet, 1H	$(\text{CH}_3)_2\text{CHC=O}$	$\delta = 1.0$ ppm, doublet, 6H	$(\text{CH}_3)_2\text{CH}$
$\delta = 3.8$ ppm, triplet, 2H	$\text{CH}_2\text{—CH}_2\text{—O}$												
$\delta = 3.7$ ppm, singlet, 1H	O—H												
$\delta = 3.1$ ppm, triplet, 2H	$\text{CH}_2\text{—CH}_2\text{C=O}$												
$\delta = 2.7$ ppm, septet, 1H	$(\text{CH}_3)_2\text{CHC=O}$												
$\delta = 1.0$ ppm, doublet, 6H	$(\text{CH}_3)_2\text{CH}$												

Question	Answer	Marks	Guidance
	<p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks No response or no response worthy of credit.</p>		
	Total	6	

Summary of updates

Date	Version	Change
January 2019	2.0	Minor accessibility changes to the paper: i) Additional answer lines linked to Level of Response questions ii) One addition to the rubric clarifying the general rule that working should be shown for any calculation questions

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