OCR
Oxford Cambridge and RSA

GCE

Chemistry A

H432/03: Unified chemistry

A Level

Mark Scheme for June 2022

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

MARKING INSTRUCTIONS

PREPARATION FOR MARKING

RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM 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.
3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

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 RM Assessor 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 RM Assessor messaging system.
5. Work crossed out:

   Crossed Out Responses
   Where a candidate has crossed out a response and provided a clear alternative then the crossed out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed out response where legible.

Rubric Error Responses – Optional Questions
Where candidates have a choice of question across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. Enter a mark for each question answered into RM assessor, which will select the highest mark from those awarded. *(The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)*

Multiple Choice Question Responses
When a multiple choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).
When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses
When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only **one mark per response**)
Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. *(The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)*

Short Answer Questions (requiring a more developed response, worth **two or more marks**)
If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space.)

Longer Answer Questions (requiring a developed response)
Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

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. Award No Response (NR) if:

- there is nothing written in the answer space.

Award Zero '0' if:

- anything is written in the answer space and is not worthy of credit (this includes text and symbols).

Team Leaders must confirm the correct use of the NR button with their markers before live marking commences and should check this when reviewing scripts.

8. The RM Assessor **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 RM Assessor 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, using the Level descriptors to help you decide whether it is a strong or weak answer. The indicative scientific content in the Guidance column 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 skills and science content evidenced within the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer.

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 skills and science content determines the level.

The communication statement determines the mark within a level.

Level of response questions on this paper are **3a** and **5a.**

The only annotation on a level of response question should be the indication of the level.

A level annotation should be used where all marks for a level have been achieved e.g. a candidate has 6 marks, so they would have this annotation on their script:

If a candidate has achieved 5 marks then they have reached Level 3 but with one mark omitted. They should have the following annotations on their scripts:

The same principle should be applied to Level 2 and Level 1.

No marks (0) should have a cross: 

Place the annotations alongside the mark for the question.

On additional pages, annotate using 

11. Annotations available in RM Assessor

Annotation	Meaning
	Correct response
	Incorrect response
	Omission mark
BOD	Benefit of doubt given
CON	Contradiction
RE	Rounding error
SF	Error in number of significant figures
ECF	Error carried forward
L1	Level 1
L2	Level 2
L3	Level 3
NBOD	Benefit of doubt not given
SEEN	Noted but no credit given
I	Ignore

12. Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

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

13. **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.

Question			Answer	Marks	AO element	Guidance
1	(a)	(i)	**Structure and bonding** NH_3 is (simple) molecular/simple covalent/ /has intermolecular forces **AND** NH_4NO_3 is ionic ✓ **Comparison of strength** Ionic bonds are stronger than intermolecular bonds / forces between molecules **OR** Ionic bonds need more energy to break than intermolecular bonds ✓	**2**	AO1.1 ×2	For intermolecular bonds/forces **ALLOW** hydrogen bonds **OR** London Forces/induced dipole forces/permanent dipole forces **OR** van der Waals' forces **ALLOW** NH_4NO_3 has molecular **ions** *NH_4^+ and NO_3^- are molecular ions* **ORA** **ALLOW:** Intermolecular bonds are weak **AND** ionic bonds are strong ✓
		(ii)	(NH_4^+) nitrogen has oxidation number of –3 **AND** (NO_3^-) nitrogen has oxidation number of +5 ✓ *i.e. nitrogens are –3 **AND** +5 gets the mark* ***BOTH** signs essential*	**1**	AO1.2	Statement that one student is correct is **NOT** required. *Implicit in answer* **ALLOW** 3– **AND** 5+

Question			Answer	Marks	AO element	Guidance
	(b)	(i)	Cu: 66% **AND** Zn 34% ✓	1	AO2.6	
		(ii)	**FIRST CHECK ANSWER ON THE ANSWER LINE** **If answer = 65.42 (to 2 DP) award 2 marks** --- **Numerator from Zn isotopes** $(64 \times 16.82) + (66 \times 9.53) + (67 \times 1.38) + (68 \times 6.27)$ **OR** 2224.28 ✓ **Relative atomic mass** Numerator ÷ 34 **AND** answer to 2 DP ✓ *Mark **ECF** from numerator* $\frac{(64 \times 16.82) + (66 \times 9.53) + (67 \times 1.38) + (68 \times 6.27)}{34}$ ✓ = 65.42 (to 2 DP) ✓	2	AO1.2 ×2	**Refer to answer to 1b(i) for ECF from incorrect % composition of Zn and Cu** **ECF** ÷ by Zn % in **b(i)** --- **Common errors** 22.24 ÷100 and answer to 2 DP → *1 mark for numerator* 64.23 All 6 isotopes used → No marks 188.91 All 6 isotopes used → 6423 for numerator ÷34 and 2 DP → 1 mark by ECF

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AO element</th><th>Guidance</th></tr>
<tr><td></td><td>(c)</td><td>(i)</td><td>
<table>
<tr><th>Proton environment</th><th>Splitting pattern</th><th></th></tr>
<tr><td>1</td><td>Triplet</td><td rowspan="2">Triplet
AND
quartet ✓</td></tr>
<tr><td>2</td><td>Quartet</td></tr>
<tr><td>3</td><td>Doublet</td><td rowspan="2">Doublet
AND
triplet ✓</td></tr>
<tr><td>4</td><td>Triplet</td></tr>
</table>
</td><td>2</td><td>AO1.2
×2</td><td>For quartet,
ALLOW Quad….
e.g. quadruplet, quadlet, quadret, etc

For doublet, ALLOW duplet

ALLOW diagrams to show splitting pattern
e.g.
  for triplet  for quartet

ALLOW splitting patterns shown as numbers
i.e. ‘3’ for triplet, ‘4’ for quartet</td></tr>
<tr><td></td><td>(c)</td><td>(ii)</td><td>Environment 2:
(Protons) adjacent to (one) C=O ✓

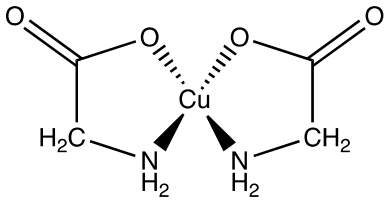
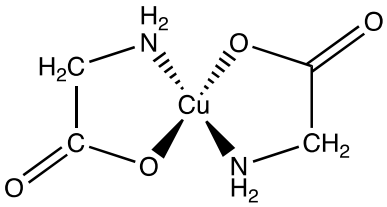
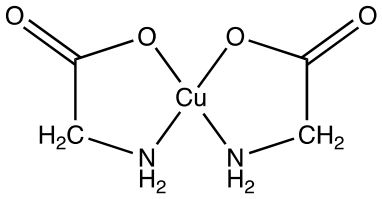
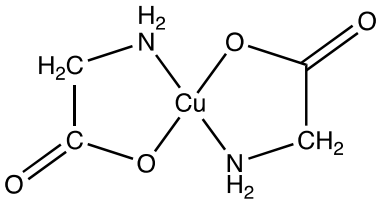
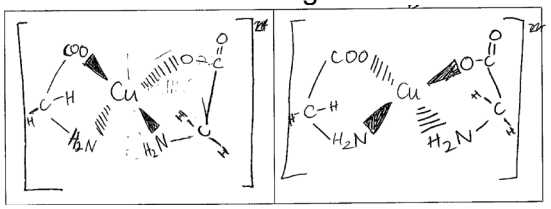
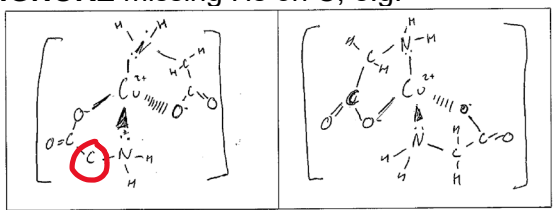
Environment 3:
(Protons) adjacent/between/surrounded by
2 C=O / a ketone AND aldehyde
OR
C=O on both sides ✓</td><td>2</td><td>AO3.1
×2</td><td>ALLOW HC–C=O

DO NOT ALLOW H–C=O

DO NOT ALLOW HC–O
Simply reading δ = 3.6 ppm from data sheet)

IGNORE ‘next to 2 Os’</td></tr>
</table>

Question			Answer	Marks	AO element	Guidance
	(d)	(i)	***Bond angles*** H_2NCH_2COONa, bond angle = 107º **AND** $HOOCCH_2NH_3Cl$, bond angle = 109.5º ✓ ***Number of electron pairs*** ***Mark independently of angles*** In NaOH/107º, (NH_2 has) **3** bonded pairs **/ 3** bonds **AND** **1** lone pair ✓ In HCl/109.5º, (NH_3^+ has) **4** bonded pairs / **4** bonds ✓	**3**	AO1.2 ×3	**ALLOW** 107 ± 0.5 **ALLOW** 109 **OR** 110º **ALLOW** NH_2 has **4** pairs, one of which is a lone pair **For bonded pairs/bonds** **ALLOW bonded** groups, atoms, elements, regions ***Bonded** essential* **IGNORE** electron region **OR** electron density **IGNORE** NH_3 has no lone pairs **IGNORE** lone pairs repel more (than bonded pairs) **IGNORE** shapes, even if wrong **ALLOW** bp for bonded pair and lp for lone pair
		(ii)	**Equation:** **2** $H_2NCH_2COOH + Cu(CH_3COO)_2$ $\rightarrow Cu(H_2NCH_2COO)_2$ + **2** CH_3COOH ✓	**3**	AO2.6	**ALLOW** molecular formulae or mixture, e.g. $2C_2H_5NO_2 + CuC_4H_6O_4$ $\rightarrow CuC_4H_8N_2O_4 + 2C_2H_4O_2$ **IGNORE** charges

Question	Answer	Marks	AO element	Guidance
	Structures  ✓  ✓ **OR**  ✓  ✓ Ligands **must** shown as bidentate rings **IGNORE** connectivity for NH_2 **BUT** connectivity **must** be to O of COO		AO2.5 ×2	**i.e. IGNORE** wrong or missing charges in ionic compounds if formula is correct/ e.g. **ALLOW** $Cu(CH_3COO^-)_2$, $Cu^+(CH_3COO^-)_2$ **ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **IGNORE** charges **ALLOW** arc to represent $–CH_2–$ between: C of C=O and NH_2 **ALLOW** 1 mark for 2 'correct' structures shown as tetrahedral e.g.  **IGNORE** missing Hs on C, e.g. 

Question			Answer	Marks	AO element	Guidance
2	(a)	(i)	**FIRST CHECK ANSWER ON THE ANSWER LINE** **If answer = 2.19×10^{-3} award 3 marks** **----------** ***n*(C*l*$_2$)** = 420/24 = 17.5 (mol) ✓ ***n*(Ca(C*l*O)$_2$)** = $\frac{17.5}{2}$ = 8.75 (mol) ✓ **Concentration Ca(C*l*O)$_2$** = $\frac{8.75}{4 \times 1000}$ = **2.19×10^{-3}** (mol dm^{-3}) ✓ **3SF AND standard form**	**3**	AO2.2 ×3	Use of ideal gas equation for all 3 marks provided 'sensible' *p* and *T* used: e.g. from 101 kPa and 298 K $\rightarrow n = 17.122 \rightarrow 2.14 \times 10^{-3}$ from 100 kPa and 298 K $\rightarrow n = 16.952 \rightarrow 2.12 \times 10^{-3}$ Examples of 'sensible' *p* = 100 kPa, 101 kPa, 101,325 Pa *T* = 273 – 298 K **ALLOW ECF** **----------** **Common errors** 4.38×10^{-3} (no ÷ 2) $\rightarrow$ 2 marks $2.19 \times 10^{n} \rightarrow$ 2 marks $4.38 \times 10^{n} \rightarrow$ 1 mark $2.2 \times 10^{-3} \rightarrow$ 2 marks *not appropriate SF*

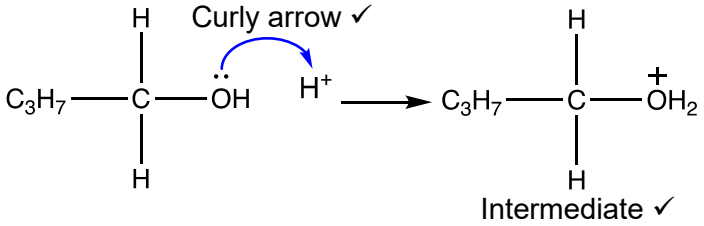
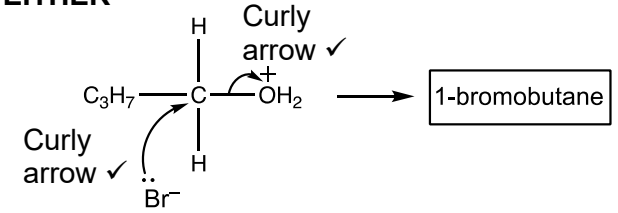
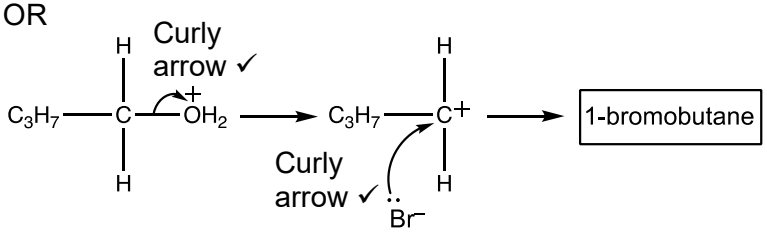
Question			Answer	Marks	AO element	Guidance
		(ii)	**Equation** 3 $Ca(ClO)_2 \rightarrow 2\ CaCl_2 + Ca(ClO_3)_2$ ✓ **Reduction** C*l* reduced from +1 to –1 ✓ **Oxidation** C*l* oxidised from +1 to +5 ✓ *+1 starting oxidation number seen once* *Cl required for both explanation marks* **IGNORE** oxidation numbers shown below/above equation *(treat as rough working)* **BUT** If **no** oxidation numbers in explanation*, look at equation for oxidation numbers*	**3**	AO2.6 AO1.2 ×2	**ALLOW** multiples **ALLOW** 3 $ClO^- \rightarrow 2\ Cl^- + ClO_3^-$ **ALLOW** 1 out of 2 redox marks if oxidation number changes are **BOTH** correct …**BUT** reduction/oxidation is incorrectly assigned, i.e. C*l* is oxidised from +1 to –1 C*l* is reduced from +1 to +5 **ALLOW** 1 out of 2 redox marks if oxidation changes correct but red and ox not stated C*l* **changes** from +1 to –1 C*l* **changes** from +1 to +5 **----------** **General:** **ALLOW number before sign in ox no, e.g.** 1– for –1 **IGNORE** ionic charges, e.g. Cl^{5+} **IGNORE** '1' (signs required) **IGNORE** references to electron loss/gain (even if wrong)

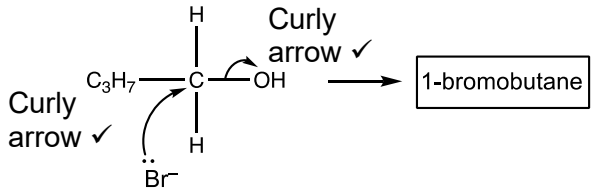
Question	Answer	Marks	AO element	Guidance
(b)	**6 marking points → 5 MAX** --- **ALLOW** labels **1**, **2** and **3**; **A**, **B** and **C**, etc, provided that meaning is clear --- ***Oxidising agent AND equation*** $Cr_2O_7^{2-}$ is oxidising agent with C_2H_5OH /oxidises C_2H_5OH ✓ $Cr_2O_7^{2-} + 8H^+ + 3C_2H_5OH \rightarrow 2Cr^{3+} + 7H_2O + 3CH_3CHO$ ✓ **Explanation for $Cr_2O_7^{2-}/Cr^{3+}$ and CH_3CHO/C_2H_5OH** *E* for $Cr_2O_7^{2-}/Cr^{3+}$ is **more** +ve /higher /greater **OR** E_{cell} = (+)1.527 V + *sign not required* **OR** $Cr_2O_7^{2-}/Cr^{3+}$ equilibrium shifts right ✓ ***Reducing agent AND equation*** Cr^{3+} is reducing agent with FeO_4^{2-} /reduces FeO_4^{2-} ✓ $2Cr^{3+} + 2H^+ + 2FeO_4^{2-} \rightarrow Cr_2O_7^{2-} + H_2O + 2Fe^{3+}$ ✓ **Explanation for $Cr_2O_7^{2-}/Cr^{3+}$ and FeO_4^{2-}/Fe^{3+}** *E* for $Cr_2O_7^{2-}/Cr^{3+}$ is **less** +ve (*E*) / lower /smaller **OR** E_{cell} = (+)0.87 V + *sign not required* **OR** $Cr_2O_7^{2-}/Cr^{3+}$ equilibrium shifts left ✓	**5** AO2.5 AO2.6 AO2.6 AO2.5 AO2.6 AO2.6	**ALLOW** reverse argument **(ORA)** throughout For equations, **ALLOW** multiples In equations, **ALLOW** ⇌ for → **ALLOW** $Cr_2O_7^{2-}$ is oxidising agent if linked to C_2H_5OH as reactant in equation **ALLOW** Cr^{6+} for $Cr_2O_7^{2-}$ **ALLOW** $Cr_2O_7^{2-}$ is reduced by C_2H_5OH In explanation, look for **CON**s between '**OR**' statements **ALLOW** Cr^{3+} is reducing agent if clearly linked to FeO_4^{2-} as reactant in equation **ALLOW** Fe^{6+} for FeO_4^{2-} **ALLOW** Cr^{3+} is oxidised by FeO_4^{2-} In explanation, look for **CON**s between '**OR**' statements ---

Question			Answer	Marks	AO element	Guidance
						Note on equations There are 2 marks for the equations with H^+, H_2O and e^- cancelled down **ALLOW** 1 mark for 2 'correct' equations where H^+, H_2O and e^- have **NOT** all been cancelled down. *e.g. 1 mark from 2 uncancelled equations* $Cr_2O_7^{2-} + 14H^+ + 3C_2H_5OH \rightarrow 2Cr^{3+} + 6H^+ + 7H_2O + 3CH_3CHO$ $2Cr^{3+} + 2H^+ + 2FeO_4^{2-} + 6e^- \rightarrow Cr_2O_7^{2-} + H_2O + 2Fe^{3+} + 6e^-$
	(c)		$5\ H_2S + 2\ MnO_4^- + 6\ H^+ \rightarrow 2\ Mn^{2+} + 5\ S + 8\ H_2O$ **OR** $40\ H_2S + 16\ MnO_4^- + 48\ H^+ \rightarrow 16\ Mn^{2+} + 5\ S_8 + 64\ H_2O$ Any **FIVE** correct species ✓ Correct balanced equation ✓	**2**	AO3.2	**ALLOW** multiples e.g. $2½\ H_2S + MnO_4^- + 3\ H^+ \rightarrow Mn^{2+} + 2½\ S + 4\ H_2O$ $20\ H_2S + 8\ MnO_4^- + 24\ H^+ \rightarrow 8\ Mn^{2+} + 2½\ S_8 + 32\ H_2O$ **IGNORE** extra species containing: Mn, H, S and O **ONLY** **BUT ALLOW** $KMnO_4$ on LHS, forming K^+ on RHS **IGNORE** electrons **IGNORE** state symbols

Question			Answer	Marks	AO element	Guidance
3	(a)*		*Refer to marking instructions on page 4 of mark scheme for guidance on marking this question.* **Level 3 (5-6 marks)** Diagram showing reflux with most labels **AND** A **CORRECT** calculation of the % yield of 1-bromobutane **AND** A **detailed** description of most purification steps. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3-4 marks)** Diagram showing reflux with some labels **AND** Calculates the % yield of 1-bromobutane with some errors **OR** Diagram showing reflux with most labels **AND** describes some purification steps, with some detail **OR** Calculates the % yield of 1-bromobutane with some errors **AND** describes some purification steps, with some detail *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.*	**6**	AO2.8 ×2 AO3.3 ×4	**Indicative scientific points may include:** **Diagram** Diagram draw with condenser above flask Labels including • condenser • water in at bottom and out at top • pear-shaped or round-bottom flask **Calculation of % yield of 1-bromobutane** • n(butan-1-ol) = $\frac{9.25}{74.0}$ = 0.125 (mol) • mass 1-bromobutane = 6.10 × 1.268 = 7.7348 g • n(1-bromobutane) = $\frac{7.7348}{136.9}$ = 0.0565 (mol) • % yield = $\frac{0.0565}{0.125}$ × 100 = 45.2% **ALLOW** 45.2 ± 0.2 for small slip/rounding --- **NOTE Use of 6.1 g (omission of density)** • n(1-bromobutane) = $\frac{6.10}{136.9}$ = 0.044558… (mol) • % yield = $\frac{0.044558\ldots}{0.125}$ × 100 = 35.6% **Purification** • In separating funnel, **organic layer is on bottom** • Drying with an **anhydrous salt by formula or name**, e.g. $MgSO_4$, Na_2SO_4, $CaCl_2$ • Redistil **at 102ºC** **Examples** of detail in **bold** (**NOT INCLUSIVE**) **NOTE**: 'Use a separating funnel', dry, and 'redistil' on their own are **NOT** detailed descriptions

Question			Answer	Marks	AO element	Guidance
			Level 1 (1-2 marks) Diagram showing reflux **OR** Attempts to calculate the % yield of 1-bromobutane **OR** Describes few purification steps. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** No response or no response worthy of credit.			

Question	Answer	Marks	AO element	Guidance
(b)	**Step 1** The oxygen atom of the alcohol group accepts a proton to form a positively-charged intermediate. ***2 marks***  **Step 2** Bromide ions react with the intermediate by nucleophilic substitution to form 1-bromobutane. ***2 marks*** *2 possible routes:* **EITHER**  OR 	**4**	AO3.2 ×4	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous For $CH_3CH_2CH_2$, **ALLOW** $CH_3(CH_2)_2$, C_3H_7 **IGNORE** dipoles --- **ALLOW** curly arrow to H of H–O–SO_3H **OR** H–Br **IGNORE** absence of curly arrow from H–O or from H–Br + charge **MUST** be on O of intermediate **Curly arrow** must • start from, **OR** be traced back to **any point across width** of lone pair on :Br^- **OR** :OH **OR** start from – charge on Br^- *(Lone pair **NOT** needed if curly arrow shown from – charge on Br^-)* **IGNORE** final products: 1-bromobutane and H_2O **IF** $C_3H_7CH_2–O^+H_2$ is **not** shown, **ALLOW** intermediate mark for carbocation: $C_3H_7CH_2^+$

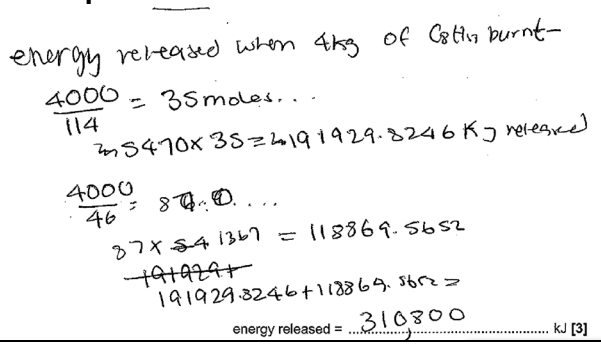
Question			Answer	Marks	AO element	Guidance
						ALLOW 2 marks max for mechanism without positively charge intermediate, i.e.  **If in doubt, contact Team Leader**

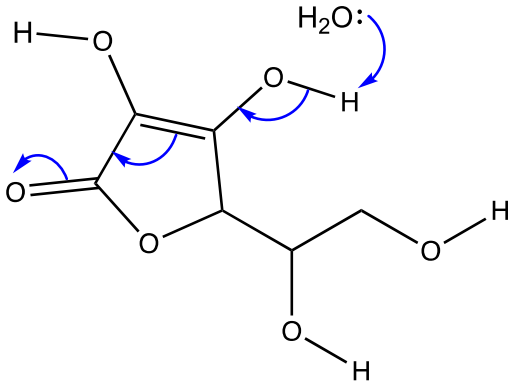
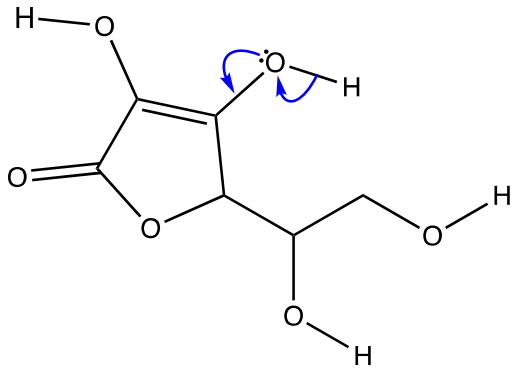
Question			Answer	Marks	AO element	Guidance
4	(a)		**At 90 ºC**/higher temperature • Faster rate **AND** more frequent collisions ✓ • More particles have the activation energy/E_a or greater ✓ • $[Co(H_2O)_6]^{2+}$ is lower ✓ • (forward reaction) ΔH –ve **OR** exothermic ✓	4	AO2.7 ×1 AO1.2 ×1 AO2.3 ×1 AO1.2 ×1	**ORA for 50 ºC** **IGNORE** more successful collisions **ALLOW** more molecules have enough energy to react **ALLOW** atoms/molecules/ions **ALLOW** decreases
	(b)	(i)	Cl^- /It/They react with $AgNO_3$ / Ag^+ /silver ions **OR** AgC*l* formed **OR** $Ag^+ + Cl^- \rightarrow AgCl$ ✓	1	AO3.2	**IGNORE** chlorine/C*l* for chloride ion **IGNORE** $AgCl_2$

Question			Answer	Marks	AO element	Guidance
		(ii)	$[CoCl_4^{2-}]$ decreases **AND** $[Co(H_2O)_6]^{2+}$ increases ✓	3	AO3.1 ×2	**IGNORE** missing charges and small slips in formulae, e.g. $CoCl_4$ missing bracket, etc
			Cl^- increase is 4 × change in $[CoCl_4^{2-}]$ / $[Co(H_2O)_6]^{2+}$ ✓			**IGNORE** Cl^- for changes in concentration
			Equilibrium shifts to right ✓		AO3.2 ×1	**ALLOW** suitable alternatives for 'shifts to right', e.g. towards products **OR** in forward direction **OR** 'favours the right'

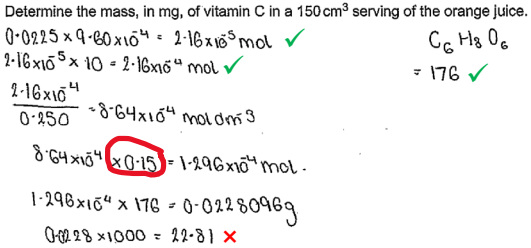
Question			Answer	Marks	AO element	Guidance
5	(a)*		*Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Calculates **correct** enthalpy change with correct – sign for $\Delta_{hy}H$ (Ca^{2+}), allowing for acceptable errors. *There is a well-developed line of reasoning which is clear and logically structured.* *The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Calculates a value of $\Delta_{sol}H$ ($CaCl_2$(s)) from the: Energy change **AND** Amount in mol of $CaCl_2$. *There is a line of reasoning presented with some structure.* *The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Processes experimental data to obtain the: Energy change from $mc\Delta T$ **OR** Amount in mol of $CaCl_2$. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks –** No response or no response worthy of credit.	**6**	AO3.1 ×4 AO3.2 ×2	*Indicative scientific points may include:* **1. Processing experimental data** **Energy change from $mc\Delta T$** • Energy in J **OR** kJ = **106.6** × 4.18 × **18.5** = 8243.378 (J) **OR** 8.243378 (kJ) *3SF or more* **Amount in mol of $CaCl_2$** • $n(CaCl_2) = \frac{9.28}{111.1}$ = 0.0835…….. (mol) 0.08352835284 unrounded --- **2. ± value of $\Delta_{sol}H(CaCl_2(s))$** $= \pm \frac{8.24…..}{0.0835….}$ = **±** 98.68957929 (kJ mol^{-1}) *3 SF or more.* From 3 SF: $\frac{8.24}{0.0835}$ = 98.7 --- **3. CORRECT $\Delta_{hy}H(Ca^{2+})$ calculated with signs** $\Delta_{hy}H(Ca^{2+})$ = L.E. + $\Delta_{sol}H(CaCl_2)$ – 2 $\Delta_{hy}H(Cl^-)$ = –2223 + (–98.7) – (2 × –378) = **–1566** (kJ mol^{-1}) *3SF or more with correct – sign* From unrounded values, –1565.689579 --- **See next page for examples of acceptable errors**

Question			Answer	Marks	AO element	Guidance
						Acceptable errors **ALLOW** omission of trailing zeroes **ALLOW** minor slips in rounding, transcription errors, etc throughout **ALLOW** one small error, e.g. subtracting mass of $CaCl_2$ for m m = 106.60 – 9.28 = 97.32 q = 7.5257556 (kJ) $\Delta_{sol}H$ = 90.09821629 (kJ mol^{-1}) $\Delta_{hy}H(Ca^{2+})$ = –1557 (kJ mol^{-1}) **OR** adding mass of $CaCl_2$ for m m = 106.60 + 9.28 = 115.88 q = 8.9610004 kJ $\Delta_{sol}H$ = 107.2809423 (kJ mol^{-1}) $\Delta_{hy}H(Ca^{2+})$ = –1574 (kJ mol^{-1})
	(b)	**(i)**	$C_8H_{18} + C_2H_5OH + 15½\ O_2 \rightarrow 10\ CO_2 + 12\ H_2O$ ✓	**1**	AO2.6	**ALLOW** multiples e.g. $2\ C_8H_{18} + 2\ C_2H_5OH + 31\ O_2 \rightarrow 20\ CO_2 + 24\ H_2O$ **ALLOW** $C_{10}H_{24}O$ for $C_8H_{18} + C_2H_5OH$ *Combining ethanol and octane!*

Question			Answer	Marks	AO element	Guidance
		(ii)	**FIRST CHECK ANSWER ON THE ANSWER LINE** **If answer = 341850 to 2 SF or more award 3 marks** --- $M(C_8H_{18})$ = 114 **AND** $M(C_2H_5OH)$ = 46 **OR** 1 mol C_8H_{18} + 1 mol C_2H_5OH has mass of 160 g ✓ 50 mol C_8H_{18} **OR** 50 mol C_2H_5OH **OR** 50 mol (C_8H_{18} + C_2H_5OH) **OR** 8.00 kg fuel contains 50 mol C_8H_{18} + 50 mol C_2H_5OH ✓ Energy = (50 × 5470) + (50 × 1367) **OR** 50 × (5470 + 1367) **OR** 50 × 6837 **OR** 273500 + 68350 **= 341850 (kJ)** ✓	**3**	AO2.2 ×3	**IGNORE** sign throughout **ALLOW** approach based on mass for 2nd mark $m(C_8H_{18})$ = (114/160) × 8000 = 5700 g **AND** $m(C_2H_5OH)$ = (46/160) × 8000 = 2300 g Energy = 5700/114 × 5470 + 2300/46 × 1367 = 341850 (kJ) **ALLOW 2 SF or more** correctly rounded --- **Common errors** **310800 → 2 marks** *Use of equal masses (4 kg) of C_8H_{18} & C_2H_5OH (rather than equal moles)* **Example**  energy released = 310800 kJ [3]

Question			Answer	Marks	AO element	Guidance
6	(a)		Number of optical isomers = 4 ✓	1	AO2.1	
	(b)	(i)	Hydrogen bonding **AND** **Many** OH/hydroxyl / hydroxy / alcohol ✓	1	AO2.1	**ALLOW** 4 OH **DO NOT ALLOW** OH^-
		(ii)	x = 15 ✓ y = 31 ✓	2	AO3.2 ×2	
	(c)	(i)	 3 **OR** 4 curly arrows correct → 2 marks ✓✓ 1 curly arrow correct → 1 mark ✓	2	AO3.2 ×2	**IGNORE incorrect curly arrows** **IGNORE** 'double' curly arrows such as:  **H_2O Curly arrow** must • start from, **OR** be traced back to **any point across width** of lone pair on H_2O**:**

Question			Answer	Marks	AO element	Guidance
		(ii)	**FIRST CHECK ANSWER ON THE ANSWER LINE** **If answer = 2.16 award 3 marks** --- [Vitamin C] = 0.150 × 4 = 0.600 (mol dm^{-3}) ✓ *0.6 seen anywhere* $[H^+]$ = √ (K_a × [Vitamin C]) = √ ($7.94 \times 10^{-5} \times 0.600$) = 6.90×10^{-3} (mol dm^{-3}) ✓ pH = –log $[H^+]$ = –log 6.90×10^{-3} = 2.16 ✓ **2 DP required**	**3**	AO2.4 ×2 AO1.2 ×1	**For $[H^+]$** **ALLOW ECF** from incorrect [vitamin C] for pH **ALLOW ECF ONLY** if $[H^+]$ has been derived from K_a **AND** [vitamin C] --- **COMMON ERRORS** pH = 4.32 2/3 calculation marks *No square root of* ($7.94 \times 10^{-5} \times 0.600$) pH = 2.46 2/3 calculation marks *No × 4* ($7.94 \times 10^{-5} \times 0.150$) pH = 2.76 2/3 calculation marks *÷ 4* ($7.94 \times 10^{-5} \times 0.0375$) pH = 4.92 1/3 calculation mark *No square root AND 0.150* pH = 5.53 1/3 calculation mark *No square root AND 0.0375*

Question	Answer	Marks	AO element	Guidance
(d)	**FIRST CHECK ANSWER ON THE ANSWER LINE** **If answer = 38 (mg) award 4 marks** --- $n(I_2) = 22.50 \times \frac{9.60 \times 10^{-4}}{1000} = 2.16 \times 10^{-5}$ (mol) ✓ n(vitamin C) in 250 cm^3 volumetric flask $= 10 \times 2.16 \times 10^{-5} = 2.16 \times 10^{-4}$ (mol) ✓ M(Vitamin C: $C_6H_8O_6$) = 176 **OR** $(12 \times 6) + (1 \times 8) + (16 \times 6)$ *Seen anywhere* Mass vitamin C in 150 cm^3 of orange $= 2.16 \times 10^{-4} \times 176.0$ = 0.038016 g = 38 (**mg**) ✓ ***2 SF or more***	**4**	AO2.8 ×4	**Use ECF throughout** Intermediate values for working to **at least 3 SF.** **TAKE CARE** as value written down may be truncated value stored in calculator. Depending on rounding, either can be credited. --- **COMMON ERRORS:** **22.81 mg scaling by 150/250 → 3 marks** **FINAL MARK LOST BY SCALING**  Determine the mass, in mg, of vitamin C in a 150 cm^3 serving of the orange juice. $0.0225 \times 9.60 \times 10^{-4} = 2.16 \times 10^{-5}$ mol ✓ $2.16 \times 10^{-5} \times 10 = 2.16 \times 10^{-4}$ mol ✓ $\frac{2.16 \times 10^{-4}}{0.250} = 8.64 \times 10^{-4}$ mol dm^{-3} $8.64 \times 10^{-4} \times 0.15 = 1.296 \times 10^{-4}$ mol. $1.298 \times 10^{-4} \times 176 = 0.02280960$ g $0.0228 \times 1000 = 22.81$ × $C_6H_8O_6$ = 176 ✓ **42.24 mg** using 25.0 cm^3 instead of 22.50 → 3 marks **25.34 mg** using 25.0 cm^3 **AND** scaling by 150/250 instead of 22.50 → 2 marks **63.36 mg** scaling by 250/150 → 3 marks

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