



GCE

Chemistry A

H432/03: Unified chemistry

A Level

Mark Scheme for June 2025

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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.

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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. 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. 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 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 **3(b)* and Q6***.

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:

L3

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:

L3 

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

No marks (0) should have a cross: 

On additional pages, annotate using 

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11. Annotations available in RM Assessor

Annotation	Meaning
	Correct response
	Incorrect response
	Omission mark
	Benefit of doubt given
	Contradiction
	Rounding error
	Error in number of significant figures
	Error carried forward
	Level 1
	Level 2
	Level 3
	Benefit of doubt not given
	Noted but no credit given
	Ignore

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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

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.

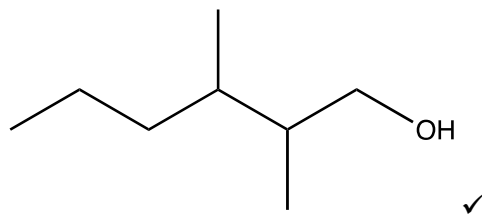
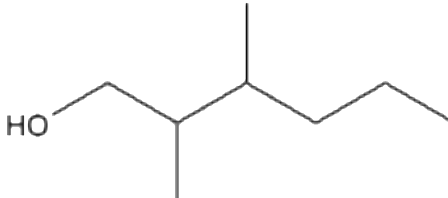
Question			Answer	Marks	Guidance												
1	(a)	(i)		2													
			<table><tr><th><i>m/z</i></th><th>Number of protons</th><th>Number of neutrons</th><th>Number of electrons</th></tr><tr><td>79</td><td>35</td><td>44</td><td>34</td></tr><tr><td>81</td><td>35</td><td>46</td><td>34</td></tr></table>			<i>m/z</i>	Number of protons	Number of neutrons	Number of electrons	79	35	44	34	81	35	46	34
			<i>m/z</i>			Number of protons	Number of neutrons	Number of electrons									
			79			35	44	34									
			81			35	46	34									
Protons AND Neutrons correct ✓																	
Electrons correct ✓																	
	(a)	(ii)	Explanation (<i>m/z</i>) 158: ⁷⁹Br⁷⁹Br OR ⁷⁹Br₂ OR 79 + 79 (<i>m/z</i>) 160: ⁷⁹Br⁸¹Br OR ⁸¹Br⁷⁹Br OR 79 + 81 (<i>m/z</i>) 162: ⁸¹Br⁸¹Br OR ⁸¹Br₂ OR 81 + 81 3 correct ✓ ✓ 2 correct ✓ Relative abundancies 1 : 2 : 1 ✓ OR 25 : 50 : 25	3	Mark explanation and Relative Abundances together IGNORE charges <i>m/z value needs linking with isotopes in Br₂</i> ALLOW 0.25 : 0.5 : 0.25 ALLOW peak at 160 is twice/double 158 and 162												

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Question		Answer		Marks	Guidance												
	(b)	<table><tr><th>Compound</th><th>Number of peaks</th><th>CH₂ splitting pattern(s)</th></tr><tr><td>BrCH₂CH₂Br</td><td>1</td><td>Singlet ✓</td></tr><tr><td colspan="2" style="text-align: center;">AND</td></tr><tr><td>BrCH₂CH₂CH₂Br</td><td>2 ✓</td><td>Triplet AND Quintet ✓</td></tr></table>		Compound	Number of peaks	CH ₂ splitting pattern(s)	BrCH ₂ CH ₂ Br	1	Singlet ✓	AND		BrCH ₂ CH ₂ CH ₂ Br	2 ✓	Triplet AND Quintet ✓		3	For BrCH₂CH₂Br splitting pattern, ALLOW 'No splitting' OR 'None' For BrCH₂CH₂CH₂Br splitting pattern ALLOW multiplet, quinruplet, quinlet, quinret, pentet, pentuplet, pentex etc ALLOW splitting patterns shown as numbers i.e. '1' for singlet, '3' for triplet, '5' for quintet ALLOW diagrams to show splitting pattern e.g.  for triplet  for quintet
		Compound	Number of peaks	CH ₂ splitting pattern(s)													
		BrCH ₂ CH ₂ Br	1	Singlet ✓													
AND																	
BrCH ₂ CH ₂ CH ₂ Br	2 ✓	Triplet AND Quintet ✓															
Mark number of peaks and splitting patterns independently																	

Question			Answer	Marks	Guidance												
2	(a)	(i)	 Count main carbon chain first (watch for only 5 or 7 Cs) Watch for correct reversed orientation: 	1	Structure MUST be skeletal (NO CH₃). BUT ALLOW O–H DO NOT ALLOW OH– ALLOW any vertical bond to the OH group i.e. ALLOW  OR  IGNORE any structural formulae, etc <i>Treat as working</i>												
	(a)	(ii)	FIRST, CHECK ANSWER IF answer = 7.04×10^{23} OR 7.05×10^{23}, award 3 marks ----- $n(\text{C}_8\text{H}_{18}\text{O}) = \frac{8.45}{130.0}$ OR 0.065(0) (mol) ✓ $n(\text{H atoms}) = 18 \times 0.0650$ OR 1.17✓ H atoms = $1.17 \times 6.02 \times 10^{23}$ = 7.04×10^{23} ✓ 3 SF and standard form required ALLOW use of $6.022 \times 10^{23} \rightarrow 7.05 \times 10^{23}$	3	ALLOW ECF throughout Alternative working <i>18 and 6.02×10^{23} in different order</i> $0.0650 \times 6.02 \times 10^{23}$ OR 3.913×10^{22} ✓ $3.913 \times 10^{22} \times 18$ = 7.04×10^{23} ✓ ----- Common errors <table><tr><td>3.91×10^{22}</td><td>→ 2 marks</td><td>No $\times 18$</td></tr><tr><td>2.17×10^{21}</td><td>→ 2 marks</td><td>$\div 18$</td></tr><tr><td>7.0434×10^{23}</td><td>→ 2 marks</td><td>Not 3 SF</td></tr><tr><td>5.42×10^{21}</td><td>→ 2 marks</td><td>$\div 130$ twice</td></tr></table> ALLOW $5.40\text{--}5.42 \times 10^{21}$ (intermediate rounding)	3.91×10^{22}	→ 2 marks	No $\times 18$	2.17×10^{21}	→ 2 marks	$\div 18$	7.0434×10^{23}	→ 2 marks	Not 3 SF	5.42×10^{21}	→ 2 marks	$\div 130$ twice
3.91×10^{22}	→ 2 marks	No $\times 18$															
2.17×10^{21}	→ 2 marks	$\div 18$															
7.0434×10^{23}	→ 2 marks	Not 3 SF															
5.42×10^{21}	→ 2 marks	$\div 130$ twice															

Question		Answer	Marks	Guidance
	(b) (i)	Assume that 'It' means paracetamol It is a phenol OR It is not a carboxylic acid/no carboxyl group/no carboxylic OR It does not contain COOH ✓ A correct functional group must be in answer	1	IGNORE It is too weak an acid/not strong enough It is a weak acid <i>So is COOH</i> It does not react with Na₂CO₃ <i>In Q</i> It contains amide OR benzene ring IGNORE reference to an alcohol/hydroxyl group DO NOT ALLOW It is not acidic <i>It is!</i> It is a phenol which is not acidic is a CON It contains ketone OR amine CON
	(b) (ii)	FIRST, CHECK ANSWER IF Mass ibuprofen = 206 mg AND mass paracetamol = 494 mg award 4 marks ----- $n(\text{CO}_2) = \frac{48.0}{24000} = 2 \times 10^{-3} \text{ (mol) } \checkmark$ $n(\text{ibuprofen}) = 2 \times 2 \times 10^{-3} = 4 \times 10^{-3} \text{ (mol) } \checkmark$ In 4 tablets Mass of ibuprofen = $4 \times 10^{-3} \times 206 = 0.824 \text{ g } \checkmark$ In 1 tablet ($\div 4$) Mass ibuprofen = 206 mg AND mass paracetamol = 494 mg ✓ NOTE: Mass ibuprofen + mass paracetamol in 1 tablet = 700 mg Mass ibuprofen + mass paracetamol in 4 tablets = 2800 mg	4	ECF throughout ----- Alternative order for 1st 3 marks: $n(\text{CO}_2)$ from 1 tablet = $5 \times 10^{-4} \text{ (mol) } \checkmark$ $n(\text{ibuprofen})$ in 1 tablet = $1 \times 10^{-3} \text{ (mol) } \checkmark$ Mass of ibuprofen = $1 \times 10^{-3} \times 206 = 0.206 \text{ g } \checkmark$ Common errors 103 AND 597 3 marks no $\times 2$ for $n(\text{ibuprofen})$ 824 AND 1976 3 marks no $\div 4$ for 1 tablet 824 + 1976 = 2800 ----- ALLOW use of ideal gas equation with a sensible temperature (290–298K) and pressure (100/101/101325 kPa) e.g. At 298 K and 100 kPa, $n(\text{CO}_2) = \frac{100 \times 10^3 \times 48.0 \times 10^{-6}}{8.314 \times 298} = 1.937 \dots \times 10^{-3} \text{ (mol)}$ ALLOW use of 8.31 for R 298K $\rightarrow = 1.938 \dots \times 10^{-3} \text{ (mol)}$

Question	Answer	Marks	Guidance
(c)	FIRST, CHECK ANSWER IF pH = 13.04 award 5 marks [Ba(OH)₂] $\frac{46.80}{171.3}$ OR 0.273..... mol dm⁻³ ✓ <i>Calculator: 0.2732049037</i> Concentration of diluted Ba(OH)₂ $\frac{0.273.....}{5}$ = 0.0546..... (mol dm⁻³) ✓ <i>Calculator: 0.05464098074</i> [OH⁻] $2 \times 0.0546.....$ = 0.1092..... (mol dm⁻³) ✓ <i>Calculator 0.1092819615</i> pH $[H^+] = \frac{1.00 \times 10^{-14}}{0.1092...}$ OR 9.15..... $\times 10^{-14}$ (mol dm⁻³) ✓ <i>Calculator 9.150641026 $\times 10^{-14}$</i> pH = $-\log(9.15..... \times 10^{-14})$ = 13.04 to 2 DP ✓ No pH mark without use of K_w OR pOH DO NOT ALLOW a pH value ≤ 7 for last mark	5	ALLOW ECF throughout 3SF minimum ALLOW acceptable rounding written on scripts and take care as candidate may carry their calculator answer. Alternatives for 1st and 2nd marks: mass in 20 cm³ = 100 cm³ = 46.80 $\times$ 0.02 = 0.936 g ✓ $[Ba(OH)_2] = \frac{0.936}{171.3} \times 10$ = 0.0546.... ✓ $[Ba(OH)_2]$ in diluted solution = $\frac{46.80}{5}$ = 9.36 (g dm⁻³) ✓ $[Ba(OH)_2] = \frac{9.36}{171.3}$ = 0.0546.... ✓ For pH marks ALLOW pOH = $-\log 0.1092...$ = 0.96.... ✓ pH = 14 – 0.96 = 13.04 ✓ Common errors pH = 11.04 4 marks $\div 10$ instead of $\times 10$ in alternative pH = 12.44 4 marks $\div 2$ instead of $\times 2$ for OH⁻ pH = 12.74 4 marks No $\times 2$ for OH⁻ pH = 13.74 4 marks No $\div 5$ pH = 15.27 4 marks No $\div 171.3$ pH = 13.44 3 marks No $\div 5$ and no $\times 2$ pH = 13.97 3 marks No $\div 171.3$ and no $\times 2$ pH = 14.27 3 marks No $\div 171.3$ and $\times 10$ pH = 14.44 2 marks No $\div 5$ and no $\times 2$ and $\times 10$ pH = 15.67 2 marks K_w and pH only

Question	Answer	Marks	Guidance
3 (a)	Conditions of pressure and temperature 2 marks Pressure: Right-hand side has fewer (gaseous) moles/ 3 (gaseous) moles form 1 (gaseous) moles AND High pressure ✓ Temperature: (Forward reaction) is exothermic/ gives out heat/ ΔH –ve AND Low temperature ✓ ===== Calculation 3 marks FIRST CHECK ANSWER IF $[H_2] = 0.48 \text{ (mol dm}^{-3}\text{)}$ award all 3 marks for calc IF $[H_2] = 0.476 \text{ (mol dm}^{-3}\text{)}$ award 2 marks for calc ----- K_c expression $K_c = \frac{[CH_3OH]}{[CO][H_2]^2}$ OR $1.8 = \frac{0.11}{0.27 \times [H_2]^2}$ OR $1.8 = \frac{0.11}{0.27 \times x^2}$ ✓ Calculation of $[H_2]$ $[H_2] = \sqrt{\left(\frac{0.11}{0.27 \times 1.8}\right)}$ OR 0.476 ✓ <i>Calculator: 0.4757493548</i> = 0.48 (mol dm⁻³) AND 2 SF ✓ 2 SF is 'appropriate' with 2 SF values in question NOTE: 0.48 subsumes mark for 0.476	5	FULL ANNOTATIONS MUST BE USED For moles, ALLOW molecules/particles ORA for reverse reaction DO NOT ALLOW gaseous atoms ALLOW increase pressure ALLOW Reverse reaction is endothermic/ takes in heat/ ΔH +ve ALLOW decrease temperature ===== Square brackets required in K_c expression DO NOT ALLOW inverted K_c: $\frac{[CO][H_2]^2}{[CH_3OH]}$ ALLOW ECF for calculation from inverted K_c expression i.e. $[H_2] = \sqrt{\left(\frac{0.11 \times 1.8}{0.27}\right)}$ OR 0.856..... ✓ = 0.86 to 2 SF ✓ IF no square root, $[H_2] = \frac{0.11}{0.27 \times 1.8} = 0.226337.....$ X = 0.23 to 2 SF ✓ ECF NO other ECFs

Question	Answer	Marks	Guidance
(b)	<i>Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.</i> Level 3 (5–6 marks) All three student's results are used to determine ALL correct orders AND correct rate equation AND correct rate constant, k AND explanation for why the mechanism has more than one step. <i>There is a well-developed line of reasoning which is clear and logically structured.</i> Level 2 (3–4 marks) Three orders correct AND explanation for why the mechanism has more than one step. OR Two orders correct AND rate equation consistent with any incorrect orders OR One order correct AND attempts to calculate rate constant consistent with any incorrect orders AND explanation for why the mechanism has more than one step. <i>There is a line of reasoning presented with some structure.</i> Level 1 (1–2 marks) One order correct AND rate equation consistent with any incorrect orders OR two orders correct <i>The information is basic and communicated in an unstructured way.</i> 0 marks <i>No response or no response worthy of credit.</i>	6	Indicative scientific points may include: PAGE 8 NEEDS SEEN Order from Experiment 1 • CH_3COCH_3 is 1st order • $[\text{CH}_3\text{COCH}_3] \times 3$, rate $\times 3$ Order from Experiment 2 • Br_2 is zero order • constant gradient OR constant rate OR rate independent of concentration OR linear negative gradient Order from Experiment 3 • H^+ is 1st order • straight line through 0,0 OR rate proportional to $[\text{H}^+]$ OR linear increase OR doubling $[\text{H}^+]$ leads to doubling of rate Rate equation and rate constant • rate = $k [\text{CH}_3\text{COCH}_3] [\text{H}^+]$ ALLOW rate = $k [\text{Br}_2]^0 [\text{CH}_3\text{COCH}_3]^1 [\text{H}^+]^1$ • $k = \frac{\text{rate}}{[\text{CH}_3\text{COCH}_3][\text{H}^+]}$ OR $\frac{1.70 \times 10^{-7}}{1.50 \times 10^{-3} \times 2.50 \times 10^{-1}}$ • $k = 4.53 \times 10^{-4}$ • IGNORE units: ($\text{dm}^3 \text{mol}^{-1} \text{s}^{-1}$) (Any order, e.g. $\text{mol}^{-1} \text{dm}^3 \text{s}^{-1}$) Communication Aspects of the communication statement might typically have been met when: <i>there is a link between evidence and orders is clear for three students results.</i>

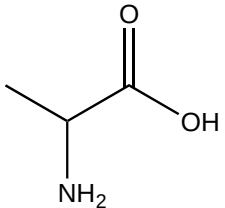
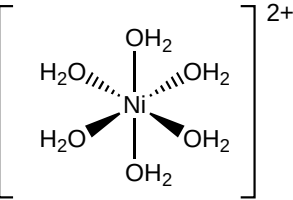
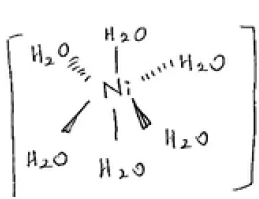
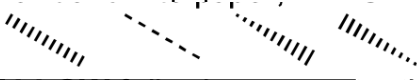
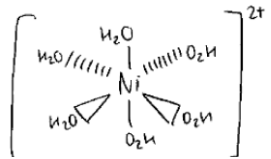
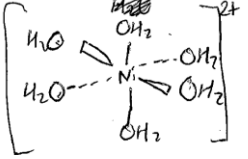
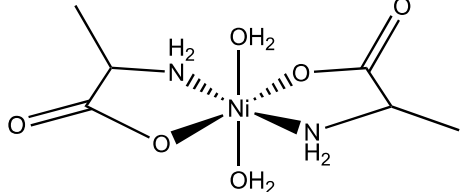
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Question			Answer	Marks	Guidance
					Possible explanation of multi-step mechanism e.g. • Br₂ in overall equation; not in rate equation OR • H⁺ in rate equation; not in overall equation • OR CH₃COCH₃ + H⁺ → slow /rate-determining step • OR stoichiometry of overall equation different from rate equation IGNORE attempts at full mechanism

Question	Answer	Marks	Guidance
4 (a) (i)	sulfate(IV) (ion) ✓ IV essential	1	ALLOW sulphate(IV) ALLOW sulfite OR sulphite DO NOT ALLOW 'oxide' in name: e.g. sulfur trioxide OR sulfur(IV) oxide
(a) (ii)		7	For top left box, ALLOW Ag ₂ SO ₄ All responses must be formulae. DO NOT ALLOW 'sulfur' for S ALLOW 3 ions from the following 5 ions: H ⁺ OR H ₃ O ⁺ , Cl ⁻ , ClO ⁻ , HSO ₄ ⁻ , SO ₄ ²⁻ MUST be ions ALLOW S ₈ DO NOT ALLOW S ₂
(a) (iii)	$3 \text{SO}_3^{2-} + \text{Cr}_2\text{O}_7^{2-} + 8 \text{H}^+ \rightarrow 2 \text{Cr}^{3+} + 3 \text{SO}_4^{2-} + 4 \text{H}_2\text{O}$ SO₃²⁻ and Cr₂O₇²⁻ on left-hand side AND Cr³⁺ + SO₄²⁻ on right hand side ✓ Correct balanced equation ✓ DO NOT ALLOW additional incorrect Cr or S species in equation, e.g. Cr²⁺, Cr(OH)₃, [Cr(OH)₆]³⁻	2	ALLOW multiples IGNORE state symbols ALLOW Cr ₂ (SO ₄) ₃ for 2 Cr ³⁺ + 3 SO ₄ ²⁻ ALLOW Cr ³⁺ + H ₂ SO ₄ on right-hand side ALLOW [Cr(H ₂ O) ₆] ³⁺ for Cr ³⁺ DO NOT ALLOW [Cr(OH) ₆] ³⁻

Question	Answer	Marks	Guidance
(b) (i)	$\text{C}_6\text{H}_{16}\text{N}_2\text{NiO}_6$ ✓ Any order Count: 5 elements in formula MUST be empirical formula	1	DO NOT ALLOW $\text{Ni}(\text{C}_3\text{H}_6\text{NO}_2)_2(\text{H}_2\text{O})_2$ ALLOW $\text{C}_6\text{H}_{16}\text{N}_2\text{NiO}_6$ i.e. 1 after Ni
(b) (ii)	 Amino acid B 1 mark ✓  Complex ion C 2 marks - Ni and 6 H_2O ligands in 3D structure (see guidance) ✓ 2+ charge AND connectivity to 6 O in H_2O ligands ✓ 'O' connectivity ONLY needed for 2nd complex ion mark i.e. This response gets 1st mark point: Ni, 6H_2O and 3D 	3	In amino acid ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous IGNORE connectivity In Complex ion C 3D: Must contain 2 'out wedges', 2 'in wedges' and 2 lines in plane of paper OR 4 lines, 1 'out wedge' and 1 'in wedge': For bond into paper, ALLOW:  DO NOT ALLOW $-\text{O}_2\text{H}$ for 1st complex ion mark, e.g.  DO NOT ALLOW for 1st complex ion mark (impossible 3D) 
(b) (iii)	 ✓	1	IGNORE connectivity to NH_2 IGNORE 3D Optical isomer in amino acid Watch for adjacent Os

Question			Answer	Marks	Guidance
5	(a)	(i)	phenylmethanol ✓	1	ALLOW 1-phenylmethanol, Phenylmethan-1-ol, 1-phenylmethan-1-ol DO NOT ALLOW Hydroxymethylbenzene OR methylphenol
	(a)	(ii)	FIRST CHECK THE ANSWER ON ANSWER LINE If mass LiAlH₄ = 4.96 OR 4.97 g AND % yield = 77.6 OR 77.5 (%) award 4 marks Percentage yield 3 marks Theoretical moles $n(\text{C}_6\text{H}_5\text{COOC}_2\text{H}_5)$ OR $n(\text{C}_6\text{H}_5\text{CH}_2\text{OH})$ $= \frac{7.50 \times 1.05}{150.0}$ OR 0.0525 (mol) ✓ Actual moles $n(\text{C}_6\text{H}_5\text{CH}_2\text{OH}) = \frac{4.40}{108.0}$ OR 0.0407.... (mol) ✓ <i>Calculator = 0.04074074074</i> % yield $\% \text{ yield} = \frac{0.0407....}{0.0525} \times 100 = 77.6\%$ (3 sig fig) ✓ ALLOW 77.5 – 77.6 % <i>taking into account rounding to 0.0407</i> Mass of LiAlH₄ 1 mark $\text{mass LiAlH}_4 = 0.0525 \times 2.5 \times 37.9 = 4.97 \text{ g}$ ✓ <i>Calculator = 4.974375 g</i> 3SF ALLOW 4.96 – 4.97 g 3 SF <i>taking into account rounding to 0.131</i>	4	ALLOW ECF for each step NOTE: $7.50 \times 1.05 = 7.875 \text{ g}$ Alternative method using mass 1. Theoretical moles = 0.0525 mol 2. Mass = 0.0525×108.0 OR 5.67 g 3. $\% \text{ yield} = \frac{4.40}{5.67} \times 100 = 77.6\%$ Common errors No density: $\frac{7.50}{150.0} = 0.0500 \text{ mol}$ x • $\% \text{ yield} = 81.4 - 81.5\%$ ✓✓ ECF • $\text{LiAlH}_4 \text{ mass} = 4.74 \text{ g}$ ✓ ECF $\div \text{density: } \frac{7.50/1.05}{150.0} = 0.0476..$ x • $\% \text{ yield} = 85.5 - 85.6 \%$ ✓✓ ECF • $\text{LiAlH}_4 \text{ mass} = 4.46 \text{ g}$ ✓ ECF
	(a)	(iii)	Donates an electron pair (to another species) ✓	1	ALLOW donates a lone pair

Question	Answer	Marks	Guidance
(a) (iv)	6 curly arrows correct ✓✓✓✓ 5 curly arrows correct ✓✓✓ 4 curly arrows correct ✓✓ 3 curly arrows correct ✓ Annotate incorrect or absent curly arrows first with x or ^ Helps to account for marks.	4	IGNORE any added charges OR dipoles. <i>Marks solely for curly arrows</i> For each mark, an extra curly arrow is a CON ALLOW curly arrow from : OR from – charge on O[–] or H[–] Curly arrow from a bond MUST go to O in C=O and in –OC₂H₅ IGNORE any curly arrows on bottom structures (not in boxes): i.e.
(a) (v)	H⁺ adds to –ve ion/anion/O[–] OR –ve ions are protonated OR Protonates the product (from Step 2) OR Provides H⁺ to form the alcohol ✓ <i>Needs idea of H⁺ being gained/donated</i>	1	ALLOW O[–] + H⁺ → OH IGNORE 'to form an OH group/alcohol <i>Must include idea of H⁺ involved.</i>

Question	Answer	Marks	Guidance
(b)	8 electrons around B AND 4 covalent bonds between B and 4 H atoms AND Na with no electrons OR 8 electrons ✓ 3 covalent bonds containing x or o AND 1 covalent bond containing x OR o AND extra Na electron shown differently AND charges ✓ ALLOW dot and cross labels swapped: i.e. • for B electrons and × for H electrons	2	NOT REQUIRED • Brackets • Circles • B and H symbols IGNORE inner shells DO NOT ALLOW ANY marks for a covalent NaBH₄ IF 8 electrons around Na, the 'extra' electron around B must match Na electrons ALLOW other symbols than x and o provided that the origin of the electron is clear, e.g. Use a different symbol for the electrons from each element. Show outer electrons only.
(c) (i)	-1.24 V ✓	1	– sign required
(c) (ii)	NaBH₄ + OH⁻ on left-hand side AND NaBO₂ + H₂O on right-hand side ✓ Correct balanced equation with electrons ✓ NaBH₄ + 8OH⁻ → NaBO₂ + 6H₂O + 8e⁻ ALLOW 1 mark for 'correct equation' but wrong way round, i.e. NaBO₂ + 6H₂O + 8e⁻ → NaBH₄ + 8OH⁻	2	ALLOW: Na⁺ + BH₄⁻ and Na⁺ and BO₂⁻ IGNORE O₂ for the 1st mark only ALLOW multiples IGNORE state symbols For 2nd mark, any common species on both sides of equation needs to be cancelled

Question	Answer	Marks	Guidance
6 *	<i>Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.</i> Level 3 (5–6 marks) Calculates CORRECT enthalpy change ΔH_2 using $m = 33.5 \text{ g}$ in reaction 6.2. AND CORRECT enthalpy change ΔH_1 in reaction 6.1 <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Using $m = 30 - 33.5 \text{ g}$, $c = 4.18/4.2$ and $\Delta T = 4$ calculates a value for energy change per mole of Na_2CO_3 OR energy change per mole of HNO_3 AND the CORRECT amount in mol of Na_2CO_3 OR HNO_3 <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) Processes experimental data to obtain: Calculates energy change correctly from $mc\Delta T$ OR Attempts to calculate energy change from $mc\Delta T$ with two of m (30–33.5g), c (4.18/4.2) and ΔT (4) correct AND amount in mol of Na_2CO_3 OR HNO_3 <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks – No response or no response worthy of credit.	6	TWO APPROACHES: from $n(\text{Na}_2\text{CO}_3)$ and from $n(\text{HNO}_3)$ SEE NEXT DOUBLE PAGE FOR GUIDANCE. PAGE 16 NEEDS ‘SEEN’ ALLOW omission of trailing zeroes ALLOW minor slips 3 SF or more throughout

	Guidance		Guidance
	A: APPROACH based on $n(\text{Na}_2\text{CO}_3)$ Indicative scientific points may include: 1. Energy change from $mc\Delta T$ $33.50 \times 4.18 \times 4.0 = 560.12 \text{ (J) OR } 0.56012 \text{ (kJ)}$ OR $30.0 - 33.15$, e.g. $30 \times 4.18 \times 4.0 = 501.6 \text{ (J) OR } 0.5016 \text{ (kJ)}$ Amount of Na_2CO_3 $n(\text{Na}_2\text{CO}_3) = \frac{1.97}{106} = 0.01858\dots \text{ (mol)}$ 2. Energy change per mole of Na_2CO_3 in kJ mol^{-1} From $m = 33.50 \text{ g} = \pm \frac{0.56012}{0.01858\dots} = \pm 30.138\dots$ ALLOW $30.11 \rightarrow 30.15$ From $m = 30 \text{ g} = \pm \frac{0.5016}{0.01858\dots} = \pm 26.9896\dots$ ALLOW $\pm 27.0 \text{ OR } \pm 26.9$ 3. ΔH_2 and ΔH_1 CORRECT with signs (From 33.50 ONLY) Reaction 6.2: $\Delta H_2 = -30.138 \text{ (kJ mol}^{-1}\text{)}$ ALLOW $-30.11 \rightarrow -30.15$ Reaction 6.1 $\Delta H_1 = 2 \times \Delta H_3 - \Delta H_2$ $= 2 \times 19.8 - (-30.138\dots) = \Delta H_1 = (+)69.7 \text{ (kJ mol}^{-1}\text{)}$ NOTE: A clear and logically structured response might include an energy cycle and accurate use of SF, 4.18 and signs throughout		B: APPROACH using $n(\text{HNO}_3)$ Indicative scientific points may include: 1. Energy change from $mc\Delta T$ $33.50 \times 4.18 \times 4.0 = 560.12 \text{ (J) OR } 0.56012 \text{ (kJ)}$ OR $30.0 - 33.15$, e.g. $30 \times 4.18 \times 4.0 = 501.6 \text{ (J) OR } 0.5016 \text{ (kJ)}$ Amount of HNO_3 and the Na_2CO_3 $n(\text{HNO}_3) = \frac{1.00 \times 30.0}{1000} = 0.0300 \text{ (mol)}$ Amount of Na_2CO_3 $n(\text{Na}_2\text{CO}_3) = \frac{0.0300}{2} = 0.0150 \text{ (mol)}$ 2. Energy change per mole of Na_2CO_3 in kJ mol^{-1} From $m = 33.50 \text{ g} = \pm \frac{0.56012}{0.0150} = \pm 37.34$ From $m = 30 \text{ g} = \pm \frac{0.5016}{0.0150} = \pm 33.44$ ** Some may calculate energy change per mole of HNO_3 giving: $\pm \frac{0.56012}{0.0300} = \pm 18.67$ and $\pm \frac{0.5016}{0.0300} = \pm 16.67$ 3. ΔH_2 and ΔH_1 CORRECT with signs (From 33.50 ONLY) Reaction 6.2: $\Delta H_2 = -37.34 \text{ (kJ mol}^{-1}\text{)}$ Reaction 6.1 $\Delta H_1 = 2 \times \Delta H_3 - \Delta H_2$ $= 2 \times 19.8 - (-37.34) \Delta H_1 = (+)76.94 \text{ (kJ mol}^{-1}\text{)}$ NOTE: A clear and logically structured response might include an energy cycle and accurate use of SF, 4.18 and signs throughout

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