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 SEEN

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

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.

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td>(i)</td><td>
<table>
<tr><th>m/z</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>
Protons AND Neutrons correct ✓

Electrons correct ✓
</td><td>2</td><td></td></tr>
<tr><td></td><td>(a)</td><td>(ii)</td><td>
Explanation
(m/z) 158: $^{79}Br^{79}Br$ OR $^{79}Br_2$ OR 79 + 79

(m/z) 160: $^{79}Br^{81}Br$ OR $^{81}Br^{79}Br$ OR 79 + 81

(m/z) 162: $^{81}Br^{81}Br$ OR $^{81}Br_2$ OR 81 + 81

3 correct ✓ ✓
2 correct ✓

Relative abundancies
1 : 2 : 1 ✓
OR
25 : 50 : 25
</td><td>3</td><td>
Mark explanation and Relative Abundances together

IGNORE charges

m/z value needs linking with isotopes in Br_2

ALLOW 0.25 : 0.5 : 0.25

ALLOW peak at 160 is twice/double 158 and 162
</td></tr>
</table>

<table>
<tr><th colspan="2">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td></td><td>(b)</td><td>
<table>
<tr><th>Compound</th><th>Number of peaks</th><th>CH_2 splitting pattern(s)</th></tr>
<tr><td>$BrCH_2CH_2Br$</td><td rowspan="2">1

AND

2 ✓</td><td>Singlet ✓</td></tr>
<tr><td>$BrCH_2CH_2CH_2Br$</td><td>Triplet

AND

Quintet ✓</td></tr>
</table>

Mark number of peaks and splitting patterns independently
</td><td>3</td><td>
For $BrCH_2CH_2Br$ splitting pattern,
ALLOW ‘No splitting’ OR ‘None’

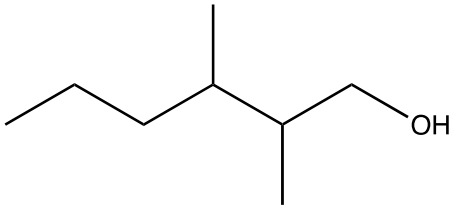
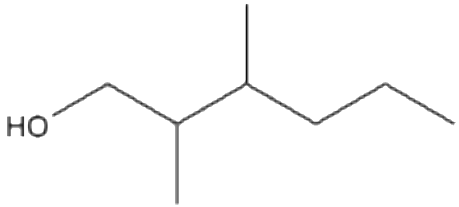
For $BrCH_2CH_2CH_2Br$ splitting pattern
ALLOW
multiplet,
quinruplet, quinlet, quinret, pentet, pentuplet, pentex
etc

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
</td></tr>
</table>

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 CH_3). **BUT** **ALLOW** O–H **DO NOT ALLOW** OH– **ALLOW** any vertical bond to the OH group i.e. **ALLOW** | **OR** | OH HO **IGNORE** any structural formulae, etc *Treat as working*
	(a)	(ii)	**FIRST, CHECK ANSWER** **IF** answer = **7.04×10^{23} OR 7.05×10^{23}**, award **3 marks** ---------- $n(C_8H_{18}O) = \frac{8.45}{130.0}$ **OR** 0.065(0) (mol) ✓ n(H atoms) = 18 × 0.0650 **OR** 1.17✓ H atoms = 1.17 × **6.02×10^{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** *18 and 6.02×10^{23} in different order* 0.0650 × **6.02×10^{23}** **OR** 3.913×10^{22} ✓ $3.913 \times 10^{22} \times 18$ = **7.04×10^{23}** ✓ ---------- **Common errors** 3.91×10^{22} → 2 marks No × 18 2.17×10^{21} → 2 marks ÷18 7.0434×10^{23} → 2 marks Not 3 SF 5.42×10^{21} → 2 marks ÷130 twice **ALLOW** $5.40–5.42 \times 10^{21}$ (*intermediate rounding*)

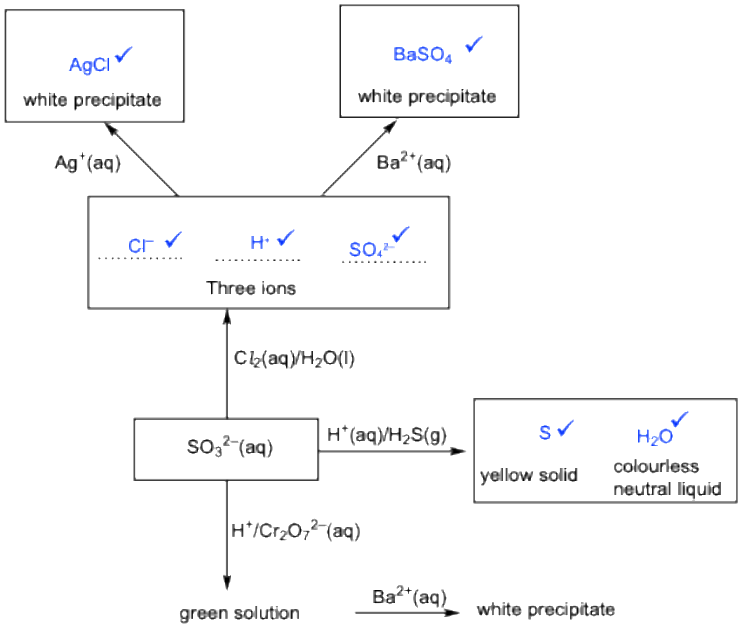
Question			Answer	Marks	Guidance
	(b)	(i)	Assume that 'It' means paracetamol It is a **phenol** **OR** It is **not** a **carboxylic acid**/no **carboxyl** group/no carboxylic **OR** It does not contain **COOH** ✓ **A correct functional group must be in answer**	1	**IGNORE** It is too weak an acid/not strong enough It is a weak acid *So is COOH* It does not react with Na_2CO_3 *In Q* It contains amide **OR** benzene ring **IGNORE** reference to an alcohol/hydroxyl group **DO NOT ALLOW** It is not acidic *It is!* 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** ---------- $n(CO_2) = \frac{48.0}{24000}$ = **2×10^{-3}** (mol) ✓ n(ibuprofen) = $2 \times 2 \times 10^{-3}$ = **4×10^{-3}** (mol) ✓ In 4 tablets Mass of ibuprofen = $4 \times 10^{-3} \times 206$ = **0.824 g** ✓ In 1 tablet (÷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:** $n(CO_2)$ from 1 tablet = 5×10^{-4} (mol) ✓ n(ibuprofen) in 1 tablet = 1×10^{-3} (mol) ✓ Mass of ibuprofen = $1 \times 10^{-3} \times 206$ = 0.206 g ✓ **Common errors** 103 **AND** 597 3 marks no ×2 for n(ibuprofen) 824 **AND** 1976 3 marks no ÷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, $n(CO_2) = \frac{100 \times 10^3 \times 48.0 \times 10^{-6}}{8.314 \times 298}$ = 1.937…. $\times 10^{-3}$ (mol) **ALLOW** use of 8.31 for R 298K → = 1.938…. $\times 10^{-3}$ (mol)

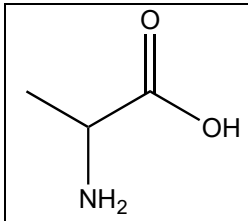
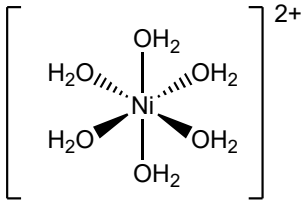
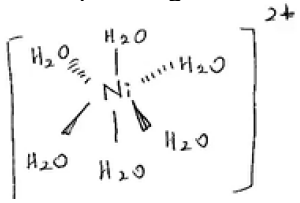
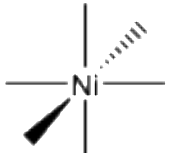
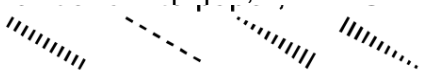
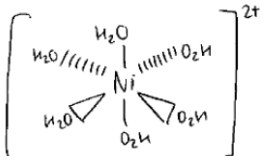
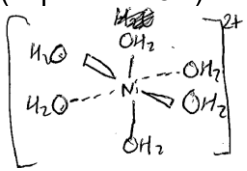
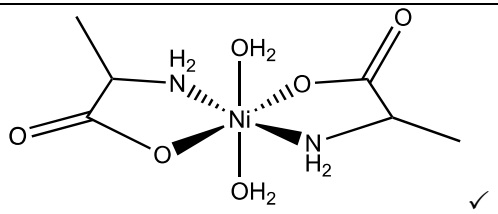
Question	Answer	Marks	Guidance
(c)	**FIRST, CHECK ANSWER** **IF pH = 13.04 award 5 marks** ---------- **[Ba(OH)$_2$]** $\frac{46.80}{171.3}$ **OR 0.273**….. mol dm^{-3} ✓ *Calculator: 0.2732049037* **Concentration of diluted Ba(OH)$_2$** $\frac{0.273.....}{5}$ = **0.0546**…… (mol dm^{-3}) ✓ *Calculator: 0.05464098074* **[OH$^-$]** 2 × 0.0546…… = **0.1092……..** (mol dm^{-3}) ✓ *Calculator 0.1092819615* **pH** [H$^+$] = $\frac{1.00 \times 10^{-14}}{0.1092...}$ **OR 9.15…… × 10^{-14}** (mol dm^{-3}) ✓ *Calculator 9.150641026 × 10^{-14}* pH = –log(9.15…… × 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 cm^3 = 100 cm^3 = **46.80 × 0.02** **= 0.936 g** ✓ [Ba(OH)$_2$] = $\frac{0.936}{171.3}$ × **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 ÷10 instead of ×10 in alternative pH = 12.44 4 marks ÷2 instead of ×2 for OH$^-$ pH = 12.74 4 marks No ×2 for OH$^-$ pH = 13.74 4 marks No ÷5 pH = 15.27 4 marks No ÷171.3 pH = 13.44 3 marks No ÷5 and no ×2 pH = 13.97 3 marks No ÷171.3 and no ×2 pH = 14.27 3 marks No ÷171.3 and ×10 pH = 14.44 2 marks No ÷5 and no ×2 and ×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 (mol dm^{-3}) award all 3 marks for calc** **IF $[H_2]$ = 0.476 (mol dm^{-3}) 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 ✓ *Calculator: 0.4757493548* = **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**

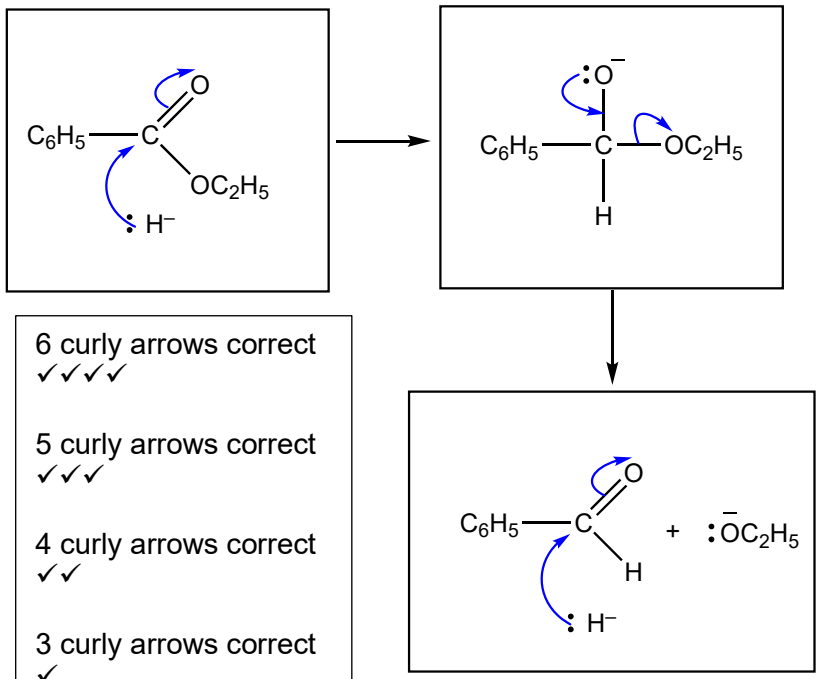
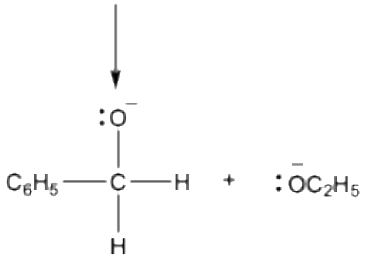
Question			Answer	Marks	Guidance
	(b)		*Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** All three student's results are used to determine **ALL correct** orders **AND** correct rate equation **AND** correct rate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

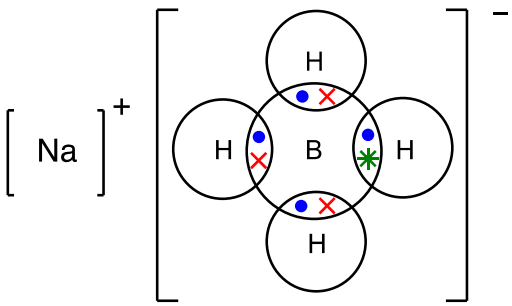
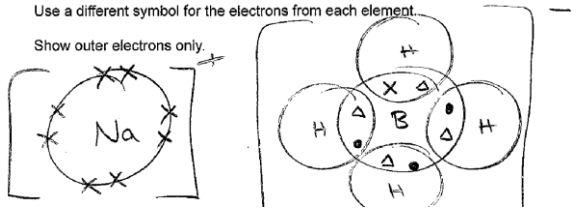
Question			Answer	Marks	Guidance
					Possible explanation of multi-step mechanism e.g. • Br_2 in overall equation; not in rate equation **OR** • H^+ in rate equation; not in overall equation • **OR** $CH_3COCH_3 + H^+ \rightarrow$ slow /rate-determining step • **OR** stoichiometry of overall equation 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_2SO_4 All responses must be formulae. **DO NOT ALLOW** 'sulfur' for S **ALLOW** 3 ions from the following 5 ions: H^+ **OR** H_3O^+, Cl^-, ClO^-, HSO_4^-, SO_4^{2-} **MUST** be ions **ALLOW** S_8 **DO NOT ALLOW** S_2
	(a)	(iii)	$3\ SO_3^{2-} + Cr_2O_7^{2-} + 8\ H^+ \rightarrow 2\ Cr^{3+} + 3\ SO_4^{2-} + 4\ H_2O$ SO_3^{2-} and $Cr_2O_7^{2-}$ on left-hand side **AND** Cr^{3+} + SO_4^{2-} on right hand side ✓ Correct balanced equation ✓ **DO NOT ALLOW** additional incorrect Cr or S species in equation, e.g. Cr^{2+}, $Cr(OH)_3$, $[Cr(OH)_6]^{3-}$	2	**ALLOW** multiples **IGNORE** state symbols **ALLOW** $Cr_2(SO_4)_3$ for $2\ Cr^{3+} + 3\ SO_4^{2-}$ **ALLOW** Cr^{3+} + H_2SO_4 on right-hand side **ALLOW** $[Cr(H_2O)_6]^{3+}$ for Cr^{3+} **DO NOT ALLOW** $[Cr(OH)_6]^{3-}$

Question			Answer	Marks	Guidance
	(b)	(i)	$C_6H_{16}N_2NiO_6$ ✓ *Any order* Count: 5 elements in formula **MUST** be empirical formula	1	**DO NOT ALLOW** $Ni(C_3H_6NO_2)_2(H_2O)_2$ **ALLOW** $C_6H_{16}N_2Ni_1O_6$ 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': **ALLOW** following geometry  For bond into paper, **ALLOW**:  **DO NOT ALLOW** $-O_2H$ 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 $LiAlH_4$ = 4.96 OR 4.97 g** **AND % yield = 77.6 OR 77.5 (%) award 4 marks** ---------- **Percentage yield 3 marks** **Theoretical moles** $n(C_6H_5COOC_2H_5)$ **OR** $n(C_6H_5CH_2OH)$ $= \frac{7.50 \times 1.05}{150.0}$ **OR** 0.0525 (mol) ✓ **Actual moles** $n(C_6H_5CH_2OH) = \frac{4.40}{108.0}$ **OR** 0.0407…. (mol) ✓ *Calculator = 0.04074074074* **% yield** % yield $= \frac{0.0407....}{0.0525} \times 100$ **= 77.6%** (3 sig fig) ✓ **ALLOW** 77.5 – 77.6 % *taking into account rounding to 0.0407* **Mass of $LiAlH_4$ 1 mark** mass $LiAlH_4$ = 0.0525 × 2.5 × 37.9 = **4.97 ……. g** ✓ *Calculator = 4.974375 g* **3SF** **ALLOW** 4.96 – 4.97 g **3 SF** *taking into account rounding to 0.131*	4	**ALLOW ECF** for each step **NOTE**: 7.50 × 1.05 = 7.875 g **Alternative method using mass** 1. Theoretical moles = 0.0525 mol 2. Mass = 0.0525 × 108.0 **OR** 5.67 g 3. % yield $= \frac{4.40}{5.67} \times 100 = 77.6\%$ **Common errors** No density: $\frac{7.50}{150.0}$ = 0.0500 mol x • % yield = 81.4 – 81.5% ✓✓ **ECF** • $LiAlH_4$ mass = 4.74 g ✓ **ECF** ÷ density: $\frac{7.50/1.05}{150.0}$ = 0.0476.. x • % yield = 85.5 – 85.6 % ✓✓ **ECF** • $LiAlH_4$ mass = 4.46 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. *Marks solely for curly arrows* 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 $-OC_2H_5$ **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 ✓ *Needs idea of **H^+** being gained/donated*	1	**ALLOW** $O^- + H^+ \rightarrow OH$ **IGNORE** 'to form an OH group/alcohol *Must include idea of H^+ involved.*

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 $NaBH_4$ **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. 
	(c)	(i)	–1.24 V ✓	**1**	– sign required
	(c)	(ii)	$NaBH_4 + OH^-$ on left-hand side **AND** $NaBO_2 + H_2O$ on right-hand side ✓ Correct balanced equation with electrons ✓ $NaBH_4 + 8OH^- \rightarrow NaBO_2 + 6H_2O + 8e^-$ **ALLOW 1 mark for 'correct equation' but wrong way round,** i.e. $NaBO_2 + 6H_2O + 8e^- \rightarrow NaBH_4 + 8OH^-$	**2**	**ALLOW: $Na^+ + BH_4^-$ and Na^+ and BO_2^-** **IGNORE** O_2 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 *			*Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Calculates **CORRECT** enthalpy change ΔH_2 using m **= 33.5 g** in **reaction 6.2**. **AND** **CORRECT** enthalpy change ΔH_1 in **reaction 6.1** *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)** Using m = 30 – 33.5 g, c = 4.18/4.2 and ΔT = 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 *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: 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 *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	***TWO APPROACHES: from n(Na_2CO_3) and from n(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(Na_2CO_3) *Indicative scientific points may include:* **1. Energy change from *mcΔT*** **33.50** × 4.18 × 4.0 = **560.12** (J) **OR** 0.56012 (kJ) **OR** 30.0 – 33.15, e.g. **30** × 4.18 × 4.0 = **501.6** (J) **OR** 0.5016 (kJ) ---------- **Amount of Na_2CO_3** $n(Na_2CO_3) = \frac{1.97}{106}$ = 0.01858…. (mol) ---------- **2. Energy change per mole of Na_2CO_3 in kJ mol^{-1}** From *m* = 33.50 g = ± $\frac{0.56012}{0.01858....}$ = **±30.138…** **ALLOW** 30.11 → 30.15 From *m* = 30 g = ± $\frac{0.5016}{0.01858....}$ = **±26.9896…** **ALLOW** ±27.0 **OR** ±26.9 ---------- **3. ΔH_2 and ΔH_1 CORRECT with signs (From 33.50 ONLY)** **Reaction 6.2:** ΔH_2 **= –30.138** (kJ mol^{-1}) **ALLOW** –30.11 → –30.15 **Reaction 6.1** $\Delta H_1 = 2 \times \Delta H_3 - \Delta H_2$ = 2 × 19.8 – (–30.138….) = ΔH_1 **= (+)69.7** (kJ mol^{-1}) **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(HNO_3)*** *Indicative scientific points may include:* **1. Energy change from *mcΔT*** **33.50** × 4.18 × 4.0 = **560.12** (J) **OR** 0.56012 (kJ) **OR** 30.0 – 33.15, e.g. **30** × 4.18 × 4.0 = **501.6** (J) **OR** 0.5016 (kJ) ---------- **Amount of HNO_3 and the Na_2CO_3** $n(HNO_3) = \frac{1.00 \times 30.0}{1000}$ = 0.0300 (mol) **Amount of Na_2CO_3** $n(Na_2CO_3) = \frac{0.0300}{2}$ = 0.0150 (mol) ---------- **2. Energy change per mole of Na_2CO_3 in kJ mol^{-1}** From *m* = 33.50 g = ± $\frac{0.56012}{0.0150}$ = **± 37.34** From *m* = 30 g = ± $\frac{0.5016}{0.0150}$ = **±33.44** ** Some may calculate energy change per mole of HNO_3 giving: ± $\frac{0.56012}{0.0300}$ = **± 18.67** **and** ± $\frac{0.5016}{0.0300}$ = **± 16.67** ---------- **3. ΔH_2 and ΔH_1 CORRECT with signs (From 33.50 ONLY)** **Reaction 6.2:** ΔH_2 **= –37.34** (kJ mol^{-1}) **Reaction 6.1** $\Delta H_1 = 2 \times \Delta H_3 - \Delta H_2$ = 2 × 19.8 – (–37.34) ΔH_1 = **(+)76.94** (kJ mol^{-1}) **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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