GCE

Chemistry A

H432/03: Unified chemistry

A Level

Mark Scheme for June 2023

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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. Work crossed out:

   a. where a candidate crosses out an answer and provides an alternative response, the crossed out response is not marked and gains no marks

   b. if a candidate crosses out an answer to a whole question and makes no second attempt, and if the inclusion of the answer does not cause a rubric infringement, the assessor should attempt to mark the crossed out answer and award marks appropriately.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen.

7. There is a NR (No Response) option. Award NR (No Response)

   - if there is nothing written at all in the answer space
   - OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
   - OR if there is a mark (e.g. a dash, a question mark) which isn't an attempt at the question.

   Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The 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 **Q3** and **Q6f.**

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: 

Place the annotations alongside the mark for the question.

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

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
	MARKING CALCULATIONS 1. Candidates are encouraged to round only at the end of multi-step calculations. 2. We are not assessing a candidate's ability to copy calculator values onto paper. Calculator values are usually taken forwards by candidates for the next step in calculations. 3. DO NOT penalise intermediate rounding errors on scripts when subsequent answers have obviously used calculator values. 4. Every response is different. Use the final answer to guide your marks and make use of intermediate values when the final answer is wrong. 5. Guidance will often include Common Errors which help with marking and obtaining consistency.			
	ANNOTATIONS 1. Every mark awarded must be accompanied by a tick. If a calculation is correct and the mark scheme allocated all marks, add the same number of ticks alongside the answer. 2. It is good practice to show an annotation to every item. 3. RM3 suppled a useful set of annotations which help to show why you have decided on a mark. Please use them. 4. Every blank page should contain an annotation to show that you have seen them. 5. Linking: If you are unsure about how to link, contact your Team Leader for advice.			

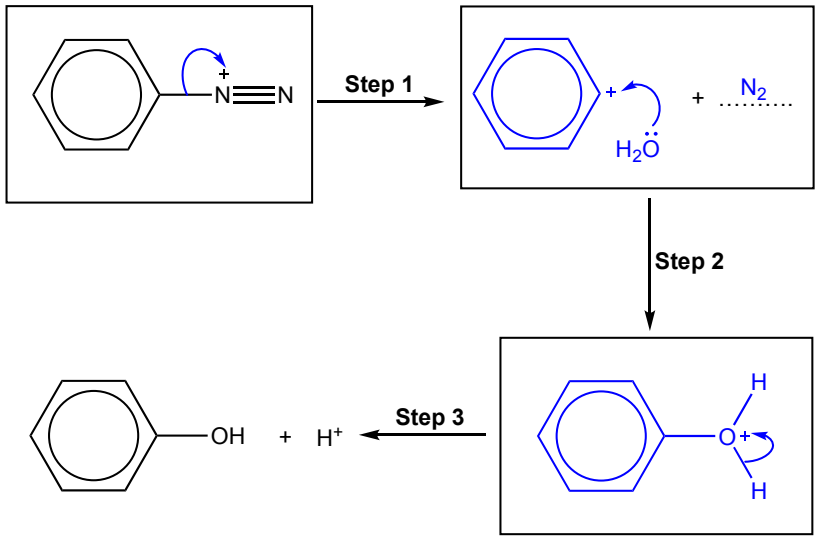
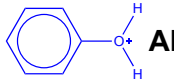
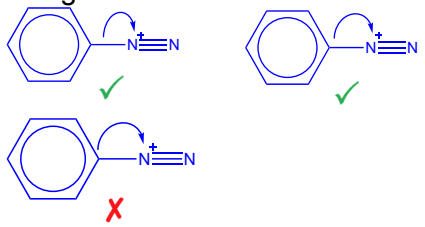
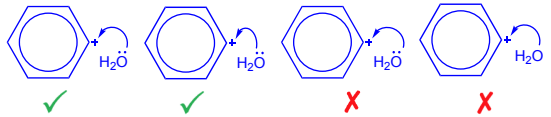
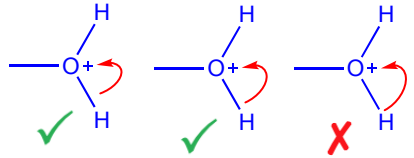
Question			Answer	Marks	AO element	Guidance
1			**ALLOW upper case when it is obvious, e.g. ALLOW CR for Cr, AS for As** **ALLOW names for elements**			
	(a)		**THREE** from: **N O F H** ✓	**1**	AO1.1	**DO NOT ALLOW ANY OTHER ELEMENTS (CON)**
	(b)		O ✓	**1**	AO2.1	**ALLOW** S **BOD**
	(c)		P **OR** S ✓	**1**	AO1.1	**ALLOW** S_8, P_4 **ALLOW** As, Se
	(d)		Cr ✓ Mn ✓	**2**	AO1.2	**IGNORE** ions
	(e)		Si ✓	**1**	AO1.1	
	(f)		S ✓	**1**	AO2.1	**ALLOW** SF_6
	(g)		F ✓	**1**	AO1.1	
	(h)		As ✓	**1**	AO2.2	

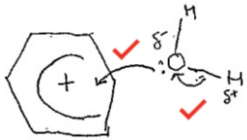
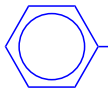
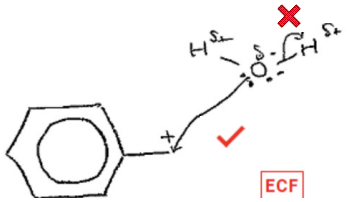
Question			Answer	Marks	AO element	Guidance
2	(a)	(i)	Rubidium chlorate(**VII**) ✓	1	AO1.1	**ALLOW** Rubidium(I) chlorate(VII) Rubidium chloroate(VII) **IGNORE** Rubidium (VII)chlorate Rubidium chlorate(IIV) Rubidium chlorate (7) Rubidium perchlorate
		(ii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 54.0 OR 54.1 OR 54.2 (kJ mol^{-1}) award 3 marks** --- **Energy change from *mc*Δ*T*** Energy in J **OR** kJ = 102 × 4.18 × 1.5 **OR** 639.54 (J) **OR** 0.63954 (kJ) ✓ --- **Amount in mol of $RbClO_3$** $n(RbClO_3) = \frac{2.00}{169}$ **OR** 0.0118…….. (mol) ✓ --- $\Delta_{sol}H$**($RbClO_3$)** $= \frac{0.63954}{0.0118…..}$ = (+) **54.0** ✓ *From unrounded values, ΔH = 54.04113* *Examples of mixed acceptable intermediate rounding, e.g.* $\frac{0.640}{0.0118}$ *ΔH = 54.237 → 54.2* $\frac{0.63954}{0.01183}$ *ΔH = 54.06 → 54.1*	3	AO2.8 ×3	**ALLOW ECF throughout** **IGNORE** sign **IGNORE RE and SF in 1st 2 marks** 0.01183431953 unrounded **ALLOW** 54 (from 54.0) **CARE 54.00 is a rounding error** --- **COMMON ERRORS** **52.98 OR 53.14** **2 marks** 100 instead of 102: Energy = 100 × 4.18 × 1.5 = 627 J From unrounded *n*, $\Delta H = \frac{0.627}{0.0118…..}$ = **52.98** kJ mol^{-1} **OR** 53.0 (3SF) **OR** 53 From rounded 0.0118, $\Delta H = \frac{0.627}{0.0118}$ = 53.14 **OR** 53.1 ---

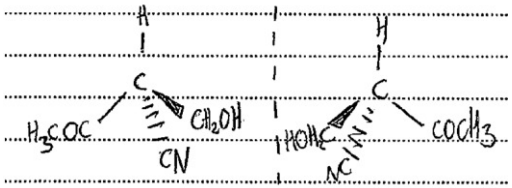
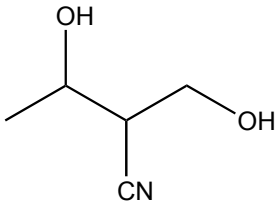
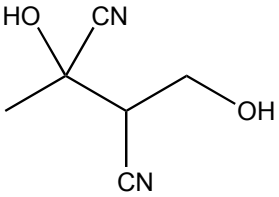
Question	Answer	Marks	AO element	Guidance
				0.02078 OR 0.0208 1 mark 102 and 2 swapped: Energy = $2 \times 4.18 \times 1.5 = 12.54$ J $n = \frac{102}{169} = 0.60355\ldots\ldots$ **ECF** $\Delta H = \frac{0.01254}{0.60355\ldots..}$ = **0.0208** kJ mol^{-1} **----------** **1.06 2 marks** 102 for *n* instead of 2.00: $n = \frac{102}{169} = 0.60355\ldots\ldots$ $\Delta H = \frac{0.63954}{0.60355\ldots..}$ = **1.06** kJ mol^{-1} **OR** 2 for energy instead of 102 Energy = $2 \times 4.18 \times 1.5 = 12.54$ J $\Delta H = \frac{0.01254}{0.0118\ldots..}$ = **1.06** kJ mol^{-1} **----------** **107.4 – 107.7 2 marks** 8.314 for c instead of 4.18: Energy = $102 \times 8.314 \times 1.5 = 1272$ J Energy = $102 \times 8.31 \times 1.5 = 1271.4$ J ΔH = **107.4 – 107.7** kJ mol^{-1} *depends on intermediate rounding* ***CHECK*** **----------** Apply **ECF** for any other comparable responses. If in doubt contact TL

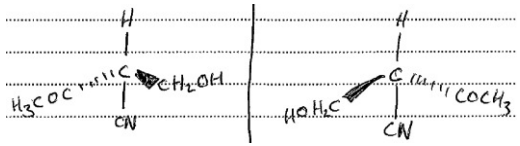
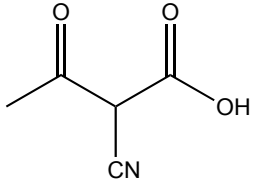
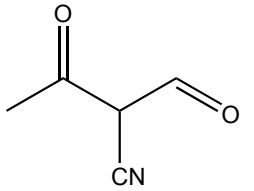
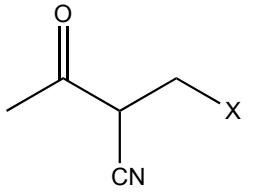
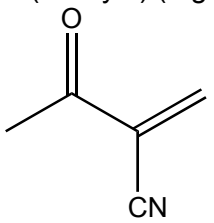
Question	Answer	Marks	AO element	Guidance
(b)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If range = $4.4 \times 10^{-5} – 4.5 \times 10^{-5}$ (kJ mol^{-1}) award 3 marks** --- $[H^+] = 10^{-1.50}$ **OR** 0.0316 … **OR** 0.032 mol dm^{-3} ✓ **1 mark** ***THEN 2 APPROACHES:*** ***EITHER:*** **Factor that concentration changes by** **1 mark** Factor = $\frac{0.0316…..}{0.680}$ = 0.0465… times **OR** $\frac{0.680}{0.0316…..}$ = 21.5….. times ✓ **Initial rate with diluted acid** **1 mark** = 0.0465… × 9.52×10^{-4} **OR** $\frac{9.52 \times 10^{-4}}{21.5…..}$ = 4.43×10^{-5} (mol dm^{-3} s^{-1}) ✓ ***OR:*** **Rate α concentration (1st order)** **1 mark** $k = \frac{\text{rate}}{[HCl]} = \frac{9.52 \times 10^{-4}}{0.680} = 1.4(0) \times 10^{-3}$ **OR** Constant = $\frac{0.680}{9.52 \times 10^{-4}}$ = 714.2857… ✓ **Initial rate with diluted acid** = 1.4(0) × 10^{-3} × 0.0316 … **OR** $\frac{0.0316…}{714.2857…}$ = 4.43×10^{-5} (mol dm^{-3} s^{-1}) ✓	**3**	AO3.1 ×3	Calculator: 0.0316227766 **ALLOW** $10^{-1.5}$ **ECF** possible from incorrect $[H^+]$ From unrounded $[H^+]$, Calculator: 0.04650408324 **From $[H^+]$ = 0.032**, Factor = 21.25 From unrounded $[H^+]$, Calculator = $4.427188724 \times 10^{-5}$ **From $[H^+]$ = 0.032**, rate = 4.48×10^{-5} --- **ECF** possible from incorrect $[H^+]$ **DO NOT ALLOW ECF** unless derived from concentration and rate

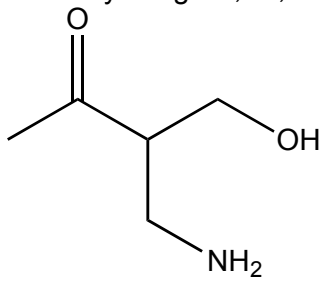
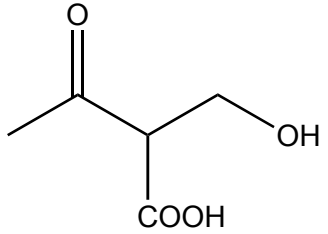
SUMMARY			
M1	**$[H^+]$**	**0.0316…. OR 0.032**	**1 mark**
M2	**Working**	**0.0465 OR 21.5 OR 1.4×10^{-3} OR 714**	**1 mark**
M3	**Initial rate**	**Range: $4.4 \times 10^{-5} – 4.5 \times 10^{-5}$ 2 SF or more** *depends on intermediate rounding* ***CHECK***	**1 mark**

Question	Answer	Marks	AO element	Guidance
(c)	**Mechanism**:  **M1**: Curly arrow from C−N bond to N^+ ✓ **M2**:  **AND** N_2 ✓ **M3**: Curly arrow from lone pair of O of H_2O to C^+ ✓ **M4**  **AND** Curly arrow from O–H bond to O^+ ✓ **For all marks, treat additional curly arrows as CON** **ALLOW M3** shown in bottom box **IGNORE partial charges**	**4**	AO3.2 ×4	**ANNOTATE ANSWER TICKS AND CROSSES** --- **NOTE:** Curly arrows can be straight, snake-like, etc. but **NOT** half arrows **1st curly arrow** must start from, **OR** be traced back to, **any part of** C–N^+ bond and go to N **OR** + of N^+  **2nd curly arrow** must • start from, **OR** be traced back to **any point across width** of lone pair on O of H_2O • go to the C or + of C^+ of $C_6H_5^+$  **3rd curly arrow** must • start from '–' **of O–H** of $–OH_2^+$ • go to O or + of O^+ 

Question	Answer	Marks	AO element	Guidance
	ALLOW M3 AND M4 combined **e.g.**  --- **For**  **DO NOT ALLOW M2** for carbocation **BUT** **ALLOW for M3 and/or M4 by ECF, e.g.** 			**For**  **+ DO NOT ALLOW M2** for carbocation **BUT** **ALLOW for M3 and/or M4 by ECF, e.g.** 

Question	Answer	Marks	AO element	Guidance
3	*Please refer to the marking instructions on page 6 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** Suggests **ALL** of the following • Reagents and conditions for **3** functional groups • Products for **3** functional groups • Optical isomerism with description and 3D optical isomers shown *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)** Suggests **two** of the following • Reagents and conditions for **2** functional groups • Products for **2** functional groups • Optical isomerism with description **OR** an attempt to show 3D optical isomers *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)** Suggests **two** of the following • Reagents and conditions for **1** functional group • Products for **1** functional group • Identifies optical isomerism with description **OR** an attempt to show 3D optical isomers *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 ×3 AO3.2 ×3	**CHECK TOP OF QUESTION FOR RESPONSES** **----------** *Indicative scientific points may include:* **Stereoisomerism** • Optical isomerism identified with description: e.g. chiral centre /non-superimposable mirror images • 3D Optical isomers drawn, e.g.  *Description is subsumed in 3D diagrams* **Reactions of ketone/carbonyl e.g.** $NaBH_4$  HCN **OR** CN^-/H^+ (e.g. $NaCN/H^+$) 

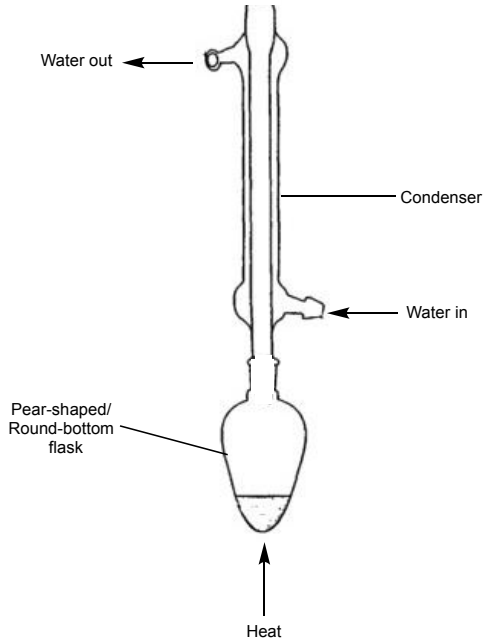
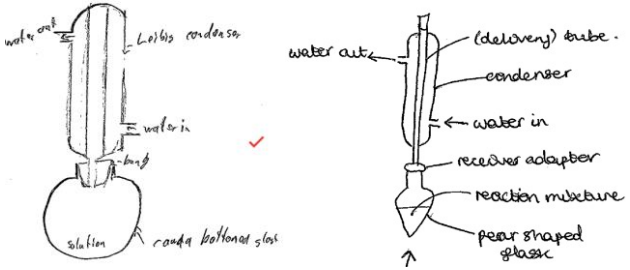
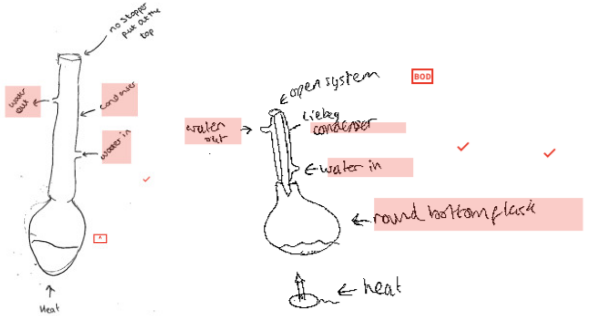
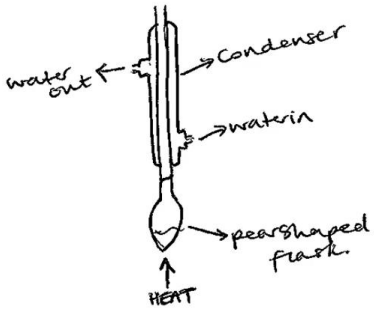
Question	Answer	Marks	AO element	Guidance
	Key points to check *CHECK TOP OF QUESTION for responses* *IGNORE CONNECTIVITY* *in 3D isomer structures* • *IGNORE bond angles* • *Wedges needed* • *ALLOW*  Some responses will not fit into this exact pattern and a best-fit match may be needed **Clear communication** Focus on • Clear diagrams of 3D optical isomers • Diagrams of unambiguous structures • Reagents and functional group formed are linked • Communication is more a general feel for the quality of the responses. **Slips and minor errors in structures** • Do not penalise the odd slip or omission, e.g. An extra C in a chain; a C short in a chain, C shown instead of CH_2 or skeletal • You need to judge the extent of any slip based on the whole response. Remember that each candidate response is unique.			**Reactions of –OH, e.g.** $H^+/Cr_2O_7^{2-}$ **OR** $H_2SO_4/K_2Cr_2O_7$ reflux  $H^+/Cr_2O_7^{2-}$ **OR** $H_2SO_4/K_2Cr_2O_7$ distil  $NaBr/KBr/Br^-$ **AND** $acid/H^+$ **OR** HBr  X = halogen $Acid/H^+$ (catalyst) (e.g. H_2SO_4) 

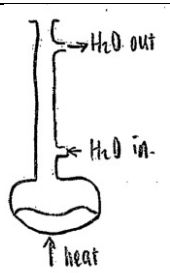
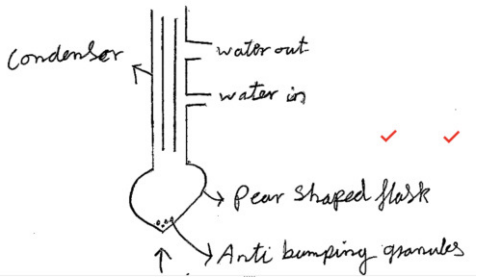
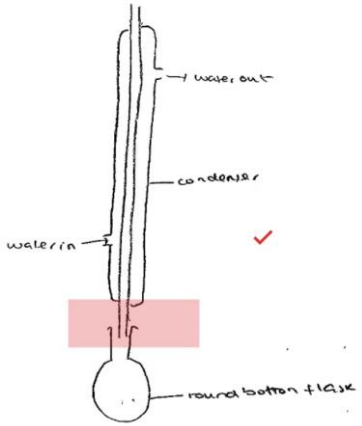
Question			Answer	Marks	AO element	Guidance
						Reactions of C–CN, e.g. H_2 **AND** metal catalyst e.g. Ni, Pt, Pd  H^+/H_2O e.g. HCl(aq) or H_2SO_4(aq)  **OTHER REAGENTS, CONDITIONS AND PRODUCTS** **e.g. $LiAlH_4$ as reagent** **Check with Team Leader**

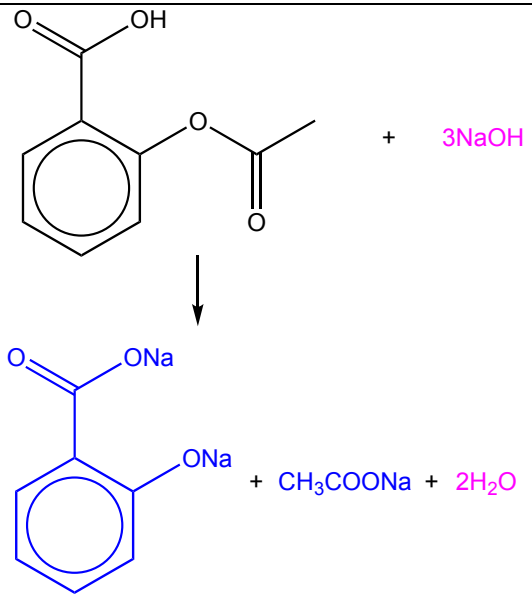
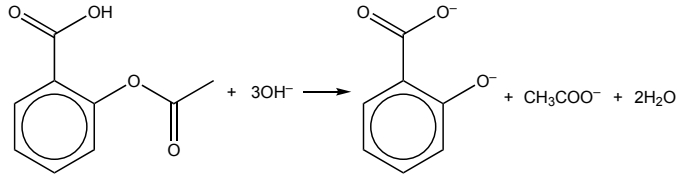
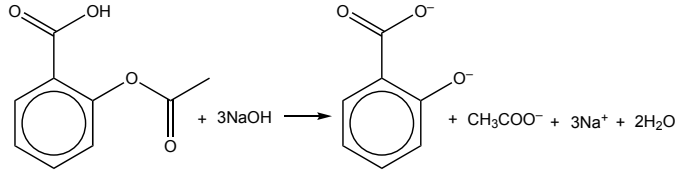
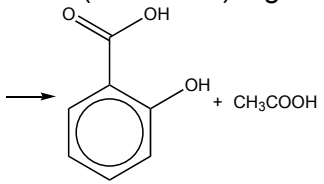
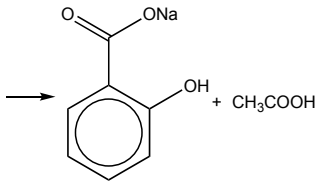
Question			Answer	Marks	AO element	Guidance
4	(a)		Any correct formula for $\mathbf{X}_2\mathbf{Y}(\mathbf{Z}O_4)_2 \cdot 6H_2O$ ✓ with suitable elements for **X**, **Y** and **Z** using information in stem: • **X** can be K, Rb, Cs, Fr **ONLY** • **Y** can be Mg or a transition element in period 4: Ti → Ni • **Z** must be Cr **Example: $K_2Mg(CrO_4)_2 \cdot 6H_2O$**	**1**	AO3.2	Suitable transition elements: Ti, V, Cr, Mn, Fe, Co, Ni • *Cu in in the Tutton's salt in Q4* • *Sc and Zn and not classified as transition elements*
	(b)	(i)	Mass $(NH_4)_2SO_4$ = 3.3025 g ✓ Mass $CuSO_4 \cdot 5H_2O$ = 6.24 g ✓	**2**	AO1.2 ×2	**ALLOW** 3.3, 3.30. 3.303 **ALLOW** 6.2
	(b)	(ii)	• Prevents water of crystallisation from being removed • Anhydrous salt would form • Prevents dehydration ✓	**1**	AO3.4	**IGNORE** all the water would be removed *water is the solvent* **IGNORE** prevents decomposition **IGNORE** increases the size of crystals
	(c)	(i)	$[Cu(NH_3)_4(H_2O)_2]^{2+}$ ✓ **TAKE CARE** with correct brackets, numbers and 2+ charge	**1**	AO2.4	**ALLOW** +2 for charge **IGNORE** $[Cu(NH_3)_4]^{2+}$ H_2O and NH_3 can be in either order, i.e. $[Cu(H_2O)_2(NH_3)_4]^{2+}$

Question			Answer	Marks	AO element	Guidance
	(c)	(ii)	**Formula of precipitate** $Cu(OH)_2$ ✓ **IGNORE** name: copper(II) hydroxide --- **Formula of gas** NH_3 ✓ **IGNORE** name: ammonia --- **Test for ammonia** Available only from a reasonable attempt for identifying the gas as NH_3, e.g. NH_4, NH_4^+, NH_2, ammonia, ammonium (Moist/damp) indicator/litmus (paper) turns blue ✓ Moist/damp **NOT** required. Initial colour of litmus **NOT** required but *blue* is **CON**	**3**	AO2.3 ×3	**ALLOW** $Cu(OH)_2(H_2O)_4$ **ALLOW** charges on Cu **AND** OH e.g. $Cu^{2+}(OH^-)_2$ ✓ **DO NOT ALLOW** unbalanced charges. e.g. $Cu(OH^-)_2$ ✖ --- **DO NOT ALLOW** correct test for NH_3 based on incorrect ID of the gas **NO ECF** for a test on the wrong gas (has to be test for NH_3) **DO NOT ALLOW** bleaches indicator **CON**
	(c)	(iii)	**Reagent** $BaCl_2$ / barium chloride (solution) **OR** $Ba(NO_3)_2$ / barium nitrate (solution) **OR** Ba^{2+} (solution/aq) / barium ions ✓ **Observation** **white** precipitate/ppt ✓ Only available from soluble Ba^{2+} reagent **ALLOW** minor slips in formula of Ba^{2+} reagent, e.g. BaCl, $BaNO_3$	**2**	AO2.3 ×2	**ALLOW** $Ba(OH)_2$ or other **soluble** Ba^{2+} compounds --- **IGNORE** test for other anions provided they do **NOT** interfere with SO_4^{2-} test **e.g.** **IGNORE** addition of $HCl/HNO_3/H^+$ **BUT DO NOT ALLOW** H_2SO_4 *Interferes with SO_4^{2-} test* **IGNORE** $Ag^+/AgNO_3$ **after** SO_4^{2-} test **DO NOT ALLOW before** SO_4^{2-} test **IGNORE** bubbling any gas through limewater **IGNORE** responses linked to CrO_4^{2-} *Not in Tutton's salt that student prepares*

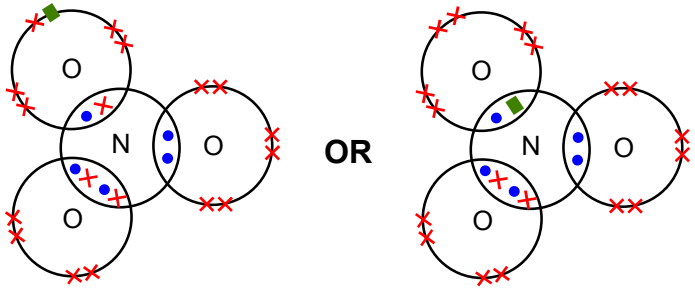
Question			Answer	Marks	AO element	Guidance
5	(a)		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If Mass = 318 (mg) award 6 marks** --- **Mean titre** **1 mark** $= \frac{(22.30 + 22.40)}{2} = 22.35(0)$ (cm^3) ✓ **Analysis of results** **5 marks** $n(HCl) = 0.200 \times \frac{22.35}{1000} = 4.47 \times 10^{-3}$ (mol) ✓ n(NaOH) remaining in 25.0 cm^3 = n(HCl) n(NaOH) remaining in 250 cm^3 $= 4.47 \times 10^{-3} \times 10 = 4.47 \times 10^{-2}$ **OR** 0.0447 (mol) ✓ n(NaOH) that reacted with **aspirin** $= 0.0500 - 4.47 \times 10^{-2} = 5.30 \times 10^{-3}$ (mol) ✓ mass in 3 tablets = $5.30 \times 10^{-3} \times 180 = 0.954$ g ✓ Mass in 1 tablet = 318 mg ✓	6	AO2.8 ×6	***FULL ANNOTATIONS MUST BE USED*** --- **Common error:** Incorrect mean from all 3 titres = 22.6 cm^3 **CHECK BELOW TITRATION TABLE** **Use ECF throughout** Intermediate values for working to **at least 3 SF.** **ALLOW** scaling for 1 aspirin tablet early in calc, e.g. for final 2 marks: n(aspirin) in 1 tablet = $\frac{5.30 \times 10^{-3}}{3} = 1.77\ldots \times 10^{-3}$ (mol) ✓ Mass in 1 tablet = $1.77\ldots \times 10^{-3} \times 180 = 0.318$ g = 318 mg ✓
			COMMON ERRORS: *No scaling × 10* $0.05 - 4.47 \times 10^{-3} \rightarrow 4.553 \times 10^{-2}$ ✓ $4.553 \times 10^{-2} \times 180 \rightarrow 8.1954$ g in 3 tablets ✓ → **2731.8/2732/2730 mg** in 1 tablet ✓ *5 marks* --- *No scaling × 10 before subtraction but scaling after* *4 marks* $0.05 - 4.47 \times 10^{-3} \rightarrow 4.553 \times 10^{-2}$ ✓ $4.553 \times 10^{-2} \times 10 \times 180 \rightarrow 81954$ g in 3 tablets ✗ → **27318 / 27320 / 27300 mg** in 1 tablet ✓			*No subtraction from 0.05* *5 marks* $\rightarrow 4.47 \times 10^{-2} \times 180 \rightarrow 8.046 \rightarrow$ **2682/2680 mg** in 1 tablet --- *Omitting initial titration calculation* *2 marks* $0.05 \times 180 \rightarrow 9$ g in 3 tablets ✓ → **3000 mg** in 1 tablet ✓ --- Mean of 22.60 (use of all 3 titres) *5 marks* Mean = 67.8/3 = 22.60 ✗→ 4.52×10^{-3} ✓ ×10 → 4.52×10^{-2} ✓ $0.05 - 4.52 \times 10^{-2} \rightarrow 4.80 \times 10^{-3}$ ✓ $4.80 \times 10^{-3} \times 180 \rightarrow 0.864$ g in 3 tablets ✓ → **288 mg** in 1 tablet ✓

Question			Answer	Marks	AO element	Guidance
	(b)	(i)	 **Reaction apparatus (Labels NOT required)** flask **AND** upright condenser **AND** open system at top ✓ *(Could be labelled)* **Labels AND direction of water flow** Pear-shaped/round-bottom flask **AND** condenser **AND** water in at bottom and out at top ✓ Heat **NOT** required **DO NOT ALLOW** flask, conical flask, volumetric flask **DO NOT ALLOW** thermometer **DO NOT ALLOW** condensing tube as label	**2**	AO3.3 ×2	For open system, **DO NOT ALLOW**  **For open system, ALLOW** label. e.g. 'open at top'  **ALLOW** line across flask 

Question			Answer	Marks	AO element	Guidance
						  **ALLOW small** gap between flask and condenser **BOD,** e.g.  **If in doubt, ask Team Leader**

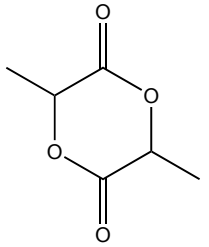
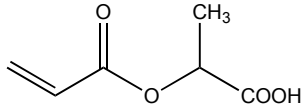
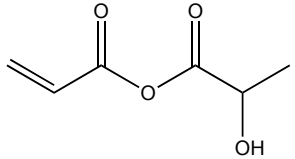
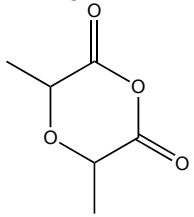
Question			Answer	Marks	AO element	Guidance
	(b)	(ii)	 Organic products ✓ ✓ ***2 marks*** 3NaOH **AND** $2H_2O$ ✓ ***1 mark*** **NOTE: ALLOW** O^-Na^+ for ONa throughout **SCROLL DOWN FOR PRODUCTS**	**3**	AO2.6 ×3	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous **IGNORE** annotations of provided structure of aspirin at top left **ALLOW** equation with $3OH^-$ **OR** 3NaOH giving anions for organic products, i.e. i.e.  **OR**  **ALLOW** 1 of the 2 organic products mark for BOTH structures as COOH and OH (or mixture) e.g  

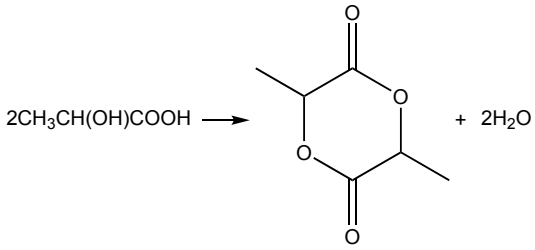
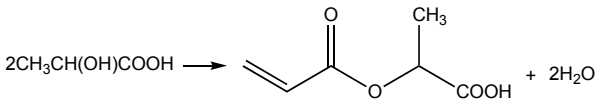
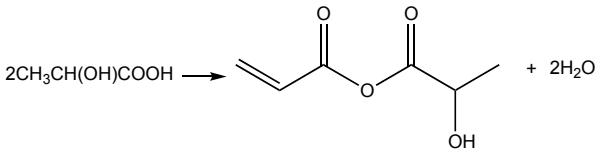
Question			Answer	Marks	AO element	Guidance
6	(a)		**H–O–N** 104.5º ✓ 2 bonded pairs/regions **AND** 2 lone pairs (around O) **AND** lone pairs repel more ✓ *Independent of bond angle* **O–N–O** 120º ✓ 3 bonded regions/pairs (around N) ✓ *Independent of bond angle*	**4**	AO1.2 AO2.1 AO1.2 AO2.1	**Throughout,** • **IGNORE** names of shapes (even if wrong) • **IGNORE** 'electrons repel' • **DO NOT ALLOW** 'atoms repel' --- **ALLOW** 104–105º **ALLOW** lp for lone pair (of electrons) bp for bonding pair (of electrons) 'bond' for 'bonded pair' **IGNORE** electron density **ALLOW** 115–125º **ALLOW** 3 bonded areas/environments 3 regions/areas of electron density 3 bonded groups **ALLOW** 2 bonded pairs and 1 double bond **OR** 2 bonded pairs and 1 bonded region
	(b)	(i)	$Al_2O_3 + 6HNO_3 \rightarrow 2Al(NO_3)_3 + 3H_2O$ Any **THREE** species correct ✓ Correct balanced equation ✓ **DO NOT ALLOW** more than 4 species in equation	**2**	AO2.5 AO2.6	**ALLOW** multiples **IGNORE** state symbols (even if wrong) **ALLOW ionic equation** $Al_2O_3 + 6H^+ \rightarrow 2Al^{3+} + 3H_2O$ Mark using same criteria

Question			Answer	Marks	AO element	Guidance
	(b)	(ii)	Always 5 ● around N ■ unbonded ■ paired in O–N  × 3 ✕ around N × 2 ✕ + 1 ■ around N × ● = N electron ✕ = O electron ■ = extra electron **1st mark**: 8 Electrons around N as above 1 single covalent bond, 1 dative covalent bond 1 double bond **2nd mark**: 8 electrons around each O **AND** 6 O electrons around each O Only award 2nd mark if 1st mark awarded **NO ECF**	**2**	AO2.1 AO2.5	**NOT REQUIRED** • Charge ('–') • Brackets • Circles • N and O symbols **IGNORE** inner shells **ALLOW** rotated diagram In **N=O bond**, **ALLOW** sequence × × • • **ALLOW** non-bonding electrons unpaired **ALLOW** dot and cross labels swapped: i.e. • for O electrons and × for N electrons

Question			Answer	Marks	AO element	Guidance
	(c)	(i)	Au + 4 HCl → 4 H^+ + $AuCl_4^-$ + 3 e^- ✓	1	AO1.2	
	(c)	(ii)	**Formulae** **X** = NO ✓ **Z** = H_2O ✓ **Equation** **Independent from ID of X and Z** HNO_3 + 3 H^+ + 3 e^- → NO + 2 H_2O **OR** NO_3^- + 4 H^+ + 3 e^- → NO + 2 H_2O ✓ **CHECK BELOW ANSWER SPACE FOR RESPONSES**	3	AO3.1 ×3	If **X** and **Z** in wrong order award 1 out of 2 formula marks i.e. **X** = H_2O and **Z** = NO *1 mark* **ALLOW** multiples

Question	Answer	Marks	AO element	Guidance
(d)	**FIRST CHECK THE ANSWERS ON ANSWER LINE** **If K_c value = 2931 OR 2930 award 4 calc marks** **If units = $dm^3\ mol^{-1}$ OR $mol^{-1}\ dm^3$ award 1 unit mark** --- **SO_2 and O_2 equilibrium moles** **$n(SO_2) = 6.20 \times 10^{-3}$** ($5.82 \times 10^{-2} - 5.20 \times 10^{-2}$) **AND $n(O_2) = 4.80 \times 10^{-2}$** ✓ ($7.4 \times 10^{-2} - \frac{5.20 \times 10^{-2}}{2}$) **Equilibrium concentrations (moles ÷ 2)** $[SO_2]$ = **3.10×10^{-3}** $\frac{6.20 \times 10^{-3}}{2}$ (mol dm^{-3}) **AND** $[O_2]$ = **2.40×10^{-2}** $\frac{4.80 \times 10^{-2}}{2}$ (mol dm^{-3}) **AND** $[SO_3]$ = **2.60×10^{-2}** ✓ $\frac{5.20 \times 10^{-2}}{2}$ (mol dm^{-3}) **K_c calculation** $K_c = \frac{(2.60 \times 10^{-2})^2}{(3.10 \times 10^{-3})^2 (2.40 \times 10^{-2})}$ ✓ = 2,930 **OR** 2,931 ✓ **At least 3 SF** required *Calc value from unrounded values: 2,930.974679* **Units** $dm^3\ mol^{-1}$ ✓ **DO NOT ALLOW** $dm^3\ mol^{-}$ **For units, ALLOW ECF** using incorrect K_c expression Units must match K_c expression used	**5**	AO2.6 ×3 AO1.2 ×2	**Use of fractions is fine but final answer MUST be shown using normal numbers** --- **COMMON ERRORS** **K_c = 1,465** (2,930/2) → ***3 calc marks*** Moles **not** converted to concentration (No ÷2) $\frac{(5.20 \times 10^{-2})^2}{(6.2 \times 10^{-3})^2 (4.80 \times 10^{-2})}$ --- **K_c = 21.6** → ***3 calc marks*** Original values used, $\frac{(2.60 \times 10^{-2})^2}{(2.91 \times 10^{-2})^2 (3.70 \times 10^{-2})}$ --- **K_c = 10.8** → ***2 calc marks*** Original values used and no ÷2, $\frac{(5.20 \times 10^{-2})^2}{(5.82 \times 10^{-3})^2 (7.40 \times 10^{-2})}$ --- **K_c = 732.74** → **3 *calc marks*** × 2 instead of ÷ 2 for concentration $\frac{(0.104)^2}{(0.0124)^2 (0.096)}$ --- **K_c = 112729.8** → **3 *calc marks*** 2.60×10^{-2} not squared $\frac{(2.60 \times 10^{-2})}{(3.10 \times 10^{-3})^2 (2.40 \times 10^{-2})}$ --- **$K_c = 3.41\ldots \times 10^{-4}$** Calculator $3.41183432 \times 10^{-4}$ Inverted K_c → **3 *calc marks*** $\frac{(3.10 \times 10^{-3})^2 (2.40 \times 10^{-2})}{(2.60 \times 10^{-2})^2}$ Units mol dm^{-3}

Question	Answer	Marks	AO element	Guidance
(e)*	*Please refer to the marking instructions on page 6 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** • Reaches a comprehensive conclusion to determine all **three** correct formulae of **D**, **E AND F** • **AND** constructs most equations with few 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)** • Reaches a comprehensive conclusion to determine **two** correct formulae of **D**, **E AND F** • **AND** constructs some equations with some errors *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)** • Determines a correct formula for **one** of **D, E AND F** • **AND** provides some evidence to support the formula *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.* **EQUATIONS SHOULD BE USED TO INFORM THE COMMUNICATION STRAND** *See next page for details* *CHECK TOP OF QUESTION FOR RESPONSES* *IGNORE CONNECTIVITY FOR F*	**6**	AO3.1 ×3 AO3.2 ×3	**Indicative scientific points may include:** **Identify of D, E and F** • **D:** $NiSO_4•6H_2O$ **OR** $NiSO_4(H_2O)_6$ **OR** $NiSO_{10}H_{12}$ • **E**: SO_2 • **F**: **Cyclic diester**  **OR unsaturated ester/acid**  **OR unsaturated acid anhydride**  **OR cyclic acid anhydride** 

Question	Answer	Marks	AO element	Guidance
	SUMMARY **Setting the level** **For Level 3 (5–6 marks)**, • All 3 identified: **D**, **E** and **F** • Most equations **For Level 2 (3–4 marks)**, • 2 identified from **D**, **E** and **F** • 2 equations **For Level 1 (1–2 marks)**, • 1 identified from **D**, **E** and **F** • Evidence --- **Evidence to support a formula for Level 1** ***Molar ratios of D*** Ni : S : O : H $\frac{22.33}{58.7} : \frac{12.20}{32.1} : \frac{60.87}{16.0} : \frac{4.60}{1.0}$ 0.38 : 0.38 : 3.80 : 4.60 1 : 1 : 10 : 12 **OR** $NiSO_{10}H_{12}$ --- **Molar mass of E** Molar mass = $2.67 \times 24 = 64(.08)$ g mol^{-1}			**Equations** $H_2SO_4 + Ni(OH)_2 \rightarrow NiSO_4 + 2H_2O$ **OR** $H_2SO_4 + Ni(OH)_2 + 4H_2O \rightarrow NiSO_4{\bullet}6H_2O$ For equation **ALLOW** $NiSO_4{\bullet}6H_2O$ **OR** $NiSO_4(H_2O)_6$ --- $H_2SO_4 + 2HBr \rightarrow Br_2 + SO_2 + 2H_2O$  **OR**  **OR**  If structure of **F** is shown, **ALLOW** equation using molecular formulae, e.g. $2\ C_3H_6O_3 \rightarrow C_6H_8O_4 + 2H_2O$

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