

Unified chemistry

June 2024 exam series

MARK SCHEME

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GCE

Chemistry A

H432/03: Unified chemistry

A Level

Mark Scheme for June 2024

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

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

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

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

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

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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. Award No Response (NR) if:
 - there is nothing written in the answer space

Award Zero '0' if:

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

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

8. The RM Assessor **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

If you have any questions or comments for your Team Leader, use the phone, the RM Assessor messaging system, or email.

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by levels of response:

Read through the whole answer from start to finish, using the Level descriptors to help you decide whether it is a strong or weak answer. The indicative scientific content in the Guidance column indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance. Using a 'best-fit' approach based on the skills and science content evidenced within the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer.

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

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

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

In summary:

The skills and science content determines the level.

The communication statement determines the mark within a level.

Level of response questions on this paper are **Q3b(iv)** and **Q5b(ii)**.

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 

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

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	Guidance
			- The start of Q1a shows pages 18 and 20 of the QP. - These pages MUST be annotated to show that they have been looked at. Use 'BP' OR 'SEEN' when pages 18 and 20 contain no responses. - LINK Pages 18 and 20 NOW before starting to mark Q1a.		
1	(a)		FIRST, CHECK THE ANSWER ON ANSWER LINE IF pH = 13.6(0), award 2 marks ----- $K_w = [H^+] \times 0.400$ OR $1.00 \times 10^{-14} = [H^+] \times 0.400$ OR $[H^+] = \frac{K_w}{0.400}$ OR $[H^+] = \frac{1.00 \times 10^{-14}}{0.400}$ OR $[H^+] = 2.5 \times 10^{-14} \checkmark$ $pH = -\log 2.5 \times 10^{-14} = 13.6(0) \checkmark$ ALLOW 13.6..... up to calculator value of 13.60205999 correctly rounded	2	ALLOW ECF from incorrect $[H^+]$ calculated from $[OH^-]$ AND K_w for pH > 7 ONLY ALLOW method based on pOH: pOH = $-\log 0.400 = 0.40 \checkmark$ <i>Calculator: 0.39794...</i> pH = $14 - 0.40 = 13.6(0) \checkmark$
	(b)		FIRST, CHECK THE ANSWER ON ANSWER LINE IF pH = 1.12, award 1 mark ----- $pH = -\log 0.075 = 1.12 \checkmark$ 2 DP required	1	

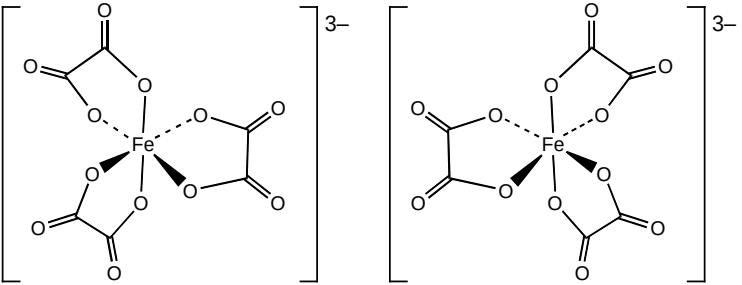
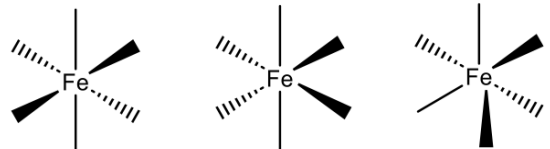
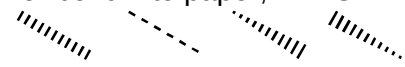
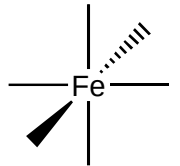
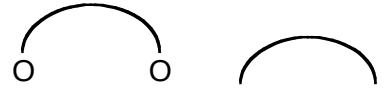
Question	Answer	Marks	Guidance
(c)	FIRST, CHECK THE ANSWER ON ANSWER LINE IF pH = 4.28, award 2 marks $1.75 \times 10^{-5} = \frac{[\text{H}^+] \times 0.100}{0.300}$ OR $[\text{H}^+] = \frac{1.75 \times 10^{-5} \times 0.300}{0.100}$ OR $[\text{H}^+] = 5.25 \times 10^{-5} \text{ (mol dm}^{-3}\text{)} \checkmark$ $\text{pH} = -\log 5.25 \times 10^{-5} = 4.28 \checkmark$ 2 DP required	2	COMMON ERRORS 1 mark for 5.23 inverted $[\text{HA}]$ and $[\text{A}^-]$ $[\text{H}^+] = \frac{1.75 \times 10^{-5} \times 0.100}{0.300}$ OR $5.83 \dots \times 10^{-6} \quad \times$ $\text{pH} = -\log 5.83 \dots \times 10^{-6} = \mathbf{5.23} \checkmark$ ECF 1 mark for 4.46 $[\text{HA}] = 0.2$ instead of 0.3 $[\text{H}^+] = \frac{1.75 \times 10^{-5} \times 0.200}{0.100}$ OR $3.5 \times 10^{-5} \quad \times$ $\text{pH} = -\log 3.5 \times 10^{-5} = \mathbf{4.46} \checkmark$ ECF Other ECF available from ONE transcription error ONLY, e.g. 1.57×10^{-5} for $K_{\text{a}} = 1.75 \times 10^{-5}$ Zero marks for square root approach e.g. via $K_{\text{a}} = \frac{[\text{H}^+]^2}{0.300}$ Zero marks for $[\text{A}^-] : [\text{HA}] = 0.1 : 0.1$ i.e. $[\text{H}^+] = \frac{1.75 \times 10^{-5} \times 0.100}{0.100} = 1.75 \times 10^{-5} \times$ $\text{pH} = 4.76 \times$ ALLOW Henderson-Hasselbalch for both marks: e.g. $\text{pH} = 4.76 + \log \frac{0.100}{0.300}$ OR $\text{pH} = -\log(1.75 \times 10^{-5}) + \log \frac{0.100}{0.300} \checkmark$ OR $\text{pH} = -\log(1.75 \times 10^{-5}) - \log \frac{0.300}{0.100}$ $\text{pH} = \mathbf{4.28} \checkmark$

Question	Answer	Marks	Guidance
(d)	Calculation 2 marks $n(\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}) = 0.200 \times \frac{100}{1000}$ OR $2(.00) \times 10^{-2} \text{ (mol)}$ OR $0.02(00)$ ✓ Mass $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O} = 2.00 \times 10^{-2} \times 241.5 = \mathbf{4.83 \text{ (g)}}$ ✓ 2 or more DP to match balances Method 3 marks Dissolve solid in (distilled) water (less than 100 cm^3) (in beaker) ✓ Transfer (solution) to volumetric flask AND Wash/rinse (from beaker to flask) ✓ Make up to mark/up to 100 cm^3 with (distilled water) AND Invert flask (several times to ensure mixing) ✓	5	FULL ANNOTATIONS MUST BE USED ALLOW ECF throughout ----- ALLOW ECF from incorrect $n(\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O})$ 4.83 g subsumes 1st mark ALLOW small amount/some DO NOT ALLOW 100 cm^3 or more of water IGNORE solvent ALLOW graduated flask ASSUME that wash/rinse is to a volumetric flask ALLOW swirl/shake ----- ALLOW preparation of solutions $> 100 \text{ cm}^3$ 4 marks e.g. for 250 cm^3 $n(\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}) = 0.200 \times \frac{250}{1000} \text{ OR } 0.05 \text{ (mol)} \times$ Mass $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O} = 0.05 \times 241.5 = \mathbf{12.075 \text{ (g)}}$ ✓ Then method adapted for 250 cm^3 volumetric flask e.g. Make up to 250 cm^3 with water

Question			Answer	Marks	Guidance
2	(a)	(i)	Bonds are breaking AND endothermic OR energy is required/needed ✓ IGNORE 'overcome' for 'break'	1	IGNORE 'more energy needed to break bonds than released in making bonds' <i>Unclear whether response refers to bond breaking or overall enthalpy change</i>
	(a)	(ii)	FIRST, CHECK THE ANSWER ON ANSWER LINE IF bond enthalpy = (+)413 (kJ mol⁻¹) award 3 marks Energy for bonds made ($3 \times \text{H-H} + 1 \times \text{C}\equiv\text{O}$) 1 mark $3 \times 436 + 1 \times 1077$ OR $1308 + 1077$ OR 2385 (kJ) ✓ IGNORE sign 4C–H bond enthalpy correctly calculated 1 mark $4 \times \text{C-H bond enthalpy} = 195 + 2385 - (2 \times \text{O-H})$ $= 195 + 2385 - 2 \times 464$ $= 195 + 2385 - 928$ $= \mathbf{1652}$ (kJ mol ⁻¹) ✓ IGNORE sign C–H bond enthalpy correctly calculated 1 mark **This mark is NOT available from TWO previous errors OR from $\Delta H = 195$ not being used ** $\text{C-H bond enthalpy} = \frac{1652}{4}$ $= (+)\mathbf{413}$ kJ mol ⁻¹ ✓ For the final answer, DO NOT ALLOW value with a negative sign COMMON ERRORS -413 → 2 marks <i>Wrong sign for answer</i> 304 → 2 marks <i>2 mol of H₂ instead of 3 mol:</i> $2 \times 436 + 1 \times 1077 = 872 + 1077 = 1949$ ✗ $195 + 1949 - 928 = 1216$ ECF ✓ $1216/4 = \mathbf{304}$ ECF ✓	3	COMMON ERRORS ECF for other numbers 315.5 OR 316 → 2 marks <i>Wrong sign for 195</i> Bonds made = 2385 ✓ $-195 + 2385 - 928 = 1262$ ✗ $1262/4 = \mathbf{315.5 OR 316}$ ✓ ECF 877 → 2 marks <i>Wrong sign for 928</i> Bonds made = 2385 ✓ $195 + 2385 + 928 = 3508$ ✗ $3508/4 = \mathbf{877}$ ✓ ECF 364 → 1 mark <i>Missing ΔH, (195)</i> <i>Potentially 2 errors: missing 195 and sign for 195</i> Bonds made = 2385 ✓ $2385 - 928 = 1457$ ✗ $1457/4 = \mathbf{364/ 364.3 /364.25}$ ✗ NO ECF 779.5 OR 780 → 1 mark <i>Wrong sign for 928 AND 195</i> Bonds made = 2385 ✓ $-195 + 2385 + 928 = 3118$ ✗ $3118/4 = \mathbf{779.5}$ ✗ NO ECF 529 → 2 marks <i>1 O–H instead of 2 O–H:</i> Bonds made = 2385 ✓ $195 + 2385 - 464 = 2116$ ✗ $2116/4 = \mathbf{529}$ ✓ ECF 181 → 2 marks <i>4 O–H instead of 2 O–H:</i> Bonds made = 2385 ✓ $195 + 2385 - 1856 = 724$ ✗ $724/4 = \mathbf{181}$ ✓ ECF

Question	Answer	Marks	Guidance
(a) (iii)	FIRST, CHECK THE ANSWER ON ANSWER LINE IF energy released = 7.15×10^5 kJ, award 2 marks $n(\text{H}_2) = \frac{60.0 \times 10^3}{24.0} = \mathbf{2500} \text{ (mol) } \checkmark$ Energy released = $2500 \times 285.8 = \mathbf{7.15 \times 10^5}$ kJ $\checkmark$ 3SF AND standard form required IGNORE sign i.e. ALLOW + OR – OR no sign	2	ALLOW ECF ONLY from incorrect $n(\text{H}_2)$ based on with incorrect unit conversion from m^3 e.g. $n(\text{H}_2) = \frac{60.0 \times 10^2}{24.0} = 250 \text{ (mol) } \times$ $250 \times 285.8 = 7.15 \times 10^4 \text{ kJ ECF } \checkmark$ So ALLOW 1 mark for: $\pm 7.15 \times 10^x$ (unit conversion) 7.145×10^5 (not 3SF) 715000 (not standard form) ALLOW use of ideal gas equation with a sensible temperature (290–298K) and pressure (100/101/101325 kPa) e.g. e.g. At 293K and 100 kPa, $n(\text{H}_2) = \frac{100 \times 10^3 \times 60.0}{8.314 \times 293} = 2463... \text{ (mol)}$ $\rightarrow 2463 \times 285.8 = \mathbf{7.04 \times 10^5}$ kJ e.g. At 298K and 100 kPa, $n(\text{H}_2) = \frac{100 \times 10^3 \times 60.0}{8.314 \times 298} = 2421.7... \text{ (mol)}$ $\rightarrow 2421.7 \times 285.8 = \mathbf{6.92 \times 10^5}$ kJ ALLOW use of 8.31 for R (same answers) 293K $\rightarrow 2464.24 \times 285.8 = \mathbf{7.04 \times 10^5}$ kJ 298K $\rightarrow 2422.89 \times 285.8 = \mathbf{6.92 \times 10^5}$ kJ

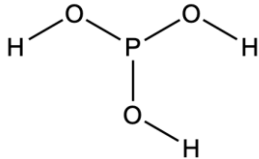
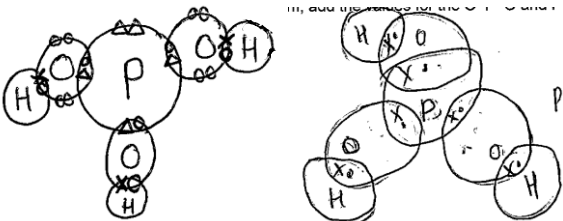
Question			Answer	Marks	Guidance
	(b)	(i)	$\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{AgCl}(\text{s})$ ✓	1	ALL 3 state symbols required
	(b)	(ii)	$n(\text{AgNO}_3)$ 1 mark $= 2.50 \times 10^{-2} \times 60.0/1000 = 1.5(0) \times 10^{-3} (\text{mol})$ ✓ Essential mark Formula 2 marks Ratio $5.00 \times 10^{-4} \text{ mol A contains } 1.5(0) \times 10^{-3} \text{ mol Cl}$ OR $\text{ratio A : Cl} = 1.5(0) \times 10^{-3} \div 5.00 \times 10^{-4} = 1 : 3$ ✓ Formula $= \text{AlCl}_3$ ✓ Automatically subsumes 1:3 ratio mark ALLOW Al_2Cl_6 ALLOW PCl_3	3	Check equation from 2b(i) at top of response ALLOW 1:3 or 3:1 ratio seen anywhere, e.g. XCl_3 ALLOW ECF from formula of silver chloride in 2b(i) e.g. From AgCl_2 $n(\text{Cl}) = 2 \times 1.5(0) \times 10^{-3} = 3.00 \times 10^{-3} (\text{mol})$ ratio = 1 : 6 Formula = SCl_6
	(c)	(i)	$\text{C}_{13}\text{H}_{19}\text{N}_3\text{O}_7$ ✓	1	ALLOW elements in formula in any order e.g. $\text{C}_{13}\text{H}_{19}\text{O}_7\text{N}_3$
	(c)	(ii)	4 ✓	1	
	(c)	(iii)	FIRST, CHECK THE ANSWER ON ANSWER LINE IF difference = 61.7, award 2 marks ----- M_r of C = 380 OR M_r of D = 441.7 ✓ Correct difference = $441.7 - 380 = 61.7$ ✓ AWARD mark for correct answer of 61.7 only	2	ALLOW other approaches based on different atoms in C and D, e.g. Difference = $7 \times (32.1 - 16) - 3 \times (31 - 14)$ $= 112.7 - 51 = 61.7$ ✓ Check answer from 2c(i) at top of response for ECF ALLOW ECF from incorrect formula from 2c(i) e.g. From $\text{C}_{12}\text{H}_{16}\text{N}_3\text{O}_6$ M_r of C = 349 OR M_r of D = 394.6 ✓ ECF difference = $394.6 - 349 = 45.6$ ✓ ECF

Question	Answer	Marks	Guidance
3 (a) (i)	species with two lone pairs (of electrons) ✓ forming dative (covalent)/ co-ordinate bond(s) OR donates electrons to a (central) metal atom/ion ✓	2	ALLOW species with lone pairs that form two dative/coordinate bonds ✓✓ ALLOW non-bonding pair for lone pair IGNORE LP for lone pair IGNORE donates two pairs of electrons alone
(a) (ii)	Charge Overall 3– charge shown (outside brackets) on at least ONE optical isomer ✓ 3– <i>must apply to the overall charge of structures</i> ----- 3D structures  1 mark for each isomer ✓✓ Bonds MUST go to O[–] of (COO[–])₂ ligands DO NOT ALLOW impossible 3D diagrams, e.g. 	3	IGNORE charges or dipoles on atoms within diagrams (even if wrong) Square brackets NOT required ALLOW unambiguous structures ----- ALLOW –3 for 3– ----- 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 :  ALLOW following geometry throughout:  DO NOT ALLOW 3D structures simplified loop for oxalate, e.g.  For incorrect element in centre, e.g. Cu, AWARD 2 marks max

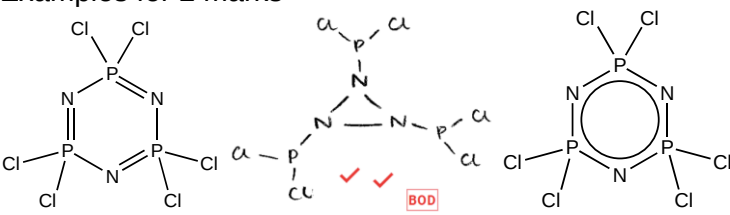
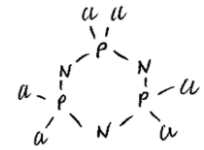
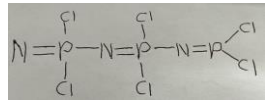
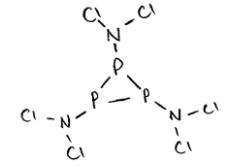
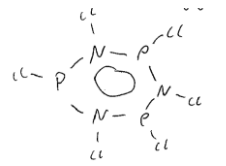
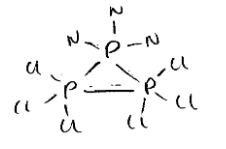
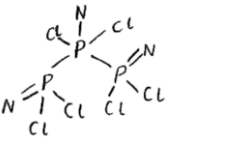
Question			Answer				Marks	Guidance													
	(b)	(i)	$\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + \text{e}^{-} \checkmark$ OR $\text{Fe}^{2+} - \text{e}^{-} \rightarrow \text{Fe}^{3+}$ $\text{C}_2\text{O}_4^{2-} \rightarrow 2\text{CO}_2 + 2\text{e}^{-} \checkmark$ OR $\text{C}_2\text{O}_4^{2-} - 2\text{e}^{-} \rightarrow 2\text{CO}_2$				2	For both half-equations, ALLOW multiples ALLOW e for e ⁻ IGNORE state symbols. ALLOW $\text{C}_2\text{O}_4^{2-} \rightarrow \text{C}_2\text{O}_4^{-} + \text{e}^{-}$ $\text{C}_2\text{O}_4^{2-} \rightarrow \text{C}_2\text{O}_4 + 2\text{e}^{-}$ $2\text{H}_2\text{O} + \text{C}_2\text{O}_4^{2-} \rightarrow 2\text{CO}_3^{2-} + 4\text{H}^{+} + 2\text{e}^{-}$ ALLOW $2\text{C}_2\text{O}_4^{2-} \rightarrow \text{C}_4\text{O}_8^{2-} + 2\text{e}^{-}$													
	(b)	(ii)	<table><tr><td></td><td>1</td><td>2</td><td>3</td></tr><tr><td>Final reading/cm³</td><td>23.55</td><td>45.40</td><td>22.75</td></tr><tr><td>Initial reading/cm³</td><td>1.90</td><td>23.55</td><td>1.20</td></tr><tr><td>Titre/cm³</td><td>21.65</td><td>21.85</td><td>21.55</td></tr></table> Readings recorded to accuracy of burette All readings recorded to two decimal places with the last figure either 0 or 5 AND Final and initial readings in correct rows ✓ Correct titres All 3 titres correct to 2 DP: ✓✓ 2 titres correct to 2 DP: ✓		1	2	3	Final reading/cm ³	23.55	45.40	22.75	Initial reading/cm ³	1.90	23.55	1.20	Titre/cm ³	21.65	21.85	21.55	3	
	1	2	3																		
Final reading/cm ³	23.55	45.40	22.75																		
Initial reading/cm ³	1.90	23.55	1.20																		
Titre/cm ³	21.65	21.85	21.55																		
	(b)	(iii)	FIRST, CHECK THE ANSWER ON ANSWER LINE IF % error = 0.46, award 1 mark ----- $\frac{2 \times 0.05}{21.65} \times 100 = 0.46 \text{ (\%)} \checkmark$ 2 DP minimum Calculator value: 0.46189...				1	Check Titres from 3b(ii) at top of response ----- ALLOW % error from ANY of the 3 titres from 3b(ii) OR from the mean titre DO NOT ALLOW 0.50%													

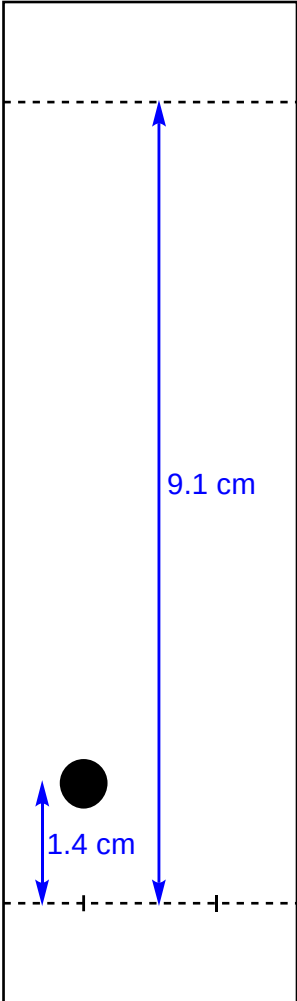
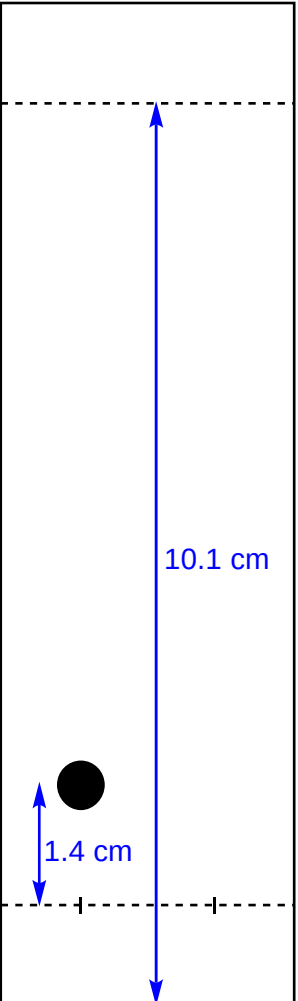
Question	Answer	Marks	Guidance
(b)* (iv)	Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) Analyses the results to calculate the correct amount of MnO_4^- using the correct mean titre from the candidate's titres AND Obtains correct value of x as 2 <i>There is a well-developed line of reasoning which is clear and logically structured.</i> <i>The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Analyses titration results to determine an amount of MnO_4^- from a mean titre of the candidate's titres AND amount of FeC_2O_4 in 25.0 cm^3 OR 250 cm^3 OR uses a mass of FeC_2O_4 to obtain a value of x with few errors <i>There is a line of reasoning presented with some structure.</i> <i>The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) Analyses results to determine an amount of MnO_4^- from the candidate's titres OR Analyses the information to obtain values of $n(\text{MnO}_4^-)$ and $n(\text{FeC}_2\text{O}_4)$ with some errors. <i>There is an attempt at a logical structure with a line of reasoning.</i> <i>The information is in the most part relevant.</i> 0 marks – No response or no response worthy of credit.	6	*For mean titre, Check Titres from 3b(ii) at top of response* Indicative scientific points may include: Mean titre and $n(\text{MnO}_4^-)$ $\text{Mean titre} = \frac{(21.65 + 21.55)}{2} = 21.6(0) \text{ (cm}^3\text{)}$ $n(\text{MnO}_4^-) = 0.0200 \times \frac{21.6(0)}{1000} = 4.32 \times 10^{-4} \text{ (mol)}$ Amount of FeC_2O_4 in mol $n(\text{FeC}_2\text{O}_4) \text{ in } 25.0 \text{ cm}^3 = 5/3 \times n(\text{MnO}_4^-)$ $= 7.2(0) \times 10^{-4} \text{ (mol)}$ $n(\text{FeC}_2\text{O}_4) \text{ in } 250 \text{ cm}^3 = 7.2(0) \times 10^{-3} \text{ (mol)}$ Value of x (final answer) $\text{Molar mass } \text{FeC}_2\text{O}_4 \cdot x\text{H}_2\text{O} = \frac{1.295}{7.2(0) \times 10^{-3}}$ $= 179.9$ $\text{Molar mass of } x\text{H}_2\text{O} = 179.9 - 143.8 = 36.(....)$ $x = 36/18 = 2$ Credit other correct methods, e.g. For value of x $\text{Mass of } \text{FeC}_2\text{O}_4 = 7.2(0) \times 10^{-3} \times 143.8 = 1.03536 \text{ g}$ $\text{Mass of } \text{H}_2\text{O} = 1.295 - 1.035 = 0.25964 \text{ g}$ $n(\text{H}_2\text{O}) = \frac{0.25964}{18} = 0.0144 \text{ mol}$ $x = \frac{0.0144}{7.2 \times 10^{-3}} = 2$

Question	Answer	Marks	Guidance
			Responses using 25.0 cm³ rather than the titres are limited to Level 1 For communication, a typical 'logical structure' would label most calculation steps in response e.g. <i>Communication strand met</i> $\text{KMnO}_4 \text{ mean titre: } \frac{21.65 + 21.55}{2} = 21.6 \text{ cm}^3$ $n(\text{KMnO}_4) = \frac{21.6 \times 10^{-3} \times 0.02}{1000} = 4.32 \times 10^{-4}$ $n(\text{Fe(C}_2\text{O}_4)_2 \cdot x\text{H}_2\text{O}) = \frac{4.32 \times 10^{-4}}{3} \times 5$ $= 7.2 \times 10^{-4} \text{ in } 25 \text{ cm}^3$ $n = 7.2 \times 10^{-3} \text{ in } 250 \text{ cm}^3$ $n = \frac{\text{mass}}{\text{mr}}$ $\text{mr} = \frac{\text{mass}}{n} = \frac{1.295}{7.2 \times 10^{-3}} = 179.86$ <i>Communication strand not met</i> $\frac{21.60}{1000} \times 0.02 = 4.32 \times 10^{-4} \text{ mol}$ $\left(\frac{4.32 \times 10^{-4}}{3} \right) \times 5 = 7.2 \times 10^{-4} \text{ mol in } 25 \text{ cm}^3$ $(7.2 \times 10^{-4}) \times 10 = 7.2 \times 10^{-3} \text{ mol in } 250 \text{ cm}^3$ $\frac{1.295}{7.2 \times 10^{-3}} = 179.86$

Question	Answer	Marks	Guidance
4 (a) (i)	In (Equilibrium) 1, H_2PO_4^-/It acts as a base AND accepts/gains H^+/a proton OR H_2PO_4^- forms H_3PO_4 ✓ In (Equilibrium) 2 H_2PO_4^-/It acts as an acid, AND donates/loses H^+/a proton OR H_2PO_4^- forms HPO_4^{2-} ✓	2	ALLOW description for 1 or 2 as long as unambiguous, e.g. Equation 1, etc IGNORE missing charge on H_2PO_4^- throughout IGNORE reference to HPO_4^{2-} acting as an acid/base OR Equilibrium 3 <i>Question is about H_2PO_4^-</i> ALLOW 'dissociates into H^+ and HPO_4^{2-}' IGNORE 'partially'
(a) (ii)	Diagram showing all bonds correctly ✓  • 3 bonds only around each P • 2 bonds only around each O • Each O bonded to an H Bond angles $\text{O}-\text{P}-\text{O} = 107^\circ$ ✓ $\text{P}-\text{O}-\text{H} = 104.5^\circ$ ✓	3	IGNORE geometry ALLOW dot and cross diagram showing 2 shared electrons for each bond and IGNORE any lone pairs e.g.  Unambiguous bond angles may be shown on dot and cross diagram ALLOW $106-108^\circ$ ALLOW $104-105^\circ$
(a) (iii)	phosphoric(III) acid ✓ Oxidation number MUST be in correct place	1	DO NOT ALLOW phosphoric acid (III) DO NOT ALLOW phosphorous acid

Question			Answer	Marks	Guidance
	(b)	(i)	$4\text{PH}_3 + 8\text{O}_2 \rightarrow \text{P}_4\text{O}_{10} + 6\text{H}_2\text{O}$ ✓	1	ALLOW multiples ALLOW $2\text{PH}_3 + 4\text{O}_2 \rightarrow \text{P}_2\text{O}_5 + 3\text{H}_2\text{O}$ IGNORE state symbols, even if wrong
	(b)	(ii)	$6\text{AgNO}_3 + (1)\text{PH}_3 + 3\text{H}_2\text{O} \rightarrow 6\text{Ag} + (1)\text{H}_3\text{PO}_3 + 6\text{HNO}_3$ ✓ Ag is reduced from +1 to 0 ✓ P is oxidised from –3 to +3 ✓ IGNORE oxidation numbers written around equation <i>Treat as rough working</i> IGNORE reference to electrons <i>Question states oxidation numbers</i>	3	ALLOW equation with ‘1’ omitted, i.e. $6\text{AgNO}_3 + \text{PH}_3 + 3\text{H}_2\text{O} \rightarrow 6\text{Ag} + \text{H}_3\text{PO}_3 + 6\text{HNO}_3$ ✓ BUT DO NOT ALLOW ‘0’ ALLOW 1 mark for BOTH correct oxidation number changes with ‘reduced’ and ‘oxidised’ omitted OR ‘oxidised and reduced the wrong way round’ + signs required for +1 and +3 For oxidation numbers, ALLOW 1+, 3– and 3+
	(c)	(i)	$3\text{PCl}_5 + 3\text{NH}_4\text{Cl} \rightarrow \text{P}_3\text{N}_3\text{Cl}_6 + 12\text{HCl}$ ✓	1	ALLOW multiples IGNORE state symbols, even if wrong
	(c)	(ii)	FIRST, CHECK THE ANSWER ON ANSWER LINE IF % by mass = 26.72, award 2 marks IF % by mass = 26.7, award 1 mark ----- M_r of $\text{P}_3\text{N}_3\text{Cl}_6 = 348(.0)$ ✓ % by mass of P = $\frac{31.0 \times 3}{348} \times 100 = 26.72$ ✓ 2 DP required	2	ALLOW 1 mark total for 26.7 <i>Question asks for 2 DP</i> ALLOW ECF from incorrect M_r ALLOW 1 mark for 8.91 (omission of ×3): $\frac{31.0}{348} \times 100 = 8.91$

Question	Answer	Marks	Guidance
(c) (iii)	(P–N) bond lengths are different ✓ OR enthalpy change of hydrogenation is more exothermic (than delocalised structure) OR reacts with bromine/electrophiles/by addition	1	Throughout, ORA for delocalised structure IGNORE C–C bond lengths are different IGNORE hydration ALLOW decolourises bromine (without a catalyst/halogen carrier) IGNORE more reactive without example IGNORE alternating single and double bonds
(c) (iv)	Structure shown with molecular formula $P_3N_3Cl_6$ 1st mark - Each P bonded to 2 Cl atoms - Each P bonded to N AND Cl - Each N has <i>at least</i> 2 bonds - Each Cl has 1 bond ✓ 2nd mark (dependent on 1st mark) - Each N has 3 bonds - Each P has 3 OR 5 bonds ✓ IGNORE charges Examples for 2 marks 	2	1st mark <i>Meets criteria for 1st mark</i>   ZERO marks <i>N bonded to Cl</i>   <i>N atom(s) with 1 bond only</i>  

Question	Answer	Marks	Guidance
5 (a) (i)	$R_f \sim \frac{1.4}{9.1}$ in cm OR $\frac{14}{91}$ in mm = 0.15 ✓ Working required Check for ~ 9.1 as denominator 	1	ALLOW 0.12 – 0.18 (i.e. ± 0.03) DO NOT ALLOW $\frac{1.4}{10.1} = 0.14$ 10.1 measured from bottom of plate to solvent front 

Question	Answer	Marks	Guidance
(a) (ii)	$ \begin{array}{c} \text{H} & \text{H} & \text{H} \\ & & \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{Br} \\ & & \\ \text{H} & \text{H} & \text{H} \end{array} + \text{OH}^- \longrightarrow \begin{array}{c} \text{H} & \text{H} & \text{H} \\ & & \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{OH} \\ & & \\ \text{H} & \text{H} & \text{H} \end{array} + \text{Br}^- $ Correct balanced equation ALLOW OH⁻ above the arrow DO NOT ALLOW if a CON reagent is present, e.g. an acid For OH⁻ and Br⁻ ALLOW KOH and KBr OR NaOH and NaBr BUT DO NOT ALLOW K-OH <i>implies covalent bond</i>	1	ALLOW any combination of skeletal OR structural OR displayed formula as long as unambiguous DO NOT ALLOW Missing H atoms DO NOT ALLOW H₂O and HBr <i>Question asks for alkaline hydrolysis</i> DO NOT ALLOW C₃H₇, i.e. C₃H₇Br OR C₃H₇OH <i>Structure asked for in Question</i> IGNORE connectivity, e.g. ALLOW $\begin{array}{c} \\ \text{OH} \end{array}$ BUT DO NOT ALLOW —HO
(a) (iii)	Difference propan-1-ol/product/bottom spot is smaller OR 1-chloropropane/reactant/top spot bigger ✓ Reasons C—Cl bond is stronger than C—Br AND 1-chloropropane reacts slower/is less reactive ✓ Use of propan-1-ol shows formation of propan-1-ol OR shows when reaction has finished OR monitors course/progress of reaction ✓	3	FULL ANNOTATIONS MUST BE USED ALLOW ECF and ORA throughout IGNORE references to halogens as elements: <i>i.e. chlorine is less reactive than bromine etc.</i> DO NOT ALLOW chloride, bromide DO NOT ALLOW 1-chloropropane has larger bond enthalpy <i>C—Cl bond required</i> IGNORE 1-chloropropane has different <i>R_f</i> value IGNORE ‘as a control’ OR ‘as a comparison’ with no further explanation

Question			Answer	Marks	Guidance
	(b)	(i)	Green solution Cr^{3+} OR $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$ ✓ Orange solution $\text{Cr}_2\text{O}_7^{2-}$ ✓ Formulae AND charges must be correct	2	Green solution IGNORE H^+ ALLOW $\text{Cr}_2(\text{SO}_4)_3$ OR CrCl_3 OR Cr^{+3} Orange solution IGNORE H^+ ALLOW $\text{K}_2\text{Cr}_2\text{O}_7$ OR $\text{Na}_2\text{Cr}_2\text{O}_7$ DO NOT ALLOW Cr^{6+} ALLOW 1 mark for correct formulae but wrong way round

Question	Answer	Marks	Guidance
(b)* (ii)	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 possible correct structures for ALL of F, G, H and I AND ALL functional groups of F, G, H and I <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) Reaches a conclusion to determine possible correct structures for two of F, G, H and I AND most functional groups of F, G, H and I <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) Reaches a simple conclusion to determine a possible correct structure for one of F, G, H and I OR some functional groups of F, G, H and I <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	Indicative scientific points may include: <u>Identity of F, G, H and I showing CORRECT structures</u> F ALLOW enols for F, e.g. G For G, DO NOT ALLOW tertiary –OH. e.g. H I IGNORE names, even if incorrect

Question			Answer	Marks	Guidance
					For communication, a typical 'logical structure' would link functional groups to SOME of the test results, e.g. 2,4-DNP H and I have carbonyl group/aldehyde or ketone H⁺/Cr₂O₇²⁻ F, G and I are primary or secondary alcohols or aldehydes Bromine F is unsaturated/has C=C Tollens I is aldehyde *Correct functional groups may be shown in correct structures*

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