



Cambridge International AS & A Level

CHEMISTRY

9701/31

Paper 3 Advanced Practical Skills 1

May/June 2022

MARK SCHEME

Maximum Mark: 40

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the May/June 2022 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

This document consists of **12** printed pages.

Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5:

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Science-Specific Marking Principles

1	Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
2	The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.
3	Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
4	The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
5	<u>'List rule' guidance</u> For questions that require <i>n</i> responses (e.g. State two reasons ...): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked <i>ignore</i> in the mark scheme should not count towards <i>n</i>. • Incorrect responses should not be awarded credit but will still count towards <i>n</i>. • Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should not be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response. • Non-contradictory responses after the first <i>n</i> responses may be ignored even if they include incorrect science.

6 Calculation specific guidance

Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'.

For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values.

For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme.

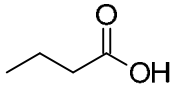
Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 Guidance for chemical equations

Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

Question	Answer	Marks
1(a)	I All the following data are recorded: - two burette readings and titre for the rough titration - initial and final burette readings for two (or more) accurate titrations	1
	II Appropriate headings and units in the accurate titration table and titre values recorded for accurate titrations - initial / start and (burette) reading / volume - final / end and (burette) reading / volume - titre or volume used / added / or FA 2 added - unit: / cm³ or (cm³) or in cm³ (for each heading) or cm³ unit given for each volume recorded	1
	III All accurate burette readings are recorded to the nearest 0.05 cm ³	1
	IV The final accurate titre recorded is within 0.10 cm ³ of any other accurate titre	1
	For assessment of accuracy marks, round all burette readings to the nearest 0.05 cm³. Check and correct subtractions where necessary. Then select the 'best' titres using the hierarchy: - two (or more) accurate identical titres (ignoring any that are labelled 'rough'), <i>then</i> - two (or more) accurate titres within 0.05 cm³, <i>then</i> - two (or more) accurate titres within 0.10 cm³, <i>etc.</i> These best titres should be used to calculate the mean titre, expressed to nearest 0.01 cm³. Write the Supervisor's [corrected] mean titre in a ring on each candidate script. Calculate the difference (δ) between the candidate's mean titre and the Supervisor's. Write the value of δ on each script. Award the accuracy marks as shown below.	
	Award V if $\delta \leq 0.50$ (cm ³) Award VI if $\delta \leq 0.30$ Award VII if $\delta \leq 0.20$	3

Question	Answer	Marks
1(b)	Candidate must average two (or more) titres that are within a total spread of not more than 0.20 cm ³ AND working / explanation must be shown or ticks must be put next to the two (or more) accurate titres selected AND mean quoted to 2 decimal places	1
1(c)(i)	Correctly calculates moles of NaOH used = $0.110 \times (b) / 1000$ AND answer to 3 or 4 sig fig	1
1(c)(ii)	Correctly uses (c)(i) to calculate $M_r = 10.5 / (c)(i) \times 40$	1
1(c)(iii)	M1 Identity of carboxylic acid [must be consistent with the M_r in (c)(ii)] M2 Skeletal formula (must correspond to candidate's name of acid) 	2
1(d)(i)	Correct equation with state symbols $\text{NH}_2\text{CH}_2\text{COOH}(\text{aq}) + \text{NaOH}(\text{aq}) \rightarrow \text{NH}_2\text{CH}_2\text{COONa}(\text{aq}) + \text{H}_2\text{O}(\text{l})$	1
1(d)(ii)	Student's titre would be larger AND M_r of amino acid is 75 / is lower than M_r of FA 1 so more moles of amino acid are present ORA	1

Question	Answer	Marks
2(a)	I Unambiguous headings and units for four weighings: • (mass of) crucible, lid (empty) • (mass of) crucible, lid and FA 4 (or ‘contents before heating’) • (mass of) crucible, lid and MgO / residue after first heating • (mass of) crucible, lid and MgO / residue after second heating	1
	II Readings are appropriately recorded: • all <u>weighings</u> recorded to same decimal places (two or more) • mass of FA 4 is within range 0.80 g–1.80 g (from weighings) • fourth weighing within +0.02 and –0.05 g of third weighing	1
	III Correct subtractions to give masses of FA 4 and MgO / residue	1
	IV and V : Accuracy marks Calculate supervisor’s mass ratio (to 2 d.p.) = $\frac{\text{mass FA 4}}{\text{mass of residue}}$ Calculate the candidate’s mass ratio (to 2 d.p.) = $\frac{\text{mass FA 4}}{\text{mass of residue}}$ Calculate 20% of this ratio and calculate ratio $\pm$ this ratio Award IV if δ is within the range 0.00–0.25 Award V if δ is within the range 0.00–0.10	2
2(b)(i)	Correctly calculates moles of MgO = $\frac{\text{mass of residue}}{40.3}$ AND answer to 2–4 sig fig	1
2(b)(ii)	Correctly uses (b)(i) to calculate M_r of X = $\frac{\text{mass lost}}{\text{moles of MgO}}$ OR M_r of X = $\left(\frac{\text{mass FA 4}}{\text{moles of MgO}}\right) - 40.3$ AND answer to 2–4 sf	1
2(b)(iii)	X is water / steam / H ₂ O / CO ₂	1
2(b)(iv)	FA 4 is magnesium hydroxide	1

Question	Answer	Marks
2(c)	Student is not correct because there is no spitting / frothing during heating OR student is correct because there was spitting / frothing during heating	1
2(d)	2 d.p. balance uncertainty = 0.01 g or 0.005 g 3 d.p. balance uncertainty = 0.001 g or 0.0005 g Correct expression for % error = $(2 \times \text{balance uncertainty} / \text{mass of residue}) \times 100$	1

Question	Answer	Marks
FA 5 is NaNO ₃ ; FA 6 is Al ₂ (SO ₄) ₃ ; FA 7 is I ₂ + KI		
3(a)(i)	M1: 'table' (2 × 2 min) with headings: 'test / experiment / reagents' and 'observations' AND two (or more) reagents listed in the space M2: (<i>eliminating ammonium ion</i>) heat FA 5 with (aqueous) NaOH AND no effervescence / (damp red) litmus stays red M3: (<i>identifying NO₂⁻ / NO₃⁻</i>) add Al to warm NaOH and FA 5 AND fizz / gas / NH₃ turns (damp red) litmus blue M4: (<i>eliminating NO₂⁻</i>) anion is NO₃⁻ / nitrate / nitrate(V) AND Either add (a few drops of) (acidified) KMnO₄ / potassium manganate(VII) AND no change / no reaction / (solution) remains purple Or add (dilute) named mineral acid to (solid or aqueous) FA 5 AND no brown fumes / no blue solution / no reaction / no change produced	4

Question	Answer	Marks
3(a)(ii)	• solid melts / solid dissolves / liquid forms • fizzing / bubbling / effervescence • (gas) re-lights glowing splint / spill • oxygen produced • (on cooling), (pale) yellow solid formed or residue is yellow <i>3 or more bullets = 2 marks</i> <i>2 bullets = 1 mark</i>	2

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3(b)(i)	<table border="1"> <thead> <tr> <th>test</th><th>FA 6</th><th>FA 7</th></tr> </thead> <tbody> <tr> <td>Test 1 NaOH</td><td>White ppt / solid (formed) * Soluble in excess *</td><td>Decolourises / turns (pale) yellow * (ppt is CON)</td></tr> <tr> <td>Test 2 Ba²⁺</td><td>White ppt</td><td>No change / no reaction</td></tr> <tr> <td>+ HCl</td><td>AND ppt insoluble / remains / no change / no reaction *</td><td>AND no change / no reaction *</td></tr> <tr> <td>Test 3 starch</td><td></td><td>Dark blue / blue-black / black (colour formed) (ignore state)</td></tr> <tr> <td>+ thio</td><td></td><td>AND colourless solution (forms) ALLOW turns colourless / decolourises *</td></tr> <tr> <td>Test 4 Ag⁺</td><td>No change / no reaction / no ppt</td><td>Yellow / brown ppt (forms) *</td></tr> <tr> <td>+ NaOH</td><td>AND ppt (forms) (ignore colour) *</td><td>Pale yellow ppt ALLOW ppt turns paler yellow * IGNORE use of excess NaOH</td></tr> <tr> <td>Test 5 + NH₃</td><td>White ppt AND ppt is insoluble in excess (NH₃) *</td><td></td></tr> </tbody> </table> 2 * = 1 mark (round down)	test	FA 6	FA 7	Test 1 NaOH	White ppt / solid (formed) * Soluble in excess *	Decolourises / turns (pale) yellow * (ppt is CON)	Test 2 Ba ²⁺	White ppt	No change / no reaction	+ HCl	AND ppt insoluble / remains / no change / no reaction *	AND no change / no reaction *	Test 3 starch		Dark blue / blue-black / black (colour formed) (ignore state)	+ thio		AND colourless solution (forms) ALLOW turns colourless / decolourises *	Test 4 Ag ⁺	No change / no reaction / no ppt	Yellow / brown ppt (forms) *	+ NaOH	AND ppt (forms) (ignore colour) *	Pale yellow ppt ALLOW ppt turns paler yellow * IGNORE use of excess NaOH	Test 5 + NH ₃	White ppt AND ppt is insoluble in excess (NH ₃) *		5
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3(b)(iii)	$Al^{3+}(aq) + 3OH^{-}(aq) \rightarrow Al(OH)_3(s)$ OR $Al(OH)_3(s) + OH^{-}(aq) \rightarrow [Al(OH)_4]^{-}(aq)$ OR $I_2(aq) + 6OH^{-}(aq) \rightarrow I^{-}(aq) + IO_3^{-}(aq) + 3H_2O(l)$	1



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1(a)	Award V if $\delta \leq 0.50$ (cm³) Award VI if $\delta \leq 0.30$ Award VII if $\delta \leq 0.20$	
1(b)	Correctly calculates the mean titre correct to 2 dp from accurate titres that are within 0.20 cm ³ total spread	1
1(c)(i)	All final answers for (c)(ii) , (c)(iii) , and (c)(iv) are to 3–4 sf	1

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Question	Answer	Marks
1(c)(ii)	Correctly calculates $n(\text{NaOH}) = 0.1 \times (\mathbf{b}) / 1000$ AND $n(\text{NaHSO}_4) = \text{same answer}$	1
1(c)(iii)	Correctly uses $[\text{NaHSO}_4] = \text{final answer } (\mathbf{c})(\mathbf{ii}) \times 1000 / 25 (= (\mathbf{c})(\mathbf{ii}) \times 40)$ AND $\text{answer above} \times 120.1$	1
1(c)(iv)	Correctly uses $\% \text{ NaHSO}_4 = \left(\frac{\text{final answer } (\mathbf{c})(\mathbf{ii})}{12.53} \right) \times 100$	1

Question	Answer	Marks
2(a)	I Ten thermometer readings recorded, all shown to .0 or .5 °C AND at least one reading at .0 and one at .5 For assessment of accuracy marks, round all thermometer readings to the nearest 0.5 °C. Calculate the supervisor's greatest ΔT ($= T_{\text{max}} - T_{\text{initial}}$) and write it ringed on each candidate script. Note volume (V) at which the T_{max} occurs. Calculate the candidate's ΔT at the same volume ($= T_{\text{at V}} - T_{\text{initial}}$) then calculate the difference, δ, from the supervisor value. Award of accuracy marks For supervisor ΔT 10.0 – 20.0: II Award if $\delta \leq 2.0$ °C III Award if $\delta \leq 1.0$ °C	3
2(b)(i)	I Axes unambiguously labelled temperature or °C on y-axis AND volume / FB 5 / H₂SO₄ / acid or cm³ on the x-axis AND some numbers for scales II Suitable scales chosen III All points recorded in the table are accurately plotted IV Lines of best fit drawn (straight or smoothly curved lines) AND extrapolated to intersect	4
2(b)(ii)	Correct volume from suitable intersect to 1 or 2 dp AND correct ΔT to 1 dp	1
2(c)(i)	Correctly calculates $n(\text{H}_2\text{SO}_4) = 1.00 \times \text{volume (b)(ii)} / 1000$ AND answer to 2–4 significant figures	1

Question	Answer	Marks
2(c)(ii)	Correctly calculates $Q = (25 + V(\mathbf{b})(\mathbf{ii})) \times 4.18 \times \Delta T(\mathbf{b})(\mathbf{ii})$ and answer to 2–4 sf	1
2(c)(iii)	Correctly uses $\Delta H = \left(\frac{(\mathbf{c})(\mathbf{ii})}{2 \times (\mathbf{c})(\mathbf{i})} \right) / (1000)$ AND answer given to minimum 2 sf AND units kJ mol^{-1} or J mol^{-1} to match use or absence of $\div 1000$ AND negative sign	1
2(d)(i)	Correct expression $[(-57.6 - (\mathbf{c})(\mathbf{iii})) / 57.6] \times 100$ OR $[((\mathbf{c})(\mathbf{iii}) - (-57.6)) / 57.6] \times 100$	1
2(d)(ii)	take more readings (near the end point) AND to improve position of intersection / owtte	1
2(e)(i)	Correctly uses $n(\text{NaOH}) = (\mathbf{c})(\mathbf{i}) \times 2 \times \frac{1000}{25}$	1

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Question	Answer	Marks
2(e)(ii)	I Correctly uses <u>(e)(i)</u> 20 AND answer to 2 or more sf	2
	II Explanation matches answer If conc NaOH > 0.1 mol dm ⁻³ then 1st box ticked and (titre remains unchanged so actual) mol NaOH↑ so mol / amount / mass NaHSO ₄ ↑ OR If conc NaOH approx. 0.1 mol dm ⁻³ then 2nd box ticked and titre not / (only) slightly changed so within experimental error OR If conc NaOH < 0.1 mol dm ⁻³ then 3rd box ticked and (titre remains unchanged so actual) mol NaOH↓ so mol / amount / mass NaHSO ₄ ↓ OR If conc NaOH < 0.1 mol dm ⁻³ then 1st box ticked and larger titre so moles / amount / mass NaHSO ₄ calculated increases OR If conc NaOH > 0.1 mol dm ⁻³ then 3rd box ticked and smaller titre so mol / amount / mass NaHSO ₄ calculated decreases	

Question	Answer	Marks
FB 6 is KI(s); FB 7 is $\text{MnCl}_2 + \text{NH}_4\text{Cl}(\text{aq})$; FB 8 is FeSO_4		
3(a)	I Suitable reagents for anion One of: If testing for <u>carbonate</u>: I named (dilute) acid (and limewater) II description of testing gas with limewater III no effervescence / no fizzing / no change IV unknown (provided test carried out and no contradictory result) OR If testing for <u>halide</u>: I (aqueous) AgNO_3 and NH_3 II use a solution of FB 6 III (pale) yellow ppt, insoluble in NH_3 IV I^- (must be from (pale) yellow ppt) OR If testing for <u>nitrate / nitrite</u> : I sodium hydroxide and Al II warm in a boiling tube III gas does not turn litmus blue / red litmus stays red IV unknown (provided test carried out and no contradictory result)	

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3(b)(ii)	FB 7: Mn ²⁺ and NH ₄ ⁺ FB 8: Fe ²⁺ 3 cations correct = 2 marks 2 cations correct = 1 mark	2															
3(b)(iii)	<i>One of:</i> Mn ²⁺ (aq) + 2OH ⁻ (aq) → Mn(OH) ₂ (s) Fe ²⁺ (aq) + 2OH ⁻ (aq) → Fe(OH) ₂ (s)	1															
3(b)(iv)	Redox / oxidation AND reduction (of manganate(VII))	1															



Cambridge International AS & A Level

CHEMISTRY

9701/33

Paper 3 Advanced Practical Skills 1

May/June 2022

MARK SCHEME

Maximum Mark: 40

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

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This document consists of **10** printed pages.

PUBLISHED**Generic Marking Principles**

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5:

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Science-Specific Marking Principles

1	Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
2	The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.
3	Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
4	The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
5	<u>'List rule' guidance</u> For questions that require <i>n</i> responses (e.g. State two reasons ...): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked <i>ignore</i> in the mark scheme should not count towards <i>n</i>. • Incorrect responses should not be awarded credit but will still count towards <i>n</i>. • Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should not be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response. • Non-contradictory responses after the first <i>n</i> responses may be ignored even if they include incorrect science.

6 Calculation specific guidance

Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'.

For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values.

For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme.

Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 Guidance for chemical equations

Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

Question	Answer	Marks
1(a)	I All the following data are recorded: - two burette readings AND titre for the rough titration - initial and final burette readings for two (or more) accurate titrations II Correct headings and units in the accurate titration table - initial / start AND (burette) reading/volume + unit - final / end AND (burette) reading/volume + unit - titre + unit OR volume / FA 2 and used / added + unit III All accurate burette readings are recorded to the nearest 0.05 cm³ IV The final accurate titre recorded is within 0.10 cm³ of any other accurate titre For assessment of accuracy marks, round all burette readings to the nearest 0.05 cm³. Check and correct subtractions. Then select the 'best' titres using the hierarchy: - two (or more) accurate identical titres (ignoring any that are labelled 'rough'), <i>then</i> - two (or more) accurate titres within 0.05 cm³, <i>then</i> - two (or more) accurate titres within 0.10 cm³, <i>etc.</i> These best titres should be used to calculate the mean titre, expressed to nearest 0.01 cm³. Write the Supervisor's [corrected] mean titre in a ring on each candidate script Calculate the difference (δ) between the candidate's mean titre and the supervisor's. Write the value of δ on each script. Award the accuracy marks as shown below. Award V if $\delta \leq 0.50$ (cm³) Award VI if $\delta \leq 0.30$ Award VII if $\delta \leq 0.20$	7
1(b)	Correctly calculates the mean titre correct to 2 dp from accurate titres that are within 0.20 cm ³ total spread	1
1(c)(i)	Correctly calculates $\text{amount of NaOH used} = 0.150 \times \frac{(b)}{1000}$ AND answer to 3 or 4 significant figures	1

Question	Answer	Marks
1(c)(ii)	Correctly calculates amount of H_3PO_4 in $25 \text{ cm}^3 = \frac{6.86}{40} \times \frac{1}{98.0} = 0.00175(0) = 1.75 \times 10^{-3} \text{ mol}$	1
1(c)(iii)	Acid is diprotic AND reason using answers (c)(i) and (c)(ii) Explanation: mole ratio of ans (c)(i) : ans (c)(ii) = 2 : 1 (approx) OR calculation shown	1
1(c)(iv)	Equation follows from the proticity stated in (c)(iii) Expected equation: $\text{H}_3\text{PO}_4 + 2\text{NaOH} \rightarrow \text{Na}_2\text{HPO}_4 + 2\text{H}_2\text{O}$	1
1(d)(i)	Correct expression for % error = $\frac{100 \times 0.06}{25}$ (= 0.24%)	1
1(d)(ii)	Student is incorrect AND explanation given: burette error = 2×0.05 (which is >0.06 / so $0.40\% > 0.24\%$)	1

Question	Answer	Marks
2(a)	I Unambiguous headings and units for four weighings and entered in the space provided: • (mass of) crucible, lid (empty) • (mass of) crucible, lid and FA 4 (or 'contents before heating') • (mass of) crucible, lid and FA 5 / residue / contents after first heating • (mass of) crucible, lid and FA 5 / residue / contents after second heating Units: / g or (g) or gram(me)s or in grams	5
	II Readings are appropriately recorded: • all <u>weighings</u> recorded to same number of decimal places (two or more) • mass of FA 4 is within the range 0.80–1.80 g (<i>from weighings</i>) • fourth weighing is within +0.02 and –0.05 g of third weighing	
	III Correct subtractions to give: • mass of FA 4 • mass of FA 5 • mass loss	
	For assessment of accuracy marks: calculate supervisor's mass ratio (to 2 d.p.) = $\frac{\text{mass FA 4}}{\text{mass FA 5 (residue)}}$ Write this value in a ring on each script. Calculate the 25% and 10% ranges correct to 2 dp. Calculate the candidate's mass ratio (to 2 dp) = $\frac{\text{mass FA 4}}{\text{mass FA 5 (residue)}}$ Award accuracy marks as shown below.	
	Award IV if δ is within 25% of supervisor AND ratio > 1.00 Award V if δ is within 10% of supervisor AND ratio > 1.00	
2(b)(i)	Correctly calculated amount of $\text{CO}_2 = \frac{\text{mass loss}}{44} \text{ mol}$ AND answer to 2–4 significant figures	1

Question	Answer	Marks
2(b)(ii)	Correctly uses $M_r \text{ of FA 4} = \frac{\text{mass of FA 4 used}}{(\text{b})(i)}$ AND answer to 2–4 sf	1
2(b)(iii)	A_r of metal = (b)(ii) – 60 AND Group 2 metal correctly deduced from A_r <i>Be if A_r is in range 0 – 12.1: Mg for A_r 12.2 – 32.2: Ca for A_r 32.2 – 63.8: Sr for A_r 63.9 – 112.4: Ba for A_r 112.5 – 250</i> (Other metals forming white carbonates with formula MCO_3 are acceptable provided the A_r is close to the value given in the periodic table.)	1
2(c)	M1 : student's mass loss is lower AND $M_r \text{ H}_2\text{O} < M_r \text{ CO}_2$ (or values given) M2 : using Mg as example $\% \text{ loss from Mg(OH)}_2 = \left(\frac{18}{58.3} \right) \times 100$ $\% \text{ loss from MgCO}_3 = \left(\frac{44}{84.3} \right) \times 100$ (which is greater than % for Mg(OH)_2)	2
2(d)	EITHER M1 : solid dissolves OR colourless solution formed M2 : decomposition is complete AND reason: no gas / no CO_2 / no fizzing produced (when acid added) OR M1 : effervescence (owtte) OR gas / CO_2 gives white ppt with limewater M2 : decomposition is not complete AND reason: carbonate reacts / fizzes / gives out CO_2 with acid / oxide does not fizz with acid	2

Question	Answer	Marks																		
FA 6 is $\text{CuCl}_2(\text{aq})$; FA 7 is $\text{FeCl}_3(\text{aq})$; FA 8 is $(\text{NH}_4)_2\text{SO}_4(\text{s})$																				
3(a)(i)	Correct observations and no extra reagents used <table border="1"> <thead> <tr> <th>test</th><th>FA 6</th><th>FA 7</th></tr> </thead> <tbody> <tr> <td>KI</td><td>ppt AND brown / yellow-brown / orange-brown / red-brown * (colour of ppt need not be given but allow shades of white and the browns given above)</td><td>red-brown / brown solution OR turns red-brown / brown *</td></tr> <tr> <td>then thio</td><td>brown colour fades / disappears OR white / off-white / cream ppt OR ppt dissolves (in excess thio) * (Insoluble in excess is incorrect) (If the colour of solution is given it must be colourless, pale yellow or pale brown.)</td><td>colourless solution (forms) OR (solution) turns colourless / decolourised * (The formation of the initial purple colour of the thiosulfate complex or the final white / off-white ppt (on standing) are not part of this mark.)</td></tr> <tr> <td>Zn</td><td>solution becomes paler blue / colourless OR brown / black / pink-brown / red-brown ppt / solid (formed) *</td><td>fizzing / bubbles / effervescence * (gas) pops with lighted splint OR (gas) burns with a pop*</td></tr> <tr> <td>AgNO_3</td><td>white ppt (formed) *</td><td>white / off-white / cream / pale yellow ppt (formed) *</td></tr> <tr> <td>NaOH</td><td>(pale) blue ppt AND insoluble in excess *</td><td>rust / brown / orange-brown / red-brown ppt (which does not dissolve in excess) *</td></tr> </tbody> </table> 2 * = 1 mark	test	FA 6	FA 7	KI	ppt AND brown / yellow-brown / orange-brown / red-brown * (colour of ppt need not be given but allow shades of white and the browns given above)	red-brown / brown solution OR turns red-brown / brown *	then thio	brown colour fades / disappears OR white / off-white / cream ppt OR ppt dissolves (in excess thio) * (Insoluble in excess is incorrect) (If the colour of solution is given it must be colourless, pale yellow or pale brown.)	colourless solution (forms) OR (solution) turns colourless / decolourised * (The formation of the initial purple colour of the thiosulfate complex or the final white / off-white ppt (on standing) are not part of this mark.)	Zn	solution becomes paler blue / colourless OR brown / black / pink-brown / red-brown ppt / solid (formed) *	fizzing / bubbles / effervescence * (gas) pops with lighted splint OR (gas) burns with a pop*	AgNO_3	white ppt (formed) *	white / off-white / cream / pale yellow ppt (formed) *	NaOH	(pale) blue ppt AND insoluble in excess *	rust / brown / orange-brown / red-brown ppt (which does not dissolve in excess) *	5
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Question	Answer	Marks
3(a)(ii)	Any one of the following ionic equations with correct state symbols: $\text{Zn(s)} + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{Cu(s)} + \text{Zn}^{2+}(\text{aq})$ $\text{Zn(s)} + 2\text{H}^{+}(\text{aq}) \rightarrow \text{H}_2(\text{g}) + \text{Zn}^{2+}(\text{aq})$ $3\text{Zn(s)} + 2\text{Fe}^{3+}(\text{aq}) \rightarrow 2\text{Fe}^{2+}(\text{aq}) + 3\text{Zn}^{2+}(\text{aq})$	1
3(b)(i)	Award any two of the following: - Sublimation occurs OR (white) solid condenses / reforms (on sides of tube) OR white smoke OR white fumes - Liquid / water forms OR frothing OR (liquid) condensation OR steam produced OR solid melts OR solid dissolves (Moist red) litmus turns blue - Residue is colourless / white / off-white / light grey / cream (on cooling) OR no residue (Gas / fumes) turn (blue) litmus red (Litmus tests must be mentioned in the right order to award both •)	2
3(b)(ii)	M1 'table' (2 × 2 min) with <u>headings</u> : 'test / experiment / reagents' and 'observations' (owtte) AND two (or more) reagents listed in the space (Cation test) M2 Warm / heat with NaOH (and without Al) M3 Gas / effervescence / NH ₃ turns (red) litmus blue (Anion test) M4 Add (aqueous) BaCl ₂ / Ba(NO ₃) ₂ AND to a solution of FA 8 M5 White ppt (forms) AND either ppt is insoluble in (excess) HCl / HNO ₃ or FA 8 / mixture does not decolorise (acidified) potassium manganate(VII) / KMnO ₄ M6 FA 8 is (NH ₄) ₂ SO ₄	6



Cambridge International AS & A Level

CHEMISTRY

9701/34

Paper 3 Advanced Practical Skills 2

May/June 2022

MARK SCHEME

Maximum Mark: 40

Published

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Science-Specific Marking Principles

- 1 Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
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- 5 'List rule' guidance

For questions that require ***n*** responses (e.g. State **two** reasons ...):
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6 Calculation specific guidance

Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'.

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Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 Guidance for chemical equations

Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

Question	Answer	Marks
1(a)	Accuracy marks Write and ring the supervisor's volume of gas evolved on each candidate script. M1 volume of gas recorded within 25% of supervisor value M2 volume of gas recorded within 10% of supervisor value AND rounded to nearest integer	2
1(b)(i)	Correctly calculates amount of $\text{CO}_2 = \frac{\text{volume of gas}}{24000} \text{ mol}$ AND answer to 2–4 significant figures	1
1(b)(ii)	M1 correctly uses amount of $\text{HCl} = (\text{b})(\text{i}) \times 2 \text{ in } 50 \text{ cm}^3 \text{ mol}$ M2 concentration of $\text{HCl} = \text{answer above} \times 20 \text{ mol dm}^{-3}$ AND answer to 2–4 significant figures	2
1(c)(i)	M1 solid / calcium carbonate / CaCO_3 / FB 2 / residue still present / when reaction finished / at the end M2 solid / calcium carbonate / CaCO_3 / FB 2 is in excess OR the acid is the limiting reagent (ora)	2
1(c)(ii)	<i>One of the following:</i> - specified method to keep solid and acid apart until bung fitted (e.g. divided flask / suspend solid in ignition tube / weighing boat / small beaker and may be shown as a labelled diagram) - use lumps of solid to reduce rate of reaction - use more dilute acid to reduce rate of reaction - cool (reaction) flask / acid to reduce rate of reaction	1

Question	Answer	Marks
2(a)	I Seven thermometer readings recorded II All thermometer readings recorded to nearest 0.5 °C with at least one at .0 and one at .5 AND all burette readings to .#0 or .#5 cm³. III Two appropriate extra volumes chosen AND volume of water used + volume of FB 4 = 10(.00) cm³ The volumes selected must be at least 0.50 cm³ from any other. One value must be the volume between the first highest temperature and one of the adjacent temperatures. The second must not be between the same two set experiments as value one. If there is no maximum temperature for experiments 1–5 then the one value must be between 7.00 and 9.00 cm³ and the other 9.50 or 10.00 cm³. Accuracy marks Calculate the supervisor's ΔT at 5.00 cm³ of added FB 4 (initial thermometer reading). This value must be written and ringed on each candidate's script. Calculate and record candidate's ΔT for the same pair of readings. Calculate and record the difference, δ, from supervisor. IV Award if $\delta \leq 1.0$ °C V Award if $\delta \leq 0.5$ °C	5

Question	Answer	Marks
2(b)	I Axes correctly labelled with temperature AND / °C or (°C) on the y-axis volume / FB 4 AND / cm ³ or (cm ³) on the x-axis AND suitable scales selected to occupy more than half of the available space on both axes and including 2 °C above the highest recorded temperature on the y-axis	4
	II All points recorded in the table are accurately plotted. Those on the line must be exactly on the line; those not on the line must be in the correct half of the small square.	
	III Lines of best fit Two straight lines of best fit drawn with a ruler. The two lines must give a sharp intersection at (or above) the highest temperature. There must be at least 3 points considered for the line of best fit where the maximum temperature is increasing. Any points labelled anomalous are disregarded.	
	IV Correct volume of FB 4 at intersection AND given to 1 (or 2) d.p.	
2(c)(i)	All answers to (c)(ii) , (iii) , (iv) and (v) are given to 2–4 significant figures	1
2(c)(ii)	Correctly calculates amount of HCl = $\frac{2.2 \times \text{volume in (b)}}{1000}$ mol	1
2(c)(iii)	Correctly uses concentration of NaOH = (c)(ii) × 100 mol dm ⁻³	1
2(c)(iv)	M1 correctly calculates ΔT_{max} (from table or graph) OR correct figures for calculation shown M2 correctly calculates energy released = 20(.00) × 4.18 × ΔT_{max} AND answer correct	2
2(c)(v)	Correctly uses enthalpy change = $\frac{\text{(c)(iv)}}{[(\text{c)(ii)} \times 1000]}$ kJ mol ⁻¹ AND answer with negative sign given	1

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Question	Answer	Marks
2(d)(i)	Correct expression $\% \text{ error} = \left[\frac{(-)57.6 - (-)(c)(v)}{(-)57.6} \right] \times 100$	1
2(d)(ii)	<i>Any one of:</i> • Measure initial temperatures of water AND FB 4 • Take more readings near the largest maximum temperature • Record initial temperature for each experiment	1

Question	Answer				Marks
FB 5 is H ₂ SO ₄ (aq); FB 6 is HCl(aq); FB 7 is HCOOH(aq); FB 8 is H ₂ O ₂ (aq); FB 9 MgSO ₄ (aq)					
3(a)(i)	test	FB 5	FB 6	FB 7	FB 8
	Test 1 Mg	fizz * H ₂ / gas pops with lighted splint / burns with pop *	fizz * H ₂ / gas pops with lighted splint / burns with pop	slower * fizz * H ₂ / gas pops with lighted splint / burns with pop	no change / no effect / no visible reaction / no fizzing *
	Test 2 KMnO ₄	no change / no effect / no (visible) reaction OR KMnO ₄ remains purple *	no change / no effect / no (visible) reaction OR KMnO ₄ remains purple *	purple to colourless / yellow / brown OR KMnO ₄ turns colourless / decolourises / yellow / brown *	purple to colourless OR KMnO ₄ turns colourless / decolourises *
	2 * = 1 mark The relative rate of reaction of Mg with the three acids may be awarded from ‘rapid’ (owtte) fizz with either or both FB 5 and FB 6 . The gas test for H ₂ may be awarded in any one of the three boxes for FB 5 , FB 6 or FB 7 . However, an incorrect gas ‘identified’ in Test 1 negates this *. A slight change in colour (purple to brown *) may be noted with KMnO ₄ and FB 6 on heating.				

Question	Answer	Marks
3(a)(ii)	M1 FB 7 is methanoic acid / HCOOH / HCO_2H AND FB 8 is hydrogen peroxide / H_2O_2 M2 Correct explanation for one of FB 7 or FB 8 from observations in table: Methanoic acid / FB 7 Fizzes with Mg / H_2 produced and slowest (reaction) OR oxidised by KMnO_4 / decolourises KMnO_4 (allow yellow / brown unless the same observations are given with FB 6) OR Hydrogen peroxide / FB 8 no fizz / no reaction with Mg OR decolourises KMnO_4 immediately / without heating / oxidised by KMnO_4 immediately	2
3(a)(iii)	M1 EITHER add (aqueous) AgNO_3 / silver nitrate AND white ppt with FB 6 OR add (aqueous) barium chloride / BaCl_2 / barium nitrate / $\text{Ba}(\text{NO}_3)_2$ AND white ppt with FB 5 M2 FB 5 is sulfuric acid / H_2SO_4 AND FB 6 is hydrochloric acid / HCl AND from correct observation	2
3(a)(iv)	$\text{Mg(s)} + 2\text{H}^+(\text{aq}) \rightarrow \text{Mg}^{2+}(\text{aq}) + \text{H}_2(\text{g})$	1
3(a)(v)	M1 magnesium: effervescence / fizz / bubbling M2 potassium manganate(VII): no effect / no (visible) reaction / KMnO_4 remains purple	2
3(b)	2 * = 1 mark use of (aqueous) NaOH AND NH_3 * with NaOH white ppt * ppt insoluble in excess * with NH_3 white ppt * ppt insoluble in excess * cation is Mg^{2+} *	3



Cambridge International AS & A Level

CHEMISTRY

9701/35

Paper 3 Advanced Practical Skills 1

May/June 2022

MARK SCHEME

Maximum Mark: 40

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the May/June 2022 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

This document consists of **10** printed pages.

PUBLISHED**Generic Marking Principles**

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5:

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Science-Specific Marking Principles

1	Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
2	The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.
3	Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
4	The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
5	<u>'List rule' guidance</u> For questions that require <i>n</i> responses (e.g. State two reasons ...): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked <i>ignore</i> in the mark scheme should not count towards <i>n</i>. • Incorrect responses should not be awarded credit but will still count towards <i>n</i>. • Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should not be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response. • Non-contradictory responses after the first <i>n</i> responses may be ignored even if they include incorrect science.

6 Calculation specific guidance

Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'.

For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values.

For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme.

Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 Guidance for chemical equations

Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

Question	Answer	Marks
1(a)	I Unambiguous headings and correct units Units: / g, (g), in gram(me)s with each entry or in heading. • (mass of) flask + acid • (mass of) container + FA 1 • (mass of) container (+ residue) • (final / constant mass of) flask + contents • (mass of) FA 1 (added) • theoretical (initial / total) mass • (mass of) CO₂ (evolved) II Four weighings recorded to the same number of decimal places and to at least 2 dp III Three masses correctly calculated IV Award if ratio $\frac{\text{mass FA 1}}{\text{mass CO}_2}$ (to 2 dp) is within 20% of supervisor's value	4
1(b)(i)	Correctly calculates moles of CO ₂ = mass loss / 44 AND answer to 2–4 significant figures	1
1(b)(ii)	Deduces moles CuCO ₃ = (b)(i) AND correctly uses mass CuCO ₃ = moles × 123.5 AND answer to 2–4 significant figures	1
1(b)(iii)	Mass Cu(OH) ₂ = FA 1 – (ii)	1
1(b)(iv)	Moles Cu(OH) ₂ = (iii) / 97.5 AND ratio moles Cu(OH) ₂ / moles CuCO ₃	1

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Question	Answer	Marks
1(c)	M1 moles $\text{HCl} = 2 \times 25 / 1000 = 0.05$ AND moles reacting in FA 1 = moles CuCO_3 + moles Cu(OH)_2 M2 $0.05 > 2 \times (\text{moles CuCO}_3 + \text{moles Cu(OH)}_2)$ OR M1 moles of HCl required = $2 \times (\text{moles CuCO}_3 + \text{moles Cu(OH)}_2)$ M2 vol of HCl required = moles required $\times 1000 / 2$ AND volume required $< 25 \text{ cm}^3$	2

Question	Answer	Marks
2(a)	I Initial and final readings AND titre recorded for rough titre and accurate titre details tabulated II Headings and units correct for accurate titrations . - initial / final (burette) reading / volume or reading / volume at start / finish - titre or volume / FA 4 - added / used Units:(cm³) or / cm³ or in cm³ or cm³ by every entry III All accurate burette readings are recorded to the nearest 0.05 cm³ IV Final (uncorrected) titre is within 0.10 cm³ of any other accurate titre For assessment of accuracy the examiner should round any burette readings to the nearest 0.05 cm³, check subtractions and then select the 'best titres' using the hierarchy: two (or more) accurate identical titres, then two (or more) accurate titres within 0.05 cm³., then two (or more) accurate titres within 0.10 cm³ etc. These best titres should be used to calculate the mean corrected titre to the nearest 0.01 cm³. Award V if $\delta \leq 0.80 \text{ cm}^3$ Award VI if $\delta \leq 0.50 \text{ cm}^3$ Award VII if $\delta \leq 0.30 \text{ cm}^3$ If supervisor's titre is $\leq 10.00 \text{ cm}^3$ then tolerances are 0.15, 0.25 and 0.40 cm³. If supervisor's titre is $\leq 5.00 \text{ cm}^3$ then tolerances are 0.10, 0.15 and 0.25 cm³.	7
2(b)	Candidate must average two (or more) accurate titres where the total spread is $\leq 0.20 \text{ cm}^3$. Working must be shown or ticks must be put next to the two (or more) accurate titres selected.	1
2(c)(i)	All quoted answers to (c)(ii) to (c)(iv) to 3–4 significant figures (minimum 3 answers attempted).	1
2(c)(ii)	Correctly calculates moles in (b) $\times 0.1 / 1000$	1

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Question	Answer	Marks
2(c)(iii)	Correctly uses moles Cu^{2+} in $25 \text{ cm}^3 = \text{(c)(ii)}$ AND moles Cu^{2+} in $1.0 \text{ dm}^3 = \text{moles Cu}^{2+} \text{ in } 25 \text{ cm}^3 \times 40$	1
2(c)(iv)	Correctly uses (c)(iii) $\times 63.5$	1
2(c)(v)	Correct expression mass of $\text{Cu}^{2+} = 63.5 (1 + x)$	1
2(c)(vi)	mass of 1 mol = $123.5 + 97.5x$	1
2(c)(vii)	M1 LHS $\frac{\text{(c)(iv)}}{10.4 \text{ g}}$ M2 RHS $\frac{63.5 (1 + x)}{123.5 + 97.5x}$ M3 shows cross multiplication and simplification in attempt to calculate x	3

Question	Answer	Marks								
FA 7 is CuCO ₃ •Cu(OH) ₂ (s); FA 8 is CuSO ₄ (aq); M is Mg(s); FA 9 is Na ₂ CO ₃ (aq); FA 10 is KI(aq)										
3(a)	Any two from: - solid goes black / colour change green to black - condensation / water on cool part tube / steam - gas / CO₂ given off turns limewater to white ppt	2								
3(b)(i)	<table><tr><td>test</td><td>observation</td></tr><tr><td>+ edta</td><td>darker blue *</td></tr><tr><td>+ HCl</td><td>green / yellow *</td></tr><tr><td>+ M</td><td>solution goes pale * black solid / ppt * ignore any fizz</td></tr></table> 2 * = 1 mark	test	observation	+ edta	darker blue *	+ HCl	green / yellow *	+ M	solution goes pale * black solid / ppt * ignore any fizz	2
test	observation									
+ edta	darker blue *									
+ HCl	green / yellow *									
+ M	solution goes pale * black solid / ppt * ignore any fizz									
3(b)(ii)	Cu ²⁺ (aq) + M(s) → Cu(s) + M ²⁺ (aq) OR Cu ²⁺ (aq) + 2M(s) → Cu(s) + 2M ⁺ (aq) OR 3Cu ²⁺ (aq) + 2M(s) → 3Cu(s) + 2M ³⁺ (aq)	1								
3(c)(i)	M1 add named acid AND effervescence M2 (to resulting solution) add NaOH AND NH ₃ M3 white ppt insoluble in excess for both alkalis	3								
3(c)(ii)	M is magnesium	1								

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Question	Answer	Marks
3(d)	M1 table with unambiguous headings (test/reagent and observations / results and conclusion) AND any 2 or more reagents M2 selects suitable reagents AgNO₃(aq) AND either named (dilute) acid or named solution that will form a ppt with carbonate but not with a halide e.g. named (aq) barium salt M3 result and conclusion for FA 9 fizz / effervescence / bubbling with acid / correct colour of ppt with suitable salt solution AND FA 9 is carbonate / CO₃²⁻ M4 result and conclusion for FA 10 yellow ppt (ignore addition of (aq) ammonia) AND FA 10 is iodide / I⁻	4