



Cambridge International AS & A Level

CHEMISTRY

9701/31

Paper 3 (Advanced Practical Skills 1)

May/June 2021

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.

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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.

When awarding accuracy (Q) marks in **Question 1**, the following information must be recorded on a blank part of Supervisor's script/report or on the form provided or on a sheet of paper stapled to the Supervisor's script.

- candidate number
- candidate titre
- difference from Supervisor
- mark awarded
- any spread penalty

The Supervisor's results are treated as suspect in either experiment if more than 50% of the candidates score **zero** Q marks. In this case, or if no supervisor's results are supplied, each Examiner should consider using a mean value derived from 'consistent' candidates' results, but this must be discussed with your team leader. If a CDM is employed in **Question 1** then the better accuracy mark stands.

Rounding errors and transcription errors are penalised only once in the paper.

Question	Answer	Marks
1(a)	I The following data must be shown • burette readings and titre for rough titration • 2×2 'box' showing both accurate burette readings <i>'Correct' headings and units are not required for this mark</i>	1
	II Headings and units correct for accurate titration table and headings match readings. • initial/start and (burette) reading / volume + unit (allow vol but not V) • final/end and (burette) reading / volume + unit (allow value for reading) • titre or volume/FA 2 and used/added (not 'difference' or 'total' or 'amount') + unit Units: (cm^3) or / cm^3 or in cm^3 or cm^3 by every entry	1
	III All accurate burette readings to 0.05 cm^3 Do not award this mark if: 50(.00) is used as an initial burette reading; More than one final burette reading is 50(.00); Any burette reading is greater than 50(.00).	1
	IV The final accurate titre recorded is within 0.10 cm^3 of any other accurate titre. Do not award the mark if any 'accurate' burette readings (apart from initial 0) are given to zero dp .	1
	For assessment of accuracy (Q) marks , the Examiner should round any burette readings to the nearest 0.05 cm^3 . 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 cm^3, <i>then</i> • two (or more) accurate titres within 0.10 cm^3, <i>etc.</i> These best titres should be used to calculate the mean titre, expressed to nearest 0.01 cm^3 . Calculate the difference (δ) between the candidate's titre and the supervisor's titre. Award the accuracy (Q) marks as shown below.	1
	Award V if $\delta \leq 0.50 \text{ cm}^3$	1
	Award VI if $\delta \leq 0.30 \text{ cm}^3$	1
	Award VII if $\delta \leq 0.20 \text{ cm}^3$	

Question	Answer	Marks
1(b)	Candidate must average two (or more) titres that are all within 0.20 cm ³ . Working must be shown or ticks must be put next to the two (or more) accurate titres selected.	1
1(c)(i)	Answers for (c)(ii) , (c)(iii) , (c)(iv) to 3–4 sf	1
1(c)(ii)	Correctly calculates $n(\text{MnO}_4^-) = 0.02 \times \mathbf{(b)} / 1000$	1
1(c)(iii)	Correctly uses $n(\text{FeSO}_4) \text{ in } 25 \text{ cm}^3 = \mathbf{(c)(ii)} \times 5 \times 40$	1
1(c)(iv)	Correctly uses $\text{mass}(\text{FeSO}_4) \text{ in } 1 \text{ dm}^3 = \mathbf{(c)(iii)} \times 151.9$	1
1(c)(v)	Correctly uses $n(\text{H}_2\text{O}) = [26.52 - \mathbf{(c)(iv)}] / 18$	1
	ratio $n(\text{H}_2\text{O}) : n(\text{FeSO}_4)$ AND x given as integer OR M1: $M_r \text{ hydrated salt} = 26.52 / \mathbf{(c)(iii)}$ M2: $(26.52 / \mathbf{(c)(iii)} - 151.9) / 18$ and answer as integer	1
1(d)	(as) mole / amount / volume MnO_4^- smaller or (as) mass / moles / amount Fe^{2+} smaller	1
	mass/moles/amount water larger so (mole) ratio larger so x increases <i>Allow difference in titre/moles of $\text{MnO}_4^- / \text{Fe}^{2+}$ will be too small to change the (integer) value of x for 1 mark.</i> <i>Allow for 1 mark: less $\text{MnO}_4^- / \text{Fe}^{2+}$ and x increases</i>	1

Question	Answer	Marks
2(a)	I Appearance FA 4: white / colourless and crystals /solid AND obs during heating: swelling / steam / (some) solid melts / dissolves / white powder forms around the edges <i>Allow evaporation of water</i> <i>Allow bubbling / bubbles of water</i> <i>Ignore fizzing / effervescence</i>	1
	II Unambiguous headings and units in list / table of data: • (Mass of) crucible and lid (<i>not 'weight' in any reading</i>) • (Mass of) crucible, lid and FA 4 (or 'contents before heating') • (Mass of) crucible, lid and residue / contents after heating • (Mass of) FA 4 (used) • (Mass of) residue • (Mass of) water (lost) <i>Ignore mention of 1st heating if reheated</i> <i>Do not allow 'mass of FA 4 after heating' in third weighing.</i> <i>Use of lid must be consistent.</i> <i>Unit must be given correctly in each case.</i>	1
	III Three weighings recorded and all listed subtractions (minimum one) correct • All weighings to the same number of dp • Mass of FA 4 used between 2.40 and 2.60 g <i>If 4 weighings shown then all must be to the same number of dp</i>	1
	IV Accuracy mark Award if ratio between 1.80–2.10	1
2(b)(i)	Correctly calculates $n(\text{H}_2\text{O}) = \text{mass loss in (a)} / 18$ and answer to 2 or more sf AND $n(\text{MZ}) = \text{mass of residue in (a)} / 120.4$ and answer to 2 or more sf <i>If masses are not shown in (a) then values used must be correct</i>	1

Question	Answer	Marks
2(b)(ii)	Shows use of ratio $n(\text{MZ}) : n(\text{H}_2\text{O})$ AND y is an integer <i>Other correct methods are available.</i>	1
2(b)(iii)	One of the following • All water (of crystallisation) was lost / dehydration was complete • No MZ decomposed on heating	1
2(c)	One of the following • student incorrect and because there was no spitting (and therefore lid not required) • student correct and to catch any spitting (check observations for spitting or swelling) • student incorrect and because putting the lid on makes no difference to water (vapour) escaping	1

Question	Answer	Marks
3(a)(i)	Test 1 no change / (pale) orange / (pale) red / (pale) pink solution <i>Allow solution becomes colourless / paler</i>	1
	Test 2	2
	+ NaOH green / dirty green / pale green / dark green ppt * ppt turns brown (at surface) *	
	+ H ₂ SO ₄ ppt dissolves or yellow / yellow-brown / orange-brown solution formed *	
	+ SCN ⁻ (solution) turns dark(er) orange / blood-red / red / dark(er) red / deep red / red-brown * colour must be more intense than in Test 1	
	2 asterisks = 1 mark (round down)	
3(a)(ii)	Fe ³⁺ is formed (in Test 2)	1
	oxidation of Fe ²⁺ / redox	1
3(a)(iii)	NH ₄ SCN	1
3(a)(iv)	Fe ²⁺ (aq) + 2OH ⁻ (aq) → Fe(OH) ₂ (s)	
	correct product formula	1
	balancing and state symbols	1

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Question	Answer	Marks				
3(b)(i)	prepare solution of FA 4	1				
	prepare a suitable table(s) minimum 2 tests and columns/ rows for tests and for observations	1				
	2 asterisks = 1 mark (round down)					
	<table><tr><td>+NaOH *</td><td>white ppt * insoluble in excess *</td></tr><tr><td>+ NH₃ *</td><td>white ppt* insoluble in excess *</td></tr></table>	+NaOH *	white ppt * insoluble in excess *	+ NH ₃ *	white ppt* insoluble in excess *	5
	+NaOH *	white ppt * insoluble in excess *				
	+ NH ₃ *	white ppt* insoluble in excess *				
<table><tr><td>BaCl₂/Ba(NO₃)₂ *</td><td>white ppt * insoluble in excess suitable named acid *</td></tr><tr><td>OR dilute acid * + KMnO₄ *</td><td>no change / no reaction / solution remains purple **</td></tr></table>	BaCl ₂ /Ba(NO ₃) ₂ *	white ppt * insoluble in excess suitable named acid *	OR dilute acid * + KMnO ₄ *	no change / no reaction / solution remains purple **		
BaCl ₂ /Ba(NO ₃) ₂ *	white ppt * insoluble in excess suitable named acid *					
OR dilute acid * + KMnO ₄ *	no change / no reaction / solution remains purple **					
<i>Ignore additional reagents</i>						
3(b)(ii)	cation: Mg ²⁺ and anion: SO ₄ ²⁻	1				



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7 Guidance for chemical equations

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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 Initial and final burette readings and volume added recorded for rough titre and accurate titre details tabulated. (<i>minimum 2 × 2 boxes with relevant information</i>).	1
	II Initial and final burette readings recorded and vol of FB 2 added recorded for each accurate titration. Headings and units correct for accurate titrations. Headings: initial / final and (burette) reading / volume or reading / volume at start / finish <i>Do not allow difference / change</i> and volume / FB 2 added / used or titre and units (cm ³) or / cm ³ or in cm ³ or cm ³ by every entry <i>Accept vol but not V</i>	1
	III All accurate burette readings are recorded to the nearest 0.05 cm ³ . Do not award this mark if: 50(.00) is used as an initial burette reading; More than one final burette reading is 50(.00) Any burette reading is > 50(.00)	1
	IV The final accurate titre recorded is within 0.1 cm ³ of any other accurate titre. <i>Do not award the mark if any accurate burette readings (apart from 0) are given to zero dp.</i>	1
	For assessment of accuracy (Q) marks, the Examiner should round any 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. Calculate the difference (δ) between the candidate’s titre and the supervisor’s titre. Award the accuracy (Q) marks as shown below.	

Question	Answer	Marks
1(a)	V, VI and VII Award V, VI and VII for $\delta \leq 0.20 \text{ cm}^3$ Award V and VI for $0.20 \text{ cm}^3 < \delta \leq 0.30 \text{ cm}^3$ Award V for $0.30 \text{ cm}^3 < \delta \leq 0.50 \text{ cm}^3$	3
1(b)	Candidate must average two (or more) titres that are all within 0.20 cm^3 . Working must be shown or ticks must be put next to the two (or more) accurate titres selected.	1
1(c)(i)	Answers to (ii) and (iii) given to 3–4 sf.	1
1(c)(ii)	Correctly calculates moles of $\text{HCl} = \frac{0.1 \times \text{vol in (b)}}{1000}$	1
1(c)(iii)	Correctly uses (c)(ii) $\div 2$ and $\times 40$	1
1(c)(iv)	Correctly uses M1: $M_r = \frac{11.30}{\text{moles from (c)(iii)}}$ M2: $x\text{H}_2\text{O} = M_r \text{ hydrated} - 106$ or $M_r = 106 + 18x$ M3: $x\text{H}_2\text{O}$ to calculate $x = M2 / 18$ and answer shown to 2–4 sf ALLOW alternative methods (e.g. ratio of anhydrous : water)	3

Question	Answer	Marks
2(a)	I Table/lists given for at least one experiment Unambiguous headings and correctly displayed units • (Mass of) cup • (Mass of) cup + FB 3 • (Mass of) FB 3 • Initial thermometer reading / temperature • Maximum / highest / final thermometer reading / temperature	1
	II Precision of all four readings • thermometer readings to .5 °C • balance readings to same number of dp	1
	III Masses of FB 3 1.90 to 2.10 and 3.90 to 4.10 g and subtractions correct	1
	IV and V Examiner to round thermometer readings to nearest .5 °C, calculate ΔT values then calculate ratio to 1 dp: ΔT experiment 2 / ΔT experiment 1 Award IV if 1.6 to 2.4 Award V if 1.8 to 2.2	2
2(b)(i)	Correctly calculates heat energy = $25 \times 4.2 \times \Delta T$ to 2–4 sf	1
2(b)(ii)	Correctly uses moles $\text{Na}_2\text{CO}_3 = \frac{(\text{b})(\text{i})}{28100}$	1
2(b)(iii)	Correctly uses mass $\text{Na}_2\text{CO}_3 = (\text{b})(\text{ii}) \times 106$ Allow ecf for RFM anhydrous Na_2CO_3 in 1(c)(iv)	1
2(b)(iv)	Correctly uses $\% = \frac{(\text{b})(\text{iii})}{\text{Mass FB3 from Expt 1}} \times 100$	1

Question	Answer			Marks																											
2(c)	The enthalpy of solution of the impurity was = 0 / negligible / the impurity does not give out / absorb any heat / cause a temperature change when it dissolves / impurity does not dissolve in water			1																											
2(d)	Experiment 1 was more accurate because a smaller temperature rise meant that heat losses were less. OR Experiment 2 was more accurate because has a larger temperature rise and therefore a smaller percentage error in temperature rise.			1																											
3(a)	<table><tr><td></td><td>FB 4</td><td>FB 5</td></tr><tr><td>Test 1 heat</td><td>blue / green solid *</td><td>white solid *</td></tr><tr><td></td><td>goes black *</td><td>goes yellow *</td></tr><tr><td></td><td colspan="2">condensation in either *</td></tr><tr><td>cooling</td><td>ignore</td><td>white / paler solid *</td></tr><tr><td>Test 2 + H₂SO₄</td><td colspan="2">bubbles in both *</td></tr><tr><td></td><td>blue soln *</td><td>colourless soln *</td></tr><tr><td></td><td colspan="2">attempts limewater in either *</td></tr><tr><td></td><td colspan="2">white ppt / turns milky / cloudy white *</td></tr></table> 2 * = 1 mark (round down)				FB 4	FB 5	Test 1 heat	blue / green solid *	white solid *		goes black *	goes yellow *		condensation in either *		cooling	ignore	white / paler solid *	Test 2 + H ₂ SO ₄	bubbles in both *			blue soln *	colourless soln *		attempts limewater in either *			white ppt / turns milky / cloudy white *		5
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Question	Answer			Marks
3(b)	test	FB 6	FB 7	7
	edta	turns brighter / more intense / darker blue * ALLOW light blue to dark blue	No (visible) change / no reaction * ALLOW (solution) stays colourless	
	NaOH	Blue ppt and insoluble in excess *	White ppt * Soluble in excess *	
	NH ₃	(Pale) blue ppt * (Soluble excess to) dark blue solution *	White ppt * Soluble in excess *	
	Mg	Pink / brown / dark grey / black solid * ALLOW ppt Blue fades / bubbles *		
	KI	Brown / yellow-brown / ochre * (ignore state)		
	+ starch	Black / blue-black / dark blue *		
	HCl	(Solution) goes green / yellow *		
	2 asterisks = 1 mark (round down)			
3(c)	2 asterisks = 1 mark (round down)			2
		FB 4	FB 5	
	cation	Cu ^{2+*}	Zn ^{2+*}	
	anion	CO ₃ ^{2-*}	CO ₃ ^{2-*}	

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Question	Answer	Marks
3(d)	$\text{Cu}^{2+}(\text{aq}) + \text{Mg}(\text{s}) \rightarrow \text{Cu}(\text{s}) + \text{Mg}^{2+}(\text{aq})$ If bubbles recorded in test 4, allow $\text{Mg}(\text{s}) + 2\text{H}^{+}(\text{aq}) \rightarrow \text{Mg}^{2+}(\text{aq}) + \text{H}_2(\text{g})$ Allow ecf on identity of FB 6	1



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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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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).
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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'.

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Question	Answer	Marks
1(a)	I The following data must be shown: • burette readings and titre for rough titration • 2×2 'box' showing both accurate burette readings	1
	II Headings and units correct for accurate titration table and headings match readings. • initial/start and (burette) reading / volume + unit • final/end and (burette) reading / volume + unit • titre or volume/FA 5 and used / added + unit Units: (cm ³) or / cm ³ or in cm ³ or cm ³ by every entry	1
	III All accurate burette readings to 0.05 cm ³	1

Question	Answer	Marks
1(a)	IV The final accurate titre recorded is within 0.10 cm³ of any other accurate titre Accuracy (Q) marks Round burette readings to the nearest 0.05 cm³. Check and correct titre subtractions where necessary. Examiner selects the best mean titre. Apply hierarchy: 2 identical, titres within 0.05 cm³, titres within 0.10 cm³ etc. Examiner subtracts (corrected) candidate's titre from Supervisor's titre. Write and ring supervisor's value next to the accurate titration table of each candidate, also candidate mean value (calculated by examiner) and difference between supervisor's and candidate's value, δ.	1
	Award accuracy marks as follows: V Award if $\delta \leq 0.60 \text{ cm}^3$ VI Award if $\delta \leq 0.40 \text{ cm}^3$ VII Award if $\delta \leq 0.20 \text{ cm}^3$ (3)	7
1(b)	Correctly calculates mean accurate titre • Candidate must take the average of two (or more) titres that are within a total spread of not more than 0.20 cm³. • Working/explanation must be shown or ticks must be put next to the two (or more) accurate readings selected. • The mean should be quoted to 2 dp and be rounded to nearest 0.01 cm³.	1
1(c)(i)	Answers for (c)(ii) and (iii) to 3 or 4 sf	1
1(c)(ii)	Correctly calculates amount of I₂ = $[(\mathbf{b}) \times 0.1] / [2 \times 1000]$ (= $(\mathbf{b}) \times 5 \times 10^{-5} \text{ mol}$)	1

Question	Answer	Marks
1(c)(iii)	Correctly uses: If candidate's answer = $400 \times \text{(c)(ii)}$ and working shown award both marks If candidate's answer = $400 \times \text{(c)(ii)}$ no working shown award 1 mark If candidate's answer = $200 \times \text{(c)(ii)}$ award 1 mark (I_2 / I^- confusion) If candidate's answer = $100 \times \text{(c)(ii)}$ award 1 mark (250 / 25 instead of 1000 / 25) If candidate's answer = $40 \times \text{(c)(ii)}$ award 1 mark (dilution factor missing)	2
1(d)(i)	moles of KI = $15 / 1000 \times 0.5 = 7.5 \times 10^{-3}$ mol moles $\text{I}^- = \text{(c)(ii)} \times 2$ $2 \times \text{(c)(ii)} < 7.5 \times 10^{-3}$ OR a comparison in words $(\text{(c)(ii)} < 3.75 \times 10^{-3})$	1
1(d)(ii)	M1: Repeat the experiment using a greater volume of KI M2: If titre value is the same then KI was in excess OR M1: Add more KI at the endpoint M2: If mixture / it goes black / blue-black / dark blue then KI was not in excess OR M1: Add AgNO_3 before titrating M2: Yellow ppt observed shows presence of I^- / no yellow ppt shows I^- not in excess OR M1: Add more/extra NaClO when the titration mixture is yellow M2: if the mixture goes darker yellow / brown etc., (this shows more iodine has been produced, as) KI is in excess. (ORA)	2

Question	Answer	Marks
2(a)	I Table / list to include initial and final balance reading, initial and final thermometer reading, mass added and temperature change. and all entries with correct units: / °C, (g) or in °C or in degrees Celcius, in g or in gram(me)s and recorded in the space provided	1
	II All balance readings recorded to the same precision (minimum 1 dp) and all thermometer readings recorded to .0 or .5 °C.	1
	Accuracy marks Examiner checks and corrects mass of FA 6 used and temperature fall (round thermometer readings to the nearest .0 or .5 °C). Examiner calculates ΔT / mass to 2 dp for supervisor and candidate Write and ring supervisor's ratio next to the results table of each candidate, also candidate ratio and difference between supervisor's and candidate's value, δ .	
	Award accuracy marks as follows: III Award if $\delta \leq 0.40 \text{ }^{\circ}\text{C g}^{-1}$ IV Award if $\delta \leq 0.20 \text{ }^{\circ}\text{C g}^{-1}$ (2)	4
2(b)(i)	Correctly calculates heat energy change = $20 \times 4.2 \times \text{temperature change}$ and answer given to 2–4 sf	1
2(b)(ii)	M1: Correct display of mass of FA 6 / moles of thiosulfate or (b)(i) / 47400 M2: Correct use of (correct mass FA 6 $\times$ 47400) / ans (b)(i) and answer given to 2–4 sf	2

Question	Answer	Marks
2(b)(iii)	Correct display $x = \frac{[(b)(ii) - 158.2]}{18}$ and answer given to the nearest integer	1
2(c)	M1: temperature fall / change would be less OR heat energy change would be less M2: therefore moles/ amount of thiosulfate would be fewer / less and so M_r would be greater	2

Question	Answer	Marks
FA 4 is KI(aq); FA 5 is NaS ₂ O ₃ (aq); FA 7 is MgCl ₂ •6H ₂ O; FA 8 is FeCl ₃ / H ⁺ ; FA 9 is HCOOH(aq); FA 10 is NaS ₂ O ₃ (aq); FA 11 is HCl(aq)		
3(a)(i)	2 * = 1 mark (round down) white solid / powder / crystals (at start) * forms liquid/ melts / dissolves (in water of crystallization) * condensation / water droplets (on side of test-tube) / water vapour * white residue / solid / powder forms * NOT ppt (blue) litmus turns red *	2
3(a)(ii)	M1: Selects NaOH and NH ₃ ONLY M2 & 3: + NaOH: white ppt * which is insoluble in excess * + NH ₃ : white ppt * which is insoluble in excess * 2 * = 1 mark (round down)	3
3(a)(iii)	+ AgNO ₃ : white ppt	1

Question	Answer	Marks
3(a)(iv)	cation: magnesium / Mg^{2+} and anion: chloride / Cl^- (from white ppt)	1
3(b)	Test 1. M1: + FA 4 yellow (solution) turns darker yellow / yellow-brown / orange-brown / red-brown / brown M2: + starch – (turns) black / blue-black / dark blue Test 2. M3: + FA 5 solution turns purple and colour fades on standing	3
3(c)(i)	Test 1 FA 9 effervescence / bubbling / fizzing * FA 10 no reaction / no effervescence / bubbling / fizzing * FA 11 faster effervescence / bubbling / fizzing * gas / H_2 pops with a lighted splint with FA 9 and / or FA 11 * Test 2 FA 9 KMnO_4 decolourised OR purple to / turns colourless * FA 10 KMnO_4 decolourised OR purple to / turns colourless * FA11 no reaction OR solution remains purple * 2* = 1 mark (round down)	3

Question	Answer	Marks
3(c)(ii)	FA 9 = HCOOH / methanoic acid; FA 10 = Na_2SO_3 / sodium sulfite / sodium sulfate(IV) FA 11 = HCl / hydrochloric acid 1 mark for one correct 2 marks for all three correct	2



Cambridge International AS & A Level

CHEMISTRY

9701/34

Paper 3 (Advanced Practical Skills 2)

May/June 2021

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 2021 series for most Cambridge IGCSE™, Cambridge International A and AS Level 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:

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- 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.

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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)	I Unambiguous headings with data are recorded in the space provided • (mass of) container with FB 1 • (mass of) (empty) container • (mass of) FB 1 used correctly subtracted Unit must be shown.	1
	II 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
	III Titre values recorded for accurate titrations, and Appropriate headings and units in the accurate titration table • initial/start and (burette) reading / volume • final/end and (burette) reading / volume • titre or volume used / added or FB 2 used / added • unit: / cm³ or (cm³) or in cm³ (for each heading) or cm ³ unit given for each volume recorded	1
	IV All accurate burette readings recorded to 0.05 cm ³	1
	V The final accurate titre recorded is within 0.1(0) cm ³ of any other accurate titre	1
	Accuracy (Q) marks Round burette readings to the nearest 0.05 cm ³ . Check and correct titre subtractions where necessary. Examiner selects the best mean titre. Apply 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> Calculate the products of (mass × titre) for candidate and supervisor, as shown below, to one d.p. . Product = mean titre × mass of FB 1 used (cm³g) <i>If no weighings are discernible, assume mass of FB 1 = 6.40 g</i> Calculate the difference (δ) between the candidate's product and the supervisor's product. Award the accuracy (Q) marks as shown below. Write and ring supervisor's value next to the accurate titration table of each candidate, also candidate mean value (calculated by examiner) and difference between supervisor's and candidate's value, δ.	

Question	Answer	Marks
1(a)	Award accuracy marks as follows: VI Award if $\delta \leq 6.0 \text{ cm}^3 \text{ g}$ VII Award if $\delta \leq 4.0 \text{ cm}^3 \text{ g}$ VIII Award if $\delta \leq 2.0 \text{ cm}^3 \text{ g}$ (3)	8
1(b)	Correctly calculates mean accurate titre • Candidate must take the average of two (or more) titres that are within a total spread of not more than 0.20 cm^3. • Working/explanation must be shown or ticks must be put next to the two (or more) accurate readings selected. • The mean should be quoted to 2 dp and be rounded to nearest 0.01 cm^3.	1
1(c)(i)	Sig fig mark All answers given for (c)(ii) , (iii) , (iv) and (v) must be to 3 or 4 sf	1
1(c)(ii)	Correctly calculates No of moles of thio = mass weighed / 248.2	1
1(c)(iii)	Correct use of (ii) Moles thio used = (c)(ii) $\times$ mean titre / 250	1
1(c)(iv)	Correct use of (iii) Concentration of KMnO_4 = $1000 / 25 \times 2 / 5 \times 1 / 2 \times \text{(c)(iii)}$ mol dm^{-3} = (c)(iii) $\times 8$	1
1(c)(v)	Correct use of (iv) Mass of KMnO_4 (g dm^{-3}) = (c)(iv) $\times 158(.0)$	1
1(d)(i)	Correct expression % error = $([3.16 - \text{(c)(v)}] / 3.16) \times 100$ or $([\text{(c)(v)} - 3.16] / 3.16) \times 100$	1
1(d)(ii)	Student is not correct since KI / FB 4 is used in excess	1

Question	Answer	Marks
2(a)(i)	M1: Unambiguous table/ list of data – 3 pieces of data shown • two thermometer readings recorded with clear headings and units • temperature rise shown correctly calculated Units must be °C either with each value or as heading or in body of text: (° C), / °C, in °C, in degrees Celsius.	
	M2: Accuracy mark Check and correct temperature rise for supervisor and candidate. Write supervisor's temp rise on the script in a ring Calculate the difference δ between these temperature rises. Award this Q mark if $\delta \leq 1.0\text{ }^{\circ}\text{C}$	2
2(a)(ii)	Correctly calculates energy released Energy = $55 \times 4.2 \times \text{temp rise (J)}$ and answer given to 2–4 sf	1
2(a)(iii)	M1: Shows that HCl is in excess by calculating $n(\text{NH}_3)$ and $n(\text{HCl})$ (no. of moles ammonia) = $2 \times 0.030 = 0.060\text{ mol}$ and (no. of moles of HCl) = $3 \times 0.025 = 0.075$ (so is in excess)	
	M2: Correct use • $\Delta H = \text{energy} / (1000 \times \text{no. of moles } \text{NH}_3 \text{ used}) (= q / 0.06)$ $(\Delta H = \text{(a)(ii)}/60)$ • Answer must have negative sign and be expressed to 2–4 sf	2

Question	Answer	Marks
2(b)(i)	M1: Unambiguous table/ list of data – 6 pieces of data shown with units (mass of) container + FB 8 / solid / NH_4Cl (mass of) container (empty or with residual FB 8) (mass of) FB 8 / solid / NH_4Cl or mass used - initial temperature / thermometer reading - final / lowest / minimum temperature / thermometer reading - temp change / decrease	
	M2: Correct data collected (all bullets below are correct) - two thermometer readings are shown - both thermometer readings recorded to .0 or .5 - two balance readings are shown - both balance readings to the same number of dp - subtractions correct	
	M3: Accuracy mark Check and correct temp decrease for supervisor and candidate. Write supervisor's temperature decrease on the script in a ring. Calculate the difference δ between these temperature decreases. Award this Q mark if $\delta \leq 1.5^\circ\text{C}$	3
2(b)(ii)	Correct expressions - Energy = $30 \times 4.2 \times$ temperature decrease - Moles NH_4Cl = mass used / 53.5 - Enthalpy change = energy / ($1000 \times$ moles NH_4Cl) - Answer given with positive sign and 2 or more sig figs 2 bullets = 1 mark (round down)	2
2(c)	Correctly uses data and answers (a)(iii) and (b)(ii) $\Delta H = -30.5 - 74.8 + \text{ans 2(a)(iii)} - \text{ans 2(b)(ii)}$ or correct numerical answer given to 2 or more sf	1

Question	Answer	Marks
FB 9 is (basic) ZnCO_3 ; FB 10 is NaOH(aq)		
3(a)(i)	Observations when heated White solid / powder * Condensation in tube / water vapour formed / steam formed / droplets / liquid inside top of test-tube * Yellow (residue) formed (when hot) * (After cooling,) solid / residue becomes paler / goes white * 2 asterisks (*) = 1 mark (round down)	2
3(a)(ii)	Observations with sulfuric acid (Mark as four ‘*’) fizzing / bubbling / effervescence * reaction is rapid / vigorous or colourless solution formed / solid / FB 9 dissolves / disappears * Attempts to test with limewater * Gas / CO_2 turns lime water milky / cloudy white / white ppt * 2 asterisks (*) = 1 mark (round down)	2
3(a)(iii)	Tests on solution (Mark as four asterisks) With NaOH: white ppt * soluble / forms (colourless) solution in excess (NaOH) * With NH_3: white ppt * soluble / forms (colourless) solution in excess (NH_3) * 2 asterisks (*) = 1 mark (round down)	2
3(a)(iv)	FB 9 is zinc carbonate / ZnCO_3	1

Question	Answer	Marks				
3(b)(i)	Observations with FB 10 Test 1 + Cu²⁺(aq): (pale) blue precipitate * then heat: black or dark brown precipitate / solid (formed) * + Al: fizzing / bubbling / effervescence * <u>gas/NH₃</u> (with Al) turns (red) litmus blue * Test 2 + Al: fizzing / bubbling / effervescence * (gas/hydrogen) ‘pops’ with a lighted spill/splint or gas has no effect on red litmus paper (OWTTE) * Al/solid dissolves/ disappears or colourless solution forms * then + HCl: (faint) white / pale grey / off white precipitate forms * Test 3 + Cr³⁺(aq): grey-green precipitate * then + excess FB 10: precipitate dissolves in excess (FB 10) or green solution formed * 2 asterisks (*) = 1 mark (round down)	5				
3(b)(ii)	Conclusion <table><tr><td>cation</td><td>anion</td></tr><tr><td>unknown</td><td>OH⁻ / hydroxide</td></tr></table>	cation	anion	unknown	OH ⁻ / hydroxide	1
cation	anion					
unknown	OH ⁻ / hydroxide					



Cambridge International AS & A Level

CHEMISTRY

9701/35

Paper 3 (Advanced Practical Skills 2)

May/June 2021

MARK SCHEME

Maximum Mark: 40

Published

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PUBLISHED

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	II All the following data is recorded • two burette readings and titre for the rough titration • initial and final burette readings for two (or more) accurate titrations	1
	III Titre values recorded for accurate titrations, and appropriate headings and units in the accurate titration table • initial / start and (burette) reading / volume • final / end and (burette) reading / volume • titre or volume used / added / or FA 3 added (<i>not 'difference' or 'total' or 'amount'</i>) Allow 'Vol', but not V • unit: /cm³ or (cm³) or in cm³ (for each heading) or cm³ unit given for each volume recordedUnits: (cm³) or /cm³ or in cm³ or cm³ by every entry	1

Question	Answer	Marks
1(a)	IV All accurate burette readings to 0.05 cm ³	1
	V The final accurate titre recorded is within 0.10 cm ³ of any other accurate titre	1
	For assessment of accuracy (Q) marks, the Examiner should round any 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. Calculate the products of mass and titre for candidate and supervisor to one d.p., as shown below. • Product = ‘best’ mean titre × mass of FA 1 used. (Theoretical product value = 56.0 cm³g) <i>If no weighings are discernible, assume mass of FA 1 = 2.25 g</i> Calculate the difference (δ) between the candidate’s product and the supervisor’s product. Award the accuracy (Q) marks as shown below.	
	Award accuracy marks as follows: VI Award if $\delta \leq 2.0 \text{ cm}^3 \text{ g}$ VII Award if $\delta \leq 1.0 \text{ cm}^3 \text{ g}$ VIII Award if $\delta \leq 0.5 \text{ cm}^3 \text{ g}$ (3)	8
1(b)	Correctly calculates mean accurate titre • Candidate must take the average of two (or more) titres that are within a total spread of not more than 0.20 cm³. • Working/explanation must be shown or ticks must be put next to the two (or more) accurate readings selected. • The mean should be quoted to 2 dp and be rounded to nearest 0.01 cm³.	1
1(c)(i)	Correctly calculates (to 3 or 4 sig fig) No of moles of Na₂CO₃ used = 0.00113 or 0.001125	1

Question	Answer	Marks
1(c)(ii)	Correct equation AND calculates moles of HX $\text{Na}_2\text{CO}_3 + 2\text{HX} \rightarrow 2\text{NaX} + \text{CO}_2 + \text{H}_2\text{O}$ and - No of moles of HX = 0.00226(0) or 0.00225(0)	1
1(c)(iii)	Correct expression shown for scale up M1: No of moles HX in $250 \text{ cm}^3 = (\text{c})(\text{ii}) \times 250 / \text{mean titre}$ Correctly uses expression for M_r M2: $M_r = \text{mass of FA 1 used} / \text{moles of FA 1 in } 250 \text{ cm}^3$ and answer given to 3 or 4 sf and to the correct power of 10	2
1(c)(iv)	Appropriate identity of E $A_r = \text{answer (iii)} - 14 - 3 - 48 (= (\text{iii}) - 65)$ and E chosen with A_r closest to this value.	1
1(d)	Correct expression for % error $= (2 \times \text{balance error} / \text{mass of FA1 used}) \times 100$	1
1(e)	M1: Method Add (aqueous silver nitrate to) FA 3 or to a <u>solution</u> of FA 1 M2: Observation and conclusion No reaction / no change / no precipitate / colourless solution (formed) and AgX is soluble	2
1(f)	Accept one answer from - end-point colour change is indistinct / difficult to see colour change occurs over addition of significant volume - accept an answer based on pH curve – e.g. colour change range not within ‘vertical’ part of graph	1

Question	Answer	Marks
2(a)	I Unambiguous headings and correct 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 contents after heating / residue (1) - Mass of crucible, lid and contents after heating / residue (2)	1
	II Readings are appropriately recorded - All weighings shown are recorded to same decimal places (one or more). - Mass of FA 4 is within range 2.00–2.20 g (<i>from weighings</i>) Third and fourth weighings are within 0.04 g of each other (or identical if a 1 dp balance was used)	1
	III Correct subtractions (answers given to 2 or more sig fig) and Mass of FA 4 used and mass of water lost both listed.	1
	Accuracy marks Use the theoretical mass ratio water/FA 4 = 0.147 - Examiner must check and correct (if needed) the mass of FA 4 used and water removed (after re-heating) by the candidate. - Work out ratio mass of water/mass of FA 4 for the candidate (to 3 dp) Award accuracy marks as follows:	
	IV Award if ratio in range 0.137–0.157 V Award if ratio in range 0.142–0.152 (2)	5
2(b)(i)	Correctly calculates percentage by mass of water Answer = ratio (see above) $\times 100$	1
2(b)(ii)	Assumption The residue does not decompose when heated / the mass loss is only due to water (OWTTE)	1

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Question	Answer	Marks
FA 4 is $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$; FA 5 is $(\text{NH}_4)_2\text{CO}_3$		
3(a)(i)	Correct reagents M1: (Reagents needed are) silver nitrate and ammonia M2: White ppt with AgNO_3 and Precipitate is partially / mostly soluble in (excess) ammonia. M3: the precipitate (of silver chloride) should dissolve completely in excess ammonia/ the ppt is insoluble in (excess) ammonia	3
3(a)(ii)	M1: White precipitate / solid and cation is barium M2: Ionic equation $\text{Ba}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$	2

Question	Answer	Marks
3(b)	Calculation of no of moles of water M1: M_r of anhydrous salt = 208.3 M2: n(anhy salt : water) $= \frac{\text{mass residue}}{M_r} : \frac{\text{mass water}}{18}$ $= \text{ans} : \text{ans}$ M3: ratio of moles and answer given to integer value or up to 4 sf OR M2: Candidate shows valid working to calculate M_r of hydrated salt or working to calculate mass of water from 1 mole FA 4. (e.g. M_r (hydrated salt) = $208.3 \times \text{mass FA 4 used} / \text{mass residue}$) or mass water (in 1 mol FA 4) = $208.3 \times \text{mass water lost} / \text{mass of residue}$ M3 Candidate attempts to divide mass of water by 18 and expresses moles of water as an integer or up to 4 sf	3
3(c)(i)	Heating FA 5: there are four marking points * FA 5 is a white solid / powder / crystals * Condensation / steam / water vapour forms * (Gas / vapour / ammonia) turns (red) litmus blue * No residue / solid left (in the tube) or solid disappears / sublimes 3 or 4 asterisks (*) = 2 marks 2 asterisks (*) = 1 mark	2

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Question	Answer	Marks
3(c)(ii)	FA 5 + acid: there are 6 marking points *Fizzing / bubbling / effervescence (but not 'gas produced') *Rapid / vigorous (reaction) owtte *Solid dissolves / (colourless) solution formed *Reaction is endothermic / solution gets colder *Attempts to test with limewater *<u>Gas / carbon dioxide</u> turns limewater milky / white precipitate 'cloudy' is not accepted, but 'cloudy white' is OK. 2 asterisks (*) = 1 mark (round down)	3
3(c)(iii)	gas / ammonia turns (red) litmus blue.	1
3(c)(iv)	Conclusion FA 5 is $(\text{NH}_4)_2\text{CO}_3$	1