



Cambridge International AS & A Level

CHEMISTRY

9701/31

Paper 3 Advanced Practical Skills 1

May/June 2023

MARK SCHEME

Maximum Mark: 40

Published

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- 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:

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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.

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Question	Answer	Marks
1(a)	I Single table to show results for five experiments (volume of FA 1 , volume of water, time and rate)	8
	II Appropriate headings and units for recorded data given Volume units for headings: / cm ³ or (cm ³) or in cm ³ Time units for headings: / s or (s) or in seconds Rate units for headings: / s ⁻¹ or (s ⁻¹) or per second OR units of cm ³ , s or s ⁻¹ against each entry	
	III All times recorded to nearest second AND all volumes given to 2 dp with the final digit being 0 or 5 cm ³	
	IV Three additional volumes chosen with intervals not less than 5 cm ³ AND all volumes of FA 1 not less than 15.00 cm ³	
	V In all additional experiments water is added to make a total of 40.00 cm ³	
	VI All rates correctly calculated using 1000 / time All recorded to minimum of two significant figures or integer value AND from at least three experiments	
	Accuracy marks Calculate ratio: $\frac{\text{Time for } 20.00 \text{ cm}^3 \text{ of FA 1}}{\text{Time for } 40.00 \text{ cm}^3 \text{ of FA 1}}$ to two decimal places VII Award for ratio 1.70–2.40 VIII Award for ratio 1.90–2.20	
1(b)	I Rate on y-axis and volume of FA 1 on x-axis with unambiguous labels or units	4
	II Linear scales (starting at 0,0) chosen so that the graph occupies at least half the available length for both axes	
	III Five recorded points plotted correctly	
	IV Draws a line of best fit straight line or smooth curve AND anomalous point(s), if any, should be ringed	

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Question	Answer	Marks
1(c)	Yes / directly proportional and as straight line through / close to origin OR no / not directly proportional and line not through origin / curve	1
1(d)	M1 Line drawn at 12.50 cm ³ and line drawn across to rate axis OR marks on rate and volume axes within half a small square M2 Time correctly calculated from candidate's rate	2
1(e)	M1 Solution is less deep / shallower M2 Time would be longer because of the need to have more S / solid to obscure insert owtte	2

Question	Answer	Marks
2(a)	I Unambiguous headings and units covering all entries • (mass of) container + solid FA 3 / FA 4 • (mass of) container (+ residue) • initial thermometer reading / temperature • lowest / highest reading / temperature • mass solid (used / added) / FA 3 / FA 4 • change in temperature / ΔT Units: / g, (g), in g and / °C, (°C), in °C	5
	II All four balance readings to the same number of decimal places (2 or 3) AND thermometer readings to .0 °C or .5 °C AND written in the table / results space	
	III Correctly calculates for both experiments • mass solid • change in temperature	
	Accuracy marks Correct all temperatures to nearest .5 °C. Calculate ΔT for supervisor and for candidate. ΔT = initial temperature – lowest / highest temperature in table Calculate the difference, δ , between supervisor and candidate values	
	IV Award if $\delta \leq 1.0$ °C for experiment 1 V Award if $\delta \leq 1.0$ °C for experiment 2	
2(b)(i)	Correctly calculates $Q = mc\Delta T$ for both experiments = $25 \times 4.18 \times \Delta T$ AND answers to 2–4 significant figures	1

Question	Answer	Marks
2(b)(ii)	M1 Correctly calculates M_r for each: 246.4 AND 120.4 M2 Shows correct working (may be in more than 1 step) <u>(b)(i) expt 1 $\times$ 246.4</u> mass FA 3 $\times$ 1000 AND <u>(b)(i) expt 2 $\times$ 120.4</u> mass FA 4 $\times$ 1000 M3 Shows correct sign for both values of ΔH AND answers from attempted calculation to 2–4 significant figures	3
2(b)(iii)	M1 Shows attempt at use of Hess' law / energy level diagram / reverse equation ($\Delta H = \Delta H_1 - \Delta H_2$) M2 Correct answer to 2–4 significant figures with appropriate sign	2

Question	Answer	Marks												
FA 5 is $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ and FA 6 is CuCO_3														
3(a)(i)	M1 Test for water Heat solid sample of FA 5 AND either (gentle heating) solution / liquid formed or solid / FA 5 dissolves / melts or observes condensation / steam produced M2 Add water / make a solution M3 Test for magnesium Add (aqueous) sodium hydroxide AND white ppt soluble in excess OR add (aqueous) ammonia AND white ppt soluble in excess M4 Test for sulfate Add (aqueous) barium chloride / nitrate AND white ppt insoluble in hydrochloric / nitric acid OR KMnO_4 is not decolourised owtte	4												
3(a)(ii)	<table border="1"> <thead> <tr> <th></th><th>yes</th><th>no</th></tr> </thead> <tbody> <tr> <td>FA 5 contains magnesium ions</td><td></td><td>✓</td></tr> <tr> <td>FA 5 contains sulfate ions</td><td>✓</td><td></td></tr> <tr> <td>FA 5 contains water of crystallisation</td><td>✓</td><td></td></tr> </tbody> </table>		yes	no	FA 5 contains magnesium ions		✓	FA 5 contains sulfate ions	✓		FA 5 contains water of crystallisation	✓		1
	yes	no												
FA 5 contains magnesium ions		✓												
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3(b)(i)	green (solid) * (goes) black (solid) * condensation * gas / carbon dioxide tested with limewater * gives white ppt * Two marks for 4 or 5 points One mark for 2 or 3 points	2												

Question	Answer		Marks						
3(b)(ii)	<table><tr><th><i>test</i></th><th><i>observations</i></th></tr><tr><td>Test 1 Hydrochloric acid</td><td>fizz / bubbles / effervescence * use limewater * blue solution * (formed)</td></tr><tr><td>Test 2 Ammonia</td><td>(pale) blue ppt * (dissolves in excess) to dark / deep blue solution (as final observation) *</td></tr></table> Two marks for 4 or 5 points One mark for 2 or 3 points	<i>test</i>	<i>observations</i>	Test 1 Hydrochloric acid	fizz / bubbles / effervescence * use limewater * blue solution * (formed)	Test 2 Ammonia	(pale) blue ppt * (dissolves in excess) to dark / deep blue solution (as final observation) *		2
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Test 1 Hydrochloric acid	fizz / bubbles / effervescence * use limewater * blue solution * (formed)								
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3(b)(iii)	cation: copper(II) / Cu ²⁺ AND anion: carbonate / CO ₃ ²⁻		1						
3(b)(iv)	Cu ²⁺ (aq) + 2OH ⁻ (aq) → Cu(OH) ₂ (s) OR M ²⁺ (aq) + 2OH ⁻ (aq) → M(OH) ₂ (s) Use of OH ⁻ scores one mark Complete correct equation scores two marks		2						



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Question	Answer	Marks
1(a)	I Unambiguous headings and units for four <u>weighings</u> • (Mass of) crucible, lid (empty) • (Mass of) crucible, lid and FB 1 (or “contents before heating”) • (Mass of) crucible, lid and residue / MO / contents after first heating • (Mass of) crucible, lid and residue / MO / contents after 2nd heating • Units must be ‘ / ’ or ‘in’ or “()” AND g or ‘grams’ in column headings or with every entry II Four weighings are recorded in space provided • All weighings recorded to same decimal places (2 or 3) • Fourth weighing is within +0.02 and -0.04 g of third weighing III Correct subtractions to give masses of FB 1 and MO / residue. • These values (with unambiguous headings) must be on page 2 Accuracy marks Calculate supervisor’s mass ratio (to 2 d.p.) = $\frac{\text{mass FB 1}}{\text{mass of residue}}$ Calculate candidate’s mass ratio (to 2 dp) = $\frac{\text{mass FB 1}}{\text{mass of residue}}$ Difference (δ) between the candidate’s mass ratio and the supervisor’s mass ratio IV if δ is within 25% of the supervisor ratio V if δ is within 10% of the supervisor ratio	5
1(b)(i)	$\text{MCO}_3 \cdot \text{M(OH)}_2(\text{s}) \rightarrow 2\text{MO}(\text{s}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{g})$	1
1(b)(ii)	Correctly calculates amount of CO_2 produced $n(\text{CO}_2) = \frac{\text{mass lost}}{(44 + 18)}$ AND answer to 2–4 significant figures	1
1(b)(iii)	Correct use of (b)(ii) to calculate M_r $M_r = \frac{\text{mass of FB 1 used}}{\text{mol of CO}_2 \text{ produced}}$ AND answer to 2–4 significant figures	1
1(b)(iv)	Correct use of M_r to calculate A_r $A_r = \frac{[M_r - (60 + 34)]}{2}$ AND answer to 2–4 significant figures	1

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Question	Answer	Marks
1(c)	relative atomic mass will be lower AND mass loss will be greater OR amount (in mol) of CO ₂ (and water) will be greater AND amount (in mol) of basic carbonate (calculated) will be greater OR M_r lower	1
1(d)	student is not correct AND sulfuric acid will not show if the metal hydroxide is still present OR student is correct AND if decomposition was not complete, residue would fizz with acid OR if decomposition was complete, residue would not fizz with acid OR carries out experiment and gives correct conclusion based on observation	1

Question	Answer	Marks
2(a)	I Data from weighings of FB 3 recorded in space provided - three masses recorded, with unambiguous headings and unit - subtraction correct (for mass of FB 3) - mass of FB 3 used is between 0.80 and 1.80 g (from weighings)	8
	II 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	
	III 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 / FB 2 AND used / added - unit: / cm³ or (cm³) or “in cm³” (for each heading) or cm³ unit given for each volume recorded	
	IV All accurate burette readings are recorded to the nearest 0.05 cm ³	
	V The final accurate titre recorded is within 0.10 cm ³ of any other accurate titre	
	Accuracy marks The Examiner should round all 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 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 cm ³ . Calculate the Supervisor’s ratio (mean titre / mass of FB 3) to two decimal places. Calculate the candidate’s ratio (mean titre / mass of FB 3) to two decimal places. Calculate the difference (δ) between the candidate’s ratio and the supervisor’s ratio.	
	Award VI if $\delta \leq 0.80$ Award VII if $\delta \leq 0.50$ Award VIII if $\delta \leq 0.30$ (cm ³ g ⁻¹)	

Question	Answer	Marks
2(b)	Correctly calculates the mean 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 shown 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 (e.g. 26.625 cm³ must be rounded to 26.63 cm³)	1
2(c)(i)	All answers to parts (c)(ii), (c)(iv), (c)(v) and (c)(vi) given to 3 or 4 significant figures.	1
2(c)(ii)	Correct calculation of number of moles of HCl number of moles = vol in (b) × 0.046 / 1000	1
2(c)(iii)	Ionic equation correct (including state symbols) $\text{CO}_3^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) \rightarrow \text{CO}_2(\text{aq}) + \text{H}_2\text{O}(\text{l})$	1
2(c)(iv)	Correct use of (b), (c)(ii) and (c)(iii) to calculate concentration of X ₂ CO ₃ $[\text{X}_2\text{CO}_3] = 0.5 \times (\text{c})(\text{ii}) \times 1000 / 25 \text{ mol dm}^{-3}$	1
2(c)(v)	Calculation of M _r of FB 3 $M_r \text{ of X}_2\text{CO}_3 = 4 \times \text{mass FB 3 used} / (\text{c})(\text{iv})$	1
2(c)(vi)	Calculation of A _r from M _r $A_r \text{ of X} = (M_r - 60) / 2$	1
2(c)(vii)	Appropriate name / symbol of X X must be in Group 1 and have nearest A _r to value calculated in (c)(vi)	1

Question	Answer	Marks
FB 6 is MgSO_4 , FB 7 is NaNO_2 , FB 8 is AgNO_3 , FB9 is ethanol and FB 10 is CH_3COOH		
3(a)(i)	No mark for reagents (NaOH and NH_3) M1 NaOH : white ppt AND insoluble in excess (NaOH) M2 NH_3 : white ppt AND insoluble in excess (ammonia)	2
3(a)(ii)	M1 Add (aq) BaCl_2 or $\text{Ba}(\text{NO}_3)_2$ AND gives a white ppt M2 ppt is insoluble in excess (dil) HCl or (dil) HNO_3 (not H_2SO_4) OR FB 6 does not decolourise KMnO_4 / KMnO_4 remains purple	2
3(a)(iii)	MgSO_4	1
3(b)	For each part award one mark for suitable reagent(s) to distinguish between the suggested identities. Then award one mark for correct observation and conclusion.	
3(b)(i)	FB 7 M1 Add (a few drops of) (acidified) KMnO_4 M2 KMnO_4 goes colourless / decolorised AND FB 7 is (sodium) nitrite / NaNO_2	2
3(b)(ii)	FB 8 M1 Add dilute HCl or BaCl_2 → white ppt OR add aq Na_2CO_3 → white / beige / pale-brown / off white / cream ppt OR add (aq) NaOH → brown ppt OR add Mg → black ppt AND FB 8 is silver nitrate / AgNO_3	2
3(b)(iii)	FB 9 Add (aqueous) iodine AND (aqueous) NaOH Gives (pale) yellow / cream / off-white precipitate AND FB 9 is ethanol / $\text{CH}_3\text{CH}_2\text{OH}$ / $\text{C}_2\text{H}_5\text{OH}$	2

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Question	Answer	Marks
3(b)(iv)	FB 10 Add Mg (strip) OR Na_2CO_3 OR named indicator OR warm with (a few drops of) (acidified) KMnO_4 Fizzing OR correct final colour of indicator OR KMnO_4 stays purple (or no change) AND FB 10 is ethanoic acid / CH_3COOH / $\text{CH}_3\text{CO}_2\text{H}$	2



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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 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 1 AND used / added + unit Units: (cm^3) or / cm^3 or in cm^3 in heading or cm^3 by every entry III All accurate burette readings to 0.05 cm^3 IV The final accurate titre recorded is within 0.10 cm^3 of any other accurate titre Accuracy 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: 2 identical, titres within 0.05 cm^3, titres within 0.10 cm^3 etc. Examiner subtracts (corrected) candidate's titre from Supervisor's titre, δ. Award accuracy marks as follows: V Award if $\delta \leq 0.50 \text{ cm}^3$ VI Award if $\delta \leq 0.30 \text{ cm}^3$ VII Award if $\delta \leq 0.20 \text{ cm}^3$	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 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 decimal places (dp) and be rounded to nearest 0.01 cm^3.	1
1(c)(i)	Correctly calculates amount of $\text{KMnO}_4 = 0.02 \times (\mathbf{b}) / 1000 \text{ mol}$ AND answer given to 3–4 significant figures	1

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Question	Answer	Marks
1(c)(ii)	Correctly calculates amount of $\text{Fe}^{2+} = 5 \times \text{(c)(i)}$ mol AND answer given to 3–4 significant figures	1
1(c)(iii)	Correctly calculates M1 $M_r(\text{NH}_2\text{OH}\cdot\text{HCl}) = 69.5$ M2 amount of $\text{NH}_2\text{OH}\cdot\text{HCl} = 3.3 / 69.5 \times 25 / 1000$ $= 1.187 \times 10^{-3} / 1.19 \times 10^{-3}$ mol AND final answer given to 3 or more significant figures	2
1(c)(iv)	Correctly uses mole ratio $n(\text{Fe}^{2+}) : n(\text{NH}_2\text{OH}\cdot\text{HCl}) = \text{(c)(ii)} / \text{(c)(iii)}$ AND states equation number that fits their data	1

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Question	Answer	Marks
2(a)	I Readings recorded to show precision of apparatus - measuring cylinder to 0.5 cm³ - stopclock to 1 s II Suitable volumes selected - total volume = 60.0 cm³ - volumes of FA 4 + distilled water = 50.0 cm³ - volume of FA 4 must be ≥ 20.0 cm³ Accuracy marks Correct times to the nearest integer. Calculate candidate's ratio of times for $\text{expt 2} / \text{expt 1}$ (to 2 decimal places) Award accuracy marks as follows: III Ratio is between 1.50 and 2.00 IV Ratio between 1.60 and 1.90	4
2(b)(i)	Correctly calculates for all three experiments M1 concentration = volume used $\times 0.1/60$ M2 rate = $1000 / \text{time}$ AND answer given to 2–4 significant figures	2

Question	Answer	Marks
Question	Answer	Marks
2(b)(ii)	M1 Correctly uses results or calculated quantities Calculates ratios between any pair of experiments for both concentration and rate M2 Selects expression Ticks appropriate box AND either from comparison of ratios showing rate $\propto$ concentration has better agreement or $\frac{\text{rate}}{\text{concentration}}$ is constant (within experimental error) (owtte) (unlike $\frac{\text{rate}}{\text{concentration}^2}$)	2
2(c)	Correctly calculates $\left(\frac{0.5}{30(0)}\right) \times 100 = 1.667\% \text{ or } 1.67\% \text{ or } 1.7\%$	1
2(d)	M1 Carry out more experiments with different volumes of FA 4 (and distilled water) (to obtain more times) M2 EITHER Plot a graph of rate vs concentration (and/or conc²) (owtte) OR Plot graph and draw line of best fit ALTERNATIVELY calculates the ratio $\frac{\text{rate}}{\text{concentration}}$ or $\frac{\text{rate}}{\text{concentration}^2}$ M3 answer is dependent on what is given for M2 (graph of or calculation of $\frac{\text{rate}}{\text{conc}}$ or vol or $\frac{\text{rate}}{\text{conc}^2}$ or vol²) Straight line implies proportional OR increasing gradient/curve implies square relationship/rate $\propto$ concentration² OR (if $\frac{\text{rate}}{\text{conc}}$ used) candidate links constant value of ratio being proportional to the concentration	3

Question	Answer	Marks			
FA 5 is $\text{NaHSO}_4(\text{s}) + \text{Na}_2\text{CO}_3(\text{s})$ and FA 6 is $\text{NH}_4\text{Cl}(\text{aq})$					
3(a)(i)	Award one mark for each correct statement up to max two marks. - condensation (further up tube)/moisture/water/steamy fumes - gas/CO_2 gives white ppt with limewater - white and residue/solid on cooling/at the end	2			
3(a)(ii)	M1 effervescence/fizzing/bubbling M2 colourless solution forms	2			
3(a)(iii)	+ NaOH: no change	1			
3(b)(i)	+ HNO_3 M1 fizzing AND either (colourless) solution formed/solid dissolves or reaction is rapid (owtte) M2 gas gives white ppt with limewater	2			
3(b)(ii)	H^+ ions are present (owtte)	1			
3(b)(iii)	M1 add $\text{BaCl}_2/\text{Ba}(\text{NO}_3)_2$ AND gives white ppt. M2 EITHER ppt insoluble in HCl or HNO_3 OR KMnO_4 is not decolourised / (KMnO_4) solution remains purple (free standing)	2			
3(b)(iv)	<table border="1"> <tr> <td>anions</td> <td>CO_3^{2-}</td> <td>SO_4^{2-}</td> </tr> </table>	anions	CO_3^{2-}	SO_4^{2-}	1
anions	CO_3^{2-}	SO_4^{2-}			
3(b)(v)	One of: $2\text{H}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq})/(\text{s}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$ $\text{Ba}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$	1			

Question	Answer	Marks
3(c)	M1 selects NaOH(aq) AND warms M2 (colourless) gas / NH ₃ turns (damp red) litmus paper blue (on warming with NaOH) M3 NH ₄ ⁺ / ammonium (ion) (present)	3



Cambridge International AS & A Level

CHEMISTRY

9701/34

Paper 3 Advanced Practical Skills 2

May/June 2023

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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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 'List rule' guidance

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

- The response should be read as continuous prose, even when numbered answer spaces are provided.
- Any response marked *ignore* in the mark scheme should not count towards ***n***.
- Incorrect responses should not be awarded credit but will still count towards ***n***.
- 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 ***n*** 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 thermometer readings to .0 or .5 °C AND at least one at .0 °C and one at .5 °C	3										
	Accuracy marks Examiner calculates $\Delta T_{\max}$ for supervisor. Examiner calculates $\Delta T_{\max}$ for candidate. Calculate and record the difference between supervisor and candidate value, δ .											
	II and III Award accuracy marks as shown:											
	<table><tr><td>Supervisor $\Delta T_{\max}$</td><td>$\leq 6.5\text{ }^{\circ}\text{C}$</td><td>7.0–15.0 °C</td><td>>15.0 °C</td></tr><tr><td>1 mark</td><td>$\delta \leq 1.0\text{ }^{\circ}\text{C}$</td><td>$\delta \leq 1.5\text{ }^{\circ}\text{C}$</td><td>$\delta \leq 2.0\text{ }^{\circ}\text{C}$</td></tr><tr><td>2 marks</td><td>$\delta \leq 0.5\text{ }^{\circ}\text{C}$</td><td>$\delta \leq 1.0\text{ }^{\circ}\text{C}$</td><td>$\delta \leq 1.5\text{ }^{\circ}\text{C}$</td></tr></table>		Supervisor $\Delta T_{\max}$	$\leq 6.5\text{ }^{\circ}\text{C}$	7.0–15.0 °C	>15.0 °C	1 mark	$\delta \leq 1.0\text{ }^{\circ}\text{C}$	$\delta \leq 1.5\text{ }^{\circ}\text{C}$	$\delta \leq 2.0\text{ }^{\circ}\text{C}$	2 marks	$\delta \leq 0.5\text{ }^{\circ}\text{C}$
Supervisor $\Delta T_{\max}$	$\leq 6.5\text{ }^{\circ}\text{C}$	7.0–15.0 °C	>15.0 °C									
1 mark	$\delta \leq 1.0\text{ }^{\circ}\text{C}$	$\delta \leq 1.5\text{ }^{\circ}\text{C}$	$\delta \leq 2.0\text{ }^{\circ}\text{C}$									
2 marks	$\delta \leq 0.5\text{ }^{\circ}\text{C}$	$\delta \leq 1.0\text{ }^{\circ}\text{C}$	$\delta \leq 1.5\text{ }^{\circ}\text{C}$									
1(b)(i)	M1 Temperature on y-axis and volume of FB 2 added on the x-axis AND with unambiguous names or units AND some numbers for scales M2 Linear scales which include 2 °C above highest <i>T</i> in table AND plotted points/data and 2 °C above highest <i>T</i> in table, would occupy at least 5 × 5 big squares M3 All recorded points plotted correctly M4 Two lines of best fit drawn (straight line or smooth curve) covering all plotted points ignoring points labelled anomalous AND extrapolated to intersect	4										
1(b)(ii)	Reads and records volume of FB 2 at intersection to 1 or 2 decimal places	1										
1(c)(i)	Correctly uses results to calculate energy released $Q = (25 + \text{volume in (b)(ii)}) \times 4.18 \times \text{temp rise}$ AND answer to 2 or more significant figures	1										

Question	Answer	Marks
1(c)(ii)	Correctly calculates amount of NaOH $(= 1.9 \times 25 / 1000) = 4.75 \times 10^{-2}$ AND answer given to 2–4 significant figures	1
1(c)(iii)	Correct use of (c)(i) and (c)(ii) to calculate enthalpy change $= - \text{(c)(i)} / [\text{(c)(ii)} \times 1000]$ AND answer given to 2–4 significant figures with negative sign shown	1
1(c)(iv)	Correct expression evaluated $M_r \text{CH}_3\text{CHXCOOH} = [312.5 \times \text{(b)(ii)}] / [\text{(c)(ii)} \times 1000]$	1
1(c)(v)	Correct use of (c)(iv) to identify acid $A_r = \text{(c)(iv)} - 73$ AND correct choice of acid $\text{CH}_3\text{CHF}\text{COOH} \leq 100.25$ $100.25 < \text{CH}_3\text{CHCl}\text{COOH} \leq 130.7$ $130.7 < \text{CH}_3\text{CHBr}\text{COOH} \leq 176.4$ $176.4 < \text{CH}_3\text{CHICOOH}$	1
1(c)(vi)	Correct expression evaluated $[\text{actual } M_r - \text{(c)(iv)}] \times 100 / \text{actual } M_r$ $\text{CH}_3\text{CHF}\text{COOH} = 92.0$ $\text{CH}_3\text{CHCl}\text{COOH} = 108.5$ $\text{CH}_3\text{CHBr}\text{COOH} = 152.9$ $\text{CH}_3\text{CHICOOH} = 199.9$	1

Question	Answer	Marks
2(a)	I Three weighings recorded in the space provided AND all weighings recorded to the same decimal places (2 or 3) II Correct headings AND correct displayed units • (Mass of) crucible (+ lid) • (Mass of) crucible (+ lid) + FB 3 (or 'contents before heating') • (Mass of) crucible (+ lid) + residue / MO / metal oxide / contents (after heating) • (Mass of) FB 3 • (Mass of) residue / MO / metal oxide / contents after heating • (Mass) loss / FB 3 – residue/ CO₂ Units must be 'g' or 'in' or '(g)' AND g or 'grams' in column headings or with every entry III Correct subtractions to give masses of FB 3, residue and mass loss AND values are correctly labelled AND mass of FB 3 is between 0.90 and 1.10 g. Accuracy marks Calculate supervisor's mass ratio (to 2 d.p.) = mass FB 3 / mass of residue Calculate candidate's mass ratio (to 2 dp) = mass FB 3 / mass of residue Difference (δ) between the candidate's mass ratio and the supervisor's mass ratio IV if δ is within 25% of the supervisor ratio V if δ is within 10% of the supervisor ratio	5
2(b)(i)	Correctly calculates amount of CO₂ lost = mass loss / 44 AND answer given to 2–4 significant figures	1
2(b)(ii)	Correct use of (b)(i) to calculate M_r M_r = mass of FB 3 used / (b)(i) AND answer given to 2–4 significant figures	1
2(b)(iii)	Correct use of (b)(ii) to identify A_r = (b)(ii) – 60 AND selects metal that forms a 2+ ion with suitable A_r	1

Question	Answer	Marks
2(c)	The M_r would appear <u>lower</u> AND it would appear that greater amount / moles of CO_2 was lost	1
2(d)	M1 test: add named acid M2 fizz / effervescence / bubbles AND (some) FB 3 not decomposed (owtte) OR no fizz / effervescence / bubbles / no reaction AND FB 3 completely decomposed (owtte)	2

Question	Answer				Marks
FB 4 is HNO ₃ (aq), FB 5 is HCOOH(aq), FB 6 is H ₂ SO ₄ (aq) and FB 7 is NaBr(aq)					
3(a)(i)	test	observations			7
		FB 4	FB 5	FB 6	
	Test 1 + KMnO ₄ (and warm)	no change / (KMnO ₄) stays purple / no (visible) reaction *	(solution) turns colourless / KMnO ₄ decolourised *	look to box below	
		ignore		no change / (solution stays) purple / no (visible) reaction *	
	Test 2 + Cu turnings	effervescence / fizzing / bubbling (on warming) * solution (turns) (pale) blue / green-blue / blue-green OR (pale) brown gas / bubbles *	no (visible) reaction / no change *	no (visible) reaction / no change *	
	Test 3 + Mg ribbon	(slow) effervescence / fizzing / bubbling *	(slow) effervescence / fizzing / bubbling *	fast / rapid / vigorous gas made / fizz / effervescence / bubbling *	
	gentle shake after leaving	Mg remaining OR effervescence *	Mg remaining OR effervescence *	becomes hot owtte / exothermic * no Mg remaining / colourless solution only *	
		anywhere in Test 3: (gas / H ₂) burns with a 'pop' / pops with a lighted splint * *			
	2 * = 1 mark (round down)				

Question	Answer	Marks
3(a)(ii)	M1 FB 4 is nitric acid / HNO_3 AND slower effervescence than FB 6 OR forms brown gas / NO_2 (with Cu) OR blue solution (with Cu) OR reacts with Cu M2 FB 5 is methanoic acid / HCOOH AND (only acid to) decolourise KMnO_4 (owtte) OR (only) methanoic acid can be oxidised M3 FB 6 is sulfuric acid / H_2SO_4 AND faster / fastest bubbling with Mg OR Mg disappears	3
3(b)(i)	M1 acidifies FB 7 with nitric acid (before testing with AgNO_3) M2 adds (aqueous) silver nitrate / AgNO_3 AND off-white / cream ppt M3 adds (aqueous) ammonia / NH_3 AND ppt partially soluble / insoluble AND bromine	3
3(b)(ii)	Two marks for fully correct equation (with excess NaOH): $2\text{NaOH} + \text{CH}_3\text{CHXCOOH} \rightarrow \text{CH}_3\text{CH(OH)COONa} + \text{NaX} + \text{H}_2\text{O}$ where X is the halogen identified in (b)(i) or 'X' One mark for: unbalanced equation with correct formulae OR $\text{NaOH} + \text{CH}_3\text{CHXCOOH} \rightarrow \text{CH}_3\text{CH(OH)COOH} + \text{NaX}$ OR $\text{NaOH} + \text{CH}_3\text{CHXCOOH} \rightarrow \text{CH}_3\text{CH(OH)COONa} + \text{HX}$	2



Cambridge International AS & A Level

CHEMISTRY

9701/35

Paper 3 Advanced Practical Skills 1

May/June 2023

MARK SCHEME

Maximum Mark: 40

Published

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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 Table to show headings and correct units to cover all data: • mass of container + FA 2 / g or (g) or in g • mass of container • mass of FA 2 correctly calculated Unit: /g or (g) or in g or in grams OR g with each mass value AND balance readings recorded to consistent 2 or 3 decimal places AND volume recorded to integer value Accuracy marks Correct volumes to the nearest integer. Calculate the ratio of $\frac{\text{volume of gas}}{\text{mass of FA 2}}$ to the nearest integer for supervisor and candidates. Calculate ranges of 20% and 10% of the supervisor's ratio to the nearest integer. II Award if candidate's ratio $\leq$ 20% range III Award if candidate's ratio $\leq$ 10% range	3
1(b)(i)	Correctly calculates amount of H_2 = volume in (a) / 24000 mol AND answer given to 2–4 significant figures	1
1(b)(ii)	M1 Shows amount of Mg as (b)(i) AND use of 24.3 M2 Correctly uses $\% \text{ Mg} = [(\text{amount Mg in (b)(i)} \times 24.3) / \text{mass in FA 2}] \times 100$ AND answers given to 2–4 significant figures	2
1(c)	M1 reaction faster due to increased surface area M2 more gas escapes so percentage purity decreases OR M1 more corrosion / more oxide layer on Mg powder due to greater surface area M2 corrosion does not produce gas / H_2 (with HCl) therefore percentage purity decreases	2
1(d)(i)	gas / carbon dioxide leaves beaker / escapes	1

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Question	Answer	Marks
1(d)(ii)	M1 comparison of M_r between CO_2 and H_2: statement that M_r of CO_2 is much greater than (M_r) of H_2 OR $44(.0) \gg 2(.0)$ M2 loss in mass is very small with hydrogen AND either therefore percentage error is large or balance calibration (owtte) does not record mass loss / small changes in mass	2
1(d)(iii)	$\text{CO}_3^{2-}(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$	1

PUBLISHED

Question	Answer	Marks																
2(a)	I All thermometer readings recorded to .0 or .5 °C AND at least one at .0 and one at .5.	3																
	Accuracy marks Correct all temperatures to nearest .5 °C. Calculate supervisor's greatest ΔT ($= T_{\text{max}} - T_{\text{initial}}$). Calculate candidate's ΔT at the same volume then calculate the difference, δ , from the supervisor value.																	
	II Award if $\delta \leq$ range A III Award if $\delta \leq$ range B <table><tr><td>Supervisor ΔT / °C</td><td>≥ 50.0</td><td>40.0 – 49.5</td><td>30.0 – 39.5</td><td>20.0 – 29.5</td><td>< 20.0</td></tr><tr><td>range A</td><td>± 5.0</td><td>± 4.0</td><td>± 3.0</td><td>± 2.0</td><td>± 1.0</td></tr><tr><td>range B</td><td>± 2.5</td><td>± 2.0</td><td>± 1.5</td><td>± 1.0</td><td>± 0.5</td></tr></table>		Supervisor ΔT / °C	≥ 50.0	40.0 – 49.5	30.0 – 39.5	20.0 – 29.5	< 20.0	range A	± 5.0	± 4.0	± 3.0	± 2.0	± 1.0	range B	± 2.5	± 2.0	± 1.5
Supervisor ΔT / °C	≥ 50.0	40.0 – 49.5	30.0 – 39.5	20.0 – 29.5	< 20.0													
range A	± 5.0	± 4.0	± 3.0	± 2.0	± 1.0													
range B	± 2.5	± 2.0	± 1.5	± 1.0	± 0.5													
2(b)(i)	M1 Temperature on y-axis and time on the x-axis AND with unambiguous names or units M2 Linear scales chosen so that the graph occupies more than half the available length for both axes M3 All recorded points plotted accurately.	3																
2(b)(ii)	M1 Two lines of best fit drawn (straight line or smooth curve) AND extrapolated Any points labelled as anomalous (up to a maximum of 3 points) are ignored M2 Correct ΔT from suitable intersect to 1 decimal place	2																
2(c)(i)	Correctly calculates energy = $25 \times 4.18 \times \Delta T$ from (b)(ii) AND answer to 2–4 significant figures	1																

Question	Answer	Marks
2(c)(ii)	Correctly uses M1 amount Mg = $0.40 / 24.3 = 1.65 \times 10^{-2}$ mol M2 $\Delta H = -(\text{c})(i) / \text{moles Mg}$ AND answer is negative and given to 2–4 significant figures	2
2(c)(iii)	Correctly uses $[(\text{c})(ii) / -452] \times 100$ AND answer to 2–4 significant figures	1

Question	Answer	Marks
FA 5 is MgCO_3 and FA 6 is FeSO_4 and KI		
3(a)	EITHER (first method) For carbonate ion add acid * named strong acid * effervescence * colourless solution formed * test with limewater* gas / CO_2 gives white ppt * For magnesium ion using a solution * add aqueous NaOH AND gives white ppt * insoluble in excess * add aqueous NH_3 AND gives white ppt AND insoluble in excess * OR (second method) For carbonate ion heat white solid * bubble gas produced through limewater * white ppt formed * residue is white solid * For magnesium ion add acid * named strong acid * using a solution * add aqueous NaOH AND gives white ppt * insoluble in excess * add NH_3 AND gives white ppt AND insoluble in excess * 2 * = 1 mark (round down)	5

Question	Answer		Marks																				
3(b)(i)	<table><tr><th>test</th><th>observations</th></tr><tr><td>Test 1 + NaOH(aq)</td><td>green ppt * goes brown on standing* insoluble in excess *</td></tr><tr><td>Test 2 + H₂O₂(aq)</td><td>effervescence / bubbles / fizzing * (gas / O₂) relights glowing splint * black solid or brown solution formed *</td></tr><tr><td>+ starch</td><td>blue-black colour *</td></tr><tr><td>+ NaOH(aq)</td><td>brown ppt *</td></tr><tr><td>Test 3 + AgNO₃(aq)</td><td>(pale) yellow ppt *</td></tr><tr><td>+ NH₃(aq)</td><td>(dark) green ppt *</td></tr><tr><td>Test 4 + BaCl₂(aq)</td><td>white ppt *</td></tr><tr><td>+ HNO₃ (dilute)</td><td>ppt insoluble *</td></tr><tr><td>Test 5 + acidified KMnO₄(aq)</td><td>purple (solution) / KMnO₄ turns yellow / yellow-brown / orange-brown / red-brown / brown OR purple (solution) / KMnO₄ decolourised *</td></tr></table>		test	observations	Test 1 + NaOH(aq)	green ppt * goes brown on standing* insoluble in excess *	Test 2 + H ₂ O ₂ (aq)	effervescence / bubbles / fizzing * (gas / O ₂) relights glowing splint * black solid or brown solution formed *	+ starch	blue-black colour *	+ NaOH(aq)	brown ppt *	Test 3 + AgNO ₃ (aq)	(pale) yellow ppt *	+ NH ₃ (aq)	(dark) green ppt *	Test 4 + BaCl ₂ (aq)	white ppt *	+ HNO ₃ (dilute)	ppt insoluble *	Test 5 + acidified KMnO ₄ (aq)	purple (solution) / KMnO ₄ turns yellow / yellow-brown / orange-brown / red-brown / brown OR purple (solution) / KMnO ₄ decolourised *	6
	test	observations																					
	Test 1 + NaOH(aq)	green ppt * goes brown on standing* insoluble in excess *																					
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2 * = 1 mark (round down) (13 * available)																							
3(b)(ii)	<table><tr><td>cations</td><td>anions</td></tr><tr><td>Fe²⁺</td><td>I⁻</td></tr><tr><td>unknown</td><td>SO₄²⁻</td></tr></table>		cations	anions	Fe ²⁺	I ⁻	unknown	SO ₄ ²⁻	3														
	cations	anions																					
	Fe ²⁺	I ⁻																					
	unknown	SO ₄ ²⁻																					

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Question	Answer	Marks
3(c)(i)	purple to colourless	1
3(c)(ii)	$\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^- \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O}$	1