



Cambridge International AS & A Level

CHEMISTRY

9701/31

Paper 3 Advanced Practical Skills 1

October/November 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.

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Question	Answer	Marks
1(a)	I Appropriate headings and units for recorded data in the space provided. (Mass of) container + FA 2 (Mass of) container (+ residual FA 2) (Mass of) FA 2 (used) (Volume of) carbon dioxide Mass units: / g or in g or (g) or g by every reading Volume units: / cm³ or in cm³ or (cm³) or cm³ by every reading II Balance readings recorded to same number of dp (2 or 3) and volumes given as integers and correctly calculates: mass of solid / FA2 used and volume of gas collected III Volume of gas collected in range 100–200 cm³	3
1(b)(i)	Correctly calculates amount CO₂ = volume of gas / 24000 and amount of Na₂CO₃ is the same Both answers correctly rounded to 2–4 sf	1
1(b)(ii)	Correctly uses $M_r = \text{mass of FA 2} / \text{amount Na}_2\text{CO}_3 \text{ from (i)}$ Answer to 2–4 sf	1
1(b)(iii)	Correctly uses M1: $M_r \text{ of } x\text{H}_2\text{O} = M_r \text{ (from (ii))} - 106$ M2: $x = M_r \text{ of } x\text{H}_2\text{O} / 18$ and Final answer to 2–4 sf	2
1(c)(i)	It is an improvement and carbon dioxide is less soluble (if water is hot)	1
1(c)(ii)	Amount of carbon dioxide / sodium carbonate is more, (M_r is less) so x is smaller	1

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Question	Answer	Marks
1(d)	I The following data must be shown - two burette readings and titre for rough titration - initial and final burette readings for two (or more) accurate titrations	
	II Titre values shown 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 / FA 3 and used / added unit: /cm ³ or (cm ³) or in cm ³ (for each heading) or cm ³ unit given for each volume recorded	
	III All accurate burette readings are to nearest 0.05 cm ³ .	
	IV The final accurate titre recorded is within 0.10 cm ³ of any other accurate titre.	
	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 the accuracy (Q) marks as follows: V, VI, VII Award V if $\delta \leq 0.50 \text{ cm}^3$ Award VI if $\delta \leq 0.30 \text{ cm}^3$ Award VII if $\delta \leq 0.20 \text{ cm}^3$	7
1(e)	Candidate calculates mean correctly to 2 dp - 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 the nearest 0.01 cm³.	1
1(f)(i)	Answers to (ii) and (iii) given to 3–4 sf	1
1(f)(ii)	Correctly calculates Amount of HCl = $0.1 \times \text{volume (e)} / 1000$	1

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Question	Answer	Marks
1(f)(iii)	Correctly uses Amount $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O} = \text{(ii)} / 2$ and multiply by 40	1
1(f)(iv)	Correctly uses $M_r = 14.30 / \text{(iii)}$ $M_r \text{ of } x\text{H}_2\text{O} = M_r - 106$ $x = M_r \text{ of } x\text{H}_2\text{O} / 18$	1
1(g)(i)	Correct expression Uncertainty in a single reading = ± 0.001 or 0.0005 and $\frac{2 \times \text{uncertainty given}}{14.3} \times 100$	1
1(g)(ii)	Correctly uses $(100 + \text{final answer to (g)(i)}) / 100 \times 242.2$ or $(14.3 + 2 \times (\text{single}) \text{ uncertainty}) / \text{answer f(iii)}$	1

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Question	Answer	Marks															
FA 6 NaNO ₃ FA 7 NaNO ₂ FA 8 NH ₄ Cl FA 9 KMnO ₄ FA 10 MnCl ₂ or MnSO ₄																	
2(a)(i)	M1: Correct three ions listed in space provided M2: Table to show FA6 / FA7 / FA8 and test reagents M3: NaOH and heat listed as a reagent M4: Only FA8 gives off a gas that turns (damp red) litmus blue M5: Add Al to NaOH and heat M6: FA6 gives off a gas that turns (damp red) litmus blue M7: To a new sample add either (acidified) KMnO ₄ or named acid M8: Only FA7 either turns KMnO ₄ colourless or gives off a brown gas with a named acid	8															
	Expected observations for reference: <table><tr><td>reagent</td><td>FA6</td><td>FA7</td><td>FA8</td></tr><tr><td>NaOH (aq) and heat</td><td>No (visible) reaction / No fizz</td><td>No (visible) reaction / No fizz</td><td>gas test with (damp red) litmus to blue</td></tr><tr><td>Then add Al</td><td>gas test with (damp red) litmus to blue</td><td>gas test with (damp red) litmus to blue</td><td>Ignore</td></tr><tr><td>(Acidified) KMnO₄ (heat with solution) or named acid</td><td>Purple remains / No decolouration No (visible) reaction / No fizz</td><td>Purple to colourless Brown gas</td><td>Purple remains / No decolouration No (visible) reaction No fizz</td></tr></table>	reagent	FA6	FA7	FA8	NaOH (aq) and heat	No (visible) reaction / No fizz	No (visible) reaction / No fizz	gas test with (damp red) litmus to blue	Then add Al	gas test with (damp red) litmus to blue	gas test with (damp red) litmus to blue	Ignore	(Acidified) KMnO ₄ (heat with solution) or named acid	Purple remains / No decolouration No (visible) reaction / No fizz	Purple to colourless Brown gas	Purple remains / No decolouration No (visible) reaction No fizz
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Question	Answer	Marks
2(a)(ii)	FA 6 is NO_3^- FA 7 is NO_2^- FA 8 is NH_4^+	1
2(b)(i)	Test 1 6 * available. 2 * = 1 mark. Round down. Observations Black solid/residue * Pops / jumps about (OWTTE) * Glowing splint relights * Product Oxygen / manganese(IV) oxide / potassium manganate(VI) * Test 2 (Dark) green * solution *	3
2(b)(ii)	M1: Test 3 Purple to colourless / pale yellow / yellow-brown (solution) M2: Test 4 Purple (to colourless) to brown (solution)	2
2(b)(iii)	M1: Off -white ppt M2: Ppt turns brown(er) (on standing) and insoluble in excess (NaOH(aq))	2
2(b)(iv)	Manganese / Mn	1



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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.

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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 Appropriate headings and units shown 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 / FA 3 and used / added - unit: / cm³ or (cm³) or in cm³ (for each heading) or cm³ unit given for each volume recorded	
	III All accurate burette readings are recorded to the nearest 0.05 cm³. <i>The requirement to record to 0.05 applies to burette readings, including 0.00 cm³ (if this was the initial reading), but it does not apply to the titre.</i>	
	IV The final accurate titre recorded is within 0.10 cm³ of any other accurate titre. <i>Do not include a reading if it is labelled 'rough'.</i>	
	For assessment of accuracy (Q) marks, the Examiner should 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. Calculate the difference (δ) between the candidate's mean titre and the supervisor's. Award three accuracy (Q) marks as shown below.	7
	Award V if $\delta \leq 0.60$ (cm³) Award VI if $\delta \leq 0.40$ Award VII if $\delta \leq 0.20$ Tolerances for low titres: If supervisor's titre is ≤ 10.00 cm³, tolerances are 0.30, 0.20, 0.10 cm³. If supervisor's titre is ≤ 5.00 cm³ then tolerances are 0.15, 0.10, 0.05 cm³.	

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Question	Answer	Marks
1(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 correctly to nearest 0.01 cm³. (e.g. 26.625 cm³ must be rounded to 26.63 cm³) • Allow a mean expressed to 1 dp, if all accurate burette readings were given to 1 dp and the mean is exactly correct. (e.g. mean of 26.0 and 26.2 = 26.1 is allowed) (e.g. mean of 26.0 and 26.1 = 26.1 is wrong: it should be 26.05)	1
1(c)(i)	All answers to parts (c)(ii), (c)(iii) and (c)(iv) quoted to 3 or 4 significant figures (sf).	1
1(c)(ii)	Correct calculation of no of moles of Na₂S₂O₃ No of moles = $0.120 \times \text{mean titre} / 1000$	1
1(c)(iii)	Correct use of 1(c)(ii) M1: amount of KMnO₄ in 25 cm³ FA 1 = $0.2 \times \text{(c)(ii)}$ mol M2: Concⁿ of KMnO₄ = $40 \times 0.2 \times \text{(c)(ii)}$ = $8 \times \text{(c)(ii)}$ mol dm⁻³	2
1(c)(iv)	Correct use of (c)(iii) to calculate volume of FA 1 Volume of FA 1 = $\frac{50}{158} \times \frac{1}{\text{(c)(iii)}}$	1
1(d)	No and FA 2 is used in excess (so exact volume is not important)	1

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Question	Answer	Marks
2(a)(i)	I Six unambiguous headings recorded, with correctly displayed units and in the space provided. - Units: (°C), / g, in g, or °C or g against each value (Mass of) container + FA 6 / MgO / contents / solid / g (Mass of) (empty) container (+ residue) / g (Mass of) FA 6 / MgO (used) / g (Initial) temperature / °C - Maximum / final temperature / °C - Temperature rise / change / ΔT / °C II Precision of <u>readings</u> in <u>both</u> experiments, 2(a) and 2(b). - Four weighings to same number of decimal places (2 or 3) - Four thermometer readings to .0 or .5 °C III Correct subtractions to calculate masses of FA 6 and FA 8 and for the temperature changes in both (a) and (b).	3
2(a)(ii)	Correct calculation of energy change Energy change = $30 \times 4.18 \times \text{temp rise}$ (= $125.4 \times \Delta T$) AND answer correctly rounded to 2–4 sf <i>Do not penalise inappropriate sf twice in question 2.</i>	1
2(a)(iii)	Correct use of (a)(ii) M1: Correct display Amount of MgO = $\frac{\text{mass used}}{40.3} \text{ mol}$ (no answer required) M2: Correctly uses Enthalpy change = $\frac{\text{(a)(ii)}}{\text{mol MgO}} \times \frac{1}{1000} \text{ kJ mol}^{-1}$ and answer shows negative sign and is quoted to 2–4 sf	2

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Question	Answer	Marks																	
2(b)(i)	I Six pieces of data recorded in the space provided (same readings are required as in (a)(i)) - Three temperatures - Three masses																		
	Accuracy marks in 2(b) - Round thermometer readings to 0.5 °C if necessary - Check supervisor's and candidate's subtractions for temp rise - Calculate difference (δ) between supervisor and candidate (to 0.5 °C).																		
	II + III: Accuracy marks in 2(b) <table><tr><td>$\Delta T_{sup} / ^\circ\text{C}$</td><td><5.0</td><td>5.0–9.5</td><td>10.0–19.5</td><td>20.0–29.5</td><td>≥ 30.0</td></tr><tr><td>1 mark</td><td>± 1.0</td><td>± 1.5</td><td>2.0</td><td>2.5</td><td>3.0</td></tr><tr><td>2 marks</td><td>± 0.5</td><td>± 1.0</td><td>1.0</td><td>1.5</td><td>2.0</td></tr></table>	$\Delta T_{sup} / ^\circ\text{C}$	<5.0	5.0–9.5	10.0–19.5	20.0–29.5	≥ 30.0	1 mark	± 1.0	± 1.5	2.0	2.5	3.0	2 marks	± 0.5	± 1.0	1.0	1.5	2.0
$\Delta T_{sup} / ^\circ\text{C}$	<5.0	5.0–9.5	10.0–19.5	20.0–29.5	≥ 30.0														
1 mark	± 1.0	± 1.5	2.0	2.5	3.0														
2 marks	± 0.5	± 1.0	1.0	1.5	2.0														
2(b)(ii)	Correct use of data in enthalpy calculation M1: Amount $\text{Mg}(\text{OH})_2$ reacting = $0.5 \times \text{mol HCl}$ (since $\text{Mg}(\text{OH})_2$ in excess) = $0.5 \times 0.030 \times 2.00 = 0.030 \text{ mol}$ M2: Correct use of data in remainder of calculation (all three bullets correct) - Energy released = $30 \times 4.18 \times \text{temp rise in (b)}$ (J) - Enthalpy change = $\frac{\text{heat released}}{1000} \times 0.030 \text{ kJ mol}^{-1}$ - Answer has negative sign and is quoted to 2–4 sig fig.	2																	
2(c)	Enthalpy change (correctly calculated, with correct sign) $\Delta H_r = \text{(a)(iii)} - \text{(b)(ii)} \text{ kJ mol}^{-1}$	1																	

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Question	Answer	Marks
FA 9 is ZnCO_3 ; FA 10 is ammonium iron(III) sulfate, $\text{NH}_4\text{Fe}(\text{SO}_4)_2$		
3(a)	Test for anion EITHER Add specified mineral acid * Fizzing / effervescence / bubbling occurs * (Bubble) gas/CO_2 through limewater * White ppt formed * Colourless solution formed or vigorous (owtte) reaction * OR Heat the solid * (Bubble) gas / CO_2 through limewater * White ppt formed * Solid goes yellow / yellow-green (when hot) * Solid becomes paler on cooling / goes white (on cooling) * Test for cation To a solution * made using acid * Add (aqueous) sodium hydroxide or ammonia * White ppt formed * Soluble in excess alkali * [Maximum mark for observations above = 3] FA 9 is ZnCO_3 * (<i>formula required</i>) 2 * = 1 mark. [Maximum mark for 3(a) = 4]	4

Question	Answer	Marks
3(b)(i)	Observations: 11 * available = 5 marks rounding down. Test 1 (KI) (Solution) <u>turns</u> dark yellow / brown / red-brown / orange-brown / yellow-brown * (With starch) (goes) dark blue / blue-black / black * (<i>Ignore state</i>) Test 2 (Ba²⁺) White precipitate * (With acid) precipitate insoluble / no change * Test 3 (AgNO₃) No change / no precipitate / no reaction / solution <u>remains</u> colourless/pale yellow * (with NH₃) brown / red-brown / orange-brown / rust precipitate * Test 4 (NaOH etc.) Brown/red-brown/orange-brown/rust precipitate * Ppt is insoluble in excess NaOH * (with heat) Gas / ammonia turns (damp red) litmus blue * (with Al) effervescence / fizzing / bubbling occurs * Gas/H₂ 'pops' with lighted splint or gas / ammonia turns (damp red) litmus blue *	5
3(b)(ii)	Ions are NH ₄ ⁺ and Fe ³⁺ and SO ₄ ²⁻	2
3(b)(iii)	M1: Tests 1 and 4 involve redox (<i>both must be correct</i>) M2: Any one strand of explanation correct (from those listed below) • Iodide ion is oxidised to iodine (or $2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^-$) • Fe³⁺ is reduced to Fe²⁺ (or $\text{Fe}^{3+} + \text{e}^- \rightarrow \text{Fe}^{2+}$) • Fe³⁺ is the oxidising agent and I⁻ is the reducing agent • Fe³⁺ is reduced and I⁻ is oxidised • Iodine changes from oxidation state -1 to 0 • Aluminium is oxidised to aluminium ions (or $\text{Al} \rightarrow \text{Al}^{3+} + 3\text{e}^-$) • Water / hydroxide ions is / are reduced to hydrogen • Al is the reducing agent and water / OH⁻ ions is / are the oxidising agent • Al is oxidised and water / OH⁻ ions is / are reduced	2
3(b)(iv)	$\text{Fe}^{3+}(\text{aq}) + 3\text{OH}^-(\text{aq}) \rightarrow \text{Fe}(\text{OH})_3(\text{s})$ OR $\text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{NH}_3(\text{g}) + \text{H}_2\text{O}(\text{l})$ or (g)	1



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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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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.

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7 Guidance for chemical equations

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PUBLISHED

Question	Answer	Marks
1(a)	I Constructs a single table on page 4 for results of experiments to include the 4 items of required data and results to show at least 2 experiments completed.	9
	II Correct headings and units for recorded data given: • volume of FB 1 given as (cm³), / cm³, in cm³ or cm³ after each entry • volume of water given as (cm³), / cm³, in cm³ or cm³ after each entry • time given as (s), / s, in seconds or s after each entry • rate given as (s⁻¹), / s⁻¹ or s⁻¹ after each entry	
	III All times recorded to the nearest second (minimum of 3 experiments) and volumes of FB 1 and water recorded to .#0 or .#5 cm ³	
	IV Three additional volumes chosen with intervals not less than 2.00 cm ³ and all volumes of FB 1 $\geq$ 5.00 cm ³	
	V In all three additional experiments water is added to make the same total volume of FB 1 + H ₂ O (20 cm ³).	
	VI All rates correctly calculated using 1000 / time and given to 2–4 significant figures and either to the same number of significant figures or decimal places.	
	VII All 5 times increase with decrease in volume of FB 1 .	
	Examiner calculates the ratio of (time for expt 2 / time for expt 1) to 2 dp for candidate.	
	VIII Award if the ratio is between 1.20 and 1.80 IX Award if the ratio is between 1.30 and 1.60	

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Question	Answer	Marks
1(b)	I Rate on <i>y</i> -axis and volume (of FB 1) on <i>x</i> -axis and axes clearly labelled with unambiguous names or units and some numbers for scales.	4
	II Linear scales based on 1, 2 or 5 and include the origin and scale chosen so that the point plotted for 20 cm ³ FB 1 is <u>more than</u> halfway along each axis.	
	III All recorded points plotted correctly to within half a small square and in the correct square and minimum of 4 experiment points plotted.	
	IV Draws a smooth curved line of best fit.	
1(c)	Curved line: Rate is <u>not</u> proportional to concentration (of FB 1) or as concentration of FB 1 increases the rate increases	1
1(d)(i)	Correctly calculates amount of Fe ³⁺ = (0.020 × 0.0500) = 1.00 × 10 ⁻³ mol and answer to 2–4 significant figures.	1
1(d)(ii)	Correctly calculates amount of I ⁻ = (0.010 × 0.0500) = 5.00 × 10 ⁻⁴ mol and answer to 2 – 4 significant figures.	1

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Question	Answer	Marks
1(d)(iii)	Correct use of (d)(i) and (d)(ii) to calculate amount of I_2 $= (d)(ii) / 2 (= 2.50 \times 10^{-4} \text{ mol})$ and answer to 2–4 significant figures.	1
1(d)(iv)	Correct use of (d)(iii) to calculate concentration of $Na_2S_2O_3$ M1 $(d)(iii) \times 2 (= 5.00 \times 10^{-4})$ M2 $((d)(iii) \times 2 / 0.020) (= 0.0250 \text{ mol dm}^{-3})$ and answer to 2–4 significant figures.	2

PUBLISHED

Question	Answer	Marks
2(a)	I Six unambiguous headings recorded, with correctly displayed units and in the space provided. Units: (°C), / g, in g, or °C or g against each value • (Mass of) container + FB 5 / contents / solid / g • (Mass of) (empty) container (+ residue) / g • (Mass of) FB 5 / Na₂A•5H₂O / solid used / g • (Initial) temperature (of water) / °C • minimum / final temperature (of solution) / °C • Temperature change / decrease / ΔT / °C II Precision of <u>readings</u>. Two weighings to same number of decimal places (2 or 3) and two thermometer readings to .0 or .5 °C and appropriate to the headings given. III Correct subtractions for mass of FB 5 and ΔT and Mass of FB 5 between 3.50 and 4.50 g IV Accuracy mark Examiner calculates ΔT / mass to 2 dp for candidate. IV Award if ΔT / mass is between 1.40 and 1.85.	4
2(b)(i)	Correct calculation of energy change Energy change = $20 \times 4.18 \times \Delta T$ (= $83.6 \times \Delta T$) and answer correctly rounded to 2–4 sf	1
2(b)(ii)	Correctly uses ans (b)(i) / 47400 and answer given to 2–4 sf	1

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Question	Answer	Marks
2(b)(iii)	Correct display of M_r = mass in (a) / ans (b)(ii) and [mass in (a) / ans (b)(ii)] –136 and a final answer shown.	1
2(c)	Student is <u>incorrect</u> as temp change/ decrease is smaller.	1

Question	Answer	Marks
FB 6 = ZnCO_3; FB 7 = HCl and HNO_3 Check for capital and lower case letters in formulae; reagents must be complete (not just ions); check for missing charges and state symbols in ionic equation and charges within formulae of solid compounds.		
3(a)	Observations: 2* = 1 mark (round down).	4
	Test 1 condensation / droplets of water / steam / water vapour* (solid) goes yellow (on heating)* (solid returns to) white on cooling*	
	Test 2 fizzing / effervescence / bubbles* solid dissolves or (colourless) solution formed* vigorous / strong / rapid reaction / fizzing or (tube / solution) becomes warm*	
	In either Test 1 or Test 2 : gas / CO_2 tested with limewater* (either on heating or adding acid.) gives white ppt*	
3(b)(i)	M1 uses NH_3 / ammonia.	2
	M2 white ppt and soluble in excess	
3(b)(ii)	Zn^{2+} and CO_3^{2-}	1

PUBLISHED

Question	Answer	Marks
3(c)(i)	M1 HCl : AgNO_3 and white ppt	4
	M2 HNO_3 : NaOH and Al and warms / heats M3 fizzing / effervescence / gas / NH_3 / fumes turns litmus blue	
	M4 H_2SO_4 : BaCl_2 / $\text{Ba}(\text{NO}_3)_2$ and no change / no ppt	
3(c)(ii)	HCl and HNO_3	1
3(c)(iii)	One from: $\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{AgCl}(\text{s})$ $3\text{NO}_3^-(\text{aq}) + 8\text{Al}(\text{s}) + 5\text{OH}^-(\text{aq}) + 18\text{H}_2\text{O}(\text{l}) \rightarrow 8\text{Al}(\text{OH})_4^-(\text{aq}) + 3\text{NH}_3(\text{g})$	1

PUBLISHED

Alternative MS for 3(a) and 3(b) if candidates have been supplied with CaCO_3 rather than ZnCO_3 because a centre could not get hold of ZnCO_3 . This part of the MS would apply to a complete centre, not individual candidates.

Question	Answer	Marks
FB 6 = CaCO_3; FB 7 = HCl and HNO_3 Check for capital and lower case letters in formulae; reagents must be complete (not just ions); check for missing charges and state symbols in ionic equation and charges within formulae of solid compounds.		
3(a)	Observations: 2* = 1 mark (round down).	4
	Test 1 no change when heated (owtte) / (solid) remains white* white residue / solid (after cooling)*	
	Test 2 fizzing / effervescence / bubbles* solid dissolves or (colourless) solution formed* vigorous / strong / rapid reaction / fizzing or (tube / solution) becomes warm*	
	Gas test in Test 2 only: gas / CO_2 tested with limewater* (either on heating or adding acid) gives white ppt*	
3(b)(i)	M1 uses NH_3 / ammonia and NaOH	2
	M2 NaOH: white ppt and insoluble in excess And NH_3: no change / no reaction / no ppt	
3(b)(ii)	Ca^{2+} and CO_3^{2-}	1



Cambridge International AS & A Level

CHEMISTRY

9701/35

Paper 3 Advanced Practical Skills 1

October/November 2023

MARK SCHEME

Maximum Mark: 40

Published

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PUBLISHED

Question	Answer	Marks
1(a)	I Appropriate headings and units for recorded data in the space provided. (Mass of) container + FA 2 (Mass of) container (+ residual FA 2) (Mass of) FA 2 (used) (Volume of) carbon dioxide Mass units: / g or in g or (g) or g by every reading Volume units: / cm³ or in cm³ or (cm³) or cm³ by every reading II Balance readings recorded to same number of dp (2 or 3) and volumes given as integers and correctly calculates: mass of solid / FA2 used and volume of gas collected III Volume of gas collected in range 100–200 cm³	3
1(b)(i)	Correctly calculates amount CO₂ = volume of gas / 24000 and amount of Na₂CO₃ is the same Both answers correctly rounded to 2–4 sf	1
1(b)(ii)	Correctly uses M_r = mass of FA 2 / amount Na₂CO₃ from (i) Answer to 2–4 sf	1
1(b)(iii)	Correctly uses M1: M_r of xH₂O = M_r (from (ii)) – 106 M2: x = M_r of xH₂O / 18 and Final answer to 2–4 sf	2
1(c)(i)	It is an improvement and carbon dioxide is less soluble (if water is hot)	1
1(c)(ii)	Amount of carbon dioxide / sodium carbonate is more, (M_r is less) so x is smaller	1

PUBLISHED

Question	Answer	Marks
1(d)	I The following data must be shown - two burette readings and titre for rough titration - initial and final burette readings for two (or more) accurate titrations	
	II Titre values shown 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 / FA 3 and used / added unit: /cm ³ or (cm ³) or in cm ³ (for each heading) or cm ³ unit given for each volume recorded	
	III All accurate burette readings are to nearest 0.05 cm ³ .	
	IV The final accurate titre recorded is within 0.10 cm ³ of any other accurate titre.	
	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 the accuracy (Q) marks as follows: V, VI, VII Award V if $\delta \leq 0.50 \text{ cm}^3$ Award VI if $\delta \leq 0.30 \text{ cm}^3$ Award VII if $\delta \leq 0.20 \text{ cm}^3$	7
1(e)	Candidate calculates mean correctly to 2 dp - 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 the nearest 0.01 cm³.	1
1(f)(i)	Answers to (ii) and (iii) given to 3–4 sf	1
1(f)(ii)	Correctly calculates Amount of HCl = $0.1 \times \text{volume (e)} / 1000$	1

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Question	Answer	Marks
1(f)(iii)	Correctly uses Amount $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O} = \text{(ii)} / 2$ and multiply by 40	1
1(f)(iv)	Correctly uses $M_r = 14.30 / \text{(iii)}$ $M_r \text{ of } x\text{H}_2\text{O} = M_r - 106$ $x = M_r \text{ of } x\text{H}_2\text{O} / 18$	1
1(g)(i)	Correct expression Uncertainty in a single reading = ± 0.001 or 0.0005 and $\frac{2 \times \text{uncertainty given}}{14.3} \times 100$	1
1(g)(ii)	Correctly uses $(100 + \text{final answer to (g)(i)}) / 100 \times 242.2$ or $(14.3 + 2 \times (\text{single}) \text{ uncertainty}) / \text{answer f(iii)}$	1

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Question	Answer	Marks														
FA 6 NaNO ₃ FA 7 NaNO ₂ FA 8 NH ₄ Cl FA 9 KMnO ₄ FA 10 MnCl ₂ or MnSO ₄																
2(a)(i)	M1: Correct three ions listed in space provided M2: Table to show FA6 / FA7 / FA8 and test reagents M3: NaOH and heat listed as a reagent M4: Only FA8 gives off a gas that turns (damp red) litmus blue M5: Add Al to NaOH and heat M6: FA6 gives off a gas that turns (damp red) litmus blue M7: To a new sample add either (acidified) KMnO₄ or named acid M8: Only FA7 either turns KMnO₄ colourless or gives off a brown gas with a named acid	8														
	Expected observations for reference: <table><tr><td>reagent</td><td>FA6</td><td>FA7</td><td>FA8</td></tr><tr><td>NaOH (aq) and heat</td><td>No (visible) reaction / No fizz</td><td>No (visible) reaction / No fizz</td><td>gas test with (damp red) litmus to blue</td></tr><tr><td>Then add Al</td><td>gas test with (damp red) litmus to blue</td><td>gas test with (damp red) litmus to blue</td><td>Ignore</td></tr><tr><td>(Acidified) KMnO₄ (heat with solution) or named acid</td><td>Purple remains / No decolouration No (visible) reaction / No fizz</td><td>Purple to colourless Brown gas</td><td>Purple remains / No decolouration No (visible) reaction No fizz</td></tr></table>		reagent	FA6	FA7	FA8	NaOH (aq) and heat	No (visible) reaction / No fizz	No (visible) reaction / No fizz	gas test with (damp red) litmus to blue	Then add Al	gas test with (damp red) litmus to blue	gas test with (damp red) litmus to blue	Ignore	(Acidified) KMnO ₄ (heat with solution) or named acid	Purple remains / No decolouration No (visible) reaction / No fizz
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PUBLISHED

Question	Answer	Marks
2(a)(ii)	FA 6 is NO_3^- FA 7 is NO_2^- FA 8 is NH_4^+	1
2(b)(i)	Test 1 6 * available. 2 * = 1 mark. Round down. Observations Black solid/residue * Pops / jumps about (OWTTE) * Glowing splint relights * Product Oxygen / manganese(IV) oxide / potassium manganate(VI) * Test 2 (Dark) green * solution *	3
2(b)(ii)	M1: Test 3 Purple to colourless / pale yellow / yellow-brown (solution) M2: Test 4 Purple (to colourless) to brown (solution)	2
2(b)(iii)	M1: Off -white ppt M2: Ppt turns brown(er) (on standing) and insoluble in excess (NaOH(aq))	2
2(b)(iv)	Manganese / Mn	1



Cambridge International AS & A Level

CHEMISTRY

9701/36

Paper 3 Advanced Practical Skills 2

October/November 2023

MARK SCHEME

Maximum Mark: 40

Published

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1(a)	I Unambiguous headings and units for four weighings (g), / g, in g or g next to each entry (Mass of) conical / flask + H₂O₂ / solution / FB 1 = W (Mass of) container + solid / catalyst / MnO₂ / FB 2 = X (Mass of) container (empty / with residual MnO₂) = Y (Mass of) conical / flask and contents (at end / after reaction / after 30 minutes) = Z II Weighings and mass of FB 2 recorded. - All weighings (minimum 3) recorded to same decimal places (either 2 dp or 3 dp) - mass of FB 2, correctly calculated. (X – Y) III: Accuracy (Q) mark in 1(a) Award III if candidate's mass loss (calculated to 2 dp) is within, or equal to, 25% of supervisor's mass loss (calculated to 2 dp). Mass loss = W + (X – Y) – Z	3
1(b)(i)	Mass of oxygen correctly calculated Mass loss = weighing 1 + mass of FB 2 added – weighing 4 = W + (X – Y) – Z and answer given to a minimum of 2 significant figures (sf)	1
1(b)(ii)	Equation with state symbols $2\text{H}_2\text{O}_2(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$	1
1(b)(iii)	Correctly uses (b)(i) to calculate [H₂O₂(aq)] in FB 1 M1: correct expression/answer for amount of O₂ liberated: $n(\text{O}_2) = \text{(b)(i)} / 32 \text{ mol}$ (does not need to be evaluated) M2: concentration of H₂O₂ and answer given to 2–4 sf $[\text{H}_2\text{O}_2(\text{aq})] = 40 \times 2 \times \text{answer to step 1}$ (final answer is approx = $2.5 \times \text{(b)(i)} \text{ mol dm}^{-3}$)	2

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Question	Answer	Mark
1(b)(iv)	Correct use of (b)(iii) to calculate volume strength of H₂O₂ Volume strength = (b)(iii) × 0.5 × 24.0 (= (b)(iii) × 12) vol and answer given to 2–4 sf	1
1(c)(i)	EITHER (Continuing) effervescence shows that reaction is not complete. OR no (more) fizzing shows that reaction has finished / is complete. or mass of flask and contents is constant shows reaction is complete (owtte)	1
1(c)(ii)	M1: Plug prevents escape of liquid droplets (owtte) or plug stops solution / FB 1 fizzing out (owtte) or plug traps aerosol formed	1
	M2: Student is <u>correct</u> (<i>must be stated explicitly</i>) and provided that plug is pre-weighed	1
1(c)(iii)	EITHER Mass is same as listed in (a) (or value stated) and MnO ₂ is a catalyst OR MnO ₂ is a catalyst so its mass will not change (during the reaction)	1

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Question	Answer	Mark
2(a)	I All the following data are recorded - two burette readings and the titre for the rough titration - initial and final burette readings for two (or more) accurate titrations	
	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 / FB 3 and used / added - unit: / cm³ or (cm³) or in cm³ (for each heading) or cm³ unit given for each volume recorded	
	III All accurate burette readings are recorded to the nearest 0.05 cm ³ . <i>The requirement to record to 0.05 applies to burette readings, including 0.00 cm³ (if this was the initial reading), but it does not apply to the titre.</i>	
	IV: The final accurate titre recorded is within 0.10 cm ³ of any other accurate titre.	
	For assessment of accuracy (Q) marks , the Examiner should round all burette readings to the nearest 0.05 cm ³ . Check and correct subtractions for supervisor and candidates. 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 difference (d) between the candidate's mean titre and the supervisor's mean titre. Write and ring the supervisor's value near each candidate's table of results. Write the value of d on each script. Award the accuracy (Q) marks as shown below.	
	Award V if d ≤ 0.80 (cm ³) Award VI if d ≤ 0.50 Award VII if d ≤ 0.30 Tolerance for low titres: If supervisor's titre is < 10.0 cm ³ , tolerances are 0.15, 0.25, 0.40 cm ³ .	7

Question	Answer	Mark
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) • Allow the mean expressed to 1 dp, if all accurate burette readings were given to 1 dp and the mean is exactly correct. (e.g. 26.0 and 26.2 = 26.1 is allowed) (e.g. 26.0 and 26.1 = 26.1 is wrong – should be 26.05)	1
2(c)(i)	Answers to parts (c)(ii), (c)(iii) and (c)(iv) all quoted to 3 or 4 significant figures.	1
2(c)(ii)	Correct calculation of amount of KMnO₄ Amount of KMnO₄ = vol in (b) × ^{0.018}/₁₀₀₀ mol	1
2(c)(iii)	Correct use of (c)(ii) to calculate amount of H₂O₂. Amount of H₂O₂ = 2.5 × (c)(ii) mol	1
2(c)(iv)	Correct use of (c)(iii) to calculate concⁿ of H₂O₂ in FB 1. [H₂O₂] = (c)(iii) × ²⁵⁰/₁₀ × ¹⁰⁰⁰/₂₅ = 1000 × (c)(iii) mol dm⁻³	1
2(d)(i)	Comparing accuracy of the two methods Expt 2(a) is <u>more</u> accurate and one reason (from the list below): • Two (or more) consistent titres are obtained in 2(a) • Mass loss in 1(a) is small, giving high(er) percentage error. • The reaction in 2(a) has definite / sudden / sharp end / finish point • The reaction in 1(a) is not complete (provided this agrees with answer 1(c)(i))	1
2(d)(ii)	Errors compared (Error in volume measured by burette =) 2 × 0.05 > 0.06	1

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Question	Answer	Mark
FB 6 is dilute HNO_3 ; FB 8 is $\text{FeSO}_4(\text{aq})$		
3(a)(i)	Off-white / cream / yellow precipitate (formed)	1
3(a)(ii)	Test for nitrogen anion M1: Add (excess) NaOH + heat + aluminium M2: Effervescence / gas / NH_3 turns (red) litmus blue Test to distinguish between nitrate and nitrite M3: Add (a few drops of acidified) KMnO_4 (<i>manganate(VII) if name used</i>) and purple colour remains / (KMnO_4) is not decolourised	3
3(a)(iii)	FB 6 is HNO_3 (<i>formula required</i>)	1
3(b)(i)	11 Observations shown in the table Test 1 (+ ammonia) • green precipitate • insoluble / no change in excess (ammonia) • (precipitate / mixture) turns brown (on surface) Test 2 (+ aq Ba^{2+} then HCl) • (with Ba^{2+}) white precipitate (<i>not 'off-white': soluble in excess is a CON</i>) • (with acid) (ppt) is insoluble (in acid) or no change / no reaction Test 3 (+ FB 1 then NaOH) • (with H_2O_2) (solution) turns / turns yellow / light brown / pale brown • Effervescence / bubbling (in either box) • (Gas) relights glowing splint • (with NaOH) red-brown / brown / rust precipitate • Precipitate is insoluble / does not dissolve / no change in excess (NaOH) Test 4 (KMnO_4) • (KMnO_4) decolourised or changes (from purple) to colourless / pale yellow	5

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Question	Answer	Mark
3(b)(ii)	Ionic equation M1: OH ⁻ is used in the equation M2: Fe ²⁺ (aq) + 2OH ⁻ (aq) → Fe(OH) ₂ (s)	2
3(b)(iii)	EITHER M1: Iron(II) oxidised to iron(III) / Fe ²⁺ → Fe ³⁺ + e ⁻ or H ₂ O ₂ oxidises Fe ²⁺ M2: (Brown) ppt is Fe(OH) ₃ / ppt (produced) is red-brown OR M1: H ₂ O ₂ disproportionates or H ₂ O ₂ is oxidised <u>and</u> reduced. M2: Oxygen is produced OR M1: 2Fe ²⁺ (aq) + 2H ⁺ (aq) + H ₂ O ₂ (aq) → 2Fe ³⁺ (aq) + 2H ₂ O(l) M2: it is stated which species is oxidised / reduced	2