

Cambridge International AS & A Level

CHEMISTRY**9701/31**

Paper 3 Advanced Practical Skills 1

May/June 2024

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.

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This document consists of **11** 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 descriptions 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.

PUBLISHED**GENERIC MARKING PRINCIPLE 5:**

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

GENERIC MARKING PRINCIPLE 6:

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

Science-Specific Marking Principles

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

6 Calculation specific guidance

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

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

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

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

7 Guidance for chemical equations

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

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

Question	Answer	Marks
1(a)	I Three pieces of data shown - Two thermometer readings recorded AND temperature rise correctly calculated, all listed in the space provided, with units. 'Correct' headings are not required for this mark, but it must be clear what the three figures refer to. - Ignore precision of readings (but see II of 1(c)(i)). - Do not award if either thermometer reading is below 10 °C. - Temperature units: / °C OR in °C OR (°C) OR °C by every reading. Accuracy mark Calculate the difference δ between temperature rises for supervisor and candidate. Supervisor value ≥ 10 °C, award mark II if $\delta \leq 1.5$ °C. Supervisor value ≥ 5 °C and < 10 °C, award mark II if $\delta \leq 1.0$ °C. Supervisor value < 5 °C, award mark II if $\delta \leq 0.5$ °C.	2
1(b)(i)	correctly calculates energy released energy = $50 \times 4.18 \times \text{temp rise (J)}$ AND answer given to 2–4 significant figures	1
1(b)(ii)	amount H_2SO_4 used = $(0.030 \times 2 \times 0.5) = 0.03(000)$ (mol)	1
1(b)(iii)	correct use of data to calculate ΔH_1 $\Delta H_1 = \frac{\text{energy}}{1000 \times (b)(ii)}$ AND answer must have negative sign AND be expressed to 2–4 significant figures	1

Question	Answer	Marks
1(c)	I Six correct headings shown, with units, in list/table • (mass of) container + FA 3 / solid / NaHCO_3 • (mass of) container (empty or with residual FA 3) • (mass of) FA 3 / solid / NaHCO_3 OR mass used • initial temperature / thermometer reading • lowest / minimum / final temperature / thermometer reading • temperature change/decrease Mass units: / g OR in g OR (g) OR g by every reading Temperature units: / °C OR in °C OR (°C) OR °C by every reading II All readings shown to appropriate precision • all four balance / thermometer readings shown • all four thermometer readings [including those in 1(a)] to .0 or .5 • both masses to 2 decimal places OR both masses to 3 decimal places III Subtractions correct • mass of solid correct AND between 5.00–7.00 g • temperature fall correct AND between 8.0–12.0 °C	3
1(d)	Correct use of data expressions for M1 and M2 need not be evaluated to score M1 energy = $25 \times 4.18 \times \text{temp decrease}$ M2 amount of H_2SO_4 used = $0.5 \times \frac{\text{mass NaHCO}_3 \text{ used}}{84}$ (mol) M3 enthalpy change = energy / amount of H_2SO_4 used $\times 1000$ AND answer has positive sign AND expressed to two or more significant figures	3
1(e)	$\Delta H_r = 0.5 \Delta H_1 - 0.5 \Delta H_2 + \Delta H_3$	1
1(f)	(student is not correct) because acid is used in excess (in candidate's experiment (c)) (so temperature fall is unchanged)	1

Question	Answer	Marks
2(a)	I 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 Titre values recorded for accurate titrations AND correct 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 4 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 recorded to 0.05 cm³. IV The final accurate titre recorded must be within 0.10 cm³ of any other accurate titre. Accuracy marks Check and correct titre subtractions. Select the 'best' titres using the hierarchy (ignoring the rough titre value): 2 identical titres, 2 titres within 0.05 cm³, 2 titres within 0.10 cm³, etc. Calculate candidate's mean titre to 2 decimal places. Calculate the difference δ between the candidate's titre and the supervisor's titre. V Award if $\delta \leq 0.60 \text{ cm}^3$ VI Award if $\delta \leq 0.40 \text{ cm}^3$ VII Award if $\delta \leq 0.20 \text{ cm}^3$	7
2(b)	Candidate calculates mean titre correctly to 2 decimal places - 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 decimal places and be rounded to the nearest 0.01 cm³.	1
2(c)(i)	All answers given for (c)(ii) , (iii) , (iv) and (v) given to 3 or 4 significant figures.	1
2(c)(ii)	Correctly calculates amount of sodium thiosulfate used = $\frac{14.24}{158.2} \times \text{mean titre} / 1000 \text{ (mol)}$	1

Question	Answer	Marks
2(c)(iii)	Correct use of 2(c)(ii) amount of iodine (in 1 dm ³) = $\frac{(c)(ii)}{2} \times \frac{1000}{25}$ (mol)	1
2(c)(iv)	Correct use of 2(c)(iii) amount of iodine reacting with sodium sulfite = 0.0600 – (c)(iii)	1
2(c)(v)	Correct use of 2(c)(iv) M_r of sodium sulfite = $\frac{5.0}{(c)(iv)}$	1
2(c)(vi)	Correct use of 2(c)(v) $x = \frac{[(c)(v) - 126.1]}{18}$ answer must be correctly rounded to an integer	1

Question	Answer	Marks
FA 7 is AgNO ₃ (aq), FA 8 is CH ₃ COOH(aq), FA 9 is HCl(aq), FA 10 is MgSO ₄ (aq) and FA 11 is Zn(NO ₃) ₂ (aq).		
3(a)(i)	M1 adds Mg to FA7: records dark grey / black AND solid / precipitate / deposit / coating / layer M2 adds Mg to FA8 and FA9: records fizzing / effervescence in both reactions M3 clear indication that the reaction with magnesium of FA9 is faster / more vigorous than the reaction with magnesium of FA8 (ORA) M4 Any one of the following: • (gas) pops with lighted splint in either the Mg / FA8 or Mg / FA9 reactions • Mg dissolves / disappears AND colourless solution formed / heat produced in either the Mg / FA8 or Mg / FA9 reactions • white precipitate forms when FA7 and FA9 are mixed. M5 all three identities correct: FA7 = AgNO₃, FA8 = CH₃COOH and FA9 = HCl	5
3(a)(ii)	$\text{Mg(s)} + 2\text{H}^+(\text{aq}) \rightarrow \text{Mg}^{2+}(\text{aq}) + \text{H}_2(\text{g})$	1

Question	Answer	Marks																					
3(b)(i)	<table border="1"> <thead> <tr> <th></th><th>FA10</th><th>FA11</th></tr> </thead> <tbody> <tr> <td>Test 1 NH₃</td><td> - white ppt AND insoluble in excess </td><td> - white precipitate - soluble in excess </td></tr> <tr> <td>Test 2 Ba²⁺</td><td> - white precipitate AND </td><td> - no reaction / no change / no ppt AND </td></tr> <tr> <td>HCl</td><td>(white ppt) insoluble / no change</td><td>no reaction / no change no ppt</td></tr> <tr> <td>Test 3 NaOH</td><td> - white ppt AND insoluble in excess </td><td> - white precipitate - soluble in excess </td></tr> <tr> <td>Heat</td><td colspan="2">Ignore anything written in either of these boxes, unless any positive gas test is recorded (including “litmus goes red”), in which case it contradicts the gas test bullet in the box below the gas test – mark by column.</td></tr> <tr> <td>+ Al</td><td> - fizzing / effervescence (gas) pops with a lighted splint OR gas does not turn (red) litmus blue </td><td> - fizzing / effervescence - gas turns (red) litmus blue. </td></tr> </tbody> </table> Two points needed for each mark.		FA10	FA11	Test 1 NH ₃	white ppt AND insoluble in excess	- white precipitate - soluble in excess	Test 2 Ba ²⁺	white precipitate AND	no reaction / no change / no ppt AND	HCl	(white ppt) insoluble / no change	no reaction / no change no ppt	Test 3 NaOH	white ppt AND insoluble in excess	- white precipitate - soluble in excess	Heat	Ignore anything written in either of these boxes, unless any positive gas test is recorded (including “litmus goes red”), in which case it contradicts the gas test bullet in the box below the gas test – mark by column.		+ Al	- fizzing / effervescence (gas) pops with a lighted splint OR gas does not turn (red) litmus blue	- fizzing / effervescence - gas turns (red) litmus blue.	5
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CHEMISTRY**9701/32**

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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>One of:</i> - would not all form pentahydrate - some would dissolve - cannot (accurately) measure (change in) temperature of a solid.	1
1(b)	I Unambiguous headings and units covering all entries (mass of) container + solid / FB 1 (mass of) container (+ residue) - initial thermometer reading / temperature (of water) - final / lowest thermometer reading / temperature (of solution) (mass of) solid (used / added) / FB 1 - change in temperature / ΔT Units: / g, (g), in g and / °C, (°C), in °C II All balance readings consistent to either 2 or 3 dp AND thermometer readings to .0 °C or .5 °C AND written in their table AND all subtractions correct Accuracy marks Calculate $\frac{\Delta T}{\text{mass}}$ to 2 decimal places for candidate and for supervisor. III Award if the candidate ratio is within 30% of the supervisor ratio IV Award if the candidate ratio is within 15% of the supervisor ratio	4
1(c)(i)	Correctly calculates energy change = $4.18 \times \text{temperature change} \times 25$ (J) AND answer given to 2–4 significant figures (ignore sign)	1

Question	Answer	Marks
1(c)(ii)	M1 Correctly uses amount of thiosulfate = candidate mass / 248.2 mol M2 Correct use of $\Delta H_2 = + (c)(i) / (\text{moles of thiosulfate} \times 1000) \text{ (kJ mol}^{-1}\text{)}$ AND answer given to 2–4 significant figures	2
1(c)(iii)	M1 diagram with two downward arrows AND correct labels $\text{Na}_2\text{S}_2\text{O}_3(\text{s}) + 5\text{H}_2\text{O}(\text{l}) \rightarrow \text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}(\text{s})$ $\Delta H_3 \text{ or } -8.1$ $\Delta H_2 \text{ or (c)(ii) or (+)31.6}$ $(\text{Na}_2\text{S}_2\text{O}_3(\text{aq}))$ M2 $\Delta H_1 = -8.1 - (\text{answer to 1(c)(ii)})$ (default answer = -39.7)	2
1(d)	(temperature change is) less / decreased because reaction of anhydrous (sodium thiosulfate) is exothermic / causes a temperature increase	1

Question	Answer	Marks
2(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 / FB 2 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. IV The final accurate titre recorded is within 0.10 cm³ of any other accurate titre. Accuracy marks Round all burette readings to the nearest 0.05 cm³. Check and correct subtractions. Then select the 'best' titres using the hierarchy: - two (or more) accurate identical titres (ignoring any that are labelled 'rough'), <i>then</i> - two (or more) accurate titres within 0.05 cm³, <i>then</i> - two (or more) accurate titres within 0.10 cm³, <i>etc</i> These 'best' titres should be used to calculate the mean titre, expressed to nearest 0.01 cm³. Calculate the Supervisor's mean titre to two decimal places. Calculate the candidate's mean titre to two decimal places. Calculate the difference (δ) between the candidate's titre and the supervisor's titre. Award V if $\delta \leq 0.50 \text{ cm}^3$ Award VI if $\delta \leq 0.30 \text{ cm}^3$ Award VII if $\delta \leq 0.20 \text{ cm}^3$ If supervisor's titre $\leq 10.00 \text{ cm}^3$ then halve the tolerances. If supervisor's titre $\leq 5.00 \text{ cm}^3$ then award for 0.15, 0.10 and 0.05 cm³.	7

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 decimal places AND be rounded correctly to nearest 0.01 cm³.	1
2(c)(i)	answers for (c)(ii) and (c)(iii) are given to 3 or 4 significant figures AND answer to (c)(iv) value of x is an integer	1
2(c)(ii)	Correctly calculates amount of I ₂ = $\frac{1}{2} (b) \times 0.1 / 1000$ (mol)	1
2(c)(iii)	Correctly calculates amount of IO _x ⁻ = $(25 \times 0.0140) / 1000 = 3.50 \times 10^{-4}$ (mol)	1
2(c)(iv)	M1 Display of (c)(ii) / (c)(iii) ratio AND correctly uses (c)(ii) and (c)(iii) ratio giving integer value for x M2 Equation balanced for value of x from M1 $x = 5$; IO ₅ ⁻ + 9I ⁻ + 10H ⁺ → 5I ₂ + 5H ₂ O $x = 4$; IO ₄ ⁻ + 7I ⁻ + 8H ⁺ → 4I ₂ + 4H ₂ O $x = 3$; IO ₃ ⁻ + 5I ⁻ + 6H ⁺ → 3I ₂ + 3H ₂ O $x = 2$; IO ₂ ⁻ + 3I ⁻ + 4H ⁺ → 2I ₂ + 2H ₂ O $x = 1$; IO ⁻ + I ⁻ + 2H ⁺ → I ₂ + H ₂ O	2
2(d)	M1 volume of FB 2 will be smaller AND as less iodine produced / less yield M2 less change in oxidation state OR balanced equation of IO ₂ ⁻ (IO ₂ ⁻ + 3I ⁻ + 4H ⁺ → 2I ₂ + 2H ₂ O)	2

Question	Answer	Marks
FB 7 is $\text{Zn}(\text{NO}_3)_2(\text{aq})$, FB 8 is $\text{KI}(\text{aq})$ and FB 9 is $\text{Na}_2\text{CO}_3(\text{aq})$.		
3(a)(i)	Test 1 - no (visible) change / no reaction / no ppt Test 2 - white ppt - soluble in excess - negative litmus test / litmus stays red / no change / no reaction - fizzing - gas / NH_3 turns (damp red) litmus blue Test 3 - white ppt - soluble in excess Two points needed for each mark.	4
3(a)(ii)	M1 cation: Zn^{2+} after correct observations in Test 3 M2 anions: NO_2^- or NO_3^- after correct ammonia gas observations in Test 2 with <i>Al</i>	2
3(a)(iii)	EITHER M1 add (a few drops of) (acidified aqueous) KMnO_4 / potassium manganate(VII) M2 no change or solution stays purple / pink AND anion is NO_3^- OR M1 add named mineral acid M2 no change / no bubbling / no brown gas / no blue solution AND anion is NO_3^-	2

Question	Answer	Marks
3(b)(i)	M1 table of results drawn with clear sections for test and for observations with each salt e.g. test as row-header and FB 8 and FB 9 as column-headers or vice versa M2 reagents are (aqueous) silver nitrate AND a named acid M3 + $\text{AgNO}_3(\text{aq})$ FB 8: (pale) yellow ppt AND insoluble in (aqueous) NH_3 AND white to brown ppt with FB 9 if tested M4 + <i>named acid</i> FB 9: effervescence / bubbling / fizzing AND gas / CO_2 gives white ppt with limewater	4
3(b)(ii)	FB 8: I^- AND FB 9: CO_3^{2-}	1
3(b)(iii)	<i>One of:</i> $\text{Ag}^+(\text{aq}) + \text{I}^-(\text{aq}) \rightarrow \text{AgI}(\text{s})$ $2\text{H}^+(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$ equation must match observation from 3(b)(i)	1

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- 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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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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7 Guidance for chemical equations

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

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

Question	Answer	Marks
1(a)	I All the following data are recorded - two burette readings AND titre for the rough titration - initial and final burette readings for two (or more) accurate titrations II 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 2 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. IV The final accurate titre recorded is within 0.10 cm³ of any other accurate titre. Accuracy marks Round all burette readings to the nearest 0.05 cm³. Check and correct subtractions. 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 supervisor's mean titre to 2 decimal places. Calculate the candidate's mean titre to 2 decimal places. Calculate the difference δ between the candidate's titre and the supervisor's titre. Award V if $\delta \leq 0.50$ (cm³) Award VI if $\delta \leq 0.30$ Award VII if $\delta \leq 0.20$ If supervisor's titre is < 10.0 cm³, tolerances are 0.10, 0.15, 0.25 cm³.	7

Question	Answer	Marks
1(b)	Correctly calculates the mean titre to 2 decimal places. • 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 decimal places and be rounded to nearest 0.01 cm³.	1
1(c)(i)	answers to (c)(ii), (c)(iii), (c)(iv) and (c)(v) are given to 3 or 4 significant figures	1
1(c)(ii)	Correctly calculates amount of H ₂ SO ₄ in mean titre = $0.052 \times \text{(b)}/1000$ (mol)	1
1(c)(iii)	Correctly uses amount of NaOH left in 25 cm ³ = (c)(ii) $\times$ 2 (mol)	1
1(c)(iv)	Correctly uses M1 initial amount of NaOH = $2.00 \times 25.0/1000 = 0.05(00)$ (mol) OR (c)(iii) $\times$ 10 (mol) M2 amount of NaOH reacting with NH ₄ Cl = $0.05 - \text{(c)(iii)} \times 10$ (mol)	2
1(c)(v)	Correctly uses concentration of NH ₄ Cl = (c)(iv) $\times 1000/10$ (mol dm ⁻³)	1
1(d)	selects either (concentrated) sulfuric acid OR phosphorus(V) oxide AND because an acidic agent would neutralise / react with NH ₃	1

Question	Answer	Marks
2(a)	I Unambiguous headings (six headings) AND correctly displayed units • (mass of) container + FA 4 • (mass of) container (+ residue) • (mass of) FA 4 • temperature of water / initial thermometer reading • minimum / lowest thermometer reading / temperature • change in temperature / temp / T or ΔT Units: /g, (g), in g; / °C, (°C), in °C to cover each entry II Balance readings consistent to either 2 or 3 decimal places AND thermometer readings to .0 °C or .5 °C AND initial thermometer reading is > 10.0 °C and < 40.0 °C III Correctly calculates • mass of solid • change in temperature Accuracy marks Correct temperatures to nearest .5 °C. IV Award for $\delta = \pm 1.0$ °C	4
2(b)(i)	Correctly calculates energy change = $mc\Delta T = 25 \times 4.18 \times \Delta T$ (J) AND answer to 2–4 sf	1
2(b)(ii)	Correctly uses amount of $\text{NH}_4\text{Br} = \frac{(b)(i)}{(16.8 \times 1000)}$ (mol) AND answer to 2–4 sf	1
2(b)(iii)	Correctly uses mass of $\text{NH}_4\text{Br} = (b)(ii) \times 97.9$ g AND answer to 2–4 sf	1

Question	Answer	Marks
2(b)(iv)	Correctly uses $\frac{\{^{(b)(iii)}\}_{\text{mass in (a)}}}{\text{mass in (a)}} \times 100$ AND answer to 2–4 sf	1
2(c)	temperature decrease is smaller AND (apparent) moles NH_4Br is smaller AND percentage by mass will be smaller	1
2(d)	Correct expression $\frac{\{^{(2 \times 0.5)}\}_{\Delta T \text{ in (a)}}}{\Delta T \text{ in (a)}} \times 100$ AND answer to 2–4 sf	1

Question	Answer	Marks
FA 5 is $\text{ZnCO}_3(\text{s}) + \text{KI}(\text{s})$, FA 7 is propanone, FA 8 is propanal and FA 9 is propanoic acid.		
3(a)(i)	Test 1 - condensation / droplets on wall (of test-tube) / moisture - purple gas / purple vapour - yellow solid (forms on heating) OR turns yellow (yellow residue / solid) pales on cooling OR yellow turns white / cream / off-white Test 2 - fizz / bubbling / effervescence - gas / CO_2 tested with limewater - white ppt formed (with limewater) - colourless / (pale) yellow solution formed Two points needed for each mark.	[3]
3(a)(ii)	Test 1 + $\text{NaClO}(\text{aq})$: • brown/ red-brown / orange- brown / yellow-brown / yellow (solution formed) + $\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$: • colourless solution Test 2 + $\text{NaOH}(\text{aq})$: • white ppt AND soluble in excess Test 3 + $\text{NH}_3(\text{aq})$: • white ppt AND soluble in excess Test 4 + $\text{CuSO}_4(\text{aq})$: • (white / off-white / cream / brown / yellow-brown) ppt formed OR (any intensity of) brown / yellow-brown (soln) + $\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$: • (then) changes to white ppt OR blue solution Test 5 + $\text{AgNO}_3(\text{aq})$: • (pale) yellow ppt + $\text{NH}_3(\text{aq})$: • ppt insoluble OR ppt turns paler Two points needed for each mark.	4

Question	Answer	Marks
3(a)(iii)	white ppt (as well as yellow) AND in Test 5 / with AgNO_3	1
3(a)(iv)	ions present: I^- , Zn^{2+} , CO_3^{2-} 2 correct = 1 mark; 3 correct = 2 marks	2
3(b)(i)	FA 7 and FA 8 no reaction / no change / no bubbling AND FA 9 fizzing / effervescence / bubbling	1
3(b)(ii)	M1 FA 7 and FA 8 are carbonyl compounds / are either aldehydes OR ketones / either propanal OR propanone M2 FA 9 contains carboxyl (group) / is carboxylic acid / propanoic acid (from correct result with Na_2CO_3)	2
3(b)(iii)	M1 add (acidified aqueous) potassium manganate(VII) / KMnO_4 M2 purple to colourless / (pale) brown / KMnO_4 decolourises and with FA 8 AND FA 7 is propanone, FA 8 is propanal	2

Cambridge International AS & A Level

CHEMISTRY**9701/34**

Paper 3 Advanced Practical Skills 2

May/June 2024**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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Cambridge International is publishing the mark schemes for the May/June 2024 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

This document consists of **11** printed pages.

PUBLISHED**Generic Marking Principles**

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GENERIC MARKING PRINCIPLE 1:

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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:

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

GENERIC MARKING PRINCIPLE 3:

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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 The following data are recorded • two burette readings AND titre for the rough titration • initial and final burette readings for two (or more) accurate titrations II Correct headings and units in the accurate titration table 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 III All accurate burette readings are recorded to the nearest 0.05 cm³. IV The final accurate titre recorded is within 0.10 cm³ of any other accurate titre. Accuracy marks Round all burette readings to the nearest 0.05cm³ then check and correct titre subtractions, where necessary. Select the 'best' mean titre, using the following 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> The 'best' titres should be used to calculate the mean titre, expressed to the nearest 0.01 cm³. Calculate the supervisor's mean titre to 2 decimal places. Calculate the candidate's mean titre to 2 decimal places. Calculate the difference δ between the candidate's titre and the supervisor's titre. V Award if $\delta \leq 0.50 \text{ cm}^3$ VI Award if $\delta \leq 0.30 \text{ cm}^3$ VII Award if $\delta \leq 0.20 \text{ cm}^3$ If Supervisor's mean titre < 10.00 cm³ then halve the tolerances (0.25, 0.15, 0.10 cm³). If Supervisor's mean titre < 5.00 cm³ then use the tolerances 0.15, 0.10, 0.05 cm³.	7

Question	Answer	Marks
1(b)	Correctly calculates the mean titre to 2 decimal places. • 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 decimal places and be rounded to nearest 0.01 cm³.	1
1(c)(i)	answers to (c)(ii), (c)(iii) and (c)(iv) are given to 3 or 4 significant figures	1
1(c)(ii)	Correctly calculates amount of KOH used = $\frac{5.05}{56.1} \times \frac{25}{1000} \text{ mol} = 0.00225(0) \text{ (mol)}$ OR $2.25(0) \times 10^{-3} \text{ (mol)}$	1
1(c)(iii)	M1 ionic equation: $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$ M2 correct use of (b) AND (c)(ii) [FB 2 / HCl] = (c)(ii) $\times \frac{1000}{(b)}$ (mol dm ⁻³)	2
1(c)(iv)	Correct use of (c)(iii) M1 mol of HCl reacting with FB 1 = $0.10 \times 5.00 - (c)(iii)$ M2 amount of FB 1 used = $\frac{(\text{mol HCl from M1})}{4}$ AND M_r of FB 1 = $\frac{22.5}{\text{amount FB 1 used}}$	2
1(d)	the acid / HCl (added to FB 1) would no longer be in excess / HCl becomes the limiting reagent OR no HCl would be left (to do the titration) / insufficient HCl to react with <u>all</u> the FB 1 / (metal) carbonate OR FB 1 / (metal) carbonate is <u>now</u> / <u>will be</u> in excess (so titration will not be possible)	1

Question	Answer	Marks
2(a)	I Headings, units and precision of data - All four balance readings consistent to either 2 or 3 decimal places - unambiguous headings for (mass of) FB 1 and (mass of) residue / MO in the space provided - units given next to each balance reading and correctly displayed units for mass of FB 1 and mass of residue / MO II Quantities - fourth reading is within +0.02 and -0.05 g of third reading - mass of FB 1 used AND mass of residue correctly calculated - mass of FB 1 used within range 1.50–2.50 g Accuracy marks mass ratio = $\frac{\text{mass FB 1}}{\text{mass of residue}}$ Calculate supervisor's mass ratio to 2 d.p. Calculate candidate's mass ratio to 2 d.p. Award III if candidate's mass ratio is within 10% of the supervisor's mass ratio. Award IV if candidate's mass ratio is within 5% of the supervisor's mass ratio.	4
2(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
2(b)(ii)	Correctly calculates $\text{mol (CO}_2\text{)} = \frac{\text{mass lost}}{(44 + 18)}$ AND answer given to 2–4 significant figures	1
2(b)(iii)	Correct use of (b)(ii) $M_r = \frac{\text{mass of FB 1 used}}{(\text{b})(\text{ii})}$ AND answer given to 2–4 significant figures	1

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Question	Answer	Marks
2(b)(iv)	Correct expression and use to find A_r $A_r = [(b)(iii) - (60 + 34)] / 2$	1
2(c)(i)	FB 1 has decomposed to metal oxide / residue is metal oxide	1
2(c)(ii)	EITHER heating for a third time would not make it more accurate AND the fourth reading is equal (within 0.02 g) to the third OR heating for a third time would make it more accurate AND the fourth weighing is <u>not</u> the same as / lower than the third	1
2(c)(iii)	<i>One of the following reasons:</i> - experiment 2 has fewer readings / steps / sources of error OR OR examples of extra steps in experiment 1 - experiment 2 end-point is easier to judge (because it is when mass is constant / experiment 1 end-point (colour change) is harder to judge) - burette / pipette has higher (percentage) error than balance	1

Question	Answer	Marks
FB 5 is $(\text{NH}_4)_2\text{CO}_3$, FB 6 is $\text{Cr}_2(\text{SO}_4)_3$, FB 7 is HNO_3 , FB 8 is ZnCO_3 and FB 9 is ethanol.		
3(a)(i)	(FB 5 is) white solid / powder or white / colourless crystals (at start) - condensation / steam produced - bullet 2 is linked to gentle heating / water vapour being produced immediately upon heating - no residue (at end) OR FB 5 / solid disappears / evaporates / sublimes (owtte) - attempts to test with litmus (paper) (Gas / NH_3) turns (moist red) litmus blue Two points needed for each mark.	2
3(a)(ii)	<u>warm</u> FB 5 with (aqueous) NaOH AND <u>gas / ammonia</u> turns (red) litmus to blue	1
3(a)(iii)	- fizzing / bubbles / effervescence (<i>not 'gas formed'</i>) - colourless solution formed / remains or vigorous / rapid reaction (owtte) - attempts to test with lime water <u>gas / carbon dioxide</u> gives white ppt / solid with lime water (<i>not 'milky'</i>) Two points needed for each mark.	2
3(a)(iv)	FB 5 is $(\text{NH}_4)_2\text{CO}_3$	1
3(b)	award M1 for suitable reagent to distinguish each pair award M2 for correct observation AND the conclusion	
3(b)(i)	M1 add NaOH or (acidified) KMnO_4 / potassium manganate(VII) M2 (grey-)green ppt AND soluble / gives a (dark green) solution <u>in excess</u> (NaOH) OR (KMnO_4) remains purple / (KMnO_4) not decolourised AND FB 6 is chromium(III) sulfate / $\text{Cr}_2(\text{SO}_4)_3$	2
3(b)(ii)	M1 <u>heat</u> with (excess) NaOH AND Al M2 gas / NH_3 turns litmus blue (after Al added) AND FB 7 is nitric acid / HNO_3	2

Question	Answer	Marks
3(b)(iii)	M1 dissolve / make a solution in a specified mineral acid AND add (aqueous) ammonia or (aqueous) NaOH M2 With NH_3/NaOH, gives white ppt AND soluble in excess AND FB 8 is zinc carbonate / ZnCO_3 OR M1 heat the solid alone AND observe the hot residue / solid M2 (hot) residue is yellow AND FB 8 is zinc carbonate / ZnCO_3	2
3(b)(iv)	M1 add iodine AND (aqueous) NaOH M2 (pale) yellow / cream / off-white precipitate (on standing) AND FB 9 is ethanol / $\text{C}_2\text{H}_5\text{OH}$	2

Cambridge International AS & A Level

CHEMISTRY**9701/35**

Paper 3 Advanced Practical Skills 1

May/June 2024**MARK SCHEME**Maximum Mark: 40

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Question	Answer	Marks
1(a)	I A single table with 4 headings for results with indication of the four items of data to be recorded (volume of FA 1, volume of water, time and rate) AND two experiments carried out II Correct headings and units for four required items of data: • volume of FA 1 (used) AND / cm³ OR (cm³) OR in cm³ • volume of (distilled) water AND / cm³ OR (cm³) OR in cm³ • (reaction) time AND / s OR (s) OR in seconds • rate AND /s⁻¹ OR (s⁻¹) OR in s⁻¹ III Precision of data recorded: • Volume of FA1 recorded to 2 decimal places with the final digit being 0 or 5 • Volume of Water recorded to 1 decimal place with the final digit being 0 or 5 • all times to the nearest second IV Rates correctly calculated using 1000 / time. Accuracy marks Correct times for each of experiments 1 and 2 to the nearest second. Calculate $\frac{\text{time for experiment 2}}{\text{time for experiment 1}}$ correct to 2 decimal places. V Award if ratio, $t_2 / t_1 = 1.80 - 2.20$ VI Award if ratio, $t_2 / t_1 = 1.90 - 2.10$	6
1(b)(i)	total volume was the same for both experiments OR the volume of water + FA1 is 20 cm ³ in both experiments	1
1(b)(ii)	M1 FA 1 + distilled water = 20.00 cm³ AND volume of FA 1 is at least 2.5 cm³ from other experiments M2 FA 2 = 10.0 cm³ AND FA 3 = 20.0 cm³	2
1(c)	time would increase AND (extra) thiosulfate reacts with more iodine / more iodine has to be formed to / before it can react with starch	1

Question	Answer	Marks
1(d)	so concentration of KI/I^- remains almost constant OR only the concentration of $\text{S}_2\text{O}_8^{2-}/\text{K}_2\text{S}_2\text{O}_8$ affects the rate	1

Question	Answer	Marks															
2(a)	I Records 16 thermometer readings with appropriate times and correctly displayed units.	5															
	II Records two balance readings and correctly calculated mass of FA 5 added with correctly displayed unit.																
	III Balance readings consistent to either 2 or 3 decimal places AND thermometer readings to .0 °C or .5 °C. At least one must be .0 °C and one .5 °C.																
	Accuracy marks Correct relevant thermometer readings to nearest .5 °C before subtraction. Calculate the difference δ between supervisor and candidate values.																
	<table><tr><td>$\Delta T_{sup} / ^\circ\text{C}$</td><td><5.0</td><td>5.0–9.5</td><td>10.0–14.5</td><td>15.0–19.5</td></tr><tr><td>IV</td><td>± 0.5</td><td>± 1.0</td><td>± 2.0</td><td>± 2.5</td></tr><tr><td>V</td><td>0</td><td>± 0.5</td><td>± 1.5</td><td>± 2.0</td></tr></table>	$\Delta T_{sup} / ^\circ\text{C}$	<5.0	5.0–9.5	10.0–14.5	15.0–19.5	IV	± 0.5	± 1.0	± 2.0	± 2.5	V	0	± 0.5	± 1.5	± 2.0	
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V	0	± 0.5	± 1.5	± 2.0													
2(b)	I Temperature on y-axis and time on x-axis with unambiguous labels and units II Linear scales based on 1, 2 or 5 AND scale chosen so that plotted points occupy <u>more than</u> half the available space along each axis including 2 °C below minimum temperature recorded. III All points recorded plotted correctly to within half a small square AND a minimum of 9 temperatures recorded. IV Draws two lines of best fit AND both lines are extrapolated to 2½ minutes AND temperature at 2½ minutes is less than or equal to lowest temperature recorded.	4															

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Question	Answer	Marks
2(c)(i)	Correct value of ΔT from graph to 1 decimal place	1
2(c)(ii)	Correctly calculates energy = $25 \times 4.18 \times \Delta T$ (J) AND answer to 2–4 significant figures.	1
2(c)(iii)	Correctly calculates amount of ammonium chloride $n(\text{NH}_4\text{Cl}) = \text{mass from (a)} / 53.5$ (mol) AND answer to 2–4 significant figures.	1
2(c)(iv)	Correctly uses $\Delta H = \text{(c)(ii)} / \text{(c)(iii)} \times 1000$ (kJ mol ⁻¹) AND correct sign (+) AND answer correct to 2–4 significant figures	1
2(d)	Correct expression $\{(0.5 \times 2) / (T_0 - T_4)\} \times 100$	1

Question	Answer	Marks															
FA 6 is $\text{KMnO}_4(\text{s})$, FA 8 is $\text{Na}_2\text{CO}_3(\text{aq})$ and FA 9 is $\text{CuSO}_4(\text{aq}) + \text{H}_2\text{SO}_4$																	
3(a)(i)	M1 Any two of: • FA 6 / solid is (dark) purple crystals • solid jumps around • solid becomes darker / black residue forms M2 gas relights glowing splint M3 oxygen	3															
3(a)(ii)	M1 (filtrate is dark) green (solution) M2 (solution) turns pink/ purple	2															
3(b)(i)	<table border="1"> <thead> <tr> <th></th><th>FA 8</th><th>FA 9</th></tr> </thead> <tbody> <tr> <td>Test 1: + acid(aq):</td><td>effervescence (owtte) * tests <u>gas/ CO_2</u> with limewater* gas/ CO_2 gives white ppt (with limewater) *</td><td>no change / solution stays blue *</td></tr> <tr> <td>Test 2: + $\text{NaOH}(\text{aq})$ then excess</td><td>no change * on warming: no change / no gas (turning red litmus blue)*</td><td>(pale) blue ppt * insoluble in excess * on warming: (ppt) turns black *</td></tr> <tr> <td>Test 3: + $\text{BaCl}_2/\text{Ba}(\text{NO}_3)_2$ then HNO_3</td><td>white ppt * effervescence (with acid) * forms (colourless) solution / ppt dissolves *</td><td>white ppt * insoluble (in acid) / no change *</td></tr> <tr> <td>Test 4: FA 8 + FA 9</td><td></td><td>effervescence * (pale) blue ppt *</td></tr> </tbody> </table> 2* = 1 mark (round down) (16 * available MAX 7 marks)		FA 8	FA 9	Test 1: + acid(aq):	effervescence (owtte) * tests <u>gas/ CO_2</u> with limewater* gas/ CO_2 gives white ppt (with limewater) *	no change / solution stays blue *	Test 2: + $\text{NaOH}(\text{aq})$ then excess	no change * on warming: no change / no gas (turning red litmus blue)*	(pale) blue ppt * insoluble in excess * on warming: (ppt) turns black *	Test 3: + $\text{BaCl}_2/\text{Ba}(\text{NO}_3)_2$ then HNO_3	white ppt * effervescence (with acid) * forms (colourless) solution / ppt dissolves *	white ppt * insoluble (in acid) / no change *	Test 4: FA 8 + FA 9		effervescence * (pale) blue ppt *	7
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Question	Answer	Marks
3(b)(ii)	FA 8 unknown and CO_3^{2-} FA 9 Cu^{2+} and H^+ and SO_4^{2-} All correct = 2 marks, 3 correct = 1 mark	2
3(b)(iii)	<i>Any one of:</i> $\text{Cu}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq}) \rightarrow \text{Cu}(\text{OH})_2(\text{s})$ $\text{Cu}(\text{OH})_2(\text{s}) \rightarrow \text{CuO}(\text{s}) + \text{H}_2\text{O}(\text{l})$	1