

Cambridge International AS & A Level

CHEMISTRY**9701/31**

Paper 3 Advanced Practical Skills 1

October/November 2024**MARK SCHEME**Maximum Mark: 40

Published

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This document consists of **9** printed pages.

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1(a)	I Thermometer readings recorded for all 9 volumes II All thermometer readings ending in $##.0$ or $##.5$. III and IV Calculate the difference between T_{max} for supervisor and candidate. Award III if $\delta \leq 2.0^{\circ}\text{C}$ Award IV if $\delta \leq 1.0^{\circ}\text{C}$	4
1(b)	I Unambiguous labelled axes with names and / or correct units: e.g. $/\text{cm}^3$, $(^{\circ}\text{C})$, in cm^3 and suitable (linear) scales based on 1, 2 or 5 per 20 small squares e.g. 10 cm^3 on 20 small squares. The intersection is part of the data. II All points plotted accurately III Both lines of best fit. The line for the increase in temperature must be a smooth curve and the line for cooling may be either straight or a smooth curve. IV Both lines extrapolated to intersect at or above the highest recorded temperature. V Volume at intersection read correctly to 1 dp.	5
1(c)(i)	Correctly calculates to 3 or 4 significant figures (sf) amount of $\text{NaOH} = \frac{25.0 \times 2.01}{1000} = 5.025 \times 10^{-2} \text{ mol}$ or $5.03 \times 10^{-2} \text{ mol}$	1
1(c)(ii)	M1 Correctly uses amount of H_2SO_4 in expt = $\frac{(c)(i)}{2} \text{ mol}$ (= 2.51 or $2.513 \times 10^{-2} \text{ mol}$) M2 Some working shown in calculation Concentration of $\text{H}_2\text{SO}_4 = \frac{\text{M1} \times 1000}{(b)} \text{ mol dm}^{-3}$ AND final answer is given to 3 – 4 sf	2

Question	Answer	Marks
2(a)	I Table with correct headings and units all shown in space given. Headings • (Mass of) flask + acid / FA 2 1 • (Mass of) container + FA 3 2 • (Mass of) container (empty/with residue) 3 • (Mass of) FA 3 added • (Mass of) flask + acid + FA 3 (added) • (Mass of) flask and contents after reaction (owtte) 4 • (Mass of) carbon dioxide / mass loss Units: / g, (g), in g or g next to each value. II All four specified balance readings shown AND All balance readings given either to 2 or to 3 dp III Correctly calculates mass of FA 3 (2 – 3) AND Correctly calculates total ('initial') mass (1 + [2 – 3]) IV Correctly calculates mass CO_2 (1 + 2 – 3 – 4) Calculate supervisor and candidate values to 2 dp for $\frac{\text{mass of FA 3}}{\text{mass loss}}$ V awarded if $\delta \pm 15\%$ between supervisor and candidate.	5
2(b)(i)	Correctly calculates amount of $\text{CO}_2 = \frac{\text{mass CO}_2}{44} \text{ mol}$ AND answer given to 2 – 4 sf	1
2(b)(ii)	M1 Correct use of 106 e.g. $\frac{\text{mass of FA 3 from (a)}}{106}$ OR (b)(i) $\times 106$ M2 Comparison of moles / masses of Na_2CO_3 used versus needed OR statement that moles $\text{Na}_2\text{CO}_3 > \text{CO}_2$ from correct M1 OR calculation of excess moles of Na_2CO_3	2
2(b)(iii)	Correctly uses (amount H_2SO_4 needed (in 25 cm^3) = amount of $\text{CO}_2 = \text{(b)(i)}$ mol) Concentration = $\frac{\text{(b)(i)} \times 1000}{25} \text{ mol dm}^{-3}$ AND answer given to 2 – 4 sf	1

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Question	Answer	Marks
2(c)(i)	Reaction / mixture froths / undergoes (rapid) effervescence AND more likely to overflow / some (reaction mixture) is lost from beaker.	1
2(c)(ii)	Student 1 M1 Hydrogen has very low density M2 Error in loss of small mass gives large % error Student 2 M3 Calcium sulfate is insoluble / sparingly soluble OR Calcium sulfate (formed) coats solid (preventing further reaction)	3
2(d)	2 dp balance uncertainty, U = 0.01 g or 0.005 g 3 dp balance uncertainty, U = 0.001 g or 0.0005 g AND Percentage error $= \frac{(2 \times \mathbf{U}) \times 100}{\text{mass FA 3}}$	1

Question	Answer	Marks
3(a)(i)	FA 4 = KMnO_4 (s); FA 5 = MnSO_4 (s); FA 6 = MnO_2 (s) (dark) purple crystals / solid (initially) * Black powder / residue / solid or black smoke * solid / crystals / powder / FA 4 'jumps about / crackles / pops' (on heating) * (Gas) relights glowing splint * 2 * = 1 mark (round down)	2

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Question	Answer	Marks
3(a)(ii)	Test 1 + FeSO₄ (aq) Purple (solution) * Becomes yellow solution * Test 2 + H₂O₂ (aq) (Purple) (solution) becomes colourless / decolourises * Effervescence / fizzing / bubbling * (Gas) relights glowing splint * 2 * = 1 mark (round down)	2
3(a)(iii)	(Colours) (dark) Green (solution)	1
3(b)	Test 1 + HNO₃ No change and + AgNO₃ (aq) No change * Test 2 + Ba²⁺ (aq) White ppt and + HNO₃ No change / ppt does not dissolve * Test 3 + NaOH (aq) Off white / cream / fawn / buff / pale brown ppt * (ppt / solid) darkens / insoluble in excess * then + H₂O₂ (aq) Black / dark brown (solid) * Effervescence / fizzing / bubbling OR (gas) relights glowing splint * 2 * = 1 mark (round down)	3

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Question	Answer	Marks
3(c)	Test 1 + HNO_3 No change / solid does not dissolve * Test 2 + concentrated HC / Bubbles * Bleaches litmus * Chlorine * Test 3 + H_2O_2 (aq) Effervescence OR (gas) relights glowing splint * Oxygen * 2* = 1 mark round down	3
3(d)(i)	Metal is manganese / Mn	1
3(d)(ii)	FA 4 = VII / (+)7 FA 5 = II / (+)2 FA 6 = IV / (+)4 All three oxidation states correct for 2 marks, any two for 1 mark	2

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1(a)	I 5 headings and units for data (Mass of conical) flask + FA 2 / g (referred to as x in 1(b)(i)) (Mass of) container + FA 1 / g. (Mass of empty) container (or with residual FA 1) / g (Mass) FA 1 (added) / g (referred to as y in 1(b)(i)) (Total mass of conical) flask and contents at end / after 15 mins / after reaction / final / g (referred to as z in 1(b)(i))	1
	II Precision and calculation All four balance readings recording consistently either to 2 or to 3 d.p. and Subtraction for mass of FA 1 correct	1
	III Accuracy (Q) mark Calculate supervisor to 2 d.p. = $\frac{\text{mass of FA 1}}{\text{mass loss}}$ Write this, in a ring, on each candidate's script. Calculate the ratio for each candidate to 2 d.p. Upper and lower limits for the accuracy mark are the supervisor value plus or minus 15% and then rounded to 2 d.p. Award mark III if rounded candidate value is between rounded upper and lower limits (inclusive).	1
1(b)(i)	Correct calculation of mass loss (= mass of CO₂) Mass loss = $x + y - z$ (see 1(a) answer I) and answer given to 2–4 sig figs.	1

Question	Answer	Marks
1(b)(ii)	Correct use of (b)(i) to calculate M_r of FA 1. M1 Correct expression to calculate no of moles of CO_2 produced $n(\text{CO}_2) = \frac{(b)(i)}{44}$ M2 Correct use of data to calculate M_r $M_r = \frac{\text{mass of FA 1}}{\text{moles of CO}_2} = \frac{\text{mass of FA 1} \times 44}{(b)(i)}$ and answer given to 2–4 sig figs	2
1(c)(i)	M1 (At lower temp) more CO_2 dissolves in the solution and less CO_2 escapes / mass loss reduced OR The reaction is slower (at a lower temperature) and less CO_2 produced / mass loss reduced M2 Lower amount / moles of CO_2 (calculated) or lower amount / moles of (metal) carbonate (calculated) and higher M_r	2
1(c)(ii)	(Tilting) allows air to replace / displace carbon dioxide in the flask or (Tilting) tips out the (denser) carbon dioxide gas (from the flask) or (Tilting) allows the acid to react with solid <u>stuck to the walls (owtte)</u> of the conical flask.	1
1(d)	Correct expression Uncertainty U (for 2 d.p. balance) = 0.01 or 0.005 and $\% \text{ error in weighing FA 1} = \frac{2 \times U}{\text{mass of FA 1 (used)}} \times 100$	1

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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 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 Award accuracy Q 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 $\delta \leq 0.20 \text{ cm}^3$ If Supervisor's mean titre > 50.00 cm³ then use the tolerances (0.30, 0.50, 0.80 cm³) 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
2(b)	Correctly calculates the mean titre to 2 decimal places. - Candidate must take the average of two (or more) accurate 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 d.p. and be rounded to nearest 0.01 cm³. (e.g. 26.675 cm³ must be rounded to 26.68 cm³)	1

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Question	Answer	Marks
2(c)(i)	All final numerical answers to parts 2(c)(ii), 2(c)(iii) and 2(c)(iv) are quoted to 3 or 4 significant figures.	1
2(c)(ii)	Correct use of (b) Amount of HCl used = $4.02 / 36.5 \times (b) / 1000$ mol	1
2(c)(iii)	Correct use of (c)(ii) Concentration of Na ₂ CO ₃ = $(c)(ii) / 2 \times 1000 / 25$ mol dm ⁻³	1
2(c)(iv)	Correct use of (c)(iii) Mr of Na ₂ CO ₃ = $15.5(0) / (c)(iii)$	1
2(c)(v)	Correct use of (c)(iv) to calculate nearest whole number value of x $x = [(c)(iv) - 106] / 18$	1
2(d)	M1 Heat FA 1 to drive off <u>water</u> (of crystallisation) or Heat FA 1 to convert it to <u>anhydrous</u> (salt) M2 (Heat to) constant mass (or description of procedure) OR Heat gently at first, with crucible lid on and to prevent solid frothing/spitting out of the crucible.	2

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Question	Answer	Marks
FA 6 is CuCO_3 ; FA7 is CuSO_4 mixed with H_2SO_4 ; FA 8 is KI		
3(a)(i)	This part is 'blob-marked'. Each available marking point is shown by a bullet. • (FA 6 is) a (light) green / blue-green and solid / powder • (When heated) condensation / steam / water vapour produced • Solid fluidises / jumps about in test tube (owtte) • Black residue / solid formed • Attempts to test (gas) with limewater • (Gas / carbon dioxide) and limewater gives a white precipitate • Gas is carbon dioxide	3
3(a)(ii)	(light) blue solution (formed)	1
3(a)(iii)	$\text{CuO(s)} + \text{H}_2\text{SO}_4\text{(aq)} \rightarrow \text{CuSO}_4\text{(aq)} + \text{H}_2\text{O(l)}$	1

Question	Answer	Marks
3(b)(i)	Observations Test 1: blue ppt * insoluble in excess (NaOH) * Test 2: (pale) blue ppt * soluble / disappears in excess (NH₃) * Deep / dark blue colour forms (with excess) * (With acid) solution becomes paler blue or blue ppt forms * Test 3: fizzing / effervescence * blue ppt (forms) * Test 4: (off-)white precipitate / solid (forms) * (with starch) goes dark blue / blue-black / black* Test 5: Brown solid / ppt forms * Fizzing or <u>solution</u> goes paler (blue) or <u>solution</u> goes colourless * (gas) pops with a lighted splint * Test 6: White precipitate (forms) *	6
3(b)(ii)	FA 8: extra test • Add (aqueous) silver nitrate / AgNO₃ • (Pale) yellow precipitate formed • Precipitate is insoluble in (excess aqueous) ammonia • (FA8) contains I⁻ OR • Add (acidified aqueous) potassium manganate (VII) / KMnO₄ • Brown / yellow solution formed • Dark blue / blue-black / black colour with starch • (FA8) contains I⁻	2

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Question	Answer	Marks
3(b)(iii)	4 and 5	1
3(b)(iv)	$\text{Cu}^{2+}(\text{aq}) + \text{Fe}(\text{s}) \rightarrow \text{Fe}^{2+}(\text{aq}) + \text{Cu}(\text{s})$ or $\text{Fe}(\text{s}) + 2\text{H}^{+}(\text{aq}) \rightarrow \text{Fe}^{2+}(\text{aq}) + \text{H}_2(\text{g})$	1

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	III All accurate burette readings are recorded to the nearest 0.05 cm ³ .	1
	IV: The final accurate titre recorded is within 0.10 cm ³ of any other accurate titre	1
	Award accuracy Q marks as follows: V Award if $\delta \leq 0.60 \text{ cm}^3$ VI Award if $\delta \leq 0.40 \text{ cm}^3$ VII Award if $\delta \leq 0.20 \text{ cm}^3$ If Supervisor's mean titre > 50.00 cm ³ then use the tolerances (0.80, 0.50, 0.30 cm ³) If Supervisor's mean titre < 10.00 cm ³ then halve the tolerances (0.30, 0.20, 0.10 cm ³) If Supervisor's mean titre < 5.00 cm ³ then use the tolerances (0.15, 0.10, 0.05 cm ³)	1
1(b)	Correctly calculates the mean titre to 2 decimal places. - Candidate must take the average of two (or more) accurate 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 d.p. and be rounded to nearest 0.01 cm³. (e.g. 26.675 cm³ must be rounded to 26.68 cm³).	1

Question	Answer	Marks
1(c)(i)	Answers to all 3 parts of (c)(ii) and (c)(iii) quoted to 3 or 4 significant figures.	1
1(c)(ii)	M1: Correctly calculates amount of $\text{S}_2\text{O}_3^{2-} = (\mathbf{b}) / 1000 \times 0.0100$ (1) M2: Correct use of $n(\text{S}_2\text{O}_3^{2-})$ amount of $\text{I}_2 = \text{ans} / 2 \times 150 / 25$ (1)	2
1(c)(iii)	Correct use of amount of I_2 from (c)(ii) / 0.150 or (M1 from (c)(ii) / 2) $\times$ (1000 / 25)	1
1(c)(iv)	M1: Correctly calculates 0.05(00) and correctly uses $(0.0500 - (\mathbf{c})(\text{iii})) / 80$ M2: Units $\text{mol dm}^{-3} \text{s}^{-1}$	2
1(d)	Release of iodine from the starch complex is slow at high iodine concentrations Or A starch-iodine complex / precipitate is formed which does not decompose (during the titration)	1
1(e)	The student is incorrect and one of: - The sodium hydrogencarbonate must be added at 80 s to stop / quench the reaction (by reacting with the acid catalyst) ORA - The reaction would continue if the sodium hydrogencarbonate is not added at 80 s - The sample can be removed before 80 s as the reaction only stops when the sodium hydrogencarbonate is added. - The sodium hydrogencarbonate reacts with the acid which is the catalyst.	1

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Question	Answer	Marks
2(a)	I 4 unambiguous headings for balance readings and correct units (Mass of) crucible + lid (Mass of) crucible, lid and FB 4 (or 'contents before heating') (Mass of) crucible, lid and contents / residue after first heating (Mass of) crucible, lid and contents / residue after second heating Units with all required headings: / g, (g), in g (or g with every entry)	1
	II Recording of all weighings - All 4 weighings recorded to same number of decimal places (two or three). - Fourth weighing is within +0.02 and –0.05 g of third weighing.	1
	III Calculated masses Correct subtractions to give masses of FB 4 and residue and both headings clearly labelled and both answers to min 2 sf.	1
	For assessment of accuracy (Q) marks Calculate the candidate's mass ratio (to 2 d.p.) = mass FB 4 / mass of residue. If 4 th weighing > 3 rd weighing, use lower value to calculate the mass of residue.	
	Award accuracy Q marks as follows: Award IV if $1.07 \leq \text{ratio} \leq 1.27$ Award V if $1.12 \leq \text{ratio} \leq 1.22$	2

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Question	Answer	Marks
2(b)	M1 Correctly calculates amount of water amount of H₂O = (mass of FB 4 – mass of residue) / 18 and answer to 2–4 s.f. M2 Correct use of amount of water M_r of MA₂ = 2 × mass of residue / amount of H₂O and answer to 2–4 s.f.	2
2(c)	Identification of A[–] • use of (aqueous) silver nitrate / AgNO₃ • white precipitate formed • precipitate is soluble in (excess aqueous) ammonia • A[–] is identified as Cl[–] / chloride	2
2(d)	Identification of M²⁺ Shows working: ((b) – 71) and selects M from Group 2 with closest A_r and 2+ charge on ion	1
2(e)	M1 (Calculated) M_r would be greater and amount / moles of water is smaller or mass of residue / MA₂ is greater	1
	M2 One of: • there are significant / big differences between the A_r s of the elements / metals (in Group 2) owtte • most of the water was driven off / very little water of crystallisation left owtte • the calculated A_r (or M_r) is still closest to the same answer	1

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Question	Answer	Marks
Q3 FB 6 is KMnO_4 ; FB 7 is $\text{CuSO}_4(\text{aq})$		
3(a)(i)	2* = 1 mark • (Dark) purple / purple-black solid / crystals (initially) • (Solid / crystals) jump(s) around the tube / pops / crackles (on heating) • Black powder / solid / residue (remains) • (gas) relights a glowing splint • (gas produced is) oxygen	1
3(a)(ii)	Test 1 (forms) purple solution Or (water) turns purple (solution)	1
	Test 2 (forms) green solution or (NaOH) turns green (solution)	1
3(a)(iii)	thermal decomposition / redox	1

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Question	Answer	Marks												
3(b)(i)	<table><tr><th colspan="2">Observations</th></tr><tr><th>Test</th><th>Observations</th></tr><tr><td>1 +NH₃</td><td>(pale) blue ppt * (ppt) soluble / disappears in excess (NH₃) or solution formed in excess (NH₃) * Deep / dark blue (solution) (with excess) *</td></tr><tr><td>+ H₂O₂</td><td>black / (dark) green* effervescence* (gas) relights a glowing splint*</td></tr><tr><td>2 + KI</td><td>brown / yellow-brown / yellow solution* (off-)white / (pale) brown / yellow-brown precipitate / solid*</td></tr><tr><td>+ Na₂S₂O₃</td><td>Solution / solid / ppt becomes paler owtte* Precipitate partially dissolves or ppt dissolves in excess (thiosulfate)*</td></tr></table>	Observations		Test	Observations	1 +NH ₃	(pale) blue ppt * (ppt) soluble / disappears in excess (NH ₃) or solution formed in excess (NH ₃) * Deep / dark blue (solution) (with excess) *	+ H ₂ O ₂	black / (dark) green* effervescence* (gas) relights a glowing splint*	2 + KI	brown / yellow-brown / yellow solution * (off-)white / (pale) brown / yellow-brown precipitate / solid *	+ Na ₂ S ₂ O ₃	Solution / solid / ppt becomes paler owtte* Precipitate partially dissolves or ppt dissolves in excess (thiosulfate)*	5
Observations														
Test	Observations													
1 +NH ₃	(pale) blue ppt * (ppt) soluble / disappears in excess (NH ₃) or solution formed in excess (NH ₃) * Deep / dark blue (solution) (with excess) *													
+ H ₂ O ₂	black / (dark) green* effervescence* (gas) relights a glowing splint*													
2 + KI	brown / yellow-brown / yellow solution * (off-)white / (pale) brown / yellow-brown precipitate / solid *													
+ Na ₂ S ₂ O ₃	Solution / solid / ppt becomes paler owtte* Precipitate partially dissolves or ppt dissolves in excess (thiosulfate)*													
3(b)(ii)	M1 Choice of reagent(s) Selects barium chloride / BaCl₂ or barium nitrate / Ba(NO₃)₂ and nitric acid / HNO₃ or hydrochloric acid / HCl OR Selects (acidified aqueous) potassium manganate(VII) / (H⁺) & KMnO₄	1												
	M2 Clear results to show: white ppt (with Ba²⁺) and insoluble in acid OR (KMnO₄) remains purple / not decolourised / no change	1												
3(b)(iii)	CuSO ₄	1												

Cambridge International AS & A Level

CHEMISTRY**9701/35**

Paper 3 Advanced Practical Skills 1

October/November 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 October/November 2024 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

This document consists of **9** 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 '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'.

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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.

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 Thermometer readings recorded for all 9 volumes II All thermometer readings ending in $##.0$ or $##.5$. III and IV Calculate the difference between T_{max} for supervisor and candidate. Award III if $\delta \leq 2.0^{\circ}\text{C}$ Award IV if $\delta \leq 1.0^{\circ}\text{C}$	4
1(b)	I Unambiguous labelled axes with names and / or correct units: e.g. $/\text{cm}^3$, $(^{\circ}\text{C})$, in cm^3 and suitable (linear) scales based on 1, 2 or 5 per 20 small squares e.g. 10 cm^3 on 20 small squares. The intersection is part of the data. II All points plotted accurately III Both lines of best fit. The line for the increase in temperature must be a smooth curve and the line for cooling may be either straight or a smooth curve. IV Both lines extrapolated to intersect at or above the highest recorded temperature. V Volume at intersection read correctly to 1 dp.	5
1(c)(i)	Correctly calculates to 3 or 4 significant figures (sf) amount of $\text{NaOH} = \frac{25.0 \times 2.01}{1000} = 5.025 \times 10^{-2} \text{ mol}$ or $5.03 \times 10^{-2} \text{ mol}$	1
1(c)(ii)	M1 Correctly uses amount of H_2SO_4 in expt = $\frac{(c)(i)}{2} \text{ mol}$ (= 2.51 or $2.513 \times 10^{-2} \text{ mol}$) M2 Some working shown in calculation Concentration of $\text{H}_2\text{SO}_4 = \frac{\text{M1} \times 1000}{(b)} \text{ mol dm}^{-3}$ AND final answer is given to 3 – 4 sf	2

Question	Answer	Marks
2(a)	I Table with correct headings and units all shown in space given. Headings • (Mass of) flask + acid / FA 2 1 • (Mass of) container + FA 3 2 • (Mass of) container (empty/with residue) 3 • (Mass of) FA 3 added • (Mass of) flask + acid + FA 3 (added) • (Mass of) flask and contents after reaction (owtte) 4 • (Mass of) carbon dioxide / mass loss Units: / g, (g), in g or g next to each value. II All four specified balance readings shown AND All balance readings given either to 2 or to 3 dp III Correctly calculates mass of FA 3 (2 – 3) AND Correctly calculates total ('initial') mass (1 + [2 – 3]) IV Correctly calculates mass CO₂ (1 + 2 – 3 – 4) Calculate supervisor and candidate values to 2 dp for $\frac{\text{mass of FA 3}}{\text{mass loss}}$ V awarded if $\delta \pm 15\%$ between supervisor and candidate.	5
2(b)(i)	Correctly calculates amount of CO₂ = $\frac{\text{mass CO}_2}{44}$ mol AND answer given to 2 – 4 sf	1
2(b)(ii)	M1 Correct use of 106 e.g. $\frac{\text{mass of FA 3 from (a)}}{106}$ OR (b)(i) × 106 M2 Comparison of moles / masses of Na₂CO₃ used versus needed OR statement that moles Na₂CO₃ > CO₂ from correct M1 OR calculation of excess moles of Na₂CO₃	2
2(b)(iii)	Correctly uses (amount H₂SO₄ needed (in 25 cm³) = amount of CO₂ = (b)(i) mol) Concentration = $\frac{\text{(b)(i)} \times 1000}{25}$ mol dm⁻³ AND answer given to 2 – 4 sf	1

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Question	Answer	Marks
2(c)(i)	Reaction / mixture froths / undergoes (rapid) effervescence AND more likely to overflow / some (reaction mixture) is lost from beaker.	1
2(c)(ii)	Student 1 M1 Hydrogen has very low density M2 Error in loss of small mass gives large % error Student 2 M3 Calcium sulfate is insoluble / sparingly soluble OR Calcium sulfate (formed) coats solid (preventing further reaction)	3
2(d)	2 dp balance uncertainty, U = 0.01 g or 0.005 g 3 dp balance uncertainty, U = 0.001 g or 0.0005 g AND Percentage error $= \frac{(2 \times \mathbf{U}) \times 100}{\text{mass FA 3}}$	1

Question	Answer	Marks
3(a)(i)	FA 4 = KMnO_4 (s); FA 5 = MnSO_4 (s); FA 6 = MnO_2 (s) (dark) purple crystals / solid (initially) * Black powder / residue / solid or black smoke * solid / crystals / powder / FA 4 'jumps about / crackles / pops' (on heating) * (Gas) relights glowing splint * 2 * = 1 mark (round down)	2

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Question	Answer	Marks
3(a)(ii)	Test 1 + FeSO₄ (aq) Purple (solution) * Becomes yellow solution * Test 2 + H₂O₂ (aq) (Purple) (solution) becomes colourless / decolourises * Effervescence / fizzing / bubbling * (Gas) relights glowing splint * 2 * = 1 mark (round down)	2
3(a)(iii)	(Colours) (dark) Green (solution)	1
3(b)	Test 1 + HNO₃ No change and + AgNO₃ (aq) No change * Test 2 + Ba²⁺ (aq) White ppt and + HNO₃ No change / ppt does not dissolve * Test 3 + NaOH (aq) Off white / cream / fawn / buff / pale brown ppt * (ppt / solid) darkens / insoluble in excess * then + H₂O₂ (aq) Black / dark brown (solid) * Effervescence / fizzing / bubbling OR (gas) relights glowing splint * 2 * = 1 mark (round down)	3

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Question	Answer	Marks
3(c)	Test 1 + HNO_3 No change / solid does not dissolve * Test 2 + concentrated HC / Bubbles * Bleaches litmus * Chlorine * Test 3 + H_2O_2 (aq) Effervescence OR (gas) relights glowing splint * Oxygen * 2* = 1 mark round down	3
3(d)(i)	Metal is manganese / Mn	1
3(d)(ii)	FA 4 = VII / (+)7 FA 5 = II / (+)2 FA 6 = IV / (+)4 All three oxidation states correct for 2 marks, any two for 1 mark	2

Cambridge International AS & A Level

CHEMISTRY**9701/36**

Paper 3 Advanced Practical Skills 2

October/November 2024**MARK SCHEME**Maximum Mark: 40

Published

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1(b)(i)	All answers to (b)(ii) , (b)(iii) and (b)(iv) given to 2–4 sf.	1
1(b)(ii)	Correctly calculates Amount of CO ₂ = $\frac{\text{Volume of gas}}{24000} \text{ mol}$	1
1(b)(iii)	Correctly uses Amount of Na ₂ CO ₃ = (b)(ii) mol and Mass of Na ₂ CO ₃ = (b)(ii) × 106 g	1
1(b)(iv)	Shows % purity = $\frac{\text{mass from (iii)} \times 100}{\text{mass of FB 1 in (a)}}$	1
1(c)	Some means of mixing solid and acid after bung inserted – e.g. little tube suspended / flask with shelf / divided flask.	1
1(d)	Use hot water / saturate water with CO ₂	1

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Question	Answer	Marks
1(e)	2 dp balance uncertainty, U = 0.01 g or 0 .005 g 3 dp balance uncertainty, U = 0.001 g or 0.0005 Correct expression for maximum % error = $\frac{(2 \times U) \times 100}{\text{mass}}$ FB 1	1

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Question	Answer	Marks
2(a)	I Unambiguous headings and correct units – no data needed. Headings (mass of) crucible + lid (mass of) crucible + lid + FB 3 (mass of) FB 3 added (mass of) crucible + lid + contents / residue after 1st heating (mass of) crucible + lid + contents / residue after 2nd heating (mass of) residue (mass of) CO₂ / mass loss	
	II No more than + 0.02 g or – 0.05 g between first and second balance readings after heating. and All specified balance readings shown to the same number of dp – either 2 dp or 3 dp	
	III Correctly calculates mass of FB 3 and mass of carbon dioxide and mass of residue	
	IV Accuracy within 0.80 to 1.20 × supervisor value V Accuracy within 0.90 to 1.10 × supervisor value	5
2(b)(i)	Correctly calculates amount of CO₂ = mass CO₂ / 44 mol and answer given to 2–4 sf	1
2(b)(ii)	Correctly uses mass MgCO₃ = (b)(i) × 84.3 g and answer given to 2–4 sf	1

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Question	Answer	Marks
2(b)(iii)	Correctly uses $\% \text{MgCO}_3 = \frac{(\mathbf{b})(\mathbf{ii}) \times 100}{\text{mass FB 3}}$ and $\% \text{Na}_2\text{CO}_3 = 100 - \% \text{MgCO}_3$ and answer given to 2–4 sf	1
2(c)(i)	pH $\geq$ 9 and temperature goes up	1
2(c)(ii)	$\text{MgO(s)} + \text{H}_2\text{O(l)} \rightarrow \text{Mg(OH)}_2\text{(s / aq)}$ ΔH –ve M1 correct species M2 correct state symbols and sign follows temperature change (should be –ve ΔH)	2
2(c)(iii)	M1 add named (dilute) acid / correct formula M2 fizzing / bubbles / effervescence or gas / CO_2 will give / gives a white ppt with limewater	2

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Question	Answer	Marks
FB 4 = $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ and NH_4Cl		
3(a)	M1–3 (Observations are in the expected order) (gentle heating towards stronger heating) condensation / steam produced * (gas given off and) litmus goes blue * sublimation / solid on colder tube * solid dissolves / melts * (solution / liquid) bubbles * white smoke * (then) litmus goes red * residue is white / grey (on cooling) * 8 * available: 2 * = 1 mark (round down, max 3) M4 Ammonia / hydrogen chloride / sulfur trioxide from correct observation (name or correct formula)	4

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Question	Answer	Marks
3(b)(i)	Test 1 with sodium hydroxide white ppt * soluble in excess * then with Al and warm fizz / bubbling / effervescence * ammonia / gas turns litmus blue * Al turns black/dark grey (solid) / disappears * Test 2 with nitric acid no change / no reaction / no fizzing * then silver nitrate white ppt * Test 3 with barium chloride or barium nitrate white ppt * then nitric acid no change * Test 4 with sodium carbonate white ppt * 2 * = 1 mark (round down)	5
3(b)(ii)	M1 chloride / Cl^- M2 sulfate / SO_4^{2-}	2

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Question	Answer	Marks
3(b)(iii)	M1 table to show minimum of 2 tests with suitable headings and ‘Test’ and ‘Observation’ (owtte) tabulated and ‘Conclusion’ either tabulated or under the ‘reagents and results’ table. Testing for Zn^{2+} or Al^{3+} M2 (aqueous) ammonia to solution of FB 4 M3 white ppt soluble in excess and Zn^{2+} Testing for NH_4^+ M4 (aqueous) sodium hydroxide and warm (without aluminium) M5 gas / ammonia turns (damp red) litmus blue (ammonia formed) and NH_4^+	5