



Cambridge International AS & A Level

CHEMISTRY

9701/31

Paper 3 Advanced Practical Skills 1

October/November 2022

MARK SCHEME

Maximum Mark: 40

Published

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This document consists of **10** printed pages.

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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
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GENERIC MARKING PRINCIPLE 2:

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Science-Specific Marking Principles

- 1 Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
- 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 ...):
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Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'.

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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 recorded - 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 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 to nearest 0.05 cm³ IV the final accurate titre recorded is within 0.10 cm³ of any other accurate titre V, VI, VII award V if $\delta \leq 0.60$ (cm³) award VI if $\delta \leq 0.40$ (cm³) award VII if $\delta \leq 0.20$ (cm³) where δ is the difference between the supervisor's and candidate's mean titre	7
1(b)	candidate calculates mean correctly to 2 decimal places (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(c)(i)	significant figures (sf) all quoted answers in (c)(ii) – (c)(iv) are expressed to 3 or 4 sf	1
1(c)(ii)	correctly calculates amount of MnO₄⁻ used amount of MnO₄⁻ = $\frac{0.02 \times \text{vol in (b)}}{1000}$ (mol)	1

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Question	Answer	Marks
1(c)(iii)	correctly uses equation and converts volume amount of $(\text{COO}^-)_2$ that reacted = (c)(ii) $\times \frac{5}{2}$ (mol) and concentration of $(\text{COO}^-)_2$ in FA 1 = amount of $(\text{COO}^-)_2 \times \frac{1000}{25}$ (mol dm⁻³)	1
1(c)(iv)	correctly uses $M_r = \frac{\text{mass}}{\text{moles}}$ $M_r = \frac{10.14}{\text{concentration from (c)(iii)}}$	1
1(c)(v)	identity of M M1: A_r of M = $\frac{M_r \text{ from (c)(iv)} - 124}{2}$ M2: identifies M as being the Group 1 element with the nearest A_r (Li $\leq$ 14.9; 15.0 $\leq$ Na $\leq$ 31.0; 31.1 $\leq$ K $\leq$ 62.3; 62.3 $\leq$ Rb $\leq$ 111.4; 111.4 $\leq$ Cs $\leq$ 250)	2
1(d)	explanation for use of acid to provide H^+ and for the reaction (to proceed) / as given in the equation / to acidify the KMnO_4	1

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Question	Answer	Marks
2(a)	M1: table of readings with unambiguous headings and correctly displayed units for all entries in the space for Results • (mass of) container + FA 4 • (mass of) container (+ residue) • first / start / initial temperature / temperature of water • lowest / final temperature M2: readings in 2(a) • both thermometer readings shown to 0.0 °C or 0.5 °C • balance readings shown consistently to either 2 dp or to 3 dp • mass and temperature rise in (a) subtracted correctly and shown in the space for results	2
2(b)(i)	correctly calculates energy change energy change = $25 \times 4.18 \times T$ fall (J) and answer to 2–4 sf	1
2(b)(ii)	correctly calculates amount of FA 4 amount = $\frac{\text{mass FA 4}}{249.6}$ (mol) and answer to 2–4 sf	1
2(b)(iii)	correctly uses $\frac{(b)(i)}{(b)(ii)}$ enthalpy change = $\frac{(b)(ii)}{(b)(ii) \times 1000}$ (kJ mol⁻¹) and + sign and answer to 2–4 sf	1
2(c)	readings mass of FA 5 and temperature rise are correctly calculated two thermometer readings are both above 10 °C temperature rise is greater than T fall in (a)	1

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Question	Answer	Marks
2(d)(i)	correct expressions shown for enthalpy change - energy change = $25 \times 4.18 \times T \text{ change (J)}$ - amount used = mass of FA 5 used / 159.6 (mol) $\Delta H = \text{energy change} / \text{number of moles} \times 1000 \text{ (kJ mol}^{-1}\text{)}$ - negative sign in answer	2
2(d)(ii)	Hess's cycle calculation correct calculation of $\Delta H = \text{(b)(iii)} - \text{(d)(i)} \text{ (kJ mol}^{-1}\text{)}$ and some working shown e.g., equation as shown and 2 downward arrows with labelling / correct values from (b)(iii) and (d)(i) with correct signs	1
2(e)	explanation for answer selected box 1 ticked: ΔT is larger for (b)(iii) (ora) box 2 ticked: ΔT is the same for both experiments box 3 ticked: ΔT is larger for (d)(i) (ora)	1

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Question	Answer	Marks
FA 6 is aqueous $\text{Zn}(\text{NO}_3)_2$ and KI ; FA 7 gives results for ethanal but is actually butan-2-ol		
3(a)(i)	observations Test 1 M1: NaOH: white ppt and soluble in excess M2: Heat: no change / no (visible) reaction / litmus stays red Test 2 M3: Al: fizz and NH_3 / gas turns (damp red) litmus blue Test 3 M4: H_2O_2 : brown / (darker) yellow / yellow-brown / orange-brown / red-brown (solution)	4
3(a)(ii)	possible cations: aluminium / Al^{3+} and zinc / Zn^{2+}	1
3(a)(iii)	identifying the cation M1: cation test: add (aqueous) ammonia M2: white ppt soluble in excess $\text{NH}_3(\text{aq})$ shows Zn^{2+}	2
3(a)(iv)	possible anions: any two from NO_3^- , NO_2^- , I^-	1
3(a)(v)	identifying the anion if iodide in (iv) M1: test: add (aqueous) silver nitrate / AgNO_3 M2: yellow ppt (insol in NH_3) shows I^- if nitrite and nitrate (no iodide) in (iv) M1: test: add (acidified aqueous) potassium manganate(VII) / KMnO_4 M2: purple / KMnO_4 solution turns (dark) yellow / yellow-brown / orange-brown / red-brown / brown / decolourised shows nitrite OR M1: add named (dilute) acid M2: no fizzing / no brown gas shows nitrate	2

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Question	Answer	Marks
3(b)(i)	M1: Test 2 (triiodomethane test) (Pale) yellow ppt M2: Test 3 add (acidified aqueous) potassium manganate(VII) purple / KMnO_4 decolourised	2
3(b)(ii)	any 2 of the following tests correct Test 1: does not contain $-\text{OH}$ / not an alcohol / not a carboxylic acid / not hydroxyl group Test 2: contains $-\text{CH}_2\text{C}=\text{O}$ (or $-\text{CH}(\text{OH})\text{CH}_3$) group Test 3: is an aldehyde (or a 1° or 2° alcohol)	2
3(b)(iii)	FA 7 is ethanal / CH_3CHO	1



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PUBLISHED**Examples of how to apply the list rule**State **three** reasons ... [3]

A	1	Correct	✓	2
	2	Correct	✓	
	3	Wrong	✗	

B (4 responses)	1	Correct, Correct	✓, ✓	3
	2	Correct	✓	
	3	Wrong	ignore	

C (4 responses)	1	Correct	✓	2
	2	Correct, Wrong	✓, ✗	
	3	Correct	ignore	

D (4 responses)	1	Correct	✓	2
	2	Correct, CON (of 2.)	✗, (discount 2)	
	3	Correct	✓	

E (4 responses)	1	Correct	✓	3
	2	Correct	✓	
	3	Correct, Wrong	✓	

F (4 responses)	1	Correct	✓	2
	2	Correct	✓	
	3	Correct CON (of 3.)	✗ (discount 3)	

G (5 responses)	1	Correct	✓	3
	2	Correct	✓	
	3	Correct Correct CON (of 4.)	✓ ignore ignore	

H (4 responses)	1	Correct	✓	2
	2	Correct	✗	
	3	CON (of 2.) Correct	(discount 2) ✓	

I (4 responses)	1	Correct	✓	2
	2	Correct	✗	
	3	Correct CON (of 2.)	✓ (discount 2)	

Question	Answer	Marks
1(a)	I table or list to include: - initial and final balance readings to same precision and to 2 or 3 dp - correctly calculated mass of FA 1 II the following data must be shown: - two burette readings and titre for rough titration - initial final burette readings for two (or more) accurate titrations III 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 2 and used / added unit: / cm³ or (cm³) or in cm³ (for each heading) or cm³ unit given for each volume recorded IV all accurate burette readings are to nearest 0.05 cm³ V the final accurate titre recorded is within 0.10 cm³ of any other accurate titre VI, VII, VIII award VI if $\delta \leq 0.80$ (cm³) award VII if $\delta \leq 0.50$ (cm³) award VIII if $\delta \leq 0.30$ (cm³) where d is the difference between the supervisor's mean titre and the candidate's scaled mean titre = candidate's scaled mean titre $\times \frac{\text{supervisor's mass used}}{\text{candidate's mass used}}$ (calculated to 2 decimal places (dp))	8
1(b)	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 titres selected - the mean should be quoted to 2 dp and be rounded to the nearest 0.01 cm³	1
1(c)(i)	Significant figures all quoted answers in (c)(ii) – (c)(iv) are expressed to 3 or 4 sf.	1

Question	Answer	Marks
1(c)(ii)	correctly calculates amount of $\text{MnO}_4^- = \frac{0.01 \times \text{vol (b)}}{1000}$ (mol)	1
1(c)(iii)	correctly uses $5 \times \text{(c)(ii)}$ AND $10 \times \text{ANS}$	1
1(c)(iv)	M1: correct expression display of $\text{(c)(iii)} \times 55.8$ M2: correctly uses percentage by mass of iron $= \left[\frac{\text{(c)(iii)} \times 55.8}{\text{mass in (a)}} \right] \times 100$ (%)	2
1(d)	the (apparent) mass of the sample would be higher AND the percentage would decrease	1
1(e)	M1: all the iron is present as Fe^{2+} ions / no Fe^{3+} present M2: only Fe^{2+} / iron ions react with KMnO_4 OR the unknown anion / (any other) cation does not react with KMnO_4 OR there are no impurities that react with KMnO_4	2

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Question	Answer	Marks
2(a)	I table of data must show all of the following: • (mass of) crucible + lid • (mass of) crucible + lid + FA 5 • (mass of) crucible + lid + residue / contents / MgX • (mass of) FA 5 • (mass of) water lost / mass lost	5
	II recording of data • unit / g, (g) or in grams is covering each entry • all three balance readings are recorded to the same number of decimal points (2 or 3 dp).	
	III correctly calculates • mass of FA 5 • mass of water lost	
	IV, V award IV if $\delta \leq 0.20$ award V if $\delta \leq 0.10$ where d is the difference between the supervisor's and candidate's mass ratio = $\frac{\text{mass of FA 5}}{\text{mass of water lost}}$ and calculated correct to 2 dp the theoretical value of 1.96 is used if there is no supervisor's value available	
2(b)(i)	correctly calculates amount of H ₂ O lost = $\frac{\text{mass of water lost}}{18}$ (mol) AND answer to 2 – 4 sf	1

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Question	Answer	Marks
2(b)(ii)	correctly uses M1: amount of Mg = (b)(i) / 7 (mol) M2: percentage of Mg = $\frac{[(b)(i) \times 24.3]}{(7 \times \text{mass of FA 5})} \times 100$ (%) AND answer to 2 – 4 sf	2
2(c)	M1: all the water is lost. OR heating was for long enough to reach constant mass. (owtte) M2: MgX / residue is thermally stable / does not decompose. OR the mass loss is due to the water only.	2

Question	Answer	Marks
FA 6 is $\text{NH}_4\text{Fe}(\text{SO}_4)_2(\text{aq})$; FA 7 is $\text{NaBr}(\text{aq})$; FA 8 is $\text{Na}_2\text{CO}_3(\text{aq})$; FA 9 is $\text{NaCl}(\text{aq})$.		
3(a)(i)	M1: selects NaOH OR NH_3 AND red-brown / brown / rust / orange-brown ppt on adding NaOH or NH_3 M2: warms solution with NaOH AND ammonia / gas (given off on warming) that turns (damp red) litmus blue.	2
3(a)(ii)	M1: selects (acidified) potassium manganate(VII) / KMnO_4 (with or without barium salt) OR selects BaCl_2 or $\text{Ba}(\text{NO}_3)_2$ AND HCl or HNO_3 (in either order) (or full names) M2: (KMnO_4) solution stays purple / no change / no reaction OR white ppt AND insoluble in (excess) acid	2

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Question	Answer	Marks
3(a)(iii)	identifies ions from (partially) successful tests: cations NH_4^+ Fe^{3+} anion SO_4^{2-} Any 2 ions correct = 1 mark All ions correct = 2 marks	2
3(b)	Test 1 + $\text{Na}_2\text{SO}_3(\text{aq})$ - forms red solution / (pale) yellow solution turns red + H_2SO_4 (solution turns) colourless / pale yellow Test 2 + $\text{KI}(\text{aq})$ (solution turns) darker yellow / yellow-brown / brown / colourless (solution) turns yellow + starch - turns blue-black / black 2 • = 1 mark	2
3(c)(i)	FA 7: - cream / off-white ppt with $\text{AgNO}_3(\text{aq})$ - insoluble / partially soluble in $\text{NH}_3(\text{aq})$ FA 8: - white / off-white / cream / brown ppt with $\text{AgNO}_3(\text{aq})$ - soluble in $\text{NH}_3(\text{aq})$ / forms colourless solution FA 9: - white ppt with $\text{AgNO}_3(\text{aq})$ - soluble in $\text{NH}_3(\text{aq})$ / forms colourless solution	3

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Question	Answer	Marks
3(c)(ii)	one of: selects named acid AND observes fizzing with FA 8 or limewater gives white ppt with gas / CO ₂ OR tests solution(s) with litmus paper or universal indicator AND only FA 8 turns (red) litmus blue or (yellow / green) UI turns blue	1
3(c)(iii)	all identities are correct the CO ₃ ²⁻ ion is present in FA 8 the Cl ⁻ ion is present in FA 9 the Br ⁻ ion is present in FA 7	1



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Examples of how to apply the list ruleState **three** reasons ... [3]

A	1	Correct	✓	2
	2	Correct	✓	
	3	Wrong	✗	

B (4 responses)	1	Correct, Correct	✓, ✓	3
	2	Correct	✓	
	3	Wrong	ignore	

C (4 responses)	1	Correct	✓	2
	2	Correct, Wrong	✓, ✗	
	3	Correct	ignore	

D (4 responses)	1	Correct	✓	2
	2	Correct, CON (of 2.)	✗, (discount 2)	
	3	Correct	✓	

E (4 responses)	1	Correct	✓	3
	2	Correct	✓	
	3	Correct, Wrong	✓	

F (4 responses)	1	Correct	✓	2
	2	Correct	✓	
	3	Correct CON (of 3.)	✗ (discount 3)	

G (5 responses)	1	Correct	✓	3
	2	Correct	✓	
	3	Correct Correct CON (of 4.)	✓ ignore ignore	

H (4 responses)	1	Correct	✓	2
	2	Correct	✗	
	3	CON (of 2.) Correct	(discount 2) ✓	

I (4 responses)	1	Correct	✓	2
	2	Correct	✗	
	3	Correct CON (of 2.)	✓ (discount 2)	

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Question	Answer	Marks
1(a)	I the following data must be shown: with unambiguous headings and correct units (mass of) container + FB 2 (mass of) container (+ residue) (mass of) FB 2 correctly calculated units: / g, (g) or g by every entry II all thermometer readings recorded to .0 or .5 °C at least one reading should be .0 and at least one reading should be .5 III and IV award of accuracy marks check supervisor's ΔT ($=T_{\text{max}} - T_{t=2}$ from table), choose the applicable range then mark accordingly: ΔT less than 10.0 °C: δ within 0.5 = 2 marks: δ within 1.0 = 1 mark ΔT in range 10.0–19.5 °C: δ within 1.0 = 2 marks: δ within 2.0 = 1 mark ΔT in range 20.0–29.5 °C: δ within 2.0 = 2 marks: δ within 3.5 = 1 mark ΔT in range 30.0–39.5 °C: δ within 3.0 = 2 marks: δ within 5.0 = 1 mark where δ is the difference between the supervisor's and candidate's ΔT	4
1(b)(i)	M1 axes correctly labelled temperature on y-axis and time on the x-axis and correct units M2 appropriate scales linear scales chosen so that the graph occupies, including the extra 5 °C on the y-axis, more than half the available length for both axes M3 all points recorded in table accurately plotted if the point should be on a line, it must be on the line if the point should not be on a line, it must not be on a line the point should be in the correct small square and must be correct to within half a small square	3

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Question	Answer	Marks
1(b)(ii)	M1 2 lines of best fit drawn (straight or smoothly curved lines), one before adding FB 2 and one for the cooling of the mixture and extrapolated to 2½ minutes so intersect is at or above the maximum thermometer reading recorded in (a) and vertical line drawn at 2½ minutes M2 correct ΔT from the intersect at 2½ minutes to 1 dp and to within 0.5 °C of examiner value	2
1(c)(i)	correctly calculates amount of CuSO₄ = 0.80 × 0.03 = 0.024(00) (mol) and answer to 2–4 significant figures (sf)	1
1(c)(ii)	correctly calculates amount of Zn = $\frac{\text{mass in (a)}}{65.4}$ (mol) and moles Zn > moles Cu²⁺ (owtte)	1
1(c)(iii)	correctly calculates heat energy = 30 × 4.18 × ΔT(b)(ii) (J) and answer to 2–4 sf	1
1(c)(iv)	correct expression $\Delta H = \frac{\text{(c)(iii)}}{\text{(c)(i)}} \times 1000$ (kJ mol⁻¹) and negative sign shown and answer given to 2–4 sf	1

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Question	Answer	Marks
1(d)	conclusion M1 ticks 3rd box and an explanation attempted explanation M2 more (moles of) Cu^{2+} present in (old) FB 1 (so $\Delta T \uparrow$) / solution (for old sample) is more concentrated with respect to Cu^{2+} (ora)	2

Question	Answer	Marks
2(a)	I correct headings and units in Results section • mass of crucible (+ lid) • mass of crucible (+ lid) + FB 3 • mass of crucible (+ lid) + residue / contents / CuO • mass of FB 3 • mass of residue units: / g, (g) or g by every entry II readings and subtraction • all balance readings are to 2 or 3 dp • mass of FB 3 and residue are correctly calculated • mass of FB 3 added is between 1.50 and 1.80 g (candidate's value) III and IV award of accuracy marks award III mark if $\delta \leq \pm 0.25$ award IV marks if $\delta \leq \pm 0.10$ where δ is the difference between the supervisor's and candidate's mass ratio $= \frac{\text{mass in FB 3}}{\text{mass residue}}$ calculated to 2 dp	4

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Question	Answer	Marks
2(b)(i)	correctly calculates amount of CuO = mass of residue from (a) / 79.5 (mol) and answer given to 2–4 sf	1
2(b)(ii)	correctly calculates mass of CO ₂ = mass of FB 3 – mass of residue and amount of CO ₂ = answer / 44 (mol) and answer given to 2–4 sf	1
2(b)(iii)	either - yes, amount / moles of CuO = amount / moles of CO₂ (within experimental error) (so no other decomposition product) or - no, amount / moles of CuO does not equal amount / moles of CO₂ (so another decomposition product formed)	1
2(c)	award for any possible formula of basic copper(II) carbonate which includes CuCO ₃ and either one or both of Cu(OH) ₂ and CuO e.g. CuCO ₃ •Cu(OH) ₂ , CuCO ₃ •CuO, CuCO ₃ •CuO•Cu(OH) ₂ , CuCO ₃ •CuO•2Cu(OH) ₂	1
2(d)(i)	improvement: heat to constant mass (owtte)	1

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Question	Answer	Marks
2(d)(ii)	M1 reagent: selects a named (mineral) acid or gives its correct formula M2 observation and conclusion either no fizzing / no reaction / no change = no carbonate (remains) / complete decomposition or fizzing = some carbonate remains / not fully decomposed or gas / CO₂ gives white ppt with limewater = some carbonate remains / not fully decomposed	2

Question	Answer	Marks
FB 4 is $\text{CuSO}_4(\text{aq})$; FB 5 is $\text{C}_6\text{H}_{12}\text{O}_6(\text{aq})$		
3(a)(i)	observations with FB 4 Test 1 + $\text{NH}_3(\text{aq})$: • (pale) blue ppt • dark / deep blue (solution) forms (with excess) + $\text{EDTA}(\text{aq})$: • paler / lighter (blue) Test 2 + $\text{EDTA}(\text{aq})$: • (slightly) deeper / darker (blue) + $\text{NaOH}(\text{aq})$: • no change / no ppt / remains blue (solution) + FB 5 and warm: • green / yellow / brown (colour) • ppt / solid Test 3 + Mg: • bubbles (on ribbon) • solution colour fades / paler blue / colourless • ribbon darkens or pink / red-brown / brown / black and solid / ppt / coating / layer on Mg	5

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Question	Answer	Marks
3(a)(ii)	M1: 'Table' with headings: 'test / experiment / reagents' and 'observations' (owtte) and at least 1 appropriate reagent and at least 1 observation shown M2 and M3: marks are awarded using 2 • = 1 mark reagent: • selects a named (aqueous) barium salt / correct formula observation: • White ppt either reagent: • hydrochloric / nitric acid / HCl / HNO₃ (add to ppt) observation: • ppt insoluble or reagent: • (acidified aqueous) potassium manganate(VII) / KMnO₄ (add to fresh sample of solution or to mixture after addition of (aqueous) barium salt) observation: • (solution / KMnO₄) remains purple / no change	3
3(a)(iii)	identifies CuSO ₄ with evidence of sulfate from results	1
3(a)(iv)	Mg(s) + Cu²⁺(aq) → Mg²⁺(aq) + Cu(s) or Mg(s) + 2H⁺(aq) → Mg²⁺(aq) + H₂(g)	1

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Question	Answer	Marks												
3(b)(i)	observations with FB 5 <table border="1"> <thead> <tr> <th><i>mark</i></th><th><i>test</i></th><th><i>observation</i></th></tr> </thead> <tbody> <tr> <td>M1</td><td>+ Tollens'</td><td>(silver) mirror / black ppt on warming</td></tr> <tr> <td>M2</td><td>+ (acidified) $\text{KMnO}_4(\text{aq})$</td><td>pink / purple to colourless (solution) OR KMnO_4 decolourises (on warming)</td></tr> <tr> <td>M3</td><td>+ $\text{Na}_2\text{CO}_3(\text{aq})$</td><td>no change / no bubbling</td></tr> </tbody> </table>	<i>mark</i>	<i>test</i>	<i>observation</i>	M1	+ Tollens'	(silver) mirror / black ppt on warming	M2	+ (acidified) $\text{KMnO}_4(\text{aq})$	pink / purple to colourless (solution) OR KMnO_4 decolourises (on warming)	M3	+ $\text{Na}_2\text{CO}_3(\text{aq})$	no change / no bubbling	3
<i>mark</i>	<i>test</i>	<i>observation</i>												
M1	+ Tollens'	(silver) mirror / black ppt on warming												
M2	+ (acidified) $\text{KMnO}_4(\text{aq})$	pink / purple to colourless (solution) OR KMnO_4 decolourises (on warming)												
M3	+ $\text{Na}_2\text{CO}_3(\text{aq})$	no change / no bubbling												
3(b)(ii)	identifies aldehyde / RCHO / $-\text{CHO}$ and states positive result with Tollens' (owtte)	1												



Cambridge International AS & A Level

CHEMISTRY

9701/35

Paper 3 Advanced Practical Skills 1

October/November 2022

MARK SCHEME

Maximum Mark: 40

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the October/November 2022 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

This document consists of **10** printed pages.

PUBLISHED**Generic Marking Principles**

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

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'.

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

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

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

7 Guidance for chemical equations

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

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

Question	Answer	Marks
1(a)	I all the following data recorded - 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 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 to nearest 0.05 cm³ IV the final accurate titre recorded is within 0.10 cm³ of any other accurate titre V, VI, VII award V if $\delta \leq 0.60$ (cm³) award VI if $\delta \leq 0.40$ (cm³) award VII if $\delta \leq 0.20$ (cm³) where δ is the difference between the supervisor's and candidate's mean titre	7
1(b)	candidate calculates mean correctly to 2 decimal places (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(c)(i)	significant figures (sf) all quoted answers in (c)(ii) – (c)(iv) are expressed to 3 or 4 sf	1
1(c)(ii)	correctly calculates amount of MnO₄⁻ used amount of MnO₄⁻ = $\frac{0.02 \times \text{vol in (b)}}{1000}$ (mol)	1

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Question	Answer	Marks
1(c)(iii)	correctly uses equation and converts volume amount of $(\text{COO}^-)_2$ that reacted = (c)(ii) $\times \frac{5}{2}$ (mol) and concentration of $(\text{COO}^-)_2$ in FA 1 = amount of $(\text{COO}^-)_2 \times \frac{1000}{25}$ (mol dm⁻³)	1
1(c)(iv)	correctly uses $M_r = \frac{\text{mass}}{\text{moles}}$ $M_r = \frac{10.14}{\text{concentration from (c)(iii)}}$	1
1(c)(v)	identity of M M1: A_r of M = $\frac{M_r \text{ from (c)(iv)} - 124}{2}$ M2: identifies M as being the Group 1 element with the nearest A_r (Li $\leq$ 14.9; 15.0 $\leq$ Na $\leq$ 31.0; 31.1 $\leq$ K $\leq$ 62.3; 62.3 $\leq$ Rb $\leq$ 111.4; 111.4 $\leq$ Cs $\leq$ 250)	2
1(d)	explanation for use of acid to provide H⁺ and for the reaction (to proceed) / as given in the equation / to acidify the KMnO₄	1

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Question	Answer	Marks
2(a)	M1: table of readings with unambiguous headings and correctly displayed units for all entries in the space for Results • (mass of) container + FA 4 • (mass of) container (+ residue) • first / start / initial temperature / temperature of water • lowest / final temperature M2: readings in 2(a) • both thermometer readings shown to 0.0 °C or 0.5 °C • balance readings shown consistently to either 2 dp or to 3 dp • mass and temperature rise in (a) subtracted correctly and shown in the space for results	2
2(b)(i)	correctly calculates energy change energy change = $25 \times 4.18 \times T$ fall (J) and answer to 2–4 sf	1
2(b)(ii)	correctly calculates amount of FA 4 amount = $\frac{\text{mass FA 4}}{249.6}$ (mol) and answer to 2–4 sf	1
2(b)(iii)	correctly uses $\frac{(b)(i)}{(b)(ii)}$ enthalpy change = $\frac{(b)(ii)}{(b)(ii) \times 1000}$ (kJ mol⁻¹) and + sign and answer to 2–4 sf	1
2(c)	readings mass of FA 5 and temperature rise are correctly calculated two thermometer readings are both above 10 °C temperature rise is greater than T fall in (a)	1

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Question	Answer	Marks
2(d)(i)	correct expressions shown for enthalpy change - energy change = $25 \times 4.18 \times T$ change (J) - amount used = mass of FA 5 used / 159.6 (mol) $\Delta H = \frac{\text{energy change}}{\text{number of moles} \times 1000}$ (kJ mol⁻¹) - negative sign in answer	2
2(d)(ii)	Hess's cycle calculation correct calculation of $\Delta H = \text{(b)(iii)} - \text{(d)(i)}$ (kJ mol ⁻¹) and some working shown e.g., equation as shown and 2 downward arrows with labelling / correct values from (b)(iii) and (d)(i) with correct signs	1
2(e)	explanation for answer selected box 1 ticked: ΔT is larger for (b)(iii) (ora) box 2 ticked: ΔT is the same for both experiments box 3 ticked: ΔT is larger for (d)(i) (ora)	1

PUBLISHED

Question	Answer	Marks
FA 6 is aqueous $\text{Zn}(\text{NO}_3)_2$ and KI ; FA 7 gives results for ethanal but is actually butan-2-ol		
3(a)(i)	observations Test 1 M1: NaOH: white ppt and soluble in excess M2: Heat: no change / no (visible) reaction / litmus stays red Test 2 M3: Al: fizz and NH_3 / gas turns (damp red) litmus blue Test 3 M4: H_2O_2 : brown / (darker) yellow / yellow-brown / orange-brown / red-brown (solution)	4
3(a)(ii)	possible cations: aluminium / Al^{3+} and zinc / Zn^{2+}	1
3(a)(iii)	identifying the cation M1: cation test: add (aqueous) ammonia M2: white ppt soluble in excess $\text{NH}_3(\text{aq})$ shows Zn^{2+}	2
3(a)(iv)	possible anions: any two from NO_3^- , NO_2^- , I^-	1
3(a)(v)	identifying the anion if iodide in (iv) M1: test: add (aqueous) silver nitrate / AgNO_3 M2: yellow ppt (insol in NH_3) shows I^- if nitrite and nitrate (no iodide) in (iv) M1: test: add (acidified aqueous) potassium manganate(VII) / KMnO_4 M2: purple / KMnO_4 solution turns (dark) yellow / yellow-brown / orange-brown / red-brown / brown / decolourised shows nitrite OR M1: add named (dilute) acid M2: no fizzing / no brown gas shows nitrate	2

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Question	Answer	Marks
3(b)(i)	M1: Test 2 (triiodomethane test) (Pale) yellow ppt M2: Test 3 add (acidified aqueous) potassium manganate(VII) purple / KMnO_4 decolourised	2
3(b)(ii)	any 2 of the following tests correct Test 1: does not contain $-\text{OH}$ / not an alcohol / not a carboxylic acid / not hydroxyl group Test 2: contains $-\text{CH}_2\text{C}=\text{O}$ (or $-\text{CH}(\text{OH})\text{CH}_3$) group Test 3: is an aldehyde (or a 1° or 2° alcohol)	2
3(b)(iii)	FA 7 is ethanal / CH_3CHO	1



Cambridge International AS & A Level

CHEMISTRY

9701/36

Paper 3 Advanced Practical Skills 2

October/November 2022

MARK SCHEME

Maximum Mark: 40

Published

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PUBLISHED**Examples of how to apply the list rule**State **three** reasons ... [3]

A	1	Correct	✓	2
	2	Correct	✓	
	3	Wrong	✗	

B (4 responses)	1	Correct, Correct	✓, ✓	3
	2	Correct	✓	
	3	Wrong	ignore	

C (4 responses)	1	Correct	✓	2
	2	Correct, Wrong	✓, ✗	
	3	Correct	ignore	

D (4 responses)	1	Correct	✓	2
	2	Correct, CON (of 2.)	✗, (discount 2)	
	3	Correct	✓	

E (4 responses)	1	Correct	✓	3
	2	Correct	✓	
	3	Correct, Wrong	✓	

F (4 responses)	1	Correct	✓	2
	2	Correct	✓	
	3	Correct CON (of 3.)	✗ (discount 3)	

G (5 responses)	1	Correct	✓	3
	2	Correct	✓	
	3	Correct Correct CON (of 4.)	✓ ignore ignore	

H (4 responses)	1	Correct	✓	2
	2	Correct	✗	
	3	CON (of 2.) Correct	(discount 2) ✓	

I (4 responses)	1	Correct	✓	2
	2	Correct	✗	
	3	Correct CON (of 2.)	✓ (discount 2)	

Question	Answer	Marks
1(a)	I the following data must be shown - two burette readings and titre for the 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 / FB 4 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 to the nearest 0.05 cm³. IV the final accurate titre recorded is within 0.10 cm³ of any other accurate titre. V, VI, VII award V if $d \leq 0.60$ (cm³) award VI if $d \leq 0.40$ (cm³) award VII if $d \leq 0.20$ (cm³) where d is the difference between the supervisor's and candidate's mean titres	7
1(b)	candidate calculates mean correctly to 2 decimal places (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(c)(i)	all answers to (c)(ii) , (c)(iv) and (c)(v) expressed to 3 or 4 significant figures (sf)	1
1(c)(ii)	correctly calculates amount of K₂CO₃ in 25 cm³ $\text{amount} = \frac{8.46}{40} \times \frac{1}{138.2} = 1.53(0) \times 10^{-3} \text{ (mol)}$	1
1(c)(iii)	CO ₃ ²⁻ (aq) + 2H ⁺ (aq) → CO ₂ (g) + H ₂ O(l)	1

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Question	Answer	Marks
1(c)(iv)	correct use of (c)(ii) to calculate HCl concentration in FB 4 concentration of HCl in FB 4 = $0.00153(0) \times 2 \times \frac{1000}{\text{titre}}$ (mol dm ⁻³)	1
1(c)(v)	correct use of (c)(iv) to calculate HCl concentration in FB 1 concentration of HCl in FB 1 = (c)(iv) $\times \frac{250}{10}$ (mol dm ⁻³)	1
1(d)	titre will be smaller / reduced because amount / concentration of K ₂ CO ₃ (in hydrated salt) is smaller	1
1(e)	one of: • use 62.5 cm³ / 2.5 $\times$ the volume of FB 2 • change the concentration of FB 2 to 21.15 g dm⁻³ • make a subsequent dilution of FB 4 of 100 cm³ to 250 cm³	1

Question	Answer	Marks
2(a)	I six pieces of data recorded two balance readings, two thermometer readings, mass used, temperature rise and all shown in the Results space provided II correct subtractions in (a) to calculate the mass of FB 5 and the temperature change III, IV award III for $d \leq 0.60$ ($^{\circ}\text{C g}^{-1}$) award IV for $d \leq 0.30$ ($^{\circ}\text{C g}^{-1}$) where d is the difference between the supervisor's and candidate's ratio of $\frac{\text{rise in temperature}}{\text{mass of FB 5}}$ calculated correctly to 2 dp	4
2(b)(i)	correct calculation of energy change energy change = $30 \times 4.18 \times \text{temperature rise (J)}$ and answer given to 2 – 4 sf	1
2(b)(ii)	correctly calculates amount of Na_2CO_3 amount = $\frac{\text{mass used}}{106}$ (mol) and answer given to 2 – 4 sf	1
2(b)(iii)	correct use of (c)(i) and (c)(ii) enthalpy change = $\frac{(b)(i)}{(b)(ii)} \times \frac{1}{1000}$ (kJ mol^{-1}) and answer with negative sign and given to 2 – 4 sf	1

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Question	Answer	Marks
2(c)	student is not correct because temperature rise will be halved / lower so greater percentage error in measurement OR student is correct because there will be less spray / frothing out of the cup	1
2(d)	I six unambiguous headings with correct units given for all readings (/ °C and / g, etc.) - initial thermometer reading / temperature - minimum / final thermometer reading / temperature (mass of) container and FB 6 / solid (mass of) container (empty or with residual FB 6) (mass of) FB 6 / solid used - temperature change / decrease II four readings recorded - two thermometer readings and two balance readings recorded in the space for Results - mass used is between 7.00 – 11.00 g - thermometer readings show a decrease in temperature of at least half of the supervisor's value III precision of all readings in (a) and (d) - four balance readings recorded to same dp (two or more) - four thermometer readings recorded to .0 or .5°C	3
2(e)(i)	worrecr working shown - energy change = $30 \times 4.18 \times \text{temperature decrease (J)}$ - amount of carbonate = $\frac{\text{mass used}}{286}$ (mol) - enthalpy change = $\frac{\text{energy change}}{\text{no. of moles}} \times \frac{1}{1000}$ (kJ mol⁻¹) - answer shown with positive sign and to 2 or more sf	2
2(e)(ii)	correct calculation: enthalpy of dehydration = 2(e)(i) – 2(b)(iii) (kJ mol⁻¹)	1

Question	Answer	Marks
FB 7 is NaBr(aq) + Na ₂ SO ₄ (aq); FB 8 is ZnCO ₃ (s)		
3(a)(i)	potassium manganate(VII) / KMnO ₄ is decolorised or (purple solution) turns yellow / yellow-brown / orange-brown / amber / brown	1
3(a)(ii)	reagents selected: (aqueous) silver nitrate / AgNO₃ (aqueous) barium nitrate / Ba(NO₃)₂ or (aqueous) barium chloride / BaCl₂ observations: (adding) AgNO₃ gives a cream / off-white precipitate - precipitate is insoluble / partially soluble in (excess) ammonia (adding) Ba(NO₃)₂ / BaCl₂ gives a white precipitate - precipitate insoluble / not soluble in HCl / HNO₃ conclusions: the anions in FB 7 are - Br⁻ / bromide - SO₄²⁻ / sulfate	4
3(b)(i)	heating FB 8 - condensation (of liquid) (solid) turns yellow / yellow-green or yellow(-green) solid formed - on cooling, (residue) becomes paler / turns white <u>attempts</u> to test with limewater - gas / CO₂ gives a white precipitate (with limewater) (There are 5 marking points. The last 2 may be awarded if the gas test and result is given in (b)(ii) .)	2
3(b)(ii)	fizzing / bubbling / effervescence and either (reaction is) rapid / vigorous or solid dissolves / colourless solution formed	1

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Question	Answer	Marks
3(b)(iii)	observations: M1: add (aqueous) ammonia / NH_3 giving white precipitate M2: ppt soluble / dissolves in excess (NH_3)	2
3(b)(iv)	FB 8 is ZnCO_3	1