



Cambridge International AS & A Level

CHEMISTRY

9701/31

Paper 3 Advanced Practical Skills 1

October/November 2021

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 2021 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.

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 Unambiguous headings and correct units (Mass of) crucible and lid (Mass of) crucible, lid and FA 1 (or ‘contents before heating’) (Mass of) crucible, lid and residue / oxide / contents after first heating / contents after cooling (Mass of) crucible, lid and residue / oxide / contents after second heating / contents after cooling (Mass of) FA 1 used	1
	II Weighings recorded appropriately - Four weighings recorded in the space provided - All weighings recorded to same number of decimal places (one or more) - Mass used between 1.40 and 1.60 g	1
	III Mass after second heating within 0.05 g of mass after first heating for 2 or 3 dp balance. Mass FA 1 and residue calculated correctly.	1
	IV and V Award IV if mass ratio within 0.30 of supervisor Award V if mass ratio within 0.15 of supervisor	2
1(b)(i)	Correctly calculates Mass CO_2 = mass FA 1 – mass X_2O OR total mass before heating – total mass after 2nd heating	1
1(b)(ii)	Correctly calculates moles X_2CO_3 = moles of CO_2 = (b)(i) / 44 correctly calculated AND to 2–4 sf	1
1(b)(iii)	Correctly uses: M_r of X_2CO_3 = $\frac{\text{mass FA 1 used}}{\text{ans (b)(ii)}}$ AND Ans to 2–4 sf	1

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Question	Answer	Marks
1(b)(iv)	Correctly shows and uses: M1: $A_r = \frac{(\mathbf{b})(\text{iii}) - 60}{2}$ M2: Chooses Group 1 nearest A_r using value from M1 and explains reason that it is closer to the A_r value. $0.1 < \text{Li} \leq 14.9$ $15.0 \leq \text{Na} \leq 31.1$ $31.2 \leq \text{K} \leq 62.3$ $62.3 \leq \text{Rb} \leq 109.2$ $109.2 \leq \text{Cs} \leq 250$	2
1(c)	If no change in mass between first and second heating decomposition was complete OR Not complete if further loss of mass	1

Question	Answer	Marks
2(a)	I The following data must be shown • burette readings and titre for rough titration • 2×2 'box' showing both accurate burette readings <i>'Correct' headings and units are not required for this mark</i>	1
	II Headings and units correct for accurate titration table and headings match readings. • initial / start and (burette) reading / volume + unit • final / end and (burette) reading / volume + unit • titre or volume / FA 3 and used / added + unit <i>Units: (cm³) or / cm³ or in cm³ or cm³ by every entry</i>	1
	III All accurate burette readings to 0.05 cm ³	1
	IV The final accurate titre recorded is within 0.10 cm ³ of any other accurate titre. <i>Do not award the mark if any 'accurate' burette readings (apart from initial 0) are given to zero dp.</i>	1
	Award V if $\delta \leq 0.50 \text{ cm}^3$ Award VI if $\delta \leq 0.30 \text{ cm}^3$ Award VII if $\delta \leq 0.20 \text{ cm}^3$	3
2(b)	Candidate must average two (or more) titres that are all within 0.20 cm ³ and quoted to 2 dp. Working must be shown or ticks must be put next to the two (or more) accurate titres selected.	1
2(c)(i)	Answers for (c)(ii) , (c)(iii) , (c)(iv) to 3–4 sf	1
2(c)(ii)	Correctly calculates $n(\text{H}_2\text{SO}_4) = 0.050 \times \text{(b)} / 1000$	1
2(c)(iii)	Correctly uses [FA 4] = (c)(ii) $\times 2 \times 40 \text{ mol dm}^{-3}$	1
2(c)(iv)	Correctly calculates [FA 2] = (c)(iii) $\times 10 \text{ mol dm}^{-3}$	1

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Question	Answer	Marks
2(c)(v)	Correctly uses M1: $M_r = \frac{26.3}{\text{(c)(iv)}} = \text{Answer}$ M2: Use of Answer – 17 and identify Z $< \text{Li} \leq 14.9$ $15.0 \leq \text{Na} \leq 31.1$ $31.2 \leq \text{K} \leq 62.3$ $62.3 \leq \text{Rb} \leq 109.2$ $109.2 \leq \text{Cs} \leq 250$	2
2(d)	Correctly uses $A_r \text{ from (c)(v)} - A_r \text{ from periodic table} \times 100 / A_r \text{ from periodic table}$ Answer from default = 18.16 or 18.2 or 18 %	1

Question	Answer				Marks
FA 5 is BaCl ₂ (aq); FA 6 is H ₂ SO ₄ (aq); FA 7 is NaOH(aq); FA 8 is HCOOH(aq)					
3(a)(i)		FA 5	FA 6	FA 7	5
	H ₂ SO ₄	white ppt / solid *	no (visible) reaction / no change / no ppt / solution remains colourless *	no (visible) reaction / no change / no ppt / solution remains colourless *	
	Na ₂ CO ₃	white ppt / solid *	effervescence / fizzing / bubbles * gas / CO ₂ turns limewater milky / cloudy white / forms white ppt *	no (visible) reaction / no change / no ppt / solution remains colourless *	
	MgCl ₂	no (visible) reaction / no change / no ppt / solution remains colourless *	no (visible) reaction/ no change / no ppt / solution remains colourless *	white ppt / solid *	
3(a)(ii)	M1: Cation in FA 5 is Ba ²⁺ or Ca ²⁺ M2: Cation in FA 6 is H ⁺ M3: Anion in FA 7 is OH ⁻				3
3(a)(iii)	Test for OH ⁻ Add specified (aqueous) metal compound gives appropriate (coloured) ppt OR Add a specified nitrate and Al and warm Positive test for ammonia OR Add a specified ammonium compound and warm Positive test for ammonia				1
3(a)(iv)	Yes, because the test gave a named ppt of specified hydroxide which is insoluble (in water). OR Yes, because it gave ammonia gas (on warming) which is alkaline.				1

Question	Answer	Marks
3(b)(i)	M1: Test 1 purple / pink to colourless / (pale) yellow / pale brown OR KMnO_4 is decolourised M2: Test 2 effervescence / fizzing / bubbles AND gas/ H_2 pops with a lighted splint / burns with a pop	2
3(b)(ii)	M1: (FA 8) can be oxidised / is a reducing agent M2: (FA 8) is an acid	2



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Question	Answer	Marks
1(a)	I Unambiguous headings AND correct units in the space provided • (mass) flask + acid / FA 2 • (mass) container + M₂CO₃ / FA 1 • (mass) container (+ residue) • (mass) flask + contents (provided this label not used for theoretical mass) • (mass) FA 1 (added) • theoretical / total mass or flask + FA 2 / acid + FA 1 / M₂CO₃ • (mass) CO₂	1
	II Four balance readings recorded to the same number of decimal places AND answer to at least 1 decimal place	1
	III Three masses correctly calculated.	1
	IV Examiner calculates ratio $\frac{\text{mass FA 1}}{\text{mass carbon dioxide}}$ to 2 dp for candidate and difference from supervisor ratio. The mark is awarded for a difference ≤ 0.25 .	1
1(b)(i)	Correctly calculates amount of CO ₂ = mass CO ₂ lost / 44 mol AND answer given to 2 – 4 significant figures	1
1(b)(ii)	Correctly uses $M_r = \frac{\text{mass FA 1}}{\text{(b)(i)}}$ AND answer given to 2 – 4 sf (sf error is not penalised more than once in 1(b))	1

Question	Answer	Marks
1(b)(iii)	Correct expression $A_r M^+ = \frac{((b)(ii) - 60)}{2}$ AND M⁺ is the closest group 1 cation 0.1 < Li⁺ ≤ 14.9 15.0 ≤ Na⁺ ≤ 31.1 31.2 ≤ K⁺ ≤ 62.3 62.3 ≤ Rb⁺ ≤ 109.2 109.2 ≤ Cs⁺ ≤ 250	1
1(c)(i)	Any one of: • saturate the acid with CO₂ initially • pre-heat the acid • use more concentrated acid • shake / swirl the flask vigorously / more • add named inert solute to solution	1
1(c)(ii)	M1: amount of acid added to flask, n(H⁺) = 0.05 mol correct working or answer OR 2 × (b)(i) M2: n(H⁺) > 2 × n(M₂CO₃) where n(M₂CO₃) = (b)(i) or $\frac{\text{mass FA 1}}{(b)(ii)}$ Other valid methods may be awarded.	2

Question	Answer	Marks
2(a)	I The following data must be shown: • burette readings and titre for rough titration • 2 × 2 'box' showing both accurate burette readings.	1
	II Headings and units correct for accurate titration table and headings match readings. • initial / start AND (burette) reading / volume + unit • final / end AND (burette) reading / volume + unit • titre OR volume / FA 4 AND used / added + unit	1
	III All accurate burette readings given 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
	Examiner calculates the mean titres for supervisor and candidate and awards marks according to the difference, d, in the values. Award V if $\delta \leq 0.60 \text{ cm}^3$ Award VI if $\delta \leq 0.40 \text{ cm}^3$ Award VII if $\delta \leq 0.20 \text{ cm}^3$	3
2(b)	Candidate must average two (or more) titres that are all within 0.20 cm ³ AND give the answer to 2 dp. AND working must be shown or ticks must be put next to the two (or more) accurate titres selected.	1
2(c)(i)	All answers for (c)(ii) , (c)(iii) , (c)(iv) are to 3 – 4 sf	1
2(c)(ii)	Correctly calculates amount of acid $n(\text{HCl}) = 0.110 \times (\mathbf{b}) / 1000$	1

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Question	Answer	Marks
2(c)(iii)	Correctly uses $n(\text{M}_2\text{CO}_3)$ in $25 \text{ cm}^3 = \frac{(\text{c})(\text{ii})}{2}$	1
2(c)(iv)	Correctly uses $M_r = \frac{7.46}{(\text{c})(\text{iii}) \times 40}$	1
2(c)(v)	Correctly uses $\frac{((\text{c})(\text{iv}) - 60)}{2}$ AND M⁺ is the closest group 1 cation $0.1 < \text{Li}^+ \leq 14.9$ $15.0 \leq \text{Na}^+ \leq 31.1$ $31.2 \leq \text{K}^+ \leq 62.3$ $62.3 \leq \text{Rb}^+ \leq 109.2$ $109.2 \leq \text{Cs}^+ \leq 250$	1
2(d)	Acid was more concentrated because smaller titre gives fewer moles of M_2CO_3 OR specimen calculation showing effect of different concentration provided. (titre ↓ = > $n(\text{M}_2\text{CO}_3)$ ↓ = > $M_r \uparrow$) ORA	1

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Question	Answer	Marks																
FA 5 is (NH ₄) ₂ CO ₃ (s); FA 7 is CrK(SO ₄) ₂ (aq); FA 8 is BaCl ₂ (aq)																		
3(a)(i)	Award any two - Sublimes / solid diminishes / disappears / solid formed on cooler part of tube / no residue - Condensation / water droplets / steam - Gas / NH₃ turns (damp red) litmus blue. A positive test with limewater is credited in (a)(ii)	2																
3(a)(ii)	Effervescence / bubbling / fizzing AND forms a white ppt with limewater/ limewater turns milky / chalky / cloudy white	1																
3(b)(i)	M1, M2, M3 and M4 from observations table 2 * = 1 mark (round down) <table><tr><th></th><th>FA 6</th><th>FA 7</th><th>FA 8</th></tr><tr><td>+ Ag⁺</td><td>white ppt * (insoluble in excess)</td><td>no (visible) reaction / no change / no ppt / solution remains blue / green / blue-green *</td><td>white ppt * (insoluble in excess)</td></tr><tr><td>+ FA 6</td><td></td><td>effervescence / fizzing / bubbles * (blue) solution turns green / greener * grey-blue / grey-green / (pale) green ppt * (award a positive limewater test in (a)(ii))</td><td>white ppt * (insoluble in excess)</td></tr><tr><td>+ FA 7</td><td></td><td></td><td>white ppt * (insoluble in excess)</td></tr></table>		FA 6	FA 7	FA 8	+ Ag ⁺	white ppt * (insoluble in excess)	no (visible) reaction / no change / no ppt / solution remains blue / green / blue-green *	white ppt * (insoluble in excess)	+ FA 6		effervescence / fizzing / bubbles * (blue) solution turns green / greener * grey-blue / grey-green / (pale) green ppt * (award a positive limewater test in (a)(ii))	white ppt * (insoluble in excess)	+ FA 7			white ppt * (insoluble in excess)	4
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3(b)(ii)	M1: Tabulates the two reagents and observations for FA 6, FA 7 and FA 8 in clearly labelled sections. M2, M3, M4 and M5: from observations table 2 * = 1 mark (round down) <table><tr><th></th><th>FA 6</th><th>FA 7</th><th>FA 8</th></tr><tr><td>+ NaOH</td><td>no (visible) reaction / no change / no ppt / remains colourless solution *</td><td>grey-green ppt * soluble in excess / (dark) green solution formed with excess *</td><td>(faint) white ppt and insoluble in excess * (allow no change / no (visible) reaction / no ppt)</td></tr><tr><td>+ warm *</td><td>gas / NH₃ turns (red) litmus blue *</td><td colspan="2">If (red) litmus turning blue is reported for either FA 7 or FA 8 then gas / NH₃ turns (red) litmus blue with FA 6 cannot be credited.</td></tr><tr><td>+ H₂SO₄</td><td>Fizzing / bubbling/ effervescence * (award a positive limewater test in (a)(ii))</td><td>no (visible) reaction / no change / no ppt *</td><td>white ppt * (insoluble in excess)</td></tr></table>		FA 6	FA 7	FA 8	+ NaOH	no (visible) reaction / no change / no ppt / remains colourless solution *	grey-green ppt * soluble in excess / (dark) green solution formed with excess *	(faint) white ppt and insoluble in excess * (allow no change / no (visible) reaction / no ppt)	+ warm *	gas / NH ₃ turns (red) litmus blue *	If (red) litmus turning blue is reported for either FA 7 or FA 8 then gas / NH ₃ turns (red) litmus blue with FA 6 cannot be credited.		+ H ₂ SO ₄	Fizzing / bubbling/ effervescence * (award a positive limewater test in (a)(ii))	no (visible) reaction / no change / no ppt *	white ppt * (insoluble in excess)	5
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Question	Answer	Marks
3(c)(ii)	Correct ionic equation from test in (a) or (b) and ion given in (c)(i) Examples of correct ionic equations: $\text{Ba}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$ $\text{Ba}^{2+}(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{BaCO}_3(\text{s})$ $\text{Ba}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) \rightarrow \text{Ba}(\text{OH})_2(\text{s})$ $\text{Ag}^{+}(\text{aq}) + \text{Cl}^{-}(\text{aq}) \rightarrow \text{AgCl}(\text{s})$ $2\text{Ag}^{+}(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{Ag}_2\text{CO}_3(\text{s})$ $\text{Ca}^{2+}(\text{aq}) + \text{CO}_3^{2-}(\text{aq}) \rightarrow \text{CaCO}_3(\text{s})$	1



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Question	Answer	Marks
1(a)(i)	I Constructs a single 4×5 table for results for 5 experiments AND at least one experiment attempted	1
	II Correct headings and units for data given. • volume of FB1 and in cm^3 or $/\text{cm}^3$ or (cm^3) • volume of water and in cm^3 or $/\text{cm}^3$ or (cm^3) • time and in seconds or $/\text{s}$ or (s) • rate and $/\text{s}^{-1}$ or (s^{-1})	1
	III All times recorded to the nearest second AND all volumes given to nearest 0.05	1
	IV 3 additional volumes chosen with intervals not less than 5.00 cm^3 AND all additional volumes of FB 1 $\geq 25.00 \text{ cm}^3$ AND In all 3 additional experiments water is added to make a total of 45.00 cm^3	1
	V All rates correctly calculated using $1000 / \text{time}$ AND all recorded to the same number of dp or same number of sf.	1
	VI All five times increase with decreasing volume of FB 1	1
	VII & VIII Compare ratio of time for 20.00 cm^3 of FB 1 /time for 45.00 cm^3 of FB 1 to 2 dp. Award VII for ratio 2.10 – 2.60 Award VIII for ratio 2.20 – 2.50	2

Question	Answer	Marks
1(b)	I Rate on y axis and volume of FB 1 on the x axis With correct labels and units. Do not penalise missing / incorrect unit if penalised in 1(a) II (ecf)	1
	II Linear scales chosen so that the graph occupies more than half the available length for both axes (7×5 big squares)	1
	III All points recorded plotted correctly to within half a small square and in the correct square or on the line if it should be on the line and not on the line if it shouldn't.	1
	IV Draws a line of best fit. This can be a straight line or smooth curve.	1
1(c)	Rate is proportional to concentration of thiosulfate	1
1(d)(i)	(Carbonate/ quenching bath) removes H^+ / neutralises acidic solution (so reaction stops).	1
1(d)(ii)	To know when all the carbonate has been neutralised / no more carbonate (solution) remains / more carbonate needs to be added OR mixture becomes acidic / pH drops below 7 / pH is no longer ≥ 7	1
1(e)(i)	M1: moles of $H^+ = 2(.00) \times 10^{-2}$ AND moles of $S_2O_3^{2-} = 4.5(0) \times 10^{-3}$ M2: $2(.00) \times 10^{-2} > 2 \times 4.5(0) \times 10^{-3} / 9(.0) \times 10^{-3}$ Other valid methods exist (e.g., comparison of volume of acid required to react and volume used).	2
1(e)(ii)	So acid concentration remains (almost) constant throughout the experiment OR only the conc of thiosulfate affects the rate.	1

Question	Answer	Marks
2(a)	M1: Unambiguous headings and units: / °C or (°C). - two thermometer readings - change / increase in temperature / ΔT AND subtraction correct. M2: Both thermometer readings recorded to either 0.0 or 0.5 °C M3: Award 1 mark for $15.0 \leq \Delta T \leq 35.0$	3
2(b)(i)	Correctly calculates $\Delta T \times 4.2 \times 40$ AND answer expressed to 2 – 4 sf	1
2(b)(ii)	M1: Shows use of moles of $\text{CuSO}_4 = \text{ans (b)(i)} / (218.7 \times 1000)$ OR uses $(\text{b)(i)} / (40/1000)$ M2: Correctly uses conc = $(\text{b)(i)} / (218.7 \times 1000) \times 0.04$ AND answer expressed to 2 – 4 sf (unless already penalised in (b)(i)).	2
2(c)(i)	Shows use of $((2 \times 0.5) / \text{temp rise}) \times 100$ AND answer is correct	1
2(c)(ii)	M1: The student is incorrect AND The temperature rise would remain the same M2: The heat given out per unit volume is the same OR Although more heat is given out the volume is greater	2

Question	Answer	Marks
FB 5 is $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2$; FB 6 is NaNO_3 ; FB 7 is NH_4Cl		
3(a)(i)	I Selects (aqueous) NaOH and / or (aqueous) NH_3 .	1
	II Selects named carbonate or Mg strips or named pH indicator	1
	III With either NaOH or NH_3 : green ppt AND turning brown / insoluble in excess	1
	IV Warm with NaOH AND gas / NH_3 that turns (damp red) litmus blue	1
	V With carbonate: effervescence / fizzing / bubbling OR gas / CO_2 gives white ppt with limewater / limewater turns milky / chalky / cloudy white With Mg : effervescence / fizzing / bubbling OR (gas / H_2) pops with a lighted splint With named indicator: change to correct colour to indicate acidic solution	1
	VI mark for any two ions correctly identified. VI and VII for all three ions correct: NH_4^+ , H^+ and Fe^{2+} Minimum evidence: - green ppt or ppt turns brown or insoluble in excess with $\text{NaOH} / \text{NH}_3$ for Fe^{2+} - fizz with Mg or CO_3^{2-} or A / or correct final colour of indicator - litmus turns blue	2

Question	Answer	Marks
3(a)(ii)	M1: Selects BaCl_2 or $\text{Ba}(\text{NO}_3)_2$ followed by HCl or HNO_3 (or names) $(\text{H}_2\text{SO}_4 \text{ CONS both marks})$ OR Add either specified acid with BaCl_2 or $\text{Ba}(\text{NO}_3)_2$ OR Warm solution with any named mineral acid and test gas with litmus paper / (H^+) / KMnO_4 paper M2: White ppt insoluble in (unspecified) acid OR White ppt with acidified BaCl_2 or $\text{Ba}(\text{NO}_3)_2$ (or names) OR Gas does not turn blue litmus red or does not decolourise (H^+) / KMnO_4 paper AND Sulfate identified.	2
3(b)(i)	Observations for FB 6 Melts / turns liquid * Turns yellow * Fizzing / effervescence * Gas / O_2 relights glowing splint * Observations for FB 7 Sublimation / white fumes / white smoke forms / white solid forms near top of tube * Gas / NH_3 turns (red) litmus blue * Gas turns (Blue) litmus red (must be in correct order) *	3
3(b)(ii)	Thermal decomposition OR Redox	1



Cambridge International AS & A Level

CHEMISTRY

9701/35

Paper 3 Advanced Practical Skills 1

October/November 2021

MARK SCHEME

Maximum Mark: 40

Published

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

PUBLISHED**Generic Marking Principles**

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- | | |
|---|--|
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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 Unambiguous headings and correct units (Mass of) crucible and lid (Mass of) crucible, lid and FA 1 (or ‘contents before heating’) (Mass of) crucible, lid and residue / oxide / contents after first heating / contents after cooling (Mass of) crucible, lid and residue / oxide / contents after second heating / contents after cooling (Mass of) FA 1 used	1
	II Weighings recorded appropriately - Four weighings recorded in the space provided - All weighings recorded to same number of decimal places (one or more) - Mass used between 1.40 and 1.60 g	1
	III Mass after second heating within 0.05 g of mass after first heating for 2 or 3 dp balance. Mass FA 1 and residue calculated correctly.	1
	IV and V Award IV if mass ratio within 0.30 of supervisor Award V if mass ratio within 0.15 of supervisor	2
1(b)(i)	Correctly calculates Mass CO_2 = mass FA 1 – mass X_2O OR total mass before heating – total mass after 2nd heating	1
1(b)(ii)	Correctly calculates moles X_2CO_3 = moles of CO_2 = (b)(i) / 44 correctly calculated AND to 2–4 sf	1
1(b)(iii)	Correctly uses: M_r of X_2CO_3 = $\frac{\text{mass FA 1 used}}{\text{ans (b)(ii)}}$ AND Ans to 2–4 sf	1

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Question	Answer	Marks
1(b)(iv)	Correctly shows and uses: M1: $A_r = \frac{(\mathbf{b})(\text{iii}) - 60}{2}$ M2: Chooses Group 1 nearest A_r using value from M1 and explains reason that it is closer to the A_r value. $0.1 < \text{Li} \leq 14.9$ $15.0 \leq \text{Na} \leq 31.1$ $31.2 \leq \text{K} \leq 62.3$ $62.3 \leq \text{Rb} \leq 109.2$ $109.2 \leq \text{Cs} \leq 250$	2
1(c)	If no change in mass between first and second heating decomposition was complete OR Not complete if further loss of mass	1

Question	Answer	Marks
2(a)	I The following data must be shown • burette readings and titre for rough titration • 2 × 2 'box' showing both accurate burette readings <i>'Correct' headings and units are not required for this mark</i>	1
	II Headings and units correct for accurate titration table and headings match readings. • initial / start and (burette) reading / volume + unit • final / end and (burette) reading / volume + unit • titre or volume / FA 3 and used / added + unit <i>Units: (cm³) or / cm³ or in cm³ or cm³ by every entry</i>	1
	III All accurate burette readings to 0.05 cm ³	1
	IV The final accurate titre recorded is within 0.10 cm ³ of any other accurate titre. <i>Do not award the mark if any 'accurate' burette readings (apart from initial 0) are given to zero dp.</i>	1
	Award V if $\delta \leq 0.50 \text{ cm}^3$ Award VI if $\delta \leq 0.30 \text{ cm}^3$ Award VII if $\delta \leq 0.20 \text{ cm}^3$	3
2(b)	Candidate must average two (or more) titres that are all within 0.20 cm ³ and quoted to 2 dp. Working must be shown or ticks must be put next to the two (or more) accurate titres selected.	1
2(c)(i)	Answers for (c)(ii) , (c)(iii) , (c)(iv) to 3–4 sf	1
2(c)(ii)	Correctly calculates $n(\text{H}_2\text{SO}_4) = 0.050 \times \text{(b)} / 1000$	1
2(c)(iii)	Correctly uses $[\text{FA 4}] = \text{(c)(ii)} \times 2 \times 40 \text{ mol dm}^{-3}$	1
2(c)(iv)	Correctly calculates $[\text{FA 2}] = \text{(c)(iii)} \times 10 \text{ mol dm}^{-3}$	1

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Question	Answer	Marks
2(c)(v)	Correctly uses M1: $M_r = \frac{26.3}{\text{(c)(iv)}} = \text{Answer}$ M2: Use of Answer – 17 and identify Z $< \text{Li} \leq 14.9$ $15.0 \leq \text{Na} \leq 31.1$ $31.2 \leq \text{K} \leq 62.3$ $62.3 \leq \text{Rb} \leq 109.2$ $109.2 \leq \text{Cs} \leq 250$	2
2(d)	Correctly uses $A_r \text{ from (c)(v)} - A_r \text{ from periodic table} \times 100 / A_r \text{ from periodic table}$ Answer from default = 18.16 or 18.2 or 18 %	1

Question	Answer				Marks
FA 5 is BaCl ₂ (aq); FA 6 is H ₂ SO ₄ (aq); FA 7 is NaOH(aq); FA 8 is HCOOH(aq)					
3(a)(i)		FA 5	FA 6	FA 7	5
	H ₂ SO ₄	white ppt / solid *	no (visible) reaction / no change / no ppt / solution remains colourless *	no (visible) reaction / no change / no ppt / solution remains colourless *	
	Na ₂ CO ₃	white ppt / solid *	effervescence / fizzing / bubbles * gas / CO ₂ turns limewater milky / cloudy white / forms white ppt *	no (visible) reaction / no change / no ppt / solution remains colourless *	
	MgCl ₂	no (visible) reaction / no change / no ppt / solution remains colourless *	no (visible) reaction / no change / no ppt / solution remains colourless *	white ppt / solid *	
3(a)(ii)	M1: Cation in FA 5 is Ba ²⁺ or Ca ²⁺ M2: Cation in FA 6 is H ⁺ M3: Anion in FA 7 is OH ⁻				3
3(a)(iii)	Test for OH ⁻ Add specified (aqueous) metal compound gives appropriate (coloured) ppt OR Add a specified nitrate and Al and warm Positive test for ammonia OR Add a specified ammonium compound and warm Positive test for ammonia				1
3(a)(iv)	Yes, because the test gave a named ppt of specified hydroxide which is insoluble (in water). OR Yes, because it gave ammonia gas (on warming) which is alkaline.				1

Question	Answer	Marks
3(b)(i)	M1: Test 1 purple / pink to colourless / (pale) yellow / pale brown OR KMnO_4 is decolourised M2: Test 2 effervescence / fizzing / bubbles AND gas/ H_2 pops with a lighted splint / burns with a pop	2
3(b)(ii)	M1: (FA 8) can be oxidised / is a reducing agent M2: (FA 8) is an acid	2



Cambridge International AS & A Level

CHEMISTRY

9701/36

Paper 3 Advanced Practical Skills 2

October/November 2021

MARK SCHEME

Maximum Mark: 40

Published

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	II The following data must be shown - burette readings and titre for rough titration 2 × 2 'box' showing both accurate burette readings	1
	III Headings and units correct for accurate titration table and headings match readings. - initial / start and (burette) reading / volume + unit - final / end and (burette) reading / volume + unit titre or volume / FB 4 and used / added + unit	1
	All accurate burette readings are recorded to the nearest 0.05 cm ³	1
	The final accurate titre recorded is within 0.10 cm ³ of any other accurate titre.	1
1(a)	VI, VII and VII: Award V for a range of 15% of the supervisor value for M_r Award VI for a range of 10% of the supervisor value for M_r Award VII for a range of 5% of the supervisor value for M_r If the supervisor titre is ≤ 10.00 cm ³ then halve tolerances (0.10, 0.15, 0.25). If supervisor titre & candidate titres ≤ 5.00 cm ³ contact TL	3
1(b)	Candidate must average two (or more) accurate titres with total spread of not more than 0.20 cm ³ . Working must be shown or ticks must be put next to the two (or more) accurate readings selected. The mean should be correctly calculated to the nearest 0.01.	1
1(c)(i)	All answers in (c)(iii) , (c)(iv) and (c)(vi) given to 3 or 4 sf	1
1(c)(ii)	Correctly calculates moles of HCl added: $0.800 \times (50 / 1000) = 0.0400$	1

Question	Answer	Marks
1(c)(iii)	Correctly calculates mol of NaOH used: (b) $\times (0.1 / 1000)$ and moles of HCl remaining = moles of NaOH $\times 10$	1
1(c)(iv)	Correct expression (d)(iv) = (c)(ii) – (c)(iii)	1
1(c)(v)	$\text{Na}_2\text{CO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow 2\text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$ OR $\text{Na}_2\text{CO}_3 \cdot x\text{H}_2\text{O}(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow 2\text{NaCl}(\text{aq}) + (x + 1)\text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$	1
1(c)(vi)	Correctly uses (c)(iv) / 2	1
1(c)(vii)	Correctly uses $M_r = m / n = \text{mass of FB 1 from (a) / (c)(vi)}$	1
	Correct expression $x = (M_r - 106) / 18$ and expressed to the nearest integer or to 2–4 sf	1
1(d)	0.05 or 0.1 if 1 dp balance used / 0.005 or 0.01 if 2 dp balance used / 0.0005 or 0.001 if 3 dp balance used and Correct expression $\{(2 \times \text{error above}) / \text{mass from (a)}\} \times 100$	1
1(e)	Titre would be smaller and More acid has reacted in Step 1 / less acid remaining after reaction in Step 1	1

Question	Answer	Marks
2(a)	I Unambiguous headings and correct units: • (mass of) crucible and lid • (mass of) crucible and lid and contents (before heating) / FB 5 • (mass of) FB 5 • (mass of) crucible and lid and residue / contents (after heating) • (mass of) residue / contents (after heating) • (mass of) mass lost during heating / water Units: (g), / g, in grams	1
	II All weighings recorded to same number of decimal places and All calculations of mass correct and matching headings	1
	III Accuracy (Q) mark • Examiner must check and correct (if necessary) the masses of FB 5 used and of residue (smaller mass) obtained by supervisor and by candidate. • Calculate [(mass of FB 5) / (mass of residue)] for the supervisor to 2 dp • Write this ratio, in a ring, on the candidate script • Calculate [(mass of FB 5) / (mass of residue)] for the Candidate to 2 dp • Calculate d, the difference between these two ratios Award III if $d \leq 0.20$	1
2(b)	Correct calculation of moles of: anhydrous sodium carbonate (mass of residue / 106) and water (mass lost / 18)	1
	y found by calculation of moles of water / moles of sodium carbonate and answer expressed to nearest integer value or to 2–4 sf	1
2(c)	Heat to constant mass / use larger initial mass of FB 5 / use a balance that reads to more dp	1

Question	Answer	Marks
3	FB 6 is MnO_2 FB 7 is FeSO_4 FB 8 is NH_4Cl	
3(a)(i)	Test 1 Effervescence * (gas / O_2) relights a glowing splint *	1
	Test 2 Filtrate / solution is green * filtrate after addition of acid is purple / pink *	1
	Test 3 solution turns yellow / yellow-brown * + NaOH brown / red-brown ppt * fizzing (in either part) *	1
	Test 4 White ppt * insoluble in acid / no (visible) change *	1 1
	Test 5 Solid sublimes / white solid forms further up the test tube / solid disappears / white smoke / white fumes / no residue * Gas / NH_3 turns red litmus blue * (On further heating) gas turns blue litmus red *	1
	Test 6 White ppt * ppt dissolves *	1
3(a)(ii)	FB 6: unknown FB 7: SO_4^{2-} / sulfate FB 8: Cl^- / chloride All three correct: 2 marks any two correct: 1 mark	2

Question	Answer	Marks
3(b)	I Table or clear display of reagents, results and conclusions for minimum of 2 tests attempted	1
	II Correct results: FB 7: green ppt and ppt insoluble in excess / turning brown on standing	1
	III Heats FB 8 with NaOH and gas / NH ₃ turns (red) litmus blue	1
	IV FB 7 = Fe ²⁺ and FB 8 = NH ₄ ⁺	1
3(c)(i)	FB 7 acts as a reducing agent / FB 7 is oxidised and FB 7 / Fe ²⁺ is oxidised / changes to Fe ³⁺ / red-brown ppt shows Fe ³⁺ / red-brown ppt forms / H ₂ O ₂ is an oxidising agent / Fe ²⁺ – e [–] → Fe ³⁺ OR FB 7 acts as a catalyst and rate of decomposition increases	1
3(c)(ii)	Any one of: Ag ⁺ (aq) + Cl [–] (aq) → AgCl (s) Ba ²⁺ (aq) + SO ₄ ^{2–} (aq) → BaSO ₄ (s) Fe ³⁺ (aq) + 3OH [–] (aq) → Fe(OH) ₃ (s)	1