Cambridge Assessment International Education

Cambridge International AS & A Level

CHEMISTRY **9701/03**

Paper 3 **For examination from 2022**

MARK SCHEME

Maximum Mark: 40

Specimen

This document has **12** pages. Blank pages are indicated.

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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).

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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 (see examples below) 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.

Mark scheme abbreviations:

;	separates marking points
/	separates alternatives within a marking point
R	reject
I	ignore mark as if this material was not present
A	accept (a less than ideal answer which should be marked)
COND	indicates mark is conditional on previous marking point
OWTTE	or words to that effect (accept other ways of expressing the same idea)
AW	alternative wording (where responses vary more than usual)
underline	actual word given must be used by candidate (grammatical variants accepted)
max	indicates the maximum number of marks that can be awarded
ECF	credit a correct statement that follows a previous wrong answer
( )	the word / phrase in brackets is not required, but sets the context
ORA	or reverse argument

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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)	

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>1(a)</td><td>All thermometer readings recorded ;
All temperatures recorded to either .0 or to .5 °C (at least one must be .0 and at least one .5) ;
Do not award if any thermometer reading < 10.0 °C

Calculate ΔT for supervisor and for candidate.
ΔT = highest temperature (in the table) – temperature at t = 0.
Calculate the difference, δ, between supervisor and candidate values.
Award 1 mark for δ within range 1 of supervisor’s value ;
Award 1 mark for δ within range 2 of supervisor’s value ;
<table>
<tr><td>Supervisor’s ΔT / °C</td><td>$\geqslant$ 46.0</td><td>36.0–45.5</td><td>26.0–35.5</td><td>16.0–25.5</td><td>6.0–15.5</td><td>< 6.0</td></tr>
<tr><td>range 1</td><td>$\pm$5.0</td><td>$\pm$4.0</td><td>$\pm$3.0</td><td>$\pm$2.0</td><td>$\pm$1.0</td><td>$\pm$0.5</td></tr>
<tr><td>range 2</td><td>$\pm$2.5</td><td>$\pm$2.0</td><td>$\pm$1.5</td><td>$\pm$1.0</td><td>$\pm$0.5</td><td>–</td></tr>
</table>
</td><td>4</td></tr>
<tr><td>1(b)</td><td>Axes labelled unambiguously with uniform scales chosen to use more than half of each axis including 10 °C above the highest recorded temperature ;

All recorded points plotted:
• points that should be on a line must be on the line
• points that should be in a small square must be plotted to within the correct half of the small square ;

Appropriate lines of best fit drawn:
• best-fit lines must be straight (no change in gradient) or a smooth curve
• points not on the line must be balanced on either side of the best-fit line and any points ringed or labelled as anomalous ignored. ;

Lines extrapolated AND correct value of T read from the graph to within $\frac{1}{2}$ a small square AND ΔT correctly calculated ;
Do not award if the extrapolated value at 2 minutes is lower than the maximum temperature recorded in the table</td><td>4</td></tr>
<tr><td>1(c)(i)</td><td>Correctly calculates to 2 or more significant figures
$Q = 25 \times 4.2 \times \Delta T$ from (b)</td><td>1</td></tr>
<tr><td>1(c)(ii)</td><td>Correctly uses
ΔH = value of $\dfrac{\textbf{(c)(i)} \times 24.3}{0.19 \times 1000}$;
Negative sign AND answer to 2–4 sf ;</td><td>2</td></tr>
</table>

Question	Answer	Marks
1(d)	Student's prediction is incorrect **AND** as acid already in excess / moles of Mg is the same	**1**
1(e)	Any **one** from: • use lid or use specified extra insulation **AND** to reduce heat losses ; • use a pipette or burette for **FA 1 AND** to reduce percentage error / as more precisely calibrated (**OWTTE**) ; • use magnesium turnings / powder **AND** so reaction is complete sooner ; • use lid or plastic cup with higher walls **AND** to reduce acid spray ;	**1**

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Question	Answer	Marks
2(a)	Initial and final readings and titre recorded for rough titration **AND** burette readings for a minimum of two accurate titrations ; All **three** headings and units correct for accurate titrations Headings: initial (burette) **and** reading / volume / vol **AND** final (burette) **and** reading / volume / vol **AND** titre (allow volume / **FA 3 and** added / used) **AND** Units: (cm^3) **or** / cm^3 **or** in cm^3 (allow cm^3 by every entry) ; All accurate burette readings are recorded to the nearest 0.05 cm^3 (minimum 4 readings) ; The **final** accurate titre recorded is within 0.1(0) cm^3 of any other accurate titre. ; Do **not** award the mark if any 'accurate' burette readings (apart from initial 0) are given to **zero** dp. For awarding accuracy marks All burette readings should be rounded to the nearest 0.05 cm^3. Subtractions should be checked. The 'best' titres should be selected using the hierarchy: two (or more) identical; then two (or more) within 0.05 cm^3; then two (or more) within 0.10 cm^3 and so on until a mean titre can be calculated. The mean titre is calculated and this is then compared with the supervisor's mean titre. Award 1 mark for a difference, δ, from supervisor $0.30 < \delta \leqslant 0.50$ cm^3 ; Award 1 mark for a difference, δ, from supervisor $0.20 < \delta \leqslant 0.30$ cm^3 ; Award 1 mark for a difference, δ, from supervisor within $0.0 \leqslant \delta \leqslant 0.20$ cm^3 ; If there is only one accurate titration award accuracy marks based on that titration without further penalty. If titres selected differ $\geqslant$ 0.50 cm^3 then not all relevant accuracy marks can be accessed. If the supervisor titre is $\leqslant$ 10.00 cm^3 then halve the tolerances for award of accuracy marks (0.25, 0.15, 0.10 cm^3).	**7**
2(b)	Candidate must average two (or more) correctly subtracted 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 quoted to 2 dp rounded to the nearest 0.01. e.g. 26.667 must be rounded to 26.67 (Allow mean to 1 dp if all accurate burette readings were given to 1 dp and the mean is exactly correct) (Allow mean to 3 dp only for 0.025 or 0.075 e.g. 26.325 cm^3)	**1**

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Question	Answer	Marks
2(c)(i)	Answers to **(c)(ii)**, **(c)(iii)** and **(c)(iv)** correct to 3 or 4 sig figs.	**1**
2(c)(ii)	Correctly calculates moles of $Na_2CO_3 = \frac{1.25 \times 25}{106 \times 250} = 1.18 \times 10^{-3}$ or 1.179×10^{-3}	**1**
2(c)(iii)	Correctly uses concentration of HC*l* in **FA 3** = **(c)(ii)** × 2 × 1000 / **(b)**	**1**
2(c)(iv)	Correctly uses concentration of HC*l* in **FA 1** = **(c)(iii)** × 250 / 10	**1**
2(c)(v)	Correctly uses mol Mg = 0.19 / 24.3 = 7.82×10^{-3} **AND** mol HC*l* = **(c)(iv)** × 25 / 1000 **AND** mol HC*l* > 2 × mol Mg (**OWTTE**) so the statement is correct. Alternative valid methods of calculation are acceptable.	**1**

Question	Answer	Marks
3(a)	**FA 5** is $(NH_4)_2Fe(SO_4)_2(s)$, **FA 6** is $(NH_4)_2Fe(SO_4)_2(aq)$, **FA 7** is $NaNO_2(aq)$ Award 1 mark for any 2 correct observations. Award 2 marks for any 3 correct observations. Award 3 marks for any 4 correct observations. • green crystals at start ; • water droplets / steam / water vapour/ moisture or condensation ; • gas turns damp red litmus blue ; • white smoke (allow white fumes) ; • off-white / yellow / brown / black **AND** solid / residue (**not** precipitate) ; • solid (**not** crystalline) / powder formed ;	**3**

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>3(b)</td><td>Award 1 mark (max 7) for every two marking points (each marking point is indicated with an *).

<table>
<tr><th rowspan="2">test</th><th colspan="2">observations</th></tr>
<tr><th>FA 6</th><th>FA 7</th></tr>
<tr><td>+ NaOH</td><td>green ppt*
insoluble in excess / turning brown*</td><td>no reaction / no (visible) change / no ppt
AND</td></tr>
<tr><td>warm</td><td>gas / NH_3 AND turns (damp) red litmus blue*</td><td>no reaction / no gas turning red litmus blue / litmus stays red*</td></tr>
<tr><td>+ Al</td><td></td><td>effervescence / fizzing / bubbling*
gas / NH_3 AND turns (damp) red litmus blue*</td></tr>
<tr><td>+ MnO_4^-</td><td>purple decolourises / purple turns yellow*
(do not award if ppt reported)</td><td>purple decolourises / purple turns colourless*
(do not award if ppt reported)</td></tr>
<tr><td>+ H_2O_2</td><td>effervescence / fizzing / bubbling*
gas / O_2 AND relights a glowing splint / splint glows brighter*</td><td>no reaction / no (visible) change (not no ppt)*</td></tr>
<tr><td>after $\frac{1}{2}$ min</td><td>yellow solution (allow brown; do not allow orange)*
(allow in box above) (ignore slight cloudiness; do not allow ppt)</td><td>ignore any observation here</td></tr>
<tr><td>+ Ba^{2+}</td><td>white ppt*</td><td>no reaction / no (visible) change / no ppt*</td></tr>
<tr><td>+ H^+</td><td>ppt insoluble*
(allow no change / no reaction)</td><td>ignore any observation here</td></tr>
</table>
</td><td>7</td></tr>
<tr><td>3(c)</td><td>Award 1 mark if 2 boxes are correct.
Award 2 marks if 3 boxes are correct.
Award 3 marks if 4 boxes are correct.

<table>
<tr><td></td><td>cations</td><td>anions</td></tr>
<tr><td>FA 6</td><td>NH_4^+; Fe^{2+}</td><td>SO_4^{2-}</td></tr>
<tr><td>FA 7</td><td>unknown</td><td>NO_2^-</td></tr>
</table>
</td><td>3</td></tr>
</table>

Question	Answer	Marks
3(d)	Correctly balanced ionic equation with correct state symbols $Fe^{2+}(aq) + 2OH^{-}(aq) \rightarrow Fe(OH)_2(s)$ **OR** $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$	**1**

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