CAMBRIDGE
International Education

Cambridge International AS & A Level

CHEMISTRY **9701/22**

Paper 2 AS Level Structured Questions **May/June 2025**

MARK SCHEME

Maximum Mark: 60

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 May/June 2025 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

PUBLISHED

Generic Marking Principles

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

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

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

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

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.

Annotations guidance for centres

Examiners use a system of annotations as a shorthand for communicating their marking decisions to one another. Examiners are trained during the standardisation process on how and when to use annotations. The purpose of annotations is to inform the standardisation and monitoring processes and guide the supervising examiners when they are checking the work of examiners within their team. The meaning of annotations and how they are used is specific to each component and is understood by all examiners who mark the component.

We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of the quality of the response.

The annotations listed below were available to examiners marking this component in this series.

Annotations

Annotation	Meaning
	Correct point **or** mark awarded
	Incorrect point **or** mark not awarded
	Unclear
	Information missing or insufficient for credit
	Benefit of the doubt given
	Contradiction in response otherwise markworthy, mark not given
	Part of the correct answer has been seen. Full credit has not been awarded.
	Error carried forward applied
	Incorrect or insufficient point ignored while marking the rest of the response
	Benefit of the doubt not applied in this instance

Annotation	Meaning
RE	Rounding error
REP	Repetition
SEEN	Blank page **or** part of script seen
SF	Error in number of significant figures
TE	Transcription error

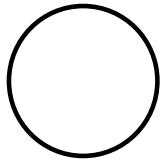
<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>1(a)(i)</td><td>(both) giant molecular</td><td>1</td></tr>
<tr><td>1(a)(ii)</td><td>delocalised electrons move through the structure
OR delocalised electrons move through / between the layers</td><td>1</td></tr>
<tr><td>1(a)(iii)</td><td>no delocalised electrons (to carry charge through the structure)
OR <u>all</u> (4) outer electrons are used in bonding</td><td>1</td></tr>
<tr><td rowspan="2">1(b)(i)</td><td>$PCl_5 + 4H_2O \rightarrow H_3PO_4 + 5HCl$</td><td>1</td></tr>
<tr><td>$SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl$</td><td>1</td></tr>
<tr><td>1(b)(ii)</td><td>M1 phosphorus(V) chloride white / yellow solid

M2 silicon(IV) chloride colourless liquid</td><td>2</td></tr>
<tr><td>1(b)(iii)</td><td>M1 (phosphorus(V) chloride) produces colourless solution

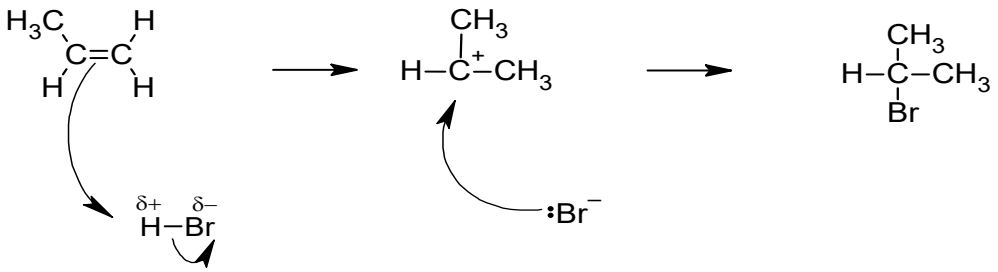
M2 silicon(IV) chloride produces white suspension / white precipitate (in a colorless liquid / mixture / solution)</td><td>2</td></tr>
<tr><td>1(c)(i)</td><td>species behaves as acid and base
OR species reacts with (both) acid and base</td><td>1</td></tr>
<tr><td>1(c)(ii)</td><td>Al_2O_3</td><td>1</td></tr>
<tr><td>1(d)(i)</td><td>
<table>
<tr><td>SO_2</td><td>–73</td><td>pd</td></tr>
<tr><td>H_2O</td><td>0</td><td>H</td></tr>
<tr><td>SiO_2</td><td>1600</td><td>C</td></tr>
<tr><td>Na_2O</td><td>1132</td><td>I</td></tr>
<tr><td>MgO</td><td>2852</td><td>I</td></tr>
</table>
</td><td>3</td></tr>
</table>

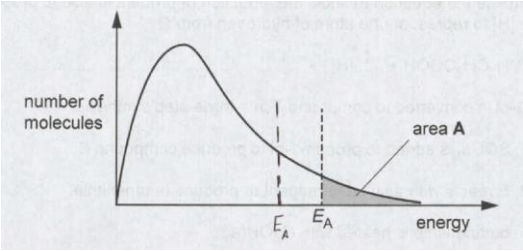
Question	Answer	Marks
1(d)(ii)	*Evaluate hypotheses based on the information candidates have given in the table* **M1** not enough information **M2** SO_2 and / or H_2O break intermolecular forces **OR** SO_2 and / or H_2O does not break covalent bonds **OR** only SiO_2 breaks covalent bonds	**2**

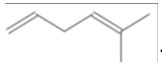
Question	Answer	Marks
2(a)(i)	**route 1** **M1** average (weighted) mass of (an) atom(s) (of an element) **OR** average (weighted) mass of the isotope(s) (of an element) **M2** compared to the mass of the unified atomic mass unit **OR** on a scale in which a carbon-12 atom / isotope has a mass of exactly 12 (units) **OR** on a scale in which the mass of a carbon-12 atom/isotope is exactly 12 (units) **OR** compared to $\frac{1}{12}$ mass of one atom of C-12 **route 2** **M1** average mass of one mol of isotopes / atoms (of an element) **M2** relative / compared to $\frac{1}{12}$ of the mass of one mol of C-12 atoms/isotopes **OR** when the mass of one mol C-12 atoms / isotopes is exactly 12 (000) g	**2**
2(a)(ii)	**M1** relative abundance of unknown isotope = (100 – 91.9 – 6.0) = 2.1% **M2** $55.8 = (53.9 \times 6.0 + 55.9 \times 91.9 + ? \times M1) / 100 = 56.9$	**2**
2(b)	1 (pair)	**1**

Question	Answer	Marks
2(c)		**1**
2(d)	<table><tr><td>species present in an ion of 56-Fe^{3+}</td><td>number</td></tr><tr><td>electrons</td><td>**M1** 23</td></tr><tr><td>**M2** neutrons</td><td>30</td></tr></table>	**2**
2(e)	**M1** smaller / decreases **M2** loss of outer / valence shell (of electrons) **OR** loss of electrons so increase in (force of) attraction from nucleus **OR** loss of electrons so increase nuclear attraction	**2**

Question	Answer	Marks
3(a)(i)	two (or more) reactants / molecules react to make (only) one product	**1**

Question	Answer	Marks
3(a)(ii)	 **M1** curly arrow from = of C=C to H (of HBr) **M2** curly arrow from bond of $H^{\delta+}$—$Br^{\delta-}$ to $Br^{\delta-}$ (dipole is essential) **M3** correct intermediate **M4** curly arrow from lone pair of Br^- to C^+ of intermediate drawn	**4**
3(a)(iii)	**M1**(2-bromopropane is made from the) more stable intermediate / carbocation **M2** (due to positive) inductive effect of more alkyl groups (attached to the C^+ / central carbon atom) **OR** (due to) greater (positive) inductive effect of 2 methyl groups (rather than 1 ethyl group)	**2**
3(b)(i)	H_2 / hydrogen **AND** some X / alkene left(over) / remains (at the end of this reaction)	**1**
3(b)(ii)	*link the significance of gradient values to rate **AND** describe either the decrease in rate or the decrease in gradient* as the gradient decreases the rate decreases **OR** rate decreases until the reaction stops when gradient = 0	**1**

Question	Answer	Marks
3(c)	**method 1** – breaking all bonds in molecules $(2 \times 610) + (2 \times 436) + (10 \times 410) + (3 \times 350) – (14 \times 410) – (5 \times 350)$ • energy involved when all bonds are broken = (7242) • energy involved when all bonds are made = (7490) • energy to break bonds – energy to make bonds = (7242 – 7490) = –248 **method 2** – ignore any bonds that do not change from reactants to products $(2 \times 610) + (2 \times 436) – (4 \times 410) – (2 \times 350)$ • energy involved when all bonds are broken = (2092) • energy involved when all bonds are made = (2340) • energy to break bonds – energy to make bonds (2092 – 2340) = –248	**2**
3(d)(i)	E_A shown on Fig. 3.3 to the left of original (on the x axis)  	**1**

Question	Answer	Marks
3(d)(ii)	**M1** it / (area) **B** larger **AND** rate (reaction / hydrogenation) increases **OR** (area) **B** identified by shading or labelling on Fig 3.3 **AND** rate (reaction / hydrogenation) increases in prose **M2** increase in the frequency of effective / successful collisions **OR** increase in rate of effective / successful collisions	**2**
3(e)	$H_2C{=}CHCH_2CH{=}C(CH_3)_2$ ✓✓  ✓✓ $H_2CCHCH_2CHC(CH_3)_2$ ✓✓ **M1** $H_2C{=}C\ldots$ on one end of their molecule **OR** …$C{=}C(CH_3)_2$ on one end of their molecule **OR** …$C{=}CHCH_2CH{=}C$… in the middle of their molecule **M2** correct structure	**2**

Question	Answer	Marks
4(a)(i)	$LiAlH_4$	**1**
4(a)(ii)	$CH_3CH_2CO_2H + 4[H] \rightarrow CH_3CH_2CH_2OH + H_2O$	**1**
4(b)(i)	substitution	**1**
4(b)(ii)	KCN / potassium cyanide in ethanol / C_2H_5OH **AND** heat	**1**
4(b)(iii)	$CH_3CH_2CH_2CN + NaOH + H_2O \rightarrow CH_3CH_2CH_2CO_2Na + NH_3$ **OR** $CH_3CH_2CH_2CN + NaOH + 2H_2O \rightarrow CH_3CH_2CH_2CO_2Na + NH_4OH$ **M1** correct organic product (as molecule or anion) **M2** rest of equation is correct	**2**
4(b)(iv)	(alkaline) hydrolysis	**1**
4(c)(i)	sp^3	**1**

Question	Answer	Marks
4(c)(ii)	hydrogen / H_2	**1**
4(c)(iii)	(It / Na) reduces **A** / **B** / **C** / the alcohol (group) **OR** (it / Na behaves as) reducing agent **OR** (it / Na) donates electrons to **A** / **B** / **C** / the alcohol (group)	**1**
4(d)(i)	$(CH_3)_3COH$	**1**
4(d)(ii)	butan-1-ol **OR** (2) methylpropan-1-ol	**1**
4(d)(iii)	butan-2-ol **OR** $CH_3CH_2CH(OH)CH_3$.	**1**

Question	Answer	Marks
5(a)	$C_3H_4O_3$	**1**
5(b)(i)	$5.00 \times 10^{-3} \times 36.65 / 1000$ $= 1.833 \times 10^{-4} / 1.8325 \times 10^{-4}$	**1**
5(b)(ii)	**M1** expression and / or correct calculation to show how the amount of vitamin C in 150 g of lemon peel is calculated 1.8325×10^{-4} mol $\times 176 \times 4$ **M2** correct calculation based on (**M1** / 150) $\times$ 100 = 0.086(%) Using 1.8325×10^{-4} for **M1**, **M2** = 0.086 **OR** 0.087(%) Alternative answer using 7.65×10^{-4}: **M1** $7.65 \times 10^{-4} \times 176 \times 4 = 0.5386 / 0.539$ **M2** correct calculation based on (**M1** / 150) $\times$ 100 = 0.359 / 0.36 (%)	**2**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>5(b)(iii)</td><td>
<table>
<tr><th>absorption / cm^{-1}</th><th>present in spectrum of vitamin C</th><th>present in spectrum of M</th></tr>
<tr><td>1500–1680</td><td>✓</td><td>× / – / blank</td></tr>
<tr><td>2850–2950</td><td>✓</td><td>✓</td></tr>
<tr><td>3200–3650</td><td>✓</td><td>✓</td></tr>
</table>
</td><td>1</td></tr>
</table>