CAMBRIDGE
International Education

Cambridge International AS & A Level

CHEMISTRY **9701/41**

Paper 4 A Level Structured Questions **May/June 2025**

MARK SCHEME

Maximum Mark: 100

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

Question	Answer	Marks
1(a)	$CaCO_3 \rightarrow CaO + CO_2$ [1]	**1**
1(b)	**M1:** calcium carbonate **AND** calcium ion / Ca^{2+} smaller / ionic radius bigger down group **M2:** carbonate ion / anion / CO_3^{2-} is more distorted/polarised by Ca^{2+}	**2**
1(c)(i)	calcium hydroxide / $Ca(OH)_2$	**1**
1(c)(ii)	**M1: A** / calcium hydroxide has more exothermic ΔH_{latt} **AND** ΔH_{hyd} than **B** / barium hydroxide **M2:** difference in ΔH_{latt} is greater for **A /** calcium hydroxide than for **B** / barium hydroxide **M3:** ΔH_{sol} is less exothermic for **A /** calcium hydroxide than for **B** / barium hydroxide	**3**

Question	Answer	Marks
2(a)(i)	$mol^{-2}\,dm^6\,s^{-1}$	**1**
2(a)(ii)	**M1:** $2.57 \times 10^{-6} = 26.4 \times [\text{concentration}]^3$ **M2:** $[\text{concentration}] = 4.60 \times 10^{-3}$	**2**
2(a)(iii)	2.57×10^{-3}	**1**
2(b)(i)	overall 1st order / pseudo 1st order **OR** 1st order with respect to Cl_2 **AND** concentration of NO doesn't change	**1**
2(b)(ii)	ln2 / 105.6 or 0.693 / 105.6	**1**
2(b)(iii)	0.0262 / 2.62×10^{-2}	**1**

Question	Answer	Marks
2(c)	**M1:** homogeneous catalyst **OR** catalyst because it is regenerated **M2:** $2NO + O_2 \rightarrow 2NO_2$ **M3:** $NO_2 + SO_2 \rightarrow NO + SO_3$	**3**

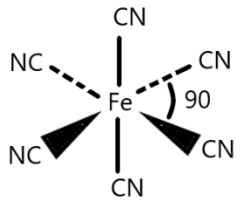
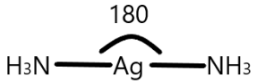
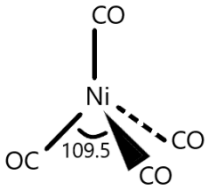
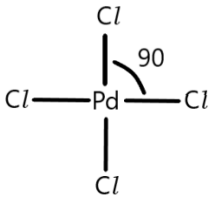
Question	Answer	Marks
3(a)(i)	**M1:** $K_{sp} = [Cr^{3+}][OH^-]^3$ **M2:** $mol^4\ dm^{-12}$	**2**
3(a)(ii)	**M1:** $[OH^-] = 3[Cr^{3+}]$ **M2:** $2.47 \times 10^{-9}\ mol\ dm^{-3}$ **M3:** $2.54 \times 10^{-7}\ g\ dm^{-3}$	**3**
3(a)(iii)	common ion effect	**1**
3(b)(i)	**M1:** $[H^+] = 1.23 \times 10^{-3}$ **M2:** pH = 2.91	**2**
3(b)(ii)	13.0	**1**
3(b)(iii)	**M1:** $[CH_3CH_2CH_2COOH] = [CH_3CH_2CH_2COO^-]$ **M2:** pH = 4.82	**2**
3(c)	**M1:** 0.148 g is left in water **M2:** K_{pc} = 3.01 **OR** 0.333	**2**

Question	Answer	Marks
4(a)(i)	energy change when one mole of gaseous ions dissolves in water	1
4(a)(ii)	**M1:** K^+ has larger radius **AND** K^+ has smaller charge **M2:** Ca^{2+} has larger attraction for H_2O	2
4(a)(iii)	energy change when one mole of **ionic** solid forms from gaseous ions	1
4(a)(iv)	**M1:** $-1650-(2 \times 506) + 2602$ **M2:** –60	2
4(b)	**M1:** $\Delta G = \Delta H - T\Delta S$ **AND** T = 298 **M2:** –174.5 [1]	2

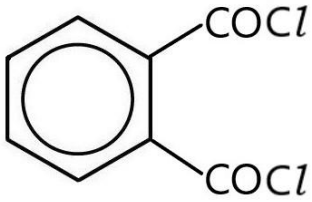
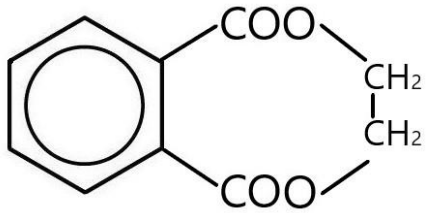
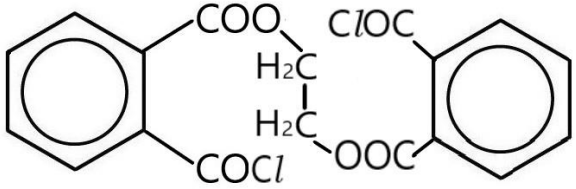
Question	Answer	Marks
5(a)(i)	(Ar) $3d^{10}$ **AND** (Ar) $3d^9$	1
5(a)(ii)	similar energy of 3d and 4s subshells	1
5(b)(i)	pale blue precipitate	1
5(b)(ii)	$[Cu(H_2O)_6]^{2+} + 2OH^- \rightarrow Cu(OH)_2(H_2O)_4 + 2H_2O$	1
5(c)(i)	deep blue solution	1
5(c)(ii)	$[Cu(H_2O)_6]^{2+} + 4NH_3 \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+} + 4H_2O$	1
5(c)(iii)	ligand exchange	1
5(d)(i)	**M1:** $E = E^{\ominus} + (0.059 / z) \log(ox/red)$ **M2:** $E = 1.52 + (0.059 / 5) \times \log (0.002)$	2

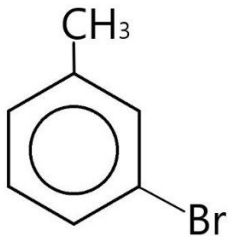
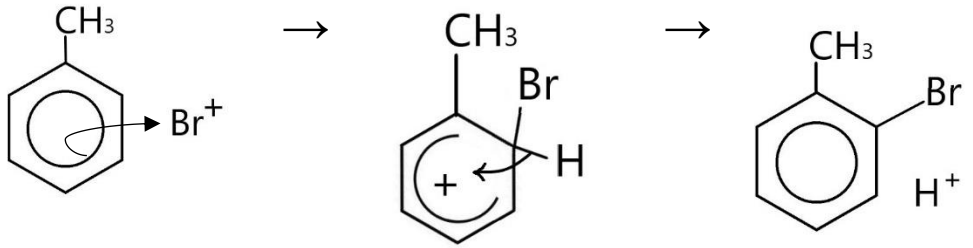
Question	Answer	Marks
5(d)(ii)	1.15	**1**
5(d)(iii)	$5Cu + 2MnO_4^- + 16H^+ \rightarrow 5Cu^{2+} + 2Mn^{2+} + 8H_2O$	**1**
5(d)(iv)	Cu^{2+} / Cu, Cu^{2+} / Cu, MnO_4^- / Mn^{2+} / platinum	**1**
5(e)	**M1:** moles of copper = 0.0120 mol **M2:** coulombs required = 2322 C **M3:** current required = 0.129 A	**3**

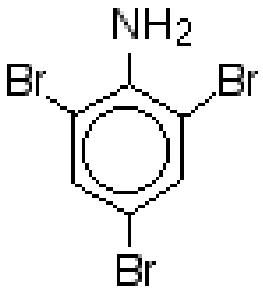
Question	Answer	Marks
6(a)(i)	$[Fe(CN)_6]^{3-}$ **AND** $[Fe(CN)_6]^{4-}$	**1**
6(a)(ii)	**M1:** different ΔE **M2:** absorption of different frequency of visible light **OR** wavelength of visible light	**2**
6(a)(iii)	dative covalent / coordinate	**1**

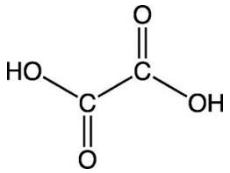
Question	Answer	Marks
6(b)	    Each correct structure = [1]	**4**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>7(a)</td><td>1,3-diethylbenzene</td><td>1</td></tr>
<tr><td>7(b)(i)</td><td>$CDCl_3$</td><td>1</td></tr>
<tr><td>7(b)(ii)</td><td>no difference AND no H that can be exchanged with D</td><td>1</td></tr>
<tr><td>7(b)(iii)</td><td>
<table>
<tr><th>δ / ppm</th><th>number of protons</th><th>group responsible</th><th>name of splitting pattern</th></tr>
<tr><td>1.3</td><td>6</td><td>CH_3</td><td>triplet</td></tr>
<tr><td>2.7</td><td>4</td><td>CH_2</td><td>quartet / quadruplet</td></tr>
<tr><td>7.1</td><td>4</td><td></td><td></td></tr>
</table>
Each correct column = [1]
</td><td>3</td></tr>
<tr><td>7(b)(iv)</td><td>5 AND 6</td><td>1</td></tr>
<tr><td>7(c)(i)</td><td>$C_{10}H_{14} + 12[O] \rightarrow C_8H_6O_4 + 2CO_2 + 4H_2O$</td><td>1</td></tr>
</table>

Question	Answer	Marks
7(c)(ii)	compound **G**  compound **J**  compound **K**  Each correct structure = [1]	**3**

Question	Answer	Marks
8(a)(i)	$Br_2 + AlBr_3 \rightarrow Br^+ + AlBr_4^-$	**1**
8(a)(ii)	 • reference to methyl group having an effect • methyl group is 2,4,6 directing Correct structure and one correct point [1] correct structure and two correct points [2]	**2**
8(a)(iii)	 **M1:** first curly arrow from inside hexagon towards Br^+ **M2:** correct intermediate **M3:** second curly arrow from bond into hexagon **AND** organic product, H^+	**3**
8(b)(i)	chlorobutane **AND** white precipitate	**1**
8(b)(ii)	**M1:** $C_4H_9Cl + H_2O \rightarrow C_4H_9OH + H^+ + Cl^-$ **M2:** $Cl^- + Ag^+ \rightarrow AgCl$ [1]	**2**

Question	Answer	Marks
8(b)(iii)	**M1:** delocalisation of lone pair of C*l* into benzene ring / π system **M2:** strengthens C–C*l* bond / causes C–C*l* bond to have partial double bond nature	**2**
9(a)(i)	• nitrobenzene / $C_6H_5NO_2$ • Sn and HC*l* • concentrated HC*l* and heat / boil / reflux Two correct point [1] all three correct points [2]	**2**
9(a)(ii)	**M1:** propylamide / propenamide / $C_2H_5CONH_2$ **OR** propanenitrile / C_2H_5CN **M2:** Li*A*lH_4	**2**
9(a)(iii)	**M1:** bromine (aq) **AND** phenylamine / $C_6H_5NH_2$  **M2:** correct structure	**2**
9(b)	**M1:** phenylamine ammonia propylamine **M2:** a base has a lone pair that can accept a proton / H^+ **M3:** the lone pair on the nitrogen atom of phenylamine is delocalised into the benzene ring / π-system **M4:** propylamine has an electron donating alkyl group	**4**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>10(a)</td><td>  </td><td>1</td></tr>
<tr><td>10(b)</td><td>M1: reagent 1:Fehling’s OR Tollens’ reagent

M2: acidified MnO_4^-

<table>
<tr><th></th><th>observation when treated with reagent 1</th><th>observation when treated with reagent 2</th></tr>
<tr><td>propanoic acid</td><td>no change</td><td>no change</td></tr>
<tr><td>methanoic acid</td><td>red ppt OR silver mirror</td><td>colourless</td></tr>
<tr><td>ethanedioic acid</td><td>no change</td><td>colourless</td></tr>
</table>
M3 / M4: One completely correct column [1] both completely correct columns [2]</td><td>4</td></tr>
<tr><td>10(c)</td><td>M1: chlorine atoms are electron withdrawing / electronegative

M2: weakening O–H bond OR stabilising conjugate base</td><td>2</td></tr>
</table>