CAMBRIDGE
International Education

Cambridge International AS & A Level

CHEMISTRY **9701/42**

Paper 4 A Level Structured Questions **October/November 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 October/November 2025 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

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	<u>'List rule' guidance</u> 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
BOD	Benefit of the doubt given
CON	Contradiction in response otherwise markworthy, mark not given
●	Part of the correct answer has been seen. Full credit has not been awarded.
ECF	Error carried forward applied
I	Incorrect or insufficient point ignored while marking the rest of the response
RE	Rounding error

Annotation	Meaning
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)	$Mg(NO_3)_2 \rightarrow MgO + 2NO_2 + ½O_2$ **OR** $2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$	**1**
1(b)	**M1:** $Mg(NO_3)_2$ / magnesium nitrate **AND** magnesium ion / Mg^{2+} **AND** is smaller / has higher charge density **M2:** nitrate ion / anion is more distorted / polarised	**2**
1(c)(i)	magnesium sulfate and water / $MgSO_4$ and H_2O	**1**
1(c)(ii)	**M1:** magnesium sulfate / **A** has a more exothermic ΔH_{latt} and ΔH_{hyd} **M2:** difference in ΔH_{hyd} is greater **M3:** magnesium sulfate / **A** has a more exothermic ΔH_{sol}	**3**

Question	Answer	Marks
2(a)(i)	homolytic fission	**1**
2(a)(ii)		**1**
2(a)(iii)	115–120°	**1**
2(b)	**M1:** 3.825×10^{-3} / 0.003825 / 0.00383 / 0.0038 / 3.8×10^{-3} **M2:** units = $mol^{-1}\,dm^3\,s^{-1}$	**2**
2(c)	not constant half-life because overall second order	**1**

Question	Answer	Marks
2(d)	8.17 / 8.2	**1**
2(e)	• reactants are adsorbed onto the catalyst surface • bonds within reactant molecules are weakened • products are desorbed from catalyst surface Any two [1], all three [2]	**2**

Question	Answer	Marks
3(a)(i)	two species that differ by one proton / H^+	**1**
3(a)(ii)	$H_2PO_4^-$ **AND** PO_4^{3-}	**1**
3(b)(i)	**M1:** $[H^+] = 2.51 \times 10^{-4}$ **M2:** $[CH_3CH_2COOH] = 4.67 \times 10^{-3}$	**2**
3(b)(ii)	3.98×10^{-11}	**1**
3(b)(iii)	$[HCl] = 2.51 \times 10^{-4}$	**1**
3(b)(iv)	**M1:** top box ticked **AND** weaker acid **M2:** alkyl group is electron donating **M3:** O–H bond strengthened / anion is destabilised	**3**
3(c)(i)	NaOH **AND** $CH_3CH_2COOH + OH^- \rightarrow CH_3CH_2COO^- + H_2O$	**1**
3(c)(ii)	H_2SO_4 **AND** conjugate base of CH_3CH_2COOH is not present	**1**
3(d)(i)	3.69×10^{-5}	**1**

Question	Answer	Marks
3(d)(ii)	**M1:** $K_{sp} = [Mn^{2+}][OH^-]^2$ **M2:** units = $mol^3\ dm^{-9}$	**2**
3(d)(iii)	2.0×10^{-13}	**1**

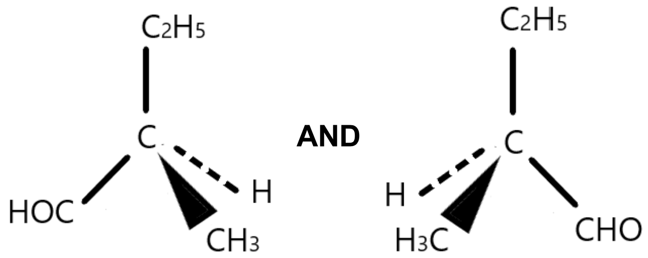
Question	Answer	Marks
4(a)	energy required when one mole of gaseous atoms is formed from the element	**1**
4(b)	energy released when one mole of gaseous atoms gains one mole of electrons and becomes one mole of gaseous 1⁻ ions	**1**
4(c)	**M1:** iodine atom has greater radius **M2:** less attraction between nucleus and incoming electron in iodine	**2**
4(d)	**M1:** ½ (–486 + (2 × 364)) **M2:** +121	**2**

Question	Answer	Marks
5(a)(i)	Co^{2+} = [Ar] $3d^7$ **AND** Co^{3+} = [Ar] $3d^6$	**1**
5(a)(ii)	has vacant d orbitals that are energetically accessible	**1**
5(a)(iii)	• pink • blue • aqueous Any two [1], all three [2]	**2**
5(a)(iv)	$[Co(H_2O)_6]^{2+} + 4HCl \rightarrow [CoCl_4]^{2-} + 6H_2O + 4H^+$ **OR** $[Co(H_2O)_6]^{2+} + 4Cl^- \rightarrow [CoCl_4]^{2-} + 6H_2O$	**1**

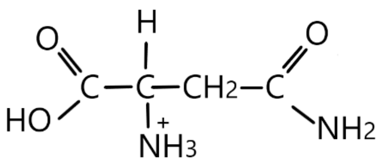
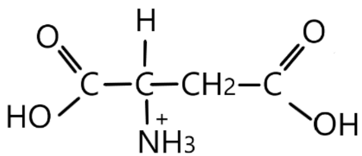
Question	Answer	Marks
5(a)(v)	ligand exchange	**1**
5(a)(vi)	$[Co(H_2O)_6]^{2+} + 2OH^- \rightarrow Co(OH)_2(H_2O)_4 + 2H_2O$ **OR** $[Co(H_2O)_6]^{2+} + 2OH^- \rightarrow Co(OH)_2 + 6H_2O$	**1**
5(b)(i)	**M1:** Nernst equation $E = E^{\ominus} + (0.059 / z) \times \log(\frac{[\text{oxidised}]}{[\text{reduced}]})$ **M2:** E = –0.28 + (0.059 / 2) × log(0.02)	**2**
5(b)(ii)	1.66 V	**1**
5(b)(iii)	$3Co + Cr_2O_7^{2-} + 14H^+ \rightarrow 3Co^{2+} + 2Cr^{3+} + 7H_2O$	**1**
5(b)(iv)	Co^{2+} / Co, Co^{2+}/ Co, $Cr_2O_7^{2-}$/ Cr^{3+}	**1**
5(c)	**M1:** moles of cobalt = 0.547 / 58.9 = 0.00929 **M2:** coulombs required = 0.00929 × 96500 × 2 = 1792 **M3:** time required = 1792 / 0.50 = 3584.8 s = 59.7 minutes 3sf	**3**

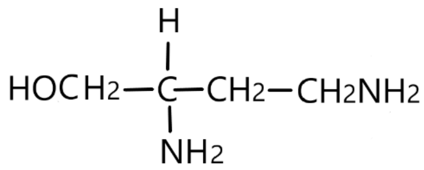
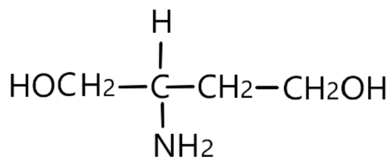
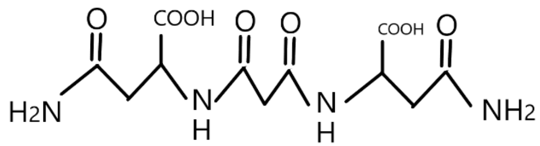
Question	Answer	Marks
6(a)(i)	$Ni(CO)_4$	**1**
6(a)(ii)	• ethanedioate given as C_2O_4 • formula shows one Ni and three ligands • charge = 4⁻ any two [1], all three [2] $Ni(C_2O_4)_3^{4-}$ scores [2]	**2**

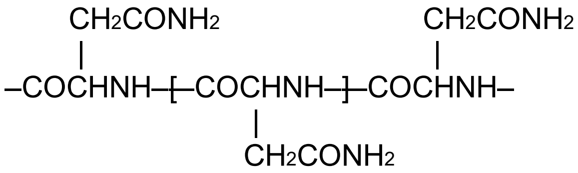
Question	Answer	Marks
6(a)(iii)	**F AND** optical	1
6(b)(i)	N atom can donate one lone pair of electrons	1
6(b)(ii)	$[Cd(en)_2]^{2+}$ **AND** has a larger K_{stab} / is more stable	1
6(b)(iii)	$\frac{[[Cd(CH_3NH_2)_4]^{2+}]}{[Cd^{2+}][CH_3NH_2]^4}$	1

Question	Answer	Marks
7(a)	**M1**: **Q** $CH_3CH_2CH(CH_3)CHO$ **M2:** 	2
7(b)(i)	**T** $CH_3CH_2CH_2COCH_3$ **AND V** $(CH_3)_2CHCOCH_3$	1
7(b)(ii)	• yellow solid • $CH_3CH_2CH_2COOH$ **OR** $(CH_3)_2CHCOOH$ • CHI_3 Any two [1], all three [2]	2
7(c)(i)	**S** $(CH_3)_3CCHO$	1

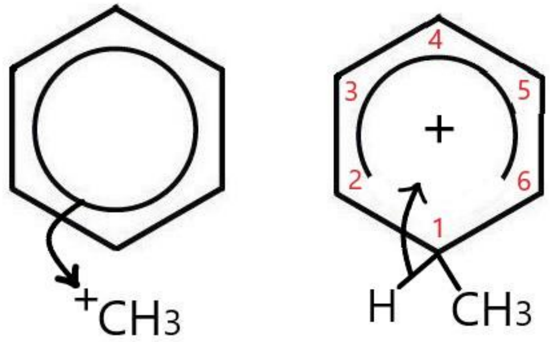
Question	Answer	Marks
7(c)(ii)	**U** $CH_3CH_2COCH_2CH_3$	**1**
7(c)(iii)	triplet **AND** two hydrogen atoms on neighbouring carbon atoms	**1**
7(c)(iv)	TMS / tetramethylsilane / $Si(CH_3)_4$	**1**
7(d)	4 3 5 3 Any two [1], all four [2]	**2**

Question	Answer	Marks
8(a)	the pH at which an amino acid exists as a zwitterion	**1**
8(b)	**M1:** $[HOOCCH(NH_3)CH_2CONH_2]^+$ **M2:** $[HOOCCH(NH_3)CH_2COOH]^+$ 	**2**

Question	Answer	Marks
8(c)	**M1:** $HOCH_2CH(NH_2)CH_2CH_2NH_2$ **M2:** $HOCH_2CH(NH_2)CH_2CH_2OH$  	**2**
8(d)(i)	$HOOCCH_2COOH + 2SOCl_2 \rightarrow ClOCCH_2COCl + 2SO_2 + 2HCl$ [1]	**1**
8(d)(ii)	$HOOCCH(CH_2CONH_2)NHCOCH_2CONHCH(CH_2CONH_2)COOH$ **M1:** three molecules joined, with four correct amide groups only **M2:** whole structure correct as above, displayed formula accepted, skeletal formula as below accepted 	**2**
8(e)	**M1:** hydrolysis of amide to carboxylate ion **M2:** hydrolysis of –COOH to carboxylate ion and rest of molecule $^{-}OOCCH(NH_2)CH_2COO^{-}$	**2**

Question	Answer	Marks
8(f)	• three monomer residues • all linkages correct • correct trailing bonds • repeat unit marked contains correct atoms Any two [1], any three [2], all four [3] 	**3**
8(g)(i)	• rotate the plane of the plane polarised light • by the same angle • in opposite directions Any two [1], all three [2]	**2**
8(g)(ii)	racemic mixture	**1**

Question	Answer	Marks
9(a)	• all C atoms are sp^2 hybridised • bonds between C atoms are σ and π • C–C σ bonds are formed by overlap of sp^2 hybrid orbitals • C–C π bonds are formed by overlap of p orbitals • bonds between C and H atoms are σ • C–H bonds are formed by overlap of sp^2 hybrid orbitals and s orbitals Any two [1], any four [2], all six [3]	**3**

Question	Answer	Marks
9(b)	CH_3Cl and $AlCl_3$	1
9(c)	 **M1:** curly arrow from within hexagon towards ^+C **M2:** intermediate, usual rules for horseshoe and + charge **M3:** curly arrow from C–H bond into ring **AND** H^+ product	3
9(d)	**M1:** HNO_3 **AND** H_2SO_4 **M2:** concentrated **AND** 25 °C $\leqslant$ T $\leqslant$ 60 °C	2
9(e)	alkaline $KMnO_4$	1
9(f)	4-nitrobenzoic acid	1
9(g)	(hot) concentrated HCl and Sn	1
9(h)	**M1:** perform step 3 before step 2 **OR** perform step 2 before step 1 **M2:** COOH is 3-directing **OR** NO_2 is 3-directing	2