CAMBRIDGE
International Education

Cambridge International AS & A Level

CHEMISTRY **9701/44**

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.

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	<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 standard isation 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.

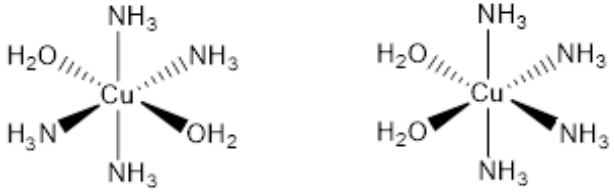
We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of 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
	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)	forms (one or more) stable ions / compounds / oxidation states with incomplete / partially filled (3)d orbital(s) / d shell / d sub-shell	**1**
1(b)(i)	(orbitals) are at the same energy	**1**
1(b)(ii)	$(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^9$	**1**
1(c)(i)	$[Cu(NH_3)_4(H_2O)_2]^{2+}(aq)$ deep / dark / royal blue **AND** $[CuCl_4]^{2-}(aq)$ yellow	**1**
1(c)(ii)	**M1:** d orbital(s) of different energy / d-d splitting occurs / d sub-shell splits **M2:** electron(s) promoted / excited **M3:** light / wavelength / frequency / photon absorbed **AND** complementary colour seen	**3**
1(d)(i)	**M1:** ligand exchange / replacement / substitution / displacement **M2:** $[CuCl_4]^{2-} + 4NH_3 + 2H_2O \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+} + 4Cl^-$	**2**
1(d)(ii)	**M1:** one correct 3D structure of $[Cu(H_2O)_2(NH_3)_4]^{2+}$ **M2:** correct 3D stereoisomer structure of isomer 1 	**2**
1(d)(iii)	cis isomer **AND** dipoles do not cancel	**1**
1(e)(i)	(two) oxygen and (one) nitrogen (can donate) three lone pair(s) of electrons (to the metal ion)	**1**

Question	Answer	Marks
1(e)(ii)	$[Co(C_4H_5NO_4)_2]^-$	**1**
1(f)(i)	equilibrium constant for the formation of the complex (ion) in a solvent / water / solution **OR** from its constituent ions or molecules	**1**
1(f)(ii)	$[Ag(CN)_2]^-$(aq) **AND** largest (value of) K_{stab}	**1**
1(g)	**M1 M2:** any two [1], all four [2] • moles MnO_4^- = 0.015 ×18.70/1000 = 2.805×10^{-4} • moles SO_3^{2-} = 2.805×10^{-4} × 5/2 = 7.0125×10^{-4} (in 10 cm^3) • moles SO_3^{2-} = 1.753×10^{-2} (in 250 cm^3) • mass Na_2SO_3 = 1.753×10^{-2} × 126.1 = 2.21 g **M3:** % purity = 100 × 2.21 / 3.75 = **58.9 – 59.0 %** min 2sf	**3**

Question	Answer	Marks
2(a)	**M1:** (solubility) decreases down the group **M2:** ΔH_{latt} and ΔH_{hyd} decrease / become less exothermic / less negative **M3:** ΔH_{hyd} decreases / changes more **/** dominant factor / becomes less exothermic by a larger extent **OR** ΔH_{latt} decreases / changes less / changes slower **M4:** ΔH_{sol} becomes less exothermic / less negative **OR** ΔH_{sol} becomes (more) endothermic / (more) positive	**4**
2(b)(i)	$Ag_2CrO_4(s) \rightleftharpoons 2Ag^+(aq) + CrO_4^{2-}(aq)$	**1**
2(b)(ii)	**M1:** $K_{sp} = [Ag^+]^2 [CrO_4^{2-}]$ **M2:** $\sqrt[3]{(1.12 \times 10^{-12} \div 4)} = 6.54 \times 10^{-5}$ **M3:** $[Ag^+] = 2 \times 6.54 \times 10^{-5} = 1.31 \times 10^{-4}$ (mol dm^{-3}) min 2sf	**3**

Question	Answer	Marks
2(c)(i)	$K_a = 10^{-6.49} = 3.236 \times 10^{-7}$ $[H^+]^2 = 8.08984 \times 10^{-9}$ **M1:** $[H^+] = 8.99 \times 10^{-5}$ **M2:** $pH = -\log(8.99 \times 10^{-5}) = 4.05$ min 2sf	**2**
2(c)(ii)	conjugate acid H_2CrO_4 **AND** conjugate base CrO_4^{2-}	**1**
2(d)(i)	(the energy change / released when) one mole of gaseous atoms become 1^- ions / gain one mole of electrons	**1**
2(d)(ii)	due to repulsion between negative ion and incoming / gained electron	**1**
2(d)(iii)	$2Ag^+(g)$ $S^{2-}(g)$ → $Ag_2S(s)$	**1**
2(d)(iv)	**M1:** selection of correct six numbers only: –33, 731, 279, –200, 532, –2677 **M2:** use of × 2 as only multiplier with Ag **M3:** correct signs and evaluation of data $-33 = 2\Delta H_{at} + (2 \times 731) + 279 + (-200) + 532 + (-2677)$ $2\Delta H_{at} = 571$ (kJ mol $^{-1}$) $\Delta H_{at} = +285.5$ (kJ mol $^{-1}$)	**3**
2(e)	Ag_2S smaller / less negative / less exothermic lattice neergy **AND** larger ionic radius (of cation)	**1**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>3(a)</td><td>number of possible arrangements of particles and energy in a system</td><td>1</td></tr>
<tr><td>3(b)(i)</td><td>
<table>
<tr><th>process</th><th>ΔS is negative</th><th>ΔS is positive</th></tr>
<tr><td>steam condensing into water</td><td>✓</td><td></td></tr>
<tr><td>solid KCl dissolving into water</td><td></td><td>✓</td></tr>
</table>
</td><td>1</td></tr>
<tr><td>3(b)(ii)</td><td>M1: three numbers and correct multipliers used

M2: correct signs and evaluation

$\Delta S^{\ominus} = (3 \times 203.0) + (223.1) – (2 \times 281.6) = (+)268.9$ (J K^{-1} mol^{-1})</td><td>2</td></tr>
<tr><td>3(c)(i)</td><td>positive

AND

gas produced / on the right OR less / no gas on left</td><td>1</td></tr>
<tr><td>3(c)(ii)</td><td>M1 and M2: calculation of gradient from the graph for ΔS

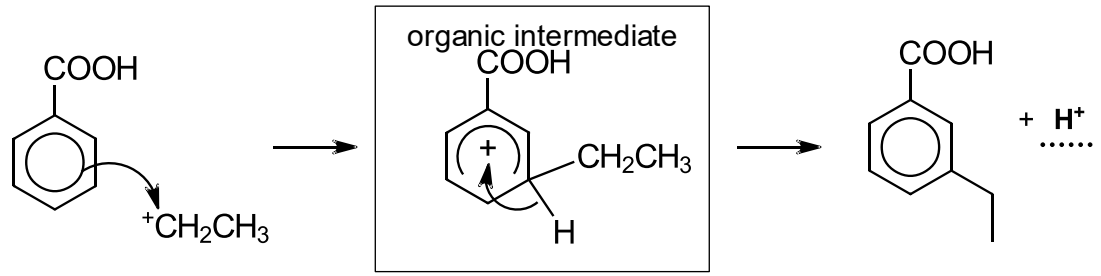
gradient = (–)140 / 900 = (–)0.1556

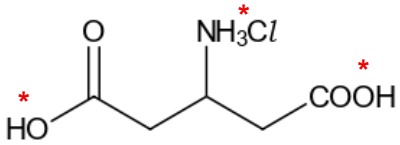
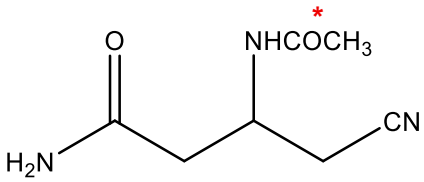
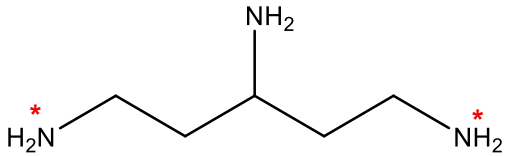
$\Delta S^{\ominus}$ = (–)0.1556 $\times$ 1000
= (+)155.6 ± 5 (J K^{-1} mol^{-1})

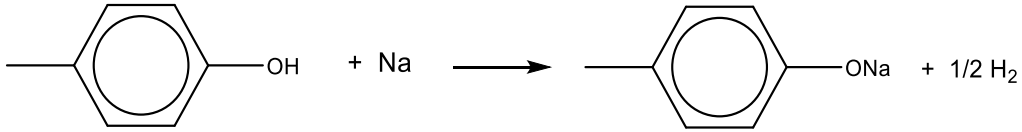
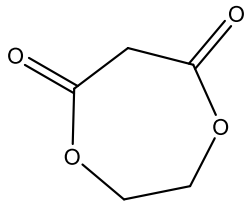
M3: T = 1120 ± 5 (K)

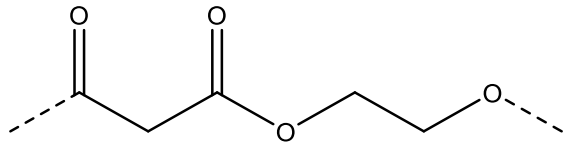
M4: $\Delta H^{\ominus}$ = (+)172 ± 10 (kJ mol^{-1})</td><td>4</td></tr>
</table>

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>4(a)(i)</td><td><table>
<tr><td>the order of reaction with respect to [H_2]</td><td>1</td></tr>
<tr><td>the order of reaction with respect to [NO]</td><td>2</td></tr>
<tr><td>overall order of the reaction</td><td>3</td></tr>
</table></td><td>1</td></tr>
<tr><td>4(a)(ii)</td><td>rate $\times \frac{1}{4}$</td><td>1</td></tr>
<tr><td>4(a)(iii)</td><td>rate $\times$ 27</td><td>1</td></tr>
<tr><td>4(a)(iv)</td><td>a four-particle collision is unlikely</td><td>1</td></tr>
<tr><td>4(a)(v)</td><td>step 1 $2NO \rightarrow N_2O_2$
step 2 $N_2O_2 + H_2 \rightarrow N_2O + H_2O$
step 3 $N_2O + H_2 \rightarrow N_2 + H_2O$</td><td>2</td></tr>
<tr><td>4(a)(vi)</td><td>intermediate formed (step 2) then used up later (step 3)</td><td>1</td></tr>
<tr><td>4(b)</td><td>$k = 0.693 / 720 = 9.625 \times 10^{-4}$ min 2sf
AND units: s^{-1}</td><td>1</td></tr>
<tr><td>4(c)(i)</td><td>homogeneous
AND Co^{3+} / catalyst / it is in the same phase / same state as the reactants</td><td>1</td></tr>
<tr><td>4(c)(ii)</td><td>M1: (equation 1) $2Co^{3+} + 2I^- \rightarrow 2Co^{2+} + I_2$
M2: (equation 2) $2Co^{2+} + S_2O_8^{2-} \rightarrow 2Co^{3+} + 2SO_4^{2-}$</td><td>2</td></tr>
<tr><td>4(c)(iii)</td><td>repulsion of two negative / same charge ions slows the reaction / raises E_A</td><td>1</td></tr>
</table>

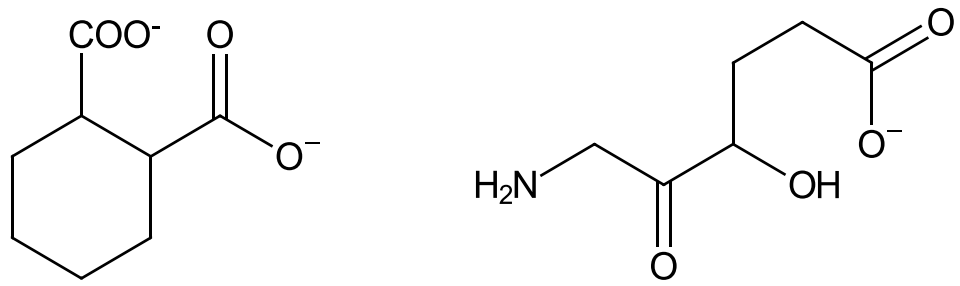
Question	Answer	Marks
5(a)	**M1** and **M2:** any two [1], all three [2] • (hexagonal ring) planar / (trigonal) planar • 120° • sp^2 hybridised **M3:** p orbitals overlap sideways / laterally (with each other above and below the ring) forming π bonds **M4:** σ bonds form when sp^2 / hybridised orbitals overlap end-on-end / head on	**4**
5(b)(i)	**M1:** (reaction 5) Pt / Ni + H_2 (+ heat) **M2:** (reaction 6) $(CH_3)_2CHCOCl$ + $AlCl_3$ (+ heat)	**2**
5(b)(ii)	reduction / hydrogenation	**1**
5(c)(i)	(CH_2CH_3 group) directs to 2-, 4- (and 6-) positions **AND** due to being an electron donating group	**1**
5(c)(ii)	$CH_3CH_2Br + FeBr_3 \rightarrow CH_3CH_2^+ + FeBr_4^-$	**1**
5(c)(iii)	 **M1:** curly arrow from inside / touching the hexagon to (CH_2) group / C^+ charge **M2:** structure of the intermediate **M3:** curly arrow from C-H bond into / onto the ring **AND** formation / loss of H^+	**3**
5(c)(iv)	$H^+ + FeBr_4^- \rightarrow HBr + FeBr_3$	**1**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>6(a)</td><td>sp = 1 AND $sp^2 = 1$ AND $sp^3 = 3$</td><td>1</td></tr>
<tr><td>6(b)(i)</td><td>acid-base / neutralisation AND hydrolysis</td><td>1</td></tr>
<tr><td>6(b)(ii)</td><td>reaction 7 
reaction 8 
reaction 9 
any two * [1], any three * [2], any five * [3], all six * [4]</td><td>4</td></tr>
<tr><td>6(c)(i)</td><td>five / 5</td><td>1</td></tr>
<tr><td>6(c)(ii)</td><td><table><tr><td>proton environment</td><td>a</td><td>b</td><td>c</td></tr><tr><td>name of splitting pattern</td><td>doublet</td><td>multiplet</td><td>doublet</td></tr><tr><td>chemical shift range, δ / ppm</td><td>2.2–3.0</td><td>3.2–4.0</td><td>2.0–3.0</td></tr></table>any three [1], all six [2]</td><td>2</td></tr>
</table>

Question	Answer	Marks
7(a)	**M1:** (most acidic) benzoic acid 4-methylphenol water (least acidic) phenylmethanol **M2:** correct link of acidity to weakens O—H / H^+ more easily lost / anion stabilised / conjugate base stabilised **M3** and **M4:** any two [2] • for benzoic acid: negative inductive effect of C=O / electronegative C=O / two electronegative O / –ve charge delocalised (across two O) / resonance in $–COO^-$ • for 4-methylphenol: as lone pair on oxygen delocalised into the ring / π system / delocalised system **OR** p orbital on oxygen overlaps with ring / π system / delocalised system • for phenylmethanol: positive inductive effect of alkyl group / R / CH_2	**4**
7(b)		**1**
7(c)(i)		**1**
7(c)(ii)	(reaction 10) addition–elimination / condensation / esterification **AND** (reaction 11) addition–elimination / condensation (polymerisation) / esterification	**1**

Question	Answer	Marks
7(c)(iii)	 **M1:** ester linkage shown **M2:** rest of the structure correct with continuation bonds	**2**

Question	Answer	Marks
8(a)	• chlorobenzene is less reactive than ethanoyl chloride • p orbital / lone pair on Cl / –Cl will overlap / delocalise into the ring **OR** C of COCl has most electron deficient **OR** has an electronegative oxygen atom / two electronegative atoms / electron withdrawing C=O group • due to partial double C–Cl bond **OR** C–Cl bond strengthened (more) / stronger bond between Cl and benzene / ring **OR** C–Cl weakened in ROCl any two [1], all three [2]	**2**
8(b)(i)	• nitrile • amide • ketone / carbonyl • ester any two [1], all four [2]	**2**
8(b)(ii)	8 / eight	**1**
8(b)(iii)	no need to separate optical isomers	**1**

Question	Answer	Marks
8(c)	 **M1:** amide bond hydrolysed and COO^- and NH_2 formed **M2:** nitrile bond hydrolysed and COO^- formed **M3:** ester bond hydrolysed and COO^- and OH formed	**3**
8(d)(i)	percentage = $100 \times 28 / (28 + 58 + 13 + 42) = 19.9\,(\%)$ min 2sf	**1**
8(d)(ii)	**D** is attracted more strongly to the stationary phase **/** forms stronger intermolecular forces with the stationary phase	**1**