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CAMBRIDGE
International Education

Cambridge International AS & A Level

CHEMISTRY **9701/44**

Paper 4 A Level Structured Questions **May/June 2026**

MARK SCHEME

Maximum Mark: 100

Published

This mark scheme contains the instructions and marking guidance that our examiners used to mark candidate responses for this component.

Before they start marking, examiners complete a standardisation process. They review a range of candidate responses and discuss the mark scheme in detail to agree which answers can and cannot be accepted. Examiners award marks where it is clear that candidate responses have met the requirements of the mark scheme. These requirements may vary between different components or different versions of the same component, depending on the exact requirements of the question and the candidate responses seen during the standardisation process.

Sometimes, our mark schemes may allow marks to be awarded to responses which contain elements that are factually incorrect or for content not covered by the syllabus. We do this in response to the demands of a specific question to support candidates and make sure that our assessments are fair. However, these allowances should not be used as a guide for teaching and learning.

We cannot discuss the mark scheme with schools, and we recommend that schools read the mark scheme together with the assessment material and the Principal Examiner Report for Teachers.

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General marking principles

All examiners must apply these marking principles when marking candidate responses.

1	Examiners must award marks for each response in line with: • the specific **content** defined in the mark scheme • the specific **skills** defined in the mark scheme or in the level descriptions • the **standard of response** required as exemplified by the standardisation scripts.
2	Examiners must award **whole marks** (not half marks, or other fractions).
3	Examiners must award marks **positively**. This means that: • marks are not deducted for errors or omissions • marks are awarded for correct/valid answers as defined in the mark scheme and also for **other valid answers** which go beyond the scope of the syllabus and mark scheme referring to your team leader as appropriate • the quality of spelling, punctuation and grammar are judged **only** when the mark scheme indicates that these features are **specifically assessed** in the question. However, the meaning of all responses must be unambiguous.
4	Examiners must **consistently** apply the requirements of the mark scheme and any rules for what to do when candidates have not followed instructions correctly.
5	Examiners must use the **full range of marks** defined in the mark scheme, unless limited by the quality of the candidate responses seen.
6	Examiners must award marks according to the mark scheme and **must not** award marks with grade thresholds or grade descriptions in mind.

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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.

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6	<u>Calculation specific guidance</u> 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	<u>Guidance for chemical equations</u> 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.

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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
	Rounding error

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

Mark Scheme abbreviations

/	alternative responses for the same marking point
R	reject the response
A	accept the response
I	ignore the response
ecf	error carried forward
AVP	any valid point
ora	or reverse argument
AW	alternative wording
underline	actual word given must be used by candidate (grammatical variants excepted)
( )	the word / phrase in brackets is not required but sets the context
max	indicates the maximum number of marks that can be given
M	marking point

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Question	Answer	Marks	Guidance
1(a)	**M1** Oxygen / O_2 **M2** $4OH^- \rightarrow 2H_2O + O_2 + 4e^-$	**2**	**I** 'O' alone. **I** state symbols. **A** multiples, use of '⇌'. **A** $4OH^- - 4e^- \rightarrow 2H_2O + O_2$.
1(b)(i)	**M1** $2.4 \times 12 \times 60$ **or 1728** (C) **M2** $1728 / (2 \times 96\,500)$ = **0.00895 / 0.0090** mol min 2sf **or** $\frac{1728}{2\times\left(1.6\times10^{-19}\times6.022\times10^{23}\right)} = 0.00897$ min 2sf ecf	**2**	**A** 0.00896 or 0.008955. 1.4945×10^{-4} (no $\times$ 60) [1]. 0.0179 [1] (no ÷ 2). Correct answer [2]. 0.009 [1] (1sf).
1(b)(ii)	$V = \frac{nRT}{p} \rightarrow \frac{\textbf{1(b)(i)}\times8.31\times653}{101000} = 4.81\times10^{-4}$ m^3 4.81×10^{-4} m^3 × 1000 = **0.481** (dm^3) **answer must be 3sf**	**1**	**ECF** from **1(b)(i)**, e.g. if mol in **1(b)(i)** = 0.0179, volume = 0.962. 0.482 if 0.00897 mol. 0.484 if 0.0090 mol. 0.962 if 0.0179 mol. **A** use of their unrounded previous value, e.g. 0.962 if 0.018 mol (i.e. they are *using* 0.0179). correct answer [1].

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Question	Answer	Marks	Guidance
1(c)	Full expression: **M1** $\frac{36\,000 \times 23}{1.6 \times 10^{-19} \times 8.51} = 6.08 \times 1023 \left(\text{mol}^{-1}\right)$ 36 000 ÷ 1.6×10^{-19} **or 2.25 × 10^{23}** electrons / atoms Na **M2** ans ÷ (8.51 / 23) = **6.08 × 10^{23}** **must be 3sf** **or** (using F = –Le) **M1** 8.51 ÷ 23.0 = 0.370 moles of electrons / atoms Na **and** 36 000 ÷ 0.370 **or 97 297** (value for F) **M2** ans ÷ 1.6×10^{-19} = **6.08 × 10^{23}** **must be 3sf**	**2**	**I** 6×10^{23}, 6.1×10^{23} as not 3 sf **6.08 × 10^{23}** scores [2]. **A** – ve sign if seen in working, but -6.08×10^{23} scores max [1]. **ECF** from use of incorrect A_r for **M2**. M_r for NaC*l* used instead of Na gives L = 1.55×10^{24} [1] use of atomic number instead of A_r gives L = 2.91×10^{23} [1] × rather than ÷ A_r gives 8.33×10^{22} [1].

Question	Answer	Marks	Guidance
2(a)	**M1** (strong acid) fully ionised / dissociated **and** (weak acid) partially ionised / dissociated **M2** to give / donate H^+ / proton **or** is a proton donor (mentioned once)	**2**	**I** fully / partially **dissolves.** **I** 'not fully' for 'partially' dissociated / ionised **I** 'strongly dissociates', 'dissociates easily'.
2(b)	pair 1: HOOCCOOH **and** $HOOCCOO^-$ **and** pair 2: $HOOCCOO^-$ **and** $^-OOCCOO^-$ pairs can be in either order	**1**	**CON** Na^+ salts (question asks for **organic** pairs) . **A** other representations if correct, e.g. $(COOH)_2$, $(COO^-)_2$, $(OOCCOO)^{2-}$, $C_2O_4^{2-}$ but not $OOCCOO^{2-}$.

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Question	Answer	Marks	Guidance
2(c)(i)	**M1** Two **reactants** that will work (ignore stoichiometry) **M2** Correct balanced equation e.g: $Ca + 2CH_3COOH \rightarrow Ca(CH_3COO)_2 + H_2$ **or** $CaO + 2CH_3COOH \rightarrow Ca(CH_3COO)_2 + H_2O$ **or** $Ca(OH)_2 + 2CH_3COOH \rightarrow Ca(CH_3COO)_2 + 2H_2O$ **or** $CaCO_3 + 2CH_3COOH \rightarrow Ca(CH_3COO)_2 + CO_2 + H_2O$ **or** $Ca(HCO_3)_2 + 2CH_3COOH \rightarrow Ca(CH_3COO)_2 + 2CO_2 + 2H_2O$	**2**	**I** Ca^{2+} as a reactant. **M2** dependent on **M1**. **I** state symbols. pass other correct examples to TL. **I** where a chemical reaction is not happening, e.g. $CaCl_2 + 2CH_3COOH \rightarrow Ca(CH_3COO)_2 + 2HCl$.
2(c)(ii)	(a solution that) resists / opposes / minimises changes in pH when small amounts / volumes of acid / H^+ or base / alkali / OH^- are added to it	**1**	**A** keeps pH *almost* constant. **A** pH does not change much. **A** 'does not change significantly' for resists. **A** 'controls pH' as it is in **2(c)(iii)** **I** 'minimises pH' alone. **CON** 'kept constant' / 'maintains pH' but **A** maintains pH in a small range. **I** moderate for 'small'.
2(c)(iii)	**M1** $CH_3COOH + OH^- \rightarrow CH_3COO^- + H_2O$ **M2** $CH_3COO^- + H^+ \rightarrow CH_3COOH$ **or** $Ca(CH_3COO)_2 + 2H^+ \rightarrow 2CH_3COOH + Ca^{2+}$	**2**	If full salt formula used, must be correct. **A** use of '⇌' but read in forward direction. **A** use of HCl, NaOH, etc. **I** $CH_3COOH \rightarrow CH_3COO^- + H^+$ and/or $H^+ + OH^- \rightarrow H_2O$. If more than two eqns given, mark answers on answer lines.

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Question	Answer	Marks	Guidance
2(d)	**M1** In NaOH : $[H^+] = 10^{-11.34}$ **or** 4.57×10^{-12} **M2** In NaOH: $[OH^-] = 10^{-14} \div 4.57 \times 10^{-12}$ **or** 2.19×10^{-3} In $Ba(OH)_2$: $[OH^-] = 2.19 \times 10^{-3} \times 2$ **or** 4.376×10^{-3} **M3** In $Ba(OH)_2$: $[H^+] = 10^{-14} \div 4.376 \times 10^{-3}$ **or** 2.29×10^{-12} pH = **11.6(41)** min 1dp Alternative method: **M1** $[H^+] = 10^{-11.34}$ **or** 4.57×10^{-12} **M2** $4.57 \times 10^{-12} \div 2 = 2.29 \times 10^{-12}$ **M3** pH = **11.6(41)** (No mention of $[OH^-]$)	**3**	11.6 scores [3]. 11.04 [2] with working and one mistake seen ecf throughout **A** use of pOH: pOH = 14 – 11.34 **or** 2.66. [1] $[OH^-] = 10^{-2.66}$ **or** 2.188×10^{-3} $[OH^-]$ in $Ba(OH)_2 = 2 \times 2.188 \times 10^{-3}$ **or** 4.376×10^{-3} [1] new pOH = $-\log(4.376 \times 10^{-3})$ **or** 2.36 new pH = 14 – 2.36 = 11.64 [1]
2(e)(i)	(the) **ratio** of the **concentrations** of a **solute / substance / compound** between **two** (immiscible) **solvents / liquids** (at) **equilibrium** **A** the **equilibrium** constant that relates the **concentration** of a **solute / substance / compound** (partitioned) between **two** (immiscible) **solvents / liquids**	**1**	**A** eqm for equilibrium. **I** equations. 'Ratio' may be given using mathematical expression. 'Solvents / liquids' may be clearly implied. **I** 'solubility', 'species'. **I** 'solutions' for solvent.
2(e)(ii)	(0.68 / 5.32 =) 0.13 / 0.128 / 0.1278 min 2sf	**1**	Only answer 0.1278195489.
2(e)(iii)	• less than / lower (ecf if K_{pc} from **2(e)(ii)** is the wrong way up) • solute / **A** must be polar / form H-bonds / ionic (as more soluble in water) • cyclohexane is non-polar / less polar than butan-1-ol **or** cyclohexane does not form H-bonds • **A** is less soluble in cyclohexane (than in butan-1-ol) **or** less (**A**) will dissolve in cyclohexane **or** more (**A**) will dissolve in water (than cyclohexane) ●✓✓✓	**3**	(inverse K_{pc} = 7.82) Bullets 2, 3 and 4 are unconditional. No ecf, marks are unconditional throughout.

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Question	Answer	Marks	Guidance
3(a)	1 / first 1 / first 2 / second	**1**	Only answer.
3(b)(i)	**M1** … **0.120** … unc **M2** … … **6.90×10^{-6}** unc min 2sf	**2**	No efc from **3(a)**.
3(b)(ii)	**M1** 0.0046 / 4.6×10^{-3} min 2sf unc **M2** $mol^{-1}\ dm^3\ s^{-1}$ unc	**2**	No ecf. Any order, but no work left for examiner to do so **I** s^{-1} / $mol^1\ dm^{-3}$ or $mol^{-1}\ dm^3$ / s **CON** mol^- or s^-
3(c)	69 / 68.6 / 68.61 / 68.63 min 2sf	**1**	68.63 if ln2 used rather than 0.693. **A** any answer between 68.61–68.63.
3(d)	**M1** e.g. $NO_2 + F_2 \rightarrow NO_2F_2$ **or** $NO_2 + F_2 \rightarrow NO_2F + F$ $NO_2 + NO_2F_2 \rightarrow 2NO_2F$ $F + NO_2 \rightarrow NO_2F$ step 1 step 1 first step has one NO_2 and one F_2 **only** as reactants (ignore products) **and** step 1 / their equation for step 1 is slowest **M2** two steps add up to equation	**2**	Equations must be balanced for charge as well as species for **M2**. **I** radical dots. **I** equations with cancellable species.

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Question	Answer	Marks	Guidance
4(a)(i)	one mole of gaseous atoms **and** gains one mole of electrons / forms one mole of gaseous 1– ions	**1**	**A** one e^- is added to each atom in 1 mole of gaseous atoms. **CON** energy required/needed. **I** equations. **CON** incorrect near misses, e.g. '1 mol of e^- is added to each atom…' or '1 e^- is added to 1 mol of gaseous atom…'.
4(a)(ii)	(first electron affinity is) • less exothermic / less –ve down group OWTTE • (atomic) radius / size increasing **or** more shells **or** more shielding • less attraction of **nucleus** for valence / incoming / outer shell electron ●✓✓	**2**	**A** decreases / less exothermic. **I** less energy needed. **I** charge density. **CON** ionic radius for second bullet. **A** nuclear charge / protons for nucleus.
4(b)	**M1** any number more negative than –670 for NaC*l* **and** even more negative than that for MgO **M2** *explanation for NaCl:* correct reference to smaller ions / cation **and** anion **M3** *explanation for MgO:* correct reference to higher charge(s) of $Mg^{(2+)}$ and / or $O^{(2-)}$ **or** correct reference to smaller radius / radii of cation and / or anion **M4 ONE** correct reference to strong**er** forces / attraction between **ions or** strong**er ionic bonds**	**4**	e.g. –700 for NaC*l* and –750 for MgO. **A** NaC*l* has smaller **ionic** radius for **M2.** **I** charge density unless incorrect. **I** higher *nuclear* charge. **I** atomic radius throughout. **A** comparison with NaC*l* or KBr for MgO. **CON** similar radii for **M3.** no ecf.

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Question	Answer	Marks	Guidance
4(c)(i)	number of (possible) arrangements of particles / molecules / atoms **and** energy in a system	**1**	**I** references to disorder / chaos, etc. **I** 'arrangement of particles' without 'number of'. **I** randomness / extent. **I** of a substance. **I** 'measure of' for 'number of'. **I** total.
4(c)(ii)	decrease in number of **gaseous** particles OWTTE answer needs to either mention both sides of the equation or use a comparative term, e.g. larger / smaller e.g. ignore 'there are no gas molecules in the products' but allow 'there are fewer gas molecules in the products'	**1**	**A** 'gas forms solid'. **A** 'more gas in reactants' or 'less gas in products'. **A** '1 mol of gas in reactants and same mol of solid on both sides'. **I** decrease in disorder. **I** 'Cl_2 / a gas is consumed' alone. **I** 'number of mols / particles decreases'.
4(c)(iii)	• the reaction is less spontaneous • as ΔG or $(\Delta H - T\Delta S)$ becomes less negative / (more) positive • due to ΔS being negative **or** $T\Delta S$ (becoming more) negative **or** $-T\Delta S$ (becoming more) positive ●✓✓	**2**	**A** 'ΔG more likely to be positive' **I** ΔG or ΔS becomes less exothermic **I** increases / decreases, etc. **A** $\Delta S < 0$. **I** ↑ or ↓ for more / less positive.

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Question	Answer	Marks	Guidance
5(a)(i)	$Ca(NO_3)_2 \rightarrow CaO + 2NO_2 + \frac{1}{2}O_2$ **or** $2Ca(NO_3)_2 \rightarrow 2CaO + 4NO_2 + O_2$	**1**	**A** other multiples. **I** state symbols.
5(a)(ii)	**M1** increases / more stable (down the group) **and** ionic / M^{2+} radius increases / charge density of ion / M^{2+} decreases **M2** anion / nitrate ion / NO_3^- less polarised / distorted **or** N=O / N–O less polarised / distorted/weakened	**2**	**I** atomic radius. **CON** charge density increasing. **I** nitrate less polarised / distorted. **I** less polarisation 'between' ions. **A** N–O bond stronger / harder to break. **A** distortion 'with' or 'to' NO_3^-. **A** NO_3^{2-}. **CON M2** for stronger ionic bond / attraction between ions. **I** 'nitrate group' for NO_3^- .
5(b)(i)	$MgSO_4$ more soluble than $BaSO_4$ **Must explicitly be a comparison of the sulfates**	**1**	**A** $MgSO_4$ is soluble **and** $BaSO_4$ is insoluble. **A** solubility of Gp2 sulfates decreases (down the group). **I** comparison of basicity. **I** comparisons between $Mg(OH)_2$ and $Ba(OH)_2$. **I** all discussion regarding ΔH_{latt}, etc.
5(b)(ii)	**M1** ΔH_{latt} and ΔH_{hyd} less negative / exothermic (down group 2) **M2** ΔH_{latt} changes more / is dominant factor / significant **M3** ΔH_{sol} more exothermic down group *or in terms of the compounds in the question:* **M1** ΔH_{latt} and ΔH_{hyd} are less negative for $Ba(OH)_2$ **M2** ΔH_{latt} is less negative by a larger amount OWTTE **M3** ΔH_{sol} is more exothermic for $Ba(OH)_2$ (than for $Mg(OH)_2$)	**3**	**A ora** throughout. **A** decreases for **M1.** **A** 'of oxides' as a slip. **M3 I** 'solubility more exothermic'. **I** HE and LE unless defined. Penalise missing Δ or H once only. **I** $\Delta H_{solubility}$. **I** any discussion of sulfates. **I** discussion of ionic radii / charge density throughout.

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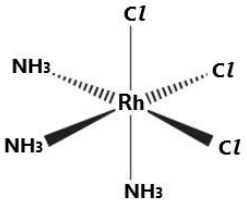
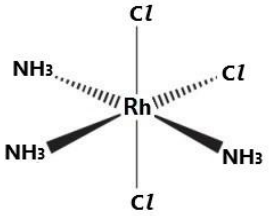
Question	Answer	Marks	Guidance
6(a)	(ion formed from a central) **metal atom / ion** (surrounded by, or bonded to, one or more) **ligands**	**1**	**A** transition element for metal.
6(b)(i)	**M1** $x = 1$, $y = 5$ **M2** x = 4, y = 2	**2**	**A** negative or positive signs.
6(b)(ii)	6 / six	**1**	Only answer.
6(b)(iii)	**M1**  one diagram with correct 3D and formula **M2**  second diagram shows correct 3D and other isomer	**2**	No mark for either diagram with wrong 3D. No mark for diagrams with bidentate ligands. **I** incorrect ligand attachment (i.e. though the H of NH_3). Penalise incorrect monodentate ligands once only, then **A.** One diagram must have <u>all</u> NH_3 ligands cis, one diagram must have <u>two</u> NH_3 ligands trans i.e one facial, one meridial.
6(b)(iv)	yes / no stereoisomerism ✓ optical isomerism ✓ geometric isomerism ✓	**1**	**A** crosses as ticks if other box on row is blank. Three ticks only, all correct.
6(c)(i)	equilibrium constant formation of a complex in a solvent / water / from its (constituent) ions / molecules	**1**	**I** 'the ratio of…'. They have been given the expression and are just describing it. **I** 'in a solution' for solvent.
6(c)(ii)	$mol^{-6}\ dm^{18}$ any order	**1**	Only answer.

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Question	Answer	Marks	Guidance
6(c)(iii)	**M1** working makes it clear all terms substituted into the expression correctly $4.80\times10^{7}=\dfrac{0.0762}{(0.455)^{6}\times\left[\left[Ni(H_2O)_6\right]^{2+}\right]}$, $\left[\left[Ni(H_2O)_6\right]^{2+}\right]=\dfrac{0.0762}{(0.455)^{6}\times4.80\times10^{7}}$ **M2 1.8 / 1.79 × 10^{-7}** min 2sf	**2**	only **ecf** is **M2** for TE errors in the concentrations / K_{stab}. Correct answer scores [2]
6(c)(iv)	$[Ni(H_2O)_6]^{2+}$ + **6** $NH_3 \rightarrow$ (**1**) $[Ni(NH_3)_6]^{2+}$ + **6** H_2O	**1**	Only answer.
6(c)(v)	**Ligand** exchange / displacement / replacement / substitution	**1**	

Question	Answer	Marks	Guidance
7(a)(i)	120° **and** sp^2	**1**	Only answers.
7(a)(ii)	• sp2 (and sp2) • head on / direct / end-on / linear / acceptable description • p (and p) • sideways / lateral / acceptable description •✓•✓	**2**	**CON** s orbital unless clearly referring to C-H, where you ignore s orbital. **A** orbital type written in overlap space if not written in 'orbitals involved' space. Otherwise consider only orbitals on the 'orbitals involved lines' and only overlap on the 'orbital overlap' lines. Read '6p orbitals' as the number of p orbitals.
7(b)(i)	conc HNO_3 + conc H_2SO_4, T = 25–60 °C	**1**	Conc, con or c seen once. **CON** aq. **A** any T in range. **I** heat / warm / reflux.
7(b)(ii)	$C_6H_5NH_2$	**1**	**A** $C_6H_5NH_3^+$ or $C_6H_5NH_3Cl$.

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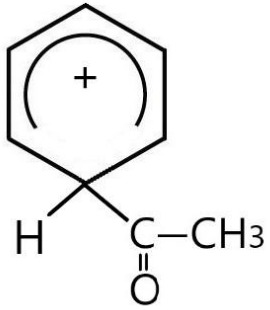
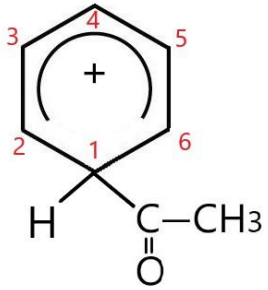
Question	Answer	Marks	Guidance
7(b)(iii)	**M1** HNO_2 / HCl + $NaNO_2$, T = 0–10 °C **M2** H_2O / (aq) **and** warm / heat / T > 10 °C	**2**	**A** any T in range. **I** HNO_3 / $NaNO_3$. **A** [1] for all correct reagents or both correct temperatures. **M2 CON** addition of NaOH but ignore acids.
7(c)(i)	**M1** curly arrow from within / touching hexagon towards C^+  **M2** intermediate **M3** curly arrow from C–H bond goes within hexagon **and** H^+	**3**	**CON** additional curly arrows in **M1**. **I** additional curly arrows in **M3**. **CON** curly arrow from H rather than middle of bond for **M3** intermediate – normal rules apply. 'Horseshoe' must include C3, C4 and C5, may include C2 and / or C6, **CON** including C1. + charge must be above a line joining C2 and C6.  **I** connectivity of side group if drawn as $OCCH_3$ for **M2**. **A** Kekulé for **M2** if correct. **A** HCl for **M3** if Cl^- introduced earlier.
7(c)(ii)	$C_6H_5COCH_3$ + **4**[O] → C_6H_5COOH + **CO_2** + **H_2O**	**1**	

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Question	Answer	Marks	Guidance
7(d)	**M1** NaOH(aq) / OH^-(aq) / alkaline **and** iodine / I_2 **M2** any acid / H^+ unc (pass alternative (correct) method to TL for advice, e.g. $LiAlH_4$ then alkaline I_2 followed by acid)	**2**	**A** NaOH and I_2(aq). **A** Cl_2 / OH^-. **A** HCl, H_2SO_4. **CON** additional reagents.

Question	Answer	Marks	Guidance
8(a)	TMS / tetramethylsilane / $(CH_3)_4Si$	**1**	
8(b)(i)	**M1 Q and** (peak at) 5.4 / 4.5–7.0 = Ar-OH / phenol **M2 Q and** (peak(s)) at 6.8–7.3 / 6.0–9.0 = aromatic / H–Ar	**2**	**I Q and** 4 peaks for 4 (proton) environments (question asks for protons responsible). If explanation is blank, check spectra. **A** benzene ring for aromatic.
8(b)(ii)	• triplet • two protons/H on neighbouring/adjacent **C** • quartet • three protons/H on neighbouring/adjacent **C** • ✓ • ✓	**2**	**A** neighbouring CH_2 or CH_3 for adjacent. **A** quadruplet for quartet. **A** near-miss spellings (e.g. one letter missing / incorrect only or 'tirplet', etc.).
8(c)	peak (at 5.4) disappears **and** the OH / 5.4 proton / H is liaible **or** the OH / 5.4 proton / H exchanges / replaced with D **or** equation, e.g. ROH + D_2O → ROD + DHO	**1**	**A** chemical shift disappears. **I** it would have 3 or 4 peaks as we don't know if they are counting the TMS peak. **I** OH exchanges with D_2O. **I** (OH) reacts with D_2O. **I** OH exchanges with OD. **CON** incorrect peak / spectra.

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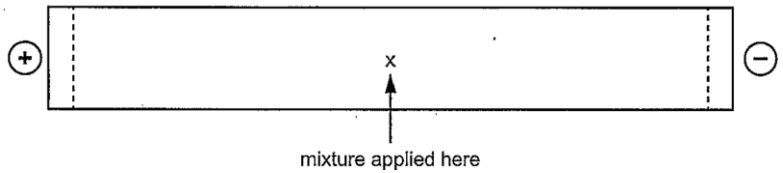
GradeMax

Question	Answer	Marks	Guidance
8(d)	ethanoic acid phenol ethanol • correct reference to O-H bond strength / anion stability • (ethanoic acid) C=O has electron withdrawing / –I effect • (phenol) LP/p-orbital **on O** overlaps/is delocalised **and** with/into ring/π system • (ethanol) electron donating/+I effect of alkyl/R/CH_2/CH_3/C_2H_5 • ✓ ✓ ✓ for four bullets	**4**	**A** ecf for matching O–H strength / anion stability correctly to incorrect order for bullet 1. **CON** bullet 1 for incorrect reference to O–H bond strength / anion stability. **I** $COOH$ / COO^- is an electron withdrawing group. **A** e^- / negative charge delocalises over COO^- / C=O.
9(a)	• asparagine is negative / contains COO^- • asparagine moves left / towards the positive/anode • histidine is a zwitterion / neutral / uncharged • histidine does not move • lysine is positive / contains NH_3^+ • lysine moves right / towards the negative/cathode •✓•✓•✓  	**3**	**A** ecf for **bullets 2 and 6** if charges **and** directions are reversed. **A** bullets 2, 4 and 6 from diagram only if directions not mentioned.

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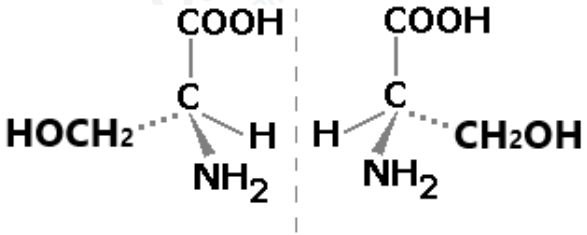
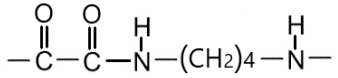
Question	Answer	Marks	Guidance
9(b)(i)		1	Correct 3D. Correct formulae. Diagrams are different isomers. No connectivity penalty for any group may see RH structure same orientation as LH structure with any 2 groups switched.
9(b)(ii)	racemic / racemate	1	**A** near misses, e.g. racemix.
9(b)(iii)	**M1** effect on/rotation of plane polarised light **M2** biological activity / interaction with enzyme	2	**I** angle of rotation, optical activity. **A** biological reactivity / biochemistry. / biological effects / bioactivity. **A** interaction with chiral reagents. **I** comments on structure. **I** chemical biology, biological active, etc.
9(b)(iv)	$H_2NCH(CH_2OH)COOH + \mathbf{2}PCl_5 \rightarrow \mathbf{2POCl_3 + 2HCl + H_2NCH(CH_2Cl)COCl}$ **M1** Correct organic product **M2** all correct **A** ammonium salt but beware balancing with HCl, e.g. $H_2NCH(CH_2OH)COOH + \mathbf{2}PCl_5 \rightarrow \mathbf{2POCl_3 + HCl + ClH_3NCH(CH_2Cl)COCl}$	2	**A** [1] if molecular formula used, $C_3H_5NOCl_2$ as only mistake. **A** any unambiguous structure. **A** [1] if only one OH substituted and otherwise all correct.

GradeMax

Question	Answer	Marks	Guidance
10(a)	ethan(e)dioyl (di)chloride / oxalyl chloride	**1**	**A** ethdioyl (di)chloride, oxal(di)oyl (di)chloride, oxalic acid dichloride, oxalic dichloride **I** numbers. **I** ethanoyl dichloride, ethanediacyl (di)chloride, diethanoyl (di)chloride.
10(b)(i)	 **M1** one correct amide link displayed **M2** exactly one RU, trailing bonds, no errors	**2**	**A** skeletal, but beware leading/trailing bonds. **A** [1] if NH has incorrect number of H's. **A** additional atoms if outside of bracketed repeat unit. **A** –NH–. correct amide link should be attached to a C at each end, e.g. C–CO–NH–C, and not Cl–CO–NH–.
10(b)(ii)	condensation **and** (poly) amide (group/bond/linkage)	**1**	**I** CONH as linkage. **A** polyamide for amide. **I** peptide.
10(c)	$LiAlH_4$ or acceptable name	**1**	**CON** aqueous / (aq). (**A** H_2 **and** Ni / Pt / Pd **and** Heat **and** pressure).
10(d)	ammonia heat sealed tube/pressure	**1**	**CON** aqueous / (aq) / alkaline.

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9701/44 Mark Scheme June 2026