

Cambridge International AS & A Level

CHEMISTRY**9701/41**

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.

This document consists of **21** printed pages.

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.

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 <i>n</i> responses (e.g. State two reasons ...): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked <i>ignore</i> in the mark scheme should not count towards <i>n</i>. • Incorrect responses should not be awarded credit but will still count towards <i>n</i>. • 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 <i>n</i> 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
	Rounding error

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
<u>underline</u>	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

Question	Answer	Marks	Guidance
1(a)	$\text{Ca}^{2+}(\text{g}) + \text{S}^{2-}(\text{g}) \rightarrow \text{CaS}(\text{s})$ M1 all species M2 all state symbols	2	If reverse lattice energy equation is given $\text{CaS}(\text{s}) \rightarrow \text{Ca}^{2+}(\text{g}) + \text{S}^{2-}(\text{g})$ award [1] if all species and state symbols are correct.
1(b)	(ionic) bonds are formed / the ions bond	1	A attractive force $\times$ distance. A electrostatic attraction $\times$ distance. I electrostatic attraction alone. I exothermic / energy released. I ions come together. I formation of the lattice / solid / CaS. I reference to energy required to break bonds. CON energy required to form bonds. CON bond formed is clearly covalent, e.g. Ca–S.
1(c)	M1 MgO CaS KCl M2 CaS (and MgO) the ions / particles are more highly charged than KCl or KCl has ions with the smallest charge ora M3 MgO the ions/particles are smaller than CaS or MgO has the smallest ions ora	3	A for all four charges I nuclear charge I charge density for M2 and M3
1(d)(i)	(enthalpy of) atomisation (of Cl) or bond energy (Cl–Cl) and (first) electron affinity (of chlorine)	1	If this is given in symbols we will accept ΔH_{at} , ΔH_{atom} or $\Delta H_{\text{atomisation}}$. If symbols and words are given, I the symbols. If this is given in symbols we will accept ΔH_{EA} , ΔH_{EA1} , $\Delta H_{\text{electron affinity}}$ or $\Delta H_{\text{first electron affinity}}$. If symbols and words are given, I the symbols. CON electron affinity of chloride / Cl^- / Cl_2

Question	Answer	Marks	Guidance
1(d)(ii)	M1 chlorine value doubled / –486 seen / $2x - 243$ seen M2 answer –643 $2336 + (2x - 243) - 2493 = -643$	2	ecf use of $1x - 243$ for ans = –400 (working needed). –643 scores [2]
1(e)	M1 Correct $\Delta G = \Delta H - T\Delta S$ and use of $T = 873$ M2 $\Delta G = -36 / -35.8 / -35.78 / -35.775$ ecf T only M3 it is (feasible) ΔG is negative / ΔG is less than zero (Note: ΔG now in bold) M3 is UN Conditional on the basis it is a correct answer on the answer line. If the calculation has not been worked through to an answer, or has given a negative value for ΔG , there is no M3 for ‘not feasible because ΔG is positive’.	3 and UNC	CON G for ΔG . A Δ Gibbs. If $T = 600$ then [1] ecf for +12. CON G for ΔG but do not penalise twice If in words we need ‘change’. I ΔG is exothermic. A ΔG in words ‘Gibbs Free Energy change’
1(f)	- higher Ca^{2+} larger (than Mg^{2+}) ora (In CaCO_3) less distortion / polarisation of anion / CO_x^{y-} ora all standalone ora for MgCO_3 but must be stated	2	●✓✓ any two for one mark. All three for two marks. or ionic radius / size I atomic or group 2 trend but up / down the group must be clear. I references to ionic bond strength. or Ca^{2+} less polarising on anion / CO_x^{y-} I ‘depolarisation’. or C–O / C=O bond (must be identified, e.g. C–O) is less weakened by Ca^{2+}.

Question	Answer	Marks	Guidance
2(a)(i)	$-\log[\text{H}^+]$	1	[] essential. CON $-\log(\text{H}^+)$, $-\log_e[\text{H}^+]$, $-\ln[\text{H}^+]$.
2(a)(ii)	$[\text{H}^+][\text{OH}^-] / K_a \times K_b$	1	[] essential but do not penalise in (i) and (ii). 1 1×10^{-14} .
2(b)(i)	$(10^{-2.9})$ $0.0013/0.00126/1.3 \times 10^{-3}/1.26 \times 10^{-3}$	1	
2(b)(ii)	$2b^2 / 0.105$ $0.00126^2 / 0.105$ ecf bi $1.5 \times 10^{-5} / 1.51 \times 10^{-5} / 1.53 \times 10^{-5}$ ecf	1	
2(c)(i)	M1 $[\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}] = 0.15$ M2 $[\text{CH}_3\text{CH}_2\text{CH}_2\text{COO}^-\text{Na}^+]$ in solution D = 0.036 / 0.0359 M3 $[\text{CH}_3\text{CH}_2\text{CH}_2\text{COO}^-\text{Na}^+]$ in solution C = 0.054 / 0.0538 / 0.0539 / 0.0540 Another possible approach goes via moles of acid to get moles of salt, M1 moles acid = 0.045 mol M2 moles salt = 0.0108 / 0.0107 mol M3 original [salt] = 0.0538 / 0.0539 / 0.0540	3	If $[\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}] = 0.45$ [0] but then [salt] in mixture = 0.108 [1] ecf [salt] in solution C = 0.162 [1] ecf VERIFY with working.
2(c)(ii)	$\text{CH}_3\text{CH}_2\text{CH}_2\text{COO}^-\text{Na}^+ + \text{H}^+ \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{COOH} + \text{Na}^+$ or $\text{CH}_3\text{CH}_2\text{CH}_2\text{COO}^- + \text{H}^+ \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$ or $\text{CH}_3\text{CH}_2\text{CH}_2\text{COO}^- + \text{H}_2\text{SO}_4 \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{COOH} + \text{HSO}_4^-$ or $2\text{CH}_3\text{CH}_2\text{CH}_2\text{COO}^-\text{Na}^+ + \text{H}_2\text{SO}_4 \rightarrow 2\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH} + \text{Na}_2\text{SO}_4$	1	
2(c)(iii)	$\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH} + \text{OH}^- \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{COO}^- + \text{H}_2\text{O}$ or $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH} + \text{KOH} \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{COOK} + \text{H}_2\text{O}$ or $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH} + \text{K}^+\text{OH}^- \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{COO}^-\text{K}^+ + \text{H}_2\text{O}$	1	

Question	Answer	Marks	Guidance
2(d)	M1 2,2-dichlorobutanoic and chlorine is electron withdrawing / negative inductive effect / electronegative M2 weakens O–H bond / stabilises anion / stabilises conjugate base / stabilises carboxylate ion	2	I references to C=O, O, alkyl groups. A –O–H bond and OH bond but CON – OH bond, C–O–H bond.

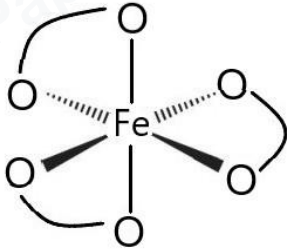
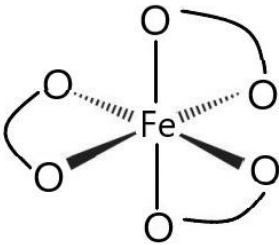
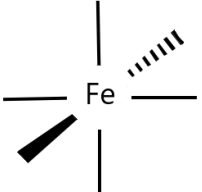
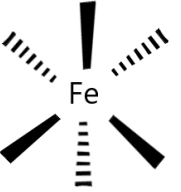
Question	Answer	Marks	Guidance
3(a)	2 1 3	1	
3(b)	M1 1.4×10^{-6} M2 $\text{mol}^{-2}\text{dm}^6\text{s}^{-1}$	2	I $\text{mol}^{-2}\text{dm}^6\text{s}^{-1}$
3(c)(i)	(overall) first order and [NO] is (almost) constant	1	I '[H ₂] first order'. I [NO] zero order. I [NO] not a limiting factor. I [H ₂] is a limiting factor. A [NO] pseudo zero order.
3(c)(ii)	M1 33 000 / 32 500 / 32 542 / 32 540 / 32 535 / 3.25×10^4 , etc. M2 130 000 / 130 141 / 1.3×10^5 / 1.32×10^5 , etc. ecf $t_{\frac{1}{2}}$	2	32 542 if ln2 used. answer = $t_{\frac{1}{2}} \times 4$
3(d)(i)	M1 one N ₂ O ₂ and one H ₂ on L or one N ₂ O and one H ₂ O on R M2 $\text{N}_2\text{O}_2 + \text{H}_2 \rightarrow \text{N}_2\text{O} + \text{H}_2\text{O}$	2	(M1 is for either correct LHS or RHS).

Question	Answer	Marks	Guidance
3(d)(ii)	no H ₂ involved in step one (and H ₂ in rate equation) or only one species from rate equation or does not contain species in the same molar proportion as rate equation or if step 1 is RDS then order wrt [H ₂] = 0 or step 1 does not include all species in rate equation or rate would be second order wrt NO only or reaction would be overall second order	1	I 'does not agree with rate equation'. I reference to NO without reference to order of reaction. I N ₂ O ₂ not in the rate equation.

Question	Answer	Marks	Guidance
4(a)	$\Delta G^\circ = -nF E^\circ_{\text{cell}}$	1	A $\Delta G^\circ = -nF E_{\text{cell}}$.
4(b)	$\text{Cu}^{2+} + 2\text{V}^{2+} \rightarrow \text{Cu} + 2\text{V}^{3+}$ (+) 0.60	2	CON cancellable species / electrons If $\rightleftharpoons$ read forwards I 0.6 + not needed but – is CON .
4(c)	M1 Cu M2 V ²⁺	2	or in words if unambiguous.
4(d)	M1 Cl ₂ / chlorine M2 V / vanadium	2	CON if both oxidised and reduced form given. CON if both oxidised and reduced form given.
4(e)	All candidates get three marks	3	

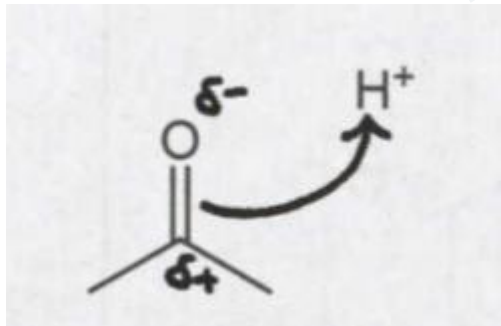
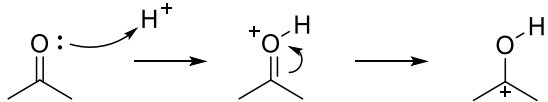
Question	Answer	Marks	Guidance
5(a)	similarity in energy of (3)d and (4)s (subshells / orbitals) A same	1	this is a syllabus statement – do not allow much variation of meaning, I statements that can be understood to refer to 3d only.
5(b)	$3d^7 4s^2 / 4s^2 3d^7$ $3d^7 / 3d^7 4s^0$	1	A full configurations with no errors.
5(c)	M1 the d orbitals are split / become non-degenerate / reference to ΔE within d-subshell or ΔE between d orbitals M2 electrons are promoted / excited / jump to higher level owtte M3 absorbing (energy of) light / photon / frequency / wavelength / $h\nu$ and complementary colour is seen / reflected / transmitted	3	'complementary' may be described but 'different colour' is not enough. M3 CON emits / energy released.
5(d)	M1 blue to red / blue to pink M2 $\text{CoCl}_2 + 6\text{H}_2\text{O} \rightarrow [\text{Co}(\text{H}_2\text{O})_6]^{2+} + 2\text{Cl}^-$ or $\text{CoCl}_4^{2-} + 6\text{H}_2\text{O} \rightarrow [\text{Co}(\text{H}_2\text{O})_6]^{2+} + 4\text{Cl}^-$	2	A named shades of blue and pink. I $\text{CoCl}_2 + 6\text{H}_2\text{O} \rightarrow \text{CoCl}_2 \cdot 6\text{H}_2\text{O}$. I $\text{Co}^{2+} + 6\text{H}_2\text{O} \rightarrow [\text{Co}(\text{H}_2\text{O})_6]^{2+}$.
5(e)(i)	(white / brown / off white) precipitate / ppt / solid and brown (solution)	1	CON clearly wrong colours, e.g. black / blue / green / purple or wrong observations, e.g. fizzing.
5(e)(ii)	starch and blue / black to colourless / white / off-white	1	colourless / white to blue / black is CON .
5(e)(iii)	redox	1	A oxidation-reduction (both needed).

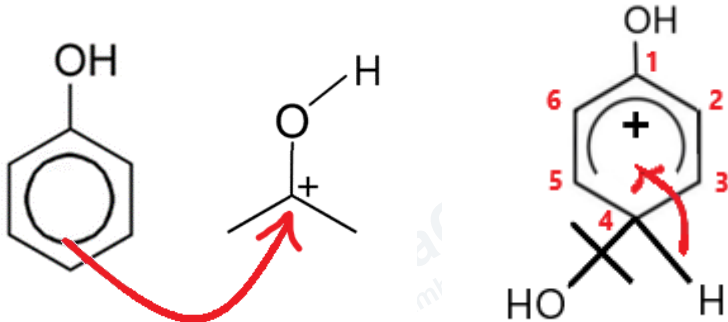
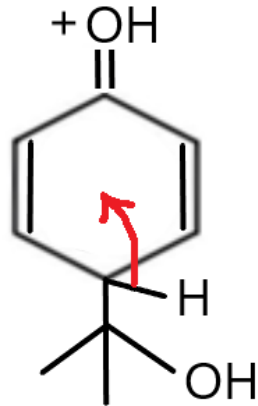
Question	Answer	Marks	Guidance
5(e)(iv)	- moles of $\text{S}_2\text{O}_3^{2-} = 0.2 \times 37.6 / 1000 = 7.52 \times 10^{-3}$ - moles of $\text{I}_2 = 3.76 \times 10^{-3}$ ecf - moles of $\text{Cu} = 7.52 \times 10^{-3}$ ecf - mass of $\text{Cu} = 0.48 / 0.478 / 0.4775 / 0.47752 \text{ g}$ ecf 0.239 g, 0.955 g or 1.41 g on the answer line, without any correct, understandable working, scores [0]	3	●✓✓✓ two points for one mark correct answer scores [3].

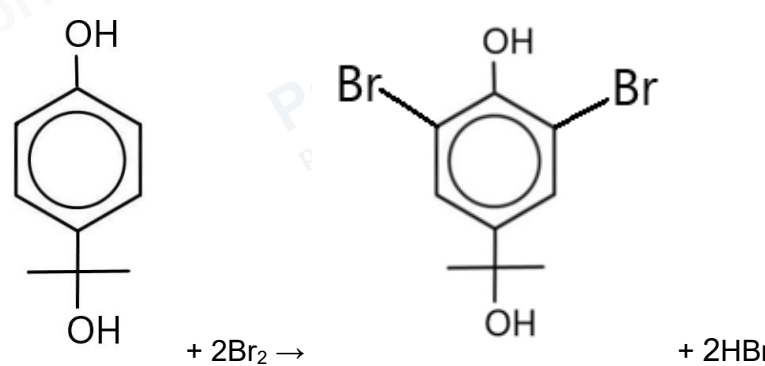
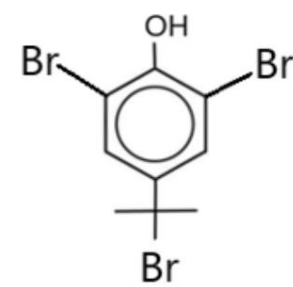
Question	Answer	Marks	Guidance
6(a)	M1 two lone pairs / LP M2 donated / form dative bond(s) / coordinate bond(s) to (central) metal / TM / TE atom / ion	2	CON '2 or more dative bonds'.
6(b)(i)	$[\text{Fe}(\text{C}_2\text{O}_4)_3]^{3-}$ or $\text{Fe}(\text{C}_2\text{O}_4)_3^{3-}$	1	
6(b)(ii)	M1 One correct isomer of $[\text{Fe}(\text{C}_2\text{O}_4)_3]^{3-}$ drawn with 3D and oct M2 Two optical isomers drawn with 3D and octahedral only  	2	Correct 3D. octahedral, different These two renditions of octahedral are acceptable.   I charges.
6(b)(iii)	optical only	1	

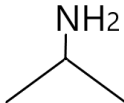
Question	Answer	Marks	Guidance
6(c)	$\frac{[\text{HgI}_4]^{2-}}{[\text{Hg}^{2+}][\text{I}^-]^4} \quad \text{M1}$ M2 mol ⁻⁴ dm ¹²	2 unc	A [HgI ₄ ²⁻]. A [Hg ²⁺] with complexing H ₂ O. The charges shown here are essential. Final set of brackets must be square ×3. Penalise two or more round outer brackets. ecf only after <i>K</i> _{stab} with 4 th power.

Question	Answer	Marks	Guidance
7(a)(i)	HNO ₃ and H ₂ SO ₄ and conc once and 25° ≤ T ≤ 60°	1	Acids may be named. Any dilute or aq is CON . Temperature must be numerical and within range. I heat or warm. CON boil or reflux.
7(a)(ii)	0° ≤ T ≤ 10° and HNO ₂ or NaNO ₂ + HCl	1	A 'T below 10°' etc. CON heat or warm. I sodium nitrate. A nitrous acid.
7(a)(iii)	benzenediazonium chloride / phenyl diazonium chloride	1	A very minor errors, e.g. word order. CON benzyl'benzoyl. I diazo.
7(b)(i)	0 1 2 0 6 3	1	A blank for zero.
7(b)(ii)	6	1	

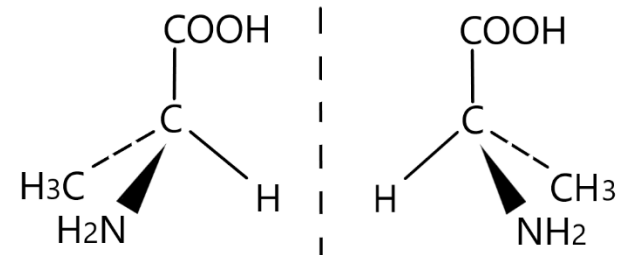
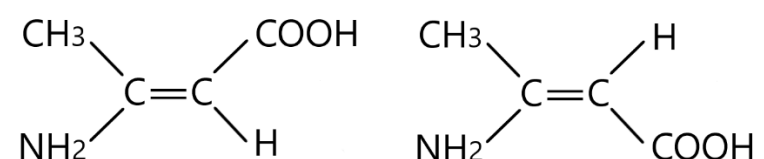
Question	Answer	Marks	Guidance
7(b)(iii)	 dipole Curly arrow from C=O to H⁺ or 	1	I δ^+ on the H⁺. Curly arrow must start on C=O. Any incorrect curly arrow is CON. A in two steps, e.g.  with dipole. Additional charges are CON.

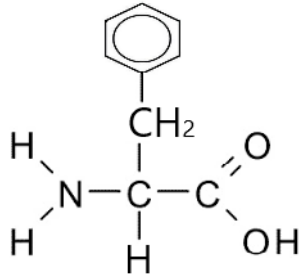
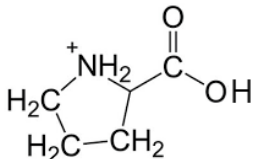
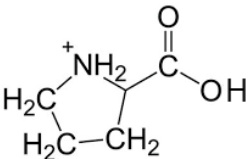
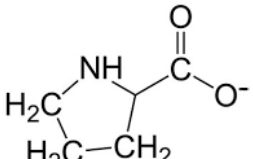
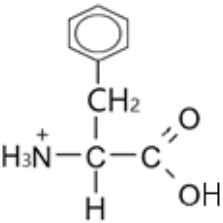
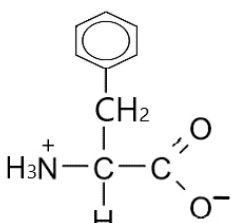
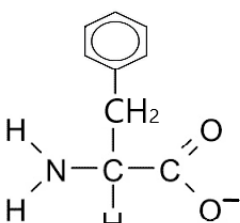
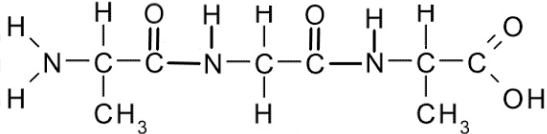
Question	Answer	Marks	Guidance
7(b)(iv)	 M1 CA on leftmost diagram M2 K, showing horseshoe, + charge and H M3 curly arrow on C–H bond in K back into ring Use of quinoid intermediate: M1 as above – curly arrow on leftmost diagram M2 for the intermediate shown at the bottom of guidance. The curly arrow for M3 is shown on this diagram but is not necessary for M2. M3 as above – curly arrow on C–H bond in K back into ring	3	'Usual rules' for K. Centre of + charge must be above a line joining C3 and C5. 'Horseshoe' must include C6, C1 and C2, may include one or both of C3 and C5, must not include C4. I curly arrow showing delocalisation of phenolic LP (LP on oxygen of phenol). CON additional curly arrows Curly arrow must start on or within hexagon and may cross hexagon anywhere. Curly arrow must touch hexagon. 

Question	Answer	Marks	Guidance
7(b)(v)	- less readily - lone pair (LP) on O (of phenol) / p-orbital on O - is delocalised into the ring / overlaps with delocalised ring / π-system - activates ring / more attractive to electrophile / electron (charge) density increased ('electron' inferred if 'LP donated to ring') / becomes more electron rich	2	●✓●✓ two points for one mark, four points for two marks. A LP on OH I LP in phenol. 'Delocalised' or 'joins π system' needed may be awarded without LP if linked to O. I references to polarisation of electrophile (it has a full + charge, stated in the Q) I makes ring more reactive / more susceptible to electrophiles / more negative. I 'O is electron donating'. I 'attracts nucleophile more'.
7(c)(i)	 M1 structure of product (compound H) M2 equation balanced, must have HBr	2	A OH of tertiary alcohol group substituted to bromide as well as ring substitutions and equation with HBr and H₂O on the right.  → product above + H₂O + HBr
7(c)(ii)	electrophilic substitution scroll and SEEN	1	CON nucleophilic substitution unless –OH on sidechain substituted with Br when it becomes I.

Question	Answer	Marks	Guidance
8(a)(i)	$\text{CH}_3\text{COOH} + \text{SOCl}_2 \rightarrow \text{CH}_3\text{COCl} + \text{SO}_2 + \text{HCl}$	1	CON aq.
8(a)(ii)	PCl_3 or PCl_5	1	A names, phosphorus(III) chloride, phosphorus trichloride, phosphorus(V) chloride, phosphorus pentachloride. CON aq, but not in both 8(a)(i) and 8(a)(ii) .
8(a)(iii)	$\begin{array}{c} \text{O} \quad \text{CH}_3 \\ \parallel \quad \\ \text{CH}_3\text{C}-\text{NH}-\text{CH} \\ \\ \text{CH}_3 \end{array}$ or $\text{CH}_3\text{CONHCH}(\text{CH}_3)_2$	1	Or any unambiguous structural or skeletal formula.
8(a)(iv)	$\begin{array}{c} \text{CH}_3 \\ \\ \text{H}_2\text{N}-\text{CH} \\ \\ \text{CH}_3 \end{array}$ or $\text{CH}_3\text{CHNH}_2\text{CH}_3$	1	No ecf from 8(a)(iii) – Q specifies L is an amide and gives the structure of M. NH_2  or skeletal
8(a)(v)	(nucleophilic) addition-elimination	1	No ecf from 8(a)(iii) – Q specifies L is an amide. I 'condensation' – correct but not a mechanism.
8(a)(vi)	LiAlH_4	1	No ecf from 8(a)(iii) – Q specifies L is an amide. CON aq.
8(b)(i)	- r – triplet - s – quartet/quadruplet - t – doublet - u – multiplet	2	●✓●✓ two points for one mark, four points for two marks. A septet, heptet, septuplet.

Question	Answer	Marks	Guidance
8(b)(ii)	M1 one more peak and reference to N-H Subject of Q is 'in CDCl_3' so assume this if no solvent specified. See first two ALLOWs in guidance. M2 H (of NH) is exchanged with D (in D_2O) / $\text{NH} + \text{D} \rightarrow \text{ND} + \text{H}$ / H (of NH) is not exchanged with D (in CDCl_3) the bits in brackets for M2 are not essential but if clearly wrong it is CON	2	A 'NH peak is present'. A 'NH peak is not present in D_2O'. A reference to five peaks or five proton environments and reference to N-H. A 'it is exchanged with D' if NH peak already referred to and you are confident they refer to 'in D_2O'. A 'it is not exchanged with D' if NH peak already referred to and you are confident they refer to 'in CDCl_3'. I 'D_2O replaces the H'.

Question	Answer	Marks	Guidance
9(a)	M1 One pair of diagrams of P with correct use of 3D showing mirror images of two optical isomers  M2 One pair of diagrams showing correct E and Z of Q  M3 Optical or enantiomerism in the right place and Geometric(al) or E / Z or A cis/trans in the right place	3	Q may be given above, and P may be given below. Mirror plane not essential. M3 conditional on optical linked to an attempt on P and geometrical / cistrans / EZ linked to an attempt on Q in M1 and M2.
9(b)(i)	the pH at which (the amino acid is) a zwitterion / no net charge / no overall charge / no total charge electrically neutral / charge is neutral	1	A clear and correct description of zwitterion for second component.

Question	Answer				Marks	Guidance
9(b)(ii)		pH 4.0	pH 5.5	pH 8.0	3	●✓●✓●✓ two structures for one mark, four structures for two marks, six structures for three mark. Phe at 5.5 can be  Table left is repeated larger after 9(c)(iii).
	T					
	U					
9(c)(i)	 M1 – amide links correct M2 – remainder is fully correct, e.g. terminal groups not trailing bonds neutral, zwitterion, 1+ or 1– side/R groups CH₃ – H – CH₃ all H atoms on α-carbons				2	Fully correct [2].
9(c)(ii)	hydrolysis				1	1 acid / alkaline / enzymatic / NS.
9(c)(iii)	condensation				1	1 addition-elimination.