
CHEMISTRY

9701/41

Paper 4 A Level Structured Questions

May/June 2019

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.

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This document consists of **14** printed pages.

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 descriptors 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:

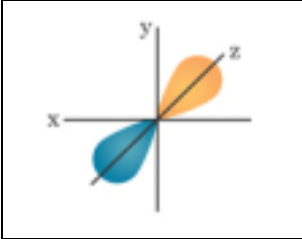
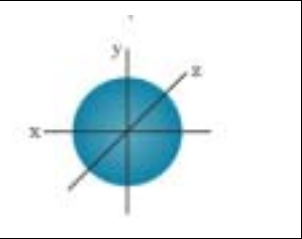
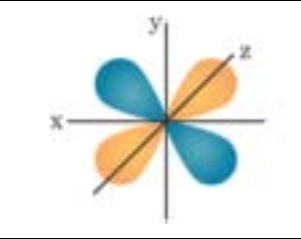
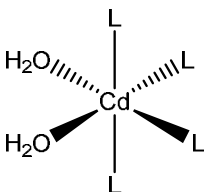
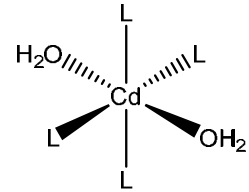
Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Question	Answer	Marks
1(a)	<p>M1 $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 2\text{OH}^- \rightarrow \text{Cu}(\text{OH})_2 + 6\text{H}_2\text{O}$</p> <p>M2 precipitation</p> <p>M3 blue precipitate</p> <p>M4 $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 4\text{Cl}^- \rightarrow \text{CuCl}_4^{2-} + 6\text{H}_2\text{O}$</p> <p>M5 ligand exchange / displacement / substitution / replacement</p> <p>M6 yellow solution</p>	6
1(b)	<p>M1 amount of $\text{Ag}^+ = 0.050 \times 0.0224 = 1.12 \times 10^{-3}$ mol (in 25 cm³) amount of $\text{Ag}^+ = 1.12 \times 10^{-3} \times 4 = 4.48 \times 10^{-3}$ mol (in 100 cm³)</p> <p>M2 amount of $\text{Cl}^- = 4.48 \times 10^{-3}$ mol (in 100 cm³) mass of $\text{Cl}^- = 4.48 \times 10^{-3} \times 35.5 = 0.159$ g (in 100 cm³) mass of S = 0.303 – 0.159 = 0.144 g (in 100 cm³) ecf</p> <p>M3 moles of S = 0.144 / 32.1 = 4.49×10^{-3} molar ratio S : Cl 1:1 → SCl ecf</p>	3

Question	Answer	Marks
2(a)	$\text{Sr}(\text{NO}_3)_2 \rightarrow \text{SrO} + 2\text{NO}_2 + \frac{1}{2}\text{O}_2$	1
2(b)	<p>M1 increases</p> <p>M2 cationic radius / ion size increases (down the group)</p> <p>M3 less polarisation/distortion of anion / nitrate ion / NO_3^- / nitrate group</p>	3
2(c)(i)	more readily and Ca^{2+} has a smaller ionic radius or more readily and Ca^{2+} has a greater charge density	1

Question	Answer	Marks
2(c)(ii)	$3\text{Ba}(\text{NH}_2)_2 \rightarrow \text{Ba}_3\text{N}_2 + 4\text{NH}_3$	1
2(d)	<p>M1 bond angle 104–105°</p> <p>M2 explanation two lone pairs and two bonding pairs</p> <p>M3 lone pairs repel more</p>	3

Question	Answer	Marks
3(a)	$2\text{ClO}_3^- + \text{SO}_2 \rightarrow 2\text{ClO}_2 + \text{SO}_4^{2-}$	1
3(b)(i)	<i>Cl</i> in ClO_2 gets both oxidised and reduced or <i>Cl</i> goes from +4 → +5 and +4 → +3	1
3(b)(ii)	<p>M1 $\text{ClO}_2 + 2\text{OH}^- \rightarrow \text{ClO}_3^- + \text{H}_2\text{O} + \text{e}^-$</p> <p>M2 $\text{ClO}_2 + \text{e}^- \rightarrow \text{ClO}_2^-$</p>	2
3(c)(i)	<p>M1 $\text{Li} \rightarrow \text{Li}^+ + \text{e}^-$ and $\text{I}_2 + 2\text{e}^- \rightarrow 2\text{I}^-$</p> <p>M2 $2\text{Li} + \text{I}_2 \rightarrow 2\text{Li}^+ + 2\text{I}^-$</p>	2
3(c)(ii)	$E^\ominus_{\text{cell}} = 0.54 - (-3.04) = +3.58 \text{ V}$ [1]	1
3(c)(iii)	<p>M1 amount of Li = $0.10 / 6.9 = 1.45 \times 10^{-2} \text{ mol}$ [1]</p> <p>M2 Q needed = $96500 \times 1.45 \times 10^{-2} = 1399$ (1398.55) C [1] ecf</p> <p>M3 $t = 1399 / (2.5 \times 10^{-5}) = 5.6 \times 10^7 \text{ s}$ [1] ecf 2sf min</p>	3

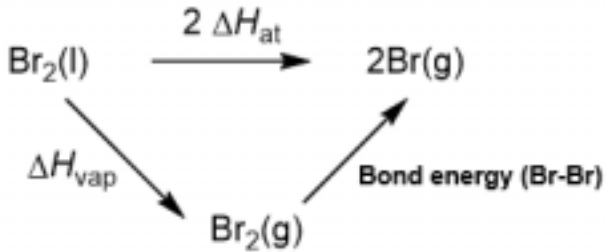
Question	Answer	Marks
4(a)	<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  <p>p</p> </div> <div style="text-align: center;">  <p>s</p> </div> <div style="text-align: center;">  <p>d</p> </div> </div> <p style="text-align: right; margin-right: 20px;">All shapes required for mark</p>	1
4(b)	both cadmium ions have full d subshells	1
4(c)(i)	donates one lone pair to the central metal ion	1
4(c)(ii)	<p>M1 one 3D diagram of $[\text{Cd}(\text{CH}_3\text{NH}_2)_4(\text{H}_2\text{O})_2]^{2+}$</p> <p>M2 cis and trans structures</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  </div> <div style="text-align: center;">  </div> </div>	2
4(d)(i)	equilibrium constant for the formation of a complex ion in solution / solvent [1]	1

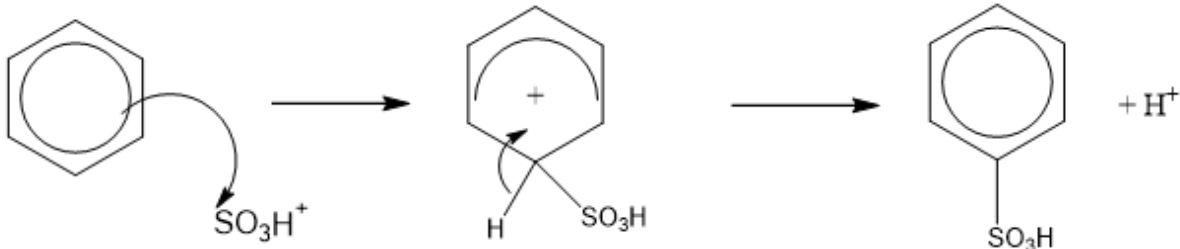
Question	Answer	Marks												
4(d)(ii)	<table border="1"> <tr> <td></td> <td>decreases</td> <td>no change</td> <td>increases</td> </tr> <tr> <td>K_{stab}</td> <td>✓</td> <td></td> <td></td> </tr> <tr> <td>$[\text{Cd}(\text{CH}_3\text{NH}_2)_4(\text{H}_2\text{O})_2]^{2+}$</td> <td>✓</td> <td></td> <td></td> </tr> </table> <p>M1 both ticks correct [1] M2 equilibrium moves to the left as the (forward) reaction is exothermic [1]</p>		decreases	no change	increases	K_{stab}	✓			$[\text{Cd}(\text{CH}_3\text{NH}_2)_4(\text{H}_2\text{O})_2]^{2+}$	✓			2
	decreases	no change	increases											
K_{stab}	✓													
$[\text{Cd}(\text{CH}_3\text{NH}_2)_4(\text{H}_2\text{O})_2]^{2+}$	✓													
4(d)(iii)	$[\text{CdEDTA}]^{2-}$ and larger K_{stab} value	1												
4(e)	$\text{CH}_3\text{NH}_2 + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{NH}_3^+ + \text{OH}^-$	1												
4(f)(i)	<p>$\text{CH}_3\text{COCl} + \text{CH}_3\text{NH}_2 \rightarrow \text{CH}_3\text{CONHCH}_3 + \text{HCl}$</p> <p>M1 Correct formulae of CH_3COCl or $\text{CH}_3\text{CONHCH}_3$ M2 rest of the equation</p>	2												
4(f)(ii)	condensation or addition-elimination	1												

Question	Answer	Marks
5(a)(i)	<p>M1: using expt 2 and 3, $[\text{NH}_3] \times 2$, rate $\times 4$ so order with respect to $[\text{NH}_3] = 2$ M2: using expt 1 and 2, $[\text{ClO}^-] \times 2$ and $[\text{NH}_3] \times 2$, as rate $\times 8 (=2^2 \times 2)$ so order with respect to $[\text{ClO}^-] = 1$</p>	2
5(a)(ii)	rate = $k[\text{NH}_3]^2[\text{ClO}^-]$	1
5(a)(iii)	<p>M1: $k = 0.256 / (0.200 \times 0.100^2)$ $k = 128$ M2: Units $\text{dm}^6 \text{mol}^{-2} \text{s}^{-1}$</p>	2

Question	Answer	Marks
5(a)(iv)	curve / line showing k increasing as temperature increases	1
5(b)(i)	M1: plot a graph of $[I^-]$ against time M2: constant half-lives	2
5(b)(ii)	$ClO^- + I^- \rightarrow IO^- + Cl^-$	1
5(b)(iii)	step 2 and Cl is reduced / oxid no. decreases / oxid no. $+1 \rightarrow -1$ or step 2 and I is oxidised / oxid no. increases / oxid no. $-1 \rightarrow +1$	1

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Question	Answer	Marks												
6(a)	<table border="1" data-bbox="663 217 1610 448"> <tr> <td>energy change</td> <td>always positive</td> <td>always negative</td> <td>either negative or positive</td> </tr> <tr> <td>bond energy</td> <td>✓</td> <td></td> <td></td> </tr> <tr> <td>enthalpy of formation</td> <td></td> <td></td> <td>✓</td> </tr> </table> <p data-bbox="320 451 555 480">both ticks correct</p>	energy change	always positive	always negative	either negative or positive	bond energy	✓			enthalpy of formation			✓	1
energy change	always positive	always negative	either negative or positive											
bond energy	✓													
enthalpy of formation			✓											
6(b)	(energy change) when 1 mole of gaseous atoms are formed (from an element in its standard state)	1												
6(c)	 <p data-bbox="320 866 920 895">M1: correct cycle: formulae and state symbols</p> <p data-bbox="320 938 752 967">M2: use of 1×193 and $2 \times (112)$</p> <p data-bbox="320 1007 958 1035">M3: for the correct sum and answer ecf from M2</p> <p data-bbox="320 1078 1149 1107">$\Delta H_{\text{vap}}^{\ominus} (= (2 \times 112) - (193)) = +31 \text{ kJ mol}^{-1}$ [scores M2 and M3]</p>	3												
6(d)	more endothermic and greater Van der Waals / London / induced dipole-dipole forces both	1												
6(e)(i)	(energy change) when 1 mole of gaseous ions is dissolved in (an excess of) water	1												
6(e)(ii)	<p data-bbox="320 1278 730 1307">M1: Br has a smaller ionic radii</p> <p data-bbox="320 1347 1066 1375">M2: stronger (ion-dipole) attractions with water molecules</p>	2												

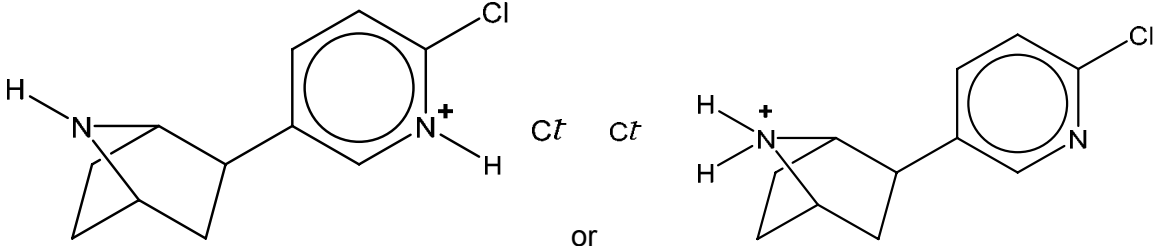
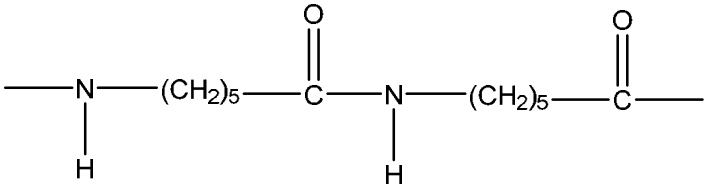
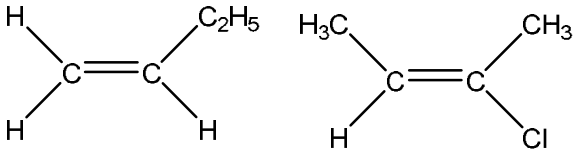
Question	Answer	Marks
7(a)(i)	M1: reduction / hydrogenation M2: H ₂ + Ni / Pt catalyst	2
7(a)(ii)	M1: benzene (120°) <u>and</u> cyclohexane (109.5°) M2: as π-bonds are transformed into σ-bonds	2
7(b)(i)	 M1: first curly arrow to the sulfur atom M2: intermediate shown M3: 2nd curly arrow and H ⁺ formed / lost	3
7(b)(ii)	HSO ₄ ⁻ + H ⁺ → H ₂ SO ₄	1
7(c)	M1: C ₁₂ H ₂₅ Br and halogen carrier e.g. AlBr ₃ (+ heat) M2: electrophilic substitution	2
7(d)(i)	$K_{a2} = \frac{[\text{H}^+][\text{SO}_4^{2-}]}{[\text{HSO}_4^-]}$	1
7(d)(ii)	K _a of H ₂ SO ₄ is larger than K _{a2}	1

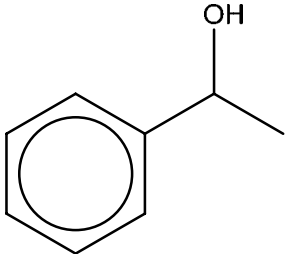
Question	Answer	Marks
7(e)	M1: $[H^+] = 10^{-2.90} = 1.26 \times 10^{-3}$ M2: $K_a = [1.26 \times 10^{-3}]^2 / 0.025 = 6.3 \times 10^{-5} \text{ (mol dm}^{-3}\text{)}$	2

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Question	Answer	Marks
8(a)(i)	no. of carbons = $100 \times 1.25 / (22.65 \times 1.1)$ (= 5.02)	1
8(a)(ii)	M1: C ₂ H ₅ O M2: C ₃ H ₅ O ⁺ (positive sign required for m / e = 57 fragment)	2
8(b)	TMS: Reference CDCl ₃ : Solvent	1
8(c)(i)	M1: CH ₃ CO M2: CH ₃ CH ₂ O M3: (CO)CH ₂ O	3
8(c)(ii)	CH ₃ COCH ₂ OCH ₂ CH ₃	1
8(d)	HCO ₂ C(CH ₃) ₃	1
8(e)(i)	this is a (carbon) atom which has four different atoms or groups attached to it	1
8(e)(ii)	CH ₃ CH ₂ CH(CH ₃)COOH	1

Question	Answer	Marks
9(a)	M1: CH ₃ COCl > CH ₃ CH ₂ Cl > C ₆ H ₅ Cl M2 & M3 any two from: <ul style="list-style-type: none"> in C₆H₅Cl (no hydrolysis) C-Cl bond is part of delocalised system OR p-orbital on Cl overlaps with π system OR electrons from Cl overlap with π system CH₃COCl carbon in C-Cl bond is more electron deficient since it is also attached to an oxygen atom (ora) or C-Cl bond strength is weakest in CH₃COCl (ora) CH₃CH₂Cl carbon in C-Cl bond strengthened by positive inductive effect of alkyl group 	3

Question	Answer	Marks												
9(b)(i)	partially ionised and proton acceptor	1												
9(b)(ii)		1												
9(c)(i)	<table border="1" data-bbox="627 571 1646 774"> <thead> <tr> <th></th> <th>σ-bonds only</th> <th>π-bonds only</th> <th>both σ- and π-bonds</th> </tr> </thead> <tbody> <tr> <td>bonds broken</td> <td></td> <td></td> <td>✓</td> </tr> <tr> <td>bonds formed</td> <td></td> <td></td> <td>✓</td> </tr> </tbody> </table> <p>Both ticks correct</p>		σ -bonds only	π -bonds only	both σ - and π -bonds	bonds broken			✓	bonds formed			✓	1
	σ -bonds only	π -bonds only	both σ - and π -bonds											
bonds broken			✓											
bonds formed			✓											
9(c)(ii)	 <p>M1: amide link M2: rest of the structure</p>	2												
9(d)	 <p>or $\text{CH}_3\text{CCl}=\text{CH}_2$ and $\text{C}_2\text{H}_5\text{CH}=\text{CHCH}_3$ each correct structure scores one mark</p>	2												

Question	Answer	Marks
9(e)	C-C bonds are non-polar / polyalkenes cannot be hydrolysed and polyamides can be broken down by hydrolysis	1
9(f)(i)		1
9(f)(ii)	M1: step 1: $\text{CH}_3\text{COCl} + \text{AlCl}_3$ [1] M2: step 2: $\text{NaBH}_4 / \text{LiAlH}_4$ [1] M3: step 3: conc. H_2SO_4 , heat [1]	3