

---

**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.

Cambridge International is publishing the mark schemes for the May/June 2019 series for most Cambridge IGCSE™, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

---

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.

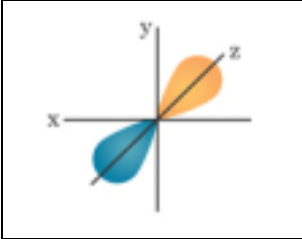
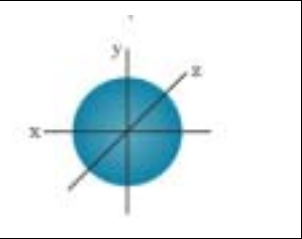
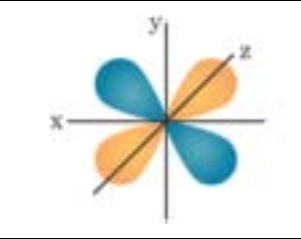
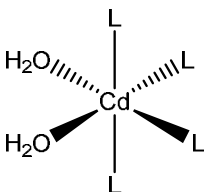
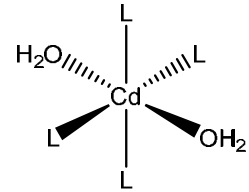
Question	Answer	Marks
1(a)	<p><b>M1</b> <math>[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 2\text{OH}^- \rightarrow \text{Cu}(\text{OH})_2 + 6\text{H}_2\text{O}</math></p> <p><b>M2</b> precipitation</p> <p><b>M3</b> blue precipitate</p> <p><b>M4</b> <math>[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 4\text{Cl}^-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

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

**PUBLISHED**

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><b>M1</b> bond angle 104–105°</p> <p><b>M2</b> <b>explanation</b> two lone pairs and two bonding pairs</p> <p><b>M3</b> 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 $\text{ClO}_2$ gets both oxidised and reduced <b>or</b> <i>Cl</i> goes from +4 → +5 and +4 → +3	1
3(b)(ii)	<p><b>M1</b> <math>\text{ClO}_2 + 2\text{OH}^- \rightarrow \text{ClO}_3^- + \text{H}_2\text{O} + \text{e}^-</math></p> <p><b>M2</b> <math>\text{ClO}_2 + \text{e}^- \rightarrow \text{ClO}_2^-</math></p>	2
3(c)(i)	<p><b>M1</b> <math>\text{Li} \rightarrow \text{Li}^+ + \text{e}^-</math> <b>and</b> <math>\text{I}_2 + 2\text{e}^- \rightarrow 2\text{I}^-</math></p> <p><b>M2</b> <math>2\text{Li} + \text{I}_2 \rightarrow 2\text{Li}^+ + 2\text{I}^-</math></p>	2
3(c)(ii)	$E^\ominus_{\text{cell}} = 0.54 - (-3.04) = \mathbf{+3.58\text{ V}}$ [1]	1
3(c)(iii)	<p><b>M1</b> amount of Li = <math>0.10 / 6.9 = 1.45 \times 10^{-2}</math> mol [1]</p> <p><b>M2</b> Q needed = <math>96500 \times 1.45 \times 10^{-2} = \mathbf{1399}</math> (1398.55) C [1] ecf</p> <p><b>M3</b> <math>t = 1399 / (2.5 \times 10^{-5}) = \mathbf{5.6 \times 10^7}</math> 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;"><b>All shapes required for mark</b></p>	<b>1</b>
4(b)	both cadmium ions have full d subshells	<b>1</b>
4(c)(i)	donates one lone pair to the central metal ion	<b>1</b>
4(c)(ii)	<p><b>M1</b> one 3D diagram of <math>[\text{Cd}(\text{CH}_3\text{NH}_2)_4(\text{H}_2\text{O})_2]^{2+}</math></p> <p><b>M2</b> cis <b>and</b> 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>	<b>2</b>
4(d)(i)	equilibrium constant for the formation of a complex ion in solution / solvent [1]	<b>1</b>

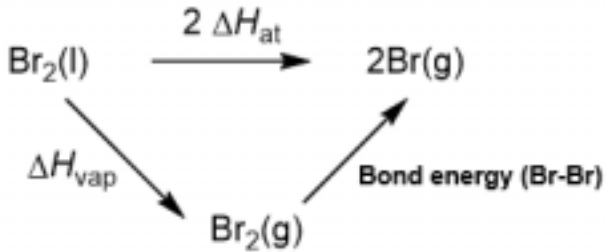
Question	Answer	Marks												
4(d)(ii)	<table border="1"> <tr> <td></td> <td>decreases</td> <td>no change</td> <td>increases</td> </tr> <tr> <td><math>K_{\text{stab}}</math></td> <td>✓</td> <td></td> <td></td> </tr> <tr> <td><math>[\text{Cd}(\text{CH}_3\text{NH}_2)_4(\text{H}_2\text{O})_2]^{2+}</math>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

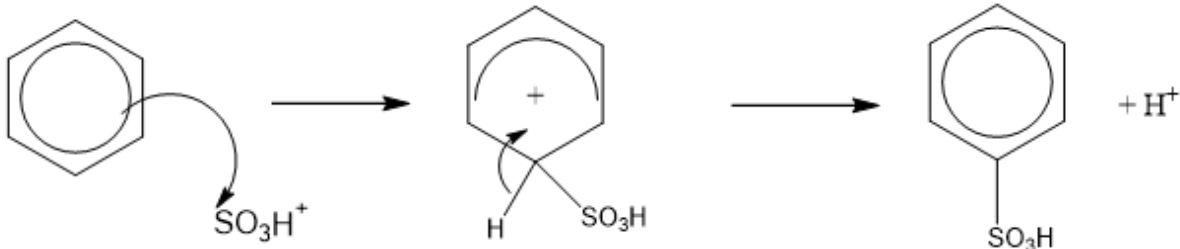
Question	Answer	Marks
5(a)(i)	<p><b>M1:</b> using expt 2 and 3, <math>[\text{NH}_3] \times 2</math>, rate <math>\times 4</math> so order with respect to <math>[\text{NH}_3] = 2</math> <b>M2:</b> using expt 1 and 2, <math>[\text{ClO}^-] \times 2</math> and <math>[\text{NH}_3] \times 2</math>, as rate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

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



**PUBLISHED**

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"><b>both</b> ticks correct</p>	energy change	always positive	always negative	either negative or positive	bond energy	✓			enthalpy of formation			✓	<b>1</b>
energy change	always positive	always negative	either negative or positive											
bond energy	✓													
enthalpy of formation			✓											
6(b)	(energy change) when <b>1 mole</b> of <b>gaseous atoms</b> are formed (from an element in its standard state)	<b>1</b>												
6(c)	 <p data-bbox="320 866 920 895"><b>M1:</b> correct cycle: formulae and state symbols</p> <p data-bbox="320 938 752 967"><b>M2:</b> use of <math>1 \times 193</math> <b>and</b> <math>2 \times (112)</math></p> <p data-bbox="320 1010 958 1038"><b>M3:</b> for the correct sum and answer ecf from M2</p> <p data-bbox="320 1082 1144 1110"><math>\Delta H_{\text{vap}}^{\ominus} (= (2 \times 112) - (193)) = +31 \text{ kJ mol}^{-1}</math> [scores M2 and M3]</p>	<b>3</b>												
6(d)	more endothermic <b>and</b> greater Van der Waals / London / induced dipole-dipole forces <b>both</b>	<b>1</b>												
6(e)(i)	(energy change) when <b>1 mole</b> of <b>gaseous ions</b> is dissolved in (an excess of) water	<b>1</b>												
6(e)(ii)	<p data-bbox="320 1278 730 1307"><b>M1:</b> Br has a smaller ionic radii</p> <p data-bbox="320 1350 1066 1378"><b>M2:</b> stronger (ion-dipole) attractions with water molecules</p>	<b>2</b>												

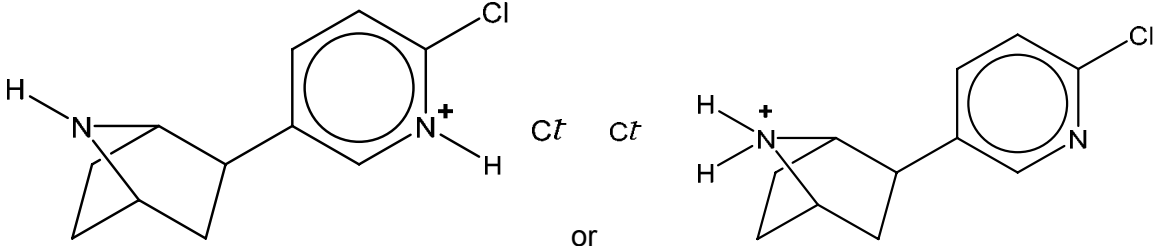
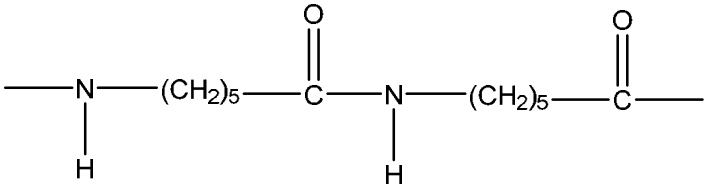
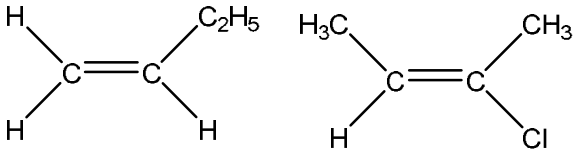
Question	Answer	Marks
7(a)(i)	<b>M1:</b> reduction / hydrogenation <b>M2:</b> H <sub>2</sub> + Ni / Pt catalyst	2
7(a)(ii)	<b>M1:</b> benzene ( <b>120°</b> ) <u>and</u> cyclohexane ( <b>109.5°</b> ) <b>M2:</b> as π-bonds are transformed into σ-bonds	2
7(b)(i)	 <p><b>M1:</b> first curly arrow to the sulfur atom  <b>M2:</b> intermediate shown  <b>M3:</b> 2nd curly arrow and H<sup>+</sup> formed / lost</p>	3
7(b)(ii)	HSO <sub>4</sub> <sup>-</sup> + H <sup>+</sup> → H <sub>2</sub> SO <sub>4</sub>	1
7(c)	<b>M1:</b> C <sub>12</sub> H <sub>25</sub> Br <b>and</b> halogen carrier e.g. AlBr <sub>3</sub> (+ heat) <b>M2:</b> electrophilic substitution	2
7(d)(i)	$K_{a2} = \frac{[H^+][SO_4^{2-}]}{[HSO_4^-]}$	1
7(d)(ii)	K <sub>a</sub> of H <sub>2</sub> SO <sub>4</sub> is larger than K <sub>a2</sub>	1

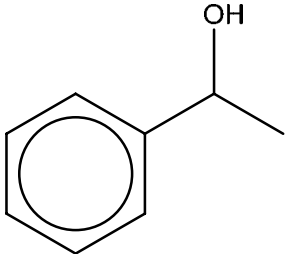
Question	Answer	Marks
7(e)	<b>M1:</b> $[H^+] = 10^{-2.90} = 1.26 \times 10^{-3}$ <b>M2:</b> $K_a = [1.26 \times 10^{-3}]^2 / 0.025 = 6.3 \times 10^{-5} \text{ (mol dm}^{-3}\text{)}$	<b>2</b>

## PUBLISHED

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

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

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

Question	Answer	Marks
9(e)	C-C bonds are non-polar / polyalkenes cannot be hydrolysed <b>and</b> polyamides can be broken down by hydrolysis	<b>1</b>
9(f)(i)		<b>1</b>
9(f)(ii)	<b>M1:</b> step 1: $\text{CH}_3\text{COCl} + \text{AlCl}_3$ [1] <b>M2:</b> step 2: $\text{NaBH}_4 / \text{LiAlH}_4$ [1] <b>M3:</b> step 3: conc. $\text{H}_2\text{SO}_4$ , heat [1]	<b>3</b>