Cambridge International AS & A Level

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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.

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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.

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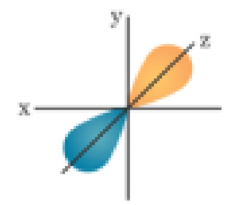
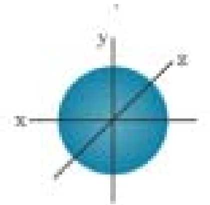
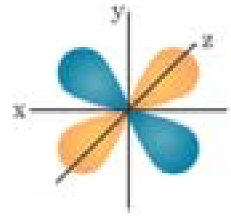
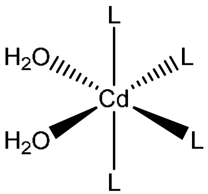
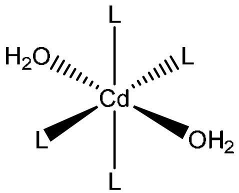
GENERIC MARKING PRINCIPLE 5: Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).
GENERIC MARKING PRINCIPLE 6: Marks awarded are based solely 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)	**M1** $[Cu(H_2O)_6]^{2+} + 2OH^- \rightarrow Cu(OH)_2 + 6H_2O$ **M2** precipitation **M3** blue precipitate **M4** $[Cu(H_2O)_6]^{2+} + 4Cl^- \rightarrow CuCl_4^{2-} + 6H_2O$ **M5** **ligand** exchange / displacement / substitution / replacement **M6** yellow solution	6
1(b)	**M1** amount of $Ag^+ = 0.050 \times 0.0224 = 1.12 \times 10^{-3}$ mol (in 25 cm^3) amount of $Ag^+ = 1.12 \times 10^{-3} \times 4$ = **4.48×10^{-3} mol (in 100 cm^3)** **M2** amount of $Cl^- = 4.48 \times 10^{-3}$ mol (in 100 cm^3) mass of $Cl^- = 4.48 \times 10^{-3} \times 35.5 = 0.159$ g (in 100 cm^3) mass of S = 0.303 – 0.159 = **0.144 g (in 100 cm^3)** ecf **M3** moles of S = 0.144 / 32.1 = 4.49×10^{-3} molar ratio S : Cl 1:1 → **SCl** ecf	3

Question	Answer	Marks
2(a)	$Sr(NO_3)_2 \rightarrow SrO + 2NO_2 + \frac{1}{2}O_2$	1
2(b)	**M1** increases **M2** cationic radius / ion size **increases** (down the group) **M3** less polarisation/distortion of anion / nitrate ion / NO_3^- / nitrate group	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)	$3Ba(NH_2)_2 \rightarrow Ba_3N_2 + 4NH_3$	**1**
2(d)	**M1** bond angle 104–105° **M2** **explanation** two lone pairs and two bonding pairs **M3** lone pairs repel more	**3**

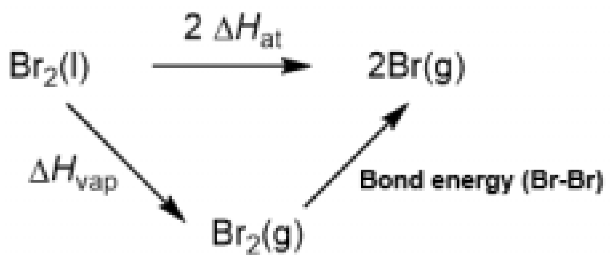
Question	Answer	Marks
3(a)	$2ClO_3^- + SO_2 \rightarrow 2ClO_2 + SO_4^{2-}$	**1**
3(b)(i)	Cl in ClO_2 gets both oxidised and reduced **or** Cl goes from +4 → +5 and +4 → +3	**1**
3(b)(ii)	**M1** $ClO_2 + 2OH^- \rightarrow ClO_3^- + H_2O + e^-$ **M2** $ClO_2 + e^- \rightarrow ClO_2^-$	**2**
3(c)(i)	**M1** $Li \rightarrow Li^+ + e^-$ **and** $I_2 + 2e^- \rightarrow 2I^-$ **M2** $2Li + I_2 \rightarrow 2Li^+ + 2I^-$	**2**
3(c)(ii)	$E^{\ominus}_{cell}$ = 0.54 –(–3.04) = **+3.58 V** [1]	**1**
3(c)(iii)	**M1** amount of Li = 0.10 / 6.9 = 1.45×10^{-2} mol [1] **M2** Q needed = $96500 \times 1.45 \times 10^{-2}$ = **1399** (1398.55) C [1] ecf **M3** t = 1399 / (2.5×10^{-5}) = $\mathbf{5.6 \times 10^7}$ s [1] ecf 2sf min	**3**

Question	Answer	Marks
4(a)	 p  s  d **All shapes required for mark**	**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)	**M1** one 3D diagram of $[Cd(CH_3NH_2)_4(H_2O)_2]^{2+}$ **M2** cis **and** trans structures  	**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><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>$[[Cd(CH_3NH_2)_4(H_2O)_2]^{2+}]$</td><td>✓</td><td></td><td></td></tr></table> **M1** **both** ticks correct [1] **M2** equilibrium moves to the left as the (forward) reaction is exothermic [1]	**2**
4(d)(iii)	$[CdEDTA]^{2-}$ **and** larg**er** K_{stab} value	**1**
4(e)	$CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$	**1**
4(f)(i)	$CH_3COCl + CH_3NH_2 \rightarrow CH_3CONHCH_3 + HCl$ **M1** Correct formulae of CH_3COCl **or** $CH_3CONHCH_3$ **M2** rest of the equation	**2**
4(f)(ii)	condensation or addition-elimination	**1**

Question	Answer	Marks
5(a)(i)	**M1**: using expt 2 and 3, $[NH_3] \times 2$, rate $\times$ 4 so order with respect to $[NH_3]$ = 2 **M2**: using expt 1 and 2, $[ClO^-] \times 2$ and $[NH_3] \times 2$, as rate $\times$ 8 (=2^2 * x) so order with respect to $[ClO^-]$ = 1	**2**
5(a)(ii)	rate = $k[NH_3]^2[ClO^-]$	**1**
5(a)(iii)	**M1:** $k = 0.256 / (0.200 \times 0.100^2)$ $k = 128$ **M2:** Units $dm^6\ mol^{-2}\ s^{-1}$	**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 → –1 ***or*** step 2 **and** I is oxidised / oxid no. increases / oxid no. –1 → +1	**1**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>6(a)</td><td>
<table>
<tr><th>energy change</th><th>always positive</th><th>always negative</th><th>either negative or positive</th></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>
both ticks correct</td><td>1</td></tr>
<tr><td>6(b)</td><td>(energy change) when 1 mole of gaseous atoms are formed (from an element in its standard state)</td><td>1</td></tr>
<tr><td>6(c)</td><td>


M1: correct cycle: formulae and state symbols

M2: use of 1 × 193 and 2 × (112)

M3: for the correct sum and answer ecf from M2

$\Delta H^{\ominus}_{vap}$ (= (2 × 112) – (193)) = +31 kJ mol^{-1} [scores M2 and M3]</td><td>3</td></tr>
<tr><td>6(d)</td><td>more endothermic and greater Van der Waals / London / induced dipole-dipole forces both</td><td>1</td></tr>
<tr><td>6(e)(i)</td><td>(energy change) when 1 mole of gaseous ions is dissolved in (an excess of) water</td><td>1</td></tr>
<tr><td>6(e)(ii)</td><td>M1: Br^{-} has a smaller ionic radii

M2: stronger (ion-dipole) attractions with water molecules</td><td>2</td></tr>
</table>

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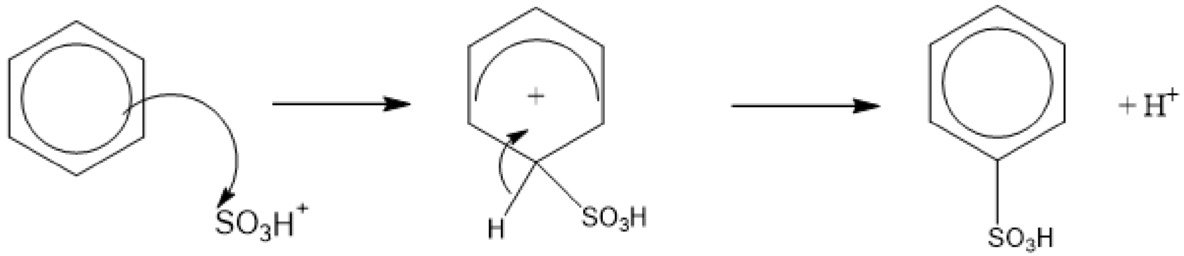
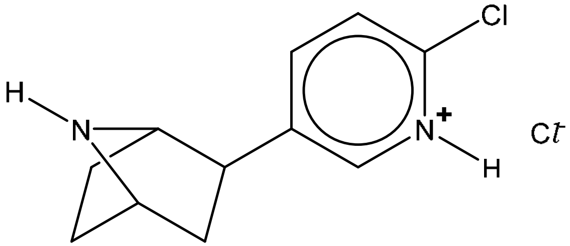
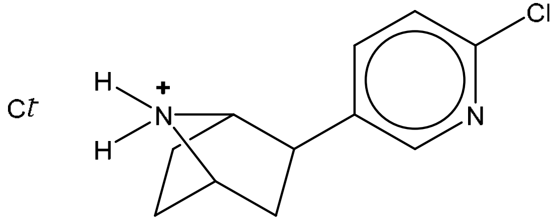
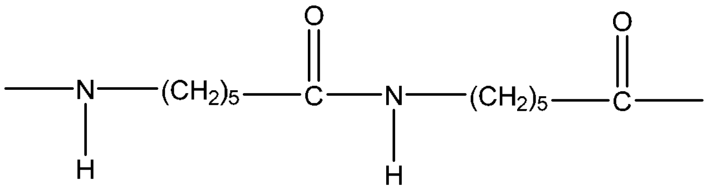
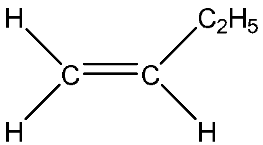
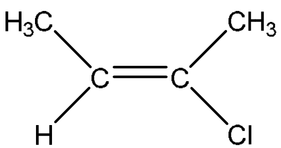
Question	Answer	Marks
7(a)(i)	**M1**: reduction / hydrogenation **M2**: H_2 + Ni / Pt catalyst	**2**
7(a)(ii)	**M1**: benzene (**120°**) <u>and</u> cyclohexane (**109.5°**) **M2**: as π-bonds are transformed into σ-bonds	**2**
7(b)(i)	 **M1**: first curly arrow to the sulfur atom **M2**: intermediate shown **M3**: 2nd curly arrow and H^+ formed / lost	**3**
7(b)(ii)	$HSO_4^- + H^+ \rightarrow H_2SO_4$	**1**
7(c)	**M1**: $C_{12}H_{25}Br$ **and** halogen carrier e.g. $AlBr_3$ (+ heat) **M2**: electrophilic substitution	**2**
7(d)(i)	$K_{a2} = \frac{[H^+][SO_4^{2-}]}{[HSO_4^-]}$	**1**
7(d)(ii)	K_a of H_2SO_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 × 10^−5^** (mol dm^−3^)	**2**

Question	Answer	Marks
8(a)(i)	no. of carbons = 100 × 1.25 / (22.65 × 1.1) (= **5.02)**	1
8(a)(ii)	M1: C_2H_5O M2: $C_3H_5O^+$ (positive sign required for m / e = 57 fragment)	2
8(b)	TMS: Reference $CDCl_3$: Solvent	1
8(c)(i)	**M1**: CH_3CO **M2**: CH_3CH_2O **M3**: $(CO)CH_2O$	3
8(c)(ii)	$CH_3COCH_2OCH_2CH_3$	1
8(d)	$HCO_2C(CH_3)_3$	1
8(e)(i)	this is a (carbon) atom which has four different atoms or groups attached to it	1
8(e)(ii)	$CH_3CH_2CH(CH_3)COOH$	1

Question	Answer	Marks
9(a)	**M1**: CH_3COCl > CH_3CH_2Cl > C_6H_5Cl **M2 & M3 any two from:** • in C_6H_5Cl (no hydrolysis) C-C*l* bond is part of delocalised system **OR** p-orbital on C*l* overlaps with π system **OR** electrons from C*l* overlap with π system • CH_3COCl carbon in C-C*l* bond is more electron deficient since it is also attached to an oxygen atom (ora) **or** C-C*l* bond strength is weakest in CH_3COCl (ora) • CH_3CH_2Cl carbon in C-C*l* bond strengthened by positive inductive effect of alkyl group	3

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>9(b)(i)</td><td>partially ionised and proton acceptor</td><td>1</td></tr>
<tr><td>9(b)(ii)</td><td> or </td><td>1</td></tr>
<tr><td>9(c)(i)</td><td>
<table>
<tr><th></th><th>σ-bonds only</th><th>π-bonds only</th><th>both σ- and π-bonds</th></tr>
<tr><td>bonds broken</td><td></td><td></td><td>✓</td></tr>
<tr><td>bonds formed</td><td></td><td></td><td>✓</td></tr>
</table>
Both ticks correct</td><td>1</td></tr>
<tr><td>9(c)(ii)</td><td>
M1: amide link
M2: rest of the structure</td><td>2</td></tr>
<tr><td>9(d)</td><td> 
or $CH_3CCl{=}CH_2$ and $C_2H_5CH{=}CHCH_3$ each correct structure scores one mark</td><td>2</td></tr>
</table>

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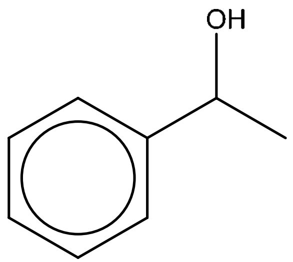
Question	Answer	Marks
9(e)	C-C bonds are non-polar / polyalkenes cannot be hydrolysed **and** polyamides can be broken down by hydrolysis	1
9(f)(i)		1
9(f)(ii)	**M1**: step 1: CH_3COCl + $AlCl_3$ [1] **M2**: step 2: $NaBH_4$ / $LiAlH_4$ [1] **M3**: step 3: conc. H_2SO_4, heat [1]	3