

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the March 2016 series

9701 CHEMISTRY

9701/42

Paper 4 (A Level Structured Questions),
maximum raw mark 100

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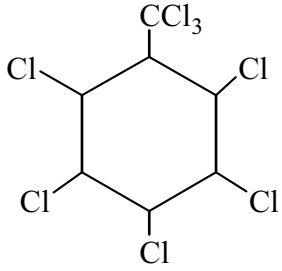
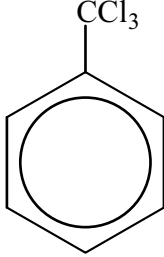
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Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – March 2016	9701	42

Question	Answer	Mark																
1 (a)	<p>Increasing energy ↑</p> <table style="margin-left: auto; margin-right: auto;"> <tr> <td>2p</td> <td>↑ ↑</td> <td>↑</td> <td>↑ ↑ ↑</td> </tr> <tr> <td>2s</td> <td>↑ ↓</td> <td>↑ ↓</td> <td>↑ ↓</td> </tr> <tr> <td>1s</td> <td>↑ ↓</td> <td>↑ ↓</td> <td>↑ ↓</td> </tr> <tr> <td></td> <td>carbon atom</td> <td>C⁺ ion</td> <td>C⁻ ion</td> </tr> </table>	2p	↑ ↑	↑	↑ ↑ ↑	2s	↑ ↓	↑ ↓	↑ ↓	1s	↑ ↓	↑ ↓	↑ ↓		carbon atom	C ⁺ ion	C ⁻ ion	2
2p	↑ ↑	↑	↑ ↑ ↑															
2s	↑ ↓	↑ ↓	↑ ↓															
1s	↑ ↓	↑ ↓	↑ ↓															
	carbon atom	C ⁺ ion	C ⁻ ion															
(b) (i)	sp ²	1																
(ii)	x = 60 / C ₆₀ H ₆₀	1																
(c) (i)	reaction 1: Cl ₂ and UV light; reaction 2: AlCl ₃ , Cl ₂ (NOT aqueous);	1 1																
(ii)	(free) radical substitution	1																
(iii)	<div style="display: flex; align-items: center; justify-content: center;"> <div style="text-align: center;">  </div> <div style="margin: 0 20px;"><i>or</i></div> <div style="text-align: center;">  </div> </div>	1																

Page 3	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark										
2 (a) (i)	$\text{Ca}^{2+}(\text{g}) + 2\text{Cl}^{-}(\text{g}) \rightarrow \text{CaCl}_2(\text{s})$ (state symbols required)	1										
(ii)		2										
(iii)	$\Delta H_{\text{latt}}^{\ominus} = -796 - 242 - 178 - 590 - 1150 + (2 \times 349) = -2258 \text{ kJ mol}^{-1}$	3										
(b)	(higher temperature means that) particles have more energy; entropy (of the gas/system) increases because of an increase in the amount of disorder/randomness;	2										
(c) (i)	<table border="1"> <thead> <tr> <th>reaction</th> <th>sign of ΔS^{\ominus}</th> </tr> </thead> <tbody> <tr> <td>$\text{CO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$</td> <td>negative</td> </tr> <tr> <td>$\text{Mg}(\text{s}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{MgO}(\text{s})$</td> <td>negative</td> </tr> <tr> <td>$\text{CuSO}_4(\text{s}) + 5\text{H}_2\text{O}(\text{l}) \rightarrow \text{CuSO}_4 \cdot 5\text{H}_2\text{O}(\text{s})$</td> <td>negative</td> </tr> <tr> <td>$\text{NaHCO}_3(\text{s}) + \text{H}^+(\text{aq}) \rightarrow \text{Na}^+(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$</td> <td>positive</td> </tr> </tbody> </table>	reaction	sign of ΔS^{\ominus}	$\text{CO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$	negative	$\text{Mg}(\text{s}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{MgO}(\text{s})$	negative	$\text{CuSO}_4(\text{s}) + 5\text{H}_2\text{O}(\text{l}) \rightarrow \text{CuSO}_4 \cdot 5\text{H}_2\text{O}(\text{s})$	negative	$\text{NaHCO}_3(\text{s}) + \text{H}^+(\text{aq}) \rightarrow \text{Na}^+(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$	positive	2
reaction	sign of ΔS^{\ominus}											
$\text{CO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$	negative											
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$\text{CuSO}_4(\text{s}) + 5\text{H}_2\text{O}(\text{l}) \rightarrow \text{CuSO}_4 \cdot 5\text{H}_2\text{O}(\text{s})$	negative											
$\text{NaHCO}_3(\text{s}) + \text{H}^+(\text{aq}) \rightarrow \text{Na}^+(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$	positive											
(ii)	there is a reduction in the overall number of <u>gaseous</u> molecules	1										
(d)	$\Delta S_{\text{f}}^{\ominus} = 386 - (192 + (3 \times 131))$ $= -199 \text{ (JK}^{-1} \text{ mol}^{-1}\text{)}$	2										
(e) (i)	$\Delta G^{\ominus} = \Delta H^{\ominus} - T\Delta S^{\ominus}$ $= 117 - ((298 \times 175) / 1000)$ $= (+) 64.85 \text{ (kJ mol}^{-1}\text{)}$	2										
(ii)	<u>ΔG^{\ominus} is positive</u> and so the reaction is <u>not spontaneous</u> (at 298 K)	1										

Page 4	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
3 (a)	Co [Ar] 3d ⁷ 4s ² Co ²⁺ [Ar] 3d ⁷	1 1
(b)		1
(c) (i)	[Co(Cl) ₃ (H ₂ O) ₃] ⁻	1
(ii)		2
(d) (i)	[Pt(Cl) ₂ (NH ₃) ₂]	1
(ii)	<p>M1, M2: diagrams M3: names</p> <p>cis-platin / cis-diamminedichloroplatinum(II)</p> <p>trans-platin / trans-diamminedichloroplatinum(II)</p>	2 1
(iii)	(<i>cis</i> isomer) this can react / bond / bind with <u>DNA</u> ; which prevents replication of the strand / prevents cell division;	1 1
(e) (i)	<p>M1: formula M2: units (ecf from formula)</p> $K_{\text{stab}} = \frac{[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}}{[\text{Cu}(\text{H}_2\text{O})_6]^{2+}[\text{NH}_3]^4} \text{ mol}^{-4} \text{ dm}^{12}$	1 1
(ii)	(large value of K_{stab} shows that) the tetrammine complex is more stable	1

Page 5	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
4 (a) (i)	1 st order	1
(ii)	1 st order	1
(iii)	rate = $k[\text{CH}_3\text{CHO}][\text{OH}^-]$	1
(iv)	$\text{mol}^{-1} \text{dm}^3 \text{s}^{-1}$ (or per any suitable time unit)	1
(v)	calculation from candidate's answer to (iii) (expected answer = 6)	1
(b) (i)	rate-determining step: step 1 explanation: both reactant species are in step 1 / rate-determining step	1 1
(ii)	acid / proton donor / acidic behaviour	1
(c)	nucleophilic addition	1
(d)	<p>M1: both curly arrows M2: dipole correctly shown</p>	1 1


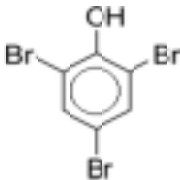

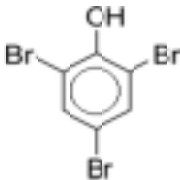

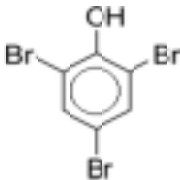
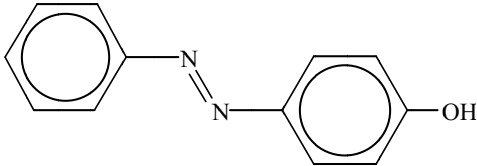
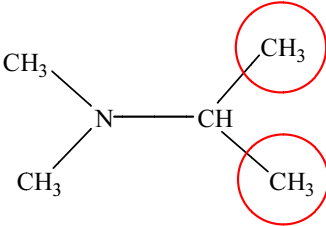
Page 6	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
5 (a) (i)	any metal with an E^\ominus value more negative than -0.41 V , e.g. Fe, Mn, Zn, Mg, Cr, Al R: Li/Na/K/Ca/Ba	1
(ii)	M1: value of E_{cell} correctly calculated (with correct sign) for metal named in (i) M2: E^\ominus_{cell} is positive and so reaction is feasible	1 1
(b)	M1: $(\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightleftharpoons 2\text{Cr}^{3+} + 7\text{H}_2\text{O}) \quad E^\ominus = +1.33\text{ V}$ $(\text{H}_2\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}) \quad E^\ominus = +1.77\text{ V}$ $E^\ominus_{\text{cell}} = 0.44\text{ (V)}$ M2: E^\ominus_{cell} (0.44 V) is positive (so the reaction is feasible) / $E^\ominus(\text{Cr}_2\text{O}_7^{2-}/\text{Cr}^{3+})$ is less positive than $E^\ominus(\text{H}_2\text{O}_2/\text{H}_2\text{O})$	1 1
(c)	M1: $\text{Cr}_2\text{O}_7^{2-}$: ox.no Cr = +6 because $-2 = 2 \times \text{ox.no}(\text{Cr}) + (7 \times -2)$ CrO_4^{2-} : ox.no Cr = +6 because $-2 = \text{ox.no}(\text{Cr}) + (4 \times -2)$ M2: no change in oxidation number, so reaction is not redox	1 1
(d)	M1: no. moles Cr deposited = $0.0312/52 = 6.0 \times 10^{-4}$ moles M2: deduction that 6 moles of e^- needed per mole of Cr/ reaction is $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 12\text{e}^- \rightarrow 2\text{Cr} + 7\text{H}_2\text{O}$ M3: no. moles of $\text{e}^- = 6 \times 6.0 \times 10^{-4} = (0.125 \times t)/96\,500$ so $t = (6 \times 6.0 \times 10^{-4} \times 96\,500)/(0.125 \times 60) = 46.3\text{ min}/0.772\text{ h}/2780\text{ s}$	1 1 1

Page 7	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark																					
6 (a)	<table border="1"> <thead> <tr> <th></th> <th colspan="2">identity or value</th> </tr> </thead> <tbody> <tr> <td>V</td> <td>nitrogen or</td> <td>chlorine</td> </tr> <tr> <td>X</td> <td>NO/NO₂</td> <td>ClO₂/ClO₃</td> </tr> <tr> <td>m</td> <td>2, 3</td> <td>1,2,3, or 4</td> </tr> <tr> <td>W</td> <td colspan="2">sulfur</td> </tr> <tr> <td>Y</td> <td colspan="2">SO₂ or SO₃</td> </tr> <tr> <td>n</td> <td colspan="2">4, 3</td> </tr> </tbody> </table>		identity or value		V	nitrogen or	chlorine	X	NO/NO ₂	ClO ₂ /ClO ₃	m	2, 3	1,2,3, or 4	W	sulfur		Y	SO ₂ or SO ₃		n	4, 3		3
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Y	SO ₂ or SO ₃																						
n	4, 3																						
(b)	<p>M1: (white precipitate is BaSO₄) descending the group ΔH_{sol} becomes more endothermic/positive;</p> <p>M2, M3 any two from: ΔH_{latt} decreases/becomes more endothermic/becomes less exothermic ΔH_{hyd} decreases/becomes more endothermic/becomes less exothermic ΔH_{hyd} decreases more than ΔH_{latt}</p>	1 2																					


Page 8	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark									
7 (a) (i)	M1: phenol is more acidic than ethanol because the O–H bond in phenol is weakened/the phenoxide anion is stabilised/ethanol has an electron donating group	1									
	M2: p orbital/lone pair of electrons on O can be delocalised over/overlaps with ring	1									
(ii)	<table border="1"> <thead> <tr> <th>reagent</th> <th>conditions</th> <th>Structure</th> </tr> </thead> <tbody> <tr> <td>HNO₃</td> <td>dilute, 5 °C</td> <td></td> </tr> <tr> <td>Br₂</td> <td>aqueous (l: temperature)</td> <td></td> </tr> </tbody> </table>	reagent	conditions	Structure	HNO ₃	dilute, 5 °C		Br ₂	aqueous (l: temperature)		3
reagent	conditions	Structure									
HNO ₃	dilute, 5 °C										
Br ₂	aqueous (l: temperature)										
(iii)	electrophilic substitution	1									
(b) (i)	white precipitate/solid	1									
(ii)	between 0 °C and 10 °C	1									
(iii)	<p>M1: double bond between nitrogen atoms M2: rest of molecule</p> 	1 1									
(c) (i)	$ \begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3 - \text{C} - \text{CH}_3 \\ \\ \text{CH}_2\text{NH}_2 \end{array} $	1									
(ii)	 <p>either one or both CH₃ groups circled</p>	1									

Page 9	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark										
8 (a)	<p>P amide Q ketone R secondary alcohol</p> <p>Q = carbonyl and R = alcohol scores [1]</p>	<p>1 1 1</p>										
(b)		1										
(c) (i)	see line on diagram in (b)	1										
(ii)		1										
(d)	<table border="1"> <thead> <tr> <th>reagent</th> <th>observation</th> </tr> </thead> <tbody> <tr> <td>alkaline iodine solution</td> <td>yellow ppt. formed</td> </tr> <tr> <td>universal indicator</td> <td>blue / purple colour formed</td> </tr> <tr> <td>2,4-dinitrophenylhydrazine</td> <td>yellow / orange ppt formed</td> </tr> <tr> <td>Tollens' reagent</td> <td>no reaction</td> </tr> </tbody> </table>	reagent	observation	alkaline iodine solution	yellow ppt. formed	universal indicator	blue / purple colour formed	2,4-dinitrophenylhydrazine	yellow / orange ppt formed	Tollens' reagent	no reaction	3
reagent	observation											
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2,4-dinitrophenylhydrazine	yellow / orange ppt formed											
Tollens' reagent	no reaction											
(e) (i)	LiAlH ₄	1										
(ii)	<p>(must be skeletal)</p>	1										
(iii)		1										

Page 10	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark										
9 (a) (i)	polyester : <i>Terylene</i> / polylactic acid (PLA) / polyamide : nylon / <i>Kevlar</i> / Nomex	1										
(ii)	water <i>or</i> hydrochloric acid / hydrogen chloride	1										
(b) (i)	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>polymer</th> <th>biodegradable</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>yes</td> </tr> <tr> <td>B</td> <td>yes</td> </tr> <tr> <td>C</td> <td>no</td> </tr> <tr> <td>D</td> <td>yes</td> </tr> </tbody> </table>	polymer	biodegradable	A	yes	B	yes	C	no	D	yes	2
polymer	biodegradable											
A	yes											
B	yes											
C	no											
D	yes											
(ii)	<p>HOCH₂CH₂OH and</p>  <p style="text-align: right;">or equivalent 1,4-diacyl chloride or equivalent 1,4-diester</p>	2										
(c) (i)	V: it has two amine /NH ₂ groups (which can be protonated) <i>or</i> it has an amine /NH ₂ group on its side chain /R group	1										
(ii)	four (TT, TU, UT, UU)	1										
(iii)	hydrogen bonds; between the O/N atoms or named group (in the polypeptide) and water; <i>or</i> ion-dipole attractions; between NH ₃ ⁺ / CO ₂ ⁻ and water;	2										