

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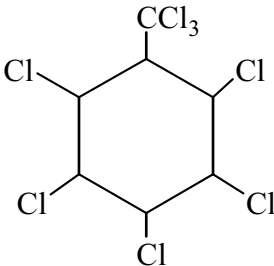
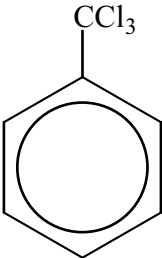
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Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – March 2016	9701	42

Question	Answer	Mark																
1 (a)	Increasing energy ↑ <table><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)	 or 	1																

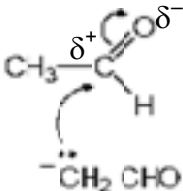
Page 3	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark										
2 (a) (i)	$\text{Ca}^{2+}(\text{g}) + 2\text{Cl}^{-}(\text{g}) \rightarrow \text{CaCl}_2(\text{s})$ (state symbols required)	1										
(ii)	Energy level diagram for the formation of $\text{CaCl}_2(\text{s})$ from $\text{Ca}^{2+}(\text{g}) + 2\text{Cl}^{-}(\text{g}) (+ 2\text{e}^{-})$. The diagram shows the following energy levels and transitions: - Top level: $\text{Ca}^{2+}(\text{g}) + 2\text{Cl}^{-}(\text{g}) (+ 2\text{e}^{-})$ - Second level: 2^{nd} I.E of Ca - Third level: 1^{st} I.E of Ca - Fourth level: Atomisation/ΔH_{at} of Ca - Fifth level: $\text{E}(\text{Cl}-\text{Cl})/2\Delta H_{\text{at}}$ of Cl - Bottom level: $\Delta H_{\text{f}}^{\circ} \text{CaCl}_2(\text{s})$ A large downward arrow from the top level to the bottom level is labeled $\Delta H_{\text{latt}}^{\circ}$. A label $\text{EA of Cl} \times 2$ is also present.	2										
(iii)	$\Delta H_{\text{latt}}^{\circ} = -796 - 242 - 178 - 590 - 1150 + (2 \times 349) = -2258 \text{ kJ mol}^{-1}$	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><tr><th>reaction</th><th>sign of ΔS°</th></tr><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></table>	reaction	sign of ΔS°	$\text{CO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$	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°											
$\text{CO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$	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											
(ii)	there is a reduction in the overall number of <u>gaseous</u> molecules	1										
(d)	$\Delta S_{\text{f}}^{\circ} = 386 - (192 + (3 \times 131))$ $= -199 \text{ (J K}^{-1} \text{ mol}^{-1}\text{)}$	2										
(e) (i)	$\Delta G^{\circ} = \Delta H^{\circ} - T\Delta S^{\circ}$ $= 117 - ((298 \times 175) / 1000)$ $= (+) 64.85 \text{ (kJ mol}^{-1}\text{)}$	2										
(ii)	<u>ΔG° 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)	M1, M2: diagrams M3: names cis-platin / cis-diamminedichloroplatinum(II) trans-platin / trans-diamminedichloroplatinum(II)	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)	M1: formula M2: units (ecf from formula) $K_{\text{stab}} = \frac{[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}}{[\text{Cu}(\text{H}_2\text{O})_6]^{2+}[\text{NH}_3]^4} \text{ mol}^{-4} \text{ dm}^{12}$	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)	M1: both curly arrows M2: dipole correctly shown 	1 1

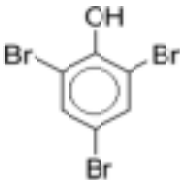
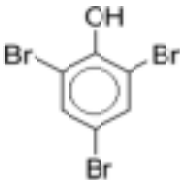
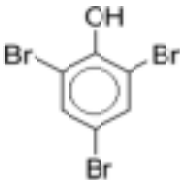
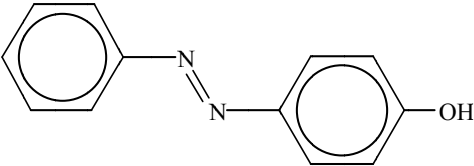
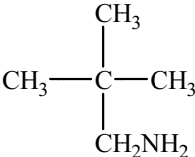
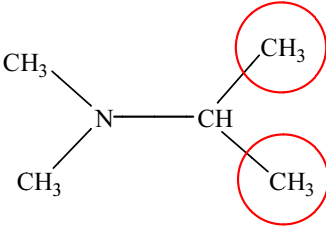
Page 6	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
5 (a) (i)	any metal with an $E^\ominus$ value more negative than -0.41 V , e.g. Fe, Mn, Zn, Mg, Cr, Al R: Li/Na/K/Ca/Ba	1
(ii)	M1: value of E_{cell} correctly calculated (with correct sign) for metal named in (i) M2: $E^\ominus_{\text{cell}}$ 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: $E^\ominus_{\text{cell}}$ (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"> <tr> <td></td><td colspan="2">identity or value</td></tr> <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> </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
	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																						
(b)	M1: (white precipitate is BaSO₄) descending the group ΔH_{sol} becomes more endothermic/positive; 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}	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 M2: p orbital / lone pair of electrons on O can be delocalised over / overlaps with ring	1 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)	M1: double bond between nitrogen atoms M2: rest of molecule 	1 1									
(c) (i)		1									
(ii)	 either one or both CH₃ groups circled	1									

Page 9	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark										
8 (a)	P amide Q ketone R secondary alcohol Q = carbonyl and R = alcohol scores [1]	1 1 1										
(b)		1										
(c) (i)	see line on diagram in (b)	1										
(ii)		1										
(d)	<table><tr><th>reagent</th><th>observation</th></tr><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></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											
alkaline iodine solution	yellow ppt. formed											
universal indicator	blue / purple colour formed											
2,4-dinitrophenylhydrazine	yellow / orange ppt formed											
Tollens' reagent	no reaction											
(e) (i)	LiAlH ₄	1										
(ii)	(must be skeletal)	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"> <tr> <td></td><td>polymer</td><td>biodegradable</td></tr> <tr> <td></td><td>A</td><td>yes</td></tr> <tr> <td></td><td>B</td><td>yes</td></tr> <tr> <td></td><td>C</td><td>no</td></tr> <tr> <td></td><td>D</td><td>yes</td></tr> </table>		polymer	biodegradable		A	yes		B	yes		C	no		D	yes	2
	polymer	biodegradable															
	A	yes															
	B	yes															
	C	no															
	D	yes															
(ii)	HOCH₂CH₂OH and  <i>or</i> equivalent 1,4-diacyl chloride <i>or</i> equivalent 1,4-diester	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															