

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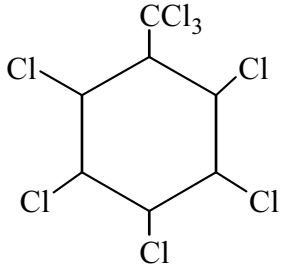
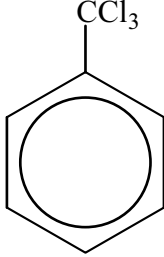
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Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – March 2016	9701	42

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<sup>+</sup> ion</td> <td>C<sup>-</sup> ion</td> </tr> </table>	2p	↑ ↑	↑	↑ ↑ ↑	2s	↑ ↓	↑ ↓	↑ ↓	1s	↑ ↓	↑ ↓	↑ ↓		carbon atom	C <sup>+</sup> ion	C <sup>-</sup> ion	2
2p	↑ ↑	↑	↑ ↑ ↑															
2s	↑ ↓	↑ ↓	↑ ↓															
1s	↑ ↓	↑ ↓	↑ ↓															
	carbon atom	C <sup>+</sup> ion	C <sup>-</sup> ion															
(b) (i)	sp <sup>2</sup>	1																
(ii)	x = 60 / C <sub>60</sub> H <sub>60</sub>	1																
(c) (i)	reaction 1: Cl <sub>2</sub> and UV light; reaction 2: AlCl <sub>3</sub> , Cl <sub>2</sub> (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 <math>\Delta S^{\ominus}</math></th> </tr> </thead> <tbody> <tr> <td><math>\text{CO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})</math></td> <td>negative</td> </tr> <tr> <td><math>\text{Mg}(\text{s}) + \frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{MgO}(\text{s})</math></td> <td>negative</td> </tr> <tr> <td><math>\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})</math></td> <td>negative</td> </tr> <tr> <td><math>\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})</math></td> <td>positive</td> </tr> </tbody> </table>	reaction	sign of $\Delta S^{\ominus}$	$\text{CO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$	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 $\Delta S^{\ominus}$											
$\text{CO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$	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											
(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><math>\Delta G^{\ominus}</math> is positive</u> and so the reaction is <u>not spontaneous</u> (at 298K)	1										

Page 4	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
3 (a)	Co [Ar] 3d <sup>7</sup> 4s <sup>2</sup> Co <sup>2+</sup> [Ar] 3d <sup>7</sup>	1 1
(b)		1
(c) (i)	[Co(Cl) <sub>3</sub> (H <sub>2</sub> O) <sub>3</sub> ] <sup>-</sup>	1
(ii)		2
(d) (i)	[Pt(Cl) <sub>2</sub> (NH <sub>3</sub> ) <sub>2</sub> ]	1
(ii)	<p><b>M1, M2:</b> diagrams <b>M3:</b> 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><b>M1:</b> formula <b>M2:</b> 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 $K_{\text{stab}}$ shows that) the tetrammine complex is more stable	1

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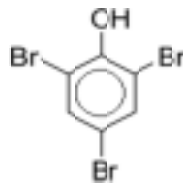

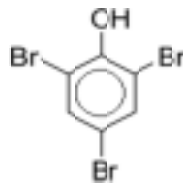

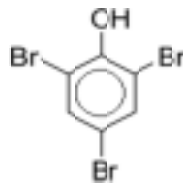
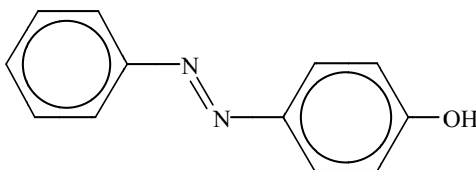
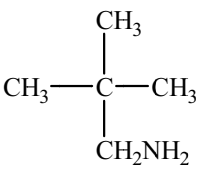
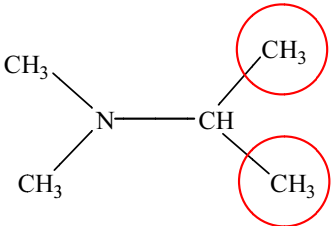
Question	Answer	Mark
4 (a) (i)	1 <sup>st</sup> order	1
(ii)	1 <sup>st</sup> order	1
(iii)	rate = $k[\text{CH}_3\text{CHO}][\text{OH}^-]$	1
(iv)	$\text{mol}^{-1} \text{dm}^3 \text{s}^{-1}$ (or per any suitable time unit)	1
(v)	calculation from candidate's answer to (iii) (expected answer = 6)	1
(b) (i)	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><b>M1:</b> both curly arrows <b>M2:</b> 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 $-0.41\text{ V}$ , e.g. Fe, Mn, Zn, Mg, Cr, Al R: Li/Na/K/Ca/Ba	1
(ii)	<b>M1:</b> value of $E_{\text{cell}}$ correctly calculated (with correct sign) for metal named in (i) <b>M2:</b> $E^\ominus_{\text{cell}}$ is positive <b>and</b> so reaction is feasible	1 1
(b)	<b>M1:</b> $(\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \rightleftharpoons 2\text{Cr}^{3+} + 7\text{H}_2\text{O}) \quad E^\ominus = +1.33\text{ V}$ $(\text{H}_2\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightleftharpoons 2\text{H}_2\text{O}) \quad E^\ominus = +1.77\text{ V}$ $E^\ominus_{\text{cell}} = 0.44\text{ (V)}$  <b>M2:</b> $E^\ominus_{\text{cell}}$ (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)	<b>M1:</b> $\text{Cr}_2\text{O}_7^{2-}$ : ox.no Cr = +6 because $-2 = 2 \times \text{ox.no}(\text{Cr}) + (7 \times -2)$ $\text{CrO}_4^{2-}$ : ox.no Cr = +6 because $-2 = \text{ox.no}(\text{Cr}) + (4 \times -2)$  <b>M2:</b> no change in oxidation number, so reaction is not redox	1  1
(d)	<b>M1:</b> no. moles Cr deposited = $0.0312/52 = 6.0 \times 10^{-4}$ moles <b>M2:</b> deduction that 6 moles of $\text{e}^-$ needed per mole of Cr/ reaction is $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 12\text{e}^- \rightarrow 2\text{Cr} + 7\text{H}_2\text{O}$ <b>M3:</b> 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

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/NO<sub>2</sub></td> <td>ClO<sub>2</sub>/ClO<sub>3</sub></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">SO<sub>2</sub> or SO<sub>3</sub></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 <sub>2</sub>	ClO <sub>2</sub> /ClO <sub>3</sub>	m	2, 3	1,2,3, or 4	W	sulfur		Y	SO <sub>2</sub> or SO <sub>3</sub>		n	4, 3		3
	identity or value																						
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n	4, 3																						
(b)	<p><b>M1:</b> (white precipitate is BaSO<sub>4</sub>) descending the group <math>\Delta H_{\text{sol}}</math> becomes more endothermic/positive;</p> <p><b>M2, M3 any two from:</b>  <math>\Delta H_{\text{latt}}</math> decreases/becomes more endothermic/becomes less exothermic  <math>\Delta H_{\text{hyd}}</math> decreases/becomes more endothermic/becomes less exothermic  <math>\Delta H_{\text{hyd}}</math> decreases more than <math>\Delta H_{\text{latt}}</math></p>	1 2																					

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



Page 9	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark										
8 (a)	<p><b>P</b> amide  <b>Q</b> ketone  <b>R</b> <b>secondary</b> alcohol</p> <p><b>Q</b> = carbonyl and <b>R</b> = 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											
alkaline iodine solution	yellow ppt. formed											
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2,4-dinitrophenylhydrazine	yellow / orange ppt formed											
Tollens' reagent	no reaction											
(e) (i)	LiAlH <sub>4</sub>	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><b>A</b></td> <td>yes</td> </tr> <tr> <td><b>B</b></td> <td>yes</td> </tr> <tr> <td><b>C</b></td> <td>no</td> </tr> <tr> <td><b>D</b></td> <td>yes</td> </tr> </tbody> </table>	polymer	biodegradable	<b>A</b>	yes	<b>B</b>	yes	<b>C</b>	no	<b>D</b>	yes	2
polymer	biodegradable											
<b>A</b>	yes											
<b>B</b>	yes											
<b>C</b>	no											
<b>D</b>	yes											
(ii)	<p>HOCH<sub>2</sub>CH<sub>2</sub>OH and</p>  <p style="text-align: right;">or equivalent 1,4-diacyl chloride or equivalent 1,4-diester</p>	2										
(c) (i)	<b>V:</b> it has two amine /NH <sub>2</sub> groups (which can be protonated) <i>or</i> it has an amine /NH <sub>2</sub> group on its side chain /R group	1										
(ii)	four (TT, TU, UT, UU)	1										
(iii)	hydrogen bonds; between the <b>O/N</b> atoms or named group (in the polypeptide) and water; <i>or</i> ion-dipole attractions; between NH <sub>3</sub> <sup>+</sup> / CO <sub>2</sub> <sup>-</sup> and water;	2										