

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

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.

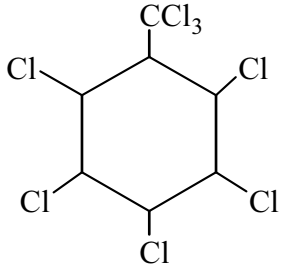
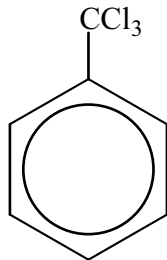
Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge will not enter into discussions about these mark schemes.

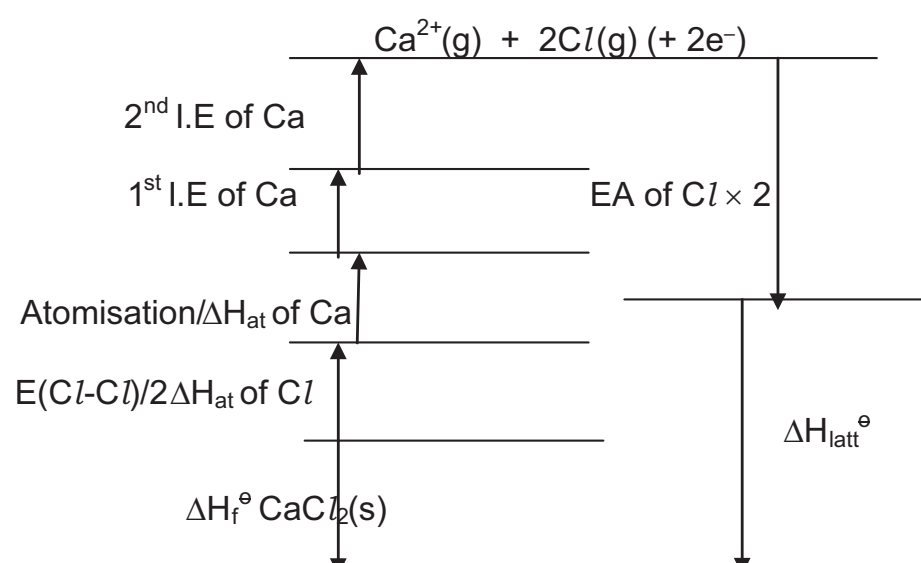
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Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – March 2016	9701	42

Question	Answer	Mark																
1 (a)	<p style="text-align: center;">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																

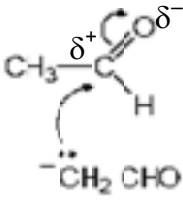
Page 3	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark										
2 (a) (i)	$\text{Ca}^{2+}(\text{g}) + 2\text{Cl}^{-}(\text{g}) \rightarrow \text{CaCl}_2(\text{s})$ (state symbols required)	1										
(ii)		2										
(iii)	$\Delta H_{\text{latt}}^{\ominus} = -796 - 242 - 178 - 590 - 1150 + (2 \times 349) = -2258 \text{ kJ mol}^{-1}$	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)	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)	<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

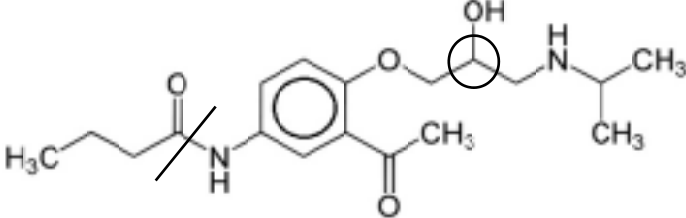
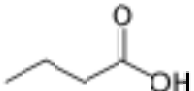
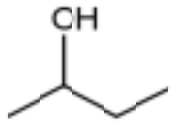
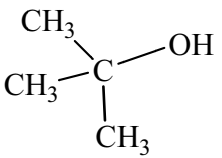
Page 7	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark																					
6 (a)	<table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td></td> <td colspan="2" style="text-align: center;">identity or value</td> </tr> <tr> <td style="text-align: center;">V</td> <td style="text-align: center;">nitrogen or</td> <td style="text-align: center;">chlorine</td> </tr> <tr> <td style="text-align: center;">X</td> <td style="text-align: center;">NO/NO₂</td> <td style="text-align: center;">ClO₂/ClO₃</td> </tr> <tr> <td style="text-align: center;">m</td> <td style="text-align: center;">2, 3</td> <td style="text-align: center;">1,2,3, or 4</td> </tr> <tr> <td style="text-align: center;">W</td> <td colspan="2" style="text-align: center;">sulfur</td> </tr> <tr> <td style="text-align: center;">Y</td> <td colspan="2" style="text-align: center;">SO₂ or SO₃</td> </tr> <tr> <td style="text-align: center;">n</td> <td colspan="2" style="text-align: center;">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)	<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)	<p>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</p> <p>M2: p orbital/lone pair of electrons on O can be delocalised over/overlaps with ring</p>	<p>1</p> <p>1</p>									
(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</p> <p>M2: rest of molecule</p>	<p>1</p> <p>1</p>									
(c) (i)		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
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alkaline iodine solution	yellow ppt. formed											
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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" 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)	HOCH ₂ CH ₂ OH and  or equivalent 1,4-diacyl chloride or 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										