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.

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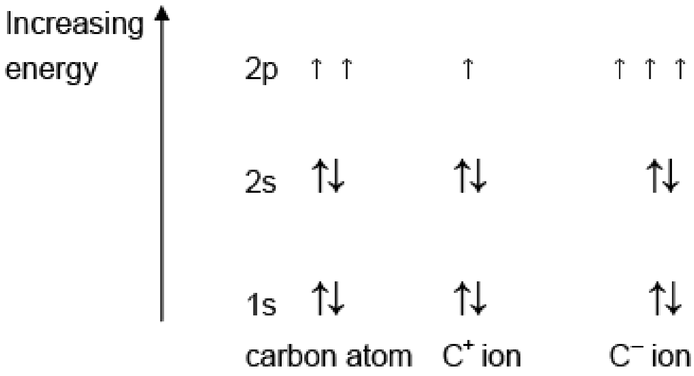
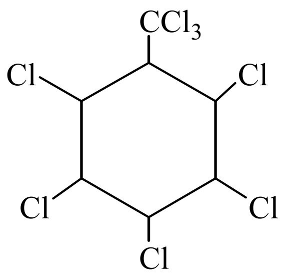
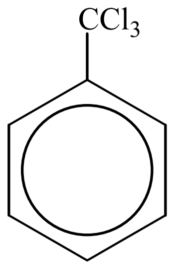
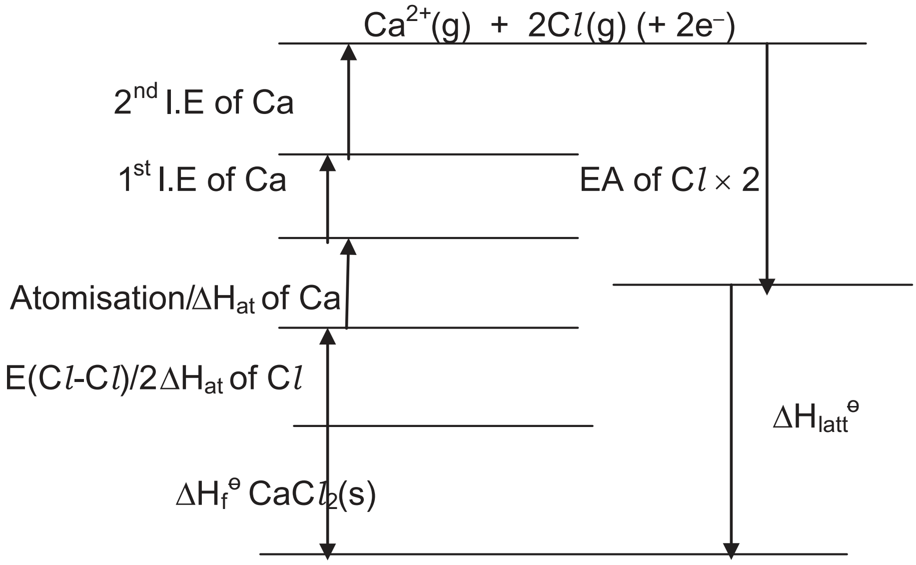
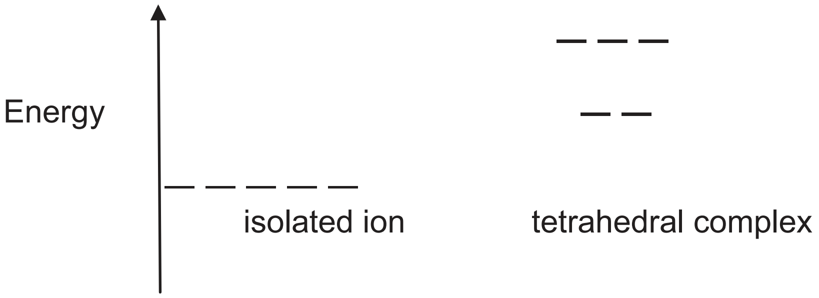
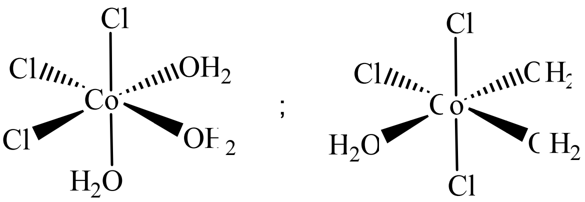
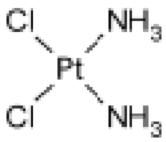
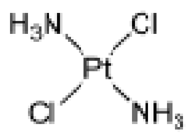
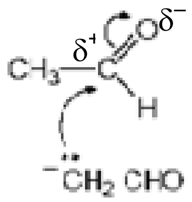
CAMBRIDGE
International Examinations

Question	Answer	Mark
1 (a)		2
(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

<table>
<tr><th>Question</th><th>Answer</th><th>Mark</th></tr>
<tr><td>2 (a) (i)</td><td>$Ca^{2+}(g) + 2Cl^{-}(g) \rightarrow CaCl_2(s)$ (state symbols required)</td><td>1</td></tr>
<tr><td>(ii)</td><td>
</td><td>2</td></tr>
<tr><td>(iii)</td><td>$\Delta H_{latt}^{\ominus} = -796 - 242 - 178 - 590 - 1150 + (2 \times 349) = -2258$ kJ mol^{-1}</td><td>3</td></tr>
<tr><td>(b)</td><td>(higher temperature means that) particles have more energy;
entropy (of the gas / system) increases because of an increase in the amount of disorder / randomness;</td><td>2</td></tr>
<tr><td>(c) (i)</td><td><table>
<tr><th>reaction</th><th>sign of $\Delta S^{\ominus}$</th></tr>
<tr><td>$CO(g) + O_2(g) \rightarrow CO_2(g)$</td><td>negative</td></tr>
<tr><td>$Mg(s) + ½O_2(g) \rightarrow MgO(s)$</td><td>negative</td></tr>
<tr><td>$CuSO_4(s) + 5H_2O(l) \rightarrow CuSO_4.5H_sO(s)$</td><td>negative</td></tr>
<tr><td>$NaHCO_3(s) + H^+(aq) \rightarrow Na^+(aq) + CO_2(g) + H_2O(l)$</td><td>positive</td></tr>
</table></td><td>2</td></tr>
<tr><td>(ii)</td><td>there is a reduction in the overall number of <u>gaseous</u> molecules</td><td>1</td></tr>
<tr><td>(d)</td><td>$\Delta S_f^{\ominus} = 386 - (192 + (3 \times 131))$
$= -199$ (J K^{-1} mol^{-1})</td><td>2</td></tr>
<tr><td>(e) (i)</td><td>$\Delta G^{\ominus} = \Delta H^{\ominus} - T\Delta S^{\ominus}$
$= 117 - ((298 \times 175) / 1000)$
$= (+)\ 64.85$ (kJ mol^{-1})</td><td>2</td></tr>
<tr><td>(ii)</td><td><u>$\Delta G^{\ominus}$ is positive</u> and so the reaction is <u>not spontaneous</u> (at 298 K)</td><td>1</td></tr>
</table>

Question	Answer	Mark
3 (a)	Co [Ar] $3d^7 4s^2$ Co^{2+} [Ar] $3d^7$	1 1
(b)		1
(c) (i)	$[Co(Cl)_3(H_2O)_3]^-$	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)	(*cis* isomer) this can react / bond / bind with DNA; which prevents replication of the strand / prevents cell division;	 1 1
(e) (i)	**M1**: formula **M2**: units (ecf from formula) $K_{stab} = \frac{[Cu(NH_3)_4(H_2O)_2^{2+}]}{[Cu(H_2O)_6^{2+}][NH_3]^4}$ $mol^{-4} dm^{12}$	1 1
(ii)	(large value of K_{stab} shows that) the tetrammine complex is more stable	1

Question	Answer	Mark
4 (a) (i)	1st order	1
(ii)	1st order	1
(iii)	rate = k[CH_3CHO][OH^-]	1
(iv)	$mol^{-1}\,dm^3\,s^{-1}$ (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

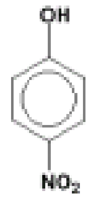
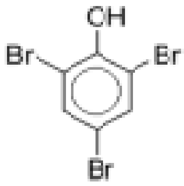
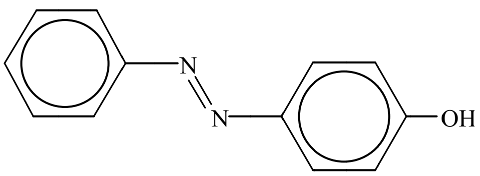
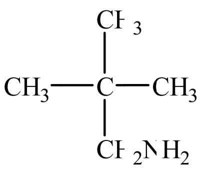
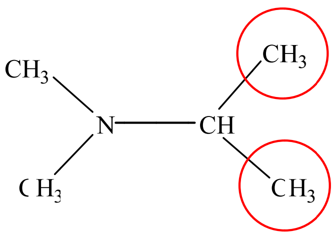
Question	Answer	Mark
5 (a) (i)	any metal with an $E^{\ominus}$ value more negative than –0.41 V, e.g. Fe, Mn, Zn, Mg, Cr, Al **R:** Li / Na / K / Ca / Ba	**1**
(ii)	**M1**: value of E_{cell} correctly calculated (with correct sign) for metal named in **(i)** **M2**: $E^{\ominus}_{cell}$ is positive **and** so reaction is feasible	**1** **1**
(b)	**M1**: ($Cr_2O_7^{2-}$ + $14H^+$ + $6e^-$ ⇌ $2Cr^{3+}$ + $7H_2O$) $E^{\ominus}$ = +1.33 V (H_2O_2 + $2H^+$ + $2e^-$ ⇌ $2H_2O$) $E^{\ominus}$ = +1.77 V $E^{\ominus}_{cell}$ = 0.44 (V) **M2**: $E^{\ominus}_{cell}$ (0.44 V) is positive (so the reaction is feasible) / $E^{\ominus}$($Cr_2O_7^{2-}$ / Cr^{3+}) is less positive than $E^{\ominus}$(H_2O_2 / H_2O)	**1** **1**
(c)	**M1**: $Cr_2O_7^{2-}$: ox.no Cr = +6 because –2 = 2 × ox.no(Cr) + (7 × –2) CrO_4^{2-}: ox.no Cr = +6 because –2 = ox.no(Cr) + (4 × –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 × 10^{-4} moles **M2**: deduction that 6 moles of e^- needed per mole of Cr / reaction is $Cr_2O_7^{2-}$ + $14H^+$ + $12e^-$ → 2Cr + $7H_2O$ **M3**: no. moles of e^- = 6 × 6.0 × 10^{-4} = (0.125 × t) / 96 500 so t = (6 × 6.0 × 10^{-4} × 96 500) / (0.125 × 60) = 46.3 min / 0.772 h / 2780 s	**1** **1** **1**

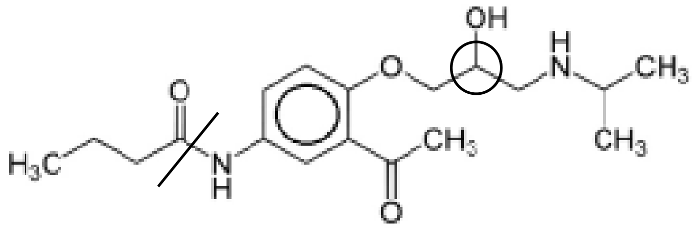
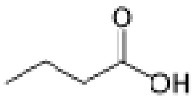
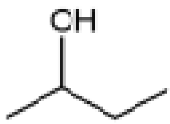
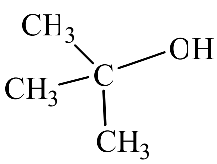
Question	Answer	Mark
6 (a)	(see table below)	3

	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	

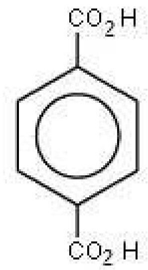
Question	Answer	Mark
(b)	**M1**: (white precipitate is $BaSO_4$) descending the group ΔH_{sol} becomes more endothermic / positive;	1
	M2, M3 any **two** from: ΔH_{latt} decreases / becomes more endothermic / becomes less exothermic ΔH_{hyd} decreases / becomes more endothermic / becomes less exothermic ΔH_{hyd} decreases more than ΔH_{latt}	2

<table>
<tr><th>Question</th><th>Answer</th><th>Mark</th></tr>
<tr><td>7 (a) (i)</td><td>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</td><td>1

1</td></tr>
<tr><td>(ii)</td><td>
<table>
<tr><th>reagent</th><th>conditions</th><th>Structure</th></tr>
<tr><td>HNO_3</td><td>dilute, 5 °C</td><td></td></tr>
<tr><td>Br_2</td><td>aqueous
(I: temperature)</td><td></td></tr>
</table>
</td><td>3</td></tr>
<tr><td>(iii)</td><td>electrophilic substitution</td><td>1</td></tr>
<tr><td>(b) (i)</td><td>white precipitate / solid</td><td>1</td></tr>
<tr><td>(ii)</td><td>between 0 °C and 10 °C</td><td>1</td></tr>
<tr><td>(iii)</td><td>M1: double bond between nitrogen atoms
M2: rest of molecule
</td><td>1
1</td></tr>
<tr><td>(c) (i)</td><td></td><td>1</td></tr>
<tr><td>(ii)</td><td>
either one or both CH_3 groups circled</td><td>1</td></tr>
</table>

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)	see table below	3
(e) (i)	$LiAlH_4$	1
(ii)	 (must be skeletal)	1
(iii)		1

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

<table>
<tr><th>Question</th><th>Answer</th><th>Mark</th></tr>
<tr><td>9 (a) (i)</td><td>polyester : Terylene / polylactic acid (PLA) /
polyamide : nylon / Kevlar / Nomex</td><td>1</td></tr>
<tr><td>(ii)</td><td>water or hydrochloric acid / hydrogen chloride</td><td>1</td></tr>
<tr><td>(b) (i)</td><td><table><tr><th>polymer</th><th>biodegradable</th></tr><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></table></td><td>2</td></tr>
<tr><td>(ii)</td><td>$HOCH_2CH_2OH$ and  or equivalent 1,4-diacyl chloride
or equivalent 1,4-diester</td><td>2</td></tr>
<tr><td>(c) (i)</td><td>V:
it has two amine / NH_2 groups (which can be protonated) or
it has an amine / NH_2 group on its side chain / R group</td><td>1</td></tr>
<tr><td>(ii)</td><td>four (TT, TU, UT, UU)</td><td>1</td></tr>
<tr><td>(iii)</td><td>hydrogen bonds;
between the O / N atoms or named group (in the polypeptide) and water;
or
ion-dipole attractions;
between NH_3^+ / CO_2^- and water;</td><td>2</td></tr>
</table>