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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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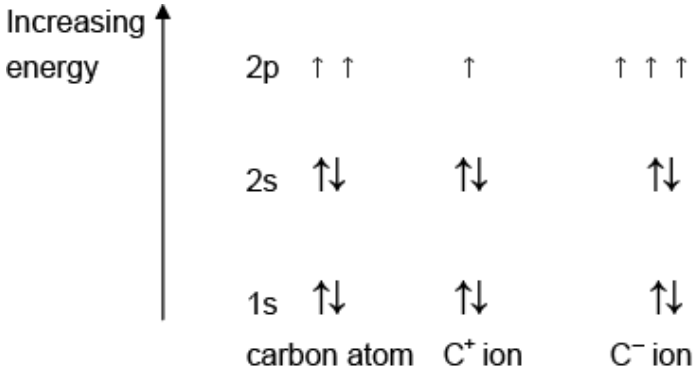
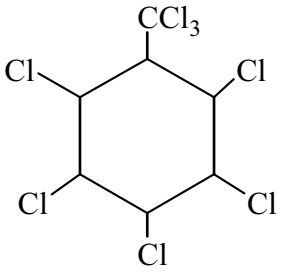
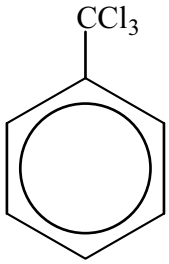
Question	Answer	Mark
1 (a)		2
(b) (i)	sp^2	1
(ii)	$x = 60$ / $C_{60}H_{60}$	1
(c) (i)	reaction 1: Cl_2 and UV light; reaction 2: $AlCl_3$, Cl_2 (NOT aqueous);	1 1
(ii)	(free) radical substitution	1
(iii)	 *or* 	1

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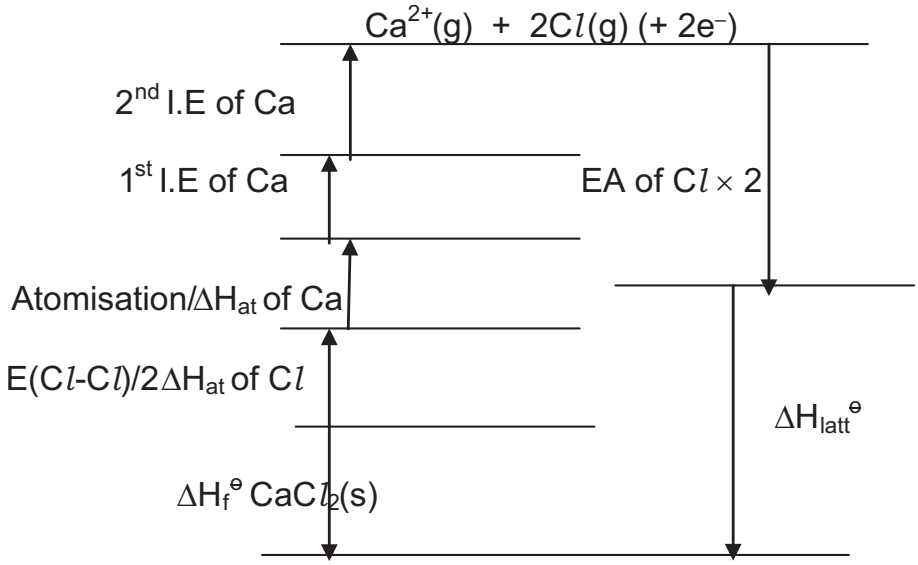
Question	Answer	Mark
2 (a) (i)	$Ca^{2+}(g) + 2Cl^{-}(g) \rightarrow CaCl_2(s)$ (state symbols required)	1
(ii)		2
(iii)	$\Delta H_{latt}^{\ominus} = -796 - 242 - 178 - 590 - 1150 + (2 \times 349) = -2258\ kJ\ mol^{-1}$	3
(b)	(higher temperature means that) particles have more energy; entropy (of the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

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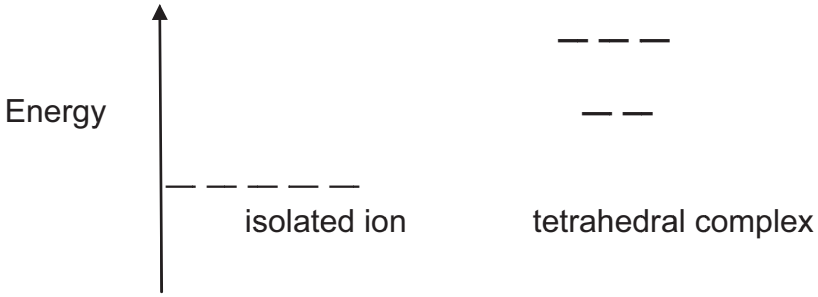
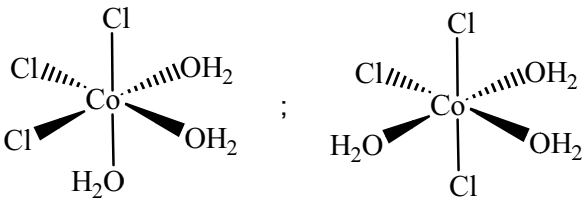
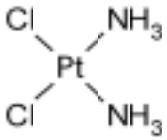
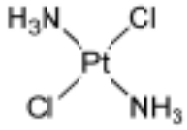
Question	Answer	Mark
3 (a)	Co [Ar] $3d^7 4s^2$ Co^{2+} [Ar] $3d^7$	1 1
(b)		1
(c) (i)	$[Co(Cl)_3(H_2O)_3]^-$	1
(ii)	 ;	2
(d) (i)	$[Pt(Cl)_2(NH_3)_2]$	1
(ii)	**M1, M2**: diagrams **M3**: names   cis-platin / cis-diamminedichloroplatinum(II) trans-platin / trans-diamminedichloroplatinum(II)	2 1
(iii)	(*cis* 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

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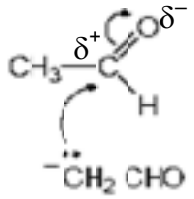
Question	Answer	Mark
4 (a) (i)	1st order	**1**
(ii)	1st order	**1**
(iii)	rate = $k[CH_3CHO][OH^-]$	**1**
(iv)	$mol^{-1}\,dm^3\,s^{-1}$ (or per any suitable time unit)	**1**
(v)	calculation from candidate's answer to **(iii)** (expected answer = 6)	**1**
(b) (i)	rate-determining step: step 1 explanation: 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**

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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, A*l* **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**: $(Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O)$ $E^{\ominus} = +1.33\,V$ $(H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O)$ $E^{\ominus} = +1.77\,V$ $E^{\ominus}_{cell} = 0.44\,(V)$ **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 $Cr_2O_7^{2-} + 14H^+ + 12e^- \rightarrow 2Cr + 7H_2O$ **M3**: no. moles of $e^- = 6 \times 6.0 \times 10^{-4} = (0.125 \times t)/96\,500$ so t = $(6 \times 6.0 \times 10^{-4} \times 96\,500)/(0.125 \times 60)$ = 46.3 min / 0.772 h / 2780 s	**1** **1** **1**

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Question	Answer	Mark

6 (a)

	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

(b)

M1: (white precipitate is $BaSO_4$)
descending the group ΔH_{sol} becomes more endothermic / positive; **1**

M2, M3 any **two** from: **2**
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}

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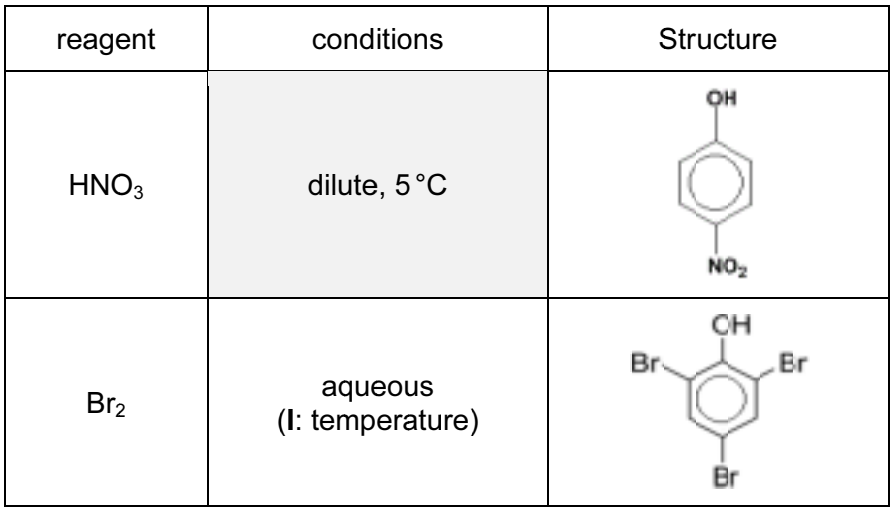
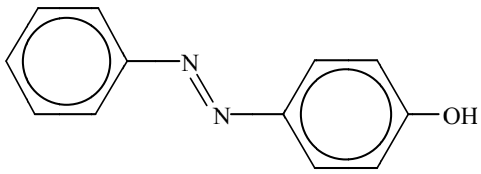
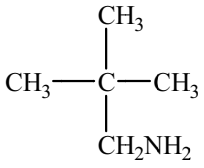
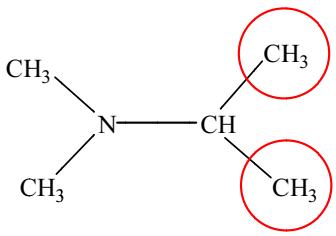
Question	Answer	Mark
7 (a) (i)	**M1**: phenol is **more acidic** than ethanol because the O–H bond in phenol is weakened / the phenoxide anion is stabilised / ethanol has an electron donating group **M2**: p orbital / lone pair of electrons on O can be delocalised over / overlaps with ring	1 1
(ii)		3
(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 CH_3 groups circled	1

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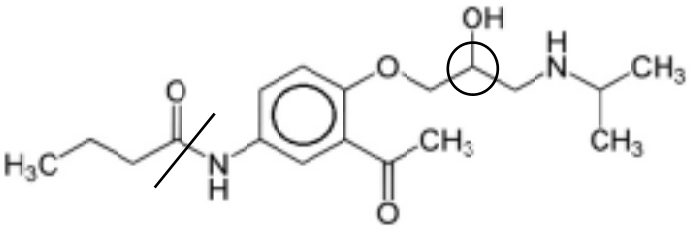
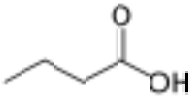
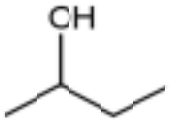
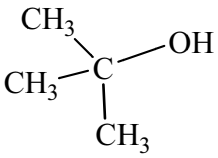
Question	Answer	Mark
8 (a)	**P** amide **Q** ketone **R** **secondary** alcohol **Q** = carbonyl and **R** = alcohol scores [1]	**1** **1** **1**
(b)		**1**
(c) (i)	see line on diagram in **(b)**	**1**
(ii)		**1**
(d)	reagent / observation alkaline iodine solution / yellow ppt. formed universal indicator / blue / purple colour formed 2,4-dinitrophenylhydrazine / yellow / orange ppt formed Tollens' reagent / no reaction	**3**
(e) (i)	$LiAlH_4$	**1**
(ii)	 (must be skeletal)	**1**
(iii)		**1**

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<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>

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