Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/41**

Paper 4 A Level Structured Questions **October/November 2016**

MARK SCHEME

Maximum Mark: 100

Published

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Question	Answer	Mark
1(a)	Cu [Ar] $3d^{10}4s^1$ Cu^{2+} [Ar] $3d^9$ ($4s^o$)	1 1 **2**
1(b)(i)	**ligand** exchange / replacement / displacement / substitution	1 **1**
1(b)(ii)	$[Cu(H_2O)_6]^{2+}$ blue **and** $[CuCl_4]^{2-}$ yellow **OR** yellow / green **OR** green / yellow	1 **1**
1(b)(iii)	tetrahedral	1 **1**
1(b)(iv)	$K_{stab} = [CuCl_4^{2-}] / [Cu(H_2O)_6^{2+}][Cl^-]^4$	1 **1**
1(c)(i)	a species that contains **two lone pairs** that (each) form a co-ordinate / dative bond **OR** are donated (to a metal ion / atom)	1 1 **2**
1(c)(ii)	equilibrium 2 lies more to the RHS / favours forward reaction more	1 **1**
1(d)(i)	**optical**	1 **1**
1(d)(ii)	3D correct for octahedral one correct structure with 3D second correct with 3D	1 1 1

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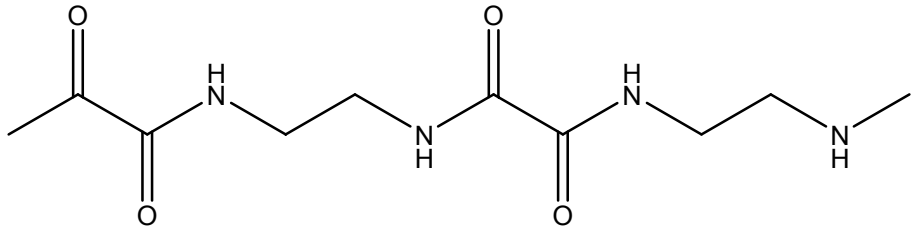
Question	Answer	Mark
		3
1(e)(i)	lone pair receive / accepts a proton / H^+	1 1 **2**
1(e)(ii)	$H_2NCH_2CH_2NH_2 + 2HCl \rightarrow ClH_3NCH_2CH_2NH_3Cl$ **OR** $H_2NCH_2CH_2NH_2 + 2H^+ \rightarrow H_3N^+CH_2CH_2N^+H_3$	 1 **1**
1(f)(i)	amide bond, displayed or –CONH– rest of the molecule with continuation bonds 	1 1 **2**
1(f)(ii)	condensation / addition – elimination	1 **1**
1(f)(iii)	any named polyalkene / eg polyethene, PVC **allow** Bakelite or Kevlar	1 **1**
	Total:	**20**

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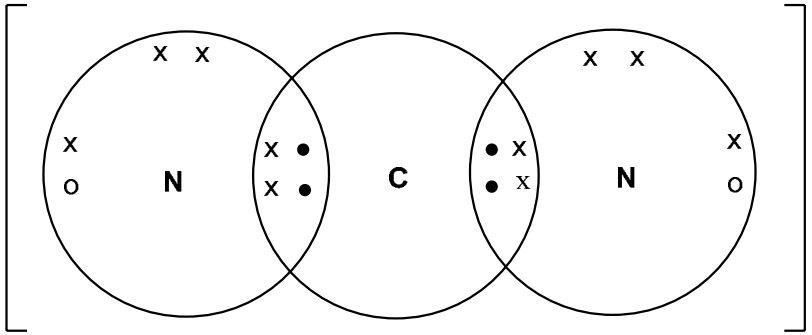
Question	Answer	Mark
2(a)	solid remains	1 **1**
2(b)	stability increases (down the group) as size / radius of (metal) **ion / M^{2+}** increases so polarisation / distortion of anion / carbonate ion decreases	1 1 1 **3**
2(c)(i)		**2**
2(c)(ii)	$CaCN_2 + 3H_2O \rightarrow CaCO_3 + 2NH_3$ $CaCO_3$ correct equation	1 1 **2**
	Total:	**8**

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Question	Answer	Mark
3(a)(i)	(entropy) increases / is positive **and** H_2 / gas is formed	1 **1**
3(a)(ii)	(entropy) increases / is positive **and** (KC*l* (aq)) solution has (free) moving / mobile ions / aqueous ions	1 **1**
3(a)(iii)	(entropy) decreases / is negative **and** decrease in **gas**	1 **1**
3(b)(i)	$\Delta S^{\ominus} = 26.9 + 214 - 65.7 = (+)\,175.2\ (J\ K^{-1}\ mol^{-1})$ $\Delta G^{\ominus} = 117 - (298 \times 175.2 / 1000)$ **OR** $\Delta G^{\ominus} = 117\,000 - (298 \times 175.2)$ $\Delta G^{\ominus} = +64.8\ (kJ\ mol^{-1})$	1 1 1 **3**
3(b)(ii)	TΔS is more positive than ΔH / TΔS increases / –TΔS more negative **and** ΔG is negative / decrease / less positive	1 **1**
3(c)	use of $\Delta G = 0$ or $\frac{T\Delta S}{\Delta H} = 1$ $T = 130 / (316 / 1000) =$ **410 / 411 / 412 / 411.4** (K)	1 1 **2**

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Question	Answer	Mark
3(d)	hydration enthalpy and lattice energy **both** more endothermic / more positive / less exothermic / less negative (down the group) ΔH_{hyd} decreases more / faster **and** ΔH_{sol} becomes (more) endothermic / (more) positive / less exothermic / less negative	1 1 **2**
	Total:	**11**

Question	Answer	Mark
4(a)	(an element) forming one or more (stable) **ions** or **compounds** or **oxidation states** with **partially filled / incomplete d orbitals**	1 **1**
4(b)(i)	**A** $Co(OH)_2$ **OR** $Co(H_2O)_4(OH)_2$ **B** $[CoCl_4]^{2-}$ **C** $[Co(NH_3)_6]^{2+}$ **OR** $[Co(NH_3)_6]^{3+}$ two correct = 1 mark three correct = 2 marks	**2**
4(b)(ii)	$[Co(H_2O)_6]^{2+}$ pink solution of **B** blue solution of **C** brown/yellow/orange	

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Question	Answer	Mark
	two correct = 1 mark three correct = 2 marks	2

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Question	Answer	Mark
4(c)	(emf / potential / *E*) of an **electrode OR** a **half-cell** compared to / connected to (**S)HE** which can be called a "hydrogen half-cell" at concentration of 1 mol dm^{-3} **and** pressure of 1 atm (or in Pa) **OR** 298 K	1 1 **2**
4(d)(i)	half-cell / electrode Co^{2+} / Co / Co / cobalt Fe^{3+} / Fe^{2+} / Pt / carbon / graphite	1 **1**
4(d)(ii)	$Co + 2Fe^{3+} \rightarrow Co^{2+} + 2Fe^{2+}$	1 **1**
4(d)(iii)	$E^{\ominus}_{cell} = 0.77 - (-0.28) = (+ \text{or} -)1.05\,(V)$	1 **1**
4(e)(i)	$E_{electrode} = -0.28 + (0.059/2)\log[0.05] =$ **–0.32** / **–0.318** (V)	1 **1**
4(e)(ii)	more positive	1 **1**
4(f)	$4Fe^{3+} + V + H_2O \rightarrow VO^{2+} + 4Fe^{2+} + 2H^+$ VO^{2+} correct equation	1 1

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Question	Answer	Mark
		2
	Total:	14

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<table>
<tr><th>Question</th><th>Answer</th><th>Mark</th></tr>
<tr><td>5(a)(i)</td><td>$(100/22.1)\times(0.7/1.1)$ or $\frac{100\times0.7}{22.1\times1.1}$ or 2.87 / 2.88 / 2.9
3 carbon atoms</td><td>1
1
2</td></tr>
<tr><td>5(a)(ii)</td><td>$C_3H_6O_3$</td><td>1
1</td></tr>
<tr><td>5(b)</td><td>
<table>
<tr><td>absorption / cm^{-1}</td><td>appearance of the peak</td><td>type of bond</td><td>functional group</td></tr>
<tr><td>3350</td><td>broad and strong</td><td>OH or O–H</td><td>alcohol / ROH</td></tr>
<tr><td>2680</td><td>very broad and strong</td><td>OH or O–H</td><td>(carboxylic) acid / CO_2H</td></tr>
<tr><td>1725</td><td>strong</td><td>C = O</td><td>(carboxylic) acid / CO_2H</td></tr>
</table>
</td><td>2</td></tr>
</table>

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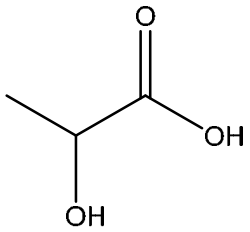
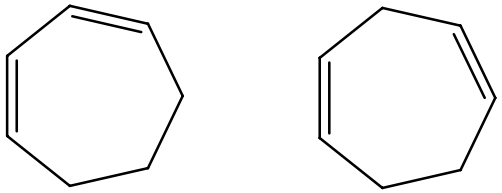
<table>
<tr><th>Question</th><th>Answer</th><th>Mark</th></tr>
<tr><td>5(c)(i)</td><td>
<table>
<tr><td>δ/ppm</td><td>type of proton</td><td>relative peak area</td></tr>
<tr><td>1.4</td><td>–CH_3 or –CH_2 or –CH or alkane</td><td>3</td></tr>
<tr><td>3.9</td><td>–OCH or –OCH_2 or –OCH_3 or CH or alkyl next to electronegative atom / oxygen</td><td>1</td></tr>
<tr><td>4.7</td><td>–OH or alcohol</td><td>1</td></tr>
<tr><td>12.9</td><td>–OH or –CO_2H or carboxylic acid</td><td>1</td></tr>
</table>
</td><td>4</td></tr>
<tr><td>5(c)(ii)</td><td>doublet and 1 / one H / proton on neighbouring OR adjacent carbon</td><td>1
1</td></tr>
<tr><td>5(c)(iii)</td><td>4.7 and 12.9 OR –OH and –CO_2H</td><td>1
1</td></tr>
<tr><td>5(c)(iv)</td><td></td><td>1
1</td></tr>
<tr><td>5(d)(i)</td><td> both required for 1 mark</td><td>1
1</td></tr>
</table>

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Question	Answer	Mark
5(d)(ii)	<table><tr><th>isomer</th><th>number of peaks</th></tr><tr><td>P</td><td>4</td></tr><tr><td>Q</td><td>4</td></tr></table>	1 1 **2**
	Total:	**15**

Question	Answer	Mark
6(a)	ibuprofen: carboxylic acid / carboxyl paracetamol: phenol and amide any two = 1 mark all three = 2 marks	 **2**
6(b)(i)	(chiral centre is a) carbon **OR** atom that has four different groups / atoms / species attached to it	1 **1**

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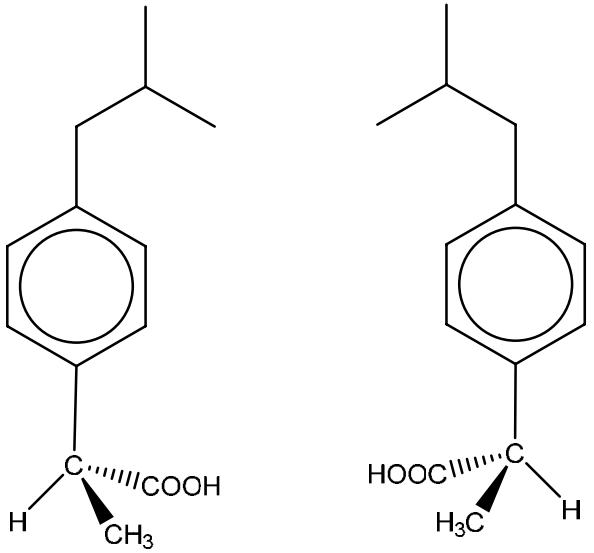
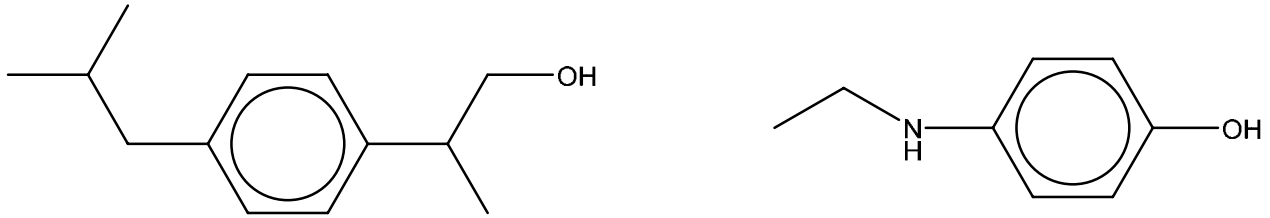
Question	Answer	Mark
6(b)(ii)	 one correct isomer second diagram shows second isomer	1 1 **2**
6(c)	 with ibuprofen with paracetamol	1 1 **2**

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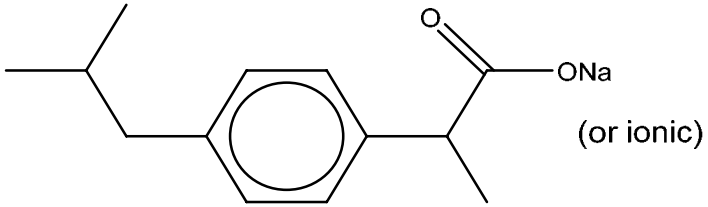
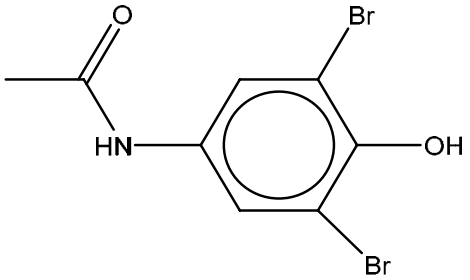
Question	Answer	Mark
6(d)(i)	(reagent **D**) Na_2CO_3 / any carbonate (reagent **E**) Cl_2 / Br_2	1 1 **2**
6(d)(ii)	 (or ionic)	1 **1**
6(d)(iii)		1 **1**
6(e)(i)	$CH_3COCl + AlCl_3 \rightarrow CH_3CO^+ + AlCl_4^-$	1 **1**

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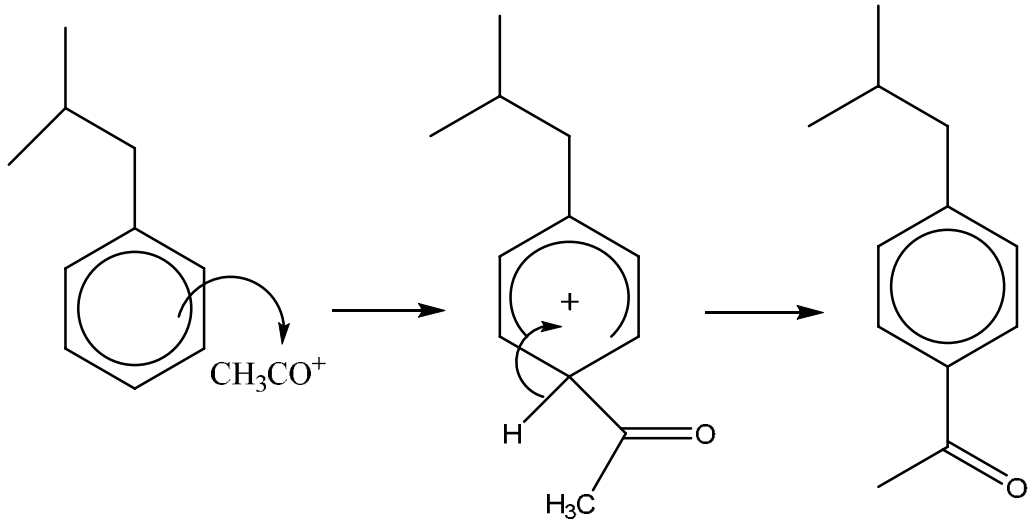
Question	Answer	Mark
6(e)(ii)		
	curly arrow from ring system to CH_3CO^+	1
	correct intermediate	1
	curly arrow from C–H bond into ring	1 **3**
6(e)(iii)	electrophilic substitution	1 **1**
	Total:	**16**

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Question	Answer	Mark
7(a)	moles of thiosulfate = $0.1 \times 20.8 / 1000 = \mathbf{2.08 \times 10^{-3}}$ moles of $C\mathit{l}O^-$ in 25 cm^3 portion = $2.08 \times 10^{-3} / 2 = \mathbf{1.04 \times 10^{-3}}$ (moles of $C\mathit{l}O^-$ in 250 cm^3 = 1.04×10^{-2}) concentration of $C\mathit{l}O^- = 1.04 \times 10^{-2} / (10 / 1000) = \mathbf{1.04}$ (mol dm^{-3})	1 1 1 **3**
7(b)(i)	starch	1 **1**
7(b)(ii)	blue **OR** black to colourless	1 **1**
7(b)(iii)	towards / close to the end-point of the titration / when the solution goes yellow	1 **1**
7(c)	moles of $O_2 = 82 / 24\,000 = 3.42 \times 10^{-3}$ = moles $C\mathit{l}O^-$ ions concentration of $C\mathit{l}O^- = 3.42 \times 10^{-3} / (5 / 1000) = \mathbf{0.68 / 0.683 / 0.684}$ (mol dm^{-3})	1 1 **2**
7(d)(i)	$K_c = \dfrac{[C_3H_3N_3O_3][HC\mathit{l}O_3]^3}{[C_3C\mathit{l}_3N_3O_3][H_20]^3}$	1 **1**
7(d)(ii)	(position of eqm) moves to the right / forward reaction predominates / more HC*l*O made (as [HC*l*O] decreases) no effect on K_c	1 1 **2**

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Question	Answer	Mark
7(d)(iii)	$2HClO \rightarrow 2HCl + O_2$ **OR** $2HClO \rightarrow H_2 + Cl_2 + O_2$	1 **1**
7(e)(i)	addition of acid: $H^+ + HCO_3^- \rightarrow H_2CO_3$ **OR** $H^+ + HCO_3^- \rightarrow H_2O + CO_2$ addition of base: $OH^- + H_2CO_3 \rightarrow HCO_3^- + H_2O$ **OR** $H^+ + OH^- \rightarrow H_2O$ **and** position of eqm moves to the right **OR** $OH^- + HCO_3^- \rightarrow CO_3^{2-} + H_2O$	1 1 **2**
7(e)(ii)	$K_a = ([H^+][HCO_3^-] / [H_2CO_3])$ $[H^+] = (7.94 \times 10^{-7}) \times 1 / 9.5 = 8.36 \times 10^{-8}$ $pH = -\log[H^+] =$ **7.08**	 1 1 **2**
	Total:	**16**

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