Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/43**

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

MARK SCHEME

Maximum Mark: 100

Published

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.

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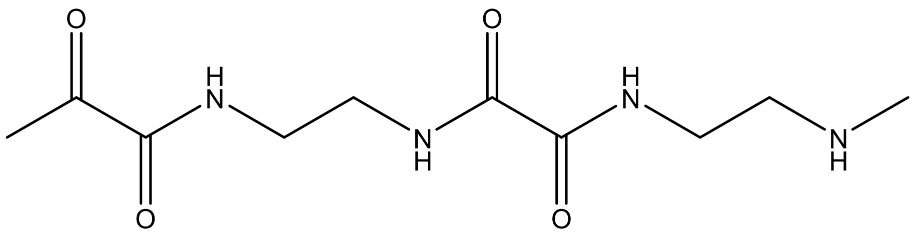
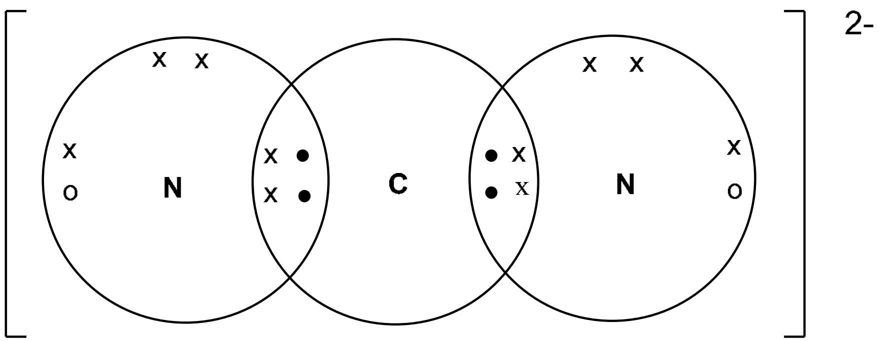
CAMBRIDGE International Examinations

Question	Answer	Mark
1(a)	Cu [Ar] $3d^{10}4s^1$ Cu^{2+} [Ar] $3d^9$ ($4s^0$)	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

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**

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**

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 $\dfrac{T\Delta S}{\Delta H} = 1$ T = 130 / (316 / 1000) = **410 / 411 / 412 / 411.4** (K)	1 1 **2**

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	

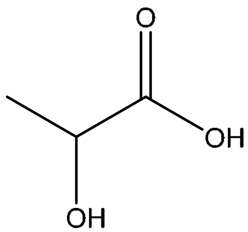
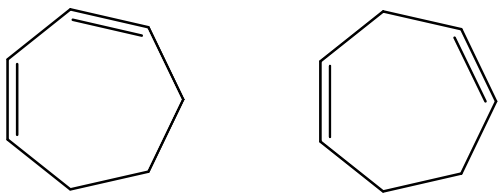
Question	Answer	Mark
	two correct = 1 mark three correct = 2 marks	**2**

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)	<table><tr><td>half-cell</td><td>electrode</td></tr><tr><td>Co^{2+} / Co</td><td>Co / cobalt</td></tr><tr><td>Fe^{3+} / Fe^{2+}</td><td>Pt / carbon / graphite</td></tr></table>	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

Question	Answer	Mark
		2
	Total:	14

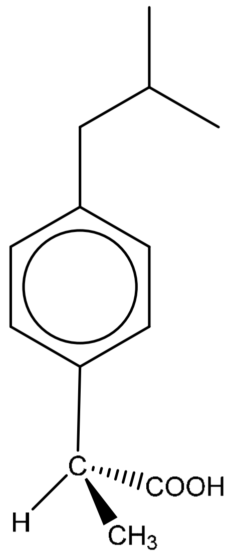
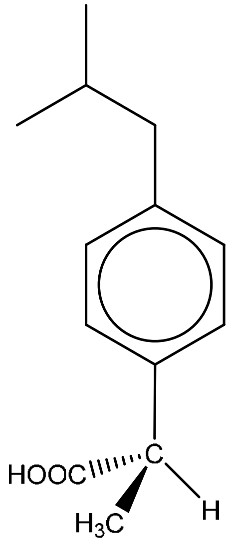
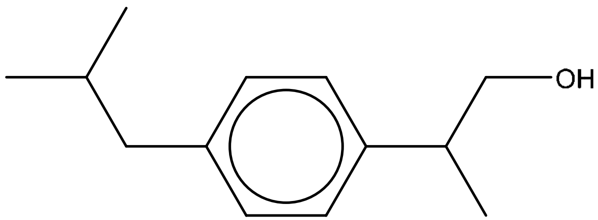
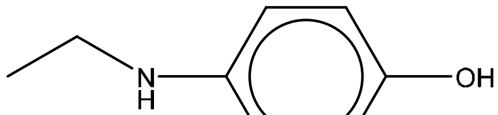
Question	Answer	Mark
5(a)(i)	$(100/22.1)\times(0.7/1.1)$ or $\dfrac{100\times0.7}{22.1\times1.1}$ or $2.87/2.88/2.9$ 3 carbon atoms	1 1 **2**
5(a)(ii)	$C_3H_6O_3$	1 **1**
5(b)	see table below	**2**

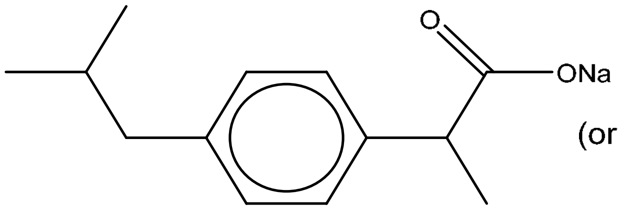
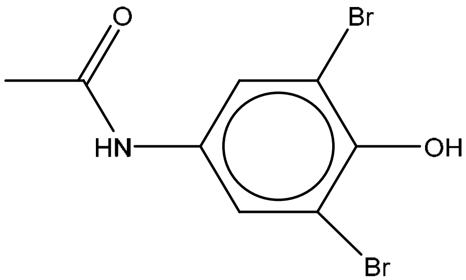
absorption / cm^{-1}	appearance of the peak	type of bond	functional group
3350	broad and strong	OH or O–H	alcohol / ROH
2680	very broad and strong	OH or O–H	(carboxylic) acid / CO_2H
1725	strong	C = O	(carboxylic) acid / CO_2H

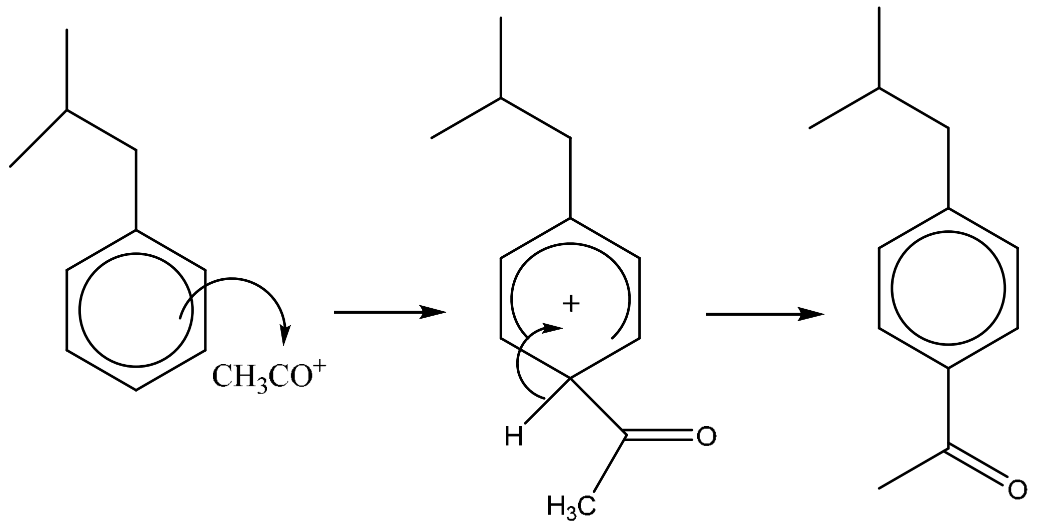
<table>
<tr><th>Question</th><th>Answer</th><th>Mark</th></tr>
<tr><td>5(c)(i)</td><td>
<table>
<tr><td>δ/ppm</td><td>type of proton</td><td>relative peak area</td></tr>
<tr><td>1.4</td><td>$–CH_3$ or $–CH_2$ or –CH or alkane</td><td>3</td></tr>
<tr><td>3.9</td><td>–OCH or $–OCH_2$ or $–OCH_3$ or CH 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>

Question	Answer	Mark
5(d)(ii)	<table><tr><td>isomer</td><td>number of peaks</td></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**

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**

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**

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

Question	Answer	Mark
7(a)	moles of thiosulfate = $0.1 \times 20.8 / 1000 = \mathbf{2.08 \times 10^{-3}}$ moles of ClO^- in 25 cm^3 portion = $2.08 \times 10^{-3} / 2 = \mathbf{1.04 \times 10^{-3}}$ (moles of ClO^- in 250 cm^3 = 1.04×10^{-2}) concentration of $ClO^- = 1.04 \times 10^{-2} / (10/1000) = \mathbf{1.04}$ (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 ClO^- ions concentration of $ClO^- = 3.42 \times 10^{-3} / (5/1000) = \mathbf{0.68 / 0.683 / 0.684}$ (mol dm^{-3})	1 1 **2**
7(d)(i)	$K_c = \dfrac{[C_3H_3N_3O_3][HClO_3]^3}{[C_3Cl_3N_3O_3][H_20]^3}$	1 **1**
7(d)(ii)	(position of eqm) moves to the right / forward reaction predominates / more $HClO$ made (as [$HClO$] decreases) no effect on K_c	1 1 **2**

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**