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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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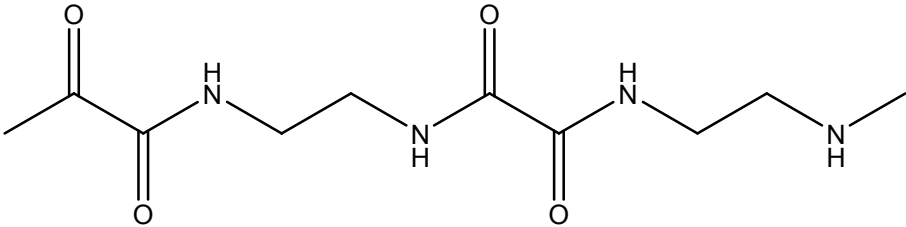
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This document consists of **17** printed pages.

Page 2	Mark Scheme	Syllabus	Paper
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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 ₂ O) 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)	$K_{\text{stab}} = [\text{CuCl}_4^{2-}] / [\text{Cu}(\text{H}_2\text{O})_6^{2+}][\text{Cl}^-]^4$	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 / M²⁺ increases so polarisation / distortion of anion / carbonate ion decreases	1 1 1 3
2(c)(i)		2
2(c)(ii)	$\text{CaCN}_2 + 3\text{H}_2\text{O} \rightarrow \text{CaCO}_3 + 2\text{NH}_3$ CaCO_3 correct equation	1 1 2
	Total:	8

Page 5	Mark Scheme	Syllabus	Paper
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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 (KCl (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)	$\Delta S^\circ = 26.9 + 214 - 65.7 = (+) 175.2 \text{ (J K}^{-1} \text{ mol}^{-1}\text{)}$ $\Delta G^\circ = 117 - (298 \times 175.2 / 1000)$ OR $\Delta G^\circ = 117\,000 - (298 \times 175.2)$ $\Delta G^\circ = +64.8 \text{ (kJ mol}^{-1}\text{)}$	1 1 1 3
3(b)(ii)	$T\Delta S$ is more positive than ΔH / $T\Delta S$ increases / $-T\Delta S$ more negative and ΔG is negative / decrease / less positive	1 1
3(c)	use of $\Delta G = 0$ or $\frac{T\Delta S}{\Delta H} = 1$ $T = 130 / (316 / 1000) = \mathbf{410 / 411 / 412 / 411.4 \text{ (K)}}$	1 1 2

Page 6	Mark Scheme	Syllabus	Paper
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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 $\text{Co(H}_2\text{O)}_4\text{(OH)}_2$ B $[\text{CoCl}_4]^{2-}$ C $[\text{Co(NH}_3)_6]^{2+}$ OR $[\text{Co(NH}_3)_6]^{3+}$ two correct = 1 mark three correct = 2 marks	 2
4(b)(ii)	$[\text{Co(H}_2\text{O)}_6]^{2+}$ 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

Page 8	Mark Scheme	Syllabus	Paper
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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)	<table><tr><td>half-cell</td><td>electrode</td></tr><tr><td>Co²⁺ / Co</td><td>Co / cobalt</td></tr><tr><td>Fe³⁺ / Fe²⁺</td><td>Pt / carbon / graphite</td></tr></table>	half-cell	electrode	Co ²⁺ / Co	Co / cobalt	Fe ³⁺ / Fe ²⁺	Pt / carbon / graphite	1 1
half-cell	electrode							
Co ²⁺ / Co	Co / cobalt							
Fe ³⁺ / Fe ²⁺	Pt / carbon / graphite							
4(d)(ii)	Co + 2Fe ³⁺ → Co ²⁺ + 2Fe ²⁺	1 1						
4(d)(iii)	$E^\ominus_{\text{cell}} = 0.77 - (-0.28) = (+ \text{ or } -) 1.05 \text{ (V)}$	1 1						
4(e)(i)	$E_{\text{electrode}} = -0.28 + (0.059 / 2) \log [0.05] = \textbf{-0.32 / -0.318} \text{ (V)}$	1 1						
4(e)(ii)	more positive	1 1						
4(f)	4Fe ³⁺ + V + H ₂ O → VO ²⁺ + 4Fe ²⁺ + 2H ⁺ VO ²⁺ correct equation	1 1						

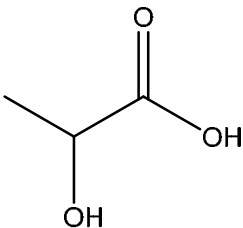
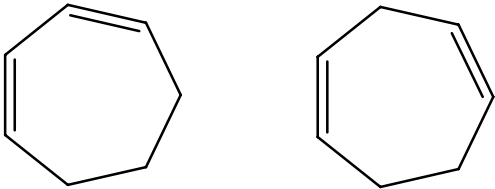
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Question	Answer	Mark
		2
	Total:	14

Page 10	Mark Scheme	Syllabus	Paper
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Question	Answer				Mark																
5(a)(i)	(100/22.1)×(0.7/1.1) or $\frac{100 \times 0.7}{22.1 \times 1.1}$ or 2.87/2.88/2.9 3 carbon atoms				1 1 2																
5(a)(ii)	C ₃ H ₆ O ₃				1 1																
5(b)	<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 / CO₂H</td></tr><tr><td>1725</td><td>strong</td><td>C = O</td><td>(carboxylic) acid / CO₂H</td></tr></table>				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 ₂ H	1725	strong	C = O	(carboxylic) acid / CO ₂ H	2
absorption / cm ⁻¹	appearance of the peak	type of bond	functional group																		
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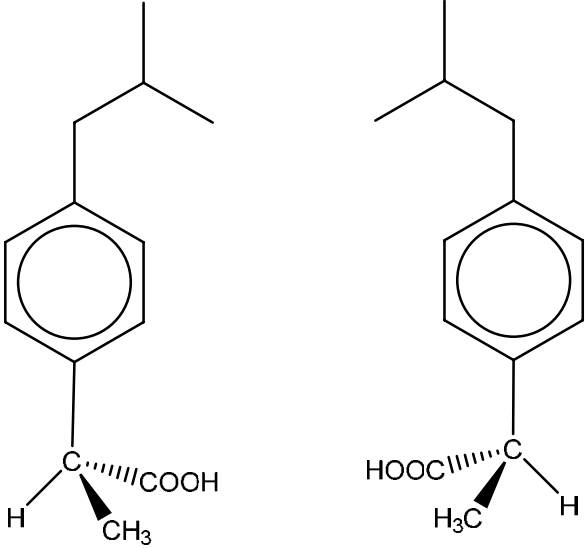
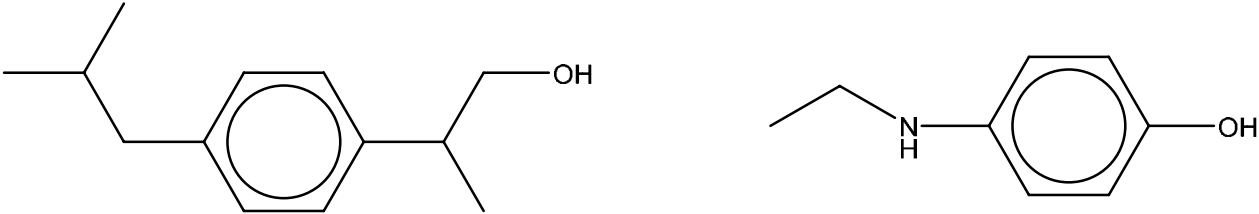
Question	Answer	Mark															
5(c)(i)	<table border="1"> <thead> <tr> <th>δ/ppm</th><th>type of proton</th><th>relative peak area</th></tr> </thead> <tbody> <tr> <td>1.4</td><td>$-\text{CH}_3$ or $-\text{CH}_2$ or $-\text{CH}$ or alkane</td><td>3</td></tr> <tr> <td>3.9</td><td>$-\text{OCH}$ or $-\text{OCH}_2$ or $-\text{OCH}_3$ or CH or alkyl next to electronegative atom/oxygen</td><td>1</td></tr> <tr> <td>4.7</td><td>$-\text{OH}$ or alcohol</td><td>1</td></tr> <tr> <td>12.9</td><td>$-\text{OH}$ or $-\text{CO}_2\text{H}$ or carboxylic acid</td><td>1</td></tr> </tbody> </table>	δ /ppm	type of proton	relative peak area	1.4	$-\text{CH}_3$ or $-\text{CH}_2$ or $-\text{CH}$ or alkane	3	3.9	$-\text{OCH}$ or $-\text{OCH}_2$ or $-\text{OCH}_3$ or CH or alkyl next to electronegative atom/oxygen	1	4.7	$-\text{OH}$ or alcohol	1	12.9	$-\text{OH}$ or $-\text{CO}_2\text{H}$ or carboxylic acid	1	4
δ /ppm	type of proton	relative peak area															
1.4	$-\text{CH}_3$ or $-\text{CH}_2$ or $-\text{CH}$ or alkane	3															
3.9	$-\text{OCH}$ or $-\text{OCH}_2$ or $-\text{OCH}_3$ or CH or alkyl next to electronegative atom/oxygen	1															
4.7	$-\text{OH}$ or alcohol	1															
12.9	$-\text{OH}$ or $-\text{CO}_2\text{H}$ or carboxylic acid	1															
5(c)(ii)	doublet and 1/one H/proton on neighbouring OR adjacent carbon	1 1															
5(c)(iii)	4.7 and 12.9 OR $-\text{OH}$ and $-\text{CO}_2\text{H}$	1 1															
5(c)(iv)		1 1															
5(d)(i)	 both required for 1 mark	1 1															

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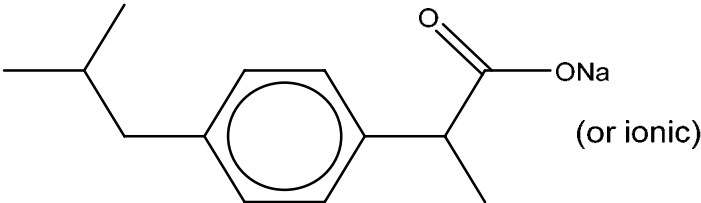
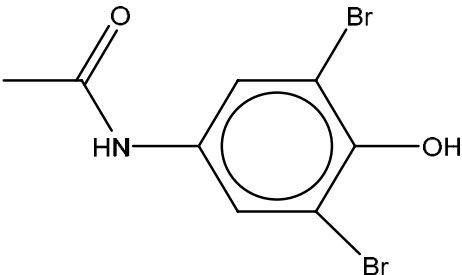
Question	Answer	Mark
5(d)(ii)	isomer	
	number of peaks	
	P	4
	Q	4
		1
		1
		2
	Total:	15

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

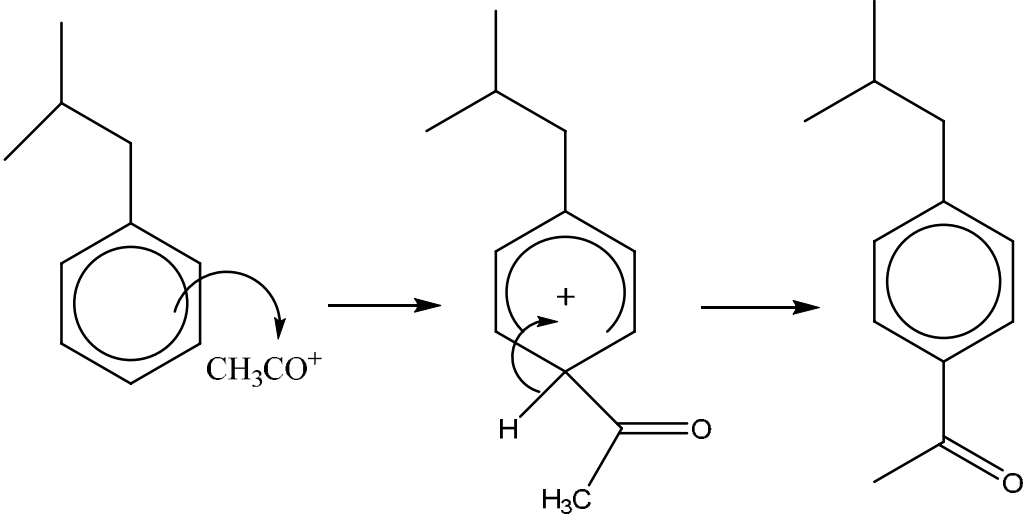
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Question	Answer	Mark
6(b)(ii)	 one correct isomer second diagram shows second isomer	1 1 2
6(c)	 with ibuprofen with paracetamol	1 1 2

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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)	$\text{CH}_3\text{COCl} + \text{AlCl}_3 \rightarrow \text{CH}_3\text{CO}^+ + \text{AlCl}_4^-$	1 1

Page 15	Mark Scheme	Syllabus	Paper
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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

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Question	Answer	Mark
7(a)	moles of thiosulfate = $0.1 \times 20.8 / 1000 = 2.08 \times 10^{-3}$ moles of ClO^- in 25 cm^3 portion = $2.08 \times 10^{-3} / 2 = 1.04 \times 10^{-3}$ (moles of ClO^- in $250 \text{ cm}^3 = 1.04 \times 10^{-2}$) concentration of $\text{ClO}^- = 1.04 \times 10^{-2} / (10 / 1000) = 1.04 \text{ (mol dm}^{-3}\text{)}$	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 $\text{O}_2 = 82 / 24\,000 = 3.42 \times 10^{-3} = \text{moles } \text{ClO}^- \text{ ions}$ concentration of $\text{ClO}^- = 3.42 \times 10^{-3} / (5 / 1000) = \mathbf{0.68 / 0.683 / 0.684} \text{ (mol dm}^{-3}\text{)}$	1 1 2
7(d)(i)	$K_c = \frac{[\text{C}_3\text{H}_3\text{N}_3\text{O}_3][\text{HClO}_3]^3}{[\text{C}_3\text{Cl}_3\text{N}_3\text{O}_3][\text{H}_2\text{O}]^3}$	1 1
7(d)(ii)	(position of eqm) moves to the right / forward reaction predominates / more HClO made (as $[\text{HClO}]$ decreases) no effect on K_c	1 1 2

Page 17	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
7(d)(iii)	$2\text{HClO} \rightarrow 2\text{HCl} + \text{O}_2$ OR $2\text{HClO} \rightarrow \text{H}_2 + \text{Cl}_2 + \text{O}_2$	1 1
7(e)(i)	addition of acid: $\text{H}^+ + \text{HCO}_3^- \rightarrow \text{H}_2\text{CO}_3$ OR $\text{H}^+ + \text{HCO}_3^- \rightarrow \text{H}_2\text{O} + \text{CO}_2$ addition of base: $\text{OH}^- + \text{H}_2\text{CO}_3 \rightarrow \text{HCO}_3^- + \text{H}_2\text{O}$ OR $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$ and position of eqm moves to the right OR $\text{OH}^- + \text{HCO}_3^- \rightarrow \text{CO}_3^{2-} + \text{H}_2\text{O}$	1 1 2
7(e)(ii)	$K_a = \frac{[\text{H}^+][\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]}$ $[\text{H}^+] = (7.94 \times 10^{-7}) \times 1/9.5 = 8.36 \times 10^{-8}$ $\text{pH} = -\log[\text{H}^+] = \mathbf{7.08}$	1 1 2
	Total:	16