

CHEMISTRY**9701/41**

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.

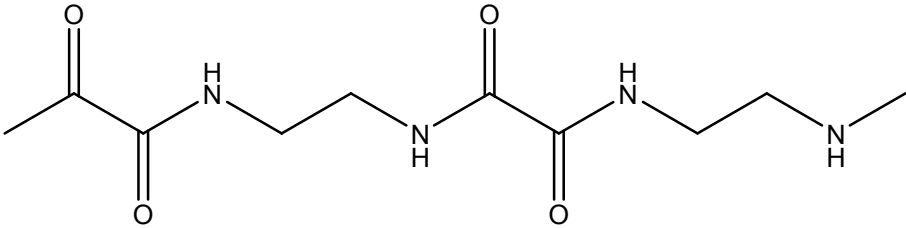
Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the October/November 2016 series for most Cambridge IGCSE[®], Cambridge International A and AS Level components and some Cambridge O Level components.

Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2016	9701	41

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)	$K_{\text{stab}} = \frac{[\text{CuCl}_4^{2-}]}{[\text{Cu}(\text{H}_2\text{O})_6^{2+}][\text{Cl}]^4}$	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

Page 3	Mark Scheme	Syllabus	Paper
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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 ₂ NCH ₂ CH ₂ NH ₂ + 2HCl → ClH ₃ NCH ₂ CH ₂ NH ₃ Cl OR H ₂ NCH ₂ CH ₂ NH ₂ + 2H ⁺ → H ₃ N ⁺ CH ₂ CH ₂ N ⁺ 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 / 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 ΔS is more positive than ΔH /T ΔS increases/–T ΔS more negative and ΔG is negative/decrease/less positive	1 1
3(c)	use of $\Delta G = 0$ or $\frac{T\Delta S}{\Delta H} = 1$ $T = 130 / (316 / 1000) = \mathbf{410 / 411 / 412 / 411.4}$ (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)	1
	ΔH_{hyd} decreases more / faster and ΔH_{sol} becomes (more) endothermic / (more) positive / less exothermic / less negative	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
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	

Page 7	Mark Scheme	Syllabus	Paper
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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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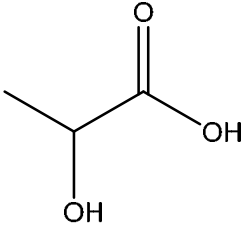
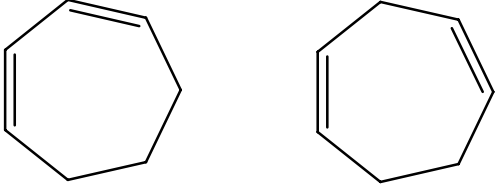
Question	Answer	Mark						
4(c)	(emf/potential/ E) of an electrode OR a half-cell compared to/connected to (S)HE which can be called a "hydrogen half-cell" at concentration of 1 mol dm^{-3} and pressure of 1 atm (or in Pa) OR 298 K	1 1 2						
4(d)(i)	<table border="1"> <tr> <td>half-cell</td> <td>electrode</td> </tr> <tr> <td>$\text{Co}^{2+} / \text{Co}$</td> <td>Co/cobalt</td> </tr> <tr> <td>$\text{Fe}^{3+} / \text{Fe}^{2+}$</td> <td>Pt/carbon/graphite</td> </tr> </table>	half-cell	electrode	$\text{Co}^{2+} / \text{Co}$	Co/cobalt	$\text{Fe}^{3+} / \text{Fe}^{2+}$	Pt/carbon/graphite	1 1
half-cell	electrode							
$\text{Co}^{2+} / \text{Co}$	Co/cobalt							
$\text{Fe}^{3+} / \text{Fe}^{2+}$	Pt/carbon/graphite							
4(d)(ii)	$\text{Co} + 2\text{Fe}^{3+} \rightarrow \text{Co}^{2+} + 2\text{Fe}^{2+}$	1 1						
4(d)(iii)	$E_{\text{cell}}^{\ominus} = 0.77 - (-0.28) = (+ \text{ or } -) 1.05 \text{ (V)}$	1 1						
4(e)(i)	$E_{\text{electrode}} = -0.28 + (0.059/2) \log [0.05] = \mathbf{-0.32 / -0.318 \text{ (V)}}$	1 1						
4(e)(ii)	more positive	1 1						
4(f)	$4\text{Fe}^{3+} + \text{V} + \text{H}_2\text{O} \rightarrow \text{VO}^{2+} + 4\text{Fe}^{2+} + 2\text{H}^+$ VO^{2+} correct equation	1 1						

Page 9	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark
		2
	Total:	14

Question	Answer				Mark																
5(a)(i)	$(100/22.1) \times (0.7/1.1)$ 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 border="1"> <thead> <tr> <th>absorption / cm⁻¹</th> <th>appearance of the peak</th> <th>type of bond</th> <th>functional group</th> </tr> </thead> <tbody> <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> </tbody> </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
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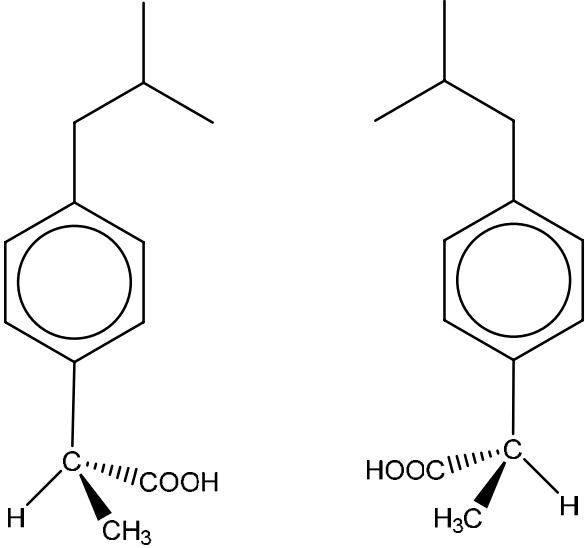
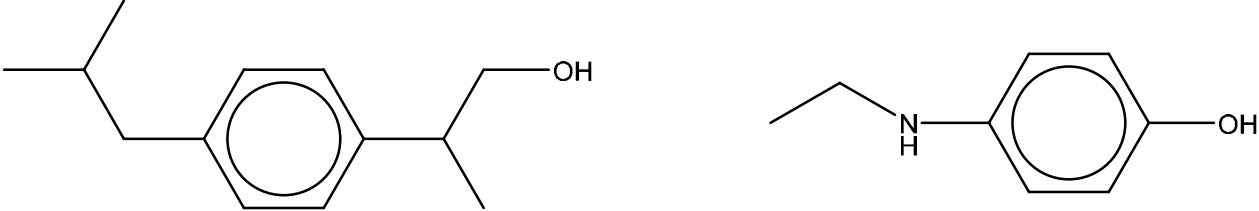
Page 11	Mark Scheme	Syllabus	Paper
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Question	Answer			Mark															
5(c)(i)	<table border="1"> <thead> <tr> <th>δ/ppm</th> <th>type of proton</th> <th>relative peak area</th> </tr> </thead> <tbody> <tr> <td>1.4</td> <td>–CH₃ or –CH₂ or –CH or alkane</td> <td>3</td> </tr> <tr> <td>3.9</td> <td>–OCH or –OCH₂ or –OCH₃ 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 –CO₂H or carboxylic acid</td> <td>1</td> </tr> </tbody> </table>	δ /ppm	type of proton	relative peak area	1.4	–CH ₃ or –CH ₂ or –CH or alkane	3	3.9	–OCH or –OCH ₂ or –OCH ₃ or CH or alkyl next to electronegative atom / oxygen	1	4.7	–OH or alcohol	1	12.9	–OH or –CO ₂ H or carboxylic acid	1			4
δ /ppm	type of proton	relative peak area																	
1.4	–CH ₃ or –CH ₂ or –CH or alkane	3																	
3.9	–OCH or –OCH ₂ or –OCH ₃ or CH or alkyl next to electronegative atom / oxygen	1																	
4.7	–OH or alcohol	1																	
12.9	–OH or –CO ₂ 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 –OH and –CO ₂ H			1 1															
5(c)(iv)				1 1															
5(d)(i)	 both required for 1 mark			1 1															

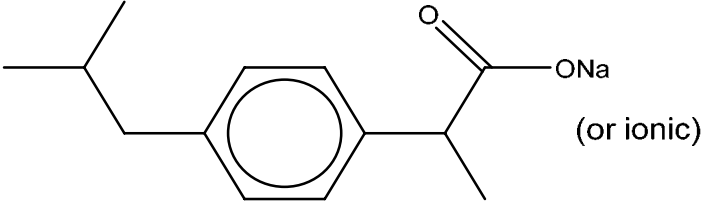
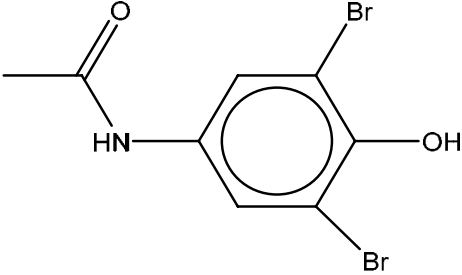
Page 12	Mark Scheme	Syllabus	Paper
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Question	Answer	Mark						
5(d)(ii)	<table border="1"> <tr> <td>isomer</td> <td>number of peaks</td> </tr> <tr> <td>P</td> <td>4</td> </tr> <tr> <td>Q</td> <td>4</td> </tr> </table>	isomer	number of peaks	P	4	Q	4	1
	isomer	number of peaks						
	P	4						
	Q	4						
		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)	 <p>one correct isomer second diagram shows second isomer</p>	<p>1 1 2</p>
6(c)	 <p>with ibuprofen with paracetamol</p>	<p>1 1 2</p>

Page 14	Mark Scheme	Syllabus	Paper
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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

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

Page 16	Mark Scheme	Syllabus	Paper
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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 $\text{ClO}^- = 3.42 \times 10^{-3} / (5 / 1000) = 0.68 / 0.683 / 0.684 \text{ (mol dm}^{-3}\text{)}$	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 $2\text{HClO} \rightarrow \text{H}_2 + \text{Cl}_2 + \text{O}_2$	<p>1</p> <p>1</p>
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 $\text{OH}^- + \text{HCO}_3^- \rightarrow \text{CO}_3^{2-} + \text{H}_2\text{O}$	<p>1</p> <p>1</p> <p>2</p>
7(e)(ii)	$K_a = \frac{[\text{H}^+][\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]}$ $[\text{H}^+] = (7.94 \times 10^{-7}) \times 1/9.5 = 8.36 \times 10^{-8}$ $\text{pH} = -\log[\text{H}^+] = \mathbf{7.08}$	<p>1</p> <p>1</p> <p>2</p>
	Total:	16