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**CHEMISTRY**

**9701/42**

Paper 4 A Level Structured Questions

**May/June 2016**

MARK SCHEME

Maximum Mark: 100

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**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.

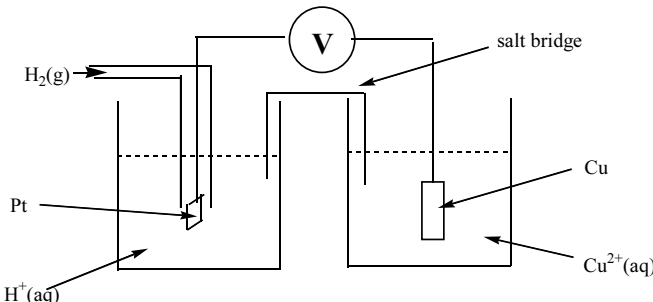
Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the May/June 2016 series for most Cambridge IGCSE<sup>®</sup>, Cambridge International A and AS Level components and some Cambridge O Level components.

<b>Page 2</b>	<b>Mark Scheme</b>	<b>Syllabus</b>	<b>Paper</b>
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<b>Question</b>	<b>Answer</b>	<b>Marks</b>
<b>1 (a) (i)</b>	dative (covalent) <i>or</i> coordinate Hydrogen/H (bonding)	2
<b>(ii)</b>	octahedral	1
<b>(iii)</b>	$\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O} \rightarrow \text{Mg}(\text{NO}_3)_2 + 6\text{H}_2\text{O}$ $\text{Mg}(\text{NO}_3)_2 \rightarrow \text{MgO} + 2\text{NO}_2 + \frac{1}{2}\text{O}_2$ <p><i>any three of</i>  (solid) dissolves/turns to liquid  condensation on tube  <u>white</u> solid (forms/remains)  brown fumes (evolved)  gas formed that relights a glowing splint</p>	4
<b>(iv)</b>	$M_r$ values: $\text{Mg}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O} = 256.3$ $\text{MgO} = 40.3$ <b>or</b> (loss in molar mass = $256.3 - 40.3 = 216$ ) percentage loss = $100 \times 216 / 256.3 = \mathbf{84.3 / 84.4\%}$	2
<b>(b)</b>	(cat)-ionic radius / ion size <b>increases</b> (down the group) less polarisation / distortion of nitrate ion / $\text{NO}_3^-$	2
<b>(c)</b>	$2\text{AgNO}_3 \rightarrow 2\text{Ag} + 2\text{NO}_2 + \text{O}_2$	1
		<b>[Total: 12]</b>
<b>2 (a) (i)</b>	(an acid that is) partially / incompletely ionised / dissociated	1
<b>(b) (i)</b>	$\text{p}K_a = -\log K_a$ <i>or</i> $K_a = 10^{-\text{p}K_a}$	1


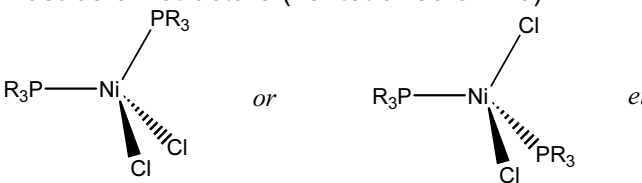
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Question	Answer	Marks
(ii)	<p>ethanoic acid (1) is <b>more acidic</b> than propanoic acid (2) due to smaller electron-donating (R/alkyl) group/less electron-donating (R/alkyl) group(s)</p> <p>2-chloropropanoic acid (3) is <b>more acidic</b> than propanoic acid (2) due to electron-withdrawing/electronegative (Cl/chlorine) atom</p> <p>2-chloropropanoic acid (3) is more acidic than 3-chloropropanoic acid (4) since the Cl/chlorine/electronegative atom is closer to the <math>\text{CO}_2^-</math>/acid</p>	3
(c) (i)	 <p>M1: voltmeter/V <b>and</b> salt bridge labelled</p> <p>M2: Cu <b>and</b> <math>\text{Cu}^{2+}</math>/CuSO<sub>4</sub> (any soluble Cu(II) salt)</p> <p>M3: H<sub>2</sub> (arrow in) and H<sup>+</sup>/HCl/H<sub>2</sub>SO<sub>4</sub>/any mineral acid</p> <p>M4 Pt <b>and</b> one solution at 1 M/1 mol dm<sup>-3</sup> OR H<sub>2</sub> at 1 atm</p>	4
(ii)	<p><math>E^\ominus_{\text{cell}} = 0.34</math> (V) <b>and</b> <math>(\text{Cu}^{2+})/\text{Cu}</math> is the positive electrode</p>	1
d (i)	<p><math>K_a = 1.23 \times 10^{-5}</math></p> <p><math>[\text{H}^+] = \sqrt{K_a \cdot c} = \sqrt{(1.23 \times 10^{-5} \times 0.1)} = 1.11 \times 10^{-3} \text{ mol dm}^{-3}</math></p> <p>pH = <b>3.0 (2.96)</b> ecf from <math>[\text{H}^+]</math></p>	2

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Question	Answer	Marks
(ii)	$E = 0.0 + 0.059\log(1.11 \times 10^{-3})$ OR $= -0.17(4)V$ so new $E_{\text{cell}} = 0.34 + 0.17 = \mathbf{0.51V}$ ecf from (d)(i)	2
		[Total: 14]
3 (a) (i)	$(\text{CH}_3)_2\text{CHCN}$	1
(ii)	reaction 1: $\text{NH}_3$ (in ethanol) under pressure (+ heat) or heat $\text{NH}_3$ in a sealed tube  reaction 2: KCN/NaCN <b>and</b> heat/reflux (in ethanol)  reaction 3: $\text{H}_2 + \text{Ni}$ or $\text{LiAlH}_4$	3
(b) (i)	$\text{CH}_3\text{CH}_2\text{NH}_2 + \text{H}_2\text{O} \rightarrow \text{CH}_3\text{CH}_2\text{NH}_3^+ (+) \text{OH}^-$	1
(ii)	ethylamine is <b>more basic</b> than ammonia... because of electron-donating (alkyl/ethyl/R) group (in ethylamine)  which makes the <u>lone pair</u> (on N) more available for donation  <b>or</b> the <u>lone pair</u> (on N) more available for a proton/ $\text{H}^+$	2
(c) (i)	A solution which resists/minimises/roughly maintains changes in <u>pH</u> when (small amounts of) $\text{H}^+$ or $\text{OH}^-$ are added	1
(ii)	$\text{CH}_3\text{NH}_2 + \text{H}^+ \rightarrow \text{CH}_3\text{NH}_3^+$  $\text{CH}_3\text{NH}_3\text{Cl} + \text{OH}^- \rightarrow \text{CH}_3\text{NH}_2 + \text{H}_2\text{O} + \text{Cl}^-$	2
		[Total: 10]

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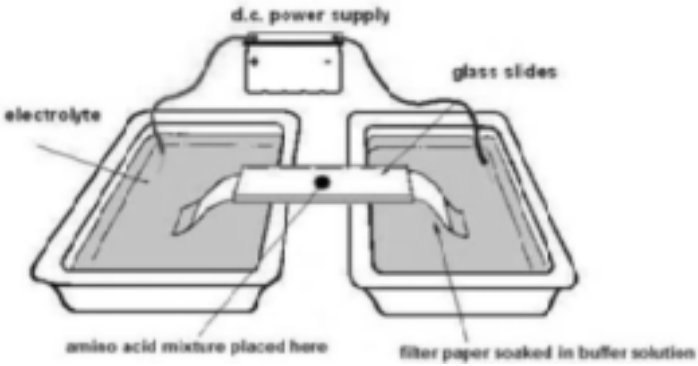
Question	Answer	Marks
4 (a) (i)	 <p>(cis)                      (trans)</p>	2
(ii)	<p><b>cis</b> is (more) <b>polar</b> due to both Cl<sup>(δ-)</sup> on same side  <b>or</b>  <b>cis</b> is (more) <b>polar</b> as dipoles do not cancel / unsymmetrical  <b>or</b>  <b>trans</b> is <b>non-polar</b> as its bond dipoles cancel</p>	1
(iii)	<p>(This can only be <i>cis</i>)  its mirror image is the same / superimposable</p> <p><b>or</b> the distance between two coordinating nitrogens / oxygens is too small to bond <i>trans</i>  <b>or</b> difficult for the NH<sub>2</sub> and O to change places (since 5-membered rings can only bridge adjacent positions)</p>	1
(b) (i)	It's not square planar <b>or</b> it's tetrahedral	1
(ii)	<p>must be 3D structure (i.e. tetrahedral-like)</p>  <p><i>or</i>                      <i>etc</i></p>	1
		[Total: 6]



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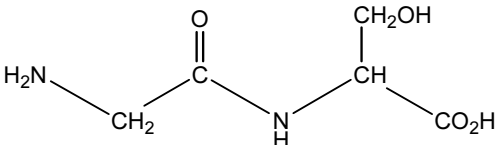
Question	Answer	Marks
6 (a)	<p><i>essential mark</i></p> <p>M1 the reactants/substrate has a <b>shape</b> complementary/<b>specific</b> to <b>active site</b> – can be awarded from a labelled diagram as below <b>or</b> diagrams showing this specificity clearly</p> <p><i>any two of</i></p> <p>M2: reactants/substrate binds to/fits into the <b>active site</b> of the enzyme</p> <p>M3: (Interaction with site) causes a specific bond to be weakened, (which breaks) <b>or</b> lowers activation energy</p> <p>M4: forms an E-S complex</p> <p>M5: products released from enzyme/active site</p> <p><b>labelled diagrams</b></p> 	3
(b) (i)	<p><math>\delta</math> 26 is <b>CH<sub>3</sub>-CO</b>      <math>\delta</math> 52 is <b>CH<sub>3</sub>-O</b></p> <p><math>\delta</math> 169 is <b>CH<sub>3</sub>CO</b>      <math>\delta</math> 167 is <b>phenyl-CO</b></p> <p><u>Phenyl ethanoate</u> is <b>B</b>    <u>methyl benzoate</u> is <b>A</b></p> <p>M1 = any two correct <math>\delta</math> linked to phenylethanoate/methyl benzoate</p> <p>M2 = the rest correct</p>	2
(ii)	<p>heat with H<sub>3</sub>O<sup>+</sup> (to hydrolyse the ester)</p> <p>then add Br<sub>2</sub>(aq)/bromine water</p> <p>decolourises/gives white ppt. (with phenol from <b>B</b>)</p>	3
		<b>[Total: 8]</b>

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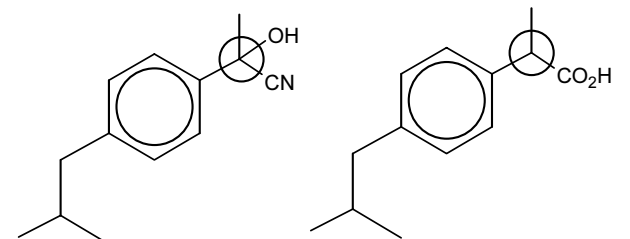
Question	Answer	Marks
7 (a) (i)	<p>labelled with</p> <p>M1: <u>DC</u> power supply + and – / battery / cell / + and – sign (on cell / electrodes) with a complete circuit</p> <p>M2: buffer solution / electrolyte labelled</p> <p>M3: (amino acid) mixture / x on (filter) paper / gel / agarose</p> 	3
(ii)	<p>direction of movement related to charge (of amino acids)</p> <p>distance travelled depends on charge / <math>M_r</math> (of amino acids)</p>	2
(b) (i)	<p>Asp + Val:</p> <p><b>pH 12</b> because Asp will be <math>-\text{CH}_2\text{COO}^-</math> (R-group) moves further (to positive electrode than Val)</p> <p><b>or pH 12</b> Asp more negative so moves further (to positive electrode)</p> <p><b>or pH 12</b> because Asp has a charge of 2– but Val has a charge of 1–</p> <p><b>or best at pH 7</b> because Asp will be negatively charged (anionic) but Val neutral</p>	1
(ii)	<p>Lys + Ser:</p> <p><b>pH 2</b> because Lys will be <math>(\text{CH}_2)_4\text{NH}_3^+</math> (R-group) moves further (to negative electrode than Ser)</p> <p><b>or pH 2</b> Lys more positive so moves further (to negative electrode)</p> <p><b>or pH 2</b> because Lys has a charge of 2+ and Ser has a charge of 1+</p> <p><b>or pH 7</b> because Lys is positively charged (cationic) but Ser neutral / zwitterionic</p>	1



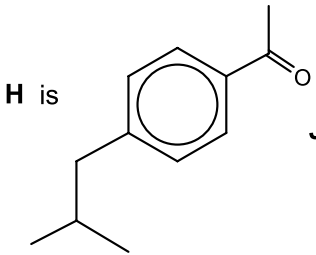
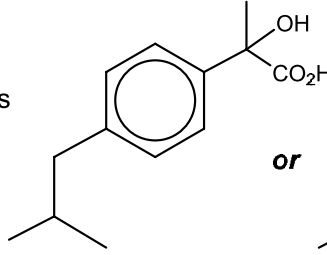
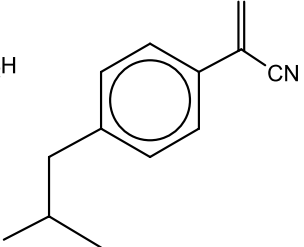
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Question	Answer	Marks
(iii)	Tyr + Phe: <b>pH 12</b> because Tyr will be $\text{C}_6\text{H}_5\text{CH}_2\text{O}^-$ (R-group) moves further / more / faster (to positive electrode than Phe) <b>or pH12</b> because Tyr has a charge of 2- but Phe has a charge of 1-	1
(c) (i)	 <p>M1: for <math>-\text{CONH}-</math> as shown above</p> <p>M2: for rest of molecule <b>and</b> correct connectivity of the bonds</p>	2
(ii)	<i>from the IR spectrum</i> <ul style="list-style-type: none"> <li>• <b>E</b> is O-H or N-H (allow <math>\text{NH}_2</math>)</li> <li>• <b>F</b> is C=O</li> <li>• <b>G</b> is C-O</li> </ul>	2
		<b>[Total: 12]</b>
8 (a)	<p>M1: solubility increases (down the group)</p> <p>M2: because lattice energy decreases faster than does <math>\Delta H_{\text{hyd}}</math></p> <p>M3: <math>\Delta H_{\text{sol}}</math> / enthalpy of solution becomes more exothermic / less endothermic</p>	3
(b) (i)	Should be the same / similar (enthalpy change), as (both acids) are fully ionised / strong acids	1

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Question	Answer	Marks
(ii)	$\text{Ca(s)} + 2\text{H}^+(\text{aq}) \longrightarrow \text{Ca}^{2+}(\text{aq}) + \text{H}_2(\text{g})$  <p>gas phase ions: <math>\text{Ca}^{2+}(\text{g}) + 2\text{H}^+(\text{g})</math></p> $x = \Delta H_{\text{at}}(\text{Ca}) + \text{IE}(1) + \text{IE}(2) - 2\Delta H_{\text{hyd}}(\text{H}^+) + \Delta H_{\text{hyd}}(\text{Ca}^{2+}) - 2\text{IE}(\text{H}) - E(\text{H}-\text{H})$ $x = 178 + 590 + 1150 + 2(1090) - 1576 - 2(1310) - 436$ $x = -534 \text{ kJ mol}^{-1}$	4
(c)	<p><math>\text{CH}_3\text{CO}_2\text{H}</math> is incompletely ionised / weak acid / weaker acid</p> <p>enthalpy change of ionisation (of <math>\text{CH}_3\text{COOH}</math>) is <math>+2 \text{ kJ mol}^{-1}</math></p> <p>or energy needed to ionise / dissociate (<math>\text{CH}_3\text{COOH}</math>)</p>	2
		[Total: 10]
9 (a)		1

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Question	Answer	Marks
(b)	<p>H is </p> <p>J is </p> <p><i>or</i> </p> <p style="text-align: center;"><b>J1</b>                      <b>J2</b></p>	2
(c)	<p>step 1: <math>(\text{CH}_3)_2\text{CHCH}_2\text{Cl} + \text{AlCl}_3</math> (+ heat)</p> <p>step 2: <math>\text{CH}_3\text{COCl} + \text{AlCl}_3</math> (+ heat)</p> <p>step 3: <math>\text{HCN} + \text{NaCN}</math> <i>or</i> <math>\text{HCN} + \text{base}</math> <i>or</i> <math>\text{HCN} + \text{CN}^-</math></p> <p><i>(steps 4 and 5 could be reversed on J)</i>  <i>If J1 step 4 then step 5    J2 step 5 then step 4</i></p> <p>step 4: <math>\text{H}_3\text{O}^+</math> + heat/aqueous <math>\text{HCl}</math> + heat</p> <p>step 5: conc <math>\text{H}_2\text{SO}_4</math> + heat/ conc <math>\text{H}_3\text{PO}_4</math> + heat  <i>or</i> <math>\text{Al}_2\text{O}_3</math> + heat</p> <p>step 6: <math>\text{H}_2 + \text{Ni}</math> (+ heat)</p>	6
(d)	<p>step 1: electrophilic substitution <i>or</i> alkylation</p> <p>step 6: reduction / hydrogenation / addition</p>	2
		<b>[Total: 11]</b>

