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**CHEMISTRY**

**9701/41**

Paper 4 A Level Structured Questions

**October/November 2017**

MARK SCHEME

Maximum Mark: 100

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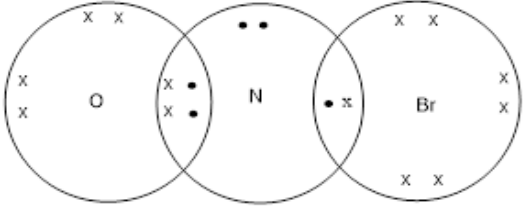
**Published**

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.

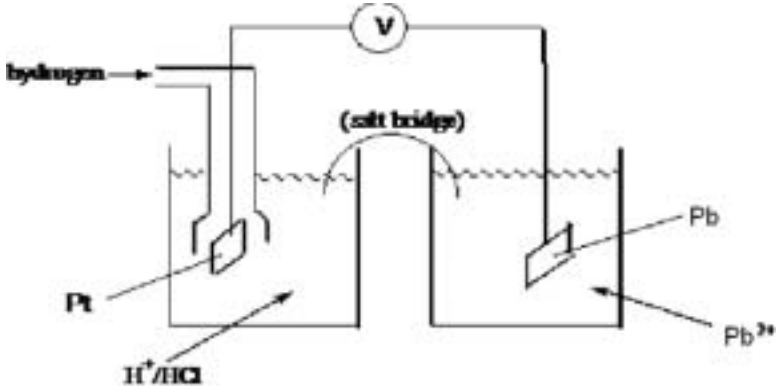
Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the October/November 2017 series for most Cambridge IGCSE<sup>®</sup>, Cambridge International A and AS Level components and some Cambridge O Level components.

Question	Answer	Marks
1(a)	N +2 to +3 (and oxidised)	1
	Br <sub>2</sub> /Br 0 to –1 (and reduced)	1
1(b)		
	3 bonding pairs around N (in a structure involving NOBr)	1
	rest of molecule correct	1
1(c)(i)	the <b>power</b> to which a concentration of a reactant is raised in the <b>rate equation</b>	1
1(c)(ii)	using expt. 2 and 3 a = 2 <b>or</b> [NO] 2nd order <b>and</b> conc × 3 rate × 9 <b>or</b> $6.1 \times 10^{-2} / 6.8 \times 10^{-3} = (0.09 / 0.03)^a$	1
	using expt. 1 and 2 b = 1 <b>or</b> [Br <sub>2</sub> ] 1 <sup>st</sup> order <b>and</b> conc × 2 rate × 2 <b>or</b> $6.8 \times 10^{-3} / 3.4 \times 10^{-3} = (0.04 / 0.02)^b$	1
(c)(iii)	initial rate = 0.16(32)	1
1(c)(iv)	$(0.0034 = k(0.03)^2(0.02))$ k = <b>188.9</b>	1
	mol <sup>-2</sup> dm <sup>6</sup> s <sup>-1</sup>	1
1(c)(v)	k decreases (as rate decreases)	1

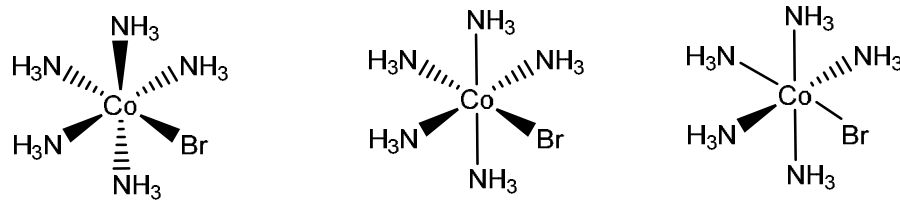
Question	Answer	Marks
1(d)	$m = 2$ and $n = 0$	1

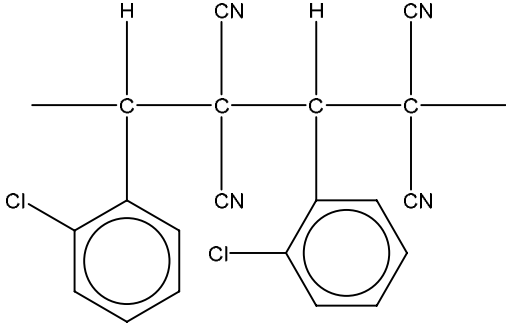
Question	Answer	Marks
2(a)	it / solubility <b>decreases</b> down the group <b>and</b> $K_{sp}$ decreases	1
2(b)(i)	$MgCO_3(s) \rightleftharpoons Mg^{2+}(aq) + CO_3^{2-}(aq)$	1
2(b)(ii)	(white) solid appears / precipitation (of $MgCO_3$ )	1
	as $[CO_3^{2-}]$ increases shifting equilibrium to the LHS (precipitating out $MgCO_3$ )	1
2(c)	solubility = $\sqrt{1.0 \times 10^{-5}} = 3.16 \times 10^{-3} \text{ mol dm}^{-3}$	1
	solubility = $3.2 \times 10^{-3} \times 84.3 = 0.27 \text{ g dm}^{-3}$	1
2(d)(i)	$Mg^{2+}$ ion is smaller than $Ba^{2+}$ ion <b>or</b> ionic radii increase down group ora	1
	( $Mg^{2+}$ ) distorts / polarises / the anion / nitrate group / nitrate <b>ion</b> / $NO_3^{(1)-}$ / $NO_3$ ion more easily (than $Ba^{2+}$ ) ora	1
2(d)(ii)	$Ba(NO_3)_2 \rightarrow BaO + 2NO_2 + \frac{1}{2}O_2$	1
2(d)(iii)	$BaO + H_2O \rightarrow Ba(OH)_2$	1
	$Ba(OH)_2 + H_2SO_4 \rightarrow BaSO_4 + 2H_2O$	1

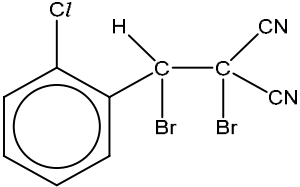
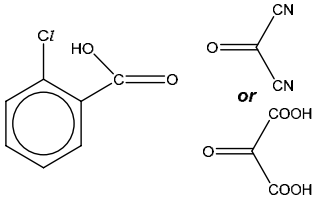
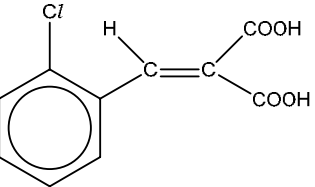
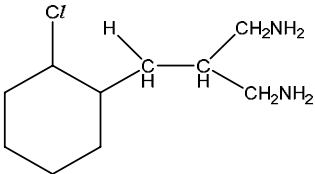
Question	Answer	Marks
3(a)	the potential <b>difference</b> between two half-cells / two electrodes (in a cell)	1
	under standard conditions of 1 atm., 298 K, (all) solutions being 1 mol dm <sup>-3</sup>	1
3(b)(i)	 <p>8 marking points, any 2 points for each mark</p> <p>H<sub>2</sub> / hydrogen  correct delivery system for H<sub>2</sub>  Pb<sup>2+</sup> (aq)  Pb electrode  Pt electrode  H<sup>+</sup>(aq) solution  salt bridge  voltmeter/V labelled</p>	4
3(b)(ii)	more negative	1
	shifts Pb <sup>2+</sup> (+ 2e <sup>-</sup> ) ⇌ Pb equilibrium / reaction to the left	1

Question	Answer	Marks
3(c)(i)	$Q = 0.4 \times 80 \times 60 = \mathbf{1920\ C}$ <b>and</b> use of 96500 / 193000 Moles of Pb = $1920 / 193000 = 9.95 \times 10^{-3}$ Mass of Pb = $207.2 \times 9.95 \times 10^{-3} = \mathbf{2.1\ g}$  <b>OR</b> $Q = 0.4 \times 80 \times 60 = \mathbf{1920\ C}$ <b>and</b> use of $1.6 \times 10^{-19} / 1.2 \times 10^{22}$ atoms Pb = $6 \times 10^{21}$ ; moles of Pb = $6 \times 10^{21} / 6 \times 10^{23} = 0.01$ Mass of Pb = $207.2 \times 0.01 = \mathbf{2.1\ g}$	<b>2</b>
3(c)(ii)	$\text{PbO}_2(\text{s}) + \text{SO}_4^{2-}(\text{aq}) + \mathbf{4\ H^+} + \mathbf{2\ e^-} \rightarrow \text{PbSO}_4(\text{s}) + \mathbf{2\ H_2O}$	<b>1</b>
3(d)	reagents / $\text{PbO}_2$ / $\text{H}_2\text{SO}_4$ <b>and</b> used up / concentration decreases	<b>1</b>
	as fuel / hydrogen is being continuously supplied / fuel has not run out	<b>1</b>

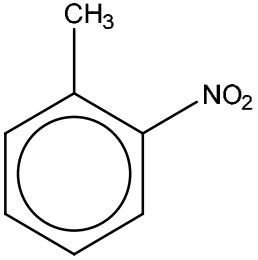
Question	Answer	Marks
4(a)	density is higher <b>and</b> melting point is higher	<b>1</b>
	(density) due to $A_r$ being larger <b>and</b> smaller atomic radii <b>or</b> (Co) <b>atoms / ions</b> heavier <b>and</b> smaller	<b>1</b>
	(melting point) due to stronger attraction to cations as more delocalised electrons	<b>1</b>
4(b)	(a molecule or ion) formed by a <b>central</b> metal <b>atom / ion</b> surrounded by (one or more) <b>ligands</b>	<b>1</b>
4(c)(i)	same number and type of <u>atoms</u> <b>and</b> different structural formula	<b>1</b>

Question	Answer	Marks															
4(c)(ii)	octahedral <b>AND</b> 3D structure of $[\text{Co}(\text{NH}_3)_5\text{Br}]^{2+}$ e.g. <div style="display: flex; justify-content: space-around; align-items: center; margin-top: 10px;">  </div>	<b>1</b>															
4(c)(iii)	co-ordinate / dative covalent	<b>1</b>															
4(c)(iv)	+3 for <b>both</b>	<b>1</b>															
4(d)	(HNO <sub>3</sub> ) Ag <sup>+</sup> / AgNO <sub>3</sub> cream(–yellow) ppt. (of AgBr) <b>and</b> no reaction / white ppt. for other isomer	<b>1</b>															
	Ba(OH) <sub>2</sub> / Ba <sup>2+</sup> (aq) / BaCl <sub>2</sub> / Ba(NO <sub>3</sub> ) <sub>2</sub> white ppt. (of BaSO <sub>4</sub> ) <b>and</b> no reaction for other isomer	<b>1</b>															
4(e)	(d-d) energy gap / $\Delta E$ is different	<b>1</b>															
	<b>absorb</b> different wavelength / frequency (of light)	<b>1</b>															
4(f)	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%;"></th> <th style="width: 25%;">heterogeneous</th> <th style="width: 25%;">homogeneous</th> </tr> </thead> <tbody> <tr> <td>Fe in the Haber process</td> <td style="text-align: center;">✓</td> <td></td> </tr> <tr> <td>Fe<sup>2+</sup> in the I<sup>-</sup> / S<sub>2</sub>O<sub>8</sub><sup>2-</sup> reaction</td> <td></td> <td style="text-align: center;">✓</td> </tr> <tr> <td>NO<sub>2</sub> in the oxidation of SO<sub>2</sub></td> <td></td> <td style="text-align: center;">✓</td> </tr> <tr> <td>V<sub>2</sub>O<sub>5</sub> in the Contact process</td> <td style="text-align: center;">✓</td> <td></td> </tr> </tbody> </table>		heterogeneous	homogeneous	Fe in the Haber process	✓		Fe <sup>2+</sup> in the I <sup>-</sup> / S <sub>2</sub> O <sub>8</sub> <sup>2-</sup> reaction		✓	NO <sub>2</sub> in the oxidation of SO <sub>2</sub>		✓	V <sub>2</sub> O <sub>5</sub> in the Contact process	✓		<b>2</b>
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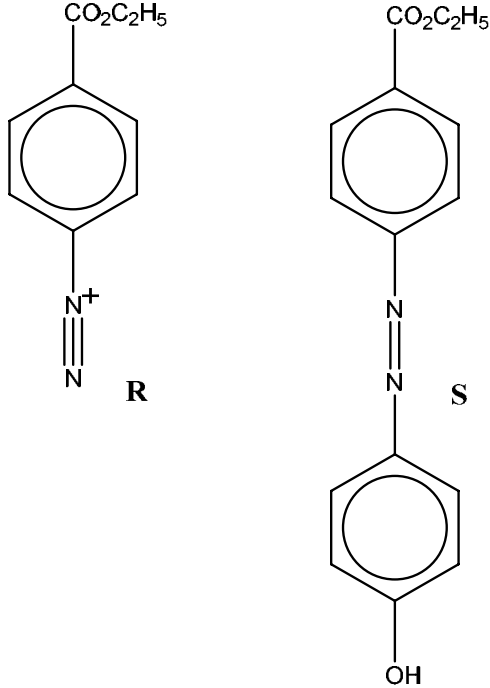
Question	Answer	Marks
5(a)	nitrile; alkene; chloro; benzene / arene	<b>2</b>
5(b)		<b>1</b>
	addition (polymerisation)	<b>1</b>

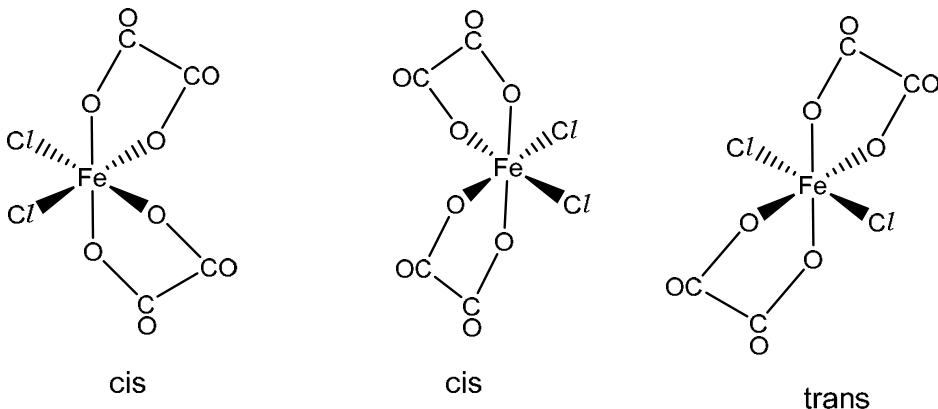
Question	Answer			Marks
5(c)	reagent	structure of product	type of organic reaction	<b>8</b>
	excess Br <sub>2</sub> (aq)	 [1]	(electrophilic) addition	
	excess hot, conc. MnO <sub>4</sub> <sup>-</sup> (aq)	 [1] + [1]	oxidation	
	excess hot, aqueous HCl	 [1]	hydrolysis	
	excess H <sub>2</sub> /Pt catalyst	 both CH <sub>2</sub> NH <sub>2</sub> formed [1] both arene and alkene reduced [1]	reduction / hydrogenation	
		structures [6]	2 correct for 1 mark total [2]	



Question	Answer	Marks
6(a)(i)		1
6(a)(ii)	$\text{HNO}_3 + 2\text{H}_2\text{SO}_4 \rightarrow \text{H}_3\text{O}^+ + \text{NO}_2^+ + 2\text{HSO}_4^-$	1
6(a)(iii)	<p><b>any three</b> from:</p> <p>Point 1: bonds/electrons are <b>partially</b> delocalised in <b>T</b>  <b>or</b> delocalised / <math>\pi</math> system / <math>\pi</math> bonding extends over only five carbons</p> <p>Point 2: four <math>\pi</math>-electrons in the (delocalised system of <b>T</b>)  <b>or</b> methylbenzene has (two) more <math>\pi</math>-electrons / (two) more delocalised electrons</p> <p>Point 3: contains a carbon that is <math>\text{sp}^3</math> hybridised in <b>T</b>  <b>or</b> (all the) carbons are <math>\text{sp}^2</math> hybridised in methylbenzene</p> <p>Point 4: one carbon has a bond angle of <math>109.5^\circ</math> / tetrahedral (in <b>T</b>)  <b>or</b> (C-C) bond strengths / lengths are not all the same  <b>or</b> not all the bond angles are <math>120^\circ</math> (in <b>T</b>)</p>	3
6(b)(i)	4-aminobenzoic acid	1
6(b)(ii)	<p>step 1 Sn + HCl [1] concentrated / reflux / heat [1]  step 2 <math>\text{CH}_3\text{COCl}</math> [1]  step 3 <math>\text{KMnO}_4</math> / manganate(VII) / <math>\text{MnO}_4^-</math> (acidified / alkaline) <b>and</b> heat [1]  step 4 aqueous HCl <b>and</b> heat [1]  step 5 ethanol, <math>\text{H}_2\text{SO}_4</math>, concentrated / reflux / heat [1]</p>	6

Question	Answer	Marks																				
6(c)	<p>(benzocaine) is less (basic than ethylamine) <b>AND</b>  <b>lone pair</b> (on N) is less available to <b>accept</b> a proton / H<sup>+</sup></p> <p>since (lone pair on N) is delocalised over the ring  <b>or</b> phenyl ring is electron withdrawing group</p> <p><b>OR</b>  ethylamine is more basic (than benzocaine) <b>AND</b>  <b>lone pair</b> (on N) is more available to <b>accept</b> a proton / H<sup>+</sup></p> <p>since ethyl/alkyl group is electron-donating group</p>	<b>2</b>																				
6(d)(i)	7 peaks	<b>1</b>																				
6(d)(ii)	CDCl <sub>3</sub> will produce no signal in the spectrum <b>or</b> CHCl <sub>3</sub> would produce a signal / would be detected	<b>1</b>																				
6(d)(iii)	<table border="1" data-bbox="512 791 1760 1179"> <thead> <tr> <th data-bbox="512 791 667 908"><math>\delta/ppm</math></th> <th data-bbox="667 791 1158 908">group responsible for the peak</th> <th data-bbox="1158 791 1458 908">number of H atoms responsible for the peak</th> <th data-bbox="1458 791 1760 908">splitting pattern</th> </tr> </thead> <tbody> <tr> <td data-bbox="512 908 667 962">1.2</td> <td data-bbox="667 908 1158 962">CH<sub>(3)</sub></td> <td data-bbox="1158 908 1458 962">3</td> <td data-bbox="1458 908 1760 962">triplet</td> </tr> <tr> <td data-bbox="512 962 667 1043">3.5</td> <td data-bbox="667 962 1158 1043">CH<sub>(2)</sub>O</td> <td data-bbox="1158 962 1458 1043">2</td> <td data-bbox="1458 962 1760 1043">quartet</td> </tr> <tr> <td data-bbox="512 1043 667 1098">5.5</td> <td data-bbox="667 1043 1158 1098">NH<sub>2</sub></td> <td data-bbox="1158 1043 1458 1098">2</td> <td data-bbox="1458 1043 1760 1098">singlet (broad)</td> </tr> <tr> <td data-bbox="512 1098 667 1179">7.1–7.4</td> <td data-bbox="667 1098 1158 1179">H attached to aromatic / benzene ring</td> <td data-bbox="1158 1098 1458 1179">4</td> <td data-bbox="1458 1098 1760 1179"><i>multiplet</i></td> </tr> </tbody> </table>	$\delta/ppm$	group responsible for the peak	number of H atoms responsible for the peak	splitting pattern	1.2	CH <sub>(3)</sub>	3	triplet	3.5	CH <sub>(2)</sub> O	2	quartet	5.5	NH <sub>2</sub>	2	singlet (broad)	7.1–7.4	H attached to aromatic / benzene ring	4	<i>multiplet</i>	<b>4</b>
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6(d)(iv)	neighbouring / adjacent carbon <b>atom</b> has two protons / H (attached to it) <b>or</b> there is an adjacent CH <sub>2</sub> (O) group	<b>1</b>																				
6(d)(v)	peak at 5.5 / NH <sub>2</sub> peak will disappear <b>and</b> NH <sub>2</sub> / protons exchange / swap with deuterium	<b>1</b>																				

Question	Answer	Marks
6(e)(i)	$\text{NaNO}_2 + \text{HCl}$ <i>or</i> $\text{HNO}_2$	1
6(e)(ii)		
	structure of diazonium salt <b>R</b>	1
	structure of azo dye <b>S</b>	1

Question	Answer	Marks
7(a)	Fe atom = $(1s^2 2s^2 2p^6) 3s^2 3p^6 3d^6 4s^2$ Fe <sup>3+</sup> ion = $(1s^2 2s^2 2p^6) 3s^2 3p^6 3d^5$	1
7(b)	$([H^+]^2 = 8.9 \times 10^{-4} \times 0.25 \text{ or } 2.225 \times 10^{-4})$ $[H^+] = 0.0149$	1
	pH = $-\log(0.0149) = 1.83$	1
7(c)(i)	( $K_{\text{stab}}$ is) the <b>equilibrium constant</b> for the formation of a complex (ion) (in a solvent from its constituent ions / molecules)	1
7(c)(ii)	$[\text{Fe}(\text{H}_2\text{O})_5\text{F}]^{2+}$ and $[\text{Hg}(\text{H}_2\text{O})_5\text{Cl}]^+$	1
7(d)	$K_{\text{stab}} = \frac{[\text{Fe}(\text{ed})_2\text{Cl}_2^{3-}]}{[\text{Fe}(\text{H}_2\text{O})_4\text{Cl}_2^+][\text{ed}]^2}$	1
	mol <sup>-2</sup> dm <sup>6</sup>	1
7(e)(i)	 <p style="text-align: center;">cis                      cis                      trans</p>	3

<b>Question</b>	<b>Answer</b>	<b>Marks</b>
7(e)(ii)	any cis isomer <b>and</b> the trans isomer identified	<b>1</b>
7(e)(iii)	<b>both</b> correct cis isomers identified	<b>1</b>
7(e)(iv)	trans isomer identified	<b>1</b>