**Cambridge Assessment International Education**
Cambridge International Advanced Subsidiary and Advanced Level

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**CHEMISTRY** **9701/43**

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.

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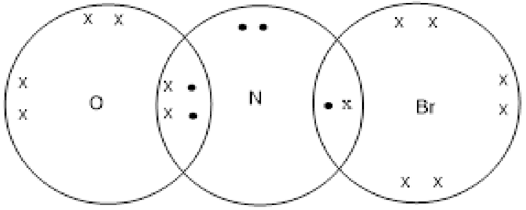
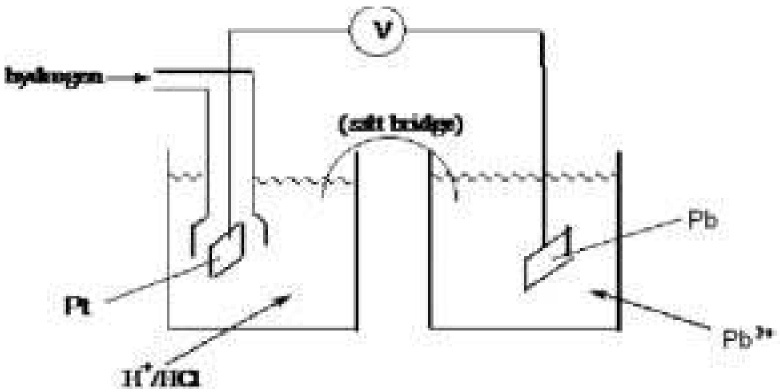
This document consists of **13** printed pages.

| Question | Answer | Marks |
|---|---|---|
| 1(a) | N +2 to +3 (and oxidised) | **1** |
| | $Br_2$ / 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 **power** to which a concentration of a reactant is raised in the **rate equation** | **1** |
| 1(c)(ii) | using expt. 2 and 3<br>a = 2 **or** [NO] 2nd order<br>**and** conc × 3 rate × 9 **or** $6.1 \times 10^{-2} / 6.8 \times 10^{-3} = (0.09 / 0.03)^a$ | **1** |
| | using expt. 1 and 2<br>b = 1 **or** $[Br_2]$ 1st order<br>**and** conc × 2 rate × 2 **or** $6.8 \times 10^{-3} / 3.4 \times 10^{-3} = (0.04 / 0.02)^b$ | **1** |
| (c)(iii) | initial rate = 0.16(32) | **1** |
| 1(c)(iv) | $(0.0034 = k(0.03)^2(0.02))$<br>k = **188.9** | **1** |
| | $mol^{-2}\,dm^6\,s^{-1}$ | **1** |
| 1(c)(v) | *k* decreases (as rate decreases) | **1** |

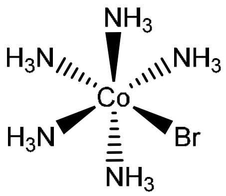
| Question | Answer | Marks |
|---|---|---|
| 1(d) | m = 2 **and** n = 0 | **1** |

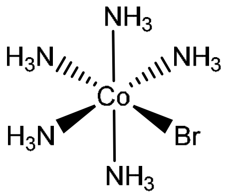
| Question | Answer | Marks |
|---|---|---|
| 2(a) | it / solubility **decreases** down the group **and** $K_{sp}$ decreases | **1** |
| 2(b)(i) | $MgCO_3$**(s)** $\rightleftharpoons$ $Mg^{2+}$**(aq)** + $CO_3^{2-}$**(aq)** | **1** |
| 2(b)(ii) | (white) solid appears / precipitation (of $MgCO_3$) | **1** |
| | as $[CO_3^{2-}]$ increases shifting equilibrium to the LHS (precipitating out $MgCO_3$) | **1** |
| 2(c) | solubility = $\sqrt{1.0 \times 10^{-5}} = 3.16 \times 10^{-3}$ mol dm$^{-3}$ | **1** |
| | solubility= $3.2 \times 10^{-3} \times 84.3 =$ **0.27** g dm$^{-3}$ | **1** |
| 2(d)(i) | $Mg^{2+}$ ion is smaller than $Ba^{2+}$ ion **or** ionic radii increase down group ora | **1** |
| | ($Mg^{2+}$) distorts / polarises / the anion / nitrate group / nitrate **ion** / $NO_3^{(1)-}$ / $NO_3$ ion more easily (than $Ba^{2+}$) ora | **1** |
| 2(d)(ii) | $Ba(NO_3)_2 \rightarrow BaO + 2NO_2 + ½O_2$ | **1** |
| 2(d)(iii) | $BaO + H_2O \rightarrow Ba(OH)_2$ | **1** |
| | $Ba(OH)_2 + H_2SO_4 \rightarrow BaSO_4 + 2H_2O$ | **1** |

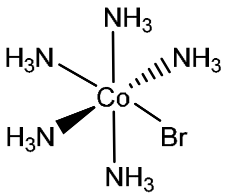
| Question | Answer | Marks |
|---|---|---|
| 3(a) | the potential **difference** between two half-cells / two electrodes (in a cell) | 1 |
| | under standard conditions of 1 atm., 298 K, (all) solutions being 1 mol dm$^{-3}$ | 1 |
| 3(b)(i) |  <br>8 marking points, any 2 points for each mark<br><br>$H_2$ / hydrogen<br>correct delivery system for $H_2$<br>$Pb^{2+}$ (aq)<br>Pb electrode<br>Pt electrode<br>$H^+$(aq) solution<br>salt bridge<br>voltmeter / V labelled | 4 |
| 3(b)(ii) | more negative | 1 |
| | shifts $Pb^{2+}$ (+ 2e$^-$) ⇋ Pb equilibrium / reaction to the left | 1 |

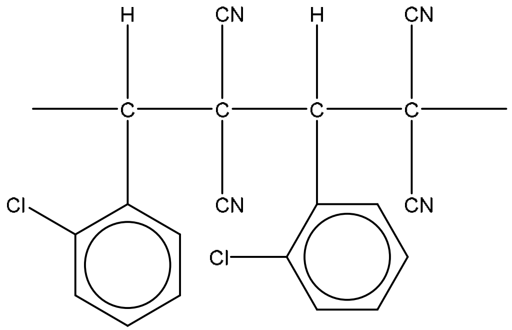
| Question | Answer | Marks |
|---|---|---|
| 3(c)(i) | Q = 0.4 × 80 × 60 = **1920** C **and** use of 96500 / 193000<br>Moles of Pb = 1920 / 193000 = $9.95 \times 10^{-3}$<br>Mass of Pb = 207.2 × $9.95 \times 10^{-3}$ = **2.1 g**<br><br>**OR**<br>Q = 0.4 × 80 × 60 = **1920** C **and** use of $1.6 \times 10^{-19}$ / $1.2 \times 10^{22}$<br>atoms Pb = $6 \times 10^{21}$; moles of Pb = $6 \times 10^{21}$ / $6 \times 10^{23}$ = 0.01<br>Mass of Pb = 207.2 × 0.01 = **2.1 g** | 2 |
| 3(c)(ii) | $PbO_2(s) + SO_4^{2-}(aq) + \mathbf{4H^+} + \mathbf{2e^-} \rightarrow PbSO_4(s) + \mathbf{2H_2O}$ | 1 |
| 3(d) | reagents / $PbO_2$ / $H_2SO_4$ **and** used up / concentration decreases | 1 |
| | as fuel / hydrogen is being continuously supplied / fuel has not run out | 1 |

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

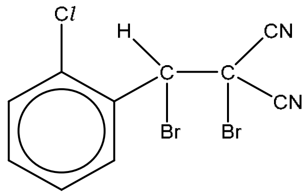
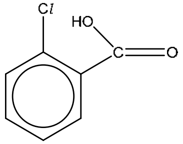
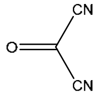
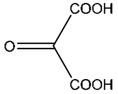
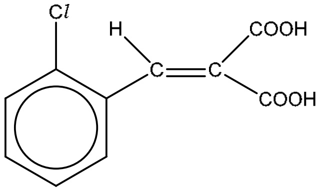
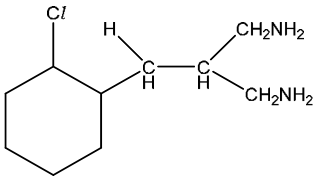
<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>4(c)(ii)</td><td>octahedral <b>AND</b> 3D structure of $[Co(NH_3)_5Br]^{2+}$<br>e.g.<br>

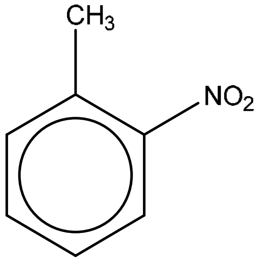



</td><td>1</td></tr>
<tr><td>4(c)(iii)</td><td>co-ordinate / dative covalent</td><td>1</td></tr>
<tr><td>4(c)(iv)</td><td>+3 for <b>both</b></td><td>1</td></tr>
<tr><td>4(d)</td><td>$(HNO_3)$ $Ag^+$ / $AgNO_3$ cream(–yellow) ppt. (of AgBr) <b>and</b> no reaction / white ppt. for other isomer</td><td>1</td></tr>
<tr><td></td><td>$Ba(OH)_2$ / $Ba^{2+}(aq)$ / $BaCl_2$ / $Ba(NO_3)_2$ white ppt. (of $BaSO_4$) <b>and</b> no reaction for other isomer</td><td>1</td></tr>
<tr><td>4(e)</td><td>(d-d) energy gap / $\Delta E$ is different</td><td>1</td></tr>
<tr><td></td><td><b><u>absorb</u> different</b> wavelength / frequency (of light)</td><td>1</td></tr>
<tr><td>4(f)</td><td>
<table>
<tr><th></th><th>heterogeneous</th><th>homogeneous</th></tr>
<tr><td>Fe in the Haber process</td><td>✓</td><td></td></tr>
<tr><td>$Fe^{2+}$ in the $I^-$ / $S_2O_8^{2-}$ reaction</td><td></td><td>✓</td></tr>
<tr><td>$NO_2$ in the oxidation of $SO_2$</td><td></td><td>✓</td></tr>
<tr><td>$V_2O_5$ in the Contact process</td><td>✓</td><td></td></tr>
</table>
</td><td>2</td></tr>
</table>

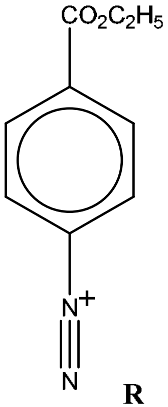
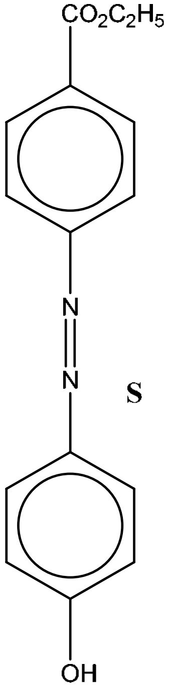
| Question | Answer | Marks |
|---|---|---|
| 5(a) | nitrile; alkene; chloro; benzene / arene | **2** |
| 5(b) |  | **1** |
| | addition (polymerisation) | **1** |

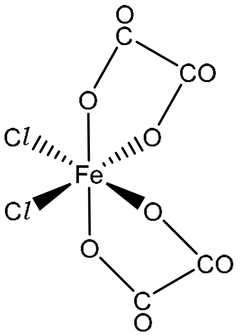
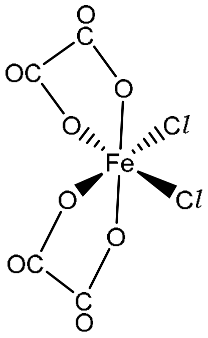
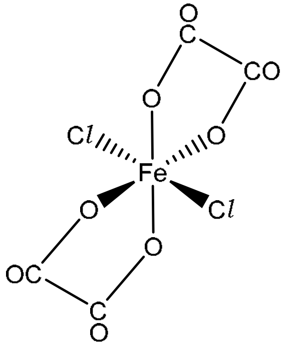
| Question | Answer | Marks |
|---|---|---|
| 5(c) | | **8** |

| reagent | structure of product | type of organic reaction |
|---|---|---|
| excess $Br_2$(aq) |  [1] | (electrophilic) addition |
| excess hot, conc. $MnO_4^-$(aq) |   **or**  [1] + [1] | oxidation |
| excess hot, aqueous HC*l* |  [1] | hydrolysis |
| excess $H_2$ / Pt catalyst |  both $CH_2NH_2$ formed [1]<br>both arene and alkene reduced [1] | reduction / hydrogenation |
| | structures [6] | 2 correct for 1 mark<br>total [2] |

| Question | Answer | Marks |
|---|---|---|
| 6(a)(i) |  | **1** |
| 6(a)(ii) | $HNO_3 + 2H_2SO_4 \rightarrow H_3O^+ + NO_2^+ + 2HSO_4^-$ | **1** |
| 6(a)(iii) | **any three** from:<br>Point 1: bonds / electrons are **partially** delocalised in **T**<br>**or** delocalised / $\pi$ system / $\pi$ bonding extends over only five carbons<br>Point 2: four $\pi$-electrons in the (delocalised system of **T**)<br>**or** methylbenzene has (two) more $\pi$-electrons / (two) more delocalised electrons<br>Point 3: contains a carbon that is $sp^3$ hybridised in **T**<br>***or*** (all the) carbons are $sp^2$ hybridised in methylbenzene<br>Point 4**:** one carbon has a bond angle of 109.5° / tetrahedral (in **T)**<br>***or*** (C-C) bond strengths / lengths are not all the same<br>**or** not all the bond angles are 120° (in **T**) | **3** |
| 6(b)(i) | 4-aminobenzoic acid | **1** |
| 6(b)(ii) | step 1 Sn + $HCl$ [1] concentrated / reflux / heat [1]<br>step 2 $CH_3COCl$ [1]<br>step 3 $KMnO_4$ / manganate(VII) / $MnO_4^-$ (acidified / alkaline) **and** heat [1]<br>step 4 aqueous $HCl$ **and** heat [1]<br>step 5 ethanol, $H_2SO_4$, concentrated / reflux / heat [1] | **6** |

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>6(c)</td><td>(benzocaine) is less (basic than ethylamine) <b>AND</b><br><b>lone pair</b> (on N) is less available to <b>accept</b> a proton / $H^+$<br><br>since (lone pair on N) is delocalised over the ring<br><b><i>or</i></b> phenyl ring is electron withdrawing group<br><br><b>OR</b><br>ethylamine is more basic (than benzocaine) <b>AND</b><br><b>lone pair</b> (on N) is more available to <b>accept</b> a proton / $H^+$<br><br>since ethyl / alkyl group is electron-donating group</td><td>2</td></tr>
<tr><td>6(d)(i)</td><td>7 peaks</td><td>1</td></tr>
<tr><td>6(d)(ii)</td><td>$CDCl_3$ will produce no signal in the spectrum<br><b>or</b> $CHCl_3$ would produce a signal / would be detected</td><td>1</td></tr>
<tr><td>6(d)(iii)</td><td>
<table>
<tr><th><i>δ / ppm</i></th><th>group responsible for the peak</th><th>number of H atoms responsible for the peak</th><th>splitting pattern</th></tr>
<tr><td><i>1.2</i></td><td>$CH_{(3)}$</td><td>3</td><td>triplet</td></tr>
<tr><td><i>3.5</i></td><td>$CH_{(2)}O$</td><td>2</td><td>quartet</td></tr>
<tr><td><i>5.5</i></td><td>$NH_2$</td><td>2</td><td>singlet (broad)</td></tr>
<tr><td><i>7.1–7.4</i></td><td>H attached to aromatic / benzene ring</td><td>4</td><td><i>multiplet</i></td></tr>
</table>
</td><td>4</td></tr>
<tr><td>6(d)(iv)</td><td>neighbouring / adjacent carbon <b>atom</b> has two protons / H (attached to it)<br><b>or</b> there is an adjacent $CH_2(O)$ group</td><td>1</td></tr>
<tr><td>6(d)(v)</td><td>peak at 5.5 / $NH_2$ peak will disappear<br><b>and</b><br>$NH_2$ / protons exchange / swap with deuterium</td><td>1</td></tr>
</table>

| Question | Answer | Marks |
|---|---|---|
| 6(e)(i) | $NaNO_2 + HCl$ ***or*** $HNO_2$ | **1** |
| 6(e)(ii) |  **R**  **S** | |
| | structure of diazonium salt **R** | **1** |
| | structure of azo dye **S** | **1** |

| Question | Answer | Marks |
|---|---|---|
| 7(a) | Fe atom= $(1s^2 2s^2 2p^6) 3s^2 3p^6 3d^6 4s^2$<br>$Fe^{3+}$ ion= $(1s^2 2s^2 2p^6) 3s^2 3p^6 3d^5$ | 1 |
| 7(b) | ($[H^+]^2 = 8.9 \times 10^{-4} \times 0.25$ ***or*** $2.225 \times 10^{-4}$)<br>$[H^+] = 0.0149$ | 1 |
| | pH = –log(0.0149) = **1.83** | 1 |
| 7(c)(i) | ($K_{stab}$ is) the **equilibrium constant** for the formation of a complex (ion) (in a solvent from its constituent ions / molecules) | 1 |
| 7(c)(ii) | $[Fe(H_2O)_5F]^{2+}$ **and** $[Hg(H_2O)_5Cl]^+$ | 1 |
| 7(d) | $K_{stab} = \frac{[Fe(ed)_2Cl_2^{3-}]}{[Fe(H_2O)_4Cl_2^{+}][ed]^2}$ | 1 |
| | $mol^{-2}\,dm^6$ | 1 |
| 7(e)(i) | <br>cis<br><br>cis<br><br>trans | 3 |

| Question | Answer | Marks |
|---|---|---|
| 7(e)(ii) | any cis isomer **and** the trans isomer identified | **1** |
| 7(e)(iii) | **both** correct cis isomers identified | **1** |
| 7(e)(iv) | trans isomer identified | **1** |