Cambridge International AS & A Level

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

**CHEMISTRY** **9701/42**

Paper 4 A Level Structured Questions **October/November 2017**

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.

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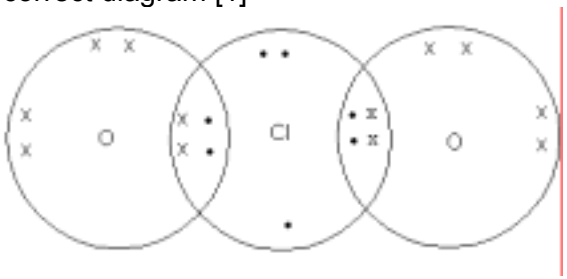
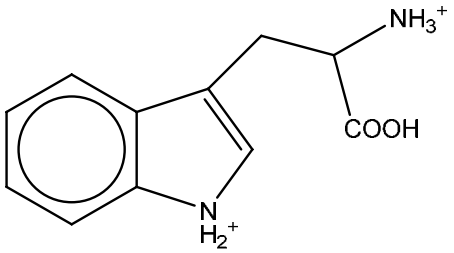
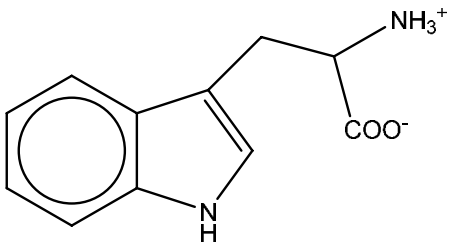
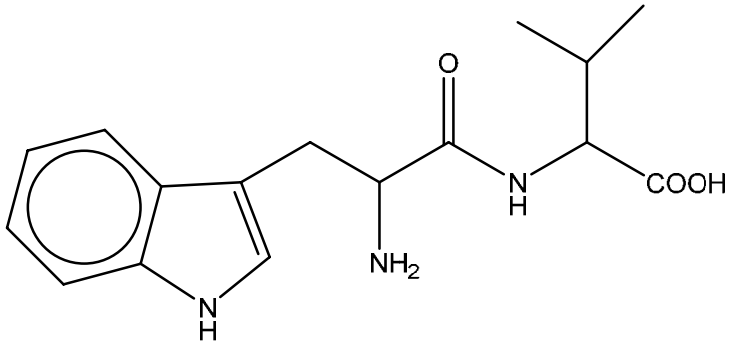
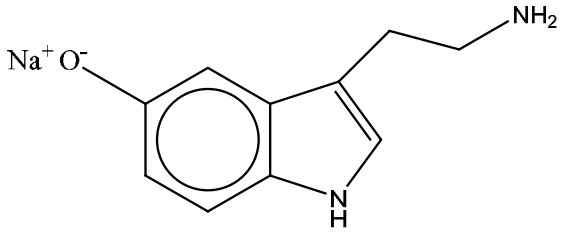
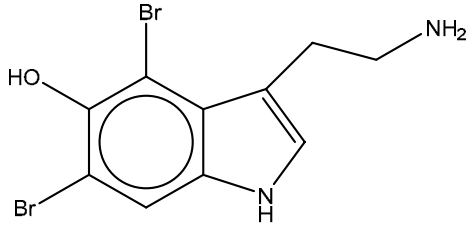
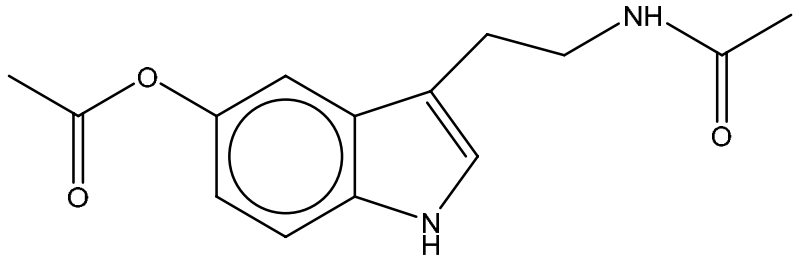
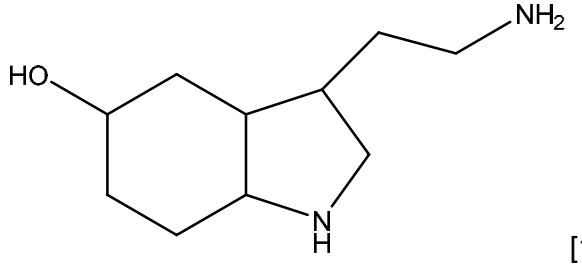
| Question | Answer | Marks |
|---|---|---|
| 1(a) | C*l* +3 to +4 (and oxidised) | **1** |
| | C*l* 0 to –1 (and reduced) | **1** |
| 1(b) | 19 electrons total [1]<br>correct diagram [1]<br>  | **2** |
| 1(c)(i) | the exponent / power to which a concentration is raised in the rate equation | **1** |
| 1(c)(ii) | (0.0022 = *k* (0.01) × (0.06))<br>k = 3.7 (3.67) | **1** |
| | $mol^{-1}\ dm^3\ s^{-1}$ | **1** |
| 1(c)(iii) | initial rate = $5.50 \times 10^{-3}$ | **1** |
| | [C*l*$O_2$] = 0.048 | **1** |
| 1(d)(i) | slowest step (in a multi-step reaction) | **1** |
| 1(d)(ii) | 1 mole of $F_2$ and 1 mole C*l*$O_2$ reacting in the rate-determining step | **1** |
| | 1st step is rate-determining step **and** a balanced mechanism consistent with overall equation<br>e.g. C*l*$O_2$ + $F_2$ → C*l*$O_2F_2$ C*l*$O_2$ + C*l*$O_2F_2$ → 2C*l*$O_2F$<br>**or** C*l*$O_2$ + $F_2$ → C*l*$O_2F$ + F C*l*$O_2$ + F → C*l*$O_2F$ | **1** |
| 1(e) | k increases (as rate increases) | **1** |

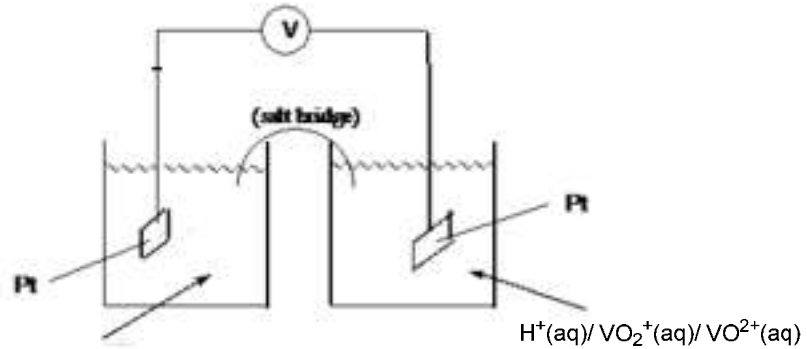
| Question | Answer | Marks |
|---|---|---|
| 2(a)(i) | $Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3$ | **1** |
| 2(a)(ii) | moles of $Mg_3N_2$ = 2.52 / 100.9 = 0.025 (0.0249) | **1** |
| | (moles of $Mg(OH)_2$ = 0.075 (0.0749))<br>mass of $Mg(OH)_2$ = (0.075 × 58.3) = 4.37 g or 4.4 g | **1** |
| 2(b) | solubility increases (down the group) | **1** |
| | $\Delta H_{latt}$ and $\Delta H_{hyd}$ both decrease / less exothermic / more endothermic | **1** |
| | but $\Delta H_{latt}$ decreases more (than $\Delta H_{hyd}$ decreases) | **1** |
| | $\Delta H_{sol}$ becomes more negative / more exothermic / less endothermic | **1** |
| 2(c)(i) | $K_{sp} = [Mg^{2+}] [OH^-]^2$ | **1** |
| 2(c)(ii) | $K_{sp} = (1.7 \text{ x } 10^{-4}) \times (2 \times 1.7 \times 10^{-4})^2 = 2.0 \times 10^{-11}$ $(1.97 \times 10^{-11})$ | **1** |
| | $mol^3\ dm^{-9}$ | **1** |
| 2(d) | cations become bigger / ionic radius increases | **1** |
| | polarisation/distortion of anion / hydroxide ion decreases | **1** |

| Question | Answer | Marks |
|---|---|---|
| 3(a)(i) |  pH 1  pH 5.9 | **2** |
| 3(a)(ii) |  peptide link [1]<br>rest of the structure [1] | **2** |

| Question | Answer | Marks |
|---|---|---|
| 3(b) | | **8** |

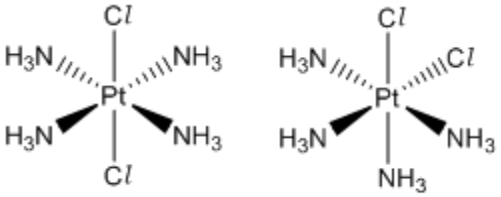
| reagent | structure of product | type of organic reaction |
|---|---|---|
| Na |  [1] | redox<br>or reduction |
| excess $Br_2(aq)$ |  [1] | (electrophilic)<br>substitution |
| excess $CH_3COCl$ |  acylated OH [1] acylated $NH_{(2)}$ [1] | condensation<br>(or addition +<br>elimination) |
| excess $H_2$ / Pt catalyst |  [1] | reduction<br>or hydrogenation or<br>addition |

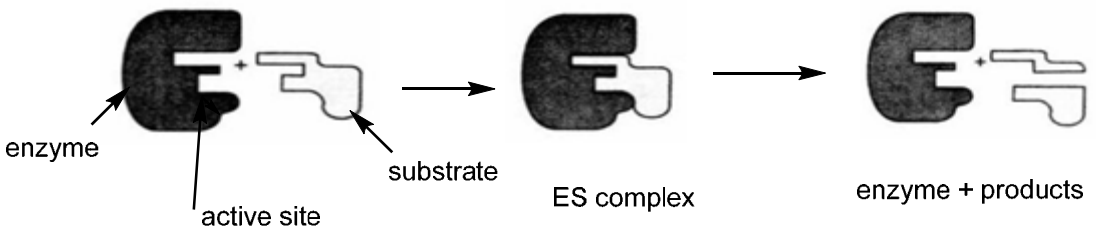
| Question | Answer | Marks |
|---|---|---|
| 3(c)(i) | (spectrum of M) contains a broad peak (for O–H) at 2500–3000 $cm^{-1}$<br>***or*** (spectrum of M) contains peak (for C=O) at 1640–1750 $cm^{-1}$<br>***or*** (spectrum of M) lacks ($NH_2$ peak) at 3300–3500 $cm^{-1}$ | **1** |
| 3(c)(ii) | 5 or 6 peaks | **1** |
| | OH/NH protons exchange with deuterium ***or*** –OH / –NH + $D_2O$ → –OD / –ND + DHO | **1** |
| 3(d) | ester **and** hydrolysed | **1** |

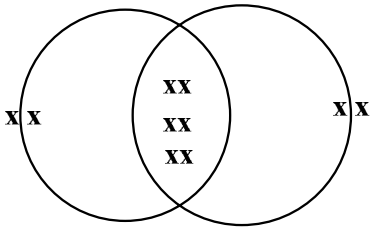
| Question | Answer | Marks |
|---|---|---|
| 4(a)(i) | $E^{\ominus}_{cell}$ = 1.00 – (–0.26) = (+)1.26 V | **1** |
| 4(a)(ii) | $VO_2^+ + V^{2+} + 2H^+ \rightarrow VO^{2+} + V^{3+} + H_2O$ | **1** |
| 4(a)(iii) |  <br>solutions labelled correctly in one half-cell [1]<br>solutions labelled correctly in both half-cells [1]<br>two graphite or platinum electrodes [1]<br>salt bridge and voltmeter [1] | **4** |

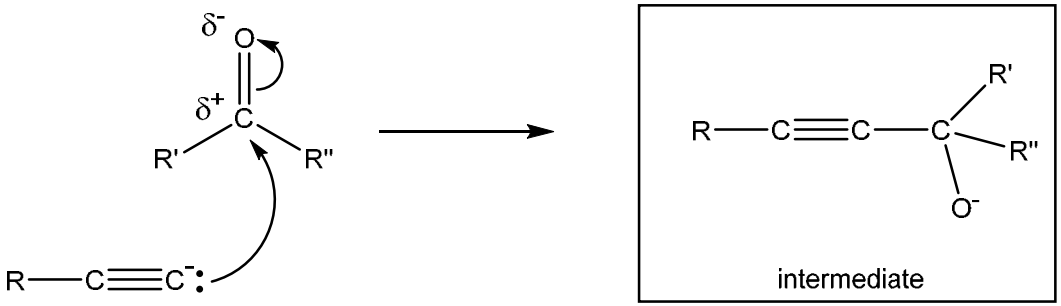
| Question | Answer | Marks |
|---|---|---|
| 4(b) | • $V^{2+}$(aq) and $Sn^{4+}$(aq):<br>yes and $E^{\ominus}_{cell}$ = +0.15 – (–0.26) = +0.41 V [1]<br>$2V^{2+} + Sn^{4+} \rightarrow 2V^{3+} + Sn^{2+}$ [1]<br><br>• $VO^{2+}$(aq) and $Fe^{3+}$(aq)<br>no reaction [1] | **3** |

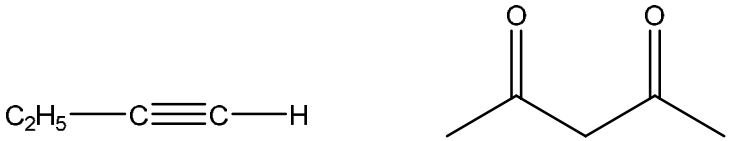
| Question | Answer | Marks |
|---|---|---|
| 5(a) | ($Na^{+}$) 0.095 / 0.181 = 0.525 **and** octahedral **and** co-ordination no. = 6 | **1** |
| | ($Mg^{2+}$) 0.065 / 0.181 = 0.359 **and** tetrahedral **and** co-ordination no. = 4 | **1** |
| 5(b) | enthalpy change = (–642) – (2 × –106) = **–430** | **1** |
| 5(c)(i) | –106 = 147 + 121 + 736 + (–349) + lattice energy<br>lattice energy = –761 | **3** |
| 5(c)(ii) | $MgCl_2$ more exothermic / negative / bigger than $MgCl$ **and** $NaCl$ more exothermic / negative / bigger than $MgCl$ | **1** |
| | (reason for $MgCl_2$) higher charge / lower radius of $Mg^{2+}$ cation | **1** |
| | (reason for $NaCl$) smaller radius of $Na^{+}$ cation | **1** |
| 5(d) | energy change when 1 mole of atoms / ions each gain an electron<br>**or** energy change when 1 mole of atoms / ions gain 1 mole of electrons | **1** |
| | gaseous | **1** |

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>6(a)</td><td>central metal atom/ion surrounded by (one or more) ligands</td><td>1</td></tr>
<tr><td>6(b)</td><td>
<table>
<tr><td></td><td>co-ordination number</td><td>oxidation number</td></tr>
<tr><td>$[Pt(NH_3)_4Cl_2]^{2+}$</td><td>6</td><td>+4</td></tr>
<tr><td>$[PtCl_4]^{2-}$</td><td>4</td><td>+2</td></tr>
</table>
</td><td>2</td></tr>
<tr><td>6(c)</td><td> 
</td><td>2</td></tr>
<tr><td rowspan="2">6(d)</td><td>($HNO_3$ +) $AgNO_3$ reagent</td><td>1</td></tr>
<tr><td>$[Pt(NH_3)_4Cl_2]Br_2$ with cream ppt. (of AgBr) and $[Pt(NH_3)_4Br_2]Cl_2$, with white ppt. (of $AgCl$) observation with both</td><td>1</td></tr>
<tr><td rowspan="3">6(e)</td><td>octahedral: both</td><td>1</td></tr>
<tr><td>square planar: geometric</td><td>1</td></tr>
<tr><td>tetrahedral: neither</td><td>1</td></tr>
</table>

| Question | Answer | Marks |
|---|---|---|
| 6(f) | diagrams<br>  <br><br>Marks can be awarded from words or diagram.<br>Any three marking points from:<br>• substrate shape is complementary to active site<br>• the substrate binds / bonds / fits into the active site<br>• products are released<br>• lower $E_A$ / bonds weakened in substrate | **3** |

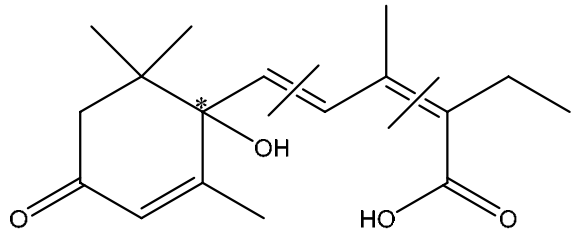
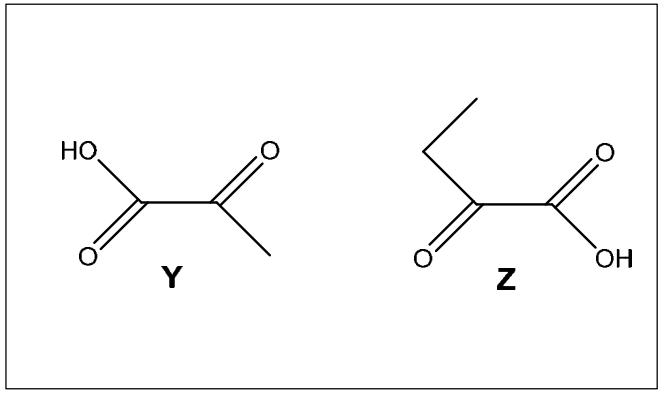
| Question | Answer | Marks |
|---|---|---|
| 7(a)(i) | $CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$ | **1** |
| 7(a)(ii) |  | **1** |
| 7(b) | $C_nH_{2n-2}$ | **1** |
| 7(c)(i) | delocalised electrons | **1** |
| 7(c)(ii) | CH | **1** |
| 7(c)(iii) | less dense | **1** |

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>7(d)(i)</td><td> 

2 curly arrows [1]<br>dipole [1]<br>intermediate [1]</td><td>3</td></tr>
<tr><td>7(d)(ii)</td><td>nucleophilic addition</td><td>1</td></tr>
<tr><td>7(d)(iii)</td><td> 

[1]<br>**Q**<br>

[1]<br>**R**</td><td>2</td></tr>
<tr><td>7(e)</td><td>
<table>
<tr><th></th><th>$CH_3CHO$</th><th>$HCO_2H$</th><th>$CH_3COCH_3$</th><th>$HO_2CCO_2H$</th></tr>
<tr><td>hot acidified $MnO_4^-$(aq)</td><td>✓</td><td>✓</td><td>×</td><td>✓</td></tr>
<tr><td>alkaline $I_2$(aq)</td><td>✓</td><td>×</td><td>✓</td><td>×</td></tr>
<tr><td>Tollens' reagent</td><td>✓</td><td>✓</td><td>×</td><td>×</td></tr>
</table>
</td><td>4</td></tr>
</table>

| Question | Answer | Marks |
|---|---|---|
| 8(a)(i) |  <br>circle or asterisk on correct C atom only [1]<br>lines through the two correct bonds only [1] | **2** |
| 8(a)(ii) | ketone, (tertiary) alcohol, alkene, carboxylic acid<br>two for each mark | **2** |
| 8(a)(iii) | sp carbons = 0 $sp^2$ carbons = 8 $sp^3$ carbons = 9 | **1** |
| 8(a)(iv) |  | **2** |
| 8(b)(i) |  | **1** |

| compound | spot |
|---|---|
| J | 2 |
| K | 3 |
| L | 1 |

| Question | Answer | Marks |
|---|---|---|
| 8(b)(ii) | The more polar the compound **and** stronger attractive forces to the (polar) stationary phase<br>ora: less polar compound **and** weaker attractive forces to the (polar) stationary phase | **1** |
| 8(b)(iii) | $R_f$ = retardation factor **or** retention factor **or**<br>$R_f$ =distance moved by compound from baseline over distance travelled by solvent front | **1** |