Cambridge International AS & A Level

**Cambridge International Examinations**
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**CHEMISTRY** **9701/42**

Paper 4 A Level Structured Questions **March 2017**

MARK SCHEME

Maximum Mark: 100

**Published**

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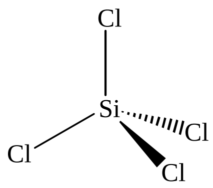
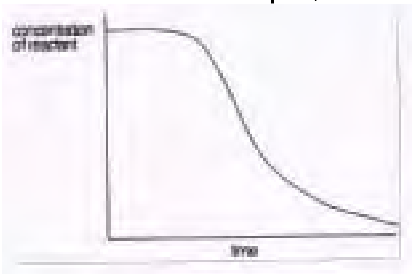
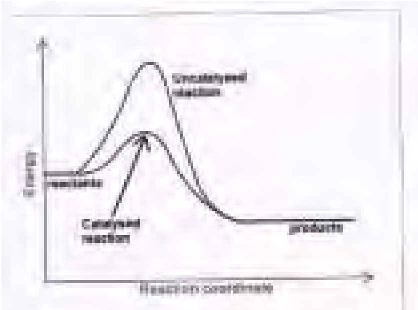
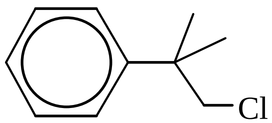
| Question | Answer | Marks |
|---|---|---|
| 1(a)(i) | (28 × 0.922) + (29 × 0.047) + (30 × 0.031) = 28.11 | **1** |
| 1(a)(ii) | $SiCl_4 + 4H_2O \rightarrow Si(OH)_4 + 4HCl$ | **1** |
| 1(a)(iii) | <br>diagram | **1** |
| | bond angle = 109.5 | **1** |
| 1(a)(iv) | $SiO_2$ | **1** |
| | $SiO_2$ is giant covalent / molecular but $SiCl_4$ is simple molecular / covalent | **1** |
| 1(b)(i) | $2\mathbf{A}(NO_3)_2 \rightarrow 2\mathbf{A}O + 4NO_2 + O_2$<br>correct formula<br>balanced equation | **2**<br>1<br>1 |
| 1(b)(ii) | giant ionic | **1** |

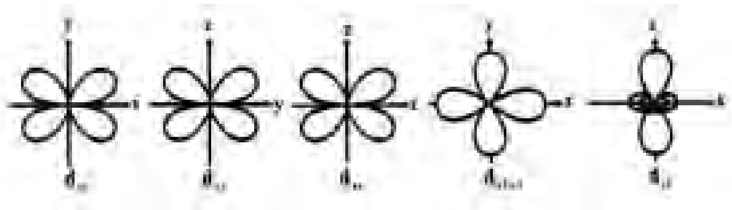
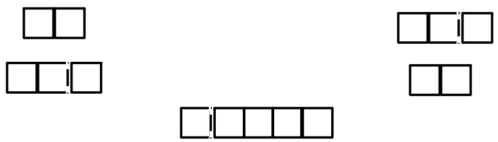
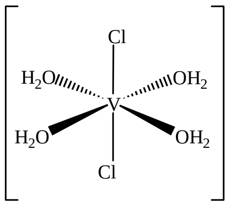
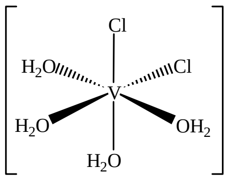
| Question | Answer | Marks |
|---|---|---|
| 2(a) | <table><tr><td>enthalpy change</td><td>positive</td><td>negative</td><td>either positive or negative</td></tr><tr><td>electron affinity</td><td></td><td></td><td>✓</td></tr><tr><td>enthalpy change of atomisation</td><td>✓</td><td></td><td></td></tr><tr><td>enthalpy change of ionisation</td><td>✓</td><td></td><td></td></tr><tr><td>lattice enthalpy</td><td></td><td>✓</td><td></td></tr></table> | **2** |
| 2(b)(i) | the second electron is removed from a (more) positively charged ion | **1** |
| 2(b)(ii) | $\Delta H_6$ is lattice (energy / enthalpy) **AND** $\Delta H_7$ is (energy / enthalpy of) formation | **1** |
| 2(c) | the electron affinity becomes less exothermic / negative down the Group 17 | **1** |
| | electron affinity depends (mainly) on the electron-nucleus distance which increases down Group 17 | **1** |
| 2(d) | **M1** correct use of $\Delta G = \Delta H - T\Delta S$ | **1** |
| | **M2** $\Delta S = 26.9 - (32.7 + 102.5) = -108.3\,J\,K^{-1}\,mol^{-1}$ **OR** $-0.1083\,kJ\,K^{-1}\,mol^{-1}$ | **1** |
| | **M3** $\Delta G = -602 - (298 \times (-0.1083)) = -570$ | **1** |
| | **M4** units: $kJ\,mol^{-1}$ | **1** |

| Question | Answer | Marks |
|---|---|---|
| 3(a)(i) | **A** – $H_2$, 1 atm<br>**B** – platinum<br>**C** – 1 mol dm$^{-3}$ $H^+$ / HC*l* etc.<br>**D** – salt bridge / $KNO_3$ etc.<br>**E** – platinum<br>**F** – 1 mol dm$^{-3}$ $Fe^{2+}$ **AND** 1 mol dm$^{-3}$ $Fe^{3+}$ | **3** |
| 3(a)(ii) | positive electrode is (Pt) on RHS **AND** electrons flow clockwise | **1** |
| 3(b) | cell potential is 0.77 – 0.34 =(+) 0.43 (V) | **1** |
| 3(c)(i) | electrode potential would become more negative as equilibrium shifts to left / explanation in terms of the Nernst equation | **1** |
| 3(c)(ii) | $E$ = –0.41 + (0.059/1)log[$Cr^{3+}$]/[$Cr^{2+}$]<br>= –0.41 + 0.059 log 4.0 | **1** |
| | = –0.37 (V) | **1** |

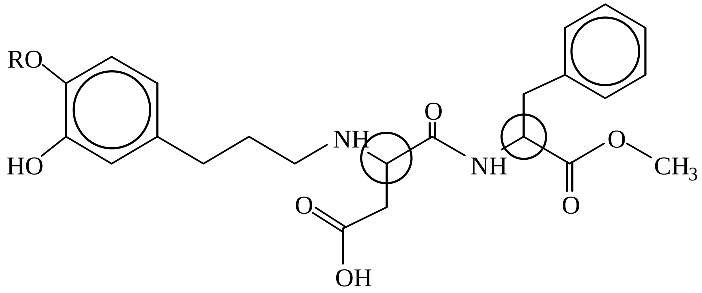
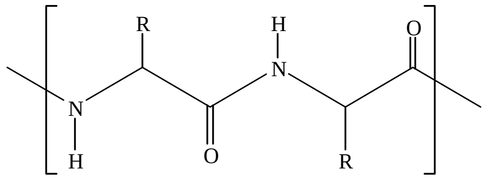
<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>4(a)(i)</td><td>experiments 1 and 2: doubling [$ClO_2$] quadruples the rate, so second order</td><td>1</td></tr>
<tr><td></td><td>experiments 2 and 3: doubling [$OH^-$] doubles the rate, so first order</td><td>1</td></tr>
<tr><td></td><td>rate equation = $k[ClO_2]^2[OH^-]$</td><td>1</td></tr>
<tr><td>4(a)(ii)</td><td>from experiment t 2: $9.34 \times 10^{-4} = k(2.50 \times 10^{-2})^2 \times 1.30 \times 10^{-3}$<br>$k = 1.15 \times 10^3$</td><td>1</td></tr>
<tr><td></td><td>units: $mol^{-2} dm^6 s^{-1}$</td><td>1</td></tr>
<tr><td>4(b)(i)</td><td>heterogeneous catalysts are in different physical state from the reactants **AND** homogeneous catalysts are in the same physical state as the reactants</td><td>1</td></tr>
<tr><td>4(b)(ii)</td><td><table><tr><th>catalysed reaction</th><th>heterogeneous</th><th>homogeneous</th></tr><tr><td>manufacture of ammonia in the Haber process</td><td>✓</td><td></td></tr><tr><td>removal of nitrogen oxides from car exhausts</td><td>✓</td><td></td></tr><tr><td>oxidation of sulfur dioxide in the atmosphere</td><td></td><td>✓</td></tr></table></td><td>2</td></tr>
<tr><td>4(c)(i)</td><td>$2MnO_4^- + 6H^+ + 5(CO_2H)_2 \rightarrow 2Mn^{2+} + 10\ CO_2 + 8\ H_2O$<br>correct Mn : $(CO_2H)_2$ ratio<br>rest of equation</td><td>2<br>1<br>1</td></tr>
<tr><td>4(c)(ii)</td><td>first section: flatter<br>second section: steeper, before flattening<br></td><td>2<br>1<br>1</td></tr>
</table>

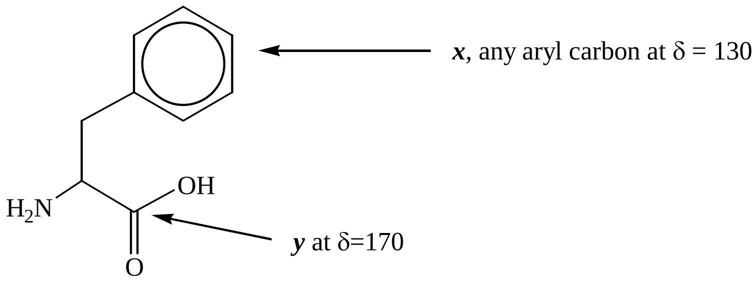
| Question | Answer | Marks |
|---|---|---|
| ,4(d)(i) | <br>diagram<br>catalyst lowers $E_a$ for both the forward and reverse reactions<br>so the process requires less energy / can occur at a lower temperature | **3**<br><br>1<br>1<br>1 |
| 4(d)(ii) | $K_p = (pNH_3)^2/(pN_2)(pH_2)^3$<br>$1.45 \times 10^{-5} = (pNH_3)^2 / 20 \times 60 \times 60 \times 60$ | **1** |
| | $pNH_3 = 7.91$ | **1** |

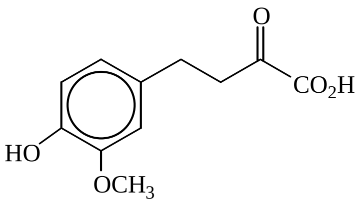
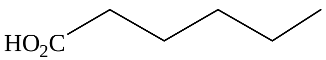
| Question | Answer | Marks |
|---|---|---|
| 5(a)(i) | $(CH_3)_3C\text{-}Cl$ / $(CH_3)_2C = CH_2$ | **1** |
| | $AlCl_3$ + heat | **1** |
| 5(a)(ii) | (UV) light | **1** |
| 5(a)(iii) |  | **1** |
| 5(a)(iv) | ammonia / $NH_3$ | **1** |
| | heat in sealed tube / heat under pressure | **1** |
| 5(b) | $C_{10}H_{13}NH_2 + H_3O^+ \rightleftharpoons C_{10}H_{13}NH_3^+ + H_2O$ | **1** |
| 5(c) | in compound **H**, the alkyl groups are electron donating / have a positive inductive effect, so it is more basic than $NH_3$ | **1** |
| | in phenylamine, the lone pair (of N) is delocalised over the aryl group / benzene ring, so phenylamine is less basic than $NH_3$ | **1** |

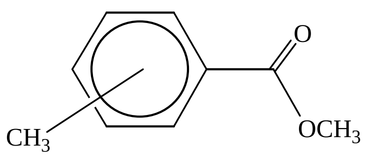
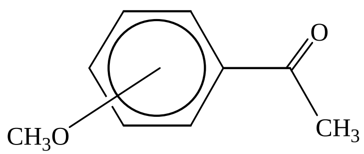
| Question | Answer | Marks |
|---|---|---|
| 6(a)(i) |  | 1 |
| 6(a)(ii) | Ni : $[1s^2 2s^2 2p^6 3s^2 3p^6]$ $\mathbf{3d^8 4s^2}$<br>$Ni^{3+}$ : $[1s^2 2s^2 2p^6 3s^2 3p^6]$ $\mathbf{3d^7}$ | 1 |
| 6(b)(i) | <br>octahedral complex    isolated ion    tetrahedral complex | 1 |
| 6(b)(ii) | energy / photon is absorbed in the visible region / light | 1 |
| | electron jumps from the lower to the upper energy level / is excited | 1 |
| 6(b)(iii) | different frequency / wavelength of light are absorbed by the two complexes<br>**OR**<br>different size of energy gap | 1 |
| 6(c) | colour of solution: green | 1 |
| | explanation: because the solution absorbs most strongly in the blue **AND** red regions | 1 |
| 6(d)(i) | <br> | 2 |

| Question | Answer | Marks |
|---|---|---|
| 6(d)(ii) | cis-trans / geometrical | **1** |
| 6(e)(i) |  | **2** |
| 6(e)(ii) | optical | **1** |
| 6(f)(i) | $K_{stab} = [Ni(NH_3)_6{}^{2+}]/([Ni(H_2O)_6{}^{2+}][NH_3]^6)$ | **1** |
| 6(f)(ii) | $[Ni(en)_3]^{2+}$ would be formed because it is much more stable / $K_{stab}$ is much greater **OR** in the presence of both ligands the overall equilibrium $[Ni(NH_3)_6]^{2+} \rightleftharpoons [Ni(H_2O)_6]^{2+} \rightleftharpoons [Ni(en)_3]^{2+}$ would shift right | **1** |
| 6(f)(iii) | cis-trans isomers identified | **1** |
| | two cis isomers identified | **1** |

| Question | Answer | Marks |
|---|---|---|
| 7(a) |  | **1** |
| 7(b)(i) | $H^+(aq)$ + heat | **1** |
| 7(b)(ii) | hydrolysis | **1** |
| 7(b)(iii) | $CH_3OH$ | **1** |
| 7(c)(i) | white precipitate | **1** |
| 7(c)(ii) | $C_{14}H_{19}O_6N + 3NaOH \rightarrow C_{14}H_{16}O_6NNa_3 + 3H_2O$ | **2** |
| 7(d)(i) | no change / colour remains orange | **1** |
| 7(d)(ii) | <br>amide bond displayed<br>**two** repeat units | **2**<br>1<br>1 |
| 7(e)(i) | seven | **1** |

| Question | Answer | Marks |
|---|---|---|
| 7(e)(ii) |   | **1** |

| Question | Answer | Marks |
|---|---|---|
| 8(a) | oxidation of –OH / alcohol to C=O / ketone / carbonyl | **1** |
| 8(b)(i) | dehydration / elimination | **1** |
| 8(b)(ii) | heat with $Al_2O_3$ **OR** heat with $H_3PO_4$ / $H_2SO_4$ | **1** |
| 8(b)(iii) |   **Q**   **R** | **2** |
| 8(c) | phenol | **1** |
| | ketone | **1** |

| Question | Answer | Marks |
|---|---|---|
| 9(a)(i) | n = 100 × (M+1)/(1.1 × M) = 100 × 3.4/(1.1 × 33.9) = 9.1 | **1** |
| | hence <u>9</u> carbons atoms | **1** |
| 9(a)(ii) | $C_9H_{10}O_2$ | **1** |
| 9(a)(iii) | (150 – 119 = 31), hence fragment is $CH_3O$ | **1** |
| 9(b) | **V** is C=O **AND W** is C–O | **1** |
| 9(c)(i) | δ 3.9 is CH or alkyl / $CH_3$ next to oxygen **AND** δ 7.2–7.9 is CH / aryl hydrogens | **1** |
| 9(c)(ii) | alkyl H next to C=O **AND** alkyl H next to aryl ring | **1** |
| 9(c)(iii) | none of the functional groups in **T** contains a labile proton / **T** does not contain –OH or –NH groups. | **1** |
| 9(d) |     | **2** |