Cambridge International AS & A Level

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Cambridge International Advanced Subsidiary and Advanced Level

CHEMISTRY **9701/42**

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

MARK SCHEME

Maximum Mark: 100

Published

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Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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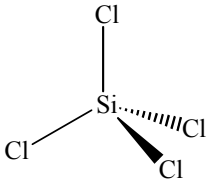
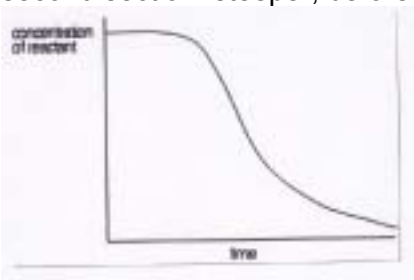
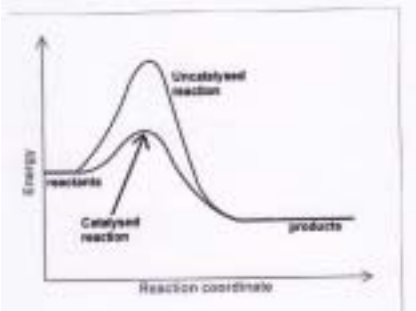
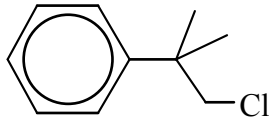
Question	Answer	Marks
1(a)(i)	$(28 \times 0.922) + (29 \times 0.047) + (30 \times 0.031) = 28.11$	**1**
1(a)(ii)	$SiCl_4 + 4H_2O \rightarrow Si(OH)_4 + 4HCl$	**1**
1(a)(iii)	 diagram	**1**
	bond angle = 109.5	**1**
1(a)(iv)	SiO_2	**1**
	SiO_2 is giant covalent / molecular but $SiCl_4$ is simple molecular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

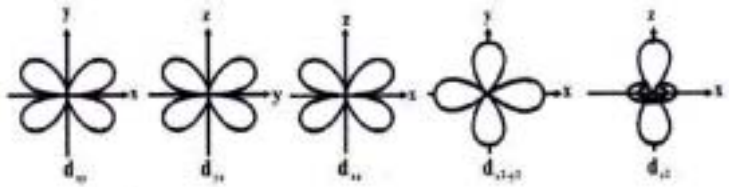
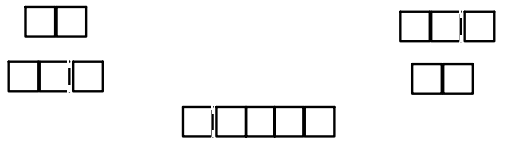
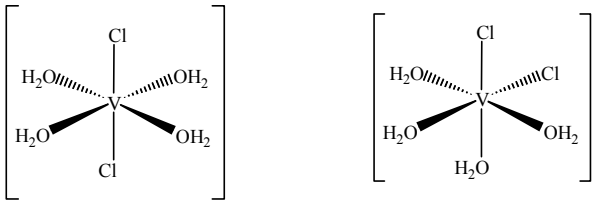
<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(a)</td><td>
<table>
<tr><td>enthalpy change</td><td>positive</td><td>negative</td><td>either positive or negative</td></tr>
<tr><td>electron affinity</td><td></td><td></td><td>✓</td></tr>
<tr><td>enthalpy change of atomisation</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>
</td><td>2</td></tr>
<tr><td>2(b)(i)</td><td>the second electron is removed from a (more) positively charged ion</td><td>1</td></tr>
<tr><td>2(b)(ii)</td><td>ΔH_6 is lattice (energy / enthalpy) AND ΔH_7 is (energy / enthalpy of) formation</td><td>1</td></tr>
<tr><td rowspan="2">2(c)</td><td>the electron affinity becomes less exothermic / negative down the Group 17</td><td>1</td></tr>
<tr><td>electron affinity depends (mainly) on the electron-nucleus distance which increases down Group 17</td><td>1</td></tr>
<tr><td rowspan="4">2(d)</td><td>M1 correct use of $\Delta G = \Delta H - T\Delta S$</td><td>1</td></tr>
<tr><td>M2 $\Delta S = 26.9 - (32.7 + 102.5) = -108.3\,J\,K^{-1}\,mol^{-1}$ OR $-0.1083\,kJ\,K^{-1}\,mol^{-1}$</td><td>1</td></tr>
<tr><td>M3 $\Delta G = -602 - (298 \times (-0.1083)) = -570$</td><td>1</td></tr>
<tr><td>M4 units: $kJ\,mol^{-1}$</td><td>1</td></tr>
</table>

Question	Answer	Marks
3(a)(i)	**A** – H_2, 1 atm **B** – platinum **C** – 1 mol dm^{-3} H^+ / HC*l* etc. **D** – salt bridge / KNO_3 etc. **E** – platinum **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$[Cr^{3+}]/[Cr^{2+}]$ = –0.41 + 0.059 log 4.0	**1**
	= –0.37 (V)	**1**

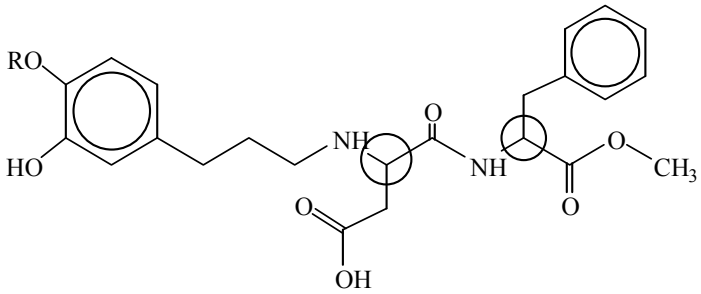
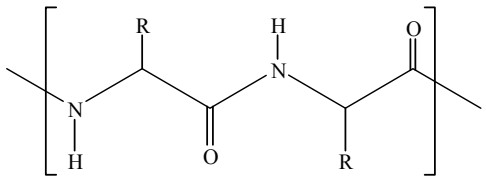
<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>4(a)(i)</td><td>experiments 1 and 2: doubling [ClO_2] quadruples the rate, so second order</td><td>1</td></tr>
<tr><td></td><td>experiments 2 and 3: doubling [OH^-] doubles the rate, so first order</td><td>1</td></tr>
<tr><td></td><td>rate equation = $k[ClO_2]^2[OH^-]$</td><td>1</td></tr>
<tr><td>4(a)(ii)</td><td>from experiment t 2: $9.34 \times 10^{-4} = k(2.50 \times 10^{-2})^2 \times 1.30 \times 10^{-3}$
$k = 1.15 \times 10^3$</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>$2MnO_4^- + 6H^+ + 5(CO_2H)_2 \rightarrow 2Mn^{2+} + 10\ CO_2 + 8\ H_2O$
correct Mn : $(CO_2H)_2$ ratio
rest of equation</td><td>2
1
1</td></tr>
<tr><td>4(c)(ii)</td><td>first section: flatter
second section: steeper, before flattening
  </td><td>2
1
1</td></tr>
</table>

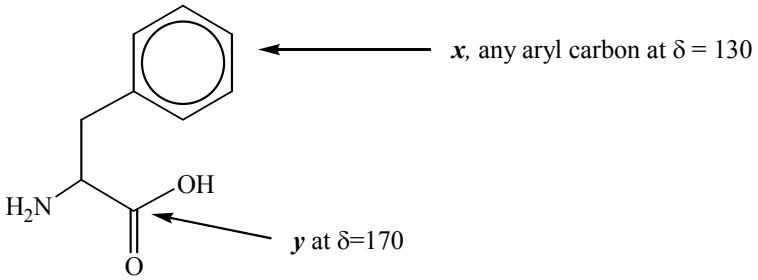
Question	Answer	Marks
,4(d)(i)	 diagram catalyst lowers E_a for both the forward and reverse reactions so the process requires less energy / can occur at a lower temperature	**3** 1 1 1
4(d)(ii)	$K_p = (pNH_3)^2/(pN_2)(pH_2)^3$ $1.45 \times 10^{-5} = (pNH_3)^2 / 20 \times 60 \times 60 \times 60$	**1**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

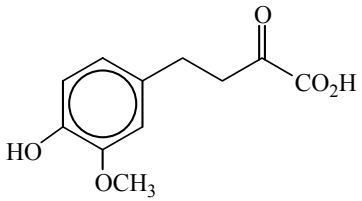
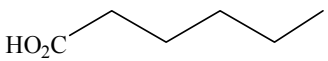
Question	Answer	Marks
5(a)(i)	$(CH_3)_3C\text{-}Cl$ / $(CH_3)_2C = CH_2$	**1**
	$AlCl_3$ + heat	**1**
5(a)(ii)	(UV) light	**1**
5(a)(iii)		**1**
5(a)(iv)	ammonia / NH_3	**1**
	heat in sealed tube / heat under pressure	**1**
5(b)	$C_{10}H_{13}NH_2 + H_3O^+ \rightleftharpoons C_{10}H_{13}NH_3^+ + H_2O$	**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**

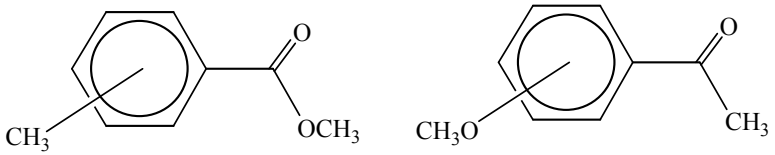
Question	Answer	Marks
6(a)(i)		**1**
6(a)(ii)	Ni : $[1s^2 2s^2 2p^6 3s^2 3p^6]$ **$3d^8 4s^2$** Ni^{3+} : $[1s^2 2s^2 2p^6 3s^2 3p^6]$ **$3d^7$**	**1**
6(b)(i)	 octahedral complex isolated ion tetrahedral complex	**1**
6(b)(ii)	energy / photon is absorbed in the visible region / light	**1**
	electron 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 **OR** 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)		**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)	 amide bond displayed **two** repeat units	**2** 1 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 9 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**