CHEMISTRY **9701/42**

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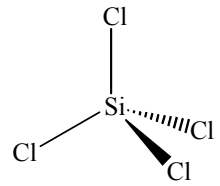
MARK SCHEME

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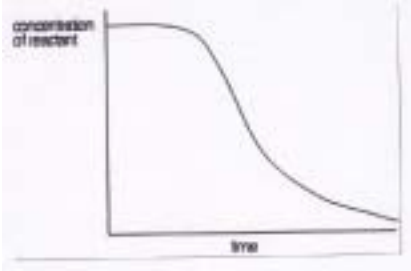
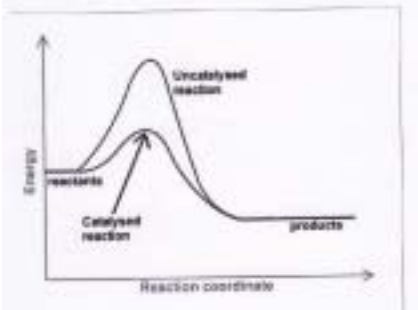Cambridge will not enter into discussions about these mark schemes.

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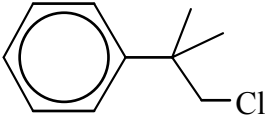
This document consists of **12** printed pages.

Cambridge International Examinations

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**

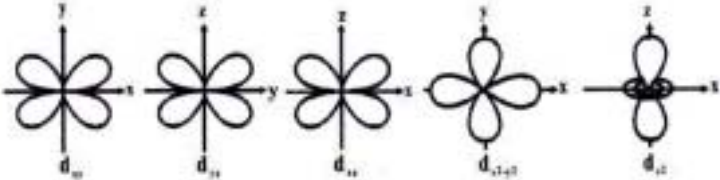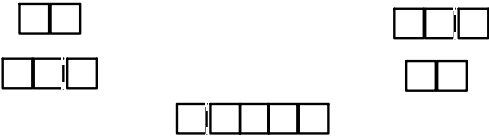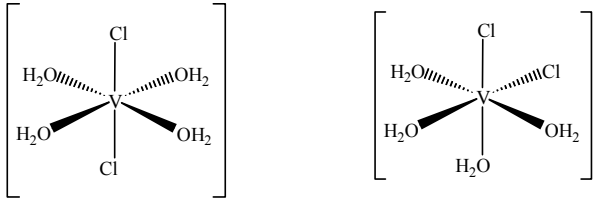| Question	Answer	Marks
2(a)	<table><tr><td>enthalpy change</td><td>positive</td><td>negative</td><td>either positive or negative</td></tr><tr><td>electron affinity</td><td></td><td></td><td>✓</td></tr><tr><td>enthalpy change of atomisation</td><td>✓</td><td></td><td></td></tr><tr><td>enthalpy change 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)	ΔH_6 is lattice (energy / enthalpy) **AND** ΔH_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 **B** – platinum **C** – 1 mol dm^{-3} H$^+$/HCl 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**
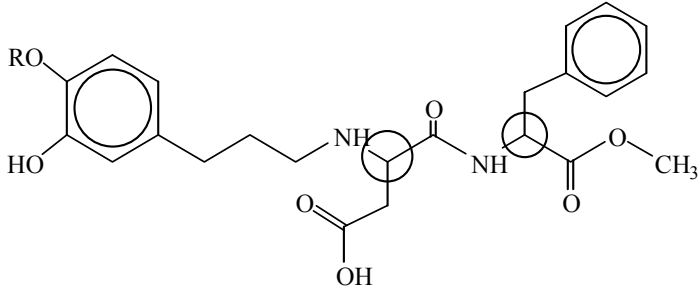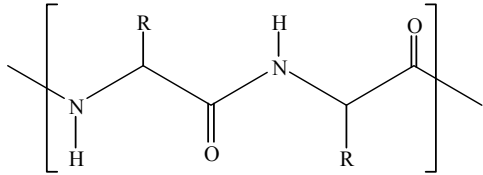
Question	Answer	Marks
4(a)(i)	experiments 1 and 2: doubling $[ClO_2]$ quadruples the rate, so second order	**1**
	experiments 2 and 3: doubling $[OH^-]$ doubles the rate, so first order	**1**
	rate equation = $k[ClO_2]^2[OH^-]$	**1**
4(a)(ii)	from experiment t 2: $9.34 \times 10^{-4} = k(2.50 \times 10^{-2})^2 \times 1.30 \times 10^{-3}$ $k = 1.15 \times 10^3$	**1**
	units: $mol^{-2} dm^6 s^{-1}$	**1**
4(b)(i)	heterogeneous catalysts are in different physical state from the reactants **AND** homogeneous catalysts are in the same physical state as the reactants	**1**
4(b)(ii)	*(see table below)*	**2**

catalysed reaction	heterogeneous	homogeneous
manufacture of ammonia in the Haber process	✓	
removal of nitrogen oxides from car exhausts	✓	
oxidation of sulfur dioxide in the atmosphere		✓

Question	Answer	Marks
4(c)(i)	$2MnO_4^- + 6H^+ + 5(CO_2H)_2 \rightarrow 2Mn^{2+} + 10 CO_2 + 8 H_2O$ correct Mn : $(CO_2H)_2$ ratio 1 rest of equation 1	**2**
4(c)(ii)	first section: flatter 1 second section: steeper, before flattening 1 	**2**

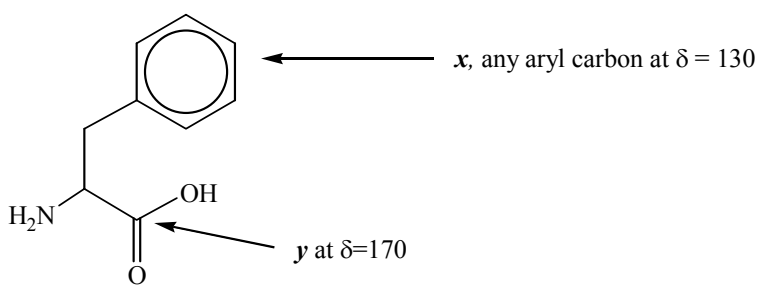| Question	Answer	Marks
,4(d)(i)	 diagram catalyst lowers E_a for both the forward and reverse reactions so the process requires less energy / can occur at a lower temperature	**3** 1 1 1
4(d)(ii)	$K_p = (pNH_3)^2/(pN_2)(pH_2)^3$ $1.45 \times 10^{-5} = (pNH_3)^2 / 20 \times 60 \times 60 \times 60$	**1**
	$pNH_3 = 7.91$	**1**
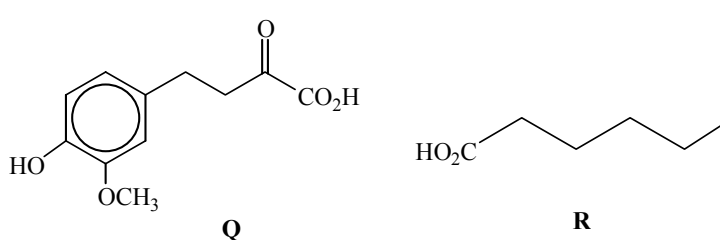
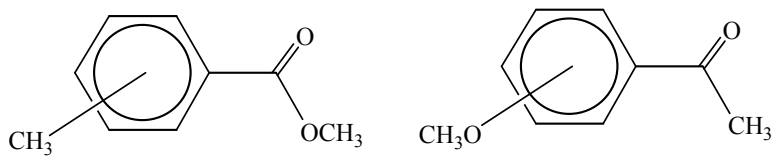| Question	Answer	Marks
5(a)(i)	$(CH_3)_3C\text{-}Cl / (CH_3)_2C = CH_2$	**1**
	$AlCl_3$ + heat	**1**
5(a)(ii)	(UV) light	**1**
5(a)(iii)		**1**
5(a)(iv)	ammonia / NH_3	**1**
	heat in sealed tube / heat under pressure	**1**
5(b)	$C_{10}H_{13}NH_2 + H_3O^+ \rightleftharpoons C_{10}H_{13}NH_3^+ + H_2O$	**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 : $[1s^22s^22p^63s^23p^6]$ **$3d^84s^2$** Ni^{3+} : $[1s^22s^22p^63s^23p^6]$ **$3d^7$**	1
6(b)(i)	 octahedral isolated ion tetrahedral complex 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$_2$O)$_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$_3$)$_6$]$^{2+}$ ⇌ [Ni(H$_2$O)$_6$]$^{2+}$ ⇌ [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 → $C_{14}H_{16}O_6NNa_3$ + $3H_2O$	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)		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