Cambridge International AS & A Level

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CHEMISTRY **9701/22**

Paper 2 AS Level Structured Questions **March 2017**

MARK SCHEME

Maximum Mark: 60

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.

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

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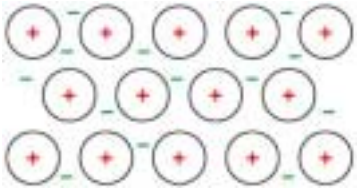
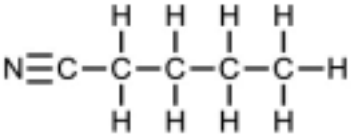
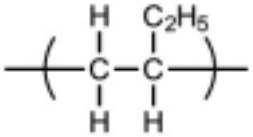
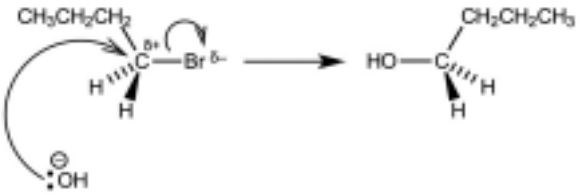
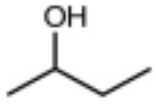
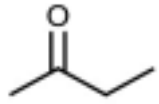
Question	Answer	Marks
1(a)(i)	max O.N. | +1 | (+)2 | (+)3 | (+)5 | (+)6 | +7	1
1(a)(ii)	(from Na to Cl) nuclear charge increases	1
	electrons are in the same shell / have same shielding	1
	greater / stronger attraction (of electrons to nucleus)	1
1(a)(iii)	Mg^{2+} **AND** S^{2-}	1
	ion of Mg / Mg^{2+} has one fewer shell (than ion of S / S^{2-})	1
1(b)(i)	$P_4 + 5O_2 \rightarrow P_4O_{10}$ / $2P_2O_5$	1
1(b)(ii)	any 2 from: • yellow / green colour (of chlorine gas) disappears • white flame • white solid • solid melts	2
1(b)(iii)	phosphoric(V) acid	1
1(c)(i)	 diagram showing regular arrangement of (positive) ions surrounded by / sea of (delocalised) electrons	2 1 1
1(c)(ii)	any 2 from: • high melting / boiling / sublimation point • electrical / thermal insulator • hard / rigid • retains strength at high temperature / pressure	2

Question	Answer	Marks
1(c)(iii)	**M1** % abundance of fourth isotope = 100 – (0.185 + 0.251 + 88.450) = 11.114	**1**
	M2 $\frac{(0.185\times135.907)+(0.251\times137.906)+(88.450\times139.905)+(11.114\times\text{RIM})}{100}$ = 140.116 ∴ (140.116 × 100) – 12434.35 = 1577.246 = 11.114 × RIM	**1**
	M3 RIM = $\frac{1577.246}{11.114}$ = 141.915	**1**

Question	Answer	Marks
2(a)(i)	bond in which the centres of positive and negative charges do not coincide **OR** electron distribution is asymmetric / unequal **OR** two (bonded) atoms are partially charged	**1**
2(a)(ii)	HF has the strongest (permanent) dipole–dipole / van der Waals' (forces) / HF has hydrogen bonding	**1**
	requires more energy to overcome (than weaker (permanent) dipole–dipole/ van der Waals' forces between other hydrogen halides)	**1**
2(a)(iii)	thermal stability of the hydrogen halides decreases down group (17)	**1**
	larger (halogen) atoms / atomic radius (down group) / increased shielding	**1**
	bond energies decrease / less energy required to break H–X	**1**
2(b)(i)	**M1** base is Cl^- **AND** conjugate acid is HCl **OR** base is HSO_4^- **AND** conjugate acid is H_2SO_4	**1**
	M2 Cl^- / HSO_4^- / base is a proton acceptor **OR** HCl / H_2SO_4 / (conjugate) acid has one more H^+	**1**
2(b)(ii)	H_2SO_4 is (too strong) an oxidising agent	**1**
	I_2 would be formed instead	**1**

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td rowspan="2">2(c)(i)</td><td>$\Delta_r H$ = $\Delta_r H${products} – $\Delta_r H${reactants} = 2 × (–242) – 4 × (–92)</td><td>1</td></tr>
<tr><td>= –116 (sign AND answer)</td><td>1</td></tr>
<tr><td rowspan="2">2(c)(ii)</td><td>heterogeneous (catalyst)</td><td>1</td></tr>
<tr><td>provides an alternative reaction pathway of lower activation energy</td><td>1</td></tr>
<tr><td rowspan="2">2(c)(iii)</td><td>reaction is exothermic</td><td>1</td></tr>
<tr><td>(increased temperature) shifts equilibrium to the left AND decreases yield of products (Cl_2 and / or H_2O) / less product formed</td><td>1</td></tr>
<tr><td>2(c)(iv)</td><td>
<table>
<tr><th></th><th>HCl</th><th>O_2</th><th>Cl_2</th><th>H_2O</th></tr>
<tr><td>initial number of moles</td><td>1.60</td><td>0.500</td><td>0</td><td>0</td></tr>
<tr><td>M1 eqm number of moles</td><td>1.60 – 2 × 0.600 = 0.400</td><td>0.500 – ½ × 0.600 = 0.200</td><td>0.600</td><td>0.600</td></tr>
<tr><td>M2 mole fraction</td><td></td><td></td><td>$\frac{0.600}{1.80}$</td><td></td></tr>
<tr><td>M3 partial pressure</td><td></td><td></td><td>$\frac{0.600}{1.80} \times p_{tot} = 5.00 \times 10^4$</td><td></td></tr>
</table>
</td><td>3</td></tr>
<tr><td rowspan="2">2(c)(v)</td><td>$K_p = \frac{(3.6\times10^4)^2 \times (3.6\times10^4)^2}{(4.8\times10^4)^4 \times 3.0\times10^4} = 1.05 \times 10^{-5}$</td><td>1</td></tr>
<tr><td>units = Pa^{-1}</td><td>1</td></tr>
<tr><td>2(c)(vi)</td><td>K_p would not change</td><td>1</td></tr>
</table>

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>3(a)(i)</td><td>  </td><td>1</td></tr>
<tr><td rowspan="2">3(a)(ii)</td><td>reaction 1 = HCl(aq)</td><td>1</td></tr>
<tr><td>reaction 2 = (conc.) NaOH / KOH AND ethanol</td><td>1</td></tr>
</table>

Question	Answer	Marks
3(a)(iii)	 C–C backbone with dangling bonds rest of structure	**2** 1 1
3(b)	 lone pair on O **AND** curly arrow from O to C of C–Br dipole on C–Br **AND** curly arrow from C–Br to Br product (butan-1-ol)	**3** 1 1 1
3(c)(i)	(electrophilic) addition	**1**
3(c)(ii)	**S** has CH_3CHOH **OR** methyl / CH_3 group next to CHOH	**1**
3(c)(iii)	positive inductive effect of more alkyl groups / more alkyl groups donate electron density	**1**
	secondary carbocation / secondary intermediate is more stable (than primary)	**1**
3(c)(iv)	**S** = 	**1**
	T = 	**1**
	U = 	**1**
3(c)(v)	$CH_3CHOHCH_2CH_3 + [O] \rightarrow CH_3COCH_2CH_3 + H_2O$	**1**
3(d)(i)	methyl pentanoate	**1**
3(d)(ii)	(compound **V** is) spectrum X	**1**
	spectra X and Z show a C=O (stretch) at 1730 (cm^{-1})	**1**
	spectra Y and Z show O–H (stretches) above 2500 (cm^{-1})	**1**
	V has a C=O (bond) and no O–H (bond)	**1**