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

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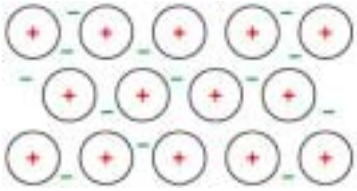
Question	Answer	Marks
1(a)(i)	max O.N. | +1 | (+)2 | (+)3 | (+)5 | (+)6 | +7	**1**
1(a)(ii)	(from Na to Cl) nuclear charge increases	**1**
	electrons are in the same shell / have same shielding	**1**
	greater / stronger attraction (of electrons to nucleus)	**1**
1(a)(iii)	Mg^{2+} **AND** S^{2-}	**1**
	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**

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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**

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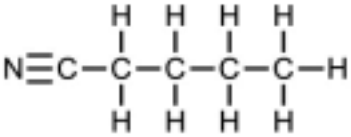
<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td rowspan="2">2(c)(i)</td><td>$\Delta_r H$ = $\Delta_r H${products} – $\Delta_r H${reactants} = 2 × (–242) – 4 × (–92)</td><td>1</td></tr>
<tr><td>= –116 (sign AND answer)</td><td>1</td></tr>
<tr><td rowspan="2">2(c)(ii)</td><td>heterogeneous (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>

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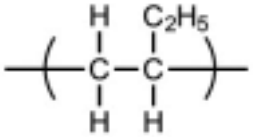
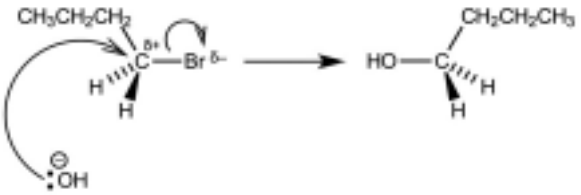
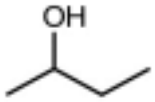
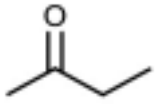
Question	Answer	Marks
3(a)(iii)	 C–C backbone with dangling bonds rest of structure	**2** 1 1
3(b)	 lone pair on O **AND** curly arrow from O to C of C–Br dipole on C–Br **AND** curly arrow from C–Br to Br product (butan-1-ol)	**3** 1 1 1
3(c)(i)	(electrophilic) addition	**1**
3(c)(ii)	**S** has CH_3CHOH **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**

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