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**CHEMISTRY**

**9701/22**

Paper 2 AS Level Structured Questions

**March 2017**

MARK SCHEME

Maximum Mark: 60

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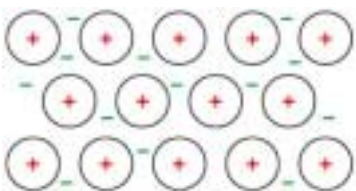
**Published**

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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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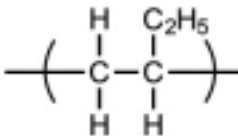
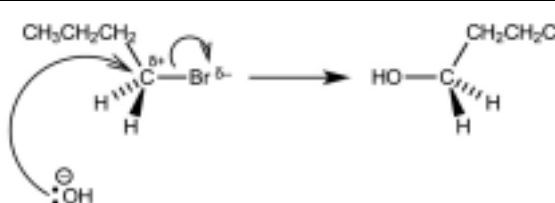
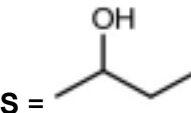
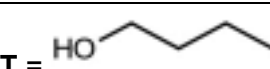
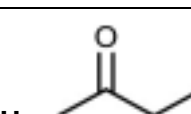
Question	Answer	Marks							
1(a)(i)	<table border="1"> <tr> <td>max O.N.</td> <td>+1</td> <td>(+)2</td> <td>(+)3</td> <td>(+)5</td> <td>(+)6</td> <td>+7</td> </tr> </table>	max O.N.	+1	(+)2	(+)3	(+)5	(+)6	+7	1
max O.N.	+1	(+)2	(+)3	(+)5	(+)6	+7			
1(a)(ii)	(from Na to Cl) nuclear charge increases	1							
	electrons are in the same shell / have same shielding	1							
	greater / stronger attraction (of electrons to nucleus)	1							
1(a)(iii)	Mg <sup>2+</sup> <b>AND</b> S <sup>2-</sup>	1							
	ion of Mg / Mg <sup>2+</sup> has one fewer shell (than ion of S / S <sup>2-</sup> )	1							
1(b)(i)	$P_4 + 5O_2 \rightarrow P_4O_{10} / 2P_2O_5$	1							
1(b)(ii)	any 2 from: <ul style="list-style-type: none"> <li>• yellow / green colour (of chlorine gas) disappears</li> <li>• white flame</li> <li>• white solid</li> <li>• solid melts</li> </ul>	2							
1(b)(iii)	phosphoric(V) acid	1							
1(c)(i)		2							
	<p>diagram showing regular arrangement of (positive) ions surrounded by / sea of (delocalised) electrons</p>		1 1						
1(c)(ii)	any 2 from: <ul style="list-style-type: none"> <li>• high melting / boiling / sublimation point</li> <li>• electrical / thermal insulator</li> <li>• hard / rigid</li> <li>• retains strength at high temperature / pressure</li> </ul>	2							

Question	Answer	Marks
1(c)(iii)	<b>M1</b> % abundance of fourth isotope $= 100 - (0.185 + 0.251 + 88.450) = 11.114$	1
	<b>M2</b> $\frac{(0.185 \times 135.907) + (0.251 \times 137.906) + (88.450 \times 139.905) + (11.114 \times \text{RIM})}{100}$ $= 140.116$ $\therefore (140.116 \times 100) - 12434.35 = 1577.246 = 11.114 \times \text{RIM}$	1
	<b>M3</b> $\text{RIM} = \frac{1577.246}{11.114} = 141.915$	1

Question	Answer	Marks
2(a)(i)	bond in which the centres of positive and negative charges do not coincide <b>OR</b> electron distribution is asymmetric / unequal <b>OR</b> 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)	<b>M1</b> base is $\text{Cl}^-$ <b>AND</b> conjugate acid is $\text{HCl}$ <b>OR</b> base is $\text{HSO}_4^-$ <b>AND</b> conjugate acid is $\text{H}_2\text{SO}_4$	1
	<b>M2</b> $\text{Cl}^- / \text{HSO}_4^-$ / base is a proton acceptor <b>OR</b> $\text{HCl} / \text{H}_2\text{SO}_4$ / (conjugate) acid has one more $\text{H}^+$	1
2(b)(ii)	$\text{H}_2\text{SO}_4$ is (too strong) an oxidising agent	1
	$\text{I}_2$ would be formed instead	1

Question	Answer	Marks																									
2(c)(i)	$\Delta_r H = \Delta_r H\{\text{products}\} - \Delta_r H\{\text{reactants}\} = 2 \times (-242) - 4 \times (-92)$	1																									
	= -116 (sign <b>AND</b> answer)	1																									
2(c)(ii)	heterogeneous (catalyst)	1																									
	provides an alternative reaction pathway of lower activation energy	1																									
2(c)(iii)	reaction is exothermic	1																									
	(increased temperature) shifts equilibrium to the left <b>AND</b> decreases yield of products ( $\text{Cl}_2$ and/or $\text{H}_2\text{O}$ )/less product formed	1																									
2(c)(iv)	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th></th> <th>HCl</th> <th><math>\text{O}_2</math></th> <th><math>\text{Cl}_2</math></th> <th><math>\text{H}_2\text{O}</math></th> </tr> </thead> <tbody> <tr> <td>initial number of moles</td> <td>1.60</td> <td>0.500</td> <td>0</td> <td>0</td> </tr> <tr> <td><b>M1</b> eqm number of moles</td> <td><math>1.60 - 2 \times 0.600 = 0.400</math></td> <td><math>0.500 - \frac{1}{2} \times 0.600 = 0.200</math></td> <td>0.600</td> <td>0.600</td> </tr> <tr> <td><b>M2</b> mole fraction</td> <td></td> <td></td> <td><math>\frac{0.600}{1.80}</math></td> <td></td> </tr> <tr> <td><b>M3</b> partial pressure</td> <td></td> <td></td> <td><math>\frac{0.600}{1.80} \times p_{\text{tot}} = 5.00 \times 10^4</math></td> <td></td> </tr> </tbody> </table>		HCl	$\text{O}_2$	$\text{Cl}_2$	$\text{H}_2\text{O}$	initial number of moles	1.60	0.500	0	0	<b>M1</b> eqm number of moles	$1.60 - 2 \times 0.600 = 0.400$	$0.500 - \frac{1}{2} \times 0.600 = 0.200$	0.600	0.600	<b>M2</b> mole fraction			$\frac{0.600}{1.80}$		<b>M3</b> partial pressure			$\frac{0.600}{1.80} \times p_{\text{tot}} = 5.00 \times 10^4$		3
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2(c)(v)	$K_p = \frac{(3.6 \times 10^4)^2 \times (3.6 \times 10^4)^2}{(4.8 \times 10^4)^4 \times 3.0 \times 10^4} = 1.05 \times 10^{-5}$	1																									
	units = $\text{Pa}^{-1}$	1																									
2(c)(vi)	$K_p$ would not change	1																									

Question	Answer	Marks
3(a)(i)	$\begin{array}{cccc} \text{H} & \text{H} & \text{H} & \text{H} \\   &   &   &   \\ \text{N} \equiv \text{C} - & \text{C} - & \text{C} - & \text{C} - \text{H} \\   &   &   &   \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array}$	1
3(a)(ii)	reaction 1 = HCl(aq)	1
	reaction 2 = (conc.) NaOH/KOH <b>AND</b> ethanol	1

Question	Answer	Marks
3(a)(iii)	 <p>C–C backbone with dangling bonds rest of structure</p>	2 1 1
3(b)	 <p>lone pair on O <b>AND</b> curly arrow from O to C of C–Br dipole on C–Br <b>AND</b> curly arrow from C–Br to Br product (butan-1-ol)</p>	3 1 1 1
3(c)(i)	(electrophilic) addition	1
3(c)(ii)	<b>S</b> has CH <sub>3</sub> CHOH <b>OR</b> methyl/CH <sub>3</sub> 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)	<p><b>S</b> = </p> <p><b>T</b> = </p> <p><b>U</b> = </p>	1 1 1
3(c)(v)	CH <sub>3</sub> CHOHCH <sub>2</sub> CH <sub>3</sub> + [O] → CH <sub>3</sub> COCH <sub>2</sub> CH <sub>3</sub> + H <sub>2</sub> O	1
3(d)(i)	methyl pentanoate	1
3(d)(ii)	(compound <b>V</b> is) spectrum X	1
	spectra X and Z show a C=O (stretch) at 1730 (cm <sup>-1</sup> )	1
	spectra Y and Z show O–H (stretches) above 2500 (cm <sup>-1</sup> )	1
	<b>V</b> has a C=O (bond) and no O–H (bond)	1