Cambridge International AS & A Level

**Cambridge International Examinations**
Cambridge International Advanced Subsidiary and Advanced Level

**CHEMISTRY** **9701/22**

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

MARK SCHEME

Maximum Mark: 60

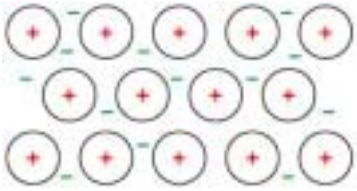
**Published**

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.

Cambridge will not enter into discussions about these mark schemes.

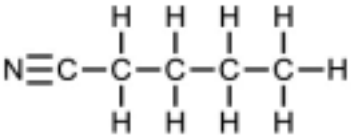
Cambridge is publishing the mark schemes for the March 2017 series for most Cambridge IGCSE®, Cambridge International A and AS Level components and some Cambridge O Level components.

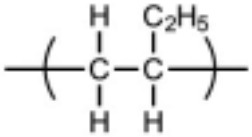
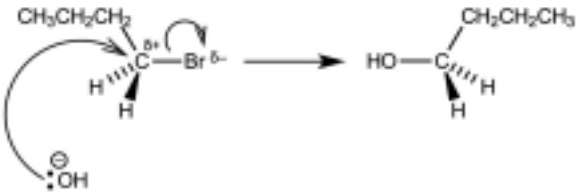
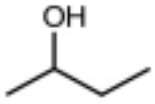
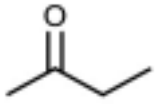
| Question | Answer | Marks |
|---|---|---|
| 1(a)(i) | max O.N. \| +1 \| (+)2 \| (+)3 \| (+)5 \| (+)6 \| +7 | 1 |
| 1(a)(ii) | (from Na to Cl) nuclear charge increases | 1 |
| | electrons are in the same shell / have same shielding | 1 |
| | greater / stronger attraction (of electrons to nucleus) | 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:<br>• yellow / green colour (of chlorine gas) disappears<br>• white flame<br>• white solid<br>• solid melts | 2 |
| 1(b)(iii) | phosphoric(V) acid | 1 |
| 1(c)(i) |  <br>diagram showing regular arrangement of (positive) ions<br>surrounded by / sea of (delocalised) electrons | 2<br>1<br>1 |
| 1(c)(ii) | any 2 from:<br>• high melting / boiling / sublimation point<br>• electrical / thermal insulator<br>• hard / rigid<br>• retains strength at high temperature / pressure | 2 |

| Question | Answer | Marks |
|---|---|---|
| 1(c)(iii) | **M1**<br>% abundance of fourth isotope<br>= 100 – (0.185 + 0.251 + 88.450) = 11.114 | **1** |
| | **M2**<br>$\frac{(0.185\times135.907)+(0.251\times137.906)+(88.450\times139.905)+(11.114\times\text{RIM})}{100}$<br>= 140.116<br><br>∴ (140.116 × 100) – 12434.35 = 1577.246 = 11.114 × RIM | **1** |
| | **M3**<br>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<br>**OR** electron distribution is asymmetric / unequal<br>**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**<br>base is $Cl^-$ **AND** conjugate acid is $HCl$<br>**OR**<br>base is $HSO_4^-$ **AND** conjugate acid is $H_2SO_4$ | **1** |
| | **M2**<br>$Cl^-$ / $HSO_4^-$ / base is a proton acceptor<br>**OR**<br>$HCl$ / $H_2SO_4$ / (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>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></td><td>= –116 (sign AND answer)</td><td>1</td></tr>
<tr><td>2(c)(ii)</td><td>heterogeneous (catalyst)</td><td>1</td></tr>
<tr><td></td><td>provides an alternative reaction pathway of lower activation energy</td><td>1</td></tr>
<tr><td>2(c)(iii)</td><td>reaction is exothermic</td><td>1</td></tr>
<tr><td></td><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>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></td><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>3(a)(ii)</td><td>reaction 1 = $HCl$(aq)</td><td>1</td></tr>
<tr><td></td><td>reaction 2 = (conc.) NaOH / KOH AND ethanol</td><td>1</td></tr>
</table>

| Question | Answer | Marks |
|---|---|---|
| 3(a)(iii) |  <br>C–C backbone with dangling bonds<br>rest of structure | **2**<br><br>1<br>1 |
| 3(b) |  <br>lone pair on O **AND** curly arrow from O to C of C–Br<br>dipole on C–Br **AND** curly arrow from C–Br to Br<br>product (butan-1-ol) | **3**<br><br>1<br>1<br>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** |