MARK SCHEME for the October/November 2013 series

9701 CHEMISTRY

9701/22 Paper 2 (AS Structured Questions), maximum raw mark 60

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 October/November 2013 series for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level components and some Ordinary Level components.
1 (a)

<table>
<thead>
<tr>
<th>number of bond pairs</th>
<th>number of lone pairs</th>
<th>shape of molecule</th>
<th>formula of a molecule with this shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0</td>
<td>trigonal planar</td>
<td>BH$_3$</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>tetrahedral</td>
<td>CH$_4$ allow other Group IV hydrides</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>pyramidal or trigonal pyramidal</td>
<td>NH$_3$ allow other Group V hydrides</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>non-linear or bent or V-shaped</td>
<td>H$_2$O allow other Group VI hydrides</td>
</tr>
</tbody>
</table>

1 mark for each correct row $\text{(3 \times 1) [3]}$

(b) (i)

(ii) octahedral or square-based bipyramid $\text{(1)}$

(iii) $90^\circ$ $\text{(1) [3]}$

[Total: 6]
2  (a)  $117^\circ$ to $120^\circ$  (1)  

(b) (i) electrophilic addition  (1)  

(ii)  

![Diagrams showing molecular structures]

1 mark for each correct structure  
allow correctly drawn optical isomers of the first structure  (3 \times 1)  (4)  

[Total: 5]

3  (a) (i) anode  
$\text{Cl}^- (aq) \rightarrow \frac{1}{2} \text{Cl}_2(g) + e^-$  (1)  

cathode  
$\text{H}^+(aq) + e^- \rightarrow \frac{1}{2} \text{H}_2(g)$ or  
$2\text{H}_2\text{O}(l) + 2e^- \rightarrow \text{H}_2(g) + 2\text{OH}^-(aq)$  (1)  

(ii) because iron in steel will react with chlorine  (1)  [3]

(b) sodium  
burns with a yellow or orange flame or  
forms a white solid  
allow – once only – colour of chlorine disappears  
$2\text{Na} + \text{Cl}_2 \rightarrow 2\text{NaCl}$  (1)  (1)  

phosphorus  
burns with a white or yellow flame or  
colour of chlorine disappears – if not given for Na – or  
for $\text{PCl}_5$ forms a white or pale yellow solid  
for $\text{PCl}_3$ forms a colourless liquid  (1)  

$\text{P} + 2\frac{1}{2}\text{Cl}_2 \rightarrow \text{PCl}_5$ or $\text{P}_4 + 10\text{Cl}_2 \rightarrow 4\text{PCl}_5$  

or  
$\text{P} + 1\frac{1}{2}\text{Cl}_2 \rightarrow \text{PCl}_3$ or $\text{P}_4 + 6\text{Cl}_2 \rightarrow 4\text{PCl}_3$  

equation must refer to compound described  (1)  [4]
(c) cold dilute aqueous NaOH

\[ \text{NaOC} \rightarrow +1 \text{(1)} \]

hot concentrated aqueous NaOH

\[ \text{NaClO}_3 \rightarrow +5 \text{(1)} \text{[4]} \]

(d) MgCl\textsubscript{2} 6.5 to 6.9

SiCl\textsubscript{4} 0 to 3

MgCl\textsubscript{2} dissolves without reaction or slight or partial hydrolysis occurs

SiCl\textsubscript{4} reacts with water or hydrolysis occurs

\[
\begin{align*}
\text{SiCl}_4 + 2\text{H}_2\text{O} & \rightarrow \text{SiO}_2 + 4\text{HCl} \quad \text{or} \\
\text{SiCl}_4 + 4\text{H}_2\text{O} & \rightarrow \text{Si(OH)}_4 + 4\text{HCl} \quad \text{or} \\
\text{SiCl}_4 + 4\text{H}_2\text{O} & \rightarrow \text{SiO}_2.2\text{H}_2\text{O} + 4\text{HCl}
\end{align*}
\]

[Total: 16]

4 (a) (i) \( \text{H}_2\text{X} + 2\text{NaOH} \rightarrow \text{Na}_2\text{X} + 2\text{H}_2\text{O} \) (1)

(ii) \( n(\text{OH}^-) = \frac{21.6 \times 0.100}{1000} = 2.16 \times 10^{-3} \text{ mol} \) (1)

(iii) \( n(\text{R}) = n(\text{H}_2\text{X}) = \frac{2.16 \times 10^{-3}}{2} = 1.08 \times 10^{-3} \text{ mol in 25.0 cm}^3 \) (1)

(iv) \( n(\text{R}) = 1.08 \times 10^{-3} \times \frac{250}{25.0} = 0.0108 \text{ mol in 250 cm}^3 \) (1)

(v) \( 0.0108 \text{ mol of } \text{R} = 1.25 \text{ g of } \text{R} \)

\[ 1 \text{ mol of } \text{R} = \frac{1.25 \times 1}{0.0108} = 115.7 = 116 \text{ g} \] (1) [5]
(b)  
(i)  $M_r$ of $S = 116$
$M_r$ of $T = 134$
$M_r$ of $U = 150$  all three needed  (1)

(ii)  $S$  (1)  [2]

(c)  $S$ into $T$
conc. $H_2SO_4$ followed by $H_2O$
or $H_3PO_4$ followed by $H_2O$ or
steam and $H_3PO_4$ catalyst  (1 + 1)

$S$ into $U$
$KMnO_4$  (1)
cold dilute acidified or cold dilute alkaline  (1)

$T$ into $S$
$P_4O_{10}$ or conc. $H_2SO_4$ or conc. $H_3PO_4$ or $Al_2O_3$
and heat in each case  (1)  [5]

(d)  $T$ reacting with an excess of Na

$NaO_2CCH(ONa)CH_2CO_2Na$  (1)

$U$ reacting with an excess of $Na_2CO_3$

$NaO_2CCH(OH)CH(OH)CO_2Na$  (1)  [2]

(e)  
\[
\begin{align*}
&\text{cis or } Z \\
&\text{trans or } E
\end{align*}
\]
two correct structures
correct labels  (1)  [2]
(f) correct ring of C and O atoms, i.e.

\[
\begin{array}{c}
\text{C} \\
\text{H} \\
\text{C} \\
\text{O} \\
\end{array}
\]

(1)

correct compound, i.e.

\[
\begin{array}{c}
\text{O} \\
\text{C} \\
\text{C} \\
\text{O} \\
\end{array}
\]

(hydrogen atoms do not need to be shown) (1) [2]

[Total: 18]

5 (a) (i) alkanes or paraffins not hydrocarbons (1)

(ii) \(2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O\) (1) [2]

(b) (i) carbon allow graphite (1)

(ii) \(2C_4H_{10} + 5O_2 \rightarrow 8C + 10H_2O\) allow balanced equations which include CO and/or CO\(_2\) (1) [2]

(c) enthalpy change when 1 mol of a substance is burnt in an excess of oxygen/air under standard conditions or is completely combusted under standard conditions (1) [2]

(d) (i) \[ m = \frac{pVM_r}{RT} = \frac{1.01 \times 10^5 \times 125 \times 10^{-6} \times 44}{8.31 \times 293} \text{ g} \]

\[ = 0.228147345 \text{ g} \]

\[ = 0.23 \text{ g} \] (1)

(ii) heat released = \(m c \delta T = 200 \times 4.18 \times 13.8 \text{ J} = 11536.8 \text{ J} = 11.5 \text{ kJ} \) (1)

(iii) 0.23 g of propane produce 11.5 kJ

\[ 44 \text{ g of propane produce } \frac{11.5 \times 44}{0.23} \text{ kJ} = 2200 \text{ kJ mol}^{-1} \] (1) [5]
(e) (i) from methane to butane
    there are more electrons in the molecule (1)
    therefore greater/stronger van der Waals' forces (1)

(ii) straight chain molecules can pack more closely (1)
    therefore stronger van der Waals' forces (1)
    or reverse argument

[Total: 15]