MARK SCHEME for the October/November 2010 question paper
for the guidance of teachers

9701 CHEMISTRY
9701/23 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 must be read in conjunction with the question papers and the report on the
examination.

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CIE is publishing the mark schemes for the October/November 2010 question papers for most IGCSE,
GCE Advanced Level and Advanced Subsidiary Level syllabuses and some Ordinary Level
syllabuses.
1 (a) atoms of the same element / with same proton (atomic) number / same number of protons (1) different numbers of neutrons / nucleon number / mass number (1) [2]

(b)  

<table>
<thead>
<tr>
<th>isotope</th>
<th>no. of protons</th>
<th>no. of neutrons</th>
<th>no. of electrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{24}\text{Mg}$</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>$^{26}\text{Mg}$</td>
<td>12</td>
<td>14</td>
<td>12</td>
</tr>
</tbody>
</table>

each correct row (1) [2]

(c) $A_i = \frac{24 \times 78.60 + 25 \times 10.11 + 26 \times 11.29}{100}$ (1)

$$= \frac{1886.40 + 252.75 + 293.54}{100}$$

gives 24.33 to 4 sig fig (same as data in question) do not credit wrong number of sig figs or incorrect rounding up/down (1) [2]

(d) \(\text{Mg} + \text{Cl}_2 \rightarrow \text{MgCl}_2\) (1) [1]

(e) (i) \(n(\text{Sb}) = \frac{2.45}{122} = 0.020\) (1)

(ii) mass of Cl in \(\text{A}\) = 4.57 – 2.45 = 2.12 g (1)

\(n(\text{Cl}) = \frac{4.57 - 2.45}{35.5} = \frac{2.12}{35.5} = 0.06\)

allow ecf as appropriate (1)

(iii) \(\text{Sb} : \text{Cl} = 0.02 : 0.06 = 1:3\)

empirical formula of \(\text{A}\) is SbCl₃ (1)

(iv) \(2\text{Sb} + 3\text{Cl}_2 \rightarrow 2\text{SbCl}_3\) (1) [5]

(f) (i) ionic (1)

(ii) covalent (1)


not\ van\ der\ Waals’\ forces\ [2]

[Total: 14]
2 (a) 1 \( S + O_2 \rightarrow SO_2 \) (1)

2 \( 2SO_2 + O_2 \rightleftharpoons 2SO_3 \) equation (1)

3 \( SO_3 + H_2O \rightarrow H_2SO_4 \) or \( SO_3 + H_2SO_4 \rightarrow H_2S_2O_7 \) (1) [4]

(b) condition 1 \( 400 – 600 ^\circ C (650 – 900K) \) (1)
condition 2 \( 1–10 \text{ atm/just above atmospheric pressure} \)
allow equivalent pressure units (1)
condition 3 vanadium pentoxide/vanadium(V) oxide/V\(_2\)O\(_5\) (1) [3]

(c) fertilisers/phosphates/ammonium sulfate or lead/acid batteries or paints/pigments or dyestuffs or steel pickling or metal treatment or detergents or explosives (1) [1]

(d) (i) \( 2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O \) (1)

(ii) \( H_2S \rightarrow 2 \text{ SO}_2 \ + 4 \text{ S} \ 0 \) all three (1)
\( \text{SO}_2 \) because the oxidation number of S is reduced (1) [3]

(e) (i) \( 2NO + O_2 \rightarrow 2NO_2 \) (1)
\( \text{SO}_2 + \text{NO}_2 \rightarrow \text{SO}_3 + \text{NO} \) (1)
\( \text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4 \)
final product must be \( \text{H}_2\text{SO}_4 \) (1)

(ii) corrosion of buildings or dissolving of \( \text{Al}^{3+} \) ions from soil or pollution of rivers/killing aquatic life or making soil acidic/killing trees/corrosion of metals (1) [4]

(f) it is a reducing agent/inhibits oxidation (1) [1]

[Total: 16]
3  (a) (i) order of atoms must be C-C-O

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

(1) linear (1)

(ii) a molecule or atom with an unpaired electron or a species formed by the homolytic fission of a covalent bond (1)

(iii) molecule has 2 bond pairs and one lone pair (1) and one unpaired electron (1) these may be shown in a diagram [5]

(b) (i) allow the structural formula \( \text{CH}_2\text{CH(CN)}\text{CH}_2\text{CH(CN)} \) (1)

(ii) addition (1) [2]

(c) (i) \( \text{CH}_3\text{CHO} \) (1)

(ii) \( \begin{array}{c}
\text{O} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array} \) or \( \begin{array}{c}
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array} \) or \( \begin{array}{c}
\text{O} \\
\end{array} \) (1) [2]

(d)

<table>
<thead>
<tr>
<th>reagent</th>
<th>product</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{Br}_2 ) in an inert solvent</td>
<td>( \text{BrCH}_2\text{CHBrCHO} )</td>
</tr>
<tr>
<td>( \text{NaCN} + \text{dil. H}_2\text{SO}_4 )</td>
<td>( \text{CH}_2=\text{CHCH(OH)}\text{CN} ) allow ( \text{CH}_2=\text{CHCH(OH)}\text{CO}_2\text{H} )</td>
</tr>
<tr>
<td>( \text{Tollens' reagent} )</td>
<td>( \text{CH}_2=\text{CHCO}_2\text{H} ) or ( \text{CH}_2=\text{CHCO}_2^- )</td>
</tr>
<tr>
<td>( \text{NaBH}_4 )</td>
<td>( \text{CH}_2=\text{CHCH}_2\text{OH} )</td>
</tr>
</tbody>
</table>

(4 × 1) [4]

[Total: 13]
4 (a) \[ \frac{C : H : Br}{12} = \frac{29.3}{1} : \frac{5.7}{1} : \frac{65.0}{79.9} \]

\[ = 2.44 : 5.7 : 0.81 \]

\[ = 3 : 7 : 1 \]

\[ C_3H_7Br = (3 \times 12) + (7 \times 1) + 79.9 = 122.9 \]

Use of 122.9 or 123 to prove molecular formula must be \( C_3H_7Br \) \( (1) \)

(b) (i) mechanism must be \( S_{N2} \)

- dipole on C-Br bond or central C atom shown with \( \delta^+ \) \( (1) \)
- attack on C atom by lone pair of OH\(^- \) not from negative charge \( (1) \)
- transition state formed with negative charge shown \( (1) \)
- Br\(^- \) leaves/NaBr formed \( (1) \)

(ii) \( C_2H_4 \)/ethane \( (1) \)

(iii) \( \text{ethanol}/C_2H_5OH \) \( (1) \)

(iv) elimination \( (1) \)

(c) (i) \[ \text{HO—C—C—C—OH} \]

(ii) must be skeletal

\[ \text{or} \]

\[ (1) \]

[Total: 12]

5 (a) \( \text{AgCl/silver chloride} \) \( (1) \)

(b) white \( (1) \)

(c) 1-iodobutane \( (1) \)

(d) C-I bond is weaker/longer than the other C-halogen bonds \( (1) \)

\[ \text{C-I bond energy is 240 kJ mol}^{-1} \]

\[ \text{or covalent radius of I is 0.133 nm} \] \( (1) \)

[Total: 5]