MARK SCHEME for the May/June 2010 question paper
for the guidance of teachers

9701 CHEMISTRY

9701/21 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 May/June 2010 question papers for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level syllabuses and some Ordinary Level syllabuses.
1 (a) fewer electrons in Cl₂ than in Br₂ (1)
smaller van der Waals’ forces in Cl₂ or stronger van der Waals’ forces in Br₂ (1) [2]

(b) CO has a permanent dipole or N₂ does not (1)
permanent dipole-permanent dipole interactions are stronger than those from induced dipoles (1) [2]

(c) (i) a co-ordinate bond (1)

(ii) a covalent bond (1)

or

(iii) a lone pair (1)

penalise any groups of 3 or 4 electrons that are circled [3]

(d) CO and HCN both have a dipole or N₂ does not have a dipole (1) [1]
(e) (i) 
\[
\begin{align*}
\text{H} & \quad \text{H} \\
\text{H} & \quad \text{C} - \text{C} - \text{O} - \text{H} \\
\text{H} & \quad \text{C} \equiv \text{N}
\end{align*}
\]

C≡N must be shown (1)

(ii) nucleophilic addition (1)

(iii) 
\[
\begin{align*}
\text{CH}_3 & \quad \text{C}=\text{O} \quad \text{CH}_3 & \quad \text{C}=\text{O}^- \\
\text{H} & \quad \text{CN}^- & \quad \text{CN} & \quad \text{CN} \\
\text{H} & \quad \text{C} \equiv \text{N} & \quad \text{C} & \quad \text{O} \\
\end{align*}
\]

C=O dipole correctly shown or correct curly arrow on C=O (1)  
attack on C\text{\textsuperscript{\textcircled{\textdegree}}} by C of CN\text{\textsuperscript{\textcircled{\textdegree}}} (1)  
correct intermediate (1)  
CN\text{\textsuperscript{\textcircled{\textdegree}}} regenerated (1)  

[5 max]  

[Total: 13]
2 (a) (i) new graph has **lower** maximum (1)
maximum is **to the right of** previous maximum (1)

(ii) \( H \) is at \( E_a \) (1) [3]

(b) the minimum amount of energy molecules must have or energy required (1)
in order for the reaction to take place (1) [2]

(c) (i) iron or iron oxide (1)
100 to 500 atm **and** 400–550°C
units necessary – allow other correct values and units (1)

(ii) \( C \) is placed to the left of \( H \) (1)

(iii) more molecules now have energy \( >E_a \) (1) [4]

(d) reaction **1**
has greater \( E_a \) (1)
because energy is needed to break covalent bonds (1)
reaction **2**
has lower \( E_a \)
or actual reaction is \( H^+ + OH^- \rightarrow H_2O \)
or reaction involves ions (1)
opposite charges attract (1) [4]

[Total: max 12]
3 (a) Accept only symbols.

(i) S or S₈ (1)
(ii) K or K⁺ (1)
(iii) Na – allow K or Li (1)
(iv) Cl or Br or F (1)
(v) Mg or Ca or Li allow Ni, Cu, or Zn (1)

(b) Accept only formulae.

(i) F₂O (1)
(ii) SO₂ and SO₃
     or P₂O₅/P₄O₁₀ and P₂O₅/P₄O₁₀
     or any two from N₂O₃, NO₂/N₂O₄, N₂O₅
     or any two from Cl₂O, ClO₂, ClO₃, Cl₂O₇ (1+1)

(c) (i) NaF, MgF₂, AlF₃ – any two (1)
(ii) octahedral (1)
(iii) I atom is larger than Cl atom (1)
(iv) cannot pack 7 F atoms around Cl atom
     or can pack 7 F atoms around I atom (1)

[Total: 12]
4 \( \text{(a)} \)

\[
\begin{align*}
\text{CH}_3\text{CHBrCH}_2\text{Br} & \quad \text{A} \\
\text{CH}_3\text{CH}=\text{CH}_2 & \quad \text{KMnO}_4/\text{H}^+ \\
& \quad \text{cold, dilute} \\
\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{OH} & \quad \text{B} \\
\text{HBr} \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{CN} & \quad \text{D} \\
\text{KCN in aqueous ethanol} \\
\text{or} \\
\text{CH}_3\text{CH(CN)}\text{CH}_3 & \quad \text{E} \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{H} \\
\text{or} \\
\text{CH}_3\text{CH(}\text{CO}_2\text{H})\text{CH}_3 & \quad \text{G} \\
\text{CH}_3\text{CH}_2\text{CH}_2\text{Br} & \quad \text{C} \\
\text{CH}_3\text{CHBrCH}_3 & \quad \text{F} \\
\text{NH}_3 \\
\text{in an excess} \\
\text{NaOH (in ethanol) heat under reflux} \\
\end{align*}
\]

Give 1 for each correct structure (7 × 1) \[7\]

4 \( \text{(b)} \) (i) ester (1)

(ii) heat under reflux (1)

trace of conc. \text{H}_2\text{SO}_4 \text{ or presence of HCl (g)} (1) \[3\]

[Total: 10]
5 (a) (i) same molecular formula
   but different structural formula/structure (1)

   (ii) asymmetric C atom/chiral centre present (1)
   \( >\text{C}=\text{C}< \) bond present (1) [3]

(b) \( \text{NaO}_2\text{CCH(OH)CH(OH)CO}_2\text{Na} \) (1) [1]

(c) no because there is no chiral carbon atom present (1) [1]

(d) (i) \( \frac{35.8}{12} : \frac{4.5}{1} : \frac{59.7}{16} \) this mark is for correct use of \( \Delta_r \) values (1)

   \( \text{C} : \text{H} : \text{O} = 2.98 : 4.5 : 3.73 \)

   \( \text{C} : \text{H} : \text{O} = 1 : 1.5 : 1.25 \) this mark is for evidence of correct calculation (1)

   gives empirical formula of \( \text{W} \) is \( \text{C}_4\text{H}_6\text{O}_5 \)

(ii) \( \text{C}_4\text{H}_6\text{O}_5 = 12 \times 4 + 1 \times 6 + 16 \times 5 = 134 \)

   molecular formula of \( \text{W} \) is \( \text{C}_4\text{H}_6\text{O}_5 \) (1) [3]
(e) (i) \[ n(\text{OH}^-) = \frac{29.4 \times 100}{1000} = 0.0294 \] (1)
\[ n(W) = \frac{1.97}{134} = 0.0147 \] (1)
no. of \(-\text{CO}_2\text{H}\) groups present
in one molecule of \(W\) = \[ \frac{0.0294}{0.0147} \] = 2 (1)

or \[ n(\text{OH}^-) = \frac{29.4 \times 1.00}{1000} = 0.0294 \] (1)
1.97 g \(W\) = 0.0294 mol NaOH
134 g \(W\) = \[ \frac{0.0294 \times 134}{1.97} \] = 1.999 \(\approx\) 2 mol NaOH (1)
no. of \(-\text{CO}_2\text{H}\) groups present in 1 molecule of \(W\) = 2 (1) [3]

(ii)

\[ \begin{align*}
\text{H-O-C-C-C-C-O-H} \\
\text{H-O-H} \\
\end{align*} \]
\[ \begin{align*}
\text{H-O-C-C-C-C-O-H} \\
\text{O-H} \\
\text{CH}_3 \\
\end{align*} \]
\[ \begin{align*}
\text{H-O-C-C-C-C-O-H} \\
\text{O-H} \\
\text{OH} \\
\end{align*} \]
\[ \begin{align*}
\text{H-O-C-C-C-C-O-H} \\
\text{O-H} \\
\text{H-C-H} \\
\end{align*} \]

one correct structure (1)
correctly displayed (1)
allow any correct ether [2]

[Total: 13]