MARK SCHEME for the October/November 2009 question paper
for the guidance of teachers

9701 CHEMISTRY

9701/41  Paper 41 (A2 Structured Questions),
maximum raw mark 100

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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GCE Advanced Level and Advanced Subsidiary Level syllabuses and some Ordinary Level
syllabuses.
1 (a) CO\textsubscript{2} is a gas (at room temperature); SiO\textsubscript{2} is a high melting solid \[1\]
\begin{align*}
\text{CO}_2: & \quad \text{simple / discrete molecular / covalent} \quad & \text{[1]} \\
\text{SiO}_2: & \quad \text{giant covalent or macromolecular / giant molecular} \quad & \text{[1]} \\
\end{align*}

(b) (a substance that is..) hard, high melting, electrical insulator any two \[1\]
SiO\textsubscript{2} has strong covalent bonds (can be in (a)) \[1\] \[2\]

(c) (i) amphoteric \[1\]
(ii) \[2\]
\begin{align*}
2\text{NaOH} + \text{PbO} & \rightarrow \text{Na}_2\text{PbO}_2 + \text{H}_2\text{O} & \text{[1]} \\
(\text{or } \text{NaOH} + \text{PbO} + \text{H}_2\text{O} & \rightarrow \text{NaPb(OH)}_3 \text{ etc.}) & \text{[2]} \\
\end{align*}

(d) (i) \[1\]
\begin{align*}
\text{Zn} + \text{Sn}^{4+} & \rightarrow \text{Zn}^{2+} + \text{Sn}^{2+} & \text{[1]} \\
\end{align*}
(ii) \[1\]
\begin{align*}
E^0 = 0.15 - (-0.76) & = 0.91 \text{ V} & \text{[1]} \\
E^0 = 1.52 - 0.15 & = 1.37 \text{ V} & \text{[1]} \\
\end{align*}
(iii) \[1\]
\begin{align*}
n(\text{Sn}^{2+}) & = 0.02 \times 13.5/1000 \times 5/2 = 6.75 \times 10^{-4} \text{ mol} \quad \text{use of the 5/2 ratio} & \text{[1]} \\
n(\text{Sn}^{2+}) & = 0.02 \times 20.3/1000 \times 5/2 = 1.02 \times 10^{-3} \text{ mol} \quad \text{correct rest of working} & \text{[1]} \\
\end{align*}
(iv) \[1\]
\begin{align*}
n(\text{Sn}^{4+}) & = 1.02 \times 10^{-3} - 6.75 \times 10^{-4} = 3.45 \times 10^{-4} \text{ mol} & \text{[1]} \\
\therefore \text{ ratio } & = 6.75/3.45 = 1.96:1 \approx 2:1 \\
\therefore \text{ formula is } 2\text{SnO} + \text{SnO}_2 & \Rightarrow \text{Sn}_3\text{O}_4 \quad (\text{cond\textsuperscript{ii} on calculation, but allow ecf}) & \text{[1]} \\
\end{align*}

(e) (i) volume = $1 \times 1 \times 1 \times 10^{-5} = 1 \times 10^{-5} \text{ m}^3 \text{ or } 10 \text{ cm}^3 \quad \text{[1]}$
(ii) mass = vol $\times$ density = $10 \times 7.3 = 73$ g \quad \text{ecf} \quad \text{[1]}$
moles = mass$/A_r = 73/119 = 0.61$ mol \quad \text{ecf} \quad \text{[1]}$
(iii) $Q = nFz = 0.61 \times 9.65 \times 10^4 \times 2 = 1.18 (1.2) \times 10^5$ coulombs \quad \text{ecf} \quad \text{[1]}$

\[\text{Total: 19}\]
2 (a)  \[ \text{Ca}^{2+}(g) + 2\text{Cl}^-(g) \rightarrow \text{CaCl}_2(s) \]  [1] [1]

(b)  \text{CaF}_2 \text{ and CaS} \text{ both} have larger lattice energies (than CaCl}_2)  [1]

(i)  \( \text{F}^- \) is smaller than \( \text{Cl}^- \)  [1]

(ii)  \( \text{S}^{2-} \) is more highly charged than \( \text{Cl}^- \)  [1]

(c)  \[ \text{LE} = -[178 + 590 + 1150] - [244 - 2 \times 349] - 796 \]

\[ \checkmark \text{ signs} \checkmark \]

\[ = -2260 \text{ (kJ mol}^{-1}\text{)} \]  [3]

(d) (i)  \text{Ca} = 28.2/40.1 = 0.703 \Rightarrow 1
\text{C} = 25.2/12 = 2.10 \Rightarrow 3
\text{H} = 1.4/1 = 1.4 \Rightarrow 2
\text{O} = 45.1/16 = 2.82 \Rightarrow 4

formula is \text{CaC}_3\text{H}_2\text{O}_4  (1)  [2]

(ii)  \text{malonic acid must be C}_2\text{H}_4\text{O}_4, \text{i.e. CH}_3(\text{CO}_2\text{H})_2 \text{ (must be structural)}  [1]

[Total: 10]

3 (a)  d-orbitals split into two / different levels

light is absorbed

electron is promoted from a lower to a higher level

colour observed is the complement of the colour absorbed

\[ \text{E} = \frac{\text{hf}}{	ext{any 3 points}} \]  [3]

(b) (i)  \[ \text{[Cu(H}_2\text{O)}_6]^{2+} \text{ is pale blue} \]
\[ \text{[Cu(NH}_3)_4(\text{H}_2\text{O})_2]^{2+} \text{ is deep / dark blue or purple} \]  [1]

(ii)  because it has a larger absorbance peak or a larger \( \varepsilon_o \) value

because \( \lambda_{\text{max}} \) is in the visible region (hence more visible light is absorbed)  [1]

(iii)  curve will have \( \lambda_{\text{max}} \) between >600 nm and 800 nm

with maximum \( \varepsilon_o \) in between the other two  [1]

[6]

(c) (i)  \[ \text{K}_c = \frac{[\text{CuCl}_4^{2-}][\text{Cl}^-]^4}{[\text{Cu}^{2+}][\text{Cl}^-]^4} \text{ units are mol}^{-4}\text{ dm}^{12} \]  [1]

(ii)  \[ \frac{[\text{CuCl}_4^{2-}]}{[\text{Cu}^{2+}]} = \text{K}_c[\text{Cl}^-]^4 = 672 \text{ (no units)} \]  [3]

[Total: 12]
4  (a) (cyclohexanol & phenol) hydrogen bonding to (solvent) water molecules due to OH group [1]

(b) phenoxide anion is more stable (than cyclohexoxide) / OH bond is weaker due to delocalisation of charge / lone pair over the ring [1]

(c) reagent | product with cyclohexanol | product with phenol
--- | --- | ---
Na(s) | RONa or RO\(^{-}\)Na\(^{+}\) | ArONa or ArO\(^{-}\)Na\(^{+}\)
NaOH(aq) | *no reaction* | ArONa or ArO\(^{-}\)Na\(^{+}\)
Br\(_2\)(aq) | *no reaction* | tribromophenol
I\(_2\)(aq) + OH\(^{-}\)(aq) | *no reaction* | *no reaction*

an excess of acidified Cr\(_2\)O\(_7\)\(^{2-}\) (aq) | cyclohexanone | *no reaction*

five correct products 5 × [1]
five correct “no reaction”s [2]
(4 correct = [1]; 3 correct = [0]) [7]

d) *either* Br\(_2\)(aq): no reaction with cyclohexanol; decolourises or white ppt with phenol

or Cr\(_2\)O\(_7\)\(^{2-}\) + H\(^{+}\): turns from orange to green with cyclohexanol; no reaction with phenol

correct reagent chosen and the correct “no reaction” specified [1]
correct positive observation [1]

[Total: 13]
(a) (i) I: KMnO₄
heat with H⁺ or OH⁻ [1]
II: SOCl₂ or PCl₅ or PCl₃ (NOT aq) [1]
(ii) -[-CO-C₆H₄-CO-NH-C₆H₄-NH-]- (Peptide bond must be displayed for minm) [1]

(b) (i) CH₃NHCO-C₆H₄-CONHCH₃ (1 mark for each end) [1] + [1]
(ii) HOCH₂CH₂O-CO-C₆H₄-CO-OCH₂CH₂OH
    or the polymer -[- OCH₂CH₂O-CO-C₆H₄-CO-]- for [1] [4 max 3]

(c) (i) Cl⁻ NH₃-C₆H₄-NH₃⁺ Cl⁻ (1 mark for each end) [1] + [1]
(ii) H₂N-C₆H₄Br₂-NH₂ or H₂N-C₆H₄Br₃-NH₂ or H₂N-C₆Br₄-NH₂ [1]

(d) I: HNO₂ (or NaNO₂ + HCl/H₂SO₄) at T < 10°C [1]
II: m-prop-2-yI phenol, (CH₃)₂CH-C₆H₄OH
    + NaOH(aq) [1] [1]

(e) (i) A species having positive and negative ionic centres / charges, with no overall charge [1]
(ii) -O₂C-C₆H₄-NH₃⁺ [1] [2]
6  (a)  All three amino acids correctly paired  (2)
   Two amino acids correctly paired  (1)
   One labelled H-bond between strands  (1)  [3]

(b)  (i)  tRNA – each amino acid has its own specific / appropriate tRNA  (1)
   – carry amino acids to ribosomes / mRNA  (1)
   – contains a triplet code / anticodon  (1)

(ii)  ribosome – attaches / moves along / binds to mRNA  (1)
   – assemble amino acids in correct sequence for / synthesises protein  (1)  [5]

(c)  (i)  Base miscopied / deleted  (1)

(ii)  Sequence of bases is changed  (1)
   This may result in different amino acid sequence – different protein  (1)
   Can affect shape / tertiary structure of protein  (1)  [Max 3]

[Total: 12 max 11]
7  (a) (i) Positions of atomic nuclei / atoms (1)

(ii) Insufficient electrons / electron density / electron cloud (around H atom) (1) [2]

(b) X-ray crystallography can show the geometry of the arrangement of atoms / bonding between atoms / shape of atoms (1)

This can help explain how e.g. enzymes work (any reasonable example) (1) [2]

(c) (i) Nuclear spin (1)

(ii) (If M : M+1 gives a ratio 15 : 2)

Then \[ x = \frac{100 \times 2}{1.1 \times 25} = 7 \] (1)

Single peak at 3.7 \( \delta \) due to \(-O-CH_3\) (1)

Single peak at 5.6 \( \delta \) due to phenol / OH (1)

1,2,1 peak at 6.8 \( \delta \) due to hydrogens on benzene ring (1)

Pattern suggests 1,4 substitution (1)

\( x = 7, \ y = 8, \ z = 2 \) (1)

Compound is 4-methoxylphenol (1)

Max 5 [6]

[Total: 10]
8  (a) Graphite / graphene

(b) They do not exist as sheets / layers of carbon atoms

(c) The lengths of nanotubes are much shorter than the curvature of the paper / they are so small that they are not effected by rolling

(d) Any molten ionic salt (or plausible organic ionic compounds)

[Total: 4]

9  (a)  (i) Covalent / co-ordinate

(ii) Mechlorethamine – binds the two chains together
     – prevents unravelling

Cis-platin – binds to two Gs / bases in one chain
     – so they are not available for base pairing

[Total: 5]