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

9701 CHEMISTRY

9701/41 Paper 4 (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.

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1 (a) P: burns with white / yellow flame or copious white smoke / fumes produced

\[ 4P \text{ (or } P_4) + 5O_2 \rightarrow P_4O_{10} \]  

S: burns with blue flame / choking / pungent gas produced

\[ S + O_2 \rightarrow SO_2 \]

(b) (i) \[ 2 \text{Ca}_3(\text{PO}_4)_2 + 6 \text{SiO}_2 + 10 \text{C} \rightarrow 1 P_4 + 6 \text{CaSiO}_3 + 10 \text{CO} \]

(ii)

<table>
<thead>
<tr>
<th>allotrope</th>
<th>type of structure</th>
<th>type of bonding</th>
</tr>
</thead>
<tbody>
<tr>
<td>white</td>
<td>simple / molecular</td>
<td>covalent</td>
</tr>
<tr>
<td>red</td>
<td>giant / polymeric</td>
<td>covalent</td>
</tr>
</tbody>
</table>

(iii) (in each case P has to be trivalent. Many alternatives allowable for the polymeric red P) (2)

[Total: 11]
2 (a) coloured ions / compounds
variable oxidation states
formation of complexes
catalytic activity

(b) (green is \[\text{Ni(H}_2\text{O)}_6\]^{2+}\n
ppt is Ni(OH)\_2

blue solution is \[\text{Ni(NH}_3\]_6^{2+} or \[\text{Ni(NH}_3\]_4^{2+} or \[\text{Ni(NH}_3\]_4(\text{H}_2\text{O})_2^{2+}\n
formed by ligand exchange

\[
\text{Ni}^{2+} + 2\text{OH}^- \rightarrow \text{Ni(OH)}_2
\]

\[
\text{Ni(OH)}_2 + 6\text{NH}_3 \rightarrow \text{[Ni(NH}_3\]_6^{2+} + 2\text{OH}^-
\]

(c) \( M_r = 58.7 + 48 + 6 + 28 + 32 = 172.7 \) (173)

\[
n(\text{Ni}) = \frac{4.00}{172.7} = 0.0232\ \text{mol}
\]

\[
\text{mass(Ni)} = 0.0232 \times 58.7 = 1.36g
\]

\[
\text{percentage} = 100 \times \frac{1.36}{3.4} = 40.0\%
\]

[Total: 10]

3 (a) PbO\_2 decomposed into PbO (and O\_2). (SnO\_2 is stable)

(b) (i) PbCl\_4 dissociates into Cl\_2 and PbCl\_2 (white solid)

\[
\text{or PbCl}_4 \rightarrow \text{PbCl}_2 + \text{Cl}_2 \text{ or in words}
\]

\[
\text{Cl}_2 + 2\text{KI} \rightarrow 2\text{KCl} + \text{I}_2
\]

\[
\text{E}^0(\text{Cl}_2/\text{Cl}^-) \text{ is more positive than } \text{E}^0(\text{I}_2/\text{I}^-)
\]

(ii) \text{SnCl}_4 is more stable than PbCl}_4 \text{ / answers using E}^0 \text{ accepted}

[5 max 4] [4]

(c) (i) \[\text{Cl}:\text{C}=\text{Cl} \text{ or CL=C-CL}\]

bent \text{ or non-linear \text{ or angle} = 100–140°}

(ii) \[\text{CC}_2 + \text{H}_2\text{O} \rightarrow \text{CO} + 2\text{HCl}\]

[Total: 8]
4 (a) hydrogen bonding

diag: \( \text{NH}_2\text{CH}_2\text{CH}_2\text{OH} \cdots \text{OH}\text{CH}_2\text{CH}_2\text{NH}_2 \) or \( \text{NH}_2\text{CH}_2\text{CH}_2\text{OH} \cdots \text{NH}\text{CH}_2\text{CH}_2\text{OH} \)
(i.e. H-bond from OH group to either OH or NH$_2$) (1) [2]

(b) propylamine is more basic than phenylamine
because lone pair on N is delocalised over ring in phenylamine (so less available for protonation)
or the propyl group is electron-donating, so the lone pair is more available (1) [2]

(c) \[
\text{HOCH}_2\text{CH}_2\text{NH}_2 + \text{H}^+ \rightarrow \text{HOCH}_2\text{CH}_2\text{NH}_3^+
\]

or
\[
\text{HOCH}_2\text{CH}_2\text{NH}_2 + \text{HCl} \rightarrow \text{HOCH}_2\text{CH}_2\text{NH}_3^+\text{Cl}^-
\]

or
\[
\text{HOCH}_2\text{CH}_2\text{NH}_2 + \text{H}_2\text{O} \rightarrow \text{HOCH}_2\text{CH}_2\text{NH}_3^+\text{OH}^-
\]

(reaction with any acceptable Bronsted acid accepted)  [1]

(d) (i) \( X \) is \( \text{CH}_3\text{CH}_2\text{CN} \) (1)

(ii) step 1 is \( \text{KCN} \) in ethanol, heat [HCN negates] (1)
step 2 is \( \text{H}_2 + \text{Ni} / \text{Pt} \) or \( \text{LiAlH}_4 \) or \( \text{Na} \) in ethanol [NOT \( \text{NaBH}_4 \) or \( \text{Sn}\text{HC}l \)] (1) [3]

(e) ethanolamine:

\[ \text{Na} \] effervescence / bubbles produced
\[ \text{Cr}_2\text{O}_7^{2-} / \text{H}^+ \] colour turns from orange to green
\[ \text{MnO}_4^- / \text{H}^+ \] purple colour disappears
\[ \text{PCl}_3 / \text{PCl}_5 / \text{SOCl}_2 \] (1) steamy fumes (1)

phenylamine:

\[ \text{Br}_2\text{(aq)} \] decolourises / white ppt formed
\[ \text{HNO}_2 / \text{H}^+ \text{ at } T<10^\circ\text{C}, \text{then phenol in NaOH} \] (1) coloured dye formed (1) [4]

[Total: 12]
5 (a) (i) \( E^0 = 0.40 - (-0.83) = 1.23 \text{V} \) (1)

(ii) \( 2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O} \) (1)

(iii) LH electrode will become more negative
    RH electrode will also become more negative / less positive (1)

(iv) no change ecf from (iii) (1)

(v) increased conductance or lower cell resistance or increased rate of reaction (1) [6]

(b) (i) \( E^0 = 1.47 - (-0.13) = 1.60 \text{V} \) (1)

(ii) \( \text{PbO}_2 + \text{Pb} + 4\text{H}^+ \rightarrow 2\text{Pb}^{2+} + 2\text{H}_2\text{O} \) (1)

(iii) \( \text{PbO}_2 + \text{Pb} + 4\text{H}^+ + 2\text{SO}_4^{2-} \rightarrow 2\text{PbSO}_4(\text{s}) + 2\text{H}_2\text{O} \) (1)

(iv) \( E^0 \text{cell will increase} \) as \([\text{Pb}^{2+}]\) decreases, \( E_{\text{electrode}}(\text{PbO}_2) \) will become more positive, but \( E_{\text{electrode}}(\text{Pb}) \) will become more negative (1) [5]

[Total: 11]

6 (a) (i) \( \text{SOCl}_2 \text{ or PCl}_5 \text{ or PCl}_3 \) (1)

(ii) \( \text{CH}_3\text{CO}_2\text{H} + \text{SOCl}_2 \rightarrow \text{CH}_3\text{COCl} + \text{SO}_2 + \text{HCl} \)
    or \( \text{CH}_3\text{CO}_2\text{H} + \text{PCl}_5 \rightarrow \text{CH}_3\text{COCl} + \text{POCl}_3 + \text{HCl} \)
    or \( 3\text{CH}_3\text{CO}_2\text{H} + \text{PCl}_3 \rightarrow 3\text{CH}_3\text{COCl} + \text{H}_3\text{PO}_3 \) (1) [2]

(b) (i) A is \( \text{C}_6\text{H}_5\text{CO}_2\text{C}_2\text{H}_5 \) (1)
    B is \( \text{C}_6\text{H}_5\text{CONH}_2 \) (1)

(ii) ester
    amide (1) (1)

(iii) nucleophilic substitution / condensation (1) [5]

(c) (i) C is \( \text{ClCOCOCl} \) (1)
    D is \( \text{ClCOCOCOCl} \) (1)

(ii) hydrogen bonding (1)

(iii) because it’s an amide or not an amine or its lone pair is delocalised (over C=O) or less available due to electronegative oxygen [NOT: E is neutral, but the diamine is basic] (1)

(iv) condensation (polymer) or polyester (1) [5]

[Total: 12]
7

(a) Hydrogen bonds (1) between the bases (1) [2]

(b) Thymine

(c) RNA is a single strand; DNA is double strand (1)
2 RNA contains ribose; DNA contains deoxyribose (1)
3 RNA contains uracil; DNA contains thymine (1)
4 RNA is shorter than DNA (1)

4 max 3) [3]

(d) mRNA – copies the DNA gene sequence
   or forms a template for a particular polypeptide / in protein synthesis (1)

tRNA – carries amino acids to the ribosome (1) [2]

[Total: 10]
9  (a) spinning proton produces two spin states / magnetic moments  
    these can align with or against an applied magnetic field  
    
(b) field experienced by protons is influenced by adjacent atoms / protons are in two  
    different chemical environments  
    peaks are in the area ratio 3 : 1 (methyl to –OH protons)  
    or are at 0.5 – 6.0δ and 3.3 – 4.0δ  
    
(c) (i)  
    ![Chemical Structures](CH3CH2CO2H) propanoic acid  
    ![Chemical Structures](CH3CO2CH3) methyl ethanoate  
    ![Chemical Structures](HCO2CH2CH3) ethyl methanoate  
    all for (2) two for (1)  
    
(ii) compound is CH3CO2CH3 or methyl ethanoate  
    the other two compounds each have 3 different proton environments, but the  
    spectrum shows only 2 peaks.  
    A is OCH3, B is CH3CO  
    (1)  
    
(iii) compound – propanoic acid or ethyl methanoate  
    the –OH proton or the H–CO proton  
    (1) [6]  
    
(d) (i) distance between atoms / bond lengths / bond angles  
    (1)  
    
(ii) hydrogen atoms  
    (1) [2]  
    [Total: 12 max 10]  
    
[Total: 10]
10  
(a) ester or amide (allow nitrile)  

(b)  

![Diagram showing amide (1) + any one ester (1) with whole groups circled.]

amide (1) + any one ester (1)  
allow whole groups circled  

(c)  
(i) hydrophilic drug at C  
hydrophobic drug at B  both needed  

(ii) (at A) the drug would be exposed to attack / breakdown / digestion  

(d)  
(i) at one of the –OH groups  

(ii) volume of sphere can be large or one PEG molecule can only carry 1 or 2 drug molecules  
or can carry different types of drug  

(e) more economic  
less chance of side-effects / side effects reduced / less chance of allergic reaction  
less risk of harming healthy tissue / organs / less chance of an overdose  

(3 max 2)  

[Total: 10]