UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

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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UNIVERSITY of CAMBRIDGE
International Examinations

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

$4P$ (or P_4) + $5O_2 \longrightarrow P_4O_{10}$ (1)

S: burns with blue flame / choking / pungent gas produced (1)

$S + O_2 \longrightarrow SO_2$ (1) [4]

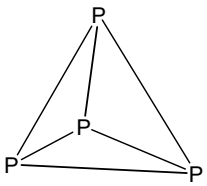
(b) (i) **2** $Ca_3(PO_4)_2$ + **6** SiO_2 + **10** C $\longrightarrow$ **1** P_4 + **6** $CaSiO_3$ + **10** CO (2)

(ii)

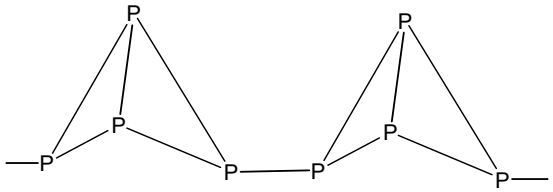
allotrope	type of structure	type of bonding
white	**simple / molecular**	**covalent**
red	**giant / polymeric**	**covalent**

(4)

(iii)



white P_4 (1)



red P_n (1)

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

(8 max 7) [7]

[Total: 11]

2 **(a)** coloured ions / compounds (1)
variable oxidation states (1)
formation of complexes (1)
catalytic activity (4 max 3) [3]

(b) (green is $[Ni(H_2O)_6]^{2+}$)
ppt is $Ni(OH)_2$ (1)

blue solution is $[Ni(NH_3)_6]^{2+}$ *or* $[Ni(NH_3)_4]^{2+}$ *or* $[Ni(NH_3)_4(H_2O)_2]^{2+}$ (1)

formed by ligand exchange (1)

$Ni^{2+} + 2OH^- \longrightarrow Ni(OH)_2$ (1)

$Ni(OH)_2 + 6NH_3 \longrightarrow [Ni(NH_3)_6]^{2+} + 2OH^-$ (1) [4]
(5 max 4)

(c) $M_r = 58.7 + 48 + 6 + 28 + 32 =$ **172.7** (173) (1)

n(Ni) = 4.00 / 172.7 = **0.0232** mol (1)

mass(Ni) = 0.0232 × 58.7 = 1.36g

percentage = 100 × 1.36 / 3.4 = **40.0**% (1) [3]

[Total: 10]

3 **(a)** PbO_2 decomposed into PbO (and O_2). (SnO_2 is stable) [1]

(b) **(i)** $PbCl_4$ dissociates into Cl_2 and $PbCl_2$ (white solid)
or $PbCl_4 \longrightarrow PbCl_2 + Cl_2$ or in words
(1) (1)
$Cl_2 + 2KI \longrightarrow 2KCl + I_2$ (1)

$E^o(Cl_2/Cl^-)$ is more positive than $E^o(I_2/I^-)$ (1)

(ii) $SnCl_4$ is more stable than $PbCl_4$ / answers using E^o accepted (1)
(5 max 4) [4]

(c) **(i)** $Cl{:}\overset{+}{C}{:}\overset{-}{C}l$ *or* $Cl{=}C{-}Cl$ (1)

bent *or* non-linear *or* angle = 100–140° (1)

(ii) $CCl_2 + H_2O \longrightarrow CO + 2HCl$ (1) [3]

[Total: 8]

4 **(a)** hydrogen bonding (1)

diag: $NH_2CH_2CH_2OH$---$OHCH_2CH_2NH_2$ *or* $NH_2CH_2CH_2OH$---$NH_2CH_2CH_2OH$
(i.e. H-bond from OH group to either OH or NH_2) (1) [2]

(b) propylamine is more basic than phenylamine (1)
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) $HOCH_2CH_2NH_2 + H^+ \longrightarrow HOCH_2CH_2NH_3^+$
or $HOCH_2CH_2NH_2 + HCl \longrightarrow HOCH_2CH_2NH_3^+Cl^-$
or $HOCH_2CH_2NH_2 + H_2O \longrightarrow HOCH_2CH_2NH_3^+OH^-$
(reaction with any acceptable Bronsted acid accepted) [1]

(d) **(i)** **X** is CH_3CH_2CN (1)

(ii) step 1 is KCN in ethanol, heat [HCN negates] (1)
step 2 is H_2+Ni / Pt or $LiAlH_4$ or Na in ethanol [NOT $NaBH_4$ or Sn/HCl] (1) [3]

(e) ethanolamine:

	Na		effervescence / bubbles produced
or	$Cr_2O_7^{2-}$ / H^+		colour turns from orange to green
or	MnO_4^- / H^+		purple colour disappears
or	PCl_3 / PCl_5 / $SOCl_2$	(1)	steamy fumes (1)

phenylamine:

	Br_2(aq)		decolourises / white ppt formed
or	HNO_2 / H^+ at T<10°C, then phenol in NaOH	(1)	coloured dye formed (1) [4]

[Total: 12]

5 **(a)** **(i)** $E^o = 0.40 - (-0.83) = 1.23V$ (1)

(ii) $2H_2 + O_2 \longrightarrow 2H_2O$ (1)

(iii) LH electrode will become more negative (1)
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)** $E^o = 1.47 - (-0.13) = 1.60V$ (1)
(ii) $PbO_2 + Pb + 4H^+ \longrightarrow 2Pb^{2+} + 2H_2O$ (1)

(iii) $PbO_2 + Pb + 4H^+ + 2SO_4^{2-} \longrightarrow 2PbSO_4(s) + 2H_2O$ (1)

(iv) E^o_{cell} will increase (1)

as $[Pb^{2+}]$ decreases, $E_{electrode}(PbO_2)$ will become more positive, but $E_{electrode}(Pb)$ will become more negative (1) [5]

[Total: 11]

6 **(a)** **(i)** $SOCl_2$ *or* PCl_5 *or* PCl_3 (1)

(ii) $CH_3CO_2H + SOCl_2 \longrightarrow CH_3COCl + SO_2 + HCl$
or $CH_3CO_2H + PCl_5 \longrightarrow CH_3COCl + POCl_3 + HCl$
or $3CH_3CO_2H + PCl_3 \longrightarrow 3CH_3COCl + H_3PO_3$ (1)
[2]

(b) **(i)** **A** is $C_6H_5CO_2C_2H_5$ (1)
B is $C_6H_5CONH_2$ (1)

(ii) ester (1)
amide (1)

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

(c) **(i)** **C** is $ClCOCOCl$ (1)
D is $ClCOCOCOCl$ (1)

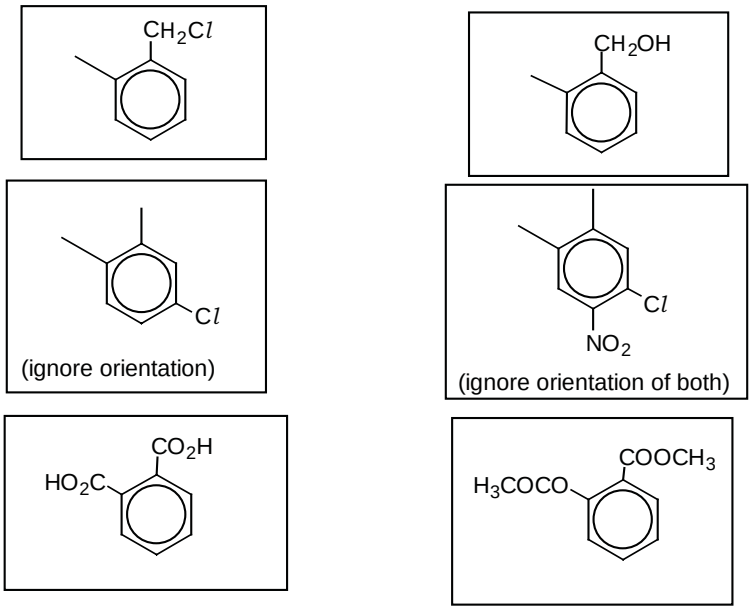
(ii) hydrogen bonding (1)

(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



[6]

[Total: 6]

8 (a)

Block letter	Identity of compound
J	Deoxyribose (NOT "sugar" or "pentose")
K	Guanine
L	Phosphate
M	Thymine

All 4 correct score 3 marks, 3 score 2, 2 score 1 [3]

(b) hydrogen bonds (1) between the bases (1) [2]

(c) 1 RNA is a single strand; DNA is double strand (1)
2 RNA contains ribose; DNA contains deoxyribose (1)
3 RNA contains <u>uracil</u>; DNA contains <u>thymine</u> (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 (1)
these can align with or against an applied magnetic field (1) [2]

(b) field experienced by protons is influenced by adjacent atoms / protons are in two different chemical environments (1)
peaks are in the area ratio 3 : 1 (methyl to –OH protons)
or are at 0.5 – 6.0δ and 3.3 – 4.0δ (1) [2]

(c) **(i)**

$CH_3CH_2CO_2H$	$CH_3CO_2CH_3$	$HCO_2CH_2CH_3$
propanoic acid	methyl ethanoate	ethyl methanoate

all for (2) two for (1)

(ii) compound is $CH_3CO_2CH_3$ *or* methyl ethanoate (1)
the other two compounds each have 3 different proton environments, but the spectrum shows only 2 peaks. (1)

A is OCH_3, B is CH_3CO (1)

(iii) compound – propanoic acid *or* ethyl methanoate
the –OH proton *or* the H–CO proton (1) [6]

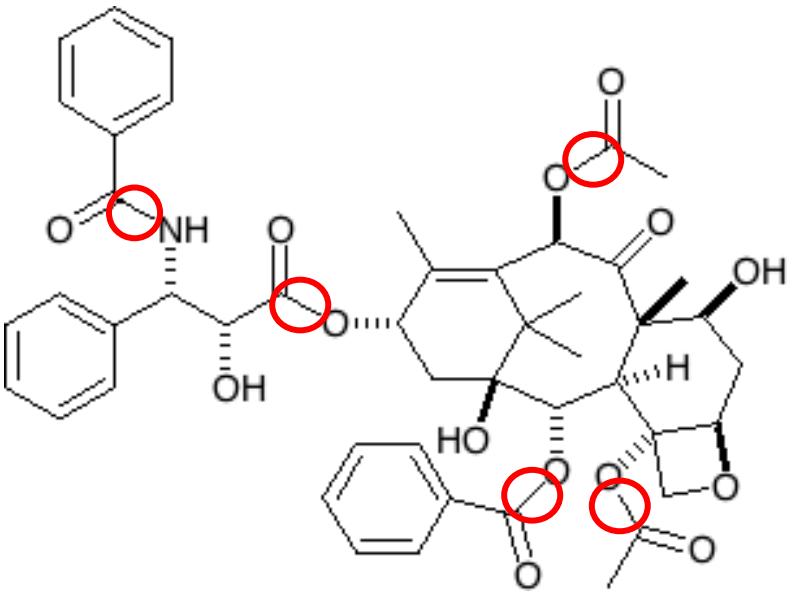
(d) **(i)** distance between atoms / bond lengths / bond angles (1)

(ii) hydrogen atoms (1) [2]
[Total: 12 max 10]

[Total: 10]

10 (a) ester or amide (allow nitrile) [1]

(b)



amide (1) + any one ester (1) [2]
allow whole groups circled

(c) (i) hydrophilic drug at **C** (1)
hydrophobic drug at **B** both needed (1)

(ii) (at **A**) the drug would be exposed to attack / breakdown / digestion (1) [3]

(d) (i) at one of the –OH groups (1)

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

(e) more economic (1)
less chance of side-effects / side effects reduced / less chance of allergic reaction (1)
less risk of harming healthy tissue / organs / less chance of an overdose (1)
(3 max 2) [2]

[Total: 10]