UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

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.

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1 **(a)** CO_2 is a gas (at room temperature); SiO_2 is a high melting solid [1]
CO_2: simple / discrete molecular / covalent [1]
SiO_2: giant covalent *or* macromolecular / giant molecular [1]
[3]

(b) (a substance that is..) hard, high melting, electrical insulator any two [1]
SiO_2 has **strong covalent** bonds (can be in **(a)**) [1]
[2]

(c) **(i)** amphoteric [1]

(ii) $2NaOH + PbO \longrightarrow Na_2PbO_2 + H_2O$ [1]
(*or* $NaOH + PbO + H_2O \longrightarrow NaPb(OH)_3$ etc.)
[2]

(d) **(i)** $Zn + Sn^{4+} \longrightarrow Zn^{2+} + Sn^{2+}$ [1]

(ii) $E^\theta = 0.15 - (-0.76) = \mathbf{0.91}$ V [1]
$E^\theta = 1.52 - 0.15 = \mathbf{1.37}$ V [1]

(iii) $n(Sn^{2+}) = 0.02 \times 13.5/1000 \times 5/2 = \mathbf{6.75 \times 10^{-4}}$ mol use of the 5/2 ratio [1]
correct rest of working [1]
$n(Sn^{2+}) = 0.02 \times 20.3/1000 \times 5/2 = \mathbf{1.02 \times 10^{-3}}$ mol [1]

(iv) $n(Sn^{4+}) = 1.02 \times 10^{-3} - 6.75 \times 10^{-4} = 3.45 \times 10^{-4}$ mol [1]
$\therefore$ ratio $= 6.75/3.45 = 1.96:1 \approx \mathbf{2:1}$
$\therefore$ formula is $2SnO + SnO_2 \Rightarrow \mathbf{Sn_3O_4}$ *(cond^l on calculation, but allow ecf)* [1]
[8]

(e) **(i)** volume $= 1 \times 1 \times 1 \times 10^{-5} = 1 \times 10^{-5}$ m^3 *or* **10** cm^3 [1]

(ii) mass = vol × density $= 10 \times 7.3 = \mathbf{73}$ g ecf [1]
moles = mass/A_r $= 73/119 = \mathbf{0.61}$ mol ecf [1]

(iii) $Q = nFz = 0.61 \times 9.65 \times 10^4 \times 2 = \mathbf{1.18\ (1.2) \times 10^5}$ coulombs ecf [1]
[4]

[Total: 19]

2 **(a)** $Ca^{2+}(g) + 2Cl^{-}(g) \longrightarrow CaCl_2(s)$ [1]
[1]

(b) CaF_2 **and** CaS **both** have larger lattice energies (than $CaCl_2$) [1]

(i) F^- is smaller than Cl^- [1]

(ii) S^{2-} is more highly charged than Cl^- [1]
[3]

(c) LE = –[178 + 590 + 1150] – [244 – 2 × 349] – 796
✓ ✓ signs✓
= **–2260** (kJ mol^{-1}) [3]
[3]

(d) **(i)**

Ca	= 28.2/40.1	= 0.703	⇒	1	
C	= 25.2/12	= 2.10	⇒	3	
H	= 1.4/1	= 1.4	⇒	2	(1 mark for initial step of calc'n)
O	= 45.1/16	= 2.82	⇒	4	

formula is $CaC_3H_2O_4$ (1) [2]

(ii) malonic acid must be $C_2H_4O_4$, i.e. **$CH_3(CO_2H)_2$** (must be structural) [1]
[3]

[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
E = hf any 3 points [3]
[3]

(b) **(i)** $[Cu(H_2O)_6]^{2+}$ is pale blue [1]
$[Cu(NH_3)_4(H_2O)_2]^{2+}$ is deep / dark blue *or* purple [1]

(ii) because it has a larger absorbance peak *or* a larger ε_o value [1]
because λ_{max} is in the visible region (hence more visible light is absorbed) [1]

(iii) curve will have λ_{max} between >600 nm and 800 nm [1]
with maximum ε_o in between the other two [1]
[6]

(c) **(i)** $K_c = [CuCl_4^{2-}]/([Cu^{2+}][Cl^-]^4)$ units are $mol^{-4}\ dm^{12}$ [1] + [1]

(ii) $[CuCl_4^{2-}]/[Cu^{2+}] = K_c[Cl^-]^4 = 672$ (no units) [1]
[3]

[Total: 12]

4 **(a)** (cyclohexanol & phenol) hydrogen bonding to (solvent) water molecules [1]
due to OH group [1]
[2]

(b) phenoxide anion is more stable (than cyclohexoxide) / OH bond is weaker [1]
due to delocalisation of charge / lone pair over the ring [1]
[2]

(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 $Cr_2O_7^{2-}$(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 $Cr_2O_7^{2-}$ + 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]
[2]

[Total: 13]

5 (a) (i) I: $KMnO_4$ [1]
heat with H^+ *or* OH^- [1]
II: $SOCl_2$ *or* PCl_5 *or* PCl_3 (NOT aq) [1]

(ii) -[-CO-C_6H_4-CO-NH-C_6H_4-NH-]- (Peptide bond must be displayed for minm) [1]
[4]

(b) (i) CH_3NHCO-C_6H_4-$CONHCH_3$ (1 mark for each end) [1] + [1]

(ii) $HOCH_2CH_2O$-CO-C_6H_4-CO-OCH_2CH_2OH for [1]
or the polymer -[- OCH_2CH_2O-CO-C_6H_4-CO-]- for [2]
[4 max 3]

(c) (i) Cl^- $^+NH_3$-C_6H_4-NH_3^+ Cl^- (1 mark for each end) [1] + [1]

(ii) H_2N-$C_6H_2Br_2$-NH_2 *or* H_2N-$C_6H_2Br_3$-NH_2 *or* H_2N-C_6Br_4-NH_2 [1]
[3]

(d) I: HNO_2 (*or* $NaNO_2$ + HCl/H_2SO_4) [1]
at T < 10°C [1]

II: *m*-prop-2-yl phenol, $(CH_3)_2CH$-C_6H_4OH [1]
+ NaOH(aq) [1]
[4]

(e) (i) A species having positive and negative ionic centres / charges, with no overall charge [1]

(ii) -O_2C-C_6H_4-NH_3^+ [1]
[2]

[Total: 16]

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 δ due to –O-CH_3 (1)

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

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

Pattern suggests 1,4 subsitution (1)

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

Compound is 4-methoxylphenol (1)

Max 5 [6]

[Total: 10]

8 **(a)** Graphite / graphene (1)

(b) They do not exist as sheets / layers of carbon atoms (1)

(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 (1)

(d) Any molten ionic salt (or plausible organic ionic compounds) (1)

[Total: 4]

9 **(a)** **(i)** Covalent / co-ordinate (1)

(ii) Mechlorethamine – binds the two chains together (1)
– prevents unravelling (1)

Cis-platin – binds to two Gs / bases in one chain (1)
– so they are not available for base pairing (1)

[Total: 5]