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

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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) $E^\theta = 0.15 - (-0.76) =$ **0.91** V [1]
$E^\theta = 1.52 - 0.15 =$ **1.37** V [1]

(iii) $n(Sn^{2+}) = 0.02 \times 13.5/1000 \times 5/2 =$ **6.75×10^{-4}** mol use of the 5/2 ratio [1]
correct rest of working [1]
$n(Sn^{2+}) = 0.02 \times 20.3/1000 \times 5/2 =$ **1.02×10^{-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 $= 6.75/3.45 = 1.96:1 \approx$ **2:1**
$\therefore$ formula is $2SnO + SnO_2 \Rightarrow$ **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 $= 10 \times 7.3 =$ **73** g ecf [1]
moles = mass/A_r $= 73/119 =$ **0.61** mol ecf [1]

(iii) $Q = nFz = 0.61 \times 9.65 \times 10^4 \times 2 =$ **1.18 (1.2) × 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 = $-[178 + 590 + 1150] - [244 - 2 \times 349] - 796$
✓ ✓ 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]