

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**

**9701/41**

**9701 CHEMISTRY**

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

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- 1 (a) CO<sub>2</sub> is a gas (at room temperature); SiO<sub>2</sub> is a high melting solid [1]  
CO<sub>2</sub>: simple / discrete molecular / covalent [1]  
SiO<sub>2</sub>: giant covalent or macromolecular / giant molecular [1]  
**[3]**
- (b) (a substance that is...) hard, high melting, electrical insulator any two [1]  
SiO<sub>2</sub> has **strong covalent** bonds (can be in (a)) [1]  
**[2]**
- (c) (i) amphoteric [1]  
(ii) 2NaOH + PbO → Na<sub>2</sub>PbO<sub>2</sub> + H<sub>2</sub>O [1]  
(or NaOH + PbO + H<sub>2</sub>O → NaPb(OH)<sub>3</sub> etc.) [1]  
**[2]**
- (d) (i) Zn + Sn<sup>4+</sup> → Zn<sup>2+</sup> + Sn<sup>2+</sup> [1]  
(ii) E<sup>θ</sup> = 0.15 – (–0.76) = **0.91 V** [1]  
E<sup>θ</sup> = 1.52 – 0.15 = **1.37 V** [1]  
(iii) n(Sn<sup>2+</sup>) = 0.02 × 13.5/1000 × 5/2 = **6.75 × 10<sup>–4</sup> mol** use of the 5/2 ratio [1]  
correct rest of working [1]  
n(Sn<sup>2+</sup>) = 0.02 × 20.3/1000 × 5/2 = **1.02 × 10<sup>–3</sup> mol** [1]  
(iv) n(Sn<sup>4+</sup>) = 1.02 × 10<sup>–3</sup> – 6.75 × 10<sup>–4</sup> = 3.45 × 10<sup>–4</sup> mol [1]  
∴ ratio = 6.75/3.45 = 1.96:1 ≈ **2:1**  
∴ formula is 2SnO + SnO<sub>2</sub> ⇒ **Sn<sub>3</sub>O<sub>4</sub>** (cond<sup>l</sup> on calculation, but allow ecf) [1]  
**[8]**
- (e) (i) volume = 1 × 1 × 1 × 10<sup>–5</sup> = 1 × 10<sup>–5</sup> m<sup>3</sup> or **10 cm<sup>3</sup>** [1]  
(ii) mass = vol × density = 10 × 7.3 = **73 g** ecf [1]  
moles = mass/A<sub>r</sub> = 73/119 = **0.61 mol** ecf [1]  
(iii) Q = nFz = 0.61 × 9.65 × 10<sup>4</sup> × 2 = **1.18 (1.2) × 10<sup>5</sup> coulombs** ecf [1]  
**[4]**

**[Total: 19]**

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

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

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

(c)  $\text{LE} = -[178 + 590 + 1150] - [244 - 2 \times 349] - 796$  signs✓  
 $\quad \quad \quad \checkmark \quad \quad \quad \checkmark$   
 $\quad \quad \quad = -2260 \text{ (kJ mol}^{-1}\text{)}$  [3]  
[3]

(d) (i)  $\text{Ca} = 28.2/40.1 = 0.703 \Rightarrow 1$   
 $\text{C} = 25.2/12 = 2.10 \Rightarrow 3$   
 $\text{H} = 1.4/1 = 1.4 \Rightarrow 2$   
 $\text{O} = 45.1/16 = 2.82 \Rightarrow 4$  (1 mark for initial step of calc'n)

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

(ii) malonic acid must be  $\text{C}_2\text{H}_4\text{O}_4$ , i.e.  $\text{CH}_3(\text{CO}_2\text{H})_2$  (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)  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$  is pale blue [1]  
 $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$  is deep / dark blue or purple [1]

(ii) because it has a larger absorbance peak or a larger  $\epsilon_0$  value [1]  
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 [1]  
with maximum  $\epsilon_0$  in between the other two [1]  
[6]

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

(ii)  $[\text{CuCl}_4^{2-}]/[\text{Cu}^{2+}] = K_c[\text{Cl}^{-}]^4 = 672$  (no units) [1]  
[3]

[Total: 12]

|               |   |                 |              |
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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 <sup>-</sup> Na <sup>+</sup> | ArONa or ArO <sup>-</sup> Na <sup>+</sup> |
| NaOH(aq)   | <b>no reaction</b>                      | ArONa or ArO <sup>-</sup> Na <sup>+</sup> |
| Br <sub>2</sub> (aq)   | <b>no reaction</b>                      | tribromophenol                            |
| I <sub>2</sub> (aq) + OH <sup>-</sup> (aq)                               | <b>no reaction</b>                      | <b>no reaction</b>                        |
| an excess of acidified Cr <sub>2</sub> O <sub>7</sub> <sup>2-</sup> (aq) | cyclohexanone                           | <b>no reaction</b>                        |

five correct products 5 × [1]

five correct "no reaction"s [2]

(4 correct = [1]; 3 correct = [0])

[7]

(d) *either* Br<sub>2</sub>(aq): no reaction with cyclohexanol; decolourises *or* white ppt with phenol

*or* Cr<sub>2</sub>O<sub>7</sub><sup>2-</sup> + H<sup>+</sup>: 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]

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- 5 (a) (i) I:  $\text{KMnO}_4$  [1]  
 heat with  $\text{H}^+$  or  $\text{OH}^-$  [1]  
 II:  $\text{SOCl}_2$  or  $\text{PCl}_5$  or  $\text{PCl}_3$  (NOT aq) [1]
- (ii)  $-\text{CO-C}_6\text{H}_4\text{-CO-NH-C}_6\text{H}_4\text{-NH-}$  (Peptide bond must be displayed for minm) [1]  
**[4]**
- (b) (i)  $\text{CH}_3\text{NHCO-C}_6\text{H}_4\text{-CONHCH}_3$  (1 mark for each end) [1] + [1]
- (ii)  $\text{HOCH}_2\text{CH}_2\text{O-CO-C}_6\text{H}_4\text{-CO-OCH}_2\text{CH}_2\text{OH}$  for [1]  
 or the polymer  $-\text{OCH}_2\text{CH}_2\text{O-CO-C}_6\text{H}_4\text{-CO-}$  for [2]  
**[4 max 3]**
- (c) (i)  $\text{Cl}^- \text{NH}_3\text{-C}_6\text{H}_4\text{-NH}_3^+ \text{Cl}^-$  (1 mark for each end) [1] + [1]
- (ii)  $\text{H}_2\text{N-C}_6\text{H}_2\text{Br}_2\text{-NH}_2$  or  $\text{H}_2\text{N-C}_6\text{H}_2\text{Br}_3\text{-NH}_2$  or  $\text{H}_2\text{N-C}_6\text{H}_4\text{-NH}_2$  [1]  
**[3]**
- (d) I:  $\text{HNO}_2$  (or  $\text{NaNO}_2 + \text{HCl}/\text{H}_2\text{SO}_4$ ) [1]  
 at  $T < 10^\circ\text{C}$  [1]
- II: *m*-prop-2-yl phenol,  $(\text{CH}_3)_2\text{CH-C}_6\text{H}_4\text{OH}$  [1]  
 +  $\text{NaOH(aq)}$  [1]  
**[4]**
- (e) (i) A species having positive and negative ionic centres / charges, with no overall charge [1]
- (ii)  $-\text{O}_2\text{C-C}_6\text{H}_4\text{-NH}_3^+$  [1]  
**[2]**

**[Total: 16]**

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- 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]**

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- 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  $-\text{O}-\text{CH}_3$  (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-methoxyphenol (1)
- Max 5 [6]

**[Total: 10]**

|               |   |                 |              |
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- 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]**