

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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Page 2	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE A/AS LEVEL – October/November 2009	9701	41

- 1 (a) CO₂ is a gas (at room temperature); SiO₂ is a high melting solid [1]
 CO₂: simple / discrete molecular / covalent [1]
 SiO₂: giant covalent or macromolecular / giant molecular [1]
[3]
- (b) (a substance that is...) hard, high melting, electrical insulator any two [1]
 SiO₂ has **strong covalent** bonds (can be in (a)) [1]
[2]
- (c) (i) amphoteric [1]
- (ii) 2NaOH + PbO → Na₂PbO₂ + H₂O [1]
 (or NaOH + PbO + H₂O → NaPb(OH)₃ etc.) [1]
[2]
- (d) (i) Zn + Sn⁴⁺ → Zn²⁺ + Sn²⁺ [1]
- (ii) E^θ = 0.15 – (–0.76) = **0.91 V** [1]
 E^θ = 1.52 – 0.15 = **1.37 V** [1]
- (iii) n(Sn²⁺) = 0.02 × 13.5/1000 × 5/2 = **6.75 × 10⁻⁴ mol** use of the 5/2 ratio [1]
 n(Sn²⁺) = 0.02 × 20.3/1000 × 5/2 = **1.02 × 10⁻³ mol** correct rest of working [1]
[1]
- (iv) n(Sn⁴⁺) = 1.02 × 10⁻³ – 6.75 × 10⁻⁴ = 3.45 × 10⁻⁴ mol [1]
 ∴ ratio = 6.75/3.45 = 1.96:1 ≈ **2:1**
 ∴ formula is 2SnO + SnO₂ ⇒ **Sn₃O₄** (cond^l on calculation, but allow ecf) [1]
[8]
- (e) (i) volume = 1 × 1 × 1 × 10⁻⁵ = 1 × 10⁻⁵ m³ or **10 cm³** [1]
- (ii) mass = vol × density = 10 × 7.3 = **73 g** ecf [1]
 moles = mass/A_r = 73/119 = **0.61 mol** ecf [1]
- (iii) Q = nFz = 0.61 × 9.65 × 10⁴ × 2 = **1.18 (1.2) × 10⁵ coulombs** ecf [1]
[4]

[Total: 19]

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	GCE A/AS LEVEL – October/November 2009	9701	41

- 2 (a) $\text{Ca}^{2+}(\text{g}) + 2\text{Cl}^{-}(\text{g}) \longrightarrow \text{CaCl}_2(\text{s})$ [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) $\text{LE} = -[178 + 590 + 1150] - [244 - 2 \times 349] - 796$ 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) (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 ϵ_0 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_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]

Page 4	Mark Scheme: Teachers' version	Syllabus	Paper
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- 4 (a) (cyclohexanol & phenol) hydrogen bonding to (solvent) water molecules due to OH group [1]
[1]
[2]

- (b) phenoxide anion is more stable (than cyclohexoxide) / OH bond is weaker due to delocalisation of charge / lone pair over the ring [1]
[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 ₂ O 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* Br₂(aq): no reaction with cyclohexanol; decolourises *or* white ppt with phenol

or Cr₂O₇²⁻ + 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]

Page 5	Mark Scheme: Teachers' version	Syllabus	Paper
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- 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) $-\text{CO-C}_6\text{H}_4\text{-CO-NH-C}_6\text{H}_4\text{-NH-}$ (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) $\text{Cl}^- \text{ } ^+\text{NH}_3\text{-C}_6\text{H}_4\text{-NH}_3^+ \text{ Cl}^-$ (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: 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]
 + 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]

Page 6	Mark Scheme: Teachers' version	Syllabus	Paper
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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]

Page 7	Mark Scheme: Teachers' version	Syllabus	Paper
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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 δ due to $-\text{O}-\text{CH}_3$ (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 substitution (1)
- ($x = 7,$) $y = 8,$ $z = 2$ (1)
- Compound is 4-methoxyphenol (1)
- Max 5 [6]

[Total: 10]

Page 8	Mark Scheme: Teachers' version	Syllabus	Paper
	GCE A/AS LEVEL – October/November 2009	9701	41

- 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]**