

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

9701/42

Paper 4 (A2 Structured Questions), maximum raw mark 100

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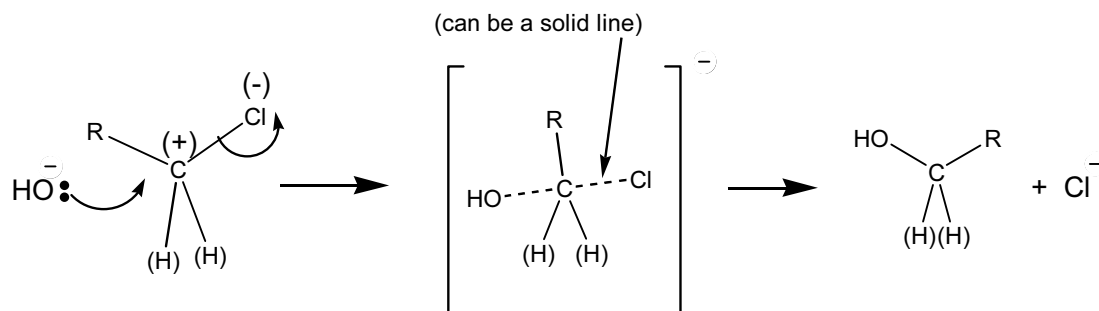
1 (a) $C_6H_5-COCH_2OH$ or $C_8H_8O_2$ and $NaCl$ or Cl (1) + (1) [2]

(b) (i) the exponent / power to which a concentration is raised in the **rate equation** (or in an equation, e.g. "a" in the equ: rate = $k[A]^a$) (1)

(ii) from 1 and 2: rate increases by 50% as does $[RCI]$, so rate $\propto [RCI]^1$ (1)
 from 1 and 3: rate $\propto [NaOH]^1$ (1)

(iii) (rate =) $k[RCI][OH^-]$ (1)

(iv)



marking points:

- (+) or δ^+ on C **and** (-) or δ^- on Cl (1)
- lone pair **and** charge on: OH (1)
- curly arrow from OH (lone pair) to $(\delta^+)C$, **and either** a curly arrow breaking C-Cl bond **or** 5-valent transition state (ignore charge) (1)
- S_N1 alternative for last mark (only award mark if candidate's rate equation shows first order reaction): curly arrow breaking C-Cl bond **and** carbocation intermediate. (1)

[7]

(c) (i) (add RCI / $RCOCl$ to) (aq) Ag^+ / $AgNO_3$ *or* named indicator (e.g. MeOr) *or* use pH probe (1)

White ppt appears (faster with $RCOCl$) *or* turns acidic colour (e.g. red) *or* shows pH decrease (1)

if water is the only reagent, and no pH meter used: award only the second mark, for "steamy / white fumes"

(ii) ($C=O$ is polarised /) carbon is more δ^+ than in $R-Cl$ *or* carbon is positive *or* $RCOCl$ can react via addition-elimination (mention of electronegativity on its own is not enough for the mark) (1) [3]

[Total: 12]

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- 2 (a) less soluble down group (1)
- lattice energy and hydration energies both decrease (i.e. become less negative) (1)
- but H.E. decreases more (than L.E.) *or* change in H.E. outweighs L.E. (1)
- so ΔH_{sol} becomes more endothermic / less exothermic (1) [4]
- (b) (i) for Mg: $\Delta H = 2993 - 1890 - (2 \times 550) = \mathbf{+3}$ (kJ mol⁻¹) (1)
- for Sr: $\Delta H = 2467 - 1414 - (2 \times 550) = \mathbf{-47}$ (kJ mol⁻¹) (1)
- (ii) Sr(OH)₂ should be **more** soluble in water, **and** ΔH is more exothermic / negative (1)
- Assuming "other factors" (e.g. ΔS , *or* temperature etc.) are the same (1)
- (iii) Sr(OH)₂ should be **less** soluble in hot water, **because** ΔH is negative / exothermic (1) [5]
- (c) (i) $K_{\text{sp}} = [\text{Ca}^{2+}][\text{OH}^-]^2$ (needs the charges) units: mol³dm⁻⁹ (1) + (1)
- (ii) $n(\text{H}^+) = n(\text{OH}^-) = 0.05 \times 21/1000 = 1.05 \times 10^{-3}$ mol in 25 cm³
- $[\text{OH}^-] = 1.05 \times 1000/25 = \mathbf{4.2 \times 10^{-2}}$ (mol dm⁻³) (1)
- $[\text{Ca}^{2+}] = \mathbf{2.1 \times 10^{-2}}$ (mol dm⁻³) (1)
- $K_{\text{sp}} = 2.1 \times 10^{-2} \times (4.2 \times 10^{-2})^2 = \mathbf{3.7 \times 10^{-5}}$ (1)
- (iii) **less** soluble in NaOH due to the common ion effect *or* equilibrium is shifted to the l.h.s. by high $[\text{OH}^-]$ (NOT just a mention of Le Chat^r on its own) (1) [6]

[Total: 15]

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- 3 (a) SiF_4 is symmetrical or tetrahedral or bonds are at 109° or has no lone pair or 4 electron pairs shared equally or all Si-F dipoles cancel out, or SF_4 has a lone pair (on S). (1) [1]

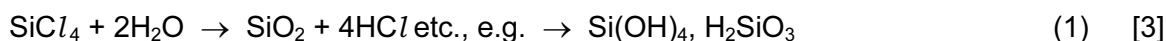
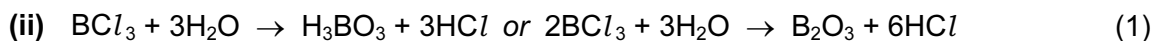
(b)

compound	molecule has an overall dipole	molecule does not have an overall dipole
BCl_3		✓
PCl_3	✓	
CCl_4		✓
SF_6		✓

mark row-by-row,

(2) [2]

- (c) (i) Si and B have empty / available / low-lying orbitals or C does not have available orbitals (allow "B is electron deficient" but not mention or implication of d-orbital on B) (1)



- (d) (i) $\text{Si}_3\text{Cl}_8\text{O}_2$ (this has $M_r = 84 + 280 + 32 = 396$) or $\text{Si}_4\text{Cl}_4\text{O}_9$ or $\text{Si}_8\text{Cl}_4\text{O}_2$ (1)

(ii)

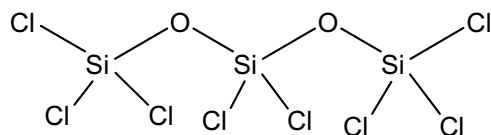
mass number	structure
133	Cl_3Si
247	$\text{Cl}_3\text{Si-O-SiCl}_2$
263	$\text{Cl}_3\text{Si-O-SiCl}_2\text{-O}$

(3)

(if correct structures are **not** given for last 2 rows, you can award (1) mark for **two** correct molecular formulae:



(iii)



allow ecf on the structure drawn in the third row of the table in (ii)

but any credited structure must show correct valencies for Si, Cl and O. (1) [5]

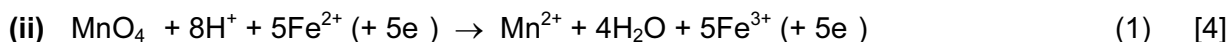
[Total: 11]

Page 5	Mark Scheme: Teachers' version	Syllabus	Paper
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- 4 (a) Cr^{3+} : $1s^2 2s^2 2p^6 \dots 3s^2 3p^6 3d^3$ (1)
 Mn^{2+} : $1s^2 2s^2 2p^6 \dots 3s^2 3p^6 3d^5$ (1)
 (allow (1) out of (2) for $3s^2 3p^6 4s^2 3d^1$ and $3s^2 3p^6 4s^2 3d^3$) [2]

(b) (i) any three of the following points:

- initial (pale) green (solution)
- fades to (almost) colourless (allow yellow)
- then (permanent faint) pink
- finally (deep) purple (3)

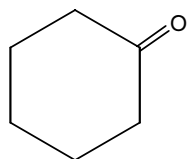


- (c) E° values: $\text{O}_2 + 4\text{H}^+ / 2\text{H}_2\text{O} = +1.23\text{V}$ $\text{Fe}^{3+} / \text{Fe}^{2+} = +0.77\text{V}$
 $\text{O}_2 + 2\text{H}_2\text{O} / 4\text{OH}^- = +0.40\text{V}$ $\text{Fe}(\text{OH})_3 / \text{Fe}(\text{OH})_2 = -0.56\text{V}$ (2)

$E^\circ_{\text{cell}} = +0.46\text{V}$ (allow -0.37) in acid, but $+0.96\text{V}$ in alkali or $E^\circ(\text{OH}^-) > E^\circ(\text{H}^+)$ (1)

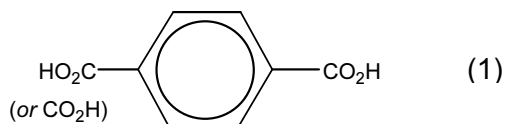
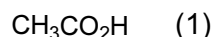
If E_{cell} is more positive it means a greater likelihood of reaction (1) [4]

(d)

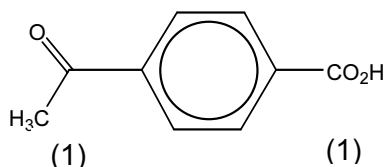


(1)

and

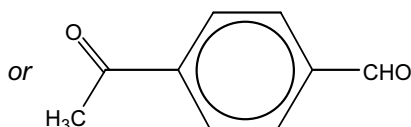


(1)



(1)

(1)



[5]

- (e) (i) $(\text{CH}_3)_2\text{C}(\text{OH})-\text{CH}_2\text{OH}$ (1)

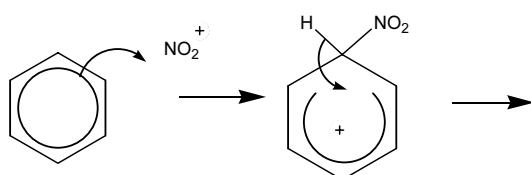
(ii) reaction I: (cold dilute) KMnO_4 ("cold" not needed, but "hot" or "warm" negates) (1)

reaction II: $\text{Cr}_2\text{O}_7^{2-} + \text{H}^+ + \text{distil}$ (1) [3]

[Total: 18 max 17]

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- 5 (a) (i) because the carbons are sp^2 / trigonal planar / bonded at 120° or are joined by π bonds / orbitals (1)
- (ii) because the π electrons / double bonds are delocalised / in resonance or electrons are evenly distributed / spread out (1) [2]
- (b) (i) $\text{HNO}_3 + 2\text{H}_2\text{SO}_4 \rightarrow \text{NO}_2^+ + \text{H}_3\text{O}^+ + 2\text{HSO}_4$ (1)
or $\text{HNO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{H}_2\text{NO}_3^+ + \text{HSO}_4$ or $\rightarrow \text{H}_2\text{O} + \text{NO}_2^+ + \text{HSO}_4$
- (ii) electrophilic substitution mechanism: (1)



curly arrows from benzene to NO_2^+ , and showing loss of H^+ (1)
correct intermediate (with "+" in the 'horse-shoe') (1) [4]

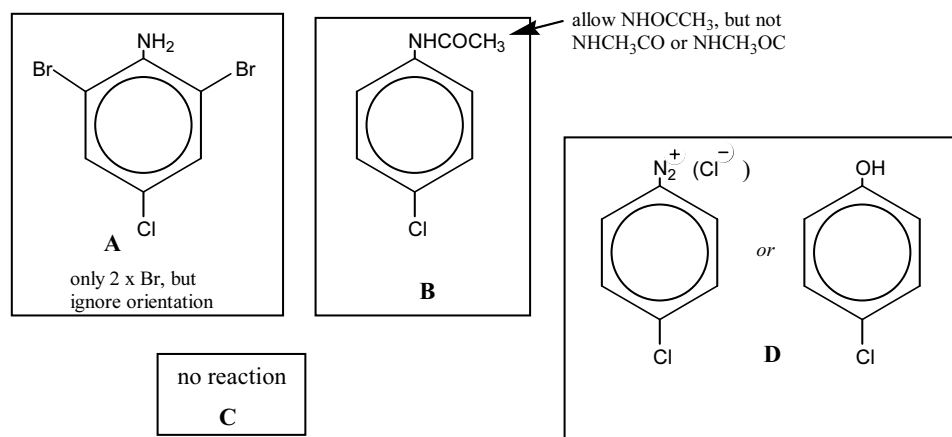
- (c) $\text{Cl}_2 + \text{AlCl}_3 / \text{FeCl}_3 / \text{Fe} / \text{Al} / \text{I}_2$ (aq or light negates this mark) (1) [1]

- (d) (i) Y is chlorobenzene (1) Z is 4-chloronitrobenzene (1) (2)

- (ii) Sn / Fe + (conc) HCl (1)

HCl is conc, and second step is to add NaOH(aq) (1)

- (iii)



(4) [8]

[Total: 15]

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- 6 (a) (i) Primary – the **amino acid** sequence / order / chain
or diag. e.g. NH-C-CO-NH-C-CO
or amino acids bonded by covalent / amide / peptide bonds (1)
- (ii) Tertiary – the coiling / folding of the protein / polypeptide chain due to interactions between side-chains on the amino acids or the structure which gives the protein its 3-D / globular shape (1) [2]
- (b) (i) Diagram:
Minimum is CH₂S-SCH₂ (1)
- (ii) Oxidation / dehydrogenation / redox (1)
- (iii) Hydrogen / H bonds; ionic interactions / bonds or ion-dipole or salt bridges; van der Waals' or id-id or induced / instantaneous dipole forces (ignore hydrophobic interactions) (2) [4]
- (c) (i) Hydrogen bonds (1)
- (ii) Correct new strand present (see below) needed
Diagram showing C=O bonding to N-H in new strand... ✓
...and N-H bonding to C=O in new strand ✓
e.g.
-
- New strand must contain a minimum of two amino acid residues in a single chain. Deduct a penalty of –(1) for any wrong H-bond **only** if (2) marks have already been scored. (2) [3]
- (d) There are bonds or S-S bridges / linkages **between the layers / sheets** (in β-keratin) (but only van der Waals interactions between the layers in silk) (1) [1]

[Total: 10]

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- 7 (a) The amino acid is uncharged / neutral / a zwitterion *or* charges balance / are equal (NOT "is non-polar")

It is equally attracted by the anode / + and the cathode / – *or* attracted by neither

The pH of the buffer is at the isoelectric point/IEP of the amino acid *any two* ✓✓ (2) [2]

- (b) (at pH 10), $\text{H}_2\text{NCH}_2\text{CO}_2^-$ *or* $\text{NH}_2\text{CH}_2\text{COO}^-$ (1) [1]

(c)

amino acid	relative size	charge
A	small(est) (1)	–ve
B	large(st) (3)	–ve
C	middle (2)	+ve

(numbers are OK to show relative sizes)

Mark each row (3) [3]

- (d) (i) lys – val – ser – ala – gly – ala – gly – asp (2)

(ii) gly – ala – gly (1)

(iii) aspartic acid (*or* lysine) (1) [4]

[Total: 10]

Page 9	Mark Scheme: Teachers' version	Syllabus	Paper
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- 8 (a) Reaction II – since electrons are used up / required / gained / received (from external circuit) (1) [1]
- (b) $(\text{Pb}^{2+} + 2\text{e}^- \rightarrow \text{Pb})$ $E^\ominus = -0.13\text{V}$
 $(\text{PbO}_2 + 4\text{H}^+ + 2\text{e}^- \rightarrow \text{Pb}^{2+} + 2\text{H}_2\text{O})$ $E^\ominus = +1.47\text{V}$
two correct E^\ominus values (1)
- Cell voltage is **1.6(0)** (V) (1) [2]
- (c) (i) 3(+) (1)
- (ii) They are less heavy / poisonous / toxic / polluting *or* are safer due to no (conc) H_2SO_4 within them (1) [2]
- (d) (i) Platinum or graphite / carbon (1)
- (ii) They need large quantities of **compressed** gases which take up space *or* the hydrogen would need to be **liquefied** *or* the reactant is (highly) **flammable / explosive / combustible** (1) [2]
- (e) *Glass:* saves **energy** – the raw materials are easily accessible / cheap *or* making glass is energy-intensive (1)
- Steel:* saves **energy** – extracting iron from the ore *or* mining the ore is energy intensive *or* saves a **resource** – iron **ore** (NOT just “iron”) is becoming scarce *either one* (1)
- Plastics:* saves a valuable / scarce **resource:** (crude) **oil / petroleum** (1) [3]

[Total: 10]

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