

**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

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.

Mark schemes must be read in conjunction with the question papers and the report on the examination.

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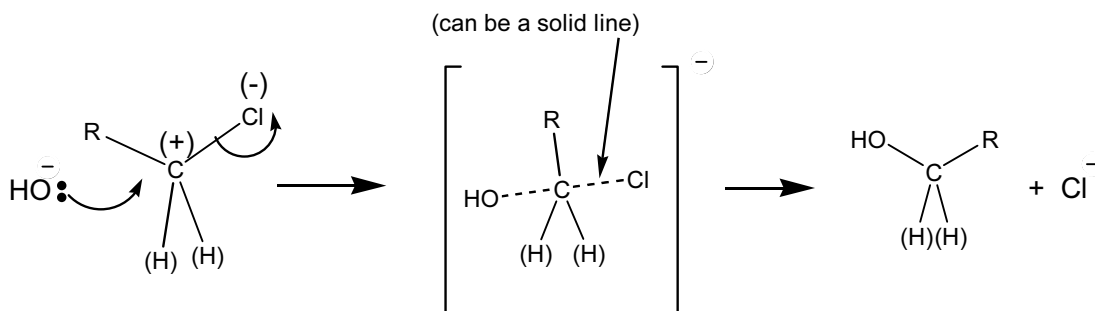
1 (a)  $C_6H_5-COCH_2OH$  or  $C_8H_8O_2$  and  $NaCl$  or  $Cl^-$  (1) + (1) [2]

(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  $\delta^+$  on C **and** (-) or  $\delta^-$  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  $\delta^+$  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  $\Delta H_{\text{sol}}$  becomes more endothermic / less exothermic (1) [4]
- (b) (i) for Mg:  $\Delta H = 2993 - 1890 - (2 \times 550) = (+)3 \text{ (kJ mol}^{-1}\text{)}$  (1)
- for Sr:  $\Delta H = 2467 - 1414 - (2 \times 550) = -47 \text{ (kJ mol}^{-1}\text{)}$  (1)
- (ii)  $\text{Sr(OH)}_2$  should be **more** soluble in water, **and**  $\Delta H$  is more exothermic / negative (1)
- Assuming "other factors" (e.g.  $\Delta S$ , or temperature etc.) are the same (1)
- (iii)  $\text{Sr(OH)}_2$  should be **less** soluble in hot water, **because**  $\Delta H$  is negative / exothermic (1) [5]
- (c) (i)  $K_{\text{sp}} = [\text{Ca}^{2+}][\text{OH}^-]^2$  (needs the charges) units:  $\text{mol}^3\text{dm}^{-9}$  (1) + (1)
- (ii)  $n(\text{H}^+) = n(\text{OH}^-) = 0.05 \times 21/1000 = 1.05 \times 10^{-3} \text{ mol in } 25 \text{ cm}^3$
- $[\text{OH}^-] = 1.05 \times 1000/25 = 4.2 \times 10^{-2} \text{ (mol dm}^{-3}\text{)}$  (1)
- $[\text{Ca}^{2+}] = 2.1 \times 10^{-2} \text{ (mol dm}^{-3}\text{)}$  (1)
- $K_{\text{sp}} = 2.1 \times 10^{-2} \times (4.2 \times 10^{-2})^2 = 3.7 \times 10^{-5}$  (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' on its own) (1) [6]

[Total: 15]

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- 3 (a)  $\text{SiF}_4$  is symmetrical or tetrahedral or bonds are at  $109^\circ$  or has no lone pair or 4 electron pairs shared equally or all Si-F dipoles cancel out, or  $\text{SF}_4$  has a lone pair (on S). (1) [1]

(b)

compound	molecule has an overall dipole	molecule does not have an overall dipole
$\text{BCl}_3$		✓
$\text{PCl}_3$	✓	
$\text{CCl}_4$		✓
$\text{SF}_6$		✓

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)

- (ii)  $\text{BCl}_3 + 3\text{H}_2\text{O} \rightarrow \text{H}_3\text{BO}_3 + 3\text{HCl}$  or  $2\text{BCl}_3 + 3\text{H}_2\text{O} \rightarrow \text{B}_2\text{O}_3 + 6\text{HCl}$  (1)

- $\text{SiCl}_4 + 2\text{H}_2\text{O} \rightarrow \text{SiO}_2 + 4\text{HCl}$  etc., e.g.  $\rightarrow \text{Si}(\text{OH})_4, \text{H}_2\text{SiO}_3$  (1) [3]

- (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)

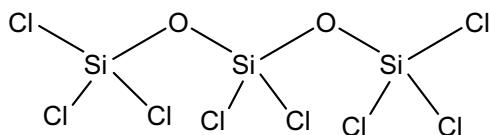
(ii)

mass number	structure
133	$\text{Cl}_3\text{Si}$
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:  
either  $\text{Si}_2\text{Cl}_5\text{O} + \text{Si}_2\text{Cl}_5\text{O}_2$  or  $\text{Si}_3\text{Cl}_8\text{O} + \text{Si}_3\text{Cl}_8\text{O}_2$  or  $\text{Si}_7\text{Cl}_8\text{O} + \text{Si}_7\text{Cl}_8\text{O}_2$ )

(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]

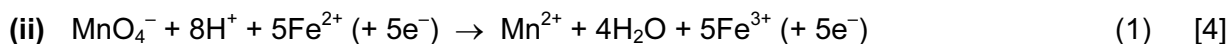
[Total: 11]

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- 4 (a)  $\text{Cr}^{3+}$ :  $1s^2 2s^2 2p^6 \dots 3s^2 3p^6 3d^3$  (1)  
 $\text{Mn}^{2+}$ :  $1s^2 2s^2 2p^6 \dots 3s^2 3p^6 3d^5$  (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)

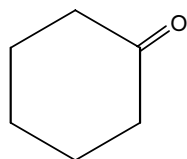


- (c)  $E^\circ$  values:  $\text{O}_2 + 4\text{H}^+ / 2\text{H}_2\text{O} = +1.23\text{V}$        $\text{Fe}^{3+} / \text{Fe}^{2+} = +0.77\text{V}$   
 $\text{O}_2 + 2\text{H}_2\text{O} / 4\text{OH}^- = +0.40\text{V}$        $\text{Fe}(\text{OH})_3 / \text{Fe}(\text{OH})_2 = -0.56\text{V}$  (2)

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

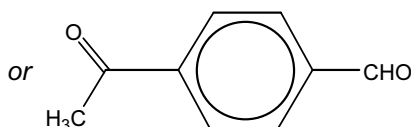
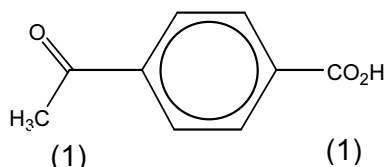
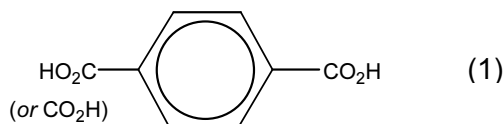
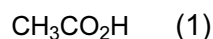
If  $E_{\text{cell}}$  is more positive it means a greater likelihood of reaction (1) [4]

(d)



(1)

and



[5]

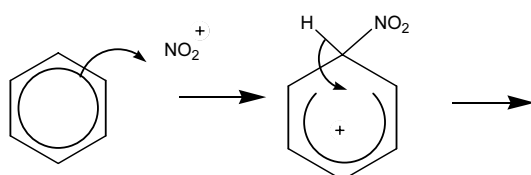
- (e) (i)  $(\text{CH}_3)_2\text{C}(\text{OH})-\text{CH}_2\text{OH}$  (1)

- (ii) reaction I: (cold dilute)  $\text{KMnO}_4$  ("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  $120^\circ$  or are joined by  $\pi$  bonds / orbitals (1)
- (ii) because the  $\pi$  electrons / double bonds are delocalised / in resonance or electrons are evenly distributed / spread out (1) [2]
- (b) (i)  $HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$  (1)  
or  $HNO_3 + H_2SO_4 \rightarrow H_2NO_3^+ + HSO_4^-$  or  $\rightarrow H_2O + NO_2^+ + HSO_4^-$
- (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]

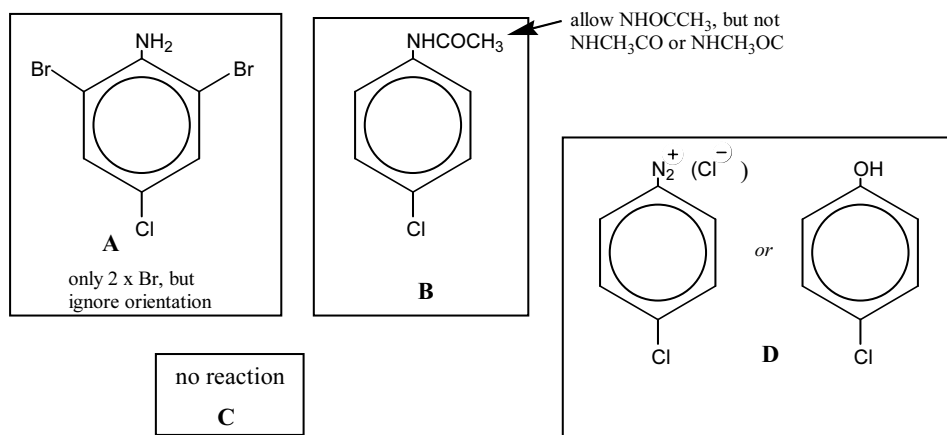
- (c)  $Cl_2 + AlCl_3 / FeCl_3 / Fe / Al / I_2$  (aq or light negates this mark) (1) [1]

- (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)

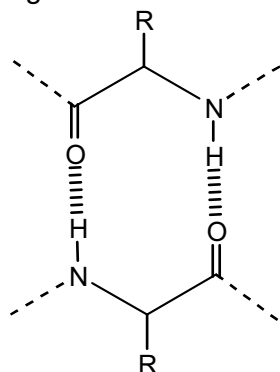


(4) [8]

[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 CH<sub>2</sub>S-SCH<sub>2</sub> (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  $\beta$ -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]**



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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)  $\text{H}_2\text{SO}_4$  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]