

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

**MARK SCHEME for the May/June 2012 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.

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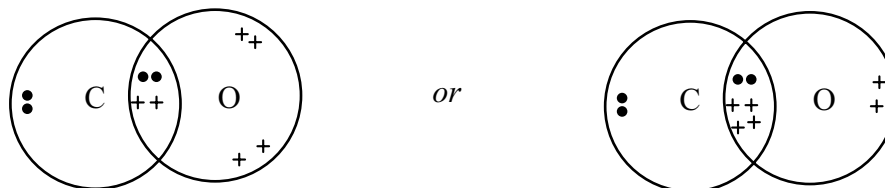


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- 1 (a) (i) enthalpy/energy change/released when 1 mol of ions... [1]  
in the gas phase (are dissolved in) water [1]
- (ii)  $\text{Mg}^{2+}(\text{g}) + \text{aq}$  (or  $\text{H}_2\text{O}$ )  $\rightarrow \text{Mg}^{2+}(\text{aq})$  or  $[\text{Mg}(\text{H}_2\text{O})_6]^{2+}$  [1]
- (iii)  $\text{Mg}^{2+}$  has a smaller radius/size or greater charge density than  $\text{Ca}^{2+}$  (**ions** required) [1]
- (iv)  $\text{O}^{2-}$  reacts with water to give  $\text{OH}^-$  or equation:  $\text{O}^{2-} + \text{H}_2\text{O} \rightarrow 2\text{OH}^-$  [1]  
**[5]**
- (b) (apparatus: “insulated” calorimeter, water and thermometer)
- measure (known volume/mass of) water or stated volume of water (into calorimeter)
  - take the temperature (of the water – NOT the  $\text{MgCl}_2$ )
  - weigh out known mass of  $\text{MgCl}_2$  or stated mass of  $\text{MgCl}_2$
  - take final/highest/constant temperature or record temperature change/rise 4 × [1]  
**[4]**
- (c) (i)  $\Delta H_{\text{sol}}^{\ominus} = 641 - 801 = -160 \text{ kJ mol}^{-1}$  [1]
- (ii)  $\Delta H_{\text{hyd}}^{\ominus} = (1890 - 2526 - 160)/2 = -398 \text{ kJ mol}^{-1}$  [2]  
**[3]**
- (d)
- solubility:  $\text{MgSO}_4 > \text{BaSO}_4$  or decreases down the group
  - because  $\Delta H_{\text{sol}}$  is more endothermic for  $\text{BaSO}_4$  or more exothermic for  $\text{MgSO}_4$
  - due to larger  $r_{\text{ion}}$  or smaller charge density of  $\text{Ba}^{2+}$  (ion has to be mentioned)
  - leading to smaller LE and HE or LE and HE decrease
  - but difference in HE (between  $\text{Mg}^{2+}$  and  $\text{Ba}^{2+}$ ) is larger than the difference in LE (between  $\text{MgSO}_4$  and  $\text{BaSO}_4$ )  
or HE is dominant or HE decreases more than LE any 4 points [4]  
**[4]**
- [Total: 16]**

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2 (a) (i)



[1]

(ii) incomplete combustion (of hydrocarbon fuels) *or* insufficient O<sub>2</sub>/air

[1]

(iii)  $\text{NO} + \text{CO} \rightarrow \frac{1}{2}\text{N}_2 + \text{CO}_2$   
*or*  $\text{CO} + \frac{1}{2}\text{O}_2 \rightarrow \text{CO}_2$   
 equation needs to be balanced

[1]  
 [3]

(b)  $\Delta H = 394 - 2 \times 111 = (+)172 \text{ kJ mol}^{-1}$

[2]  
 [2]

(c) (i) ligand exchange/displacement/replacement/substitution

[1]

(ii)

- d-orbitals are split (by the ligand field) *or* orbitals near ligands are at higher energy
- the splitting/energy gap depends on the ligands (surrounding the ion) *or* the metal (ion)
- when an electron moves from lower to higher orbital/energy level *or* is promoted/excited
- light/a photon is absorbed *or* colour seen/reflected/transmitted is complement of colour absorbed (“emitted” contradicts this mark)
- different energy gap means different frequency absorbed means different colour

5 × [1]

(iii) from rows 1 and 3:  $\text{rate}_3/\text{rate}_1 = 2.0$  which also equals  $[[\text{complex}]_3]/[[\text{complex}]_1]$  [1]  
*(or this working mark can be awarded for any valid calculation that shows that order w.r.t. complex is 1)*

Thus order w.r.t. [complex] = 1 **and** order w.r.t. [CO] is zero

[1]

rate equation: **rate = k[complex]**

[1]

(iv) mechanism 2

[1]

it's the only one that does **not** involve CO in the rate determining step *or* rate depends on [complex] only.

[1]

[11 max 10]

[Total: 15]

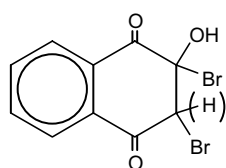
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3 (a) (i) ketone, alcohol, alkene, arene/aryl/benzene/phenyl. any three [2]  
(if more than 3 are given, mark the first 3 the candidate has written)

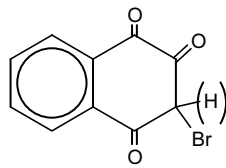
(ii) (2,4-)DNPH/Brady's or  $\text{FeCl}_3$  (aq or neutral) or  $\text{Br}_2(\text{aq})$  [1]  
 Lawsone  $\Rightarrow$  orange/red, or purple/violet with **A**, or white ppt with **A**,  
 (not yellow) ppt  
**and A**  $\Rightarrow$  nothing or **and** nothing with Lawsone or **and** decolourises [1]  
 with Lawsone

(iii)  $\text{NaBH}_4$  or  $\text{LiAlH}_4$  or  $\text{SnCl}_2$  or  $\text{Na} + \text{ethanol}$  or any suitable reducing agents with  $E^\ominus < 0.2\text{V}$ , e.g.  $\text{SO}_2$ . **NOT**  $\text{H}_2 + \text{Ni}$  etc. [1]

(iv)



or



(One of the Br atoms in either formula could be an OH group instead. Br on the **benzene** ring negates this mark)

[1]

[6]

(b) (i)  $E_{\text{cell}} = 1.33 - 0.36 = (+)0.97 \text{ (V)}$  [1]

(ii)  $\text{Cr}_2\text{O}_7^{2-} + 8\text{H}^+ + 3\text{C}_{10}\text{H}_8\text{O}_3 \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + 3\text{C}_{10}\text{H}_6\text{O}_3$

3:1 ratio [1]  
balancing [1]

(iii)  $= 0.05 \times 7.5/1000 = 3.75 \times 10^{-4} \text{ mol}$  [1]

$n(\mathbf{A}) = 3 \times 3.75 \times 10^{-4}$

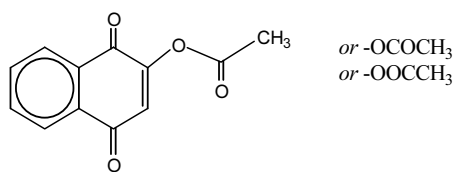
$= 1.125 \times 10^{-3} \text{ in } 20 \text{ cm}^3$

$[\mathbf{A}] = 5.63 \times 10^{-2} \text{ mol dm}^{-3}$  (allow 5.6, 5.62, 5.625 etc.) [1]

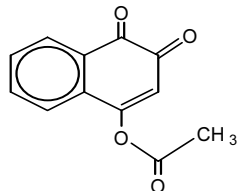
[5]

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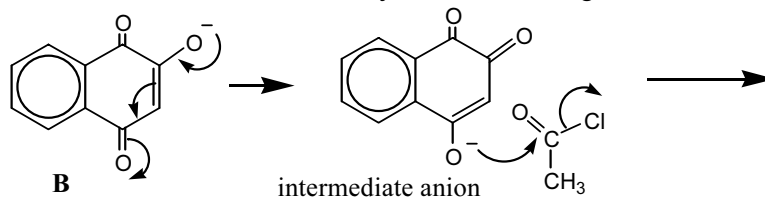
(c) (i) compound **C** is [1]



(ii) compound **D** is [1]



(iii) mechanism: 3 curly arrows in **B** or correct intermediate anion [1]  
 a curly arrow from an O<sup>-</sup> or an oxygen with a lone pair to the carbon of the C=O group in CH<sub>3</sub>COCl, and a second curly arrow breaking the C-Cl bond [1]



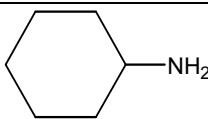
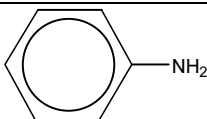
[4 max 3]

[Total: 14]

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- 4 (a) volatility:  $Cl_2 > Br_2 > I_2$  or boiling points:  $Cl_2 < Br_2 < I_2$  or  $Cl_2$  is (g);  $Br_2$  is (l);  $I_2$  is (s) [1]  
 more electrons in  $X_2$  down the group or more shells/bigger cloud of electrons [1]  
 so there's greater van der Waals/dispersion/induced/temporary dipole force/attraction [1]  
**[3]**
- (b) (i)  $H_2O > H_2S$  (see \* below for mark) [1]  
 due to H-bonding in  $H_2O$  (none in  $H_2S$ ) [1]  
 diagram minimum is:  $H_2O^{\delta-} \cdots \delta^+ H-OH$  or  $H_2O : H-OH$  [allow (+) for  $\delta^+$ ] [1]
- (ii)  $CH_3-O-CH_3 > CH_3CH_2CH_3$  (see \* below for mark) [1]  
 due to dipole in  $CH_3-O-CH_3$  (O is  $\delta^-$  not needed, but O is  $\delta^+$  negates) or  $CH_3OCH_3$  is polar [1]  
 \* correct comparison of boiling points for **both** [1]  
**[4]**
- (c)  $SF_6$  has 6 bonding pairs/bonds and no lone pairs (bonds can be read into a diagram e.g. S-F, but 'no lone pairs' can *only* be read into a diagram showing 6 bonded pairs of electrons. [1]  
clear diagram or 'shape is octahedral' [1]  
**[2]**
- [Total: 9]**
- 5 (a) acidities:  $CHCl_2CO_2H > CH_2ClCO_2H > CH_3CO_2H$  [1]  
 due to  $Cl$  being (more) electronegative/electron withdrawing (than H). [1]  
 this stabilises the anion or weakens the O-H bond [1]  
**[3]**

(b)

first compound	second compound	test	observation with first compound	observation with second compound
		Br <sub>2</sub> (aq) [not (l)]	none	decolourises/ white ppt.
		NaNO <sub>2</sub> + HCl or HNO <sub>2</sub> followed by phenol (+ NaOH)	none	yellow/orange/red ppt.
CH <sub>3</sub> CH <sub>2</sub> COCl	CH <sub>3</sub> COCH <sub>2</sub> Cl	AgNO <sub>3</sub> (aq)	(immediate) white ppt.	none
		add H <sub>2</sub> O/ROH	steamy/misty/ white fumes	none
		(2,4-)DNPH	none	orange ppt.
		I <sub>2</sub> /OH <sup>-</sup>	none	yellow ppt./ antiseptic smell
CH <sub>3</sub> CH <sub>2</sub> CHO	CH <sub>3</sub> COCH <sub>3</sub>	I <sub>2</sub> /OH <sup>-</sup>	none	yellow ppt./ antiseptic smell
		Fehling's/Benedict's solution + warm	red ppt.	none
		Tollens' reagent + warm	silver/black ppt.	none
		Cr <sub>2</sub> O <sub>7</sub> <sup>2-</sup> + H <sup>+</sup> + warm	turns green	no change
		MnO <sub>4</sub> <sup>-</sup> + H <sup>+</sup> + warm	decolourises	no change

three correct reagents

[3]

three correct positive results

[3]

three × 'none'

[1]

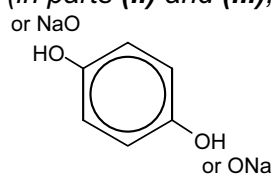
[7]

(c) (i) condensation

[1]

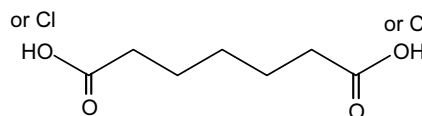
(ii) (in parts (ii) and (iii), allow structural formulae instead of skeletal formulae)

[1] + [1]



E

and



F

(N.B. letters E and F may be reversed.)

(iii) make acyl chloride from F (if not already there)

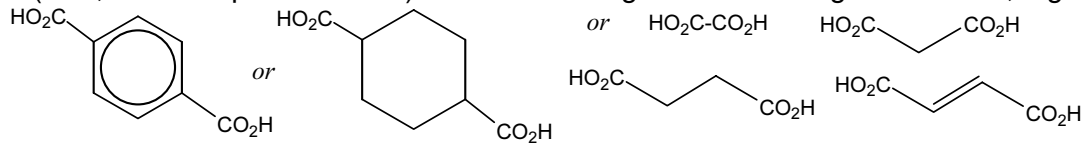
[1]

add that to a solution of E in NaOH(aq)

[1]

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(iv) **F** (or **E**, i.e. the aliphatic di-acid) should be changed to something less flexible, e.g.



(any size ring with  $n < 6$ ; any orientation)

(but not  $\text{HO}_2\text{C}(\text{CH}_2)_3\text{CO}_2\text{H}$  or longer)

(ignore side chains: length of chain is the important feature)

or allow a tri-carboxylic acid (or triphenol), i.e. one that will allow cross linking

[1]

[6]

[Total: 16]

6 (a)

amino acid	structure	type of interaction
alanine	$\text{H}_2\text{NCH}(\text{CH}_3)\text{CO}_2\text{H}$	van der Waals' (NOT hydrophobic)
cysteine	$\text{H}_2\text{NCH}(\text{CH}_2\text{SH})\text{CO}_2\text{H}$	disulfide bonds or S-S
lysine	$\text{H}_2\text{NCH}((\text{CH}_2)_4\text{NH}_2)\text{CO}_2\text{H}$	ionic/electrovalent hydrogen/H bonds
serine	$\text{H}_2\text{NCH}(\text{CH}_2\text{OH})\text{CO}_2\text{H}$	hydrogen/H bonds

[3]

[3]

(b) Iron – in haemoglobin or **red** blood cells; transport of oxygen/ $\text{CO}_2$

or in myoglobin; transport of oxygen (in muscle)

or in cytochromes; cell respiration

[1]

Potassium – in cell membranes/enzymes; controlling the flow of ions/water into or out of cells

or – in nerves; controlling nerve impulses

or –  $\text{Na}^+$  –  $\text{K}^+$  pump; nerve impulses/control of cell volume/active transport

[1]

Zinc acting as a cofactor in enzymes (or a named one, e.g. carbonic anhydrase);

or in making of insulin

[1]

[3]

(c) (i)  $\text{ATP} + \text{H}_2\text{O} \rightarrow \text{ADP} + \text{P}_i$

[1]

(ii) Hydrolysis or nucleophilic substitution

[1]

[2]

(d) (i) Sodium or chloride (sweat is salty) **and** Potassium (water retention in cells)

[1]

(ii) Hydrogen bonding **and** reference to water or bonding in mucous molecules

[1]

[2]

[Total: 10]

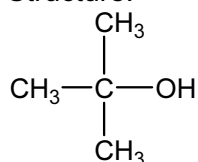


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- 7 (a) (i) + (ii) any two from:
- The nature/electronegativity of the atom the proton is attached to *or* is near *or* the electronic/chemical environment of the proton
  - The number/spin states of adjacent protons *or* protons attached to adjacent atoms
  - The (strength of) the applied/external magnetic field
- [1] + [1]  
[2]

- (b) (i) Peak at 1.26 $\delta$  = (3  $\times$ ) CH<sub>3</sub> *or* methyl **and** Peak at 2.0 $\delta$  = –O–H *or* alcohol [1]

Structure: [1]



- |      |  |  |  |
|------|--|--|--|
| (ii) | Isomer   | Isomer   | Isomer   |
|      | CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>2</sub> OH | (CH <sub>3</sub> ) <sub>2</sub> CHCH <sub>2</sub> OH | CH <sub>3</sub> CH <sub>2</sub> CH(CH <sub>3</sub> )OH |
|      | 5 groups of peaks  | 4 groups of peaks                                    | 5 groups of peaks                                      |

structures of any two isomers (Also allow both stereoisomers of butan-2-ol) [1] + [1]  
 correct assignation of no. of peaks [1] + [1]  
 [6]

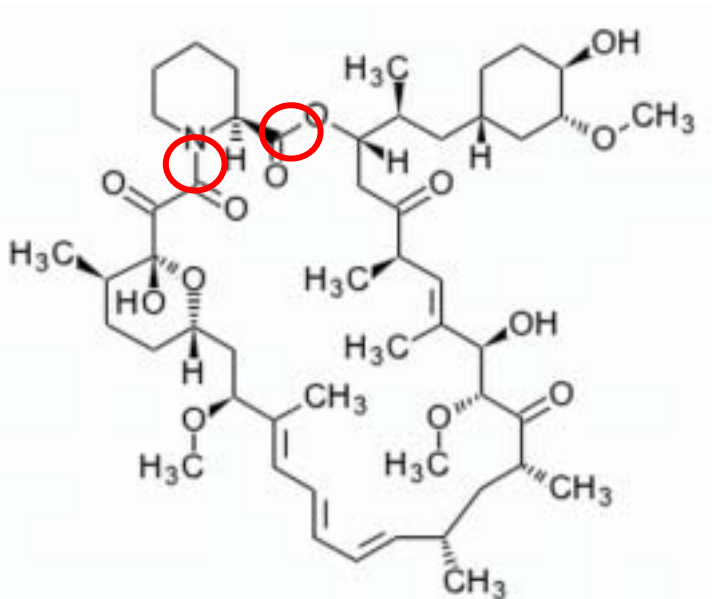
- (c) (i) Phosphorus – it has more electrons *or* high electron density (NOT phosphate) [1]
- (ii) H atoms don't have enough electron density to show up *or* they only contain one e<sup>-</sup> [1]  
 [2]

[Total: 10]

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- 8 (a) (i) hydrophilic in area C [1]  
fat-soluble in area B [1]
- (ii) A – region would be exposed to the atmosphere/water/enzymes or nothing the molecule can attach to at A [1]  
[3]

- (b) (i) amide/peptide or ester [1]
- (ii) hydrolysis [1]
- (iii)



[1] + [1]  
[4]

- (c) (i) measured in nm, i.e. between 1 and 1000 nm (or  $10^{-9}$  –  $10^{-6}$  m). Any quoted value or range between these limits is acceptable [1]
- (ii) One or both of the –OH groups (NOT just 'oxygen' or 'O') [1]
- (iii) PEG can H-bond (with water) because it is hydrophilic/contains an OH group/contains lots of oxygen atoms [1]  
[3]

[Total: 10]