

**CAMBRIDGE INTERNATIONAL EXAMINATIONS**

**GCE Advanced Level**

## **MARK SCHEME for the October/November 2012 series**

### **9701 CHEMISTRY**

**9701/43**

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 should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

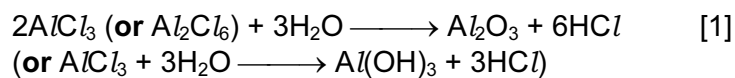
Cambridge will not enter into discussions about these mark schemes.

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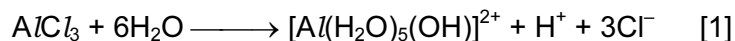
Page 2	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – October/November 2012	9701	43

1 (a)  $\text{MgCl}_2$ : forms a (colourless) solution **or** dissolves. [1]

$\text{AlCl}_3$ : produces a white ppt **or** steamy fumes [1]



**or** forms a (colourless) solution **or** dissolves [1]



$\text{SiCl}_4$ : produces a white ppt **or** steamy fumes [1]



[Total: 5]

(b) (i)  $n(\text{NaCl}) = 1.10/58.5 = 1.88 \times 10^{-2} \text{ mol}$  [1]  
 $n(\text{KCl}) = 0.90/74.6 = 1.21 \times 10^{-2} \text{ mol}$  [1]

total  $n(\text{Cl}^-) = 3.08$  or  $3.09$  or  $3.1 \times 10^{-2} \text{ mol}$  [2 or more sig. figs.] allow ecf

(ii)  $\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \longrightarrow \text{AgCl(s)}$  [1]

(iii) moles sampled for the titration =  $3.09 \times 10^{-2} \times 10/1000 = 3.09 \times 10^{-4} \text{ mol}$  ecf [1]

this equals  $n(\text{Ag}^+)$ , so vol of  $\text{AgNO}_3 = 3.09 \times 10^{-4} \times 1000/0.02 = \mathbf{15.5 \text{ cm}^3}$  ecf [1]

[Total: 5]

1) (c) (i) bonds broken are C–H and I–I =  $410 + 151 = 561 \text{ kJ mol}^{-1}$  (all bonds =  $5731 \text{ kJ mol}^{-1}$ )  
bonds formed are C–I and H–I =  $240 + 299 = 539 \text{ kJ mol}^{-1}$  (all bonds =  $5709 \text{ kJ mol}^{-1}$ )  
 $\Delta H = \mathbf{+22 \text{ kJ mol}^{-1}}$  [2]

(ii)  $4 \text{ HI} + 2 \text{ HNO}_3 \longrightarrow 2 \text{ I}_2 + \text{N}_2\text{O}_3 + 3 \text{ H}_2\text{O}$  (or double) [1]

N: (is reduced from) **5 to 3**

I: (is oxidised from) **–1 to 0** [1]

[Total: 4]

[TOTAL: 14]

Page 3	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – October/November 2012	9701	43

- 2 (a) catalyst: any two from the following three bullets for [1] mark:
- speeds up/increases (NOT alters or changes) the rate of a reaction
  - lowers energy barrier/ $E_{\text{act}}$  **or** offers a lower energy pathway
  - is not used up **or** remains unchanged **or** does not alter its mass/concentration **or** does not appear in stoichiometric equation **or** is regenerated

[1]

homogeneous: (catalyst and reactants) in the same phase/state [1]

[Total: 2]

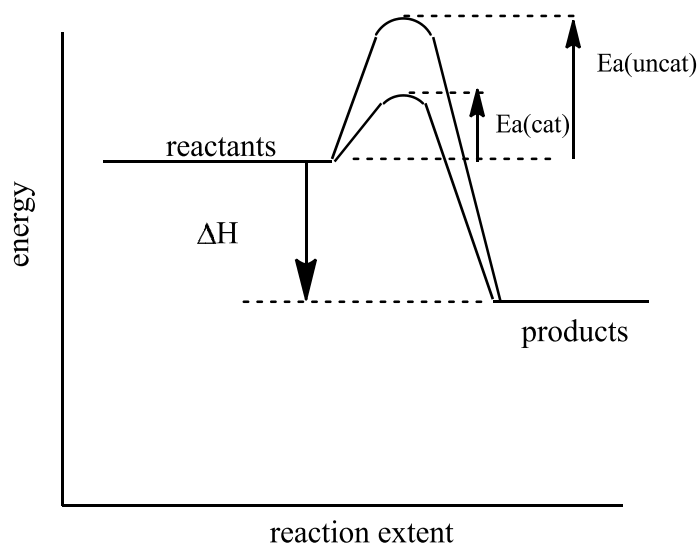
- (b) (i) e.g. car exhausts/engines **or** aeroplanes **or** lightning **or** burning fuels **or** power stations [1]

nitrogen reacts with oxygen **or**  $\text{N}_2 + \text{O}_2$  [1]

- (ii)  $\text{NO}_2 + \text{SO}_2 \longrightarrow \text{NO} + \text{SO}_3$   
 $\text{NO} + \frac{1}{2} \text{O}_2 \longrightarrow \text{NO}_2$   
 $\text{SO}_3 + \text{H}_2\text{O} \longrightarrow \text{H}_2\text{SO}_4$   
 $4\text{NO}_2 + 2\text{H}_2\text{O} + \text{O}_2 \rightarrow 4\text{HNO}_3$  **or**  $3\text{NO}_2 + \text{H}_2\text{O} \rightarrow 2\text{HNO}_3 + \text{NO}$  (any 3 equations)  $3 \times [1]$

[Total: 5]

(c)



- $\Delta H$  shown as negative [1]  
 both  $E_a$  labelled and correct – i.e. for the forward reaction [1]  
 $E_a(\text{cat}) < E_a(\text{uncat})$  [1]

[Total: 3]

[TOTAL: 10]

Page 4	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – October/November 2012	9701	43

3 (a)  $(1s^2 2s^2 2p^6) 3s^2 3p^6 3d^9$  [1]

[Total: 1]

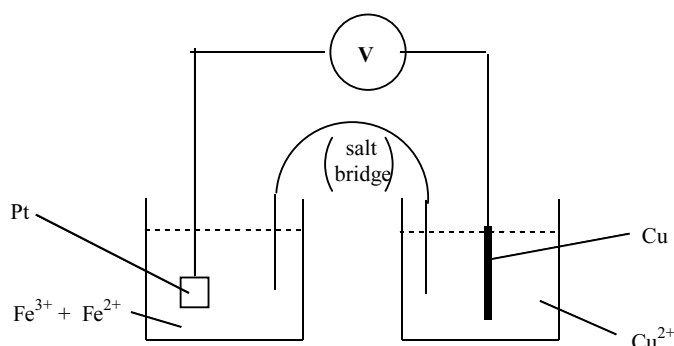
(b) (i) electron / orbitals near ligands are at a higher energy [1]  
due to repulsion from ligand lone pairs [1]

(ii) when an electron moves to higher orbital / energy level **or** is promoted [1]  
it absorbs a photon **or** light (mention of light being *emitted* negates this mark) [1]

(iii) (different ligands produce) different (sizes of) energy gap **or**  $\Delta E$  [1]

[Total: 5]

(c)



solutions at  $1 \text{ mol dm}^{-3}$  (1 M) and 298(K)/25°C [1]

salt bridge and voltmeter [1]

platinum/carbon/graphite electrode [1]

(this mark is negated by inclusion of  $\text{H}_2$  around the electrode)

copper electrode [1]

$\text{Fe}^{3+}/\text{Fe}^{2+}$  mixture **and**  $\text{Cu}^{2+}$  **or**  $\text{CuSO}_4$  etc [1]

[Total: 5]

(d) Parts (i) – (iii) have to correspond to each other.

either

or

	either	or
(i)	ligand exchange/substitution/displacement/replacement	precipitation/acid-base/deprotonation
(ii)	$[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 4\text{NH}_3 \rightarrow [\text{Cu}(\text{H}_2\text{O})_2(\text{NH}_3)_4]^{2+} + 4\text{H}_2\text{O}$ or $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 4\text{NH}_3 \rightarrow [\text{Cu}(\text{NH}_3)_4]^{2+} + 6\text{H}_2\text{O}$ or $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + n\text{NH}_3 \rightarrow [\text{Cu}(\text{H}_2\text{O})_{6-n}(\text{NH}_3)_n]^{2+} + n\text{H}_2\text{O}$	$\text{Cu}^{2+} + 2\text{NH}_3 + 2\text{H}_2\text{O} \rightarrow \text{Cu}(\text{OH})_2 + 2\text{NH}_4^+$ or $\text{Cu}^{2+} + 2\text{NH}_4\text{OH} \rightarrow \text{Cu}(\text{OH})_2 + 2\text{NH}_4^+$ or $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 2\text{NH}_3 \rightarrow [\text{Cu}(\text{H}_2\text{O})_4(\text{OH})_2] + 2\text{NH}_4^+$
(iii)	turns purple <b>or</b> deep/dark/royal blue	forms a pale blue ppt

[1] + [1] + [1]

Page 5	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – October/November 2012	9701	43

- (iv)  $E^\ominus$  will decrease/ be less positive/more negative...  
 ...because  $[\text{Cu}^{2+}]$  decreases **or**  $\text{Cu}^{2+} + 2\text{e}^- \rightleftharpoons \text{Cu}$  shifts to the LHS **or**  
 $E^\ominus[\text{Cu}(\text{NH}_3)_4]^{2+} = -0.05\text{V}$  **or**  $[\text{Cu}(\text{NH}_3)_4]^{2+}$  is more stable. [1]

[Total: 4]

- (e) (i) aldehyde [1]

- (ii) red ppt./solid [1]

- (iii)  $2\text{Cu}^{2+} + \text{CH}_3\text{CHO} + 5\text{OH}^- \rightarrow \text{Cu}_2\text{O} + \text{CH}_3\text{CO}_2^- + 3\text{H}_2\text{O}$  [1]

[Total: 3]

- (f)  $\text{pH} = \text{p}K_a + \log [\text{salt}]/[\text{acid}] = -\log(9.3 \times 10^{-4}) + \log (0.8/0.5)$   
 $= 3.032 + 0.204 = \mathbf{3.23/3.24}$  (3 or more sig. figs.) [2]

[Total: 2]

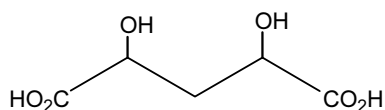
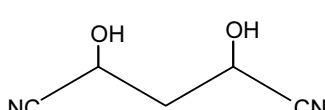
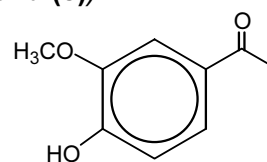
[TOTAL: 20]

- 4 (a) (i) ketone/carbonyl [NOT aldehyde] [1]

- (ii) carboxylic acid (name of group needed. NOT 'carboxyl') [1]

[Total: 2]

- (b) (i) (allow structural, displayed or skeletal formulae in (b), (c) and (e))

**B****C****D**

[1] + [1] + [1]

- (ii) heat/reflux/boil/hot/ $T > 60^\circ\text{C}$  in  $\text{H}_3\text{O}^+$  **or** aqueous/dilute  $\text{H}^+/\text{HCl}/\text{H}_2\text{SO}_4$  (**NOT**  $\text{HNO}_3$ ) [1]

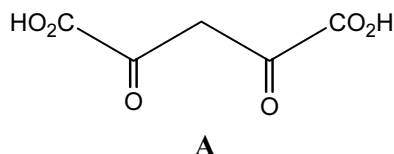
[Total: 4]

Page 6	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – October/November 2012	9701	43

(c) (i) reduction/redox (allow nucleophilic addition **or** hydrogenation, as appropriate from (ii)) [1]

(ii)  $\text{NaBH}_4$  **or**  $\text{LiAlH}_4$  **or**  $\text{H}_2 + \text{Ni/Pt}$  **or**  $\text{Na} + \text{ethanol}$  [1]

(iii)



[1]

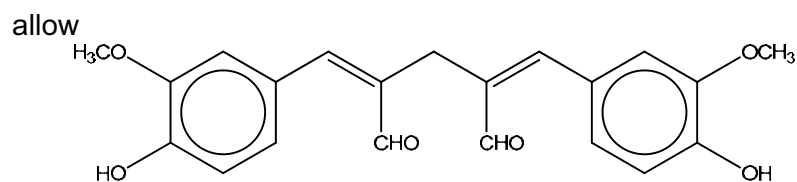
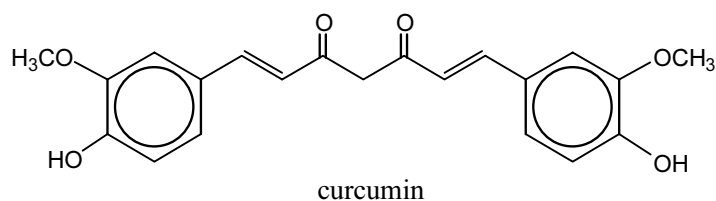
[Total: 3]

(d) (i) alkene/ $\text{C}=\text{C}/\text{C}-\text{C}$  double bond [1]

(ii) phenol **and** alkene/ $\text{C}=\text{C}/\text{C}-\text{C}$  double bond [1]

[Total: 2]

(e)



complete formula

[2]

[Total: 2]

[TOTAL: 13]

5 (a) (i) contains a lone pair on N (that can react with  $\text{H}^+$ ) [1]

(ii) e.g.  $\text{C}_2\text{H}_5\text{NH}_2 + \text{HCl} \longrightarrow \text{C}_2\text{H}_5\text{NH}_3^+ (\text{Cl}^-)$  [1]

**or**  $\text{C}_2\text{H}_5\text{NH}_2 + \text{H}_3\text{O}^+ \longrightarrow \text{C}_2\text{H}_5\text{NH}_3^+ + \text{H}_2\text{O}$

**or**  $\text{C}_2\text{H}_5\text{NH}_2 + \text{H}_2\text{O} \longrightarrow \text{C}_2\text{H}_5\text{NH}_3^+ + \text{OH}^-$  etc

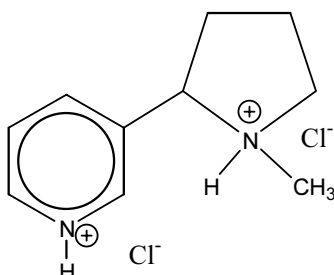
e.g.  $\text{C}_2\text{H}_5\text{NH}_2 + \text{CH}_3\text{Br} \longrightarrow \text{C}_2\text{H}_5\text{NHCH}_3 + \text{HBr}$

**or**  $\text{C}_2\text{H}_5\text{NH}_2 + \text{CH}_3\text{COCl} \longrightarrow \text{CH}_3\text{CONHC}_2\text{H}_5 + \text{HCl}$  [1]

Page 7	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – October/November 2012	9701	43

- (iii) the lone pair (on N) in phenylamine overlaps with ring **or** is delocalised [1]  
 electron density of N is reduced **or** N becomes more positive **or** lone pair is less available [1]

(iv)

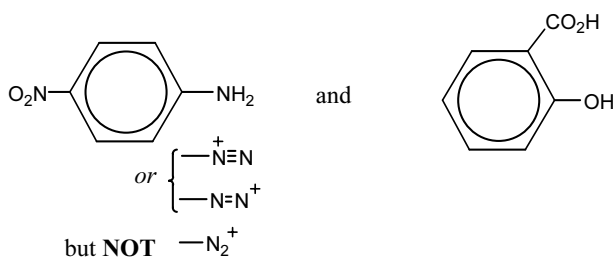


[1] + [1]

[7 max 6]

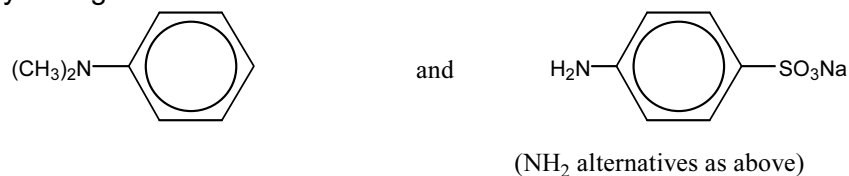
- (b) (i)  $\text{NaNO}_2 + \text{HCl}/\text{H}^+$  **or**  $\text{HNO}_2$  ( $\text{HNO}_3$  or  $\text{NO}_3^-$  negates this mark) [1]  
 $-10^\circ\text{C} < T \leq 10^\circ\text{C}$  **or** 'less than  $10^\circ\text{C}$ ' [1]

(ii) alizarin yellow R:



[1] + [1]

methyl orange:



[1] + [1]

- (iii) makes the molecule (more) hydrophilic/soluble in water (due to H-bonding or ionic solvation) [1]  
**or** increases its melting point [1]

[Total: 7]

[TOTAL: 13]

Page 8	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – October/November 2012	9701	43

- 6 (a) It has no chiral centre/asymmetric carbon/optical isomers **or** is not optically active [1]

[Total: 1]

- (b) (i) structure –  $\alpha$ -helix or  $\beta$ -(pleated) sheet [1]

hydrogen (bonding) (for either) [1]

- (ii) any two pairs from the following:

<b>bonding</b>	<b>possible amino acid</b>
van der Waals'	ala, gly, leu, ile, val, pro, phe, try, met
ionic	asp, arg, glu, his, lys
disulfide bond	cysteine
hydrogen bond	asn, asp, arg, gln, glu, his, lys, ser, thr, try, tyr

[1] + [1]

[1] + [1]

(candidates can identify amino acids by name, three-letter abbreviation, formula of sidechain or formula of whole amino acid)

[Total: 6]

- (c) (globular proteins/enzymes need) polar/H-bonding/ionic (side chains) so as to....  
....enhance their solubility **or** as part of their active site **or** to help their catalytic activity [1]

[Total: 1]

- (d) (i) A – T [1]  
C – G [1]

- (ii) (start **or** met) – **gly – ser – leu – ala – ser** – (stop)  
If an amino acid is shown before gly, then it must be met.  
correct sequence of the 5 **in bold** [2]

- (iii) leu would be replaced by val [1]

[Total: 5]

[TOTAL: 13]



Page 9	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – October/November 2012	9701	43

- 7 (a) (i) No. of carbon atoms present in **J** is  $\frac{100 \times 1.3}{1.1 \times 23.5} = 5$  carbons (must show working) [1]

(NMR spectrum shows) **10 H** (atoms present) (no reasoning need be shown) [1]

- (ii) Oxygen **or**  $O_2$  **or** O [1]

- (iii) **J** is  $(CH_3CH_2)_2C=O$  [1]

any one from:

quartet/4 peaks (at  $\delta$  2.5) shows an adjacent  $CH_3$  **or** 3 adjacent H

triplet/3 peaks (at  $\delta$  1.1) shows an adjacent  $CH_2$  **or** 2 adjacent H

two (chemical/hydrogen) environments

pair of peaks in ratio 6 :4 are (two) ethyl groups **or** the triplet + quartet shows an ethyl group

$\delta$  2.5 implies there's a  $CH_2$  next to  $C=O$  [1]

[Total: 5]

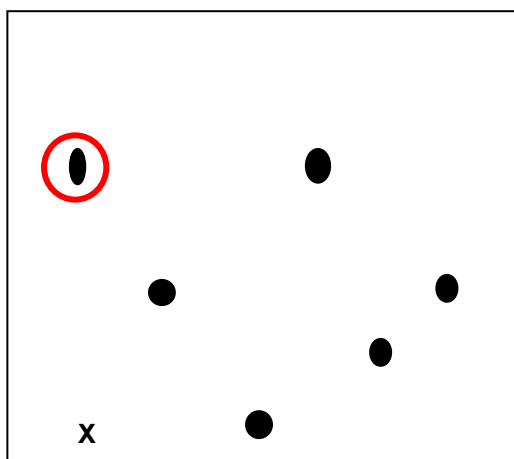
- (b) (i)

<i>technique</i>	<i>physical method</i>
paper chromatography	<b>partition</b>
thin-layer chromatography	<b>adsorption</b>
gas-liquid chromatography	<b>partition</b>

[2]

- (ii) 4 [1]

- (iii)



correct spot circled [1]

- (iv) 3 [1]

[Total: 5]

[TOTAL: 10]

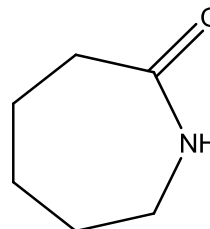
Page 10	Mark Scheme	Syllabus	Paper
	GCE A LEVEL – October/November 2012	9701	43

8 (a) **A** monomers:  $\text{H}_2\text{N}-(\text{CH}_2)_6-\text{NH}_2$  and  $\text{HO}_2\text{C}-(\text{CH}_2)_4-\text{CO}_2\text{H}$  **or**  $\text{ClCO}(\text{CH}_2)_4\text{COCl}$  [1]

Condensation **or** nucleophilic substitution **or** addition-elimination [1]

**B** monomer:  $\text{H}_2\text{C}=\text{CHCH}_3$  [1]

Addition (NOT additional) [1]



**C** monomer:  $\text{H}_2\text{N}-(\text{CH}_2)_5-\text{CO}_2\text{H}$  **or**  $\text{H}_2\text{N}-(\text{CH}_2)_5-\text{COCl}$  **or** [1]

Condensation [1]

[max 5]

(b) (i) Need a statement from both columns for [1] mark.

(a)	(b)
more compact packing in <b>A</b> chains closer in <b>A</b> chains further apart in <b>B</b>	stronger (inter-chain) forces in <b>A</b> hydrogen bonding in <b>A</b> weaker (inter-chain) <b>or</b> van der Waals' forces in <b>B</b> <b>B</b> contains side-chain/branched chains

[1]

(ii) Polymer **B** – van der Waals'/London (dispersion) forces/induced-instantaneous/induced dipoles  
NOT just 'dipole' [1]

[Total: 2]

[TOTAL: 7]