

**UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS**

**GCE Advanced Subsidiary Level and GCE Advanced Level**

**MARK SCHEME for the October/November 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.

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Page 2	Mark Scheme: Teachers' version	Syllabus	Paper 1
	GCE A LEVEL – October/November 2010	9701	042Based.com

- 1 (a)  $\text{PCl}_5 + 4\text{H}_2\text{O} \rightarrow \text{H}_3\text{PO}_4 + 5\text{HCl}$  (1)
- $\text{SiCl}_4 + 2\text{H}_2\text{O} \rightarrow \text{SiO}_2 + 4\text{HCl}$  (or giving  $\text{H}_2\text{SiO}_3$ ,  $\text{Si}(\text{OH})_4$  etc.) (1) [2]
- (b) bond energies: S-S = 264 kJ mol<sup>-1</sup>  
 Cl-Cl = 244 kJ mol<sup>-1</sup>  
 S-Cl = 250 kJ mol<sup>-1</sup>
- $\Delta H = 8 \times 264 + 8 \times 244 - 16 \times 250 = +64 \text{ kJ mol}^{-1}$  (2) [2]
- (c) (i) +2 (1)
- (ii) (half) the sulfur goes up by +2, (1)  
 (the other half) goes down by -2 (1)
- (iii) HCl (can be read into (iv)) (1)
- (iv)  $2\text{SCl}_2 + 2\text{H}_2\text{O} \rightarrow \text{S} + \text{SO}_2 + 4\text{HCl}$  (1)
- (v) (+ AgNO<sub>3</sub>) white ppt. (1)  
 (+ K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>) solution turns green (1) [7]

[Total: 11]

- 2 (a) (i) A ligand is a species that contains a lone pair of electrons, or that can form a dative bond (to a transition element) (1)

(ii)

species	can be a ligand	cannot be a ligand
OH <sup>-</sup>	✓	
NH <sub>4</sub> <sup>+</sup>		✓
CH <sub>3</sub> OH	✓	
CH <sub>3</sub> NH <sub>2</sub>	✓	

(4 × ½)

[3]

- (b) (i) C is  $[\text{Cu}(\text{NH}_3)_6]^{2+} \text{SO}_4^{2-}$  (allow  $[\text{Cu}(\text{NH}_3)_4]^{2+} \text{SO}_4^{2-}$ ) (1)  
 D is CuO (1)  
 E is Na<sub>2</sub>SO<sub>4</sub> (1)  
 F is BaSO<sub>4</sub> (1)
- (ii) acid-base or neutralisation (1) [5]
- (c) (i) any **two** from:  
 brown fumes or vapour evolved / gas relights glowing splint / black solid formed (2)
- (ii)  $2\text{Cu}(\text{NO}_3)_2 \rightarrow 2\text{CuO} + 4\text{NO}_2 + \text{O}_2$  (1) [3]

[Total: 11 max 10]

Page 3	Mark Scheme: Teachers' version	Syllabus	Paper 1
	GCE A LEVEL – October/November 2010	9701	042

- 3 (a) (i)  $\text{Cu(s)} - 2\text{e}^- \rightarrow \text{Cu}^{2+}(\text{aq})$  allow electrons on RHS (1)
- (ii)  $E^\circ$  for  $\text{Ag}^+/\text{Ag}$  is +0.80V which is more positive than +0.34V for  $\text{Cu}^{2+}/\text{Cu}$ , (1)  
so it's less easily oxidised (owtte) (1)
- (iii)  $E^\circ$  for  $\text{Ni}^{2+}$  is -0.25V, (1)  
Ni is readily oxidised and goes into solution as  $\text{Ni}^{2+}(\text{aq})$  (1) [Mark (ii) and (iii) to max 3]
- (iv)  $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu(s)}$  (1)
- (v)  $E^\circ$  for  $\text{Zn}^{2+}/\text{Zn}$  is negative / = -0.76V, so  $\text{Zn}^{2+}$  is not easily reduced. (1)
- (vi) The blue colour fades because  $\text{Cu}^{2+}(\text{aq})$  is being replaced by  $\text{Zn}^{2+}(\text{aq})$  or  $\text{Ni}^{2+}(\text{aq})$  or  $[\text{Cu}^{2+}]$  decreases (1) [7]

- (b) amount of copper =  $225/63.5 = 3.54(3)$  mol (1)  
amount of electrons needed =  $2 \times 3.54 = 7.08/9$  (7.087) mol (1)
- no. of coulombs =  $20 \times 10 \times 60 \times 60 = 7.2 \times 10^5$  C  
no. of moles of electrons =  $7.2 \times 10^5 / 9.65 \times 10^4 = 7.46$  mol (1)
- percentage "wasted" =  $100 \times (7.461 - 7.087) / 7.461 = 5.01$  (5.0)% (accept 4.98–5.10) (1) [4]

- (c)  $E^\circ$  data:  $\text{Ni}^{2+}/\text{Ni} = -0.25\text{V}$   
 $\text{Fe}^{2+}/\text{Fe} = -0.44\text{V}$  (1)

Because the Fe potential is more negative than the Ni potential, the iron will dissolve (1) [2]

[Total: 13]

- 4 (a) (i)  $\text{SnO}_2$  Can be read into equation (1)  
 $2\text{NaOH} + \text{SnO}_2 \rightarrow \text{Na}_2\text{SnO}_3 + \text{H}_2\text{O}$  (1)
- (ii)  $\text{PbO}$  Can be read into equation (1)  
 $\text{PbO} + 2\text{HCl} \rightarrow \text{PbCl}_2 + \text{H}_2\text{O}$  (1) [4]

- (b) moles of oxygen =  $9.3/16 = 0.581$  mol  
moles of lead =  $90.7/207 = 0.438$  mol (both 3 s.f.) (1)
- so formula is  $\text{Pb}_3\text{O}_4$  (1) [2]

- (c) (i)  $K_{\text{sp}} = [\text{Pb}^{2+}][\text{Cl}^-]^2$  (1) units =  $\text{mol}^3 \text{dm}^{-9}$  (1)
- (ii) if  $[\text{Pb}^{2+}] = x$ ,  $K_{\text{sp}} = 4x^3$ , so  $x = \sqrt[3]{\{K_{\text{sp}}/4\}}$   
 $[\text{Pb}^{2+}] = \sqrt[3]{\{2 \times 10^{-5}/4\}} = 1.71 \times 10^{-2} \text{mol dm}^{-3}$  (1)
- (iii)  $[\text{Pb}^{2+}] = 2 \times 10^{-5} / (0.5)^2 = 8.0 \times 10^{-5} \text{mol dm}^{-3}$  (1)
- (iv) common ion effect, or increased  $[\text{Cl}^-]$  forces solubility equilibrium over to the left (1)

[Max 4]

[Total: 10]

Page 4	Mark Scheme: Teachers' version	Syllabus	Paper 1
	GCE A LEVEL – October/November 2010	9701	42

5 (a) (i) ester (1)

(ii) H is nitrobenzene – structure needed here (1)  
J is phenyldiazonium chloride – structure needed here (1)

(iii) step 2 Sn/Zn + HCl / H<sub>2</sub> + named cat / NaBH<sub>4</sub> / LiAlH<sub>4</sub> / Na + ethanol (1)  
step 3 HNO<sub>2</sub>/NaNO<sub>2</sub> + HCl at T = 10°C or less (1)  
step 4 heat/warm to T > 10°C (1)  
step 5 CH<sub>3</sub>COCl / CH<sub>3</sub>COCOCOCH<sub>3</sub> (1)

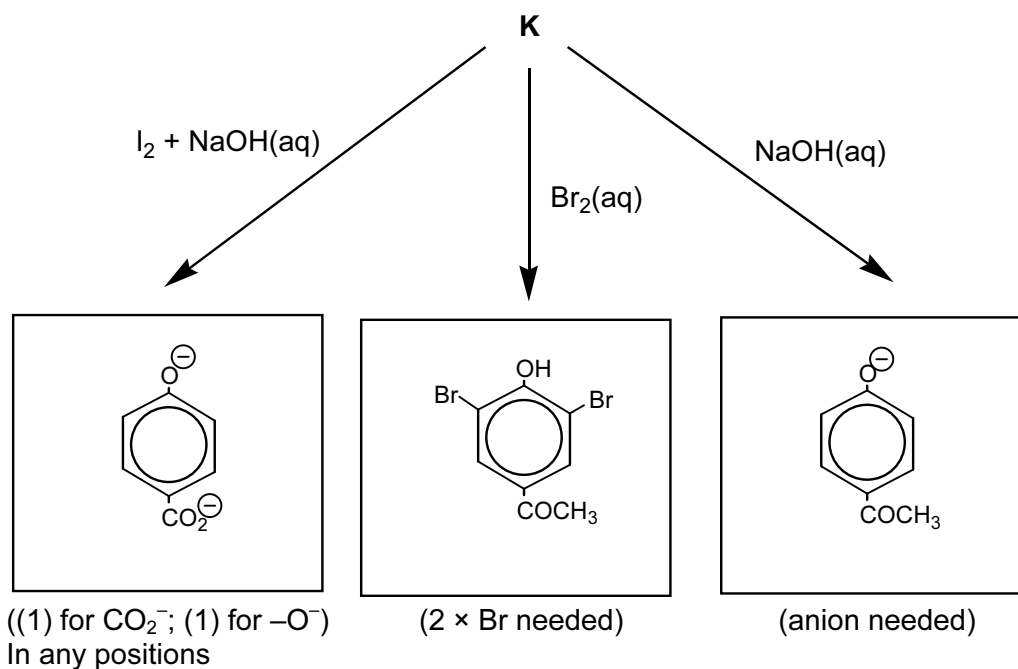
[7]

(b) (i) compounds that have the same molecular formula, but different structures (1)

(ii) phenol (NOT hydroxy) (1)  
(methyl) ketone or carbonyl (1)

(iii) K is 4-ethanoylphenol, HO-C<sub>6</sub>H<sub>4</sub>-COCH<sub>3</sub> (must be 1,4- disubstituted isomer) (1)

(iv)



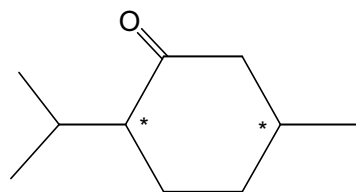
[4]

[8 max 7]

[Total: 14]

Page 5	Mark Scheme: Teachers' version	Syllabus	Paper 1
	GCE A LEVEL – October/November 2010	9701	42

6 (a)

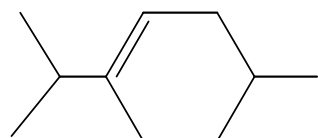


(1) for each centre – more than 2 centres shown deduct 1 mark

[2]

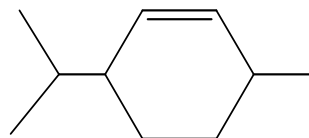
- (b) (i) step 1  $\text{LiAlH}_4$  or  $\text{NaBH}_4$  or  $\text{Na} + \text{ethanol}$  or  $\text{H}_2 + \text{Ni}$  (1)  
 step 2 heat with  $\text{Al}_2\text{O}_3$  / porous pot or conc.  $\text{H}_2\text{SO}_4$  /  $\text{H}_3\text{PO}_4$  (1)

(ii)



**L** (1)

(letters may be reversed)

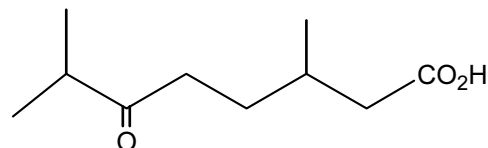


**M** (1)

[4]

- (c) (i) **M** (no mark)

(ii)



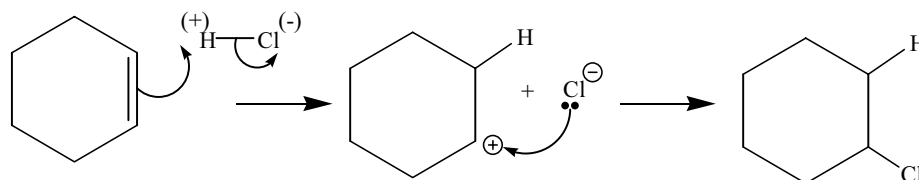
**P**

i.e. 3,7-dimethyl-6-oxo-octanoic acid (1)

- (iii) 2,4-DNPH (1) orange ppt. with **P** (none with **N**) (1)  
 Mark ecf from candidates' P

[3]

(d)



2 curly arrows (1)  
 carbocation intermediate +  $\text{Cl}^-$  (1)  
 lone pair on  $\text{Cl}^-$  and last curly arrow (1)

[3]

[Total: 12]

Page 6	Mark Scheme: Teachers' version	Syllabus	Paper 1
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- 7 (a) (i) Disulfide bond / group / bridge (1)
- (ii) The tertiary structure (1)
- (iii) The substrate will no longer bond to / fit into the active site (1)  
or shape of active site is changed [3]
- (b) (i) Acid-base / proton donor / neutralisation / salt formation (1)
- (ii) The ability of the  $-\text{CO}_2\text{H}$  group to form hydrogen bonds (1) and ionic interactions (1)  
The  $-\text{CO}_2\text{H}/-\text{CO}_2^-$  group is no longer able to interact with  $-\text{NH}_2/-\text{NH}_3^+$  (1)  
The  $\text{Ag}^+$  forms a strong bond with  $-\text{COO}^-$  (1) [5] max [4]
- (c) (i) 8 but allow  $4\text{O}_2$  if specified as molecules (1)
- (ii) Dative / co-ordinate (1)
- (iii) Octahedral / 6 co-ordinate (1) [3]
- [Total: 10]

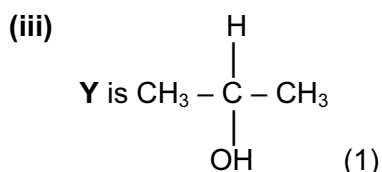
- 8 (a) (i) Protons (1)  
in NMR, energy is absorbed due to the two spin states (1)  
Electrons (1)  
in X-ray crystallography, X-rays are diffracted (by regions of high electron density) (1) [4]

- (b) (i) 1 – no mark  
The spectrum of alcohol / **Y** contains different peaks  
Alcohol / **Y** contains different chemical environments  
Spectrum 2 contains only one peak (1)
- (ii) Spectrum 2 only shows 1 peak so **Z** must be a ketone (1)  
Hence **Y** must be a  $2^\circ$  alcohol (1)

$$\text{Number of carbon atoms present} = \frac{0.6 \times 100}{17.6 \times 1.1} = 3 \quad (1)$$

Thus **Z** must be  $\text{CH}_3\text{COCH}_3$  (1)

Hence **Y** must be propan-2-ol,  $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$  (1)



- (iv) All of the protons in **Z** are in the same chemical environment (1) [8] max [7]

[Total: 11]

Page 7	Mark Scheme: Teachers' version	Syllabus	Paper 1
	GCE A LEVEL – October/November 2010	9701	042

- 9 (a) (i) A few nanometres (accept 0.5–10 nm) (1)
- (ii) Graphite/graphene (1)
- (iii) van der Waals' (1)  
 Carbon atoms in the nanotubes are joined by covalent bonds (1)  
 (as are the hydrogen atoms in a hydrogen molecule)  
 or no dipoles on C or H<sub>2</sub> or the substances are non-polar [4]
- (b) More hydrogen can be packed into the same space/volume (1) [1]
- (c) If a system at equilibrium is disturbed, the equilibrium moves in the direction which tends to reduce the disturbance (owtte) (1)
- When H<sub>2</sub> is removed the pressure drops and more H<sub>2</sub> is released from that adsorbed (1)
- The equilibrium  $\text{H}_{2\text{adsorbed}} \rightleftharpoons \text{H}_{2\text{gaseous}}$  (1)
- Equilibrium shifts to the right as pressure drops (1) [4]

[Total: 9]