

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**

**9701/43**

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.

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- 1 (a) (i)  $\text{P}_2\text{O}_5 + 3\text{H}_2\text{O} \rightarrow 2\text{H}_3\text{PO}_4$  (or similar) or  $\text{P}_4\text{O}_{10} + 6\text{H}_2\text{O} \rightarrow 4\text{H}_3\text{PO}_4$  (1)  
 $\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3$  (1)
- (ii)  $2\text{NO}_2 + \text{H}_2\text{O} \rightarrow \text{HNO}_2 + \text{HNO}_3$  (1)
- (iii)  $2\text{ClO}_2 + 2\text{NaOH} \rightarrow \text{NaClO}_2 + \text{NaClO}_3 + \text{H}_2\text{O}$  or ionic eqn (1) [4]
- (b) (i)  $2\text{CH}_4 + \text{C}_2\text{H}_6 + \text{H}_2\text{S} + 9\text{O}_2 \rightarrow 4\text{CO}_2 + \text{SO}_2 + 8\text{H}_2\text{O}$   
 Formulae (1), balanced (1)
- (ii) (The  $\text{SO}_2$  produced) causes acid rain (1)  
 or consequence of acid rain – defoliation etc. – or respiratory problem
- (iii)  $1000 \text{ dm}^3$  contains  $50 \text{ dm}^3$  of  $\text{H}_2\text{S}$   
 this is  $50/24$  (= **2.083** moles) (1)  
 $M_r(\text{ethanolamine}) = 24 + 7 + 14 + 16 = \mathbf{61}$   
 therefore mass =  $2.083 \times 61 = \mathbf{127(.1)g}$  (1) (or ecf)
- (iv) acid-base (1)
- (v)  $\Delta H = \Delta H_f(\text{rhs}) - \Delta H_f(\text{lhs})$   
 $= \{(3 \times 11 - 2 \times 242)\} - \{(2 \times -21 - 297)\} - 1$  for each { } in which there is an error  
 $= -451 + 339$   
 $= -112 \text{ (kJ mol}^{-1}\text{)}$  (2) [8]

[Total: 12]

- 2 (a) any **three** from:  
d-orbitals / sub-shells / energy levels are split or equivalent \* (1)  
colour due to absorption of light (1)  
 when e promoted to higher orbital \* (1)  
 $\Delta E = hf$  or  $h\nu$  or  $h/\lambda$  (marks \* could be in labelled diagram) (1) [3]
- (b) blue is  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$  (or full correct name of ion) (1)  
 ligand exchange/displacement/replacement (1)  
 $(\text{NH}_4)_2\text{CuCl}_4$  contains  $[\text{CuCl}_4]^{2-}$  (1)  
 $\text{CuSO}_4$  is white as it has no ligands (1) [max 3]
- (c)  $n(\text{thio}) = 0.02 \times 19.5/1000 = 3.9 \times 10^{-4} \text{ mol}$  (1)
- $n(\text{thio}) = n(\text{Cu}^{2+})$ , so  $n(\text{Cu}^{2+})$  in  $50 \text{ cm}^3 = 3.9 \times 10^{-4} \text{ mol}$   
 so  $[\text{Cu}^{2+}] = 3.9 \times 10^{-4} \times \frac{1000}{50} = \mathbf{(7.8 \times 10^{-3} \text{ mol dm}^{-3})}$  (1)  
 {or all-in-one-line:  $n(\text{thio}) = n(\text{Cu}^{2+})$ , so  $[\text{Cu}^{2+}] = 0.02 \times 19.5/50 = \mathbf{(7.8 \times 10^{-3} \text{ mol dm}^{-3})}$ } (2)
- in  $100 \text{ cm}^3$ , there will be  $7.8 \times 10^{-4} \text{ mol}$ , which is  $63.5 \times 7.8 \times 10^{-4} = \mathbf{0.049 - 0.050\%}$  (1) [3]  
 Allow ecf on 2nd and 3rd marks 0.5 gets 2 marks only

[Total: 9]

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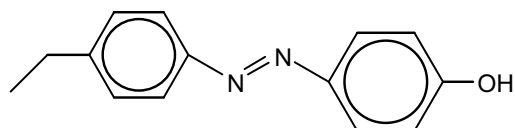
- 3 (a) reaction I: reduction or hydrogenation (1)  
 reaction II: oxidation or redox (1) [2]

- (b) thymol:  $\text{Br}_2(\text{aq})$  (1) decolourises or white ppt (1)  
 or  $\text{NaOH}(\text{aq})$  (1) dissolves (1)  
 or  $\text{FeCl}_3(\text{aq})$  (1) violet/purple (colour) (1)  
 menthol:  $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$  (1) orange  $\rightarrow$  green (1)  
 or Lucas test or  $\text{ZnCl}_2/\text{HCl}$  (1) cloudy or white ppt (1)  
 menthone: 2,4-DNPH/Brady's reagent (1) orange ppt (1) [6]

[Total: 8]

- 4 reaction I:  $\text{Cl}_2 + \text{light}$  (1) (not aq)  
 reaction II:  $\text{Br}_2 + \text{AlBr}_3$  or Fe or  $\text{FeBr}_3$  (1) (not aq)  
 reaction III:  $\text{NaOH}$ , heat in ethanol (1) (allow aqueous EtOH)  
 reaction IV:  $\text{HNO}_3 + \text{H}_2\text{SO}_4$  (1) conc and  $< 60^\circ\text{C}$  (1) (2 marks)  
 reaction V:  $\text{KMnO}_4 + \text{H}^+/\text{OH}^- + \text{heat}$  (1)  
 reaction VI:  $\text{Sn} + \text{HCl}$  (1)  
 reaction VII:  $\text{HNO}_2 + \text{HCl}$ ,  $< 10^\circ\text{C}$  (1)

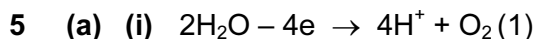
X is

(1) allow  $-\text{N}_2-$  and  $-\text{ONa}$ 

[max 8]

[Total: 8]

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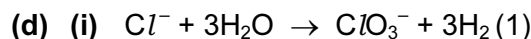


(b) (i)  $E^\circ = (1.23 - (-0.83)) = \underline{2.06\text{V}}(1)$

(ii)  $E^\circ = (1.36 - (-0.83)) = \underline{2.19\text{V}}(1)$   
(in (i) if (a)(i) as  $4(\text{OH}^-) - 4\text{e}^- \rightarrow 2\text{H}_2\text{O} + \text{O}_2$  ecf is  $\underline{0.4 - (-0.83) = 1.23}(1)$  – needs working shown) [2]

(c) (i) no change (because  $[\text{H}_2\text{O}]$  does not change) (1)  
smaller/less positive (1)

(ii) The (overall)  $E^\circ$  for  $\text{Cl}_2$  production will decrease, (whereas that) for  $\text{O}_2$  production will stay the same. (answer could be in terms of 1st  $E^\circ$  decreasing and becoming lower than 2nd)(or  $E^\circ$  for  $\text{Cl}_2$  becomes less than for  $\text{O}_2$ ) (1) [3]



(ii)  $n(\text{C}) = 250 \times 60 \times 60 = (9 \times 10^5 \text{ C})(1)$   
 $n(\text{e}^-) = 9 \times 10^5 / 96500 = 9.33 \text{ mol}$   
 $n(\text{NaClO}_3) = 9.33 / 6 = (1.55 \text{ mol}) - \text{allow ecf}(1)$   
 $\text{Mr}(\text{NaClO}_3) = 106.5$   
 $\text{mass}(\text{NaClO}_3) = 1.55 \times 106.5 = \underline{165.5 \text{ g}}(1)$  (165 – 166 gets 3 marks, 993 gets 2 marks as ecf) [4]

[Total: 11]

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- 6 (a) (i)  $\text{Br}_2$  (ignore solvent, but do not credit  $\text{AlCl}_3$  or  $\text{HCl}$  or light) (1)
- (ii) curly arrow from  $\text{C}=\text{C}$  to  $\text{Br}$  (1)  
 another one breaking  $\text{Br}-\text{Br}$  bond. (1)  
 correct intermediate cation and  $\text{Br}^-$  produced (not  $\text{Br}^{\delta-}$ ) (1) [max 3]
- (b) B is  $\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2$  (1)  
 C is  $\text{NCCH}_2\text{CH}_2\text{CN}$  (1)  
 E is  $\text{ClCOCH}_2\text{CH}_2\text{COCl}$  (1) [3]  
 (Allow  $(\text{CH}_2)_2$  or  $\text{C}_2\text{H}_4$ . Allow correct atoms in any order on LHS but order must be correct on RHS)
- (c) reaction II: heat, dilute  $\text{H}^+(\text{aq})$  or  $\text{HCl}(\text{aq})$  or  $\text{HCl}(\text{conc})$  or  $\text{H}_2\text{SO}_4(\text{aq})$  (1)  
 reaction III:  $\text{H}_2 + \text{Ni}$  (or other named catalyst) or  $\text{LiAlH}_4$  or  $\text{Na}$  in ethanol (1) [2]
- (d)  $\text{NH}_4^+$  (1) [1]
- (e) (i)  $[-\text{NHCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}-\text{COCH}_2\text{CH}_2\text{CO}-]$  (1)  
 (allow  $(\text{CH}_2)_4$  and  $(\text{CH}_2)_2$ )  
 (not dimer, needs bonds both ends)
- (ii)  $\text{HCl}$  (1) [2]
- (f) (i)  $[\text{H}^+] = 10^{-\text{pH}} = 10^{-2.6} = 2.51 \times 10^{-3} \text{ (mol dm}^{-3}\text{)}$  (1)
- (ii)  $K_a = [\text{H}^+]^2/c = 6.31 \times 10^{-5} \text{ (mol dm}^{-3}\text{)}$  (allow ecf from (i)) (1) [2]
- [Total: 13]
- 7 (a)  $\text{NH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2 + \text{HCl} \rightarrow \text{NH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_3^+ \text{Cl}^-$  (1)  
 $\text{NH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_3^+ \text{Cl}^- + \text{HCl} \rightarrow \text{Cl}^- \text{NH}_3+\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_3^+ \text{Cl}^-$  (1) [2]  
 (Deduct 1 only, if  $\text{Cl}^-$  omitted twice but allow with  $\text{H}^+$ )
- (b) starts at 11.3 and finished as 1.6 (1)  
 steep portions at  $10 \text{ cm}^3$  and  $20 \text{ cm}^3$  volume added (1) [2]
- [Total: 4]

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- 8 (a) (i) diagram to show tetrahedral arrangement (3D or bond angle marked) (1)
- (ii) 4 covalent bonds/bond pairs (with Cl) **only** or **no lone pairs**. (1) [2]
- (b) (i) steamy/white fumes/gas or heat evolved (1)  
(fumes are) HCl (from hydrolysis of Sn-Cl bonds) or exothermic reaction/bond breaking (1)  
(can award second mark for HCl (g) in eqn.)
- (ii)  $\text{SnCl}_4 + 2\text{H}_2\text{O} \rightarrow \text{SnO}_2 + 4\text{HCl}$  etc. (allow partial hydrolysis and with OHs) (1) [3]
- [Total: 5]
- 9 (a) Sugar/deoxyribose, phosphate, base (or better)(not ribose) (1) [1]
- (b) Diagram showing sugar-phosphate backbone (chain) (1)
- Bases on side-chain (1)  
Base paired – A-T or G-C (1)
- H-bonds shown and labelled (1) [4]
- (c) mRNA, ribosome, tRNA all three correct (2)  
(mRNA first allow 1 mark) [2]
- (d) (i)  $(4 \times 4 \times 4) = 64$  (1)
- (ii) START (or Met) – ser – arg – leu – asp – val (2)  
(5 correct order score (1))
- (iii) Amino acid leu is changed to pro (1) [4]
- [Total: 11]

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- 10 (a) (i) Partition – substance is distributed between the stationary and mobile phase *or* has different solubility in each phase (1)  
 Adsorption – substances form bonds of varying strength with *or* are attracted to *or* are held on to stationary phase. (1)

(ii)

Technique	Separation method
Paper chromatography	Partition
Thin-layer chromatography	Adsorption
Gas/liquid chromatography	Partition

3 correct → (2)

2 correct → (1)

- (iii) %X = 44% ( $\pm 2$ ) %; %Y = 56% ( $\pm 2$ ) % (1)

[5]

- (b) (i) They are largely composed of (carbon and) hydrogen which are active in the NMR (owtte) *or* protons/ $H^+$ /H exist in different chemical environments (with characteristic absorptions) (1)

- (ii) 2 correct displayed formulae (1)

In propanone all the protons are in a similar chemical environment (and hence there will be one proton peak.) (1)

In propanal there are (three) different chemical environments and hence there will be (three) proton peaks *or* three different chemical environments *or* three proton peaks (1)

[4]

[Total: 9]

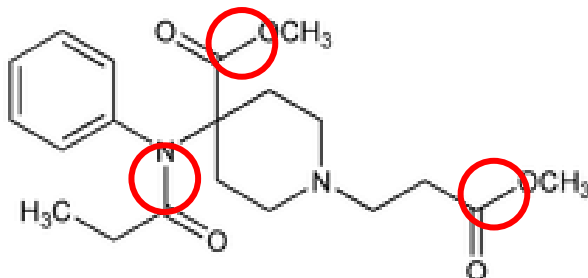
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11 (a) Any **two** from:

- The drug can be localised in a part of the body (1)
- Smaller doses can be given reducing cost (1)
- Smaller doses can be given with fewer possible side effects (1)
- More immediate action / acts faster (1)

[2]

(b)



(May circle whole functional group)  
Any 2 circles (2)

[2]

(c) (i) Must not react with the drug *or* must not breakdown too easily/quickly (1)

(ii) The swelling/hydrolysis would begin in the stomach (and the drug would be released too soon) *or* stomach is acidic or has low pH (1)

[2]

(d) Addition, condensation (1)

Suitable equation for addition (1)

Suitable equation for condensation (1)

(Addition equation must show polymerisation and balance – allow  $nX \rightarrow X_{2n}$  or  $X_n$  or  $X_{n/2}$ )

(Condensation can be simple reaction e.g. to single ester or amide but must balance – 2 products)

(If polymerisation RHS must show a repeat unit but can leave out other product – HCl etc.)

[3]

(e) Hydrolysis (1)

[1]

[Total: 11]