

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

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- 1 (a) (i) $P_2O_5 + 3H_2O \rightarrow 2H_3PO_4$ (or similar) or $P_4O_{10} + 6H_2O \rightarrow 4H_3PO_4$ (1)
 $SO_2 + H_2O \rightarrow H_2SO_3$ (1)
- (ii) $2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$ (1)
- (iii) $2ClO_2 + 2NaOH \rightarrow NaClO_2 + NaClO_3 + H_2O$ or ionic eqn (1) [4]
- (b) (i) $2CH_4 + C_2H_6 + H_2S + 9O_2 \rightarrow 4CO_2 + SO_2 + 8H_2O$
 Formulae (1), balanced (1)
- (ii) (The SO_2 produced) causes acid rain (1)
 or consequence of acid rain – defoliation etc. – or respiratory problem
- (iii) 1000 dm^3 contains 50 dm^3 of H_2S
 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/λ (marks * could be in labelled diagram) (1) [3]
- (b) blue is $[Cu(H_2O)_6]^{2+}$ (or full correct name of ion) (1)
 ligand exchange/displacement/replacement (1)
 $(NH_4)_2CuCl_4$ contains $[CuCl_4]^{2-}$ (1)
 $CuSO_4$ 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)
- $n(\text{thio}) = n(Cu^{2+})$, so $n(Cu^{2+})$ in $50 \text{ cm}^3 = 3.9 \times 10^{-4} \text{ mol}$
 so $[Cu^{2+}] = 3.9 \times 10^{-4} \times \frac{1000}{50} = \mathbf{(7.8 \times 10^{-3} \text{ mol dm}^{-3})}$ (1)
 {or all-in-one-line: $n(\text{thio}) = n(Cu^{2+})$, so $[Cu^{2+}] = 0.02 \times 19.5/50 = \mathbf{(7.8 \times 10^{-3} \text{ mol dm}^{-3})}$ } (2)
- in 100 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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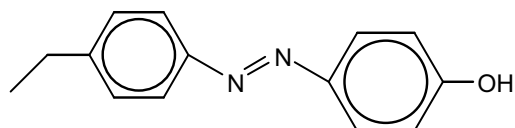
- 3 (a) reaction I: reduction or hydrogenation (1)
 reaction II: oxidation or redox (1) [2]

- (b) thymol: Br₂(aq) (1) decolourises or white ppt (1)
 or NaOH(aq) (1) dissolves (1)
 or FeCl₃(aq) (1) violet/purple (colour) (1)
 menthol: Cr₂O₇²⁻/H⁺ (1) orange → green (1)
 or Lucas test or ZnCl₂/HCl (1) cloudy or white ppt (1)
 menthone: 2,4-DNPH/Brady's reagent (1) orange ppt (1) [6]

[Total: 8]

- 4 reaction I: Cl₂ + light (1) (not aq)
 reaction II: Br₂ + AlBr₃ or Fe or FeBr₃ (1) (not aq)
 reaction III: NaOH, heat in ethanol (1) (allow aqueous EtOH)
 reaction IV: HNO₃ + H₂SO₄ (1) conc and < 60°C (1) (2 marks)
 reaction V: KMnO₄ + H⁺/OH⁻ + heat (1)
 reaction VI: Sn + HCl (1)
 reaction VII: HNO₂ + HCl, < 10°C (1)

X is



(1) allow -N₂- and -ONa

[max 8]

[Total: 8]

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- 5 (a) (i) $2\text{H}_2\text{O} - 4\text{e} \rightarrow 4\text{H}^+ + \text{O}_2$ (1)
- (ii) $2\text{Cl}^- - 2\text{e} \rightarrow \text{Cl}_2$ (1) [2]
- (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° for Cl_2 production will decrease, (whereas that) for O_2 production will stay the same. (answer could be in terms of 1st E° decreasing and becoming lower than 2nd)(or E° for Cl_2 becomes less than for O_2) (1) [3]
- (d) (i) $\text{Cl}^- + 3\text{H}_2\text{O} \rightarrow \text{ClO}_3^- + 3\text{H}_2$ (1)
- (ii) $n(\text{C}) = 250 \times 60 \times 60 = (\mathbf{9 \times 10^5})$ C (1)
 $n(\text{e}^-) = 9 \times 10^5 / 96500 = 9.33$ mol
 $n(\text{NaClO}_3) = 9.33 / 6 = (\mathbf{1.55})$ mol – allow ecf (1)
 $\text{Mr}(\text{NaClO}_3) = 106.5$
mass $(\text{NaClO}_3) = 1.55 \times 106.5 = \mathbf{165.5}$ g (1) (165 – 166 gets 3 marks, 993 gets 2 marks as ecf) [4]

[Total: 11]

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- 6 (a) (i) Br_2 (ignore solvent, but do not credit AlCl_3 or HCl or light) (1)
- (ii) curly arrow from $\text{C}=\text{C}$ to Br (1)
 another one breaking $\text{Br}-\text{Br}$ bond. (1)
 correct intermediate cation and 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 C_2H_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 LiAlH_4 or Na in ethanol (1) [2]
- (d) 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) 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 Cl^- omitted twice but allow with H^+)
- (b) starts at 11.3 and finished as 1.6 (1)
 steep portions at 10 cm^3 and 20 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% (±2) %; %Y = 56% (±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)

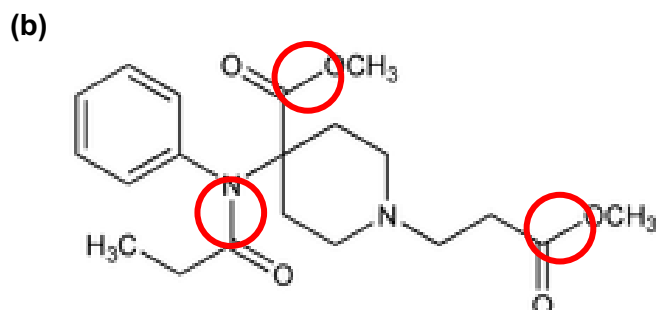
In propanone all the protons are in a similar chemical environment (and hence there will be one proton peak.) (1)

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]



(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]