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 SO₂ produced) causes acid rain (1) or consequence of acid rain defoliation etc. or respiratory problem
- (iii) 1000 dm³ contains 50 dm³ of H₂S this is 50/24 (= **2.083** moles) (1) M_r (ethanolamine) = 24 + 7 + 14 + 16 = **61** therefore mass = 2.083 × 61 = **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= $-112 \text{ (kJ mol}^{-1}) \text{ (2)}$

[Total: 12]

2 (a) any three from:

<u>d</u>-orbitals / sub-shells / energy levels are <u>split</u> or equivalent * (1) <u>colour</u> due to <u>absorption of light</u> (1) when e promoted to higher orbital * (1) $\Delta E = hf$ or hv or h / λ (marks * could be in labelled diagram) (1)
[3]

(b) <u>blue</u> is $[Cu(H_2O)_6]^{2+}$ (or full correct name of ion) (1) ligand exchange/displacement/replacement (1) $((NH_4)_2CuCl_4 \text{ contains}) [CuCl_4]^{2-}$ (1) CuSO₄ is white as it has no ligands (1)

[max 3]

(c) $n(thio) = 0.02 \times 19.5/1000 = 3.9 \times 10^{-4} \text{ mol } (1)$

n(thio) = n(Cu²⁺), so n(Cu²⁺) in 50 cm³ =
$$3.9 \times 10^{-4}$$
 mol so [Cu²⁺] = $3.9 \times 10^{-4} \times 1000/50 = (7.8 \times 10^{-3} \text{ (mol dm}^{-3})) (1)$ {or all-in-one-line: n(thio) = n(Cu²⁺), so [Cu²⁺] = $0.02 \times 19.5/50 = (7.8 \times 10^{-3} \text{ mol dm}^{-3})$ } (2)

in 100 cm^3 , there will be $7.8 \times 10^{-4} \text{ mol}$, which is $63.5 \times 7.8 \times 10^{-4} = 0.049 - 0.050\%$ (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: $Br_2(aq)(1)$ decolourises or white ppt (1)

or NaOH(aq) (1) dissolves (1)

or FeC l_3 (aq) (1) violet/purple (colour) (1) menthol: $Cr_2O_7^{2-}/H^+$ (1) or ange \rightarrow green (1) cloudy or white ppt (1)

menthone: 2,4-DNPH/Brady's reagent (1) orange ppt (1)

[6]

[Total: 8]

4 reaction **I**: <u>Cl</u>₂ + light (1) (<u>not</u> aq)

reaction II: $Br_2 + AlBr_3$ or Fe or FeBr₃ (1) (not aq)

reaction III: NaOH, heat in ethanol (1) (allow aqueous EtOH) reaction IV: $HNO_3 + H_2SO_4$ (1) conc and < 60°C (1) (2 marks)

reaction V: $KMnO_4 + H^+/OH^- + heat (1)$

reaction VI: Sn + HCl(1)

X is

reaction VII: $HNO_2 + HCl$, < 10°C (1)

[max 8]

[Total: 8]

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5 (a) (i)
$$2H_2O - 4e \rightarrow 4H^+ + O_2(1)$$

(ii)
$$2Cl^- - 2e \rightarrow Cl_2(1)$$
 [2]

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

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

- (c) (i) no change (because [H₂O] does not change) (1) smaller/less positive (1)
 - (ii) The (overall) E° for C½ production will decrease, (whereas that) for O₂ production will stay the same. (answer could be in terms of 1st E° decreasing and becoming lower than 2nd)(or E° for C½ becomes less than for O₂) (1) [3]

(d) (i)
$$Cl^- + 3H_2O \rightarrow ClO_3^- + 3H_2(1)$$

(ii)
$$n(C) = 250 \times 60 \times 60 = (9 \times 10^5 C) (1)$$

 $n(e^-) = 9 \times 10^5/96500 = 9.33 \text{ mol}$
 $n(NaC lO_3) = 9.33/6 = (1.55 \text{ mol}) - \text{allow ecf (1)}$
 $Mr(NaC lO_3) = 106.5$
mass $(NaC lO_3) = 1.55 \times 106.5 = 165.5 \text{ g (1) (165 - 166 gets 3 marks, 993 gets 2 marks as ecf)}$

[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 C=C to Br (1) another one breaking Br-Br bond. (1) correct intermediate cation and Br⁻ produced (not Br^{δ-}) (1)

[max 3]

(b) B is $NH_2CH_2CH_2NH_2$ (1) C is NCCH₂CH₂CN (1)

E is $ClCOCH_2CH_2COCl(1)$

[3] (Allow (CH₂)₂ or C₂H₄. Allow correct atoms in any order on LHS but order must be correct on RHS)

- (c) reaction II: heat, dilute H[†](aq) or HC*l*(aq) or HC*l*(conc) or H₂SO₄(aq) (1) reaction III: H_2 + Ni (or other named catalyst) or LiA lH_4 or Na in ethanol (1) [2]
- (d) $NH_4^+(1)$ [1]
- (e) (i) [-NHCH₂CH₂CH₂CH₂NH-COCH₂CH₂CO-] (1) (allow $(CH_2)_4$ and $(CH_2)_2$) (**not** dimer, needs bonds both ends)
 - (ii) HCl(1)[2]
- (f) (i) $[H^+] = 10^{-pH} = 10^{-2.6} = 2.51 \times 10^{-3} \text{ (mol dm}^{-3}\text{) (1)}$
 - (ii) Ka = $[H^{+}]^{2}/c$ = 6.31 × 10⁻⁵ (mol dm⁻³) (allow ecf from (i)) (1) [2]

[Total: 13]

- 7 (a) $NH_2CH_2CH_2CH_2NH_2 + HCl \rightarrow NH_2CH_2CH_2CH_2NH_3^+ Cl^-(1)$ $NH_2CH_2CH_2CH_2NH_3^+Cl^- + HCl \rightarrow Cl^- NH_3 + CH_2CH_2CH_2NH_3^+Cl^- (1)$ [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 cm³ and 20 cm³ 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) HC*l* (from hydrolysis of Sn-C*l* bonds) *or* exothermic reaction/bond breaking (1) (can award second mark for HC*l* (g) in eqn.)
 - (ii) $SnCl_4 + 2H_2O \rightarrow SnO_2 + 4HCl$ 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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(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

 $3 \text{ correct} \rightarrow (2)$

2 correct \rightarrow (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 <u>different chemical environments</u> (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) <u>different chemical environments</u> and hence there will be (three) <u>proton peaks</u> 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)

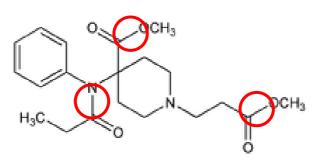
Smaller doses can be given reducing cost (1)

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 $\underline{\text{must}}$ show polymeristion $\underline{\text{and}}$ balance – allow $nX \to X_{2n}$ 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]