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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International Examinations

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(ethanolamine) = 24 + 7 + 14 + 16 = **61**
therefore mass = 2.083 × 61 = **127(.1)**g (1) (or ecf)

(iv) acid-base (1)

(v) $\Delta H = \Delta H_f(rhs) - \Delta H_f(lhs)$
= {(3 × 11 – 2 × 242)}{–}{(2 × –21 – 297)} –1 for each { } in which there is an error
= –451 + 339
= –112 (kJ mol^{-1}) (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 $h\upsilon$ 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(thio) = 0.02 × 19.5/1000 = 3.9×10^{-4} mol (1)

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

in 100 cm^3, there will be 7.8×10^{-4} 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]**

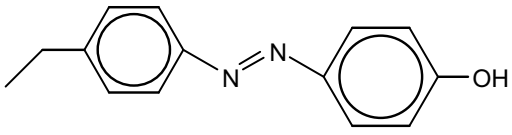
(b)

thymol:	Br_2(aq) (1)		decolourises or white ppt (1)
or	NaOH(aq) (1)		dissolves (1)
or	$FeCl_3$(aq) (1)		violet/purple (colour) (1)
menthol:	$Cr_2O_7^{2-}/H^+$ (1)		orange → green (1)
or	Lucas test or $ZnCl_2/HCl$ (1)		cloudy or white ppt (1)
menthone:	2,4-DNPH/Brady's reagent (1)		orange ppt (1)

[6]

[Total: 8]

4 reaction **I**: $\underline{Cl_2}$ + light (1) (<u>not</u> aq)
reaction **II**: $Br_2 + AlBr_3$ *or* Fe *or* $FeBr_3$ (1) (<u>not</u> 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)
reaction **VII**: HNO_2 + HCl, < 10°C (1)

X is 

(1) allow $-N_2-$ and –ONa

[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^o = (1.23 – (–0.83)) = <u>2.06V</u> (1)

(ii) E^o = (1.36 – (–0.83)) = <u>2.19V</u> (1)
(in **(i)** if **(a)(i)** as $4(OH^-) - 4e \rightarrow 2H_2O + O_2$ ecf is <u>0.4 – (–0.83) = 1.23</u> (1) – needs working shown) **[2]**

(c) (i) <u>no change</u> (because $[H_2O]$ does not change) (1)
smaller/less positive (1)

(ii) The (overall) <u>E^o for Cl_2 production will decrease</u>, (whereas that) for <u>O_2 production will stay the same</u>. (answer could be in terms of 1st E^o decreasing and becoming lower than 2nd)(or E^o for Cl_2 becomes less than for O_2) (1) **[3]**

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

(ii) n(C) = 250 × 60 × 60 = (**9×10^5** C) (1)
$n(e^-) = 9 \times 10^5/96500 = 9.33$ mol
$n(NaClO_3) = 9.33/6 =$ (**1.55** mol) – allow ecf (1)
$Mr(NaClO_3) = 106.5$
mass $(NaClO_3) = 1.55 \times 106.5 =$ **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 C=C to Br (1)
another one breaking Br-Br bond. (1)
correct intermediate cation and Br^- produced (not $Br^{\delta-}$) (1) **[max 3]**

(b) **B** is $NH_2CH_2CH_2NH_2$ (1)
C is $NCCH_2CH_2CN$ (1)
E is $ClCOCH_2CH_2COCl$ (1) **[3]**
(Allow $(CH_2)_2$ or C_2H_4. Allow correct atoms in any order on LHS but order must be correct on RHS)

(c) reaction **II**: heat, dilute H^+(aq) or HCl(aq) or HCl(conc) or H_2SO_4(aq) (1)
reaction **III**: H_2 + Ni (or other named catalyst) or $LiAlH_4$ or Na in ethanol (1) **[2]**

(d) NH_4^+ (1) **[1]**

(e) **(i)** [-$NHCH_2CH_2CH_2CH_2NH$-$COCH_2CH_2CO$-] (1)
(allow $(CH_2)_4$ and $(CH_2)_2$)
(**not** dimer, needs bonds both ends)

(ii) HCl (1) **[2]**

(f) **(i)** $[H^+] = 10^{-pH} = 10^{-2.6} = 2.51 \times 10^{-3}$ (mol dm^{-3}) (1)

(ii) $Ka = [H^+]^2/c = 6.31 \times 10^{-5}$ (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 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 C*l*) **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 × 4 × 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 <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)

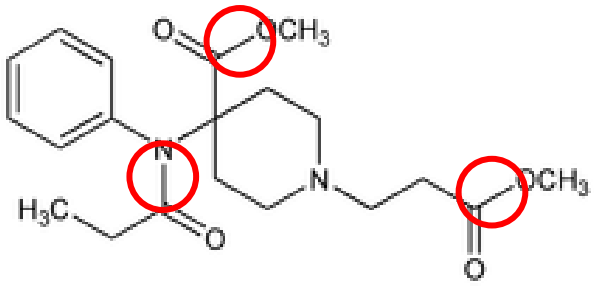
In propanal there are (three) <u>different chemical environments</u> and hence there will be (three) <u>proton peaks</u> *or* three different chemical environments *or* three proton peaks (1)
[4]

[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 must show polymeristion 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 – HC*l* etc.)
[3]

(e) Hydrolysis (1) **[1]**

[Total: 11]

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