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) $P_2O_5 + 3H_2O \rightarrow 2H_3PO_4$ (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]

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

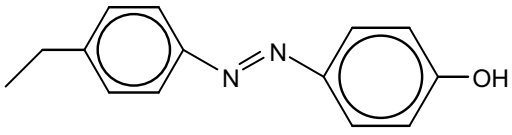
(b)

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]

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]

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]

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]

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)

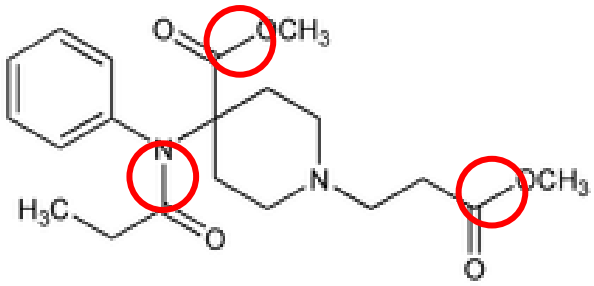
In propanone all the protons are in a similar chemical environment (and hence there will be one proton peak.) (1)

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]

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]