UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS GCE Advanced Level

MARK SCHEME for the May/June 2011 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)
$$[H^{+}] = \sqrt{(0.05 \times 5.6 \times 10^{-4})} = 5.29 \times 10^{-3} \text{ mol dm}^{-3}$$
 [1] $pH = -log_{10}(5.29 \times 10^{-3}) = 2.3$ [1]

(b) (i) (Brønsted-Lowry) acid-base/proton transfer/neutralisation/exothermic/reversible/equilibrium [1]

(ii)

(iii) (in NH₄F):

ionic: between NH₄⁺ & F⁻ or N⁺ & F⁻ or ammonium and fluor<u>ide</u> (i.e. in words) or between (oppositely charge) ions [1]

(iv) (reverse reaction, remember)

[9]

(c) (i)
$$4NH_3 + CuS + 2O_2 \rightarrow [Cu(NH_3)_4]SO_4$$
 [1]

- (iii) deep blue colour would change to light blue [NOT intensity of colour decreases] \Rightarrow hexaquocopper(II) ion or [Cu(H₂O)₆]²⁺ or [Cu(H₂O)_n(NH₃)_{a-n}]²⁺, where a = 4 or 6 or ligand exchange (of NH₃) by H₂O [1]
- (d) <u>ligand</u> exchange/substitution/displacement/replacement [IN WORDS] [1] (use of named ligands are OK instead of 'ligand'. e.g. "water is displaced by chloride")

formula of anion (see below for possibilities) [1]

halanced equation, e.g.
$$[Cu(H_0O)_0]^{2^+} + nCT \rightarrow [Cu(H_0O)_0, CI]^{2-n} + nH_0O$$
 [1]

balanced equation. e.g.
$$[Cu(H_2O)_6]^{2^+} + nCl \longrightarrow [Cu(H_2O)_{6-n}Cl_n]^{2-n} + nH_2O$$
 [1]

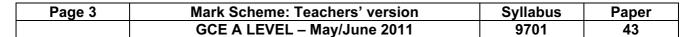
(Allow n=1 up to n=6. Also allow $[CuCl_n]^{2-n}$ as product. Examples from many possible are: $[Cu(H_2O)_6]^{2^+} + 2Cl^- \rightarrow [Cu(H_2O)_4Cl_2] + 2H_2O$

$$[Cu(H_2O)_6]^{2^+} + 4Ct \rightarrow [CuCt_4]^{2^-} + 6H_2O$$

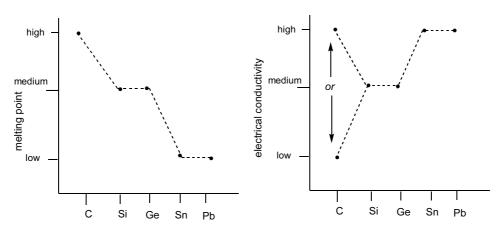
equation could include HC1 on the LHS, for example:

$$[Cu(H_2O)_6]^{2^+} + 4HCl \rightarrow H_2CuCl_4 + 2H^+ + 6H_2O \text{ or } \rightarrow CuCl_4^{2^-} + 4H^+ + 6H_2O$$
 [3]

[Total: 18 max 17]



2 (a) (i)



(ii) m. pt. trend: (from) giant/macro molecular/covalent to metallic bonding (or implied from at least two specific examples, e.g. diamond and tin) (mention of simple covalent anywhere negates this mark)

conductivity trend: increasing delocalisation of electrons (down the group) [1] or e⁻ are more free-moving

(or implied from at least two examples, e.g. Si is semiconductor, lead has delocalised e⁻) [6]

(b) (i) heat PbO₂, or T > 200°C or
$$\Delta$$
 on arrow: PbO₂ \rightarrow PbO + ½O₂ (N.B. ½O₂ NOT [O]) [1]

(ii) (burning CO in air produces
$$CO_2$$
):CO + $\frac{1}{2}O_2 \rightarrow CO_2$ [1] blue flame (ignore ref to limewater test) [1]

(iii) e.g.
$$SnCl_2(aq)$$
 will turn $KMnO_4$ from purple to colourless [1] $5Sn^{2+} + 2MnO_4^- + 16H^+ \rightarrow 5Sn^{4+} + 2Mn^{2+} + 8H_2O$ [1]

or SnC
$$l_2$$
(aq) will turn K₂Cr₂O₇ from orange to green [1] $3\text{Sn}^{2^+} + \text{Cr}_2\text{O}_7^{2^-} + 14\text{H}^+ \rightarrow 3\text{Sn}^{4^+} + 2\text{Cr}^{3^+} + 7\text{H}_2\text{O}$ [1]

or
$$SnCl_2(aq)$$
 will turn Fe^{3+} from orange/brown/yellow to green/colourless [1] $Sn^{2+} + 2Fe^{3+} \rightarrow Sn^{4+} + 2Fe^{2+}$ [1]

or $SnCl_2(aq)$ will turn $Cu^{2+}(aq)$ from blue to colourless or give a pink/brown/copper-coloured ppt. [1]

$$Sn^{2+} + Cu^{2+} \rightarrow Sn^{4+} + Cu$$
 [1]

Other possible oxidants (E^{e} must be > +0.2V) include: $S_{2}O_{8}^{2-}$, $H_{2}O_{2}$, C_{12} , Br_{2} , I_{2} and Ag^{+} . No observations with the first three of these, but this should be stated explicitly, e.g. "no colour change".

[5]

[2] + [2]

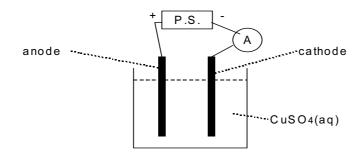
[1]

[Total: 11 max 10]

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3 (a)
$$L = F/e \text{ or } F = Le$$
 [1]

(b) (i)



correct cell (2 electrodes + PS circuit) [1] ammeter in series [1] anode and cathode of the right polarity [IN WORDS] [1]
$$CuSO_4(aq)$$
 or $CuCl_2(aq)$ or $Cu^{2+}(aq)$ or $soln$ or 1 mol dm⁻³ [1]

(ii)
$$n(Cu) = (52.542-52.243)/63.5 = 4.71 \times 10^{-3} \text{ mol } (4.67 \times 10^{-3})$$
 [1] $n(e^{-})$ required = $4.71 \times 10^{-3} \times 2 = 9.42 \times 10^{-3} \text{ mol } (9.34 \times 10^{-3})$ ecf [1]

amount of electricity passed =
$$0.5 \times 30 \times 60 = 900 \text{ C}$$

no. of electrons passed = $900/1.6 \times 10^{-19} = 5.625 \times 10^{21}$ ecf [1]

no of electrons/n(e⁻) = L =
$$5.625 \times 10^{21}/9.42 \times 10^{-3} = 5.97 \times 10^{23} \text{ mol}^{-1} (6.02 \times 10^{23})$$
 ecf [1]

(values in italics are if candidate has used $A_r = 64$, not 63.5. No last mark if not 3 s.f.: correct ans = [5])

(c)

compound	product at anode	product at cathode	
AgF	O ₂	Ag	
FeSO ₄	O ₂	H ₂	
MgBr ₂	Br ₂	H ₂	

6 correct \Rightarrow [5] 5 correct \Rightarrow [4] etc.

Names can be used instead of symbols. If the atomic symbol (e.g. Br or H or O) is used instead of the molecular formula (e.g. Br₂ etc.) then deduct [1] mark only for the whole table.

[5]

[Total: 15]

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4 (a) (i) (allow displayed, structural or skeletal formula)

(iv) e.g. add (2,4-)DNPH or DNP or Brady's reagent orange or red ppt forms (NOT yellow) ecf [1] (or could use Fehling's or Tollens', or
$$H^+ + Cr_2O_7^{2-}$$
: orange to green, or $H^+ + MnO_4^-$: purple to colourless) [6]

(b) (i) (allow displayed, structural or skeletal formula)

correct repeat unit bracketed (any 3 atoms in chain)

(ii) ester [1]

[1]

[5]

(iii) **E** is CH₃CH₂CH(OH)CO₂H (*or* skeletal structure etc.)(2-hydroxybutanoic acid) [1] allow ecf here from the formula of the repeat unit shown in **(b)(i)**

(iv) condensation (polymerisation) [1]

(v) they have the same "molecular" formula or C₄H₆O₂ (do **NOT** allow empirical formula) or same no. and type of atoms or same functional group or both are esters or they are isomers

[1]

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(c) (i) optical isomerism (or chiral) [1]

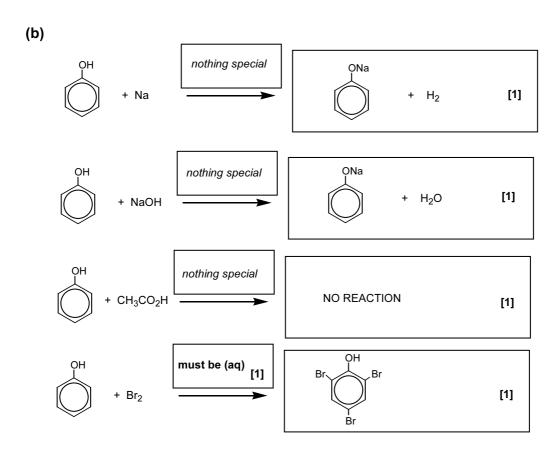
(letters may be reversed)(allow ecf from **E**, also allow ecf for **G** from **F**) [1] + [1]

cis-trans *or* geometrical isomerism [1]

[Total: 15]

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(a) acidity: ethanol < water due to +ve inductive effect of C₂H₅ group or C₂H₅ gives e⁻ to oxygen or intensifies e⁻ (in O-H bond)
 acidity: phenol > water
 due to stabilisation of the anion/anionic charge or makes the anion less basic
 [1]
 [1]



[5]

[1]

reagents & conditions:

step 1 **dilute** HNO₃ (dilute, not just 'aq'. H₂SO₄ negates) [1]

step 2 Sn/SnC l_2 /Fe + HCl or H₂ + Ni/Pd (NOT H₂ + Pt. NOT LiAlH₄ or NaBH₄) [1]

step 3 $CH_3COClor(CH_3CO)_2O$ ('aq.' negates) [1]

[Total: 13]

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6 (a) They are polar/ionic *or* can hydrogen-bond *or* are hydrophilic. (NOT 'contain the –OH group', on its own)

[1]

(b) (i) Primary structure is the sequence/order of amino acids

[1] [1]

Secondary structure is the H-bonding between C=O & N-H *or* peptide group/bonds Tertiary structure gives the (overall) 3D structure/shape/folding/globularity (not 'coiling' on its own)

or mention of at least one method of forming the 3° structure, e.g.; hydrogen bonding **between R-groups/side chains**; –S-S- bridges; van der Waals forces; ionic interactions

[1]

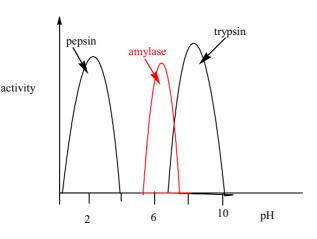
- (ii) The 3° structure provides a complementary shape to that of the <u>substrate</u> or it provides the right/specifically shaped cavity for the <u>substrate</u>. (NOT just 'a cleft') or provides nearby groups to aid the reactions of the <u>substrate</u> (owtte) [1]
- (iii) Two conditions out of the following:
 - (a) Increased temperature
 - (b) Decreased temperature
 - (c) Change in pH
 - (d) Addition of heavy metals (or specified, e.g. Hg/Ag)
 - (e) Addition of inhibitors (competitive or non-competitive)

Suitable reasons:

- (i) 3D structure changes shape/is deformed/is broken *or* R-R interactions (or a specific example, e.g. H-bonding) are broken
- (ii) inhibitor occupies active site.
- (iii) either fewer substrate molecules with $E > E_a$ or fewer successful collisions

[2] **[6]**

(c) (i)



left hand peak labelled as pepsin right hand peak labelled as trypsin

(Correct enzymes, but wrong way round, scores [1] only)

[1] [1]

(ii) Peak between pH 6 and pH 8, and correct name (amylase)

[1] **[3]**

[Total: 10]

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7 (a)

Number	Process	Correct sequence (numbers)	
Α	Place samples on agarose gel	4	
В	Use polymerase chain reaction	3	
С	Label with radioactive isotope	6	
D	Extract DNA	1	
E	Use restriction enzyme	2	
F	Carry out electrophoresis	5	

mark as follows: if \mathbf{A} is just before \mathbf{F} (i.e. $\mathbf{A} = 4$, $\mathbf{F} = 5$ or $\mathbf{A} = 5$, $\mathbf{F} = 6$) [1] mark if $\mathbf{C} = 6$ [1] mark [1] mark [3]

(b) (i) P *or* phosphorus (NOT phosphate)

[1]

(ii) Phosphate groups are present in DNA *or* it makes the DNA fragments/bands etc. visible *or* locates their position *or* identifies them on a photographic plate etc. [1] (NOT because it's radioactive *or* makes the bands coloured)

[2]

- (c) (i) Yes, all 4 children share one/some band (or match/gene/fragment/part/DNA/ amino acid) with the mother's (DNA) (NOT the general statement "matches the mother's DNA") [1]
 - (ii) Child **2**, since he/she shares none of the bands of father's DNA/fingerprint *or* their fingerprint/DNA does not match the father's DNA (the general "match" is OK here) [1] [2]
- (d) (i) Compare DNA fingerprint for **each** fragment (can be read into use of the word 'same' below)

 [1]

 Match the DNA patterns to determine which came from which skin

 [1]
 - (ii) A named example of biological origin (N.B. a material, not a whole organism) [1] e.g. leather (= bull skin), pollen, fish scales, leaves, seeds, feathers, hair, blood, textiles (or a named one like wool or silk or cotton or linen/flax), wood.
 - (N.B. NOT human or goat skin, also not metal, pottery or stone. If more than one material is given, mark the first one)

[3]

[Total: 10]

Pa	ge 10	Mark Scheme: Teachers' version	Syllabus	Paper
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3 (a)		e should be from 10^{-6} – 10^{-7} (the left hand arrow) $^{-8}$ – 10^{-9} (the right hand arrow)		[1] [1] [2]
(b)	with o	s of the same element (<i>or</i> of carbon , since carbon ifferent structures/arrangements of atoms 'different molecular structure', but not structurates the mark.	·	´ [1]
				[2]
(c)	or pa	particles are smaller than (animal) cells <i>or</i> they cass into/between cells can be bound to/enclosed by the nanoparticle	an pass through the cell	membrane [1] [1] [2]
(d)	(i) I	Reduction/redox		[1]
		M_r of chalcopyrite is 63.5 + 56 + 64 = 183.5 Mass of copper present is 63.5		
	I	Hence percentage of copper present = $\frac{63.5 \times 100}{183.5}$	= 34.6%	[1]
	($f A_r(Cu) = 64$ is used, ans = 34.8%. allow 34–35	%)	

(iii) If the ore contains 2% of chalcopyrite by mass, calculate how much copper is produced from each tonne of ore.

1 tonne = 1000 kg

1 tonne of chalcopyrite would produce 346 kg of copper

1 tonne of 2 % ore would produce 346×0.02 or **6.9** kg of copper ecf from **(d)(ii)** [1] (accept **7.0** or 7 kg)

answer may be given as 7000 g or 7×10^{-3} tonnes. If no units are given, assume they are tonnes, and mark accordingly)

(iv) By displacement with a metal (the following specified metals higher than Cu in the ECS may be used: Fe, Zn, Sn, Pb, A*l*, Mg. (NOT Ca, Li, Na. K etc.) *or* with a suitable non-metallic reducing agent, e.g. SO₂ or Sn²⁺, but not something that wouldn't react, like H₂ *or* By electrolysis (with carefully controlled voltage) [1]

[Total: 10]

[4]