UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the May/June 2011 question paper

for the guidance of teachers

9701 CHEMISTRY

9701/42 Paper 4 (A2 Structured Questions), maximum raw mark 100

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UNIVERSITY of CAMBRIDGE
International Examinations

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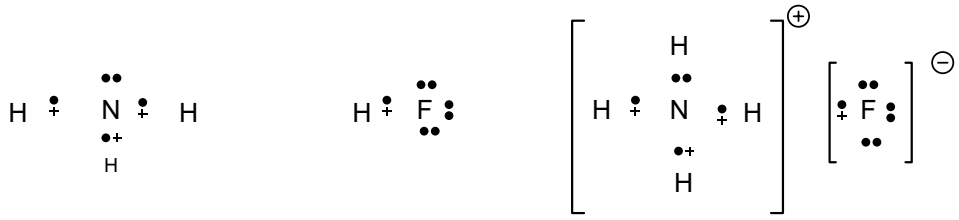
1 **(a)** $[H^+] = \sqrt{(0.05 \times 5.6 \times 10^{-4})} = 5.29 \times 10^{-3}$ mol dm^{-3} [1]
$pH = -\log_{10}(5.29 \times 10^{-3}) = 2.3$ [1]
[2]

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

(ii)



[1] [1] [1] 3 x [1]

(iii) *(in NH_4F):*
covalent: between N & H [1]
dative: between N & H [1]
ionic: between NH_4^+ & F *or* N^+ & F *or* ammonium and fluor**ide** (i.e. in words) *or* between (oppositely charge) ions [1]

(iv) (***reverse*** *reaction, remember*)
high temperature, because reverse reaction is endothermic [1]
low pressure, because reverse reaction causes an increase in no. of gaseous molecules *or* an increase in partial pressure/volume. [1]
[9]

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

(ii) deep/dark/royal blue *or* purple [NOT violet] [1]

(iii) deep blue colour would change to light blue [NOT intensity of colour decreases] [1]
$\Rightarrow$ hexaquocopper(II) ion *or* $[Cu(H_2O)_6]^{2+}$ *or* $[Cu(H_2O)_n(NH_3)_{a-n}]^{2+}$, where a = 4 or 6 *or* ligand exchange (of NH_3) by H_2O [1]
[4]

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

(Allow n=1 up to n=6. Also allow $[CuCl_n]^{2-n}$ as product. Examples from many possible are:
$[Cu(H_2O)_6]^{2+} + 2Cl \rightarrow [Cu(H_2O)_4Cl_2] + 2H_2O$
$[Cu(H_2O)_6]^{2+} + 4Cl \rightarrow [CuCl_4]^{2-} + 6H_2O$
equation could include HCl on the LHS, for example:
$[Cu(H_2O)_6]^{2+} + 4HCl \rightarrow H_2CuCl_4 + 2H^+ + 6H_2O$ *or* $\rightarrow CuCl_4^{2-} + 4H^+ + 6H_2O$ **[3]**

[Total: 18 max 17]

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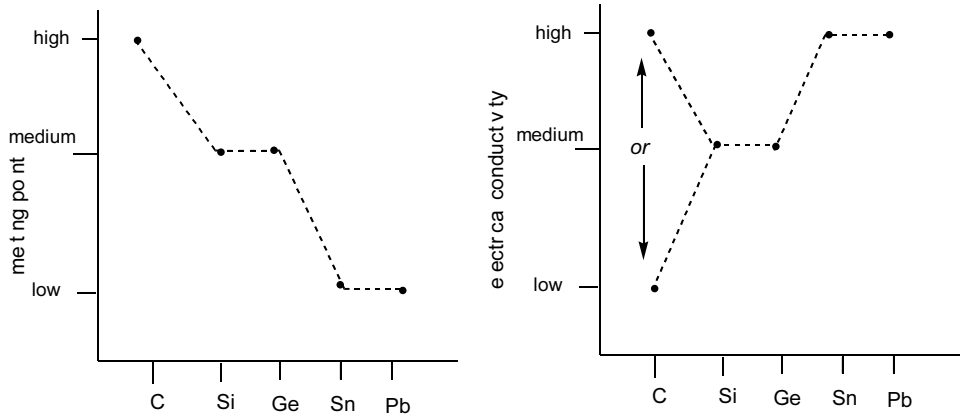
2 (a) (i)



[2] + [2]

(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) [1]
(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 PbO_2, or T > 200°C *or* Δ on arrow: $PbO_2 \rightarrow PbO + ½O_2$ (N.B. $½O_2$ NOT [O]) [1]

(ii) (burning CO in air produces CO_2):$CO + ½O_2 \rightarrow CO_2$ [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 $SnCl_2$(aq) will turn $K_2Cr_2O_7$ from orange to green [1]
$3Sn^{2+} + Cr_2O_7^{2-} + 14H^+ \rightarrow 3Sn^{4+} + 2Cr^{3+} + 7H_2O$ [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 ($E^{\ominus}$ must be > +0.2V) include: $S_2O_8^{2-}$, H_2O_2, Cl_2, 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]

[Total: 11 max 10]

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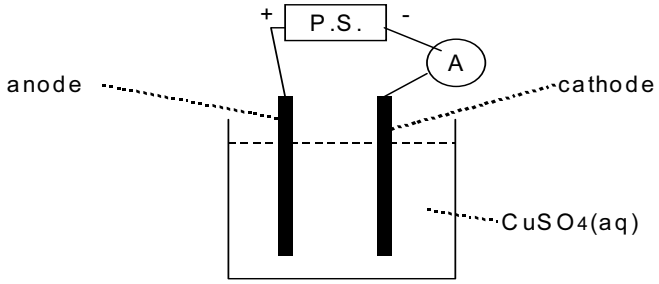
3 **(a)** L = F/e *or* F = Le [1]
[1]

(b) **(i)**



[allow the conventional symbol ⊣▮ to represent + ▭ – (the "P.S." is not required)]

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 = 4.71×10^{-3} mol (4.67×10^{-3}) [1]
n(e) required = $4.71 \times 10^{-3} \times 2$ = **9.42×10^{-3}** mol (9.34×10^{-3}) ecf [1]

amount of electricity passed = $0.5 \times 30 \times 60$ = 900 C [1]
no. of electrons passed = $900/1.6 \times 10^{-19}$ = **5.625×10^{21}** ecf [1]

no of electrons/n(e) = L = $5.625 \times 10^{21}/9.42 \times 10^{-3}$ = **5.97×10^{23}** mol^{-1} (6.02×10^{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])
[9]

(c)

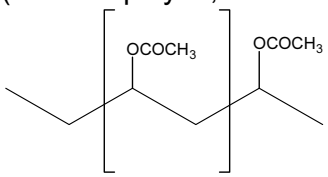
compound	product at anode	product at cathode
AgF	O_2	Ag
$FeSO_4$	O_2	H_2
$MgBr_2$	Br_2	H_2

6 correct ⇒ [5]
5 correct⇒ [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. Br_2 etc.) then deduct [1] mark only for the whole table.
[5]

[Total: 15]

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



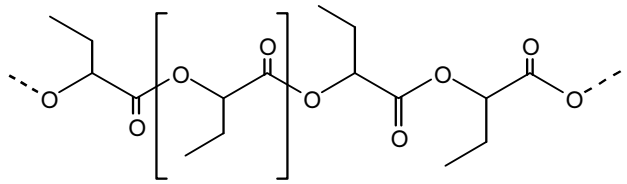
chain [1]
repeat unit [1]

(ii) **C** should be CH_2=CHOH (*or* skeletal formula) [1]

(iii) **C** is CH_3CH=O (*or* skeletal formula) [1]

(iv) e.g. add (2,4-)DNPH *or* DNP *or* Brady's reagent ecf [1]
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)



D

correct repeat unit bracketed (any 3 atoms in chain) [1]

(ii) ester [1]

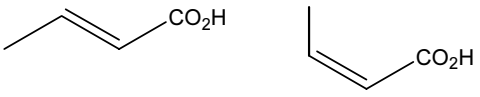
(iii) **E** is $CH_3CH_2CH(OH)CO_2H$ (*or* skeletal structure etc.)(2-hydroxybutanoic acid) [1]
allow ecf here from the formula of the repeat unit shown in **(b)(i)**

(iv) <u>condensation</u> (polymerisation) [1]

(v) they have the same "molecular" formula *or* $C_4H_6O_2$ (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]
[5]

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

(ii)



F **G**

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

cis-trans *or* geometrical isomerism [1]
[4]

[Total: 15]

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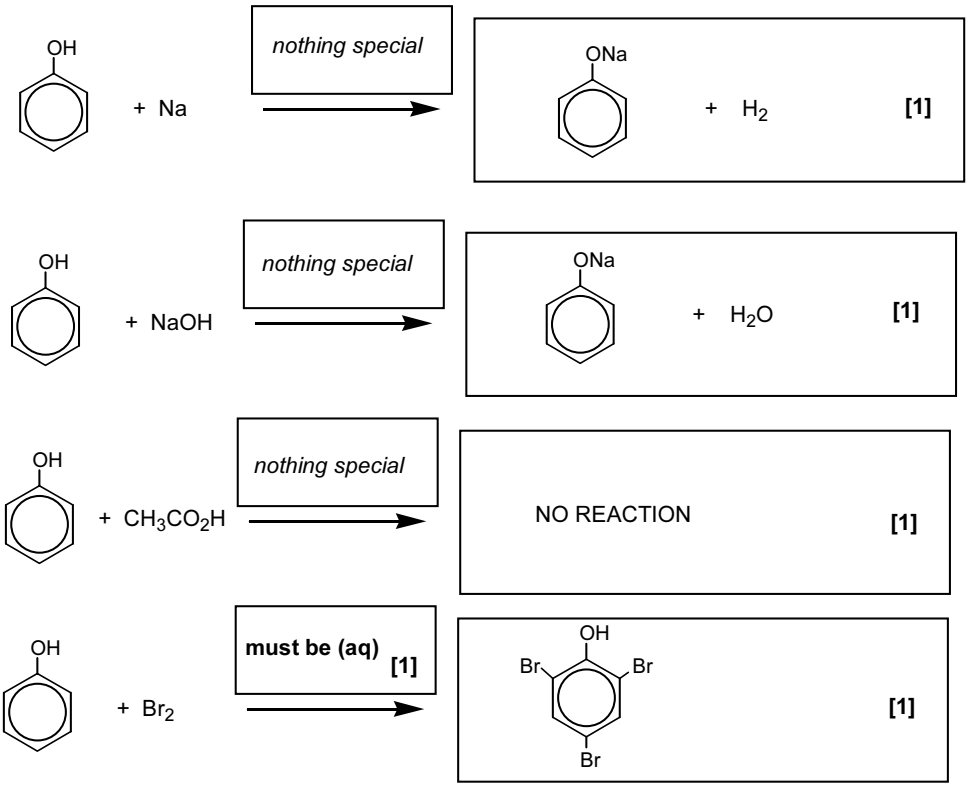
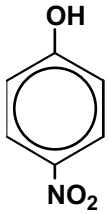
5 **(a)** acidity: ethanol < water [1]
due to +ve inductive effect of C_2H_5 group *or* C_2H_5 gives e to oxygen *or* intensifies e (in O-H bond) [1]
acidity: phenol > water [1]
due to stabilisation of the anion/anionic charge *or* makes the anion less basic [1]
[4]

(b)



[5]

(c) **H** is



[1]

reagents & conditions:
step 1 **dilute** HNO_3 (dilute, not just 'aq'. H_2SO_4 negates) [1]

step 2 Sn/SnCl_2/Fe + HCl *or* H_2 + Ni/Pd (NOT H_2 + Pt. NOT LiA$l$$H_4$ or $NaBH_4$) [1]

step 3 CH_3COCl *or* $(CH_3CO)_2O$ ('aq.' negates) [1]
[4]

[Total: 13]

6 **(a)** They are polar/ionic *or* can hydrogen-bond *or* are hydrophilic. [1]
(NOT 'contain the –OH group', on its own)

[1]

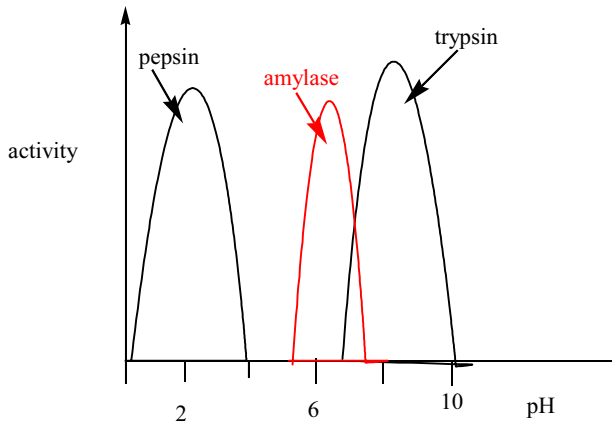
(b) **(i)** Primary structure is the sequence/order of amino acids [1]
Secondary structure is the H-bonding between C=O & N-H *or* peptide group/bonds [1]
Tertiary structure gives the (overall) 3D structure/shape/folding/globularity
(not 'coiling' on its own)
or mention of at least one method of forming 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 substrate
or it provides the right/specifically shaped cavity for the substrate. (NOT just 'a cleft')
or provides nearby groups to aid the reactions of the substrate (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 [1]
right hand peak labelled as trypsin [1]
(Correct enzymes, but wrong way round, scores [1] only)

(ii) Peak between pH 6 and pH 8, **and** correct name (amylase) [1]

[3]

[Total: 10]

7 (a)

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

mark as follows: if **A** is **just** before **F** (i.e. **A** = 4, **F** = 5 *or* **A** = 5, **F** = 6) [1] mark
if **D** = 1 and **E** = 2 [1] mark
if **C** = 6 [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]

8 **(a)** Range should be from 10^{6}–10^{7} (the left hand arrow) [1]
to 10^{8}–10^{9} (the right hand arrow) [1]
[2]

(b) Forms of the **same element** (*or* of **carbon**, since carbon is the context of the question) [1]
with different structures/arrangements of atoms [1]
allow 'different molecular structure', but not structural formula. Any mention of 'compound' negates the mark.
[2]

(c) Nanoparticles are smaller than (animal) cells *or* they can pass through the cell membrane *or* pass into/between cells [1]
Drugs can be bound to/enclosed by the nanoparticle [1]
[2]

(d) **(i)** Reduction/redox [1]

(ii) M_r of chalcopyrite is 63.5 + 56 + 64 = 183.5
Mass of copper present is 63.5

Hence percentage of copper present = $\frac{63.5 \times 100}{183.5}$ = 34.6% [1]
(if 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. SO_2 or Sn^{2+}, but not something that wouldn't react, like H_2
or By electrolysis (with carefully controlled voltage) [1]
[4]

[Total: 10]