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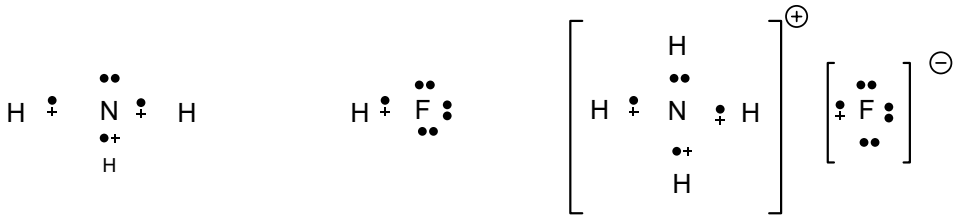
**1** **(a)** $[H^+] = \sqrt{(0.05 \times 5.6 \times 10^{-4})} = 5.29 \times 10^{-3}$ mol dm$^{-3}$ [1]
$pH = -\log_{10}(5.29 \times 10^{-3}) = 2.3$ [1]
**[2]**

**(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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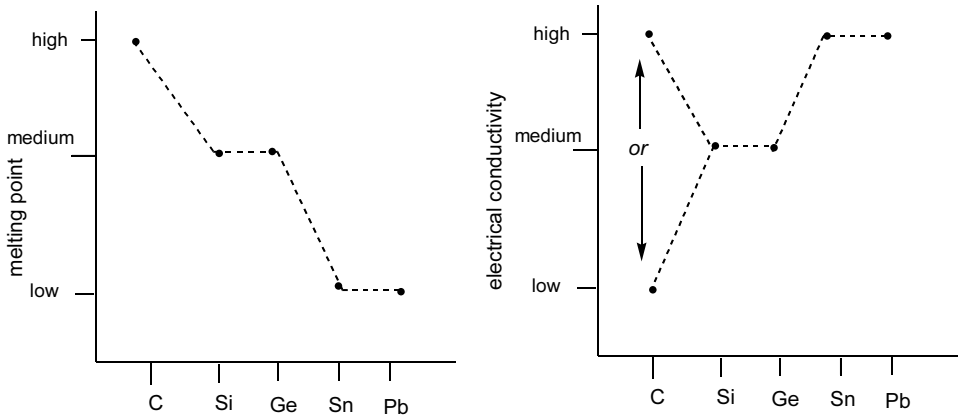
**2 (a) (i)**




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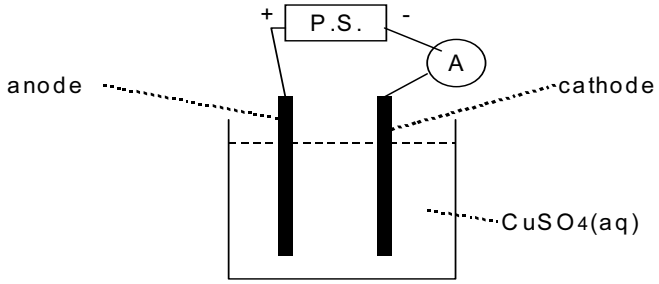
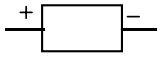
**3 (a)** L = F/e *or* F = Le [1]
**[1]**

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

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

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

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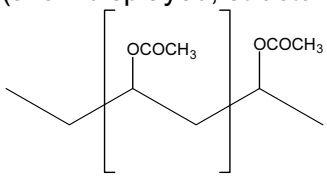
**4 (a) (i)** (allow displayed, structural or skeletal formula)



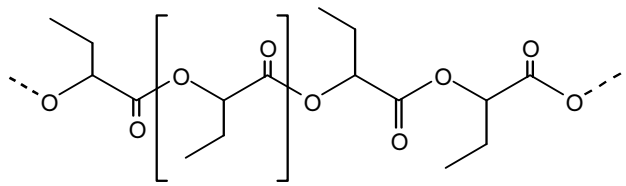

chain [1]
repeat unit [1]

**(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]**

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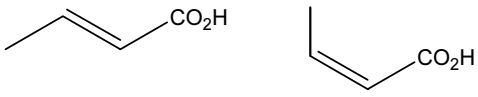
**(c) (i)** optical isomerism (*or* chiral) [1]

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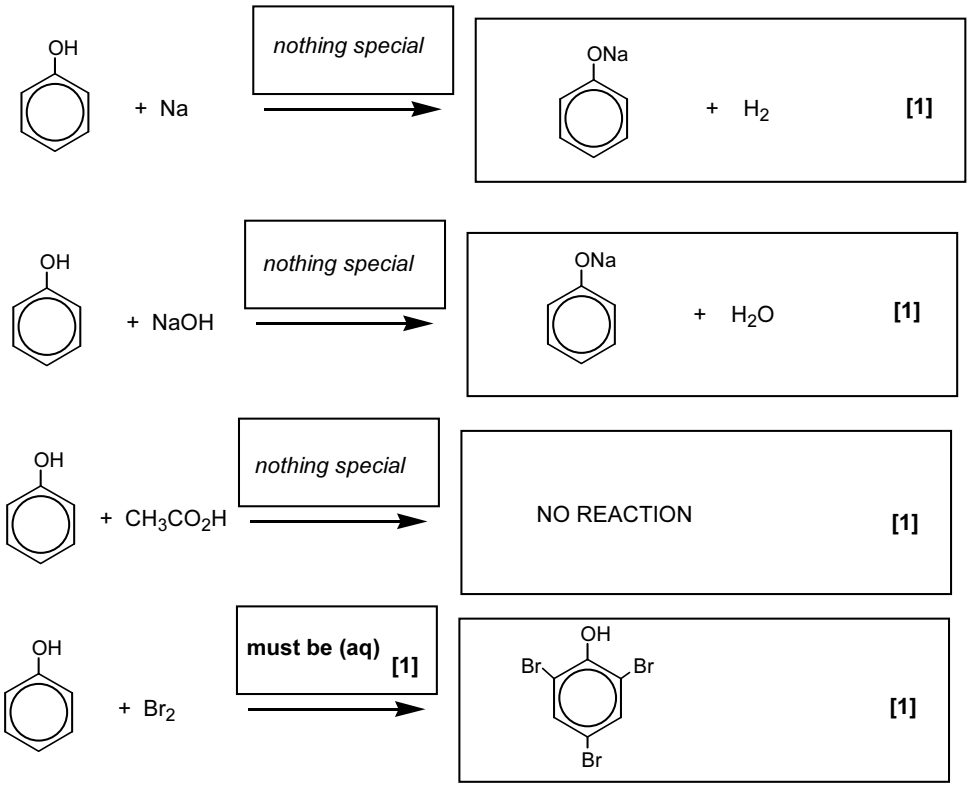
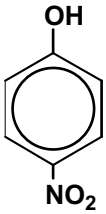
**5 (a)** acidity: ethanol < water [1]
due to +ve inductive effect of $C_2H_5$ group *or* $C_2H_5$ gives $e^-$ to oxygen *or* intensifies $e^-$ (in O-H bond) [1]
acidity: phenol > water [1]
due to stabilisation of the anion/anionic charge *or* makes the anion less basic [1]
**[4]**

**(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 + HC*l* *or* $H_2$ + Ni/Pd (NOT $H_2$ + Pt. NOT $LiAlH_4$ or $NaBH_4$) [1]

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

**[Total: 13]**

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

**[1]**

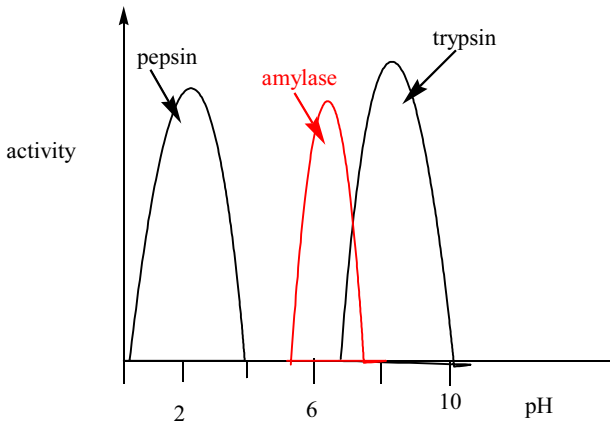
**(b)** **(i)** Primary structure is the sequence/order of amino acids [1]
Secondary structure is the H-bonding between C=O & N-H *or* peptide group/bonds [1]
Tertiary structure gives the (overall) 3D structure/shape/folding/globularity
(not 'coiling' on its own)
*or* mention of at least one method of 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]**

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**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]**

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**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]**

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