

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

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.

Mark schemes must be read in conjunction with the question papers and the report on the examination.

- Cambridge will not enter into discussions or correspondence in connection with these mark schemes.

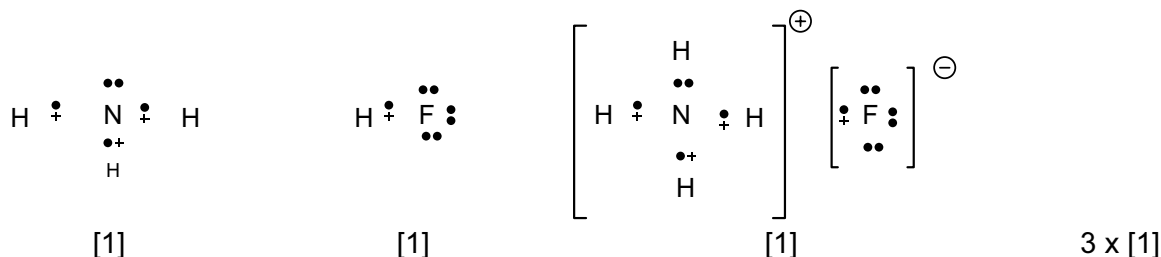
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- 1 (a)  $[H^+] = \sqrt{(0.05 \times 5.6 \times 10^{-4})} = 5.29 \times 10^{-3} \text{ mol dm}^{-3}$  [1]  
 $\text{pH} = -\log_{10}(5.29 \times 10^{-3}) = 2.3$  [1]  
[2]

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

(ii)



- (iii) (in  $\text{NH}_4\text{F}$ ):  
covalent: between N & H [1]  
dative: between N & H [1]  
ionic: between  $\text{NH}_4^+$  & F or  $\text{N}^+$  & F or ammonium and fluoride (i.e. in words) [1]  
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 [1]  
or an increase in partial pressure/volume. [1]  
[9]

- (c) (i)  $4\text{NH}_3 + \text{CuS} + 2\text{O}_2 \rightarrow [\text{Cu}(\text{NH}_3)_4]\text{SO}_4$  [1]

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

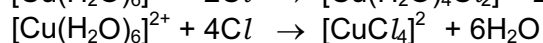
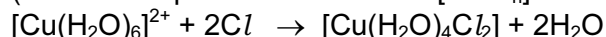
- (iii) deep blue colour would change to light blue [NOT intensity of colour decreases] [1]  
 $\Rightarrow$  hexaquacopper(II) ion or  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$  or  $[\text{Cu}(\text{H}_2\text{O})_n(\text{NH}_3)_a]^{2+}$ , where  $a = 4$  or  $6$  [1]  
or ligand exchange (of  $\text{NH}_3$ ) by  $\text{H}_2\text{O}$  [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")

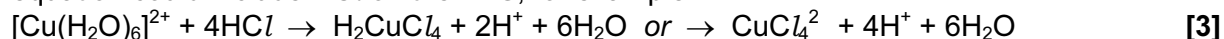
formula of anion (see below for possibilities) [1]

balanced equation. e.g.  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + n\text{Cl}^- \rightarrow [\text{Cu}(\text{H}_2\text{O})_6-n\text{Cl}_n]^{2-n} + n\text{H}_2\text{O}$  [1]

(Allow  $n=1$  up to  $n=6$ . Also allow  $[\text{CuCl}_n]^{2-n}$  as product. Examples from many possible are:



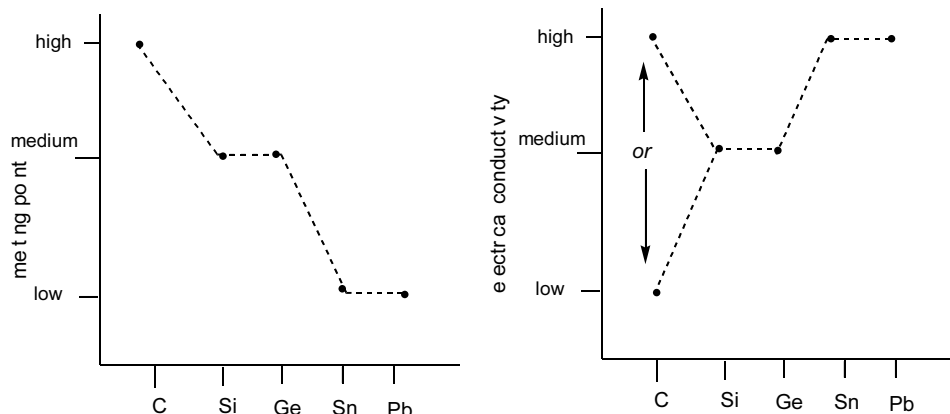
equation could include  $\text{HCl}$  on the LHS, for example:



[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  $\text{PbO}_2$ , or  $T > 200^\circ\text{C}$  or  $\Delta$  on arrow:  $\text{PbO}_2 \rightarrow \text{PbO} + \frac{1}{2}\text{O}_2$  (N.B.  $\frac{1}{2}\text{O}_2$  NOT [O]) [1]

(ii) (burning CO in air produces  $\text{CO}_2$ ):  $\text{CO} + \frac{1}{2}\text{O}_2 \rightarrow \text{CO}_2$  [1]  
blue flame (ignore ref to limewater test) [1]

(iii) e.g.  $\text{SnCl}_2(\text{aq})$  will turn  $\text{KMnO}_4$  from purple to colourless [1]  
 $5\text{Sn}^{2+} + 2\text{MnO}_4^- + 16\text{H}^+ \rightarrow 5\text{Sn}^{4+} + 2\text{Mn}^{2+} + 8\text{H}_2\text{O}$  [1]

*or*  $\text{SnCl}_2(\text{aq})$  will turn  $\text{K}_2\text{Cr}_2\text{O}_7$  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*  $\text{SnCl}_2(\text{aq})$  will turn  $\text{Fe}^{3+}$  from orange/brown/yellow to green/colourless [1]  
 $\text{Sn}^{2+} + 2\text{Fe}^{3+} \rightarrow \text{Sn}^{4+} + 2\text{Fe}^{2+}$  [1]

*or*  $\text{SnCl}_2(\text{aq})$  will turn  $\text{Cu}^{2+}(\text{aq})$  from blue to colourless *or* give a pink/brown/copper-coloured ppt. [1]  
 $\text{Sn}^{2+} + \text{Cu}^{2+} \rightarrow \text{Sn}^{4+} + \text{Cu}$  [1]

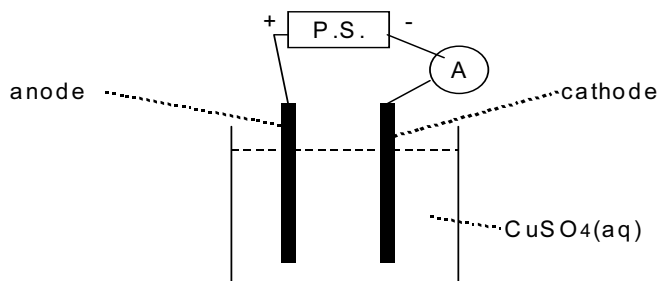
Other possible oxidants ( $E^\ominus$  must be  $> +0.2\text{V}$ ) include:  $\text{S}_2\text{O}_8^{2-}$ ,  $\text{H}_2\text{O}_2$ ,  $\text{Cl}_2$ ,  $\text{Br}_2$ ,  $\text{I}_2$  and  $\text{Ag}^+$ . No observations with the first three of these, but this should be stated explicitly, e.g. "no colour change". [5]


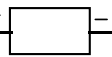
[Total: 11 max 10]

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]

$\text{CuSO}_4(\text{aq})$  or  $\text{CuCl}_2(\text{aq})$  or  $\text{Cu}^{2+}(\text{aq})$  or soln or  $1 \text{ mol dm}^{-3}$

[1]

(ii)  $n(\text{Cu}) = (52.542 - 52.243)/63.5 = 4.71 \times 10^{-3} \text{ mol}$  ( $4.67 \times 10^{-3}$ )

[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 =  $0.5 \times 30 \times 60 = 900 \text{ C}$

[1]

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

ecf [1]

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

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])

[9]

(c)

compound	product at anode	product at cathode
AgF	$\text{O}_2$	Ag
$\text{FeSO}_4$	$\text{O}_2$	$\text{H}_2$
$\text{MgBr}_2$	$\text{Br}_2$	$\text{H}_2$

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

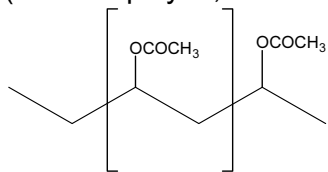
Names can be used instead of symbols. If the atomic symbol (e.g. Br or H or O) is used instead of the molecular formula (e.g.  $\text{Br}_2$  etc.) then deduct [1] mark only for the whole table.

[5]

[Total: 15]

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



chain [1]  
repeat unit [1]

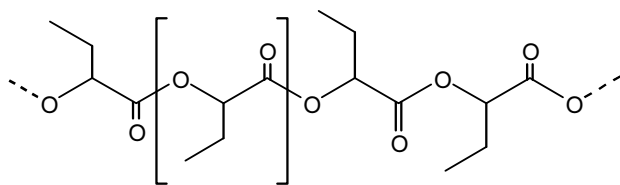
(ii) C should be CH<sub>2</sub>=CHOH (or skeletal formula) [1]

(iii) C is CH<sub>3</sub>CH=O (or skeletal formula) [1]

(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', ecf [1]  
or H<sup>+</sup> + Cr<sub>2</sub>O<sub>7</sub><sup>2-</sup> : orange to green, or H<sup>+</sup> + MnO<sub>4</sub><sup>-</sup> : 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<sub>3</sub>CH<sub>2</sub>CH(OH)CO<sub>2</sub>H (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]

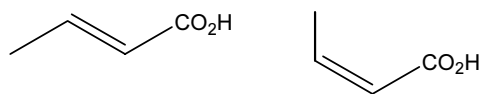
(v) they have the same "molecular" formula or C<sub>4</sub>H<sub>6</sub>O<sub>2</sub> (do **NOT** allow empirical formula) or same no. and type of atoms or same functional group or both are esters or they are isomers [1]

[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]

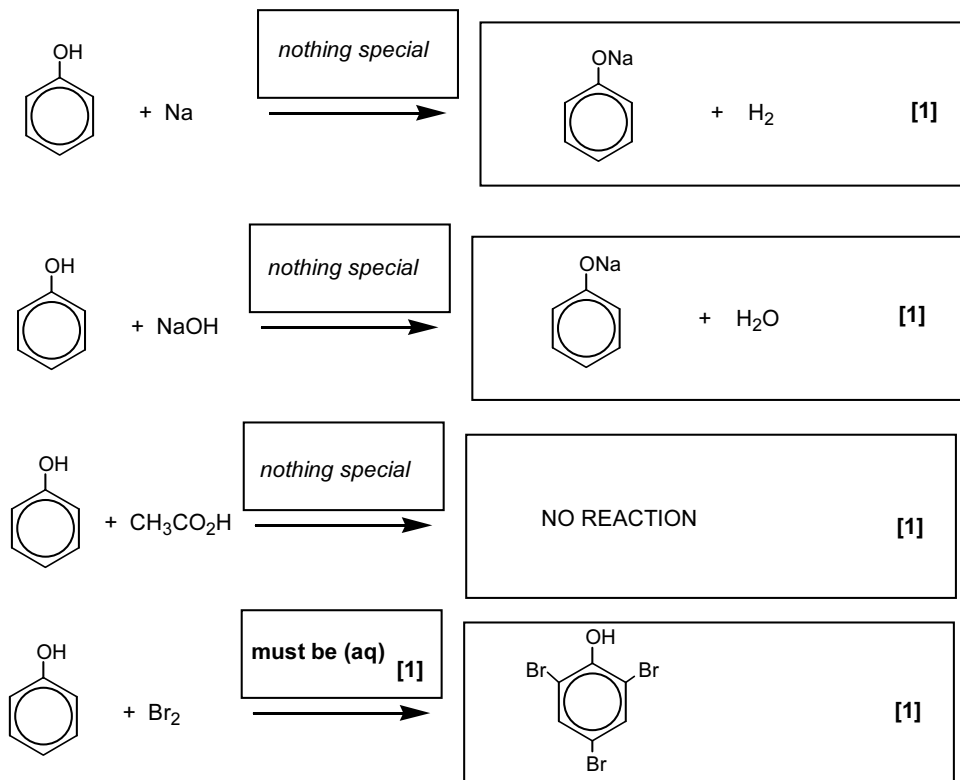
[4]

[Total: 15]

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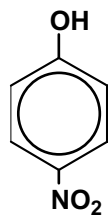
- 5 (a) acidity: ethanol < water [1]  
 due to +ve inductive effect of C<sub>2</sub>H<sub>5</sub> group or C<sub>2</sub>H<sub>5</sub> gives e<sup>-</sup> to oxygen or intensifies e<sup>-</sup> (in O-H bond) [1]  
 acidity: phenol > water [1]  
 due to stabilisation of the anion/anionic charge or makes the anion less basic [1]  
**[4]**

(b)



**[5]**

(c) H is



[1]

reagents & conditions:

step 1 **dilute** HNO<sub>3</sub> (dilute, not just 'aq'. H<sub>2</sub>SO<sub>4</sub> negates)

[1]

step 2 Sn/SnCl<sub>2</sub>/Fe + HCl or H<sub>2</sub> + Ni/Pd (NOT H<sub>2</sub> + Pt. NOT LiAlH<sub>4</sub> or NaBH<sub>4</sub>)

[1]

step 3 CH<sub>3</sub>COCl or (CH<sub>3</sub>CO)<sub>2</sub>O ('aq.' negates)

[1]

**[4]**

**[Total: 13]**

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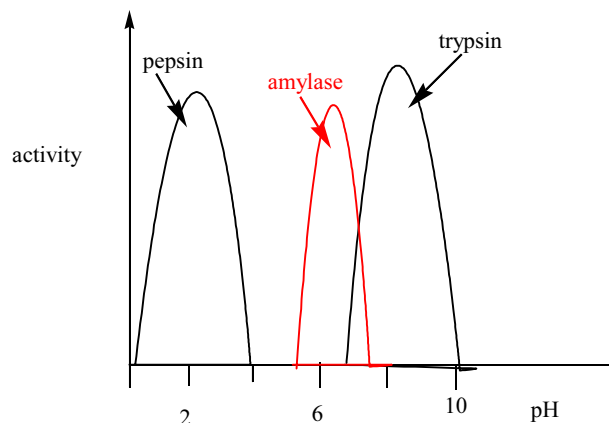
- 6 (a) They are polar/ionic *or* can hydrogen-bond *or* are hydrophilic. [1]  
(NOT 'contain the –OH group', on its own) [1]

- (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]



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 [1]  
or pass into/between cells [1]  
Drugs can be bound to/enclosed by the nanoparticle [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  $A_r(\text{Cu}) = 64$  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  $346 \times 0.02$  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  $7 \times 10^3$  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, Al, Mg. (NOT Ca, Li, Na, K etc.) or with a suitable non-metallic reducing agent, e.g.  $\text{SO}_2$  or  $\text{Sn}^{2+}$ , but not something that wouldn't react, like  $\text{H}_2$  or By electrolysis (with carefully controlled voltage) [1]  
[4]

[Total: 10]