**UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS**

**GCE Advanced Subsidiary Level and GCE Advanced Level**

# MARK SCHEME for the May/June 2007 question paper

## 9701 CHEMISTRY

**9701/04** 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.

All Examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

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

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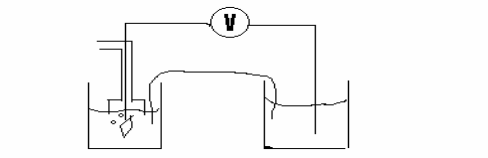
**1 (a)**



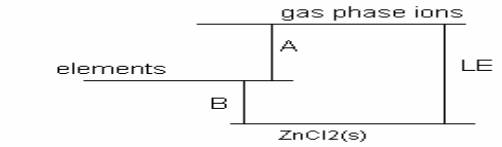

salt bridge + voltmeter [1]
zinc metal + $Zn^{2+}$ [1]
$H_2$ (in, *not* out) + $H^+$ [1]
Pt electrode [1]
all solutions at 1 mol $dm^{-3}$ [1]
T = 298K *or* 25°C [1] **[6]**

**(b)**

| conditions | product at anode | product at cathode |
|---|---|---|
| $ZnCl_2$(l) | *(chlorine)* | ***zinc* [1]** |
| $ZnCl_2$(conc aq) | ***chlorine* [1]** | *($H_2$ or zinc) (ignore)* |
| $ZnCl_2$(dil aq) | ***oxygen* [1]** | ***hydrogen* [1]** |

[1] for each product in correct place [4] **[4]**

**(c)**




LE = B – A
= –415 – (131 + 908 + 1730) – {244 + 2(–349)}
[1] [1]
= –415 – 2315
= –2730 (kJ $mol^{-1}$) [1]
(correct answer = [3]: deduct [1] for each error) **[3]**

**(d) (i)**

- instrumental method (e.g. spectrophotometer/colorimeter/conductance meter)
- what is measured (e.g. absorbance/transmission at a **stated** wavelength *or* by use of a "suitable" (green) filter *or* conductance/resistance)
- measurement of time
- relation of time to rate (e.g. gradient of absorbance/time graph, *or* rate $\propto$ 1/t)
- repeat with different $[Zn^{2+}]$, (but the same [PAR])
- relation of rate to $[Zn^{2+}]$ (either by a plot or by simple proportion)

*(all 6 points are unconditional on each other)* any 5 points **[5]**

**(ii)** e.g. add $Br_2$(aq) [1]
decolourises *or* produces a white ppt. [1]
*or add $FeCl_3$(aq or "neutral"); purple colour produced* *[1] + [1]* **[2]**

**[Total: 20]**

**2** **(a)** $2Ca(NO_3)_2 \longrightarrow 2CaO + 4NO_2 + O_2$ (*or* x ½ ) [1] **[1]**

**(b)** more stable down the group (*or* higher temperature needed) [1]
(cat)**ionic** size/radius increases down the group
(*or* **ionic** charge density decreases) [1]
distortion/polarisation of anion/nitrate (ion) decreases [1] **[3]**

**(c)** **(i)** $16 = O^+$ $17 = OH^+$ $18 = H_2O^+$ *(ignore charges)* all 3 [1]
$14 = N^+$ $16 = O^+$ $28 = N_2^+$ $30 = NO^+$ $44 = N_2O^+$ all 5 [3]
*any 4* *[2]*
*(ignore charges)* *any 3* *[1]*
$\therefore$ **A** = $H_2O$ **and** **B** = $N_2O$ (or in equation below) [1]

**(ii)** $NH_4NO_3 \longrightarrow N_2O + 2H_2O$ [1] **[6]**

**[Total: 10 max. 9]**

**3** **(a)** **(i)** $2CO + O_2 \longrightarrow 2CO_2$
$2PbO_2 \longrightarrow 2PbO + O_2$ } *(or x ½)* [1]

**(ii)** +4 state becomes less stable down the group [1]
*or* +2 state becomes more stable down the group **[2]**

**(b)** **(i)** $Pb^{II} : Pb^{IV} = 2:1$ [1]

**(ii)** $Pb_3O_4 \longrightarrow 3PbO + ½O_2$ [1]

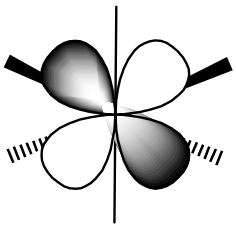
**(iii)** $Pb_3O_4 + 4HNO_3 \longrightarrow 2Pb(NO_3)_2 + PbO_2 + 2H_2O$ [1]

**(iv)** PbO/Pb(II) is more basic than $PbO_2$/Pb(IV) [1]
as $PbO_2$ does not react /form a salt with $HNO_3$ [1]
*or* PbO **does** react etc. **[5]**

**(c)** $SnO + 2NaOH \longrightarrow Na_2SnO_2 + H_2O$ (*or* $Na_2Sn(OH)_4$ *etc.*) [1]
(NOT $SnO_2$ or PbO) **[1]**

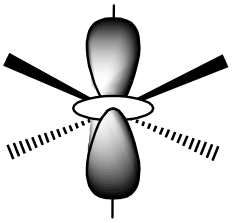
**[Total: 8]**

**4 (a)**



(between axes)

[1]



(or $d_{x^2} - d_{y^2}$ i.e. along axes)

[1] **[2]**

**(b)** ligands have (lone) pairs (of electrons) [1]
(d)-electrons in orbitals pointing towards ligands are repelled/have higher energy [1]
so these electrons (i.e. the 2-orbital group, or those in $d_{z^2}$ *or* $d_{x^2} - d_{y^2}$ have higher energy (*or* in diagram)
[*or* the 3-orbital group has the *lower* energy] [1] **[3]**

**(c) (i)** **C** = red **D** = blue [1] + [1]

**(ii)** **C**, because absorption is at lower wavelength/higher frequency [1] **[3]**

**[Total: 8]**

**5 (a)** I: $Cl_2$ + $AlCl_3$/Fe/etc [1]
II: $Cl_2$ + *hf* [1]
III: $KMnO_4 + H^+$ [1]
IV: $SOCl_2$ *or* $PCl_5/PCl_3$ *or* P + $Cl_2$ [1]
*(for I, II and IV, deduct a mark ([1] only) for one or more mentions of (aq))*
*(for I, mention of hf negates the mark)*
*(for I and II, if $Cl_2$ is omitted in one or both, deduct [1] mark only)* **[4]**

**(b)** I: electrophilic substitution [1]
III: oxidation *or* redox (NOT oxygenation) [1] **[2]**

**(c)** **H** is $C_6H_5$-$CH_2CN$ [1]
step V: NaCN/KCN [1]
heat (*or* 50-80°C) + ethanol/alcohol [1]
step VI: $LiAlH_4$ *or* $H_2$ + Ni/Pt/Pd/Rh *or* Na + ethanol [1] **[4]**

**(d)**

| compound | reagent | |
|---|---|---|
| | cold water | hot NaOH(aq) |
| E | ***no reaction*** | ***no reaction*** |
| F | ***no reaction*** | $C_6H_5CH_2OH$ |
| G | $C_6H_5CO_2H$ | $C_6H_5CO_2^-Na^+$ |

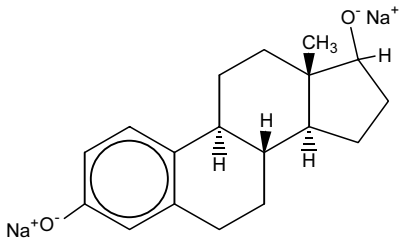
6 x [1] **[6]**

**[Total: 16]**

**6 (a) (i)** one correct atom circled *(if >1 are circled, **all** must be correct)* [1]

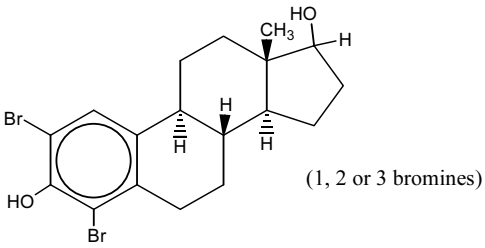
**(ii)** 5 (chiral centres) [1] **[2]**

**(b) (i)** sodium metal




*(charges not needed)* [1] + [1]

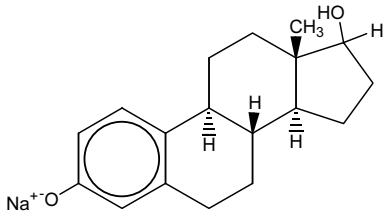
**(ii)** $Br_2$(aq)




(1, 2 or 3 bromines)

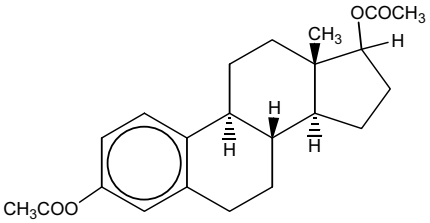
[1]

**(iii)** NaOH(aq)



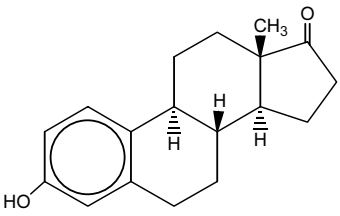

*(charges not needed)* [1]

**(iv)** $CH_3COCl$




[1]+ [1]

**(v)** hot acidified $K_2Cr_2O_7$




[1]

*(if one or more OH groups have been omitted in **(ii)**, **(iii)** or **(v)** deduct [1] mark)* **[7]**

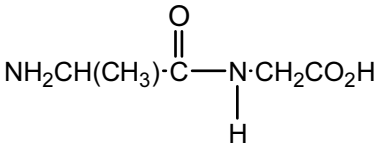
**[Total: 9]**

**7 (a) (i)**

- addition requires an unsaturated/double bond *or* alkene/C=C
- condensation **produces a small molecule *or*** water as well as the polymer *or* loss of mass occurs on polymerisation
- the empirical formula of an addition polymer is the same as that of the monomer

*any two* [1] + [1]

**(ii)** minimum is:



peptide link shown [1]
ala-gly NOT gly-ala [1] **[4]**

**(b)** **X** = deoxyribose
**Y** = phosphate
**Z** = thymine 3 x [1] **[3]**

**(c) (i)** (met)- **ser-arg-asp- gly** (ignore leading met)
whole sequence [2]
*three in correct order = [1].*
*Deduct [1] mark if "start" or "stop" is included in the amino acid sequence*

**(ii)** The amino acid **gly** (or the last amino acid) would be replaced by **trp** [1] **[3]**

**(d) (i)** e.g. Huntington's, cystic fibrosis, haemophilia, sickle cell anaemia thalassemia, muscular dystrophy, Down's syndrome, phenylketonuria [1]

**(ii)** Suitable explanation e.g. wrong amino acid coded *or* different aminoacid sequence *or* incorrect protein produced *or* extra chromosome (for Down's) [1]
...results in/change in 3D structure/change in active site/loss of enzyme activity (*or* a specific description pertinent to the mentioned disease) [1] **[3]**

**[Total: 13]**

**8** **(a)** $-NH_2$ (*or* $-CO_2^-$) group can be protonated and the molecule moves towards the cathode/negative [1]

$-CO_2H$ (*or* $-NH_3^+$) group can lose a proton and the molecule moves towards the anode/positive [1]

*salvage:* ***either****: if* $H^+$ *gain/loss is described but no direction of movement is given, award [1] mark.*

***or****: if* $H^+$ *gain/loss is not described but correct movement of ions with stated charge (+/–) is given, award [1] mark.*

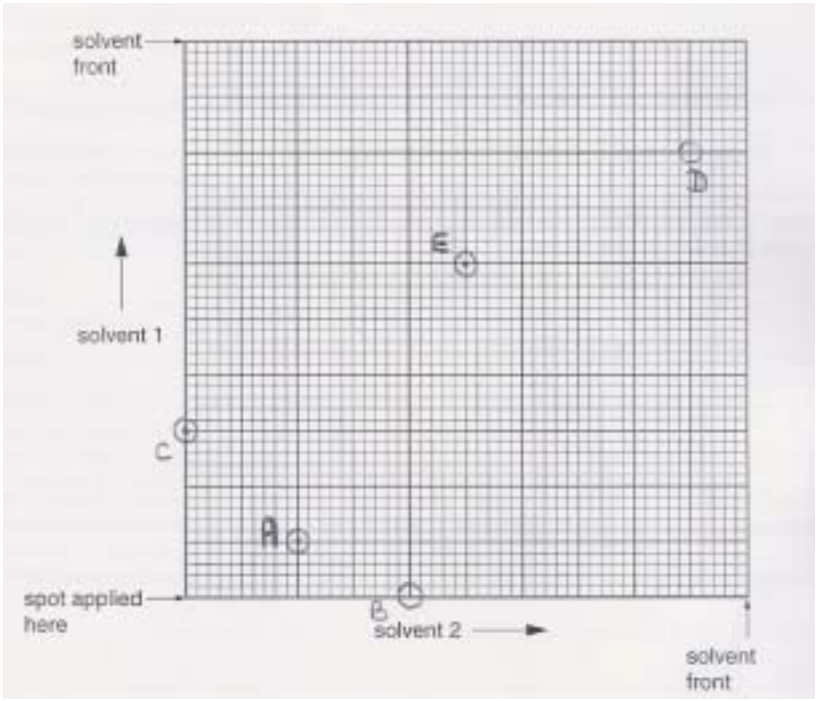
acidic/low pH will protonate the amino acid *or* basic/high pH will deprotonate [1] **[3]**

**(b)** **(i)** **Q** forms mainly zwitterions, because it does not move *or* ends up midway between (+) and (–) [1]

**(ii)** **R** is larger, since it travels more slowly/does not move as far as **S** [1] **[2]**

**(c)** **(i)** Second phase is water/moisture (NOT aqueous, NOT stationary) [1]

**(ii)**




all 5 positions correct [2]

*4 correct [1]*

**(iii)** **D** [1]

**(iv)** **C** [1] **[5]**

**[Total: 10]**

**9 (a)** Three properties e.g.

- graphite conducts **electricity**
- layers in graphite slide over one another *or* is slippery *or* acts as a lubricant
- buckyballs are ***more*** slippery *or* have lower coefficient of friction **due to** their property of being "molecular ball bearings"
- graphite has higher m.pt.
- graphite has higher density
- graphite has lower solubility
- buckyballs can trap elements/atoms/particles within themselves
- (Some comment about the strength in each of 3 dimensions)

*(any three of the above)* 3 x [1] **[3]**

**(b)** The (walls of) nano-sized test tubes consists of (rolled/single) sheets of graphite [1]

The ends are half a buckyball (buckminsterfullerene) [1] **[2]**

**(c)** Particles are similar in size to the wavelength of uv light [1]
and **reflect/deflect/scatter** (NOT absorb) the harmful radiation [1] **[2]**

**[Total: 7]**