CAMBRIDGE
INTERNATIONAL EXAMINATIONS

JUNE 2003

GCE A AND AS LEVEL

MARK SCHEME

MAXIMUM MARK: 60

SYLLABUS/COMPONENT: 9701/04

CHEMISTRY
Theory 2 (Structured Questions)

1 (a) The EMF of a cell made up of the test electrode and a standard hydrogen electrode. [1]

EMF measured under standard conditions of T, P and concentration [1]

2

(b) (i) $E_{left} = E_{right} - E_{cell}$ = 0.34 - 0.76 = **-0.42 (V)** [1]

(ii) ⟶ (arrow from left to right) [1]

(iii) I pink/red solid/ppt *or* copper will be formed *or* blue solution fades *or* M dissolves/corrodes [1]

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

II hydrogen/gas evolved *or* M dissolves
(do not allow "M dissolves" for [2] marks in both I and II) [1]

$M + 2H^{+} \rightarrow M^{2+} + H_2$ [1]

6

(c) (i) polarity of d. c. source: ⊖ is on the left, ⊕ is on the right [1]

electrolyte is $Cu^{2+}(aq)/CuSO_4/CuCl_2/Cu(NO_3)_2$ etc. *or* name [1]

(ii) moles of Cu = 0.5/63.5 = 7.87×10^{-3} [1]

moles of e^- = $2 \times 7.87 \times 10^{-3}$ = 1.57×10^{-2}

no. of coulombs = $96500 \times 1.57 \times 10^{-2}$ = 1517 (C) [1]
ecf in $n(e^-)$

time = 1520/0.5 = 5034 seconds = 50.7 min [1]
ecf in coulombs

5

Total 13

2 **(a)** **(i)** $K_{sp} = [Ba^{2+}][SO4^{2-}]$ [1] units: mol^2dm^{-6} [1] ecf

(ii) $[Ba^{2+}] = \sqrt{(1.3 \times 10^{-10})} = 1.14 \times 10^{-5}$ (mol dm^{-3}) [1]

(iii) $BaCO_3$ can react with/dissolve in the acid/HC*l* in the stomach [1]

(*or* unbalanced equation showing, e.g. $BaCO_3$ + HC*l* →)

4

(b) **(i)** $K_{sp} = [Mg^{2+}][OH^-]^2$ [1] units: mol^3dm^{-9} [1] ecf

(ii) calling $[Mg^{2+}]$ = x, then $K_{sp} = x(2x)^2 = 4x^3 \Rightarrow x = \sqrt[3]{(K_{sp}/4)}$ [1]

$\therefore [Mg^{2+}] = \sqrt[3]{(2 \times 10^{-11}/4)}$ = **1.7×10^{-4}** (mol dm^{-3}) [1]

allow ecf for use of $\sqrt[3]{}$

(iii) % left = $100 \times (1.7 \times 10^{-4})/(0.054)$ = 0.32%

$\therefore$ % extracted = **99.7** (%) [1]

5

(c) **(i)** $\Delta H_r = \Delta H^{\ominus}_f(Mg^{2+}) + 2\Delta H^{\ominus}_f(CI) - \Delta H^{\ominus}_f(MgCl_2)$

$= -467 + 2(-167) - (-641)$

= **-160** (kJ mol^{-1}) [1]

(ii) highly exothermic enthalpy change of solution
or ΔH_{sol} is very negative [1]

2

(d) mention of hydration enthalpy and lattice enthalpy [1]

hydration enthalpy decreases more than does lattice enthalpy
or
enthalpy change of solution *or* ΔH_{sol} becomes
less negative/more positive [1]

2

Total: 13, max 12

3 (a) (i) simple/discrete covalent/molecular [1]

(ii) giant/macro covalent/molecular (NOT atomic) [1]

(iii) (giant) ionic [1]

a general statement that strong attraction means high m.pt. and weak means low [1]

4

(b) (i) $CO_2 + 2NaOH \rightarrow Na_2CO_3 + H_2O$
or $CO_2 + NaOH \rightarrow NaHCO_3$ [1]
(this mark is negated if candidate states that SiO_2 dissolves/reacts)

$SnO_2 + 2NaOH \rightarrow Na_2SnO_3 + H_2O$
or $SnO_2 + 2NaOH + H_2O \rightarrow Na_2Sn(OH)_4$ etc [1]

(if neither of the above marks can be awarded, allow CO_2 **and** SnO_2 dissolve/react but SiO_2 *does not, for [1])*

(ii) CO_2 **and** SiO_2 - no reaction [1]

$SnO_2 + 4HCl \rightarrow SnCl_4$ (*or* $Sn^{4+} + 4Cl^-$) $+ 2H_2O$ [1]

4

(c) $PbO_2 + 4HCl \rightarrow PbCl_2 + 2H_2O + Cl_2$ [1]

E_{cell} = 1.47 -- 1.36
= **0.11** (V) [for 1 M HCl] [1]

or

$Pb^{4+} + 2Cl^- \rightarrow Pb^{2+} + Cl_2$ [1]

E_{cell} = 1.69 -- 1.36
= **0.33** (V) [for 1 M HCl] [1]

2

Total: 10, max 9

4 **(a)** Cl_2 + light/heat (aq negates) [1]

1

(b) Cl_2+ $AlCl_3$/$FeCl_3$/Fe etc. (aq negates) [1]

1

(c)

CO_2H

[1]

1

(d) NaOH +I_2(+ aq) (*or* I^- + OCl^- + aq) [1]

C: (pale) yellow ppt.
D: no reaction (**both**) [1]

2

(e) mass of *CN* needed = 0.03 x 60 = 1.8g [1]

M_r = 154.5, ∴ amount = 1.8/154.5 = **0.0117** (mol) (allow **0.012**) ecf [1]

2

(f) **(i)** increasing ease: H < D < G [1]

(ii) chlorine on the aryl ring is very inert *or* strong C-Cl bond
or overlap between Cl lone pair and π bond on ring (OWTTE) [1]

chlorine on C=O is reactive because of highly δ+ carbon atom bonded to electronegative O and Cl (OWTTE) [1]

3

Total 10

5 **(a)** **(i)** $SOCl_2/PCl_5/PCl_3/P + Cl_2$ (aq negates) [1]

(ii) $C_6H_5OH + NaOH \rightarrow C_6H_5O^- Na^+$ (*or* C_6H_5ONa) + H_2O [1]

(iii) **J** = $C_6H_5OCOCH_3$ [1]

K = CH_3CONH_2 [1]

4

(b) **(i)** condensation [1]

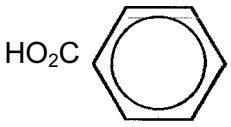
(ii) $ClCOCH_2CH_2COCl + 2HOCH_2CH_2OH \rightarrow$ [1]

$HOCH_2CH_2OCOCH_2CH_2CO_2CH_2CH_2OH$ (+ H_2O) [1]

3

(c) **(i)** polyamide *or* nylon (allow condensation) [**NOT** peptide *or* protein] [1]

(ii)



HO_2C CO_2H (*or* dichloride) $NH_2(CH_2)4NH_2$

[1] + [1]

3

Total 10

6 **(a)** **(i)** $1s^22s^22p^63s^23p^6$ $4s^23d^2$ *or* [Ar] $4s^23d^2$ (*or* vice versa) [1]

(ii) **two** of $TiCl_2$, $TiCl_3$, $TiCl_4$ [1]

2

(b) **(i)** blue solution is formed [1]

containing $[Cu(H_2O)_6]^{2+}$ [1]

(ii) NH_3 **replaces** H_2O ligands *or* forms $[Cu(NH_3)_4]^{2+}$
(*or* $[Cu(NH_3)_4(H_20)_2]^{2+}$ [1]

which is **deep blue/purple** [1]

4

Total 6