CAMBRIDGE
INTERNATIONAL EXAMINATIONS

NOVEMBER 2002

GCE Advanced Level

MARK SCHEME

MAXIMUM MARK : 60

SYLLABUS/COMPONENT :9701 /4

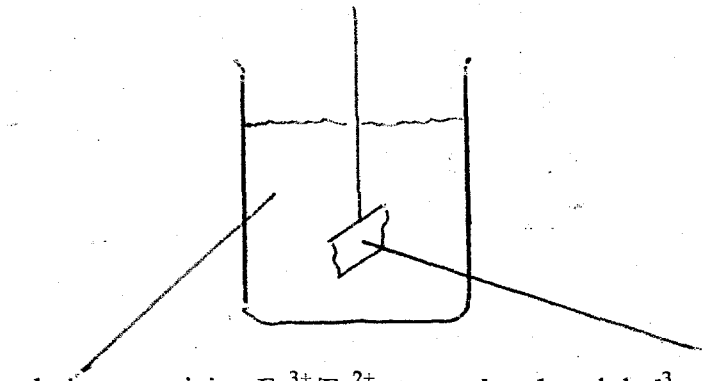
CHEMISTRY
(STRUCTURED QUESTIONS (A2 CORE))

UNIVERSITY of CAMBRIDGE
Local Examinations Syndicate

1 (a) A: voltmeter *or* **V** *or* potentiometer [NOT meter, ammeter, galvanometer]
B: salt bridge *or* potassium nitrate etc.(any sensible soluble salt, e.g. chloride, sulphate, nitrate or phosphate) [NOT just bridge, or filter paper]
C: 1 mol dm^{-3} (or 1M or M) H^+ *or* H_3O^+ *or* HCl *or* HNO_3 *or* 0.5 mol dm^{-3} H_2SO_4 (allow unit activity, allow 1.18 mol dm^{-3})

[3]
3

(b) diag



Pt electrode [1]
solution containing Fe^{3+}/Fe^{2+} at **equal** *or* 1 mol dm^{-3} concentrations [1]
2

(c) (i) $E^\ominus$ increases/becomes more positive
(ii) $E^\ominus$ decreases/becomes more negative/less positive (**both** correct) [1]
1

(d) (i) $2Fe^{3+} + Cu \longrightarrow 2Fe^{2+} + Cu^{2+}$ [1]
or $2FeCl_3 + Cu \longrightarrow 2FeCl_2 + CuCl_2$
or $Fe^{3+} + Cu \longrightarrow Fe^{2+} + Cu^{+}$ (*or* with $FeCl_3$)

(ii) E_{cell} = (0.77 - 0.34 = +)**0.43** (V) [1]
[*or* E_{cell} = (0.77 - 0.52 = +)**0.25** if Cu has been oxidised to Cu^+ in (i)]
2

(e) (i) moles(MnO_4^-) = 0.02 x 75/1000 (*or* = 1.5 x 10^{-3}) ([1] for working) [1]

moles(Fe^{2+}) = 5 x 1.5 x 10^{-3} = **7.5 x 10^{-3}**
(mark is for x 5: allow ecf if n(MnO_4^-) is wrong) [1]

(ii) moles(Cu) = (moles(Fe))/2 = 3.75 x 10^{-3} [1]

mass(Cu) = 63.5 x 3.75 x 10^{-3} = **0.24g** [1]
(ignore sig figs. allow ecf from (i) – i.e. mark is for x 63.5 *or* x 64))

(if Cu has been oxidised to Cu^+, the corresponding answers are 7.5 x 10^{-3} [1] and 0.48g [1])
(if candidates have attempted to oxidise Cu by reducing Fe^{3+} to Fe, they lose the mark in d(i), but can gain ecf marks for d(ii), (-0.56V *or* –0.38V) and also for e(ii))

4
Total: 12

2 (a) $2\,Na^+(g) + O^{2-}(g) \longrightarrow Na_2O(s)$ (must have **all 3** state symbols) [1]

1

(b) (i) A: (2)Na(**g**)
B: O(**g**) [NOT $O^-(g)$]

(ii) 1: (first) ionisation energy (of sodium) *or* IE *or* ΔH_i
2: first **and second** electron affinities (of oxygen) *or* $EA_1 + EA_2$
(if B was stated as $O^-(g)$ rather than O(g), allow ½-mark for EA_2 only)
3: lattice energy (of Na_2O) *or* LE *or* ΔH_{lat}
4: enthalpy change of formation *or* ΔH_f (of Na_2O) *or* $2\Delta H_c$

[for parts (i) and (ii) award ½ mark for each correct answer. Total the halves and round down]

[3]

3

(c) $(\Delta H_f = 2\Delta H_{at}(Na) + 2\,IE_1(Na) + \Delta H_{at}(O) + (EA_1 + EA_2)(O) + LE)$

$-414 = 2(107) + 2(494) + 496/2 + (-141 + 798) + LE$

$\therefore LE =$ **-2521** ($kJ\,mol^{-1}$)

correct answer, including sign [3]

allow [1] for use of the 6 correct values, i.e. the 4 on the question paper and 2 obtained from the data book: 496 and 494 (be aware that the "494" may appear as "988" and the "496" as "248" and the "798-141" as "657")

allow [1] for use of the correct multipliers **for the values used** , (i.e. if IE(Na) has been omitted, don't penalise for not multiplying 494 by 2). There are three multipliers: x2, x2 and x½. Some candidates are using the bond energy of O-O rather than O=O, in which case you can allow 150/2 for **this** mark (they will have forfeited the previous mark)

allow [2] for a correctly calculated answer from just **one** incorrect piece of data.

3

(d) (i) higher/bigger/more (i.e. more negative) [1]

doubly charged cation *or* bigger charge (density) of cation *or* smaller cation [1]

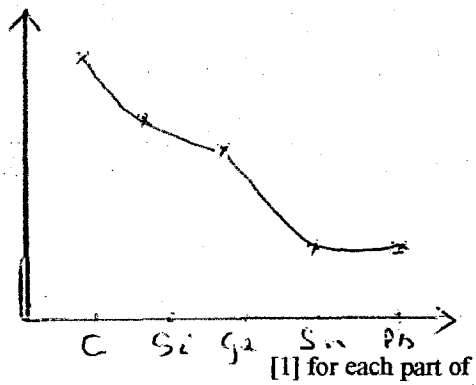
(ii) furnace linings *or* refractory material *or* crucibles [1]

high melting point [1]

4

Total: 11

3 (a) (i) diag:



[1] for each part of the curve – concave upwards [2]

If [2] cannot be awarded, look at the following alternative marking schemes:
either split the curve into two parts: C to Ge and Ge to Pb. Give [1] for each part if it's correct
or award [1] for a general downward trend in the whole curve

(ii) any two of C, Si, Ge: giant/macro covalent/molecular/atomic [1]
(if only two are stated as giant etc, the other one must NOT contradict, e.g. van der Waals or ionic)
weaker/longer bonds in Si *or* Ge than C [1]
Sn *or* Pb *or* "the last two": metallic bonding [1]
5

(b) (i) no reaction/hydrolysis *or* insoluble *or* immiscible [1]

(ii) gives (HCl) fumes/gas *or* ppt/white solid/gel (of SiO_2) [1]

(iii) $SiCl_4 + 2H_2O \longrightarrow SiO_2 + 4HCl$ [1]
[allow balanced equations giving H_2SiO_3 or $Si(OH)_4$, but not partial hydrolysis to $SiOCl_2$ etc]
[penalise other equations, e.g. $CCl_4 + H_2O$, **only** if mark in (i) HAS been awarded]

(iv) Si has (available) d-orbitals (so attack by nucleophiles is easier) [1]
4

Total: 9 max 8

4 (a) **Both** (m.pt. and density) of Fe are higher than those for Ca [1]
m.pt.: (due to:) stronger lattice/bonding *or* more delocalised electrons [1]
density:(due to:) heavier atoms/larger A_r but (roughly) the same/smaller radius/size *or* closer packing **[both** mass and size need to be referred to] [1]
3

(b) The third IE is not much greater than the second IE for iron,
or for Ca the third IE is much greater than the second IE
or Fe can use/ionise d-electrons as well as 4s electrons
or d and s electrons/orbitals are of similar energies [1]
1

(c) (i) $CaCO_3 \longrightarrow CaO + CO_2$ [1]

(ii) $2\,FeCO_3 + \frac{1}{2}\,O_2 \longrightarrow Fe_2O_3 + 2CO_2$ [1]

(iii) $FeCO_3 = 55.8 + 12 + 48 = 115.8$
$Fe_2O_3 = 2\,(55.8) + 48 = 159.6$ (both M_r values) [1]
$2 \times 115.8 \longrightarrow 159.6$
$\therefore$ 10 tonnes $\longrightarrow$ $10 \times 159.6/(2 \times 115.8)$
= **6.89** (tonnes) (2 or more sig figs. allow ecf from wrong M_r values) [1]

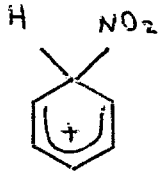
[if candidates think iron carbonate is $Fe_2(CO_3)_3$ or $Fe(CO_3)_2$, they lose the mark for (ii), but can be awarded ecf marks in (iii) as follows: for $Fe_2(CO_3)_3$, $M_r = 291.6$ and mass = 5.47 tonnes,
for $Fe(CO_3)_2$ $M_r = 175.8$ and mass = 4.54 tonnes]
[no units required, but if answer is given as 6890, kg must be specified; or 6.89×10^6 g]
4

Total: 8

5 (a) $HNO_3 + H_2SO_4$
conc acids (aq negates) **and** T between 50 - 60° C [1]
2

(b) electrophilic substitution [1]
1

(c) (i) structure:

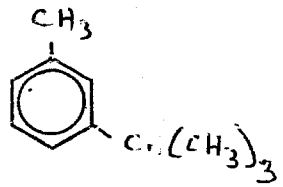


look for the "horseshoe" of delocalised electrons (somewhere around the rest of the ring, away from the sp^3 carbon atom) and the (+) charge somewhere on/near the horseshoe (NOT on the sp^3 carbon. A (+) charge on H or NO_2 negates [1]

(ii) $X^+ = NO_2^+$ [1]
(iii) $Z^+ = H^+$ (NOT H_3O^+) (penalise once only for absence of (+) signs) [1]

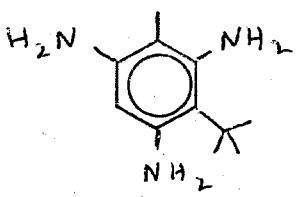
(iv) $2\,H_2SO_4 + HNO_3 \longrightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$ [2]
([1] for species, [1] for balancing. Allow [1] for: the acids $\longrightarrow NO_2^+ + HSO_4^-$ $(+H_2O)$)
5

(d) (i)



[1]

(ii)



Ignore alkyl groups – these can be "R" or even incorrect.
Allow NH_3^+ or NH_3Cl instead of one or more NH_2 groups [1]
2
Total: 10

6 (a) nucleophilic substitution (NOT elimination, NOT condensation) [1]

1

(b) $CH_3CH_2CO_2H$ (or name) [1] $SOCl_2$ *or* PCl_5 *or* PCl_3 *or* P + Cl_2 [1]
(if both given, formula takes precedence)

2

(c) (i) CH_3CH_2CN (if CN is shown in full, it must be C≡N, not C-N) [1]

(ii) NaCN *or* KCN + heat/warm/reflux/T between 50° and 100° (in ethanol) [1]
(NOT CN^-. mention of acid negates mark)

(iii) H_2 + Ni/Pt/Pd *or* $LiAlH_4$ *or* Na + ethanol (NOT $NaBH_4$) [1]

3

(d) (i) condensation [1]

(ii) H_2N-C_6H_4-NH_2 [1] HO_2C-C_6H_4-CO_2H *or* ClCO-C_6H_4-COCl [1]
[allow $NH_2C_6H_4NH_2$ but NOT $CO_2HC_6H_4CO_2H$]

(iii) Strong forces between chains *or* chains are rigid/inflexible [1]

(iv) warm/heat/boil/reflux with aq/dilute acid/H^+/H_2SO_4 *or* base/OH^-/NaOH [1]
[allow warm/heat/boil/reflux with conc HCl for [1] mark]

5

Total: 11