

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

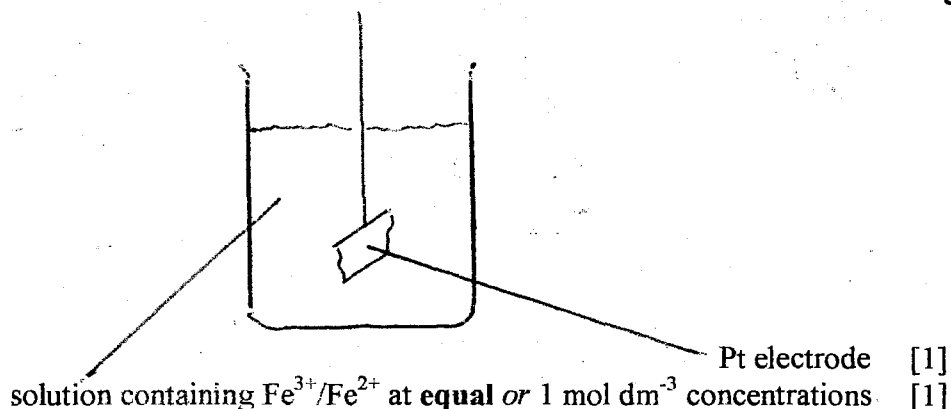
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- 1 (a) A: voltmeter *or* V *or* potentiometer [NOT meter, ammeter, galvanometer]
 B: salt bridge *or* potassium nitrate etc. (any sensible soluble salt, e.g. chloride, sulphate, nitrate or phosphate) [NOT just bridge, or filter paper]
 C: 1 mol dm^{-3} (or 1M or M) H^+ *or* H_3O^+ *or* HCl *or* HNO_3 *or* $0.5 \text{ mol dm}^{-3} \text{H}_2\text{SO}_4$
 (allow unit activity, allow 1.18 mol dm^{-3})

[3]

3

- (b) diag



2

- (c) (i) E° increases/becomes more positive
 (ii) E° decreases/becomes more negative/less positive (both correct) [1]

1

- (d) (i) $2\text{Fe}^{3+} + \text{Cu} \longrightarrow 2\text{Fe}^{2+} + \text{Cu}^{2+}$ [1]
or $2\text{FeCl}_3 + \text{Cu} \longrightarrow 2\text{FeCl}_2 + \text{CuCl}_2$
or $\text{Fe}^{3+} + \text{Cu} \longrightarrow \text{Fe}^{2+} + \text{Cu}^+$ (*or* with FeCl_3)

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

2

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

$$\text{moles}(\text{Fe}^{2+}) = 5 \times 1.5 \times 10^{-3} = 7.5 \times 10^{-3}$$

(mark is for x 5: allow ecf if n(MnO_4^-) is wrong) [1]

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

$$\text{mass}(\text{Cu}) = 63.5 \times 3.75 \times 10^{-3} = 0.24\text{g}$$

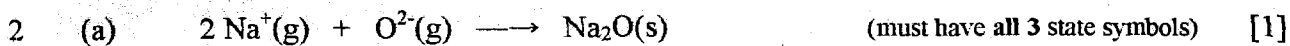
(ignore sig figs. allow ecf from (i) – i.e. mark is for x 63.5 *or* x 64)) [1]

(if Cu has been oxidised to Cu^+ , the corresponding answers are 7.5×10^{-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

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(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 Na₂O) *or* LE *or* ΔH_{lat}
 4: enthalpy change of formation *or* ΔH_f (of Na₂O) *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) $(\Delta H_f = 2\Delta H_{\text{at}}(\text{Na}) + 2 \text{IE}_1(\text{Na}) + \Delta H_{\text{at}}(\text{O}) + (EA_1 + EA_2)(\text{O}) + \text{LE})$

$-414 = 2(107) + 2(494) + 496/2 + (-141 + 798) + \text{LE}$

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

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]

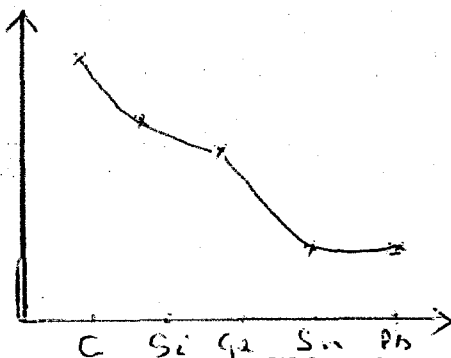
high melting point [1]

4

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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 SiO₂) [1]
 (iii) $\text{SiCl}_4 + 2\text{H}_2\text{O} \longrightarrow \text{SiO}_2 + 4\text{HCl}$ [1]
 [allow balanced equations giving H₂SiO₃ or Si(OH)₄, but not partial hydrolysis to SiOCl₂ etc]
 [penalise other equations, e.g. CCl₄ + H₂O, **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

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- 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) $\text{CaCO}_3 \longrightarrow \text{CaO} + \text{CO}_2$ [1]
 (ii) $2 \text{FeCO}_3 + \frac{1}{2} \text{O}_2 \longrightarrow \text{Fe}_2\text{O}_3 + 2\text{CO}_2$ [1]
 (iii) $\text{FeCO}_3 = 55.8 + 12 + 48 = 115.8$
 $\text{Fe}_2\text{O}_3 = 2(55.8) + 48 = 159.6$ (both M_r values) [1]
 $2 \times 115.8 \longrightarrow 159.6$
 $\therefore 10 \text{ tonnes} \longrightarrow 10 \times 159.6 / (2 \times 115.8)$
 $= 6.89 \text{ (tonnes)}$ (2 or more sig figs. allow ecf from wrong M_r values) [1]

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

4

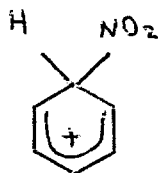
Total: 8

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5 (a) $\text{HNO}_3 + \text{H}_2\text{SO}_4$ [1]
 conc acids (aq negates) and T between 50 - 60° C [1]
 2

(b) electrophilic substitution [1]
 1

(c) (i) structure:



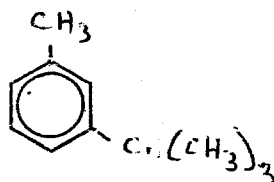
look for the "horseshoe" of delocalised electrons (somewhere around the rest of the ring, away from the sp^3 carbon atom) and the (+) charge somewhere on/near the horseshoe (NOT on the sp^3 carbon. A (+) charge on H or NO_2 negates [1]

(ii) $\text{X}^+ = \text{NO}_2^+$ [1]
 (iii) $\text{Z}^+ = \text{H}^+$ (NOT H_3O^+) (penalise once only for absence of (+) signs) [1]

(iv) $2 \text{H}_2\text{SO}_4 + \text{HNO}_3 \longrightarrow \text{NO}_2^+ + \text{H}_3\text{O}^+ + 2\text{HSO}_4^-$ [2]
 ([1] for species, [1] for balancing. Allow [1] for: the acids $\longrightarrow \text{NO}_2^+ + \text{HSO}_4^- (+\text{H}_2\text{O})$)

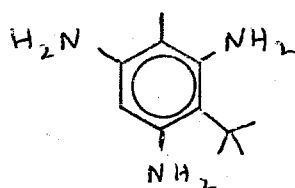
5

(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

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- 6 (a) nucleophilic substitution (NOT elimination, NOT condensation) [1] 1
- (b) $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$ (or name) [1] SOCl_2 or PCl_5 or PCl_3 or $\text{P} + \text{Cl}_2$ [1] 2
(if both given, formula takes precedence)
- (c) (i) $\text{CH}_3\text{CH}_2\text{CN}$ (if CN is shown in full, it must be $\text{C}\equiv\text{N}$, 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) $\text{H}_2 + \text{Ni/Pt/Pd}$ or LiAlH_4 or $\text{Na} + \text{ethanol}$ (NOT NaBH_4) [1] 3
- (d) (i) condensation [1]
- (ii) $\text{H}_2\text{N}-\text{C}_6\text{H}_4-\text{NH}_2$ [1] $\text{HO}_2\text{C}-\text{C}_6\text{H}_4-\text{CO}_2\text{H}$ or $\text{ClCO}-\text{C}_6\text{H}_4-\text{COCl}$ [1]
[allow $\text{NH}_2\text{C}_6\text{H}_4\text{NH}_2$ but NOT $\text{CO}_2\text{HC}_6\text{H}_4\text{CO}_2\text{H}$]
- (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