

**CAMBRIDGE**  
INTERNATIONAL EXAMINATIONS

**NOVEMBER 2002**

**GCE Advanced Level**

**MARK SCHEME**

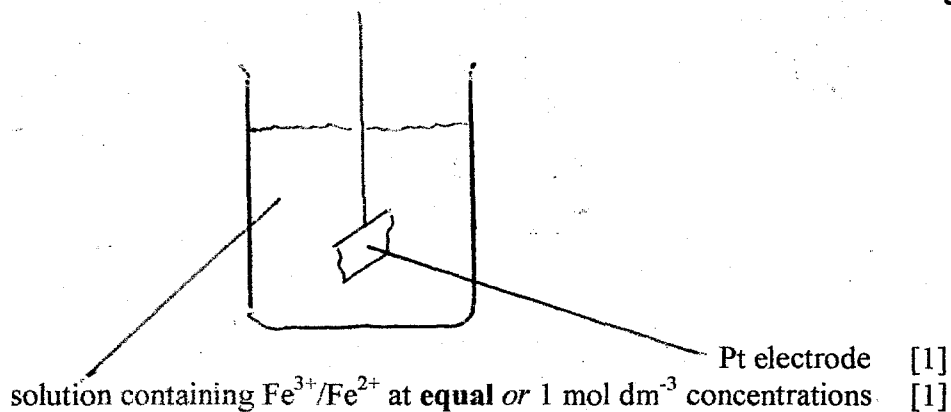
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- 1 (a) A: voltmeter *or* V *or* potentiometer [NOT meter, ammeter, galvanometer]  
 B: salt bridge *or* potassium nitrate etc. (any sensible soluble salt, e.g. chloride, sulphate, nitrate or phosphate) [NOT just bridge, or filter paper]  
 C:  $1 \text{ mol dm}^{-3}$  (or 1M or M)  $\text{H}^+$  *or*  $\text{H}_3\text{O}^+$  *or* HCl *or*  $\text{HNO}_3$  *or*  $0.5 \text{ mol dm}^{-3} \text{H}_2\text{SO}_4$   
 (allow unit activity, allow  $1.18 \text{ mol dm}^{-3}$ )

[3]

3

- (b) diag



2

- (c) (i)  $E^\circ$  increases/becomes more positive  
 (ii)  $E^\circ$  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  $\text{FeCl}_3$ )

- (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  $\text{Cu}^+$  in (i)]

2

- (e) (i) moles( $\text{MnO}_4^-$ ) =  $0.02 \times 75/1000$  (*or*  $= 1.5 \times 10^{-3}$ ) ([1] for working) [1]

moles( $\text{Fe}^{2+}$ ) =  $5 \times 1.5 \times 10^{-3} = 7.5 \times 10^{-3}$  [1]  
 (mark is for x 5: allow ecf if n( $\text{MnO}_4^-$ ) is wrong)

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

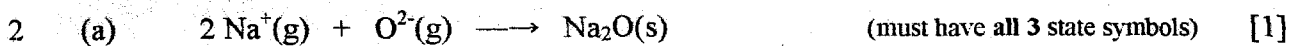
mass(Cu) =  $63.5 \times 3.75 \times 10^{-3} = 0.24\text{g}$  [1]  
 (ignore sig figs. allow ecf from (i) – i.e. mark is for x 63.5 *or* x 64))

(if Cu has been oxidised to  $\text{Cu}^+$ , the corresponding answers are  $7.5 \times 10^{-3}$  [1] and 0.48g [1])  
 (if candidates have attempted to oxidise Cu by reducing  $\text{Fe}^{3+}$  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

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1

- (b) (i) A: (2)Na(g)  
B: O(g) [NOT O<sup>-</sup>(g)]

- (ii) 1: (first) ionisation energy (of sodium) *or* IE *or*  $\Delta H_i$   
2: first **and second** electron affinities (of oxygen) *or*  $EA_1 + EA_2$   
(if B was stated as O<sup>-</sup>(g) rather than O(g), allow ½-mark for  $EA_2$  only)  
3: lattice energy (of Na<sub>2</sub>O) *or* LE *or*  $\Delta H_{\text{lat}}$   
4: enthalpy change of formation *or*  $\Delta H_f$  (of Na<sub>2</sub>O) *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]

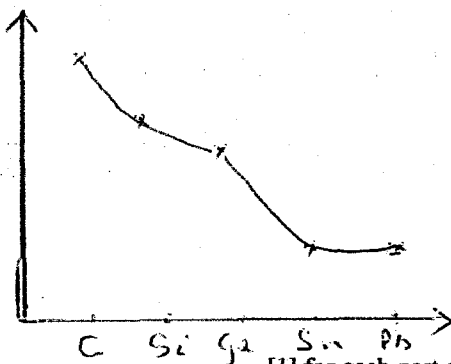
high melting point [1]

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 SiO<sub>2</sub>) [1]  
 (iii)  $\text{SiCl}_4 + 2\text{H}_2\text{O} \longrightarrow \text{SiO}_2 + 4\text{HCl}$  [1]  
 [allow balanced equations giving H<sub>2</sub>SiO<sub>3</sub> or Si(OH)<sub>4</sub>, but not partial hydrolysis to SiOCl<sub>2</sub> etc]  
 [penalise other equations, e.g. CCl<sub>4</sub> + H<sub>2</sub>O, **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  $6.89 \times 10^6 \text{ g}$ ]

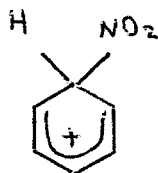
**4**  
**Total: 8**

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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:



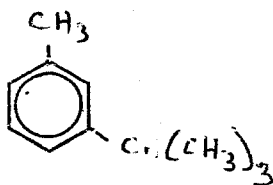
look for the "horseshoe" of delocalised electrons (somewhere around the rest of the ring, away from the  $\text{sp}^3$  carbon atom) and the (+) charge somewhere on/near the horseshoe (NOT on the  $\text{sp}^3$  carbon. A (+) charge on H or  $\text{NO}_2$  negates [1]

- (ii)  $\text{X}^+ = \text{NO}_2^+$  [1]  
 (iii)  $\text{Z}^+ = \text{H}^+$  (NOT  $\text{H}_3\text{O}^+$ ) (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  $\longrightarrow \text{NO}_2^+ + \text{HSO}_4^- (+\text{H}_2\text{O})$ )

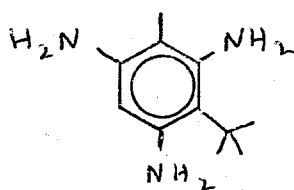
5

- (d) (i)



[1]

- (ii)



Ignore alkyl groups – these can be "R" or even incorrect.  
 Allow  $\text{NH}_3^+$  or  $\text{NH}_3\text{Cl}$  instead of one or more  $\text{NH}_2$  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]  $\text{SOCl}_2$  or  $\text{PCl}_5$  or  $\text{PCl}_3$  or  $\text{P} + \text{Cl}_2$  [1]  
(if both given, formula takes precedence) 2
- (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)  $\text{NaCN}$  or  $\text{KCN}$  + heat/warm/reflux/T between  $50^\circ$  and  $100^\circ$  (in ethanol) [1]  
(NOT  $\text{CN}^-$ . mention of acid negates mark)
- (iii)  $\text{H}_2 + \text{Ni/Pt/Pd}$  or  $\text{LiAlH}_4$  or  $\text{Na} + \text{ethanol}$  (NOT  $\text{NaBH}_4$ ) [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/ $\text{H}^+$ / $\text{H}_2\text{SO}_4$  or base/ $\text{OH}^-$ / $\text{NaOH}$  [1]  
[allow warm/heat/boil/reflux with conc  $\text{HCl}$  for [1] mark]

5  
Total: 11