

**UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS**

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

## **MARK SCHEME for the May/June 2008 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.

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- 1 (a) (i) A is  $Cl_2$ /chlorine [1]  
 B is NaCl or HCl or  $Cl^-$  [or words], etc. [1]  
 C is salt bridge or KC//KNO<sub>3</sub>, etc. [1]  
 D is platinum/Pt [1]  
 E is  $Fe^{2+} + Fe^{3+}$  or mixture of Fe(II) + Fe(III) salts [1]  
 mention of standard conditions ( $[Cl^-]$  of 1 mol dm<sup>-3</sup> or  $Cl_2$  at 1 atmos  
 or T = 25°C/298 K) [1]  
 (ii)  $E^\circ = E^\circ_R - E^\circ_L = 0.77 - 1.36 = (-)0.59$  (V) (ignore sign) [1]  
 (since R.H. electrode is negative) electrons flow (from right) **to left** or to the chlorine  
 electrode or anticlockwise or from (beaker) **E** to (beaker) **B** [1] [8]
- (b) (i)  $\Delta H = 3 \times (-167.2) + (-48.5) - (-399.5)$  [1]  
 $= -150.6$  or **151** (kJ mol<sup>-1</sup>) [1]  
 (correct ans [2])  
 (ii)  $2Fe^{3+} + Cu \longrightarrow 2Fe^{2+} + Cu^{2+}$  [1]  
 (or molecular:  $2FeCl_3 + Cu \longrightarrow 2FeCl_2 + CuCl_2$ )  
 $E^\circ = 0.77 - 0.34 = (+) 0.43$  (V) [1]  
 (no mark for -0.43V) [4]
- [Total: 12 max 11]**
- 2 (a) (i)  $\Delta H = 4 \times 278 - 244 - 2 \times 496$  [1]  
 $= -124$  (kJ mol<sup>-1</sup>) [1]  
 (correct ans [2])  
 (ii) shape is bent/V-shaped/non-linear (or diagram) [1]  
 due to (one) lone pair and/or (1) odd/unpaired electron (or shown on diag) [1]  
 (assume electrons are on chlorine unless explicitly stated otherwise, in which case  
 award no mark)  
 (iii)  $3KClO_3 + H_2SO_4 \longrightarrow K_2SO_4 + KClO_4 + H_2O + 2ClO_2$  [1] [5]
- (b) (i) coal-fired power stations; fuel in cars; car exhausts/gas emissions; other named use of a  
 fossil fuel; contact process; cement manufacture; brick manufacture; roasting of sulphide  
 ores; burning tyres (any 2) [1]  
 (NOT volcanoes etc; NOT burning of natural gas)  
 (no marks for only 1 correct source)  
 (ii) causes **acid rain** [1]  
 which lower pH of lakes; leaches aluminium from soils; kills fish/plants/rainforests;  
 dissolves/corrodes/damages buildings (any 1) [1]  
 (NOT asthma etc – since this is not environmental) [3]

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(c) (i) CO<sub>2</sub>: simple + molecular/covalent *or* weak intermolecular forces  
 SiO<sub>2</sub>: giant/macro + molecular/covalent  
 SnO<sub>2</sub>: ionic/electrovalent (ignore “giant”) (all 3 correct) [2]  
 (2 correct = [1], 1 correct = [0])

(ii) SnO<sub>2</sub> is stable, PbO<sub>2</sub> is not *or* SnO<sub>2</sub> is the more stable [1]  
 PbO<sub>2</sub> → PbO + ½ O<sub>2</sub> [1]

(iii) H<sub>2</sub>O + CO<sub>2</sub> (⇌) H<sup>+</sup> + HCO<sub>3</sub><sup>-</sup> [1]  
 $K_c = \frac{[H^+][HCO_3^-]}{[H_2O][CO_2]}$  *or* =  $\frac{[H^+][HCO_3^-]}{[CO_2]}$  ecf [1]

(iv) HCO<sub>3</sub><sup>-</sup> + H<sup>+</sup> → H<sub>2</sub>CO<sub>3</sub> *or* H<sub>2</sub>O + CO<sub>2</sub> (or equation with H<sub>3</sub>O<sup>+</sup>) [1]  
 HCO<sub>3</sub><sup>-</sup> + OH<sup>-</sup> → CO<sub>3</sub><sup>2-</sup> + H<sub>2</sub>O (NB NOT H<sub>2</sub>CO<sub>3</sub> + OH<sup>-</sup> →) [1]

(words can substitute for one of the equations but not both. If two correct word descriptions are given, in the absence of at least one correct equation, award [1] mark only) [8]

[Total: 16 max 15]

3 (a) tetrahedral diagram (either dashed+wedge, or similar representation) [1]  
 angles (all) 109° – 110° [1]  
 (award [0] for part (a) if an angle of 90° or 180° is mentioned) [2]

(b) volatility decreases *or* boiling points increase [1]  
 (allow b.pt. CCl<sub>4</sub> > SiCl<sub>4</sub> but b.pt. increases thereafter) [1]  
 due to greater van der Waals’/intermolecular forces *or* due to more electrons [1]  
 (mention of “ions” negates this mark) [2]

(c) (i) Pb<sup>4+</sup>/Pb<sup>2+</sup>: E° = +1.69V, Sn<sup>4+</sup>/Sn<sup>2+</sup>: E° = +0.15V, [both] [1]  
 a valid comment about relative redox power *or* stability, e.g.:  
 (hence) Sn<sup>2+</sup> easily oxidised *or* Sn<sup>4+</sup> is more stable than Sn<sup>2+</sup> *or*  
 Pb<sup>4+</sup> is easily reduced *or* Pb<sup>2+</sup> is more stable than Pb<sup>4+</sup> *or*  
 +2 oxidation state more stable down the group [1]

(ii) Sn<sup>2+</sup> + I<sub>2</sub> → Sn<sup>4+</sup> + 2I<sup>-</sup> [1]  
 Pb<sup>4+</sup> + SO<sub>2</sub> + 2H<sub>2</sub>O → 4H<sup>+</sup> + SO<sub>4</sub><sup>2-</sup> + Pb<sup>2+</sup> [1]  
 (N.B. no marks in (ii) for E° values) [4]

(d) (i) for Si: ΔH = 244 – 2(359) = –474 (kJ mol<sup>-1</sup>) [1]  
 for Sn: ΔH = 244 – 2(315) = –386 (kJ mol<sup>-1</sup>) [1]  
 (allow [1] out of [2] salvage mark for 474 & 386; 962 & 874; *or* –962 & –874)

(ii) Yes: the +4 state becomes decreasingly stable – the ΔH is less exothermic [1]  
 (mark is for relating ΔHs to stability: allow ecf from d(i) and also from c(i)) [3]

[Total: 11]

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- 4 (a) ester [1] [1]
- (b) reaction I: acid/H<sup>+</sup>/HCl/H<sub>2</sub>SO<sub>4</sub> or alkali/OH<sup>-</sup>/NaOH (followed by H<sup>+</sup>) [1]  
**heat/reflux** and aqueous (allow H<sub>3</sub>O<sup>+</sup> to equal H<sup>+</sup> + aq, also assume “conc” *or* “dil” means aq (but NOT H<sub>2</sub>SO<sub>4</sub>) also allow aqueous ethanol) [1]  
 (for heat: allow T ≥ 80°C; **not** “warm”)
- reaction II: methanol/CH<sub>3</sub>OH [1]  
 heat with **conc.** H<sub>2</sub>SO<sub>4</sub>/H<sub>3</sub>PO<sub>4</sub> *or* HCl(**g**) [**NOT** conc HCl] [1] [4]
- (c) (i) BrCH<sub>2</sub>-CHBr-CH<sub>2</sub>Br [1]
- (ii) HO<sub>2</sub>C-CO-CO<sub>2</sub>H [1] [2]
- (d) 890g of triglyceride produces 3 × 298 = 894g of biodiesel [1]  
 ∴ 500kg produces 500 × 894/890 = **502kg** biodiesel ecf [1]  
 (correct ans [2])  
 (1004/1005kg *or* 167kg is worth [1]; 333kg is worth [0]) [2]
- (e) (i) C<sub>17</sub>H<sub>35</sub>CO<sub>2</sub>CH<sub>3</sub> + 27.5 O<sub>2</sub> → 19CO<sub>2</sub> + 19H<sub>2</sub>O [1]  
 (*or* C<sub>19</sub>H<sub>38</sub>O<sub>2</sub>)
- (ii) 10 × 44 × 19/298 = **28.(05)/28.1kg** ecf from equ [2]  
 (-1 for each error)  
 some ecf values: n = 18 ⇒ 26.6kg  
 n = 17 ⇒ 25.1kg (allow [2] for each)  
 n = 16 ⇒ 23.6kg [3]
- (f) any one of the following.
- (saving) diminishing resources
  - economic argument (NOT just “cheaper”) – e.g. oil will become increasingly more expensive as it runs out
  - ref to CO<sub>2</sub> cycle (e.g. no net increase in CO<sub>2</sub>, i.e. “carbon neutral”) *or* less global warming (due to a smaller carbon “footprint”)
  - renewable/sustainable
  - the effect of biofuel cultivation on world food prices

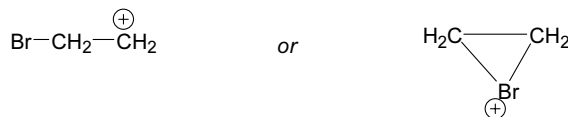
[1] [1]

[Total: 13]

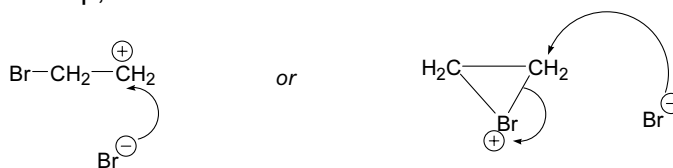
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- 5 (a) reaction I electrophilic addition [1]  
 reaction II electrophilic substitution [1]  
 (salvage: award [1] out of [2] for “addition” + “substitution”, even if nucleophilic) [2]

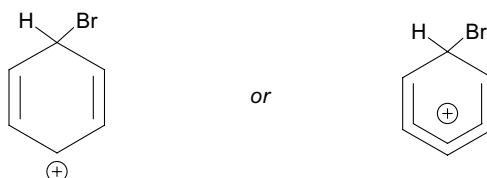
- (b) reaction I: intermediate [1]



second step, attack of  $\text{Br}^-$  on bromocation. [1]

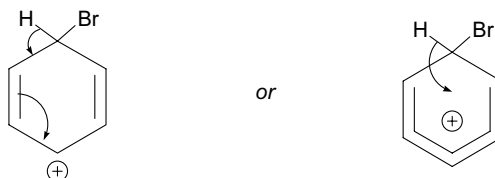


reaction II: intermediate [1]



(or with  $\oplus$  in 2-position)      (make sure  $\oplus$  is not at  $\text{sp}^3$  C-atom)

second step, loss of  $\text{H}^+$  from bromocation. [1]



[4]

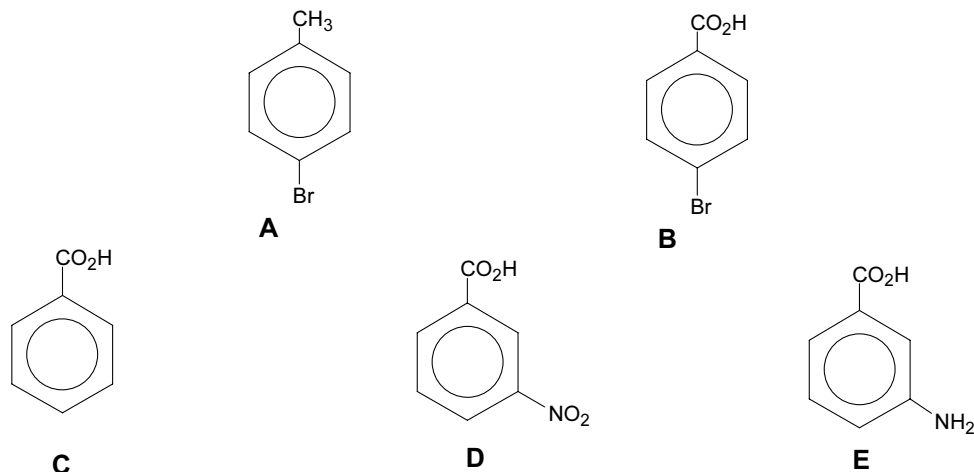
- (c) **Delocalised** ring of electrons (in benzene) is **stable**, (so is re-formed in second step in benzene.)  
 or electrons in the ethene  $\pi$  bond are localised/more available for reaction with electrophiles

[1] [1]

[Total: 7]

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6



5 x [1]

[deduct [1] mark if ring circle omitted more than once]  
 [allow ecf for **E** from structure of **D**]  
 [allow ecf for **B** from structure of **A**]  
 [allow  $\text{-CO}_2^-$  for **E**]

[5]

[Total: 5]

7

polymer	addition/condensation?	formulae of monomers
1	condensation	$\text{HO}_2\text{C-CO}_2\text{H}$ or $\text{ClCO-COCl}$ $\text{NH}_2\text{-CH}_2\text{-CH}_2\text{-NH}_2$
2	condensation	$\text{HO-CH}_2\text{-CH(C}_2\text{H}_5\text{)-CO}_2\text{H}$ $\text{HO-CH}_2\text{-CH(CH}_3\text{)-CO}_2\text{H}$
3	addition	$\text{CH}_2=\text{CH-CH}_3$ $\text{CH}_2=\text{CH-CONH}_2$ $\text{CH}_2=\text{CH-C}_6\text{H}_5$

↑  
[2]  
(2 correct: [1])

↑  
[6]  
(6 correct: [5])  
etc

(2 correct: [1])  
 (C=C bonds not needed, but penalise  $-[1]$  if C-C drawn instead of C=C)  
 (if more than 7 formulae drawn, then penalise  $-[1]$  for each formula in excess of 7)

[8]

[Total: 8]

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- 8 (a) primary: covalent (ignore amide, peptide etc) [1]  
 diagram showing peptide bond: (-CHR-)CONH(-CHR-) [1]
- secondary: hydrogen bonds (NOT “..between side chains”) [1]  
 diagram showing N-H...O = C [1]
- tertiary: two of the following:  
 • hydrogen bonds (diag. must show H-bonds *other* than those in  $\alpha$ -helix or  $\beta$ -pleated sheet – e.g. ser-ser)  
 • electrostatic/ionic attraction,  
 • van der Waals’/hydrophobic forces/bonds,  
 • (covalent) disulphide (links/bridges) [1] + [1]
- suitable diagram of **one** of the above [1]  
 (for disulphide: S-S **not** S=S or SH-SH) [7]
- (b) met-ala-gly-ala-gly-arg-val-lys [2]  
 any **possible** sequence with more than 8 residues, that “uses” all 6 tripeptides (overlapping or not), and that starts with *met* and ends with *lys* is worth [1] mark  
 any sequence that does **not** start with *met* or end with *lys* gets zero. [2]
- (c) CARE – this is not about DNA!  
 candidates should describe **TWO** potential effects on tertiary or quaternary structures caused by amino acid sidechains...  
 these include: disruption of H-bonding  
 disruption of disulphide bridges  
 disruption of electrostatic/ionic attraction  
 disruption of van der Waals’ forces  
 (only allow effects on the secondary structure if proline is specifically mentioned) 2 x [1]
- then award [1] mark each for **two** of the following bullet points:  
 • a description of the amino acids involved in the above, (*or* a labelled diagram) (award [1] mark for each example)  
 a description of an *effect* of interchanging amino acids, such as the..  
 • unfolding of tertiary structure/different folding/different shape (NOT denatured)  
 • inactivity of an enzyme *or* changing the active site  
 • causing of a protein to become less soluble/coagulate (e.g. sickle cells) 2 x [1]
- [4]
- [Total: 13 max 12]

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- 9 (a) (i)+(ii) any two of:  
 molecular mass/size/ $M_r$ /shape  
 (overall electrical) charge (on the species)  
 voltage/size/P.D. (of applied electric field) [1] + [1]  
 (salvage: if just “mass & charge” is mentioned, with no reference to species or molecule, award [1]) [2]
- (b) (i)  $\text{CH}_3\text{COCH}_3$  would show  
 a single peak/no splitting since all the Hs are in the same chemical environment  
 or a peak at  $\delta = 2.1$  due to  $\text{CH}_3\text{CO}$  group [1]
- $\text{CH}_3\text{CH}_2\text{CHO}$  would show 3 (sets of) peaks since there are 3 different proton environments  
 or there would be a peak at  $\delta = 9.5 - 10.0$  due to the  $-\text{CHO}$  group  
 or a peak at  $\delta = 0.9$  due to  $\text{CH}_3$   
 or a peak at  $\delta 1.3$  due to  $\text{CH}_2$  [1]
- (reasons needed for the marks. Salvage: if reasons are not given, but candidate states that propanone will have one peak and propanal three, then award [1] mark)
- (ii) different fragments:
- $\text{CH}_3\text{COCH}_3$  would form **fewer** fragments (must be stated in words)
  - $\text{CH}_3\text{COCH}_3$  would form a fragment of  $\text{CH}_3\text{CO}^+$  or at (m/e) 43
  - $\text{CH}_3\text{CH}_2\text{CHO}$  would form a fragment of  $\text{CH}_3\text{CH}_2^+$  or  $\text{CHO}^+$  at (m/e) 29
  - $\text{CH}_3\text{CH}_2\text{CHO}$  would form a fragment of  $\text{CH}_3\text{CH}_2\text{CO}^+$  or at (m/e) 57
- [charges on fragments not required for mark] any 3 points [3] [5]
- (c) (i) peaks at (m/e) 79 **and** 81 or at (m/e) 94 **and** 96 [1]
- (ii) in chlorine the M and M+2 peaks are the ratio 3:1 [1]  
 whereas in bromine they are approx. 1:1 [1] [3]

[Total: 10 max 9]



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10 (a) any **two** of the following:

- to speed delivery (of drug to target organ), i.e. faster response
- to avoid the drug being hydrolysed/reacted/decomposed (NOT digested) in the stomach
- to allow a smaller dose to be used *or* greater accuracy of dosage
- patient does not have to be conscious

2 × [1] [2]

(b) (i) spheres with a diameter of the order of nanometres/in the nanometre range/between 10 & 500 nm [1]

(ii) it is (highly) acidic *or* low pH *or* contains HCl (NOT contains enzymes) [1]

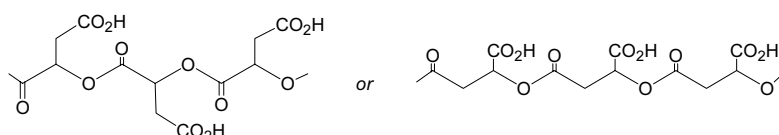
(iii) use hydrogels: of different (wall) thickness/strength (to release drug over time)  
of different chemical composition (for different breakdown times)  
incorporating pores/holes (in their walls) (any two) [1] + [1]

[4]

(c) for the **homopolymer**, **either** using the amino acid the minimum is:

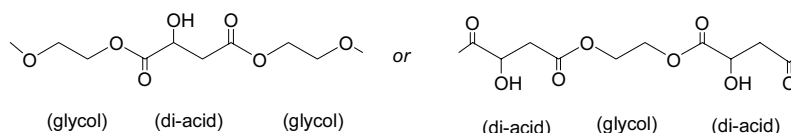


**or** using the hydroxyacid the minimum is:

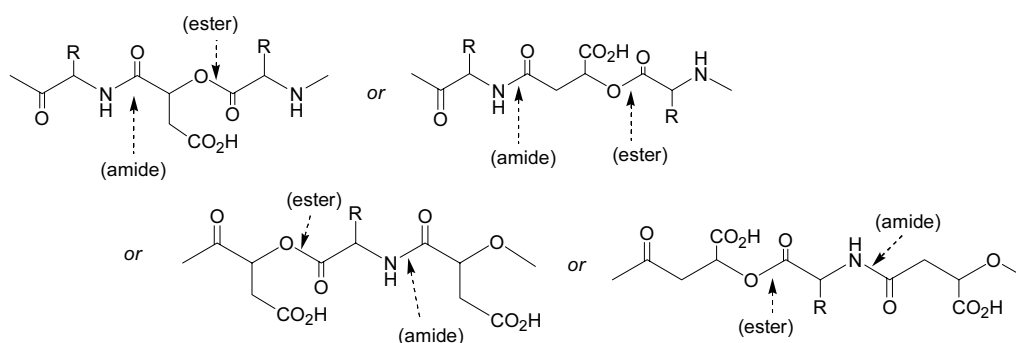


(–[1] for each error) [2]

for the **heteropolymer**, **either** using the glycol compound and the di-acid the minimum is:



**or** using the amino acid and the di-acid, the minimum is:



(A heteropolymer incorporating all three monomers can also be drawn. This should include an ester linkage between the glycol and one of the CO<sub>2</sub>H groups, and an amide linkage between the amino acid and another CO<sub>2</sub>H group. Deduct [1] mark from the whole of section (c) if complete compounds are shown rather than sections of chains. Allow 4-monomer sections instead of 3. Allow [2] marks for a polymer section even if **one** end is incomplete (e.g. is lacking an oxygen atom), but if **both** ends are incomplete deduct [1]) (–[1] for each error) [2] [4]

[Total: 10 max 9]