

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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Page 2	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	04

- 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 KCl/KNO₃, 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⁻³ 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⁻¹) [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⁻¹) [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]

Page 3	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	04

(c) (i) CO₂: simple + molecular/covalent *or* weak intermolecular forces
 SiO₂: giant/macro + molecular/covalent
 SnO₂: ionic/electrovalent (ignore "giant") (all 3 correct) [2]
 (2 correct = [1], 1 correct = [0])

(ii) SnO₂ is stable, PbO₂ is not *or* SnO₂ is the more stable [1]
 PbO₂ → PbO + ½ O₂ [1]

(iii) H₂O + CO₂ (⇌) H⁺ + HCO₃⁻ [1]
 $K_c = \frac{[H^+][HCO_3^-]}{[H_2O][CO_2]}$ *or* = $\frac{[H^+][HCO_3^-]}{[CO_2]}$ ecf [1]

(iv) HCO₃⁻ + H⁺ → H₂CO₃ *or* H₂O + CO₂ (or equation with H₃O⁺) [1]
 HCO₃⁻ + OH⁻ → CO₃²⁻ + H₂O (NB NOT H₂CO₃ + OH⁻ →) [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. CCl₄ > SiCl₄ 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) Pb⁴⁺/Pb²⁺: E° = +1.69V, Sn⁴⁺/Sn²⁺: E° = +0.15V, [both] [1]
 a valid comment about relative redox power *or* stability, e.g.:
 (hence) Sn²⁺ easily oxidised *or* Sn⁴⁺ is more stable than Sn²⁺ *or*
 Pb⁴⁺ is easily reduced *or* Pb²⁺ is more stable than Pb⁴⁺ *or*
 +2 oxidation state more stable down the group [1]

(ii) Sn²⁺ + I₂ → Sn⁴⁺ + 2I⁻ [1]
 Pb⁴⁺ + SO₂ + 2H₂O → 4H⁺ + SO₄²⁻ + Pb²⁺ [1]
 (N.B. no marks in (ii) for E° values) [4]

(d) (i) for Si: ΔH = 244 – 2(359) = **-474** (kJ mol⁻¹) [1]
 for Sn: ΔH = 244 – 2(315) = **-386** (kJ mol⁻¹) [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]

Page 4	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	04

- 4 (a) ester [1] [1]
- (b) reaction I: acid/H⁺/HCl/H₂SO₄ or alkali/OH⁻/NaOH (followed by H⁺) [1]
heat/reflux and aqueous (allow H₃O⁺ to equal H⁺ + aq, also assume “conc” *or* “dil” means aq (but NOT H₂SO₄) also allow aqueous ethanol) [1]
(for heat: allow T ≥ 80°C; **not** “warm”)
- reaction II: methanol/CH₃OH [1]
heat with **conc.** H₂SO₄/H₃PO₄ *or* HCl(**g**) [**NOT** conc HCl] [1] [4]
- (c) (i) BrCH₂-CHBr-CH₂Br [1]
- (ii) HO₂C-CO-CO₂H [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) C₁₇H₃₅CO₂CH₃ + 27.5 O₂ → 19CO₂ + 19H₂O [1]
(*or* C₁₉H₃₈O₂)
- (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 CO₂ cycle (e.g. no net increase in CO₂, 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

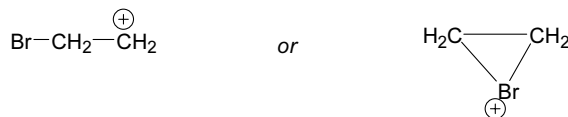
[1] [1]

[Total: 13]

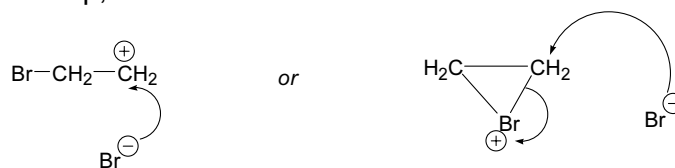
Page 5	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	04

- 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]

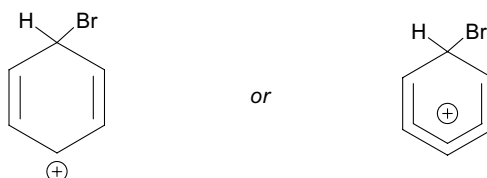
- (b) reaction I: intermediate [1]



- second step, attack of Br^- on bromocation. [1]

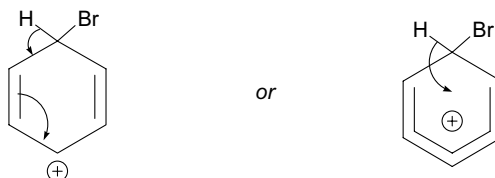


- reaction II: intermediate [1]



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

- second step, loss of H^+ from bromocation. [1]



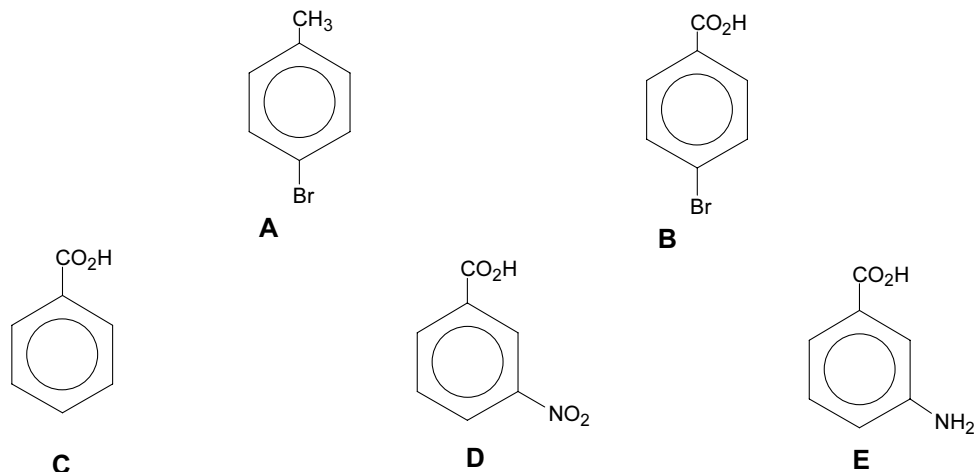
[4]

- (c) **Delocalised** ring of electrons (in benzene) is **stable**, (so is re-formed in second step in benzene.)
 or electrons in the ethene π bond are localised/more available for reaction with electrophiles [1] [1]

[Total: 7]

Page 6	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	04

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	$\text{HO}_2\text{C}-\text{CO}_2\text{H}$ or $\text{ClCO}-\text{COCl}$ $\text{NH}_2-\text{CH}_2-\text{CH}_2-\text{NH}_2$
2	condensation	$\text{HO}-\text{CH}_2-\text{CH}(\text{C}_2\text{H}_5)-\text{CO}_2\text{H}$ $\text{HO}-\text{CH}_2-\text{CH}(\text{CH}_3)-\text{CO}_2\text{H}$
3	addition	$\text{CH}_2=\text{CH}-\text{CH}_3$ $\text{CH}_2=\text{CH}-\text{CONH}_2$ $\text{CH}_2=\text{CH}-\text{C}_6\text{H}_5$

↑
[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]

Page 7	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	04

- 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 α -helix or β -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]

Page 8	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	04

- 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) CH_3COCH_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 CH_3CO 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 CH_3
 or a peak at $\delta 1.3$ due to 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:
- CH_3COCH_3 would form **fewer** fragments (must be stated in words)
 - CH_3COCH_3 would form a fragment of CH_3CO^+ or at (m/e) 43
 - $\text{CH}_3\text{CH}_2\text{CHO}$ would form a fragment of CH_3CH_2^+ or 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]

Page 9	Mark Scheme	Syllabus	Paper
	GCE A/AS LEVEL – May/June 2008	9701	04

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]

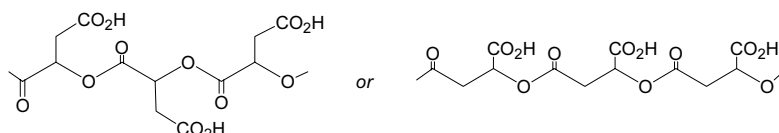
(iii) use hydrogels: of different (wall) thickness/strength (to release drug over time)
of different chemical composition (for different breakdown times)
incorporating pores/holes (in their walls) (any two) [1] + [1]

[4]

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

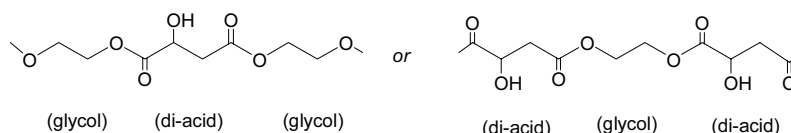


or using the hydroxyacid the minimum is:

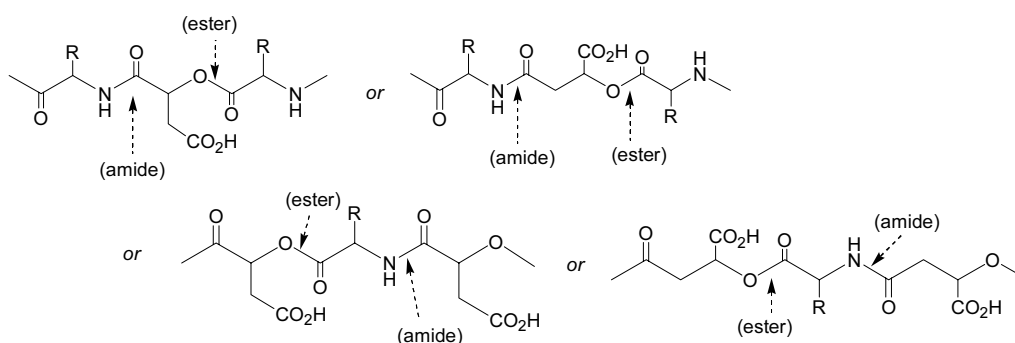


(–[1] for each error) [2]

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 CO₂H groups, and an amide linkage between the amino acid and another CO₂H 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]