

**UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS**

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

**MARK SCHEME for the October/November 2008 question paper**

**9701 CHEMISTRY**

**9701/04**

Paper 4 (Theory 2), maximum raw mark 100

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- 1 (a) (i) 162 ( $^{81}\text{Br}^- \text{ } ^{81}\text{Br}^+$ ) for molecular species [1]  
 160 ( $^{81}\text{Br}^- \text{ } ^{79}\text{Br}^+$ ) for atomic species [1]  
 158 ( $^{79}\text{Br}^- \text{ } ^{79}\text{Br}^+$ ) ignore missing charges for 5 masses [1]  
 81 ( $^{81}\text{Br}^+$ )  
 79 ( $^{79}\text{Br}^+$ )
- (ii) 158:160:162 = 1:2:1 [1]  
 79:81 = 1:1 [1]
- (b) (i) either  $\text{BrCH}_2\text{CHBr}\cdot\text{CHO}$  or  $\text{CH}_2=\text{CH}\cdot\text{CH}_2\text{OH}$  (double bond needed) [1]
- (ii) reaction I:  $\text{Br}_2$ (aq or in  $\text{CCl}_4$  etc.), light negates – solvent not needed [1]  
 reaction II:  $\text{NaBH}_4$  or  $\text{H}_2/\text{Ni}$  etc. (but not if **A** is  $\text{CH}_2=\text{CH}\cdot\text{CH}_2\text{OH}$ ) [1]  
 allow  $\text{LiAlH}_4$  or Na/ethanol [1]  
 (reactions can be reversed)
- (c) (i)  $\text{C}_3\text{H}_6\text{OBr}_2 = 216, 218$  and  $220$  (any one) [1]
- (ii) 31 is  $\text{CH}_2\text{OH}^+/\text{CH}_3\text{O}^+$   
 106 is  $\text{C}_2\text{H}_3^{79}\text{Br}^+$   
 108 is  $\text{C}_2\text{H}_3^{81}\text{Br}^+$   
 185 is  $\text{C}_2\text{H}_3^{79}\text{Br}_2^+$  ignore missing charges  
 187 is  $\text{C}_2\text{H}_3^{79}\text{Br}^{81}\text{Br}^+$  6 correct [4]  
 189 is  $\text{C}_2\text{H}_3^{81}\text{Br}_2^+$  5 correct [3] etc
- if no mass numbers given – [1] only [4]
- [Total: 13 max 12]
- 2 (a) solution will turn brown/purple [1]
- (b) table:
- | case | a | b | c |
|------|---|---|---|
| 1    | 1 | 1 | 0 |
| 2    | 1 | 1 | 1 |
| 3    | 1 | 2 | 2 |
- each horizontal row scores [1]  
 if no marks scored, a correct vertical row can score [1] [3 max]
- (c) rate =  $6.5\text{--}7.5 \times 10^{-6}$  [1]  
 units are  $\text{mol dm}^{-3} \text{ s}^{-1}$  [1]
- (d) half-life measured and quoted as  $\cong 90\text{--}94 \text{ s}$  [1]  
 evidence of two half-lives measured [1]

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- (e) lines 1 and 2: as  $[\text{H}_2\text{O}_2]$  increases by  $0.07/0.05 = 1.4$ , so does rate  
so order w.r.t.  $[\text{H}_2\text{O}_2] = 1$  [1]  
lines 1 and 3: increase in rate (1.8) is also the increase in  $[\text{H}_2\text{O}_2]$ ,  
so rate is **independent** of  $[\text{H}^+]$  (or zero order) [1]

a description can be accepted here

if both orders are correct but no working/explanation given score [1]

- (f) the first step/or the relevant equation [1]

[Total: 11]

- 3 (a) (i) carbonates become more stable down the Group/higher decomposition temperature [1]  
cation/ $\text{M}^{2+}$  radius/size increases down the group/ $\text{M}^{2+}$  charge density decreases [1]  
anion/carbonate ion/ $\text{CO}_3^{2-}$  suffers less polarisation/distortion [1]

- (ii) ionic radii quoted:  $\text{Ca}^{2+}$ : 0.099 nm  
 $\text{Zn}^{2+}$ : 0.074 nm  
 $\text{Pb}^{2+}$ : 0.120 nm [1]

thus we expect  $\text{ZnCO}_3$  to be less stable, but  $\text{PbCO}_3$  to be more stable [1]  
if candidate states  $\text{PbCO}_3$  is more stable than  $\text{ZnCO}_3$  (or converse) with no reference  
to  $\text{CaCO}_3$  give [1] as salvage.

- (b) (i)  $\text{Cu} = 57.7/63.5 = 0.91$  ratios correct scores [1]  
 $\text{O} = 36.2/16 = 2.26$   
 $\text{C} = 5.4/12 = 0.45$   
 $\text{H} = 0.9/1 = 0.90$  hence  $\text{Cu}_2\text{O}_5\text{CH}_2$  [1]

- (ii)  $\text{Cu}^{2+}(\text{aq})$  or  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$  NOT  $[\text{Cu}(\text{H}_2\text{O})_4]^{2+}$  [1]

- (iii) D is  $\text{CuO}$  / copper(II) oxide [1]



$$\therefore 10 \longrightarrow 10 \times 159/221 = 7.2 \text{ g (7.19)}$$

if candidate thinks only  $\text{CO}_2$  is lost, answer will be 8.0 g [1]

- (iv) E is copper; F is  $\text{Fe}^{2+}$  /  $\text{FeSO}_4$  [1]  
 $\text{Fe} + \text{Cu}^{2+} \longrightarrow \text{Fe}^{2+} + \text{Cu}$  (or molecular) [1]

- (v) redox/displacement [1]

- (vi) blue ppt./solid formed [1]  
(dissolves to give) dark blue/purple colour [1]  
blue ppt. is  $\text{Cu}(\text{OH})_2(\text{s})$  [1]  
deep blue is  $[\text{Cu}(\text{NH}_3)_4]^{2+}$  (allow  $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$  NOT  $[\text{Cu}(\text{NH}_3)_6]^{2+}$ ) [1]

[Total: 19]

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- 4 (a) (i)  $\text{CH}_2=\text{CH}-\text{CH}_2\text{CH}_2\text{CH}_3$  accept  $\text{C}_3\text{H}_7$  on RHS [1]
- (ii) 8 [1]
- (b) (i) e.g.  $\text{C}_{40}\text{H}_{82} \longrightarrow \text{C}_{16}\text{H}_{34} + 2 \text{C}_{12}\text{H}_{24}$  OR  $\text{C}_{24}\text{H}_{48}$  [1]
- (ii) heat + catalysts/ $\text{SiO}_2/\text{Al}_2\text{O}_3/\text{Pt/ceramic/pumice/zeolite}$  etc [1]  
if temp given  $>500^\circ\text{C}$
- (iii) bonds broken:  $4(\text{C}-\text{C}) = 4 \times 350 = 1400 \text{ kJ mol}^{-1}$   
bond formed:  $2(\text{C}=\text{C}) = 2 \times 610 = 1220 \text{ kJ mol}^{-1}$   
 $\therefore \Delta H = +180 \text{ kJ mol}^{-1}$  [1]  
from eqn in (i) :  $+90 \text{ kJ mol}^{-1}$  for each  $\text{C}=\text{C}$  formed (could be multiples of 90)
- (iv) endothermic reactions  $\Delta H > 0$  [1]

[Total: 6]

- 5 (a) **G** is 4-nitromethylbenzene [1]  
**H** is 4-nitrophenylethanoic acid [1]
- (b) step II:  $\text{Cl}_2 + \text{light or heat (T} \sim 100^\circ\text{C)}$  ( $\text{AlCl}_3$  or aq. negates) [1]  
step III:  $\text{KCN (in ethanol) + heat (T} \sim 75^\circ\text{C)}$  ( $\text{HCN}$  negates) [1]  
step V:  $\text{Sn or Fe + HCl (+ heat)}$  [1]

[Total: 5]

- 6 (a) alkaline aqueous iodine ( $\text{NaOH/I}_2$ ) (allow  $\text{NaOI}$ ) [1]  
**J** gives yellow ppt; **K** gives no reaction [1]
- (b) aqueous bromine /  $\text{Cu}^{2+}$  aq / diazotisation with phenol [1]  
**L** gives no change; **M** decolourises/gives white ppt.  
with  $\text{Cu}^{2+}$  **L** goes blue, **M** goes green  
with diazotisation **L** gives no reaction, **M** a coloured compound [1]
- (c) drop of water [1]  
**N** fizzes/gives off steamy fumes; **P** has no reaction [1]  
or add  $\text{AgNO}_3(\text{aq})$  [1]  
**N** gives rapid ppt.; **P** gives ppt. very slowly [1]  
or add  $\text{NH}_3/\text{RNH}_2$  [1]  
**N** gives off fumes; **P** has no reaction [1]  
or add alcohol/phenol [1]  
**N** produces sweet-smelling liquid, **P** gives no reaction [1]
- (d) Universal Indicator solution/litmus [1]  
**Q** shows no change; **R** will turn solution blue (alkaline) [1]

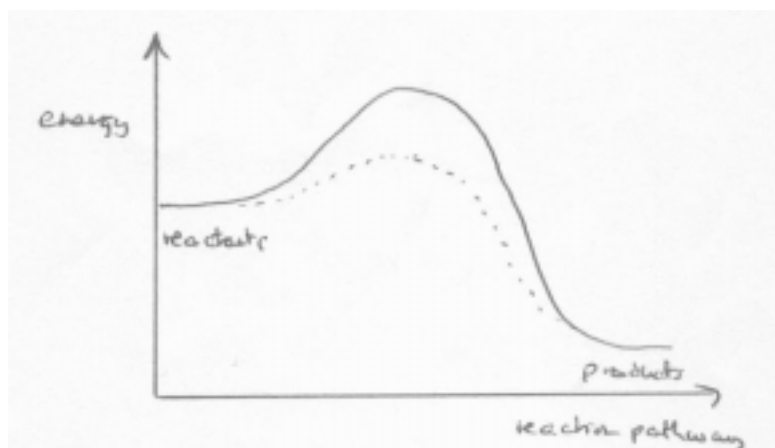
[Total: 8]

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- 7 (a) *protein*: polymer of amino acids / amino acids are monomers. [1]
- (b) diagram of at least two amino acids joining by the loss of water [1]  
 at least one peptide bond drawn out in full [1]  
 correct formula of the tripeptide [1]
- (c) acid/ $\text{H}^+$ / $\text{HCl}$  etc. or alkali/ $\text{OH}^-$ / $\text{NaOH}$  NOT conc  $\text{H}_2\text{SO}_4$  or any  $\text{HNO}_3$  [1]  
 heat/boil/reflux if temp given  $>90^\circ\text{C}$  [1]
- (d) (i) six [1]
- (ii)  $M_r = 3 \times 75 + 2 \times 89 + 2 \times 165 - 6 \times 18$  [1]  
 $= 625$  [1]  
 (allow [1] for  $M_r = 733$ )  
 (also ecf from (i))

[Total: 9]

8 (a) (i)

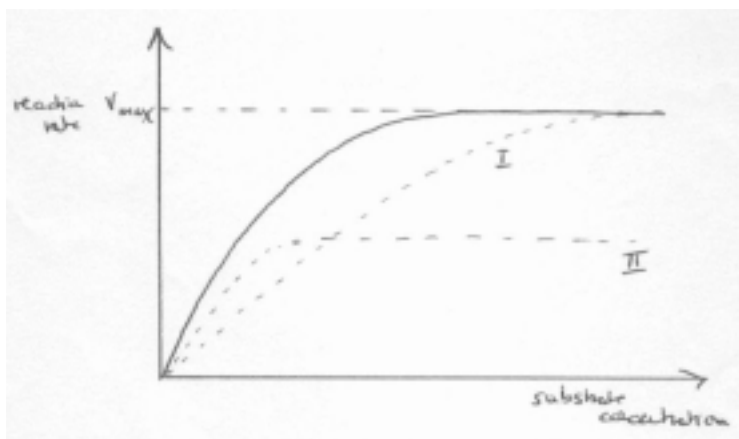


dotted line  
 must start and end  
 at same points [1]

- (ii) protein/polypeptide NOT polymer/polyamide [1]
- (iii) they are denatured/lose their  $2^\circ/3^\circ$  structure/or H-bonds/vdW [1]
- (b) (i) competitive inhibitor resembles the substrate OR competes for the active site of the enzyme [1]
- non-competitive inhibitor can bind to a different site on the enzyme OR forms a covalent bond/bonds permanently with the enzyme [1]

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(ii)



mark for each line NB lines must cross to score mark for II

[2 × 1]

- (c) (i) –S–H groups (allow sulphide/S/cysteine residue) [1]
- (ii) this inhibits/reduces/decreases the enzyme activity/stops normal function [1]  
the bonding disrupts the 3-dimensional structure of the enzyme [1]

**[Total: 10]**

- 9 (a) (i) cut DNA into sections / fragments / minisatellites [1]
- (ii) these undergo electrophoresis OR are placed on agarose gel [1]
- (iii) radioactive phosphorus /  $^{32}\text{P}$  OR darkens photographic film [1]

- (b) (i) NMR can be done in solution / *in vivo* / shows labile protons / shows positions of protons and/or carbon atoms [1]  
X-ray crystallography shows the positions of most atoms in structure / allows measurement of bond length [1]
- (ii) different types of tissue have protons in different chemical environments / tumour and healthy tissue absorb differently / allow at different frequencies [1]

- (c) (i)  $M : M+1 = 48 : 1.7$

$$x = \frac{100 \times 1.7}{1.1 \times 48} = 3.2 \text{ hence there are 3 carbon atoms in the compound} \quad [1]$$

NB if calculation shown 1.1 divisor MUST be present

since the compound has an  $m/e$  of 73 and contains 3 carbon atoms, 1 nitrogen atom and 1 oxygen atom,  $y = 73 - (36 + 14 + 16) = 7$  [1]

- (ii) the NMR spectrum shows a quartet, triplet pattern characteristic of an ethyl group [1]  
the other broad peak must be due to N–H protons [1]

thus the structure of the compound is likely to be  $\text{CH}_3\text{CH}_2\text{CONH}_2$  [1]

**[Total: 11 max 10]**

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- 10 (a) (i) silkworm – hydrogen bonds [1]  
spider – van der Waals' OR hydrogen bonds [1]
- (ii) spider silk is more elastic/flexible/less rigid than silkworm silk/has a lower density [1]  
silkworm silk absorbs water more easily [1]
- (iii) this increases the elasticity/hydrophobic nature of the silk [1]
- (b) (i) a polymer formed with the elimination/formation of a small molecule (or example) [1]
- (ii) any addition polymer e.g. poly(ethene), PVC, etc. [1]
- (iii) 3 from:  
addition polymers have a limited range of bonds/monomers [1]  
addition polymers are non-polar/have fewer/no H-bonds [1]  
condensation polymers/proteins have a range of combinations of amino acids which give a wide range of properties [1]  
condensation polymers/proteins have more functional groups/sidechains [1]  
different sequences of amino acids result in different 2°/3° structure [1]

[Total: 12 max 10]