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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UNIVERSITY of CAMBRIDGE
International Examinations

1 **(a)** **(i)** 162 ($^{81}Br^{-}\ ^{81}Br^{+}$) for molecular species [1]
160 ($^{81}Br^{-}\ ^{79}Br^{+}$) for atomic species [1]
158 ($^{79}Br^{-}\ ^{79}Br^{+}$) *ignore missing charges* for 5 masses [1]
81 ($^{81}Br^{+}$)
79 ($^{79}Br^{+}$)

(ii) 158:160:162 =1:2:1 [1]
79:81 =1:1 [1]

(b) **(i)** *either* $BrCH_2CHBr\text{-}CHO$ *or* $CH_2{=}CH\text{-}CH_2OH$ (double bond needed) [1]

(ii) reaction I: Br_2(aq or in CCl_4 etc.), light negates – *solvent not needed* [1]
reaction II: $NaBH_4$ *or* H_2/Ni etc. (but not if **A** is $CH_2{=}CH\text{-}CH_2OH$)
allow $LiAlH_4$ or Na/ethanol [1]
(*reactions can be reversed*)

(c) **(i)** $C_3H_6OBr_2$ = 216, 218 and 220 (any one) [1]

(ii)

31	is	CH_2OH^+/CH_3O^+	
106	is	$C_2H_3{}^{79}Br^+$	
108	is	$C_2H_3{}^{81}Br^+$	
185	is	$C_2H_3{}^{79}Br_2{}^+$	*ignore missing charges*
187	is	$C_2H_3{}^{79}Br^{81}Br^+$	6 correct [4]
189	is	$C_2H_3{}^{81}Br_2{}^+$	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 = $6.5–7.5 \times 10^{-6}$ [1]
units are mol dm^{-3} s^{-1} [1]

(d) half-life measured and quoted as ≅ 90–94 s [1]
evidence of two half-lives measured [1]

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(e) lines 1 and 2: as $[H_2O_2]$ increases by 0.07/0.05 = 1.4, so does rate
so order w.r.t. $[H_2O_2]$ = **1** [1]
lines 1 and 3: increase in rate (1.8) is also the increase in $[H_2O_2]$,
so rate is **independent** of $[H^+]$ (*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/M^{2+} radius/size increases down the group/M^{2+} charge density decreases [1]
anion/carbonate ion/CO_3^{2-} suffers less polarisation/distortion [1]

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

thus we expect $ZnCO_3$ to be less stable, but $PbCO_3$ to be more stable [1]
if candidate states $PbCO_3$ is more stable than $ZnCO_3$ (or converse) with no reference to $CaCO_3$ give [1] as salvage.

(b) **(i)** Cu = 57.7/63.5 = 0.91 ratios correct scores [1]
O = 36.2/16 = 2.26
C = 5.4/12 = 0.45
H = 0.9/1 = 0.90 hence $Cu_2O_5CH_2$ [1]

(ii) $Cu^{2+}(aq)$ *or* $[Cu(H_2O)_6]^{2+}$ NOT $[Cu(H_2O)_4]^{2+}$ [1]

(iii) **D** is CuO / copper(II) oxide [1]

$Cu_2O_5CH_2 \longrightarrow 2CuO + CO_2 + H_2O$ [1]
$221 \longrightarrow 159$ (M_rs) [1]

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

if candidate thinks only CO_2 is lost, answer will be 8.0 g [1]

(iv) **E** is copper; **F** is Fe^{2+} / Fe SO_4 [1]
$Fe + Cu^{2+} \longrightarrow Fe^{2+} + Cu$ (or molecular) [1]

(v) redox/displacement [1]

(vi) blue ppt./solid formed [1]
(dissolves to give) dark blue/purple colour [1]
blue ppt. is $Cu(OH)_2(s)$ [1]
deep blue is $[Cu(NH_3)_4]^{2+}$ (allow $[Cu(NH_3)_4(H_2O)_2]^{2+}$ NOT $[Cu(NH_3)_6]^{2+}$ [1]

[Total: 19]

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4 **(a)** **(i)** $CH_2=CH–CH_2CH_2CH_3$ accept C_3H_7 on RHS [1]

(ii) 8 [1]

(b) **(i)** e.g. $C_{40}H_{82} \longrightarrow C_{16}H_{34} + 2\ C_{12}H_{24}$ OR $C_{24}H_{48}$ [1]

(ii) heat + catalysts/SiO_2/Al_2O_3/Pt/ceramic/pumice/zeolite etc [1]
if temp given >500 °C

(iii) bonds broken: 4(C–C) = 4 × 350 = 1400 kJ mol^{-1}
bond formed: 2 (C=C) = 2 × 610 = 1220 kJ mol^{-1}
$\therefore \Delta H$ = **+180** kJ mol^{-1} [1]
*from eqn in **(i)** : +90 kJ mol^{-1} for each C=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: Cl_2 + light *or* heat (T~100 °C) ($AlCl_3$ or aq. negates) [1]

step III: KCN (in ethanol) + heat (T~75 °C) (HCN negates) [1]

step V: Sn or Fe + HCl (+ heat) [1]

[Total: 5]

6 **(a)** alkaline aqueous iodine ($NaOH/I_2$) (allow NaOI) [1]
J gives yellow ppt; **K** gives no reaction [1]

(b) aqueous bromine / Cu^{2+} aq / diazotisation with phenol [1]
L gives no change; **M** decolourises/gives white ppt.
with 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 $AgNO_3$(aq) *[1]*
N gives rapid ppt.; **P** gives ppt. very slowly *[1]*
or add NH_3/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]

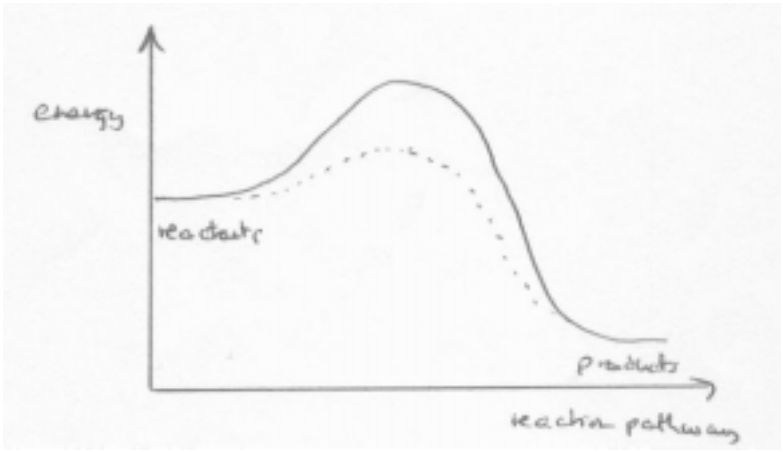
(c) acid/H^+/HC*l* etc. *or* alkali/OH^-/NaOH NOT conc H_2SO_4 or any HNO_3 [1]
heat/boil/reflux if temp given >90 °C [1]

(d) **(i)** six [1]

(ii) M_r = 3 × 75 + 2 × 89 + 2 × 165 – 6 × 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°/3° 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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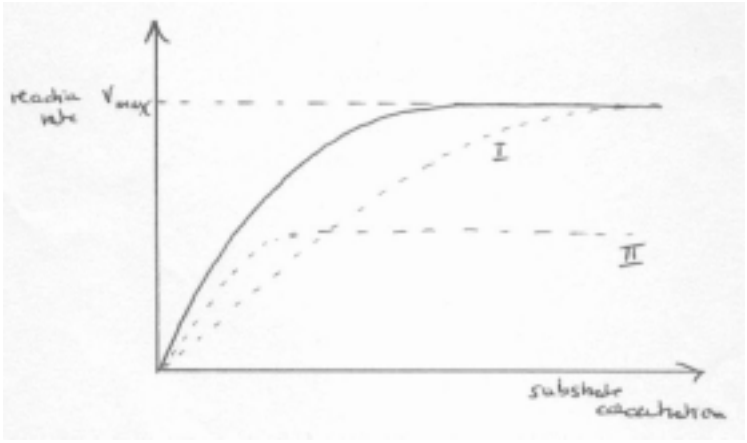
(ii)



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}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

$x = \frac{100 \times 1.7}{1.1 \times 48} = 3.2$ hence there are 3 carbon atoms in the compound [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
$CH_3CH_2CONH_2$ [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]

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