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

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.

Mark schemes must be read in conjunction with the question papers and the report on the examination.

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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 × 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]

(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]

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]

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]

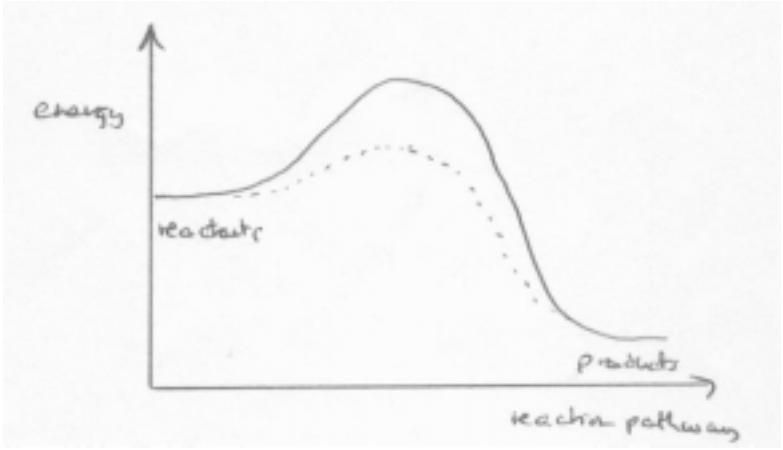
(c) acid/H^+/HC*l* etc. *or* alkali/OH^-/NaOH NOT conc H_2SO_4 or any HNO_3 [1]
heat/boil/reflux if temp given >90 °C [1]

(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]

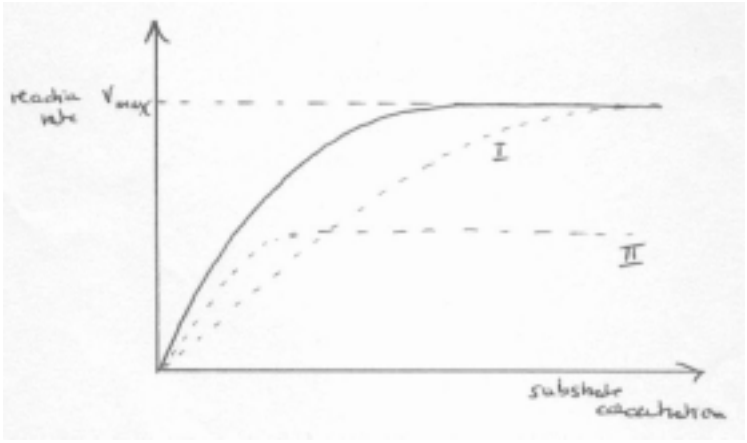
(ii) protein/polypeptide NOT polymer/polyamide [1]

(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]

(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]

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]