

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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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) 162 ($^{81}\text{Br}^-$ $^{81}\text{Br}^+$) for molecular species [1]
160 ($^{81}\text{Br}^-$ $^{79}\text{Br}^+$) for atomic species [1]
158 ($^{79}\text{Br}^-$ $^{79}\text{Br}^+$) 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 $\text{BrCH}_2\text{CHBr-CHO}$ or $\text{CH}_2=\text{CH-CH}_2\text{OH}$ (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 $\text{CH}_2=\text{CH-CH}_2\text{OH}$) [1]
allow 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 $\cong 90\text{--}94$ 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/ 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) $\text{Cu} = 57.7/63.5 = 0.91$ 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 CuO / copper(II) oxide [1]



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

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

- (iv) E is copper; F is Fe^{2+} / 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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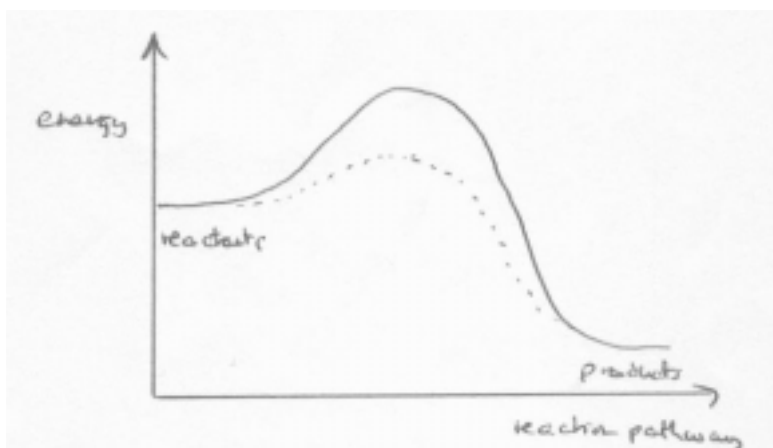
- 4 (a) (i) $\text{CH}_2=\text{CH}-\text{CH}_2\text{CH}_2\text{CH}_3$ accept C_3H_7 on RHS [1]
(ii) 8 [1]
- (b) (i) e.g. $\text{C}_{40}\text{H}_{82} \longrightarrow \text{C}_{16}\text{H}_{34} + 2 \text{C}_{12}\text{H}_{24}$ OR $\text{C}_{24}\text{H}_{48}$ [1]
(ii) heat + catalysts/ $\text{SiO}_2/\text{Al}_2\text{O}_3/\text{Pt}/\text{ceramic}/\text{pumice}/\text{zeolite}$ 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: $\text{Cl}_2 + \text{light or heat (T} \sim 100^\circ\text{C)}$ (AlCl_3 or aq. negates) [1]
step III: $\text{KCN (in ethanol) + heat (T} \sim 75^\circ\text{C)}$ (HCN negates) [1]
step V: $\text{Sn or Fe + HCl (+ heat)}$ [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 $\text{AgNO}_3(\text{aq})$ [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⁺/HCl etc. or alkali/OH⁻/NaOH NOT conc H₂SO₄ or any HNO₃ [1]
heat/boil/reflux if temp given >90 °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)

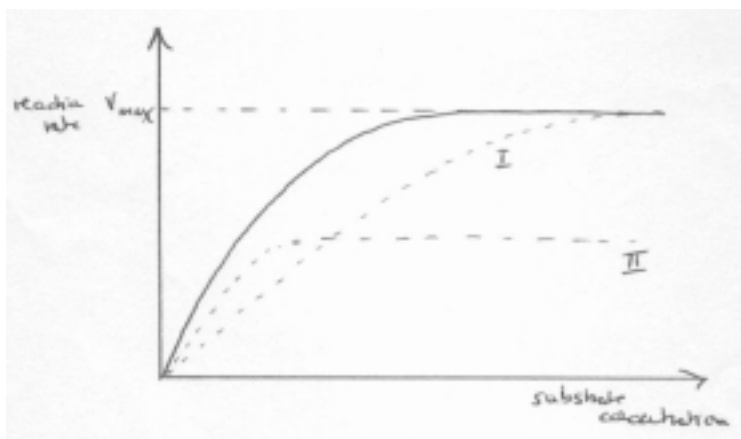


dotted line
must start and end
at same points [1]

- (ii) protein/polypeptide NOT polymer/polyamide [1]
- (iii) they are denatured/lose their 2°/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) $M : M+1 = 48 : 1.7$

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

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 $\text{CH}_3\text{CH}_2\text{CONH}_2$ [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]