CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the October/November 2013 series

9701 CHEMISTRY

9701/41 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, which would have considered the acceptability of alternative answers.

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CAMBRIDGE
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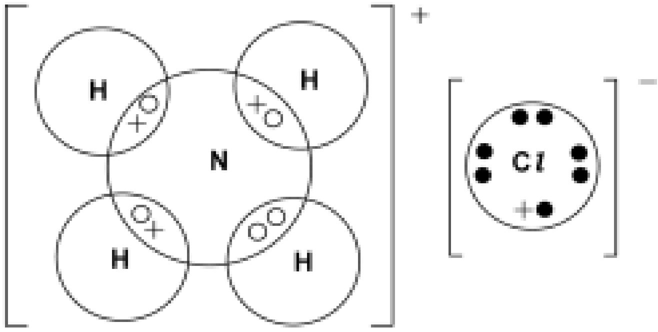
1 (a)



8 e^- around chlorine [1]
1 H–electron (+) on the Cl^- ion [1]
3 covalent (ox) and one dative (oo) around N [1]

[3]

(b) **(i)** it would react (with H_2SO_4) [1]

(ii) $CaO + H_2O \longrightarrow Ca(OH)_2$ [1]

(iii) CaO absorbs more water *or* CaO has greater affinity for water [1]

[3]

(c) **(i)** $2Ca(NO_3)_2 \longrightarrow 2CaO + 4NO_2 + O_2$ [1]

(ii) (Down the group, the nitrates)

become more stable/stability increases [1]

because the size/radius of **ion** (**M^{2+}**) increases [1]

thus causing less polarisation/distortion
of the anion/NO_3^-/N-O bond [1]

[4]

[Total: 10]

2 **(a)** **(i)** Si-Si bonds are weaker (than C-C bonds) [1]

(ii) metallic (Sn) is weaker than (giant) covalent (Ge) [1]

[2]

(b) **(i)** $SiCl_4 + 2H_2O \longrightarrow SiO_2 + 4HCl$
or $SiCl_4 + 4H_20 \longrightarrow Si(OH)_4 + 4HCl$
or $SiCl_4 + 3H_20 \longrightarrow H_2SiO_3 + 4HCl$
(partial hydrolysis is *not sufficient* e.g. to $SiCl_3OH + HCl$) [1]

(ii) $PbCl_4 \longrightarrow PbCl_2 + Cl_2$ [1]

(iii) $SnCl_2 + 2FeCl_3 \longrightarrow SnCl_4 + 2FeCl_2$ [1]

(iv) $SnO_2 + 2NaOH \longrightarrow Na_2SnO_3 + H_2O$
or $SnO_2 + 2NaOH + 2H_2O \longrightarrow Na_2Sn(OH)_6$
or ionic equation $SnO_2 + 2OH^- \longrightarrow SnO_3^{2-} + H_2O$ [1]

[4]

[Total: 6]

3 **(a)** **(i)** $NH_3 + HZ \longrightarrow NH_4^+ + Z^-$ [1]
$CH_3OH + HZ \longrightarrow CH_3OH_2^+ + Z^-$ [1]

(ii) $NH_3 + B^- \longrightarrow NH_2^- + BH$ [1]
$CH_3OH + B^- \longrightarrow CH_3O^- + BH$ [1]

[4]

(b) **(i)** a reaction that can go in either direction [1]

(ii) **rate** of forward = **rate** of backward reaction
or forward/back reactions occurring but concentrations of all species do not change [1]

[2]

(c) **(i)** a solution that resists changes in pH [1]

when small quantities of acid or base/alkali are added [1]

(ii) in the equilibrium system $HZ + H_2O \rightleftharpoons Z^- + H_3O^+$ [1]

addition of acid: reaction moves to the left
or H^+ combines with Z^- **and** forms HZ [1]

addition of base: the reaction moves to the right
or H^+ combines with OH^- **and** more Z^- formed [1]

[5 max 4]

(d) **(i)** $[H^+] = \sqrt{(0.5 \times 1.34 \times 10^{-5})} = 2.59 \times 10^{-3}$ (mol dm^{-3}) [1]

pH = **2.59/2.6** (min 1 d.p) ecf [1]

(ii) $CH_3CH_2CO_2H + NaOH \longrightarrow CH_3CH_2CO_2Na + H_2O$ [1]

(iii) n(acid) in 100 cm^3 = 0.5 × 100/1000 = 0.05 mol
n(acid) remaining = 0.05 – 0.03 = 0.02 mol
[acid remaining] = **0.2** (mol dm^{-3}) [1]

likewise, n(salt) = 0.03 mol
[salt] + **0.3** (mol dm^{-3}) [1]

(iv) pH = 4.87 + log(0.3/0.2) = **5.04–5.05** ecf [1]

[6]

(e) **G** is CH_3CH_2COCl
H is $SOCl_2$ *or* PCl_5
J is NaCl [2]
(or corresponding Br compounds for **G**, **H** and **J**; CH_3CH_2COBr, $SOBr_2$, NaBr)

[Total: 18]

4 **(a)** (the energy change) when 1 mol of bonds [1]
is broken in the gas phase [1]

[2]

(b) **(i)** (C-X bond energy) decreases/becomes weaker (from F to I) [1]

due to bond becoming longer/not such efficient orbital overlap [1]

(ii) (as the bond energy of C-X decreases) the halogenalkanes become more reactive (answer must imply that it is from F to I) [1]

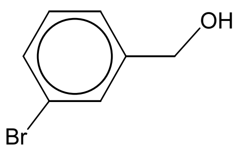
[3]

(c) The C-C*l* bond is weaker than the C-F **and** C-H bonds
or C-C*l* bond (E = 340) **and** C-H (E = 410) [1]

so is (easily) broken to form C*l*•/C*l* radicals/C*l* atoms [1]
causing the breakdown of O_3 into O_2 [1]

[3]

(d) C*l*-CH_2CH_2-CO_2H [1]
HO-$CH_2CH_2CH_2$-C*l* [1]



[1]

[3]

(e) **(i)** light/UV/hν *or* 300°C [1]

(ii) (free) radical substitution [1]

(iii) Δ*H* = E(C-H) – E(H-C*l*) = 410 – 431 = **–21** kJ mol^{-1} [1]

(iv) Δ*H* = E(C-H) – E(H-I) = 410 – 299 = **+111** kJ mol^{-1} ecf [1]

(v) The reaction with iodine is endothermic *or* Δ*H* is positive *or* requires energy [1]

(vi) $Cl_2 \longrightarrow$ **2C*l*•** [1]
$CH_3CH_2^\bullet$ + **Cl_2** $\longrightarrow$ **CH_3CH_2Cl + C*l*•** [1]
$CH_3CH_2^\bullet$ + C*l*• $\longrightarrow$ CH_3CH_2Cl [1]

[8]

[Total: 19]

5 **(a)** **(i)** **many** monomers form a polymer [1]

(ii) addition [1]

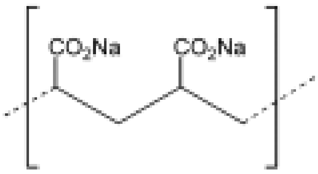
(iii) C=C/double/π bond is broken **and** new C-C single bond<u>**s**</u> are formed
or double bond breaks and forms single bonds with other monomers [1]

[3]

(b) propenoic acid [1]

[1]

(c) **(i)**

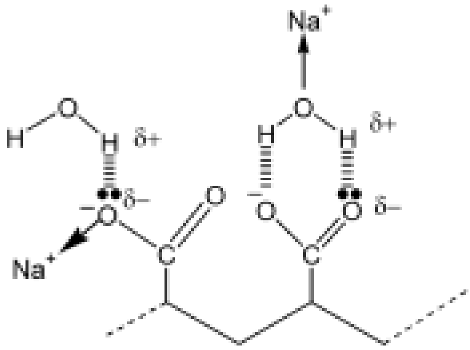


carbon chain **and** CO_2H [1]
at least one sodium salt [1]

(ii) 120° to 109(.5)° [1]
due to the change from a trigonal/sp^2 carbon to a tetrahedral/sp^3 carbon [1]

[4]

(d) **(i)**



Any four:
hydrogen bond **labelled**
water H-bonded to O through H atom
δ+/δ- shown on each end of a H-bond
lone pair shown on O^- *or* C=O *or* H_2O on a **correct H-bond**
Na^+ shown as coordinated to a water molecule [3]

(ii) Solution became paler **and** $Cu^{(2+)}$ swapped with $Na^{(+)}$
or darker in colour **and** polymer absorbs water [1]

[4]

(e) **(i)** alkene(1), amide(1) [2]

(ii) NH_3 [1]

(iii) H_2O [1]

(iv) HCl (aq)/H_3O^+ **and** heat/reflux (**not** warm) [1]
or OH^- (aq), heat and acidify

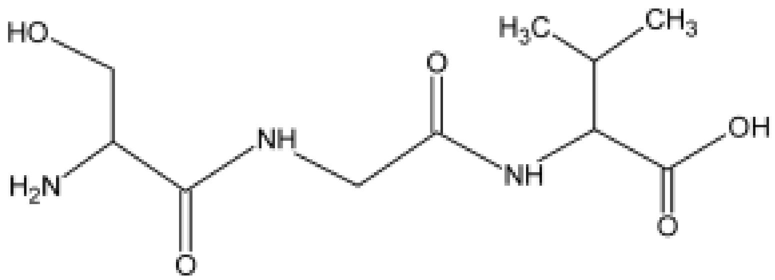
[5]

[Total: 17]

Section B

6 (a) (i) **six/6** (gsv, sgv, gvs, vgs, svg,vsg) [1]

(ii)



two **displayed** peptide bonds [1]
correct formula of peptide [1]

(iii) valine (**allow** glycine) [1]

(iv) *any two of:*
hydrogen bonds **and** CO_2H *or* OH *or* NH_2 *or* CONH *or* CO *or* NH *or* CO_2^-
ionic bonds **and** NH_3^+ *or* CO_2^-
van der Waals' **and** $-CH_3$ *or* –H 2 × [1]

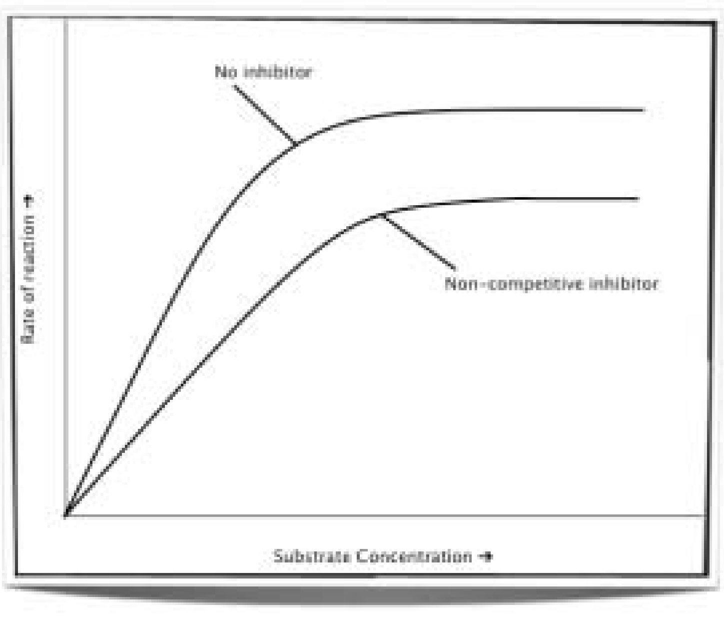
[6]

(b) (i) same shape/structure as substrate [1]

(inhibitor) competes/blocks/binds/bonds to **active site**
or substrate cannot bind to **active site** [1]

(ii) binds with enzyme **and** changes shape/3D structure (of enzyme/active site) [1]

(iii)

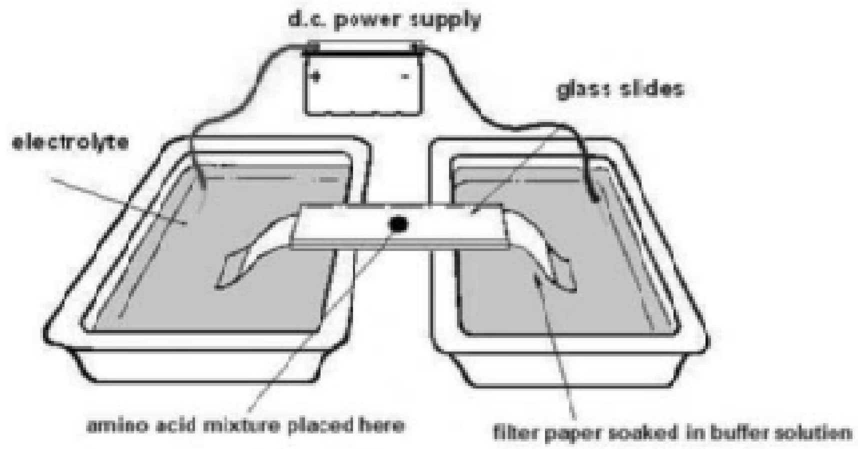


[1]

[4]

[Total: 10]

7 (a)



power supply (idea of complete circuit)
electrolyte/buffer solution
gel/filter paper/absorbent paper
(amino acid) sample/mixture [centre of plate] 4 × [1]

[4]

(b) *any two from:*
size/M_r (of the amino acid species)
charge (on the amino acid species)
temperature 2 × [1]

[2]

(c) Ratio of the concentration of a solute in each of two (immiscible) solvents
or equilibrium constant representing the distribution of a solute between two solvents
or PC = $[X]_a/[X]_b$ (at a constant temperature) [1]

[1]

(d) (i) K_{pc} = [Z in ether]/[Z in H_2O] – allow reverse ratio
40 = (x/0.05)/((4–x)/0.5) [1]

= **3.2 g** ecf [1]

(ii) First extraction
40 = (x/0.025)/((4–x)/0.5)
x = **2.67 g** ecf [1]

(iii) Second extraction: 1.33g remain in solution
Second extraction
40 = (y/0.025)/((1.33–y)/0.5)
y = **0.887 g**

mass extracted = 2.67 + 0.89 = **3.56/3.6 g** ecf [1]

[4]

[Total: 11]

8 (a) (i) (nitrates are) soluble [1]

(ii) $Ba^{(2+)}$ **and** $Pb^{(2+)}$ [1]

$SO_4^{(2-)}$ [1]

$BaCO_3/PbCO_3/CaSO_4$ are insoluble [1]

[4]

(b) (i) fertilisers/animal manure [1]

(ii) washing powder/detergents/fertilisers/animal manure [1]

(iii) growth/production of algae/weeds/plants
or eutrophication [1]

[3]

(c) (i) *any one of:*

$2SO_2 + O_2 \longrightarrow 2SO_3$ **and** $SO_3 + H_2O \longrightarrow H_2SO_4$

or $SO_2 + NO_2 \longrightarrow SO_3 + NO$ **and** $SO_3 + H_2O \longrightarrow H_2SO_4$

or $SO_2 + ½O_2 + H_2O \longrightarrow H_2SO_4$ [1]

(ii) roasting sulfide ores/extraction of metals from sulfide ores [1]

[2]

[Total: 9]