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

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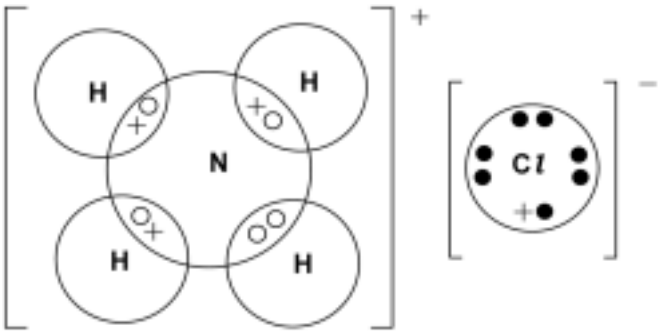
1 (a)



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** ($\mathbf{M^{2+}}$) increases [1]

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

[4]

[Total: 10]

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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]

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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]

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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]

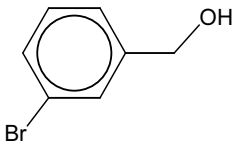
[3]

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

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

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

(vi) $Cl_2 \longrightarrow$ **2C*l*•** [1]
CH_3CH_2• + **C*l*$_2$** $\longrightarrow$ **CH_3CH_2C*l* + C*l*•** [1]
CH_3CH_2• + C*l*• $\longrightarrow$ CH_3CH_2C*l* [1]

[8]

[Total: 19]

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

(ii) addition [1]

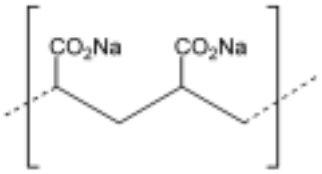
(iii) C=C/double/π bond is broken **and** new C-C single bond**s** are formed
or double bond breaks and forms single bonds with other monomers [1]

[3]

(b) propenoic acid [1]

[1]

(c) (i)

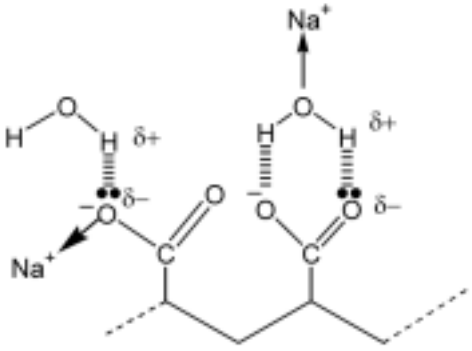


carbon chain **and** CO_2H [1]
at least one sodium salt [1]

(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]

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

(ii) NH_3 [1]

(iii) H_2O [1]

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

[5]

[Total: 17]

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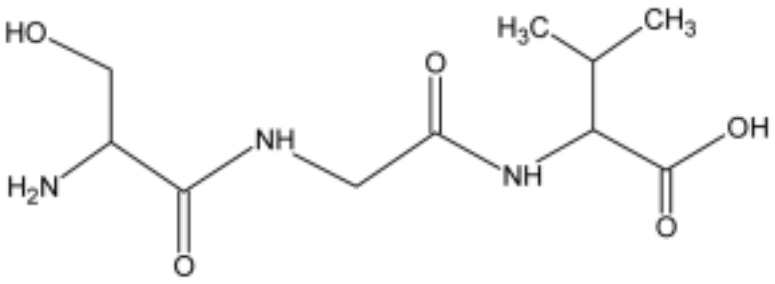
Section B

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]

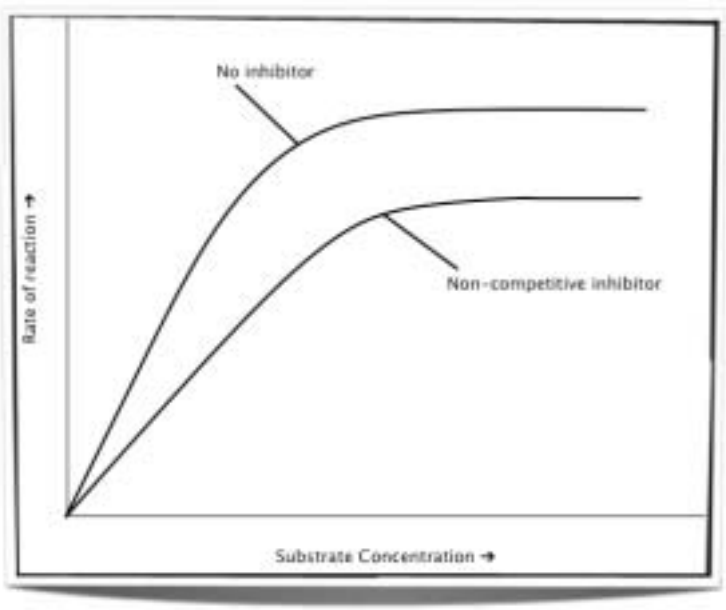
[6]

(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]

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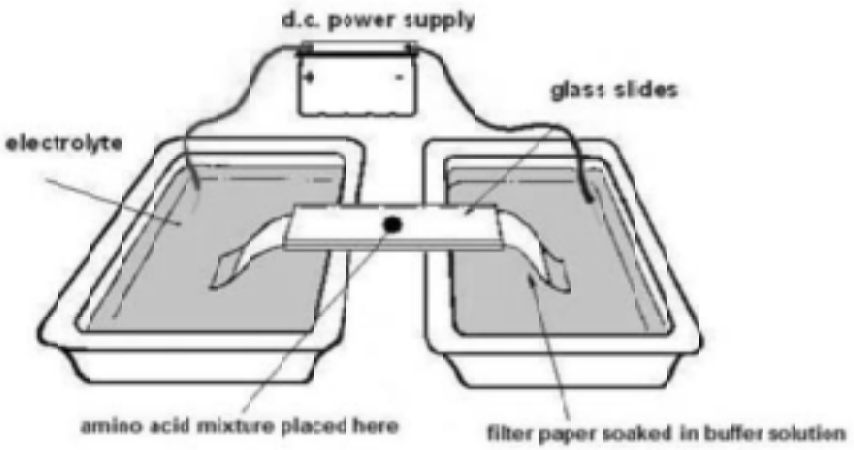
7 (a)



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 <u>concentration</u> 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]

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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]

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