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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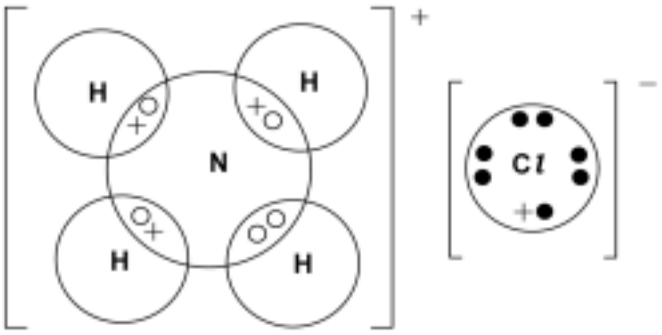
1 (a)



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]

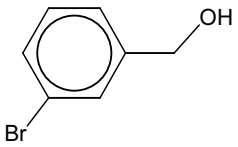
[3]

(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]

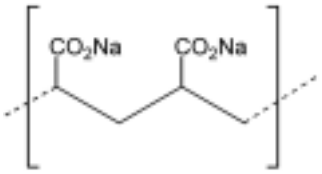
(iii) C=C/double/π bond is broken **and** new C-C single bond**s** are formed
or double bond breaks and forms single bonds with other monomers [1]

[3]

(b) propenoic acid [1]

[1]

(c) (i)

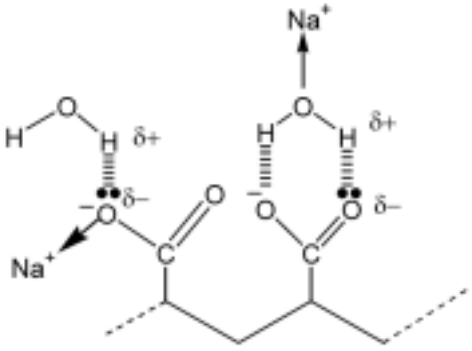


carbon chain **and** CO_2H [1]
at least one sodium salt [1]

(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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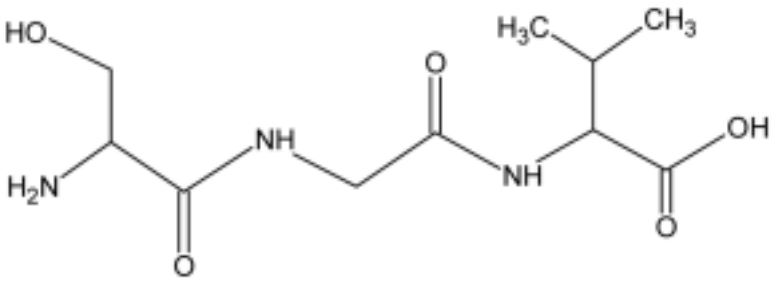
Section B

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]

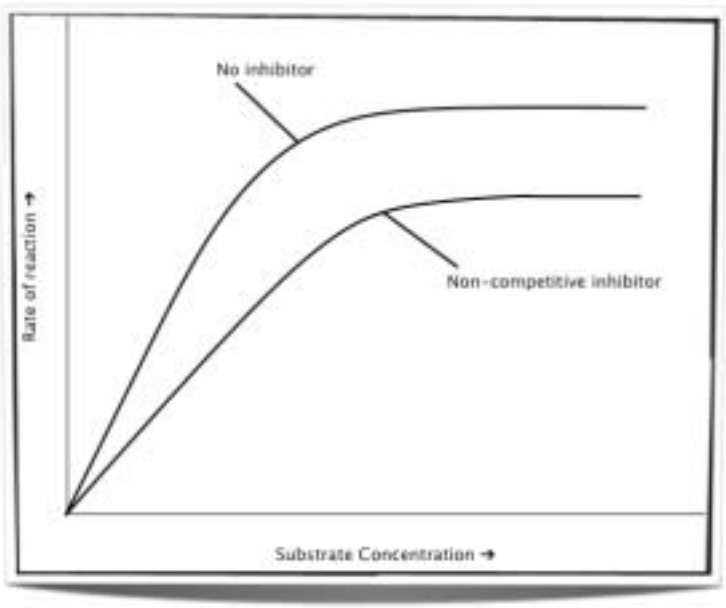
[6]

(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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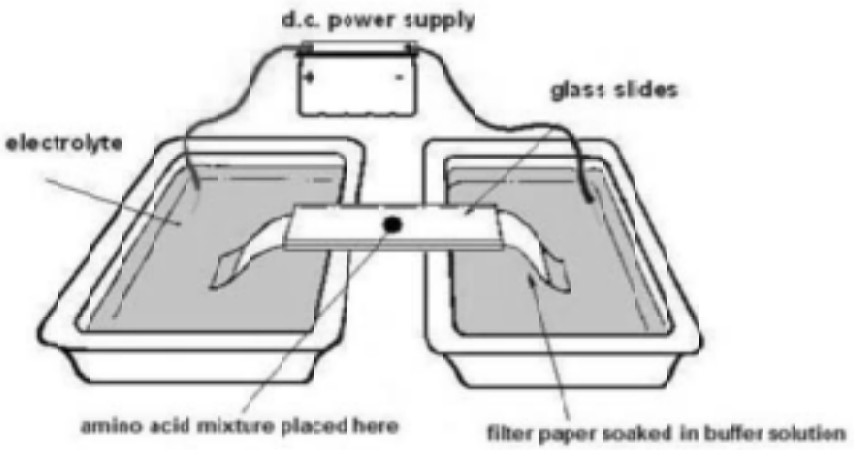
7 (a)



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

[ ]

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

[ ]

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

mass extracted = 2.67 + 0.89 = **3.5 6/3.6 g** ecf [1]

[ ]

[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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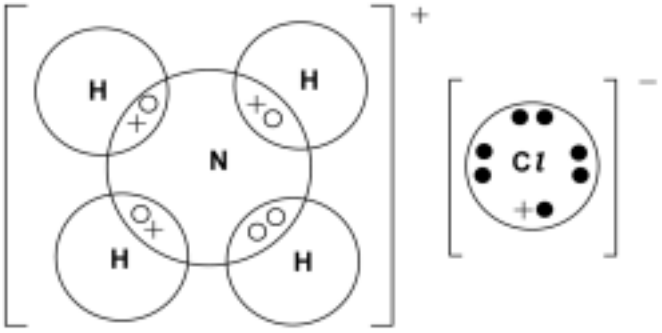
1 (a)



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3 covalent (ox) and one dative (oo) around N [1]

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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]

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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]

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[4]

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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]

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[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]

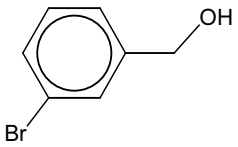
[3]

(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• + **Cl_2** $\longrightarrow$ **CH_3CH_2Cl + C*l*•** [1]
CH_3CH_2• + C*l*• $\longrightarrow$ CH_3CH_2Cl [1]

[8]

[Total: 19]

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

(ii) addition [1]

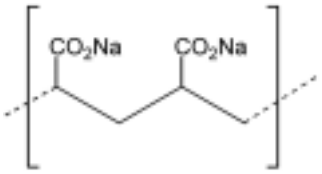
(iii) C=C/double/π bond is broken **and** new C-C single bond**s** are formed
or double bond breaks and forms single bonds with other monomers [1]

[3]

(b) propenoic acid [1]

[1]

(c) (i)

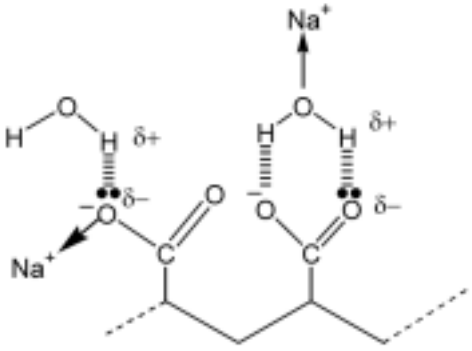


carbon chain **and** CO_2H [1]
at least one sodium salt [1]

(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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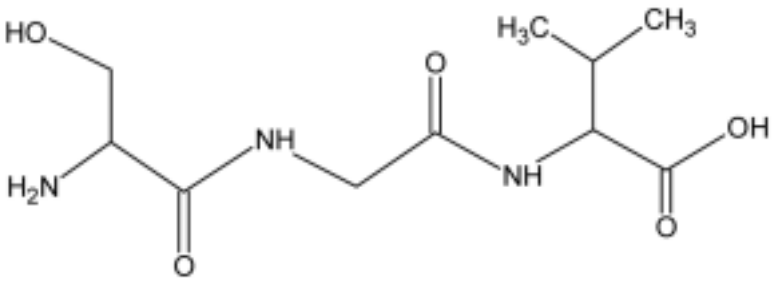
Section B

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]

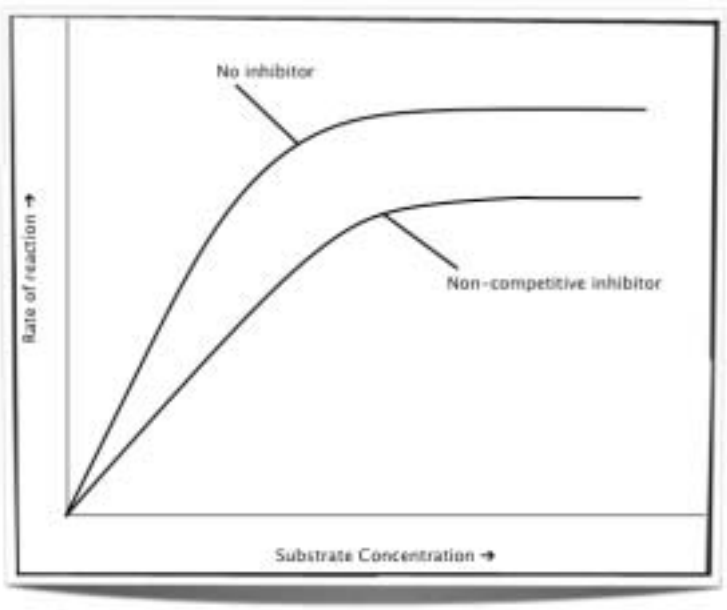
[6]

(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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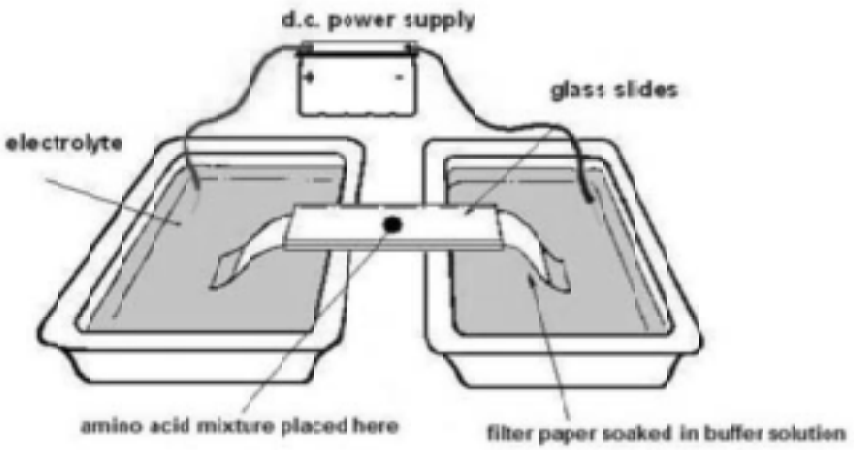
7 (a)



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

[ ]

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

[ ]

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

mass extracted = 2.67 + 0.89 = **3.5 g/3.6 g** ecf [1]

[ ]

[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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CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the October/November 2013 series

9701 CHEMISTRY

9701/43 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.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge will not enter into discussions about these mark schemes.

Cambridge is publishing the mark schemes for the October/November 2013 series for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level components and some Ordinary Level components.

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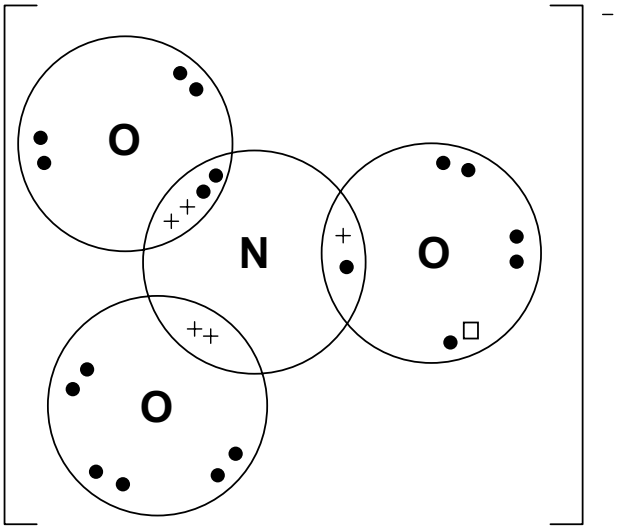
1 (a)



dative bond to an oxygen using two N electrons [1]
8 electrons around N in 1 double + 2 single bonds [1]
a total of 24 electrons, including one, and *only* one " " [1]
(the extra electron, " ", can be in a bond or a lone pair)

[3]

(b) (i) $2Mg(NO_3)_2 \longrightarrow 2MgO + 4NO_2 + O_2$ [1]

(ii) (down the group)
nitrates become more stable *or* are more difficult to decompose *or* need a higher temperature to decompose [1]

because there is less polarisation of the anion / nitrate ion / N–O bonds [1]

as radius of M^{2+} / metal ion increases *or* charge density of the cation decreases [1]

[4]

(c) $Cu + 4H^+ + 2NO_3 \longrightarrow Cu^{2+} + 2NO_2 + 2H_2O$ species [1]
balancing [1]

[2]

[Total: 9]

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2 **(a)** *any two from*: molecules have negligible volume
negligible intermolecular forces *or* particles are not attracted to each other *or* to the walls of the container
random motion
no loss of **kinetic** energy during collisions *or* elastic collisions (NOT elastic molecules) 2 × [1]
[2]

(b) **(i)** low temperature ***and*** high pressure both required [1]

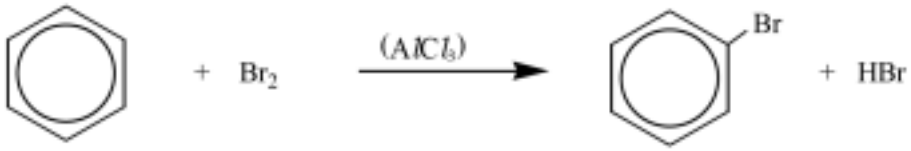
(ii) (at low T) forces between particles are more important, [1]

(at high P) volume of molecules are significant [1]

[3 max 2]

(c) **(i)** endothermic; because the equilibrium moves to the right on heating *or* with increasing temperature *or* because bonds are broken during the reaction [1]

(ii) e.g. halogenation *or* Friedel-Crafts alkylation / acylation



reactants [1]
products [1]

other possibilities: Cl_2, I_2, R–Cl, RCOCl etc.

[3]

[Total: 7]

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3 (a) (i) $CH_3Br(g) \longrightarrow CH_3(g) + Br(g)$ [1]

(ii) $^1/_3\, Al Cl_3(g) \longrightarrow {}^1/_3 Al(g) + Cl(g)$ [2]
or $AlCl_3(g) \longrightarrow AlCl_2(g) + Cl(g)$
($AlCl_3(g) \longrightarrow Al(g) + 3Cl(g)$ for (1) mark)

[3]

(b) (i) bond energies decrease from Cl_2 to I_2 [1]
due to increasing bond length *or* increase in number of electron shells [1]
which causes less effective orbital overlap *or* less attraction for the shared pair [1]

(ii) *either* because fluorine is electronegative, (hence each F wants to keep its electrons to itself)
or because the bond length is so short there is repulsion between the lone pairs (on F)
or repulsion between the nuclei (of F) [1]

[4 max 3]

(c) (i) for chlorine:
ΔH = E(H – H) + E(Cl – Cl) – 2E(H – Cl) = 436 + 242 – (2 × 431)
= **–184** kJ mol $^{-1}$ [2]
for iodine:
ΔH = E(H – H) + E(I – I) – 2E(H – I) = 436 + 151 – (2 × 299)
= **–11** kJ mol $^{-1}$ [1]

(ii) Hydrides become less thermally stable down the group from Cl to I [1]
as the H–X bond energy decreases (more than does the X–X bond energy) [1]

[5]

(d) (i)

	Na	**O**	**Br**	
	15.2 / 23	31.8 / 16	53.0 / 79.9	[1]
$\Rightarrow$	0.661	1.99	0.663	
$\div 0.661 \Rightarrow$	1.0	3.0	1.0	
			thus **$NaBrO_3$**	[1]

(ii) $3Br_2 + 6NaOH \longrightarrow NaBrO_3 + 5NaBr + 3H_2O$
or $3Br_2 + 6OH \longrightarrow BrO_3 + 5Br + 3H_2O$ species [1]
balancing [1]
[4]

[Total: 15]

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4 (a) (i) Carbon (graphite) has delocalised electrons whereas silicon's electrons are localised. [1]

(ii) Tin has metallic structure *or* delocalised / mobile electrons whereas germanium has localised electrons *or* giant covalent structure [1]
[2]

(b) (i) $2\,PbO_2 \longrightarrow 2PbO + O_2$ [1]

(ii) $PbO_2 + 4HCl \longrightarrow PbCl_2 + Cl_2 + 2H_2O$ [1]

(iii) $SnO + 2NaOH \longrightarrow Na_2SnO_2 + H_2O$ [1]

(iv) $GeCl_4 + 2H_2O \longrightarrow GeO_2 + 4HCl$ [1]
[4]

[Total: 6]

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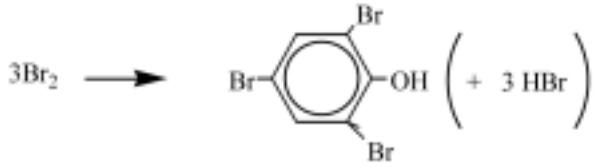
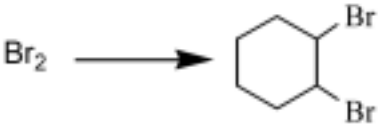
5 (a) (i) Br_2(aq) [1]
electrophilic substitution [1]



[1]

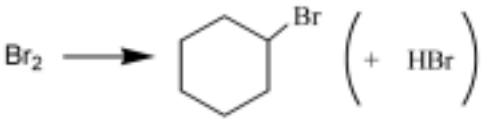
(ii) no special conditions [1]
electrophilic addition [1]



(allow bromohydrin *or* dibromide if Br_2(aq) has been used)

product [1]

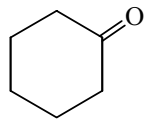
(iii) light / UV *or* heat [1]
(free) radical substitution [1]



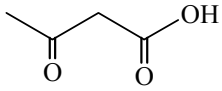
product [1]
balanced equation in (i) (i.e. 3 Br_2 and 3 HBr) [1]
balanced equation in (iii) (i.e. Br_2 and HBr) [1]

[11 max 10]

(b) (i)



C



D

CH_3CO_2H

E

3 correct structures (can be in any order) 3 × [1]

(ii) results of tests:
with 2,4–DNPH: **C** and **D** [1]
with I_2 + OH⁻ : **D** only [1]
with NaOH: **D** and **E** [1]
(N.B. letters may be different – must refer to the candidate's formulae)

[6]

[Total: 16]

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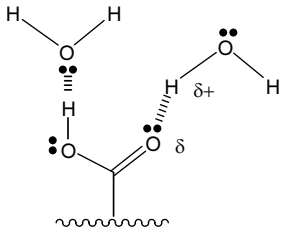
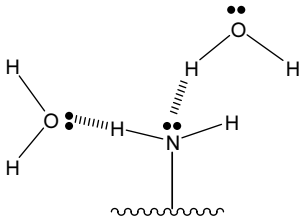
6 **(a)** A (Bronsted-Lowry) acid is a proton donor. [1]
[1]

(b) **(i)**



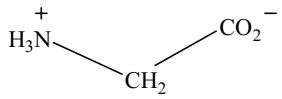
carboxylic acid



amino group

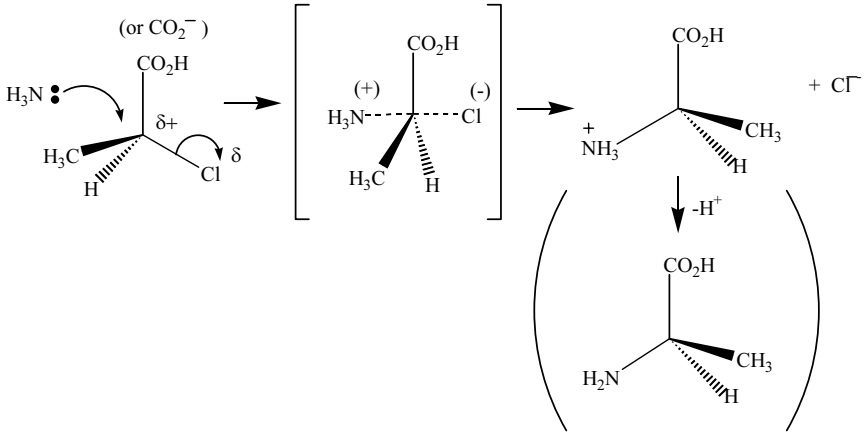
at least one H_2O molecule in the right orientation: attached to $–CO_2H$ [1]
attached to $–NH_2$ [1]
lone pair (on oxygen in H_2O *or* $–CO_2H$ *or* on nitrogen) shown at least once on a H-bond [1]
δ+ and δ– shown at least once (at each end of the same H-bond) [1]

(ii)



[1]
[5]

(c) allow either S_N1 or S_N2



any three of δ+ and δ– shown in C–C*l*
curly arrow from **lone pair on NH_3** to (δ+) carbon
curly arrow from C–C*l* bond to C*l*
5-coordinate transition state *or* carbocation intermediate if S_N1, with correct charge

[3]
[3]

(d) lysine @ pH 1: $^{+}NH_3(CH_2)_4CH(NH_3^{+})CO_2H$ [1]
aspartic acid @ pH 12: $O_2C\,CH_2\,CH(NH_2)CO_2$ [1]
[2]

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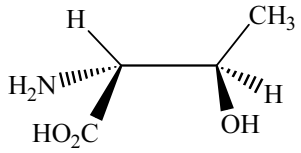
(e) (i) 6 (six) [1]

(ii) *either* $H_2NCH(CH_3)CO–NHCH(CH_2OH)CO_2H$
or $H_2NCH(CH_2OH)CO–NHCH(CH_3)CO_2H$ [2]
[3]

(f) (i) Compounds have the same **structural** formula but ....
different (spatial) arrangement / position *or* orientation of atoms in space [1]

(ii) **J** [1]

(iii)



[1]
[3]

[Total: 17]

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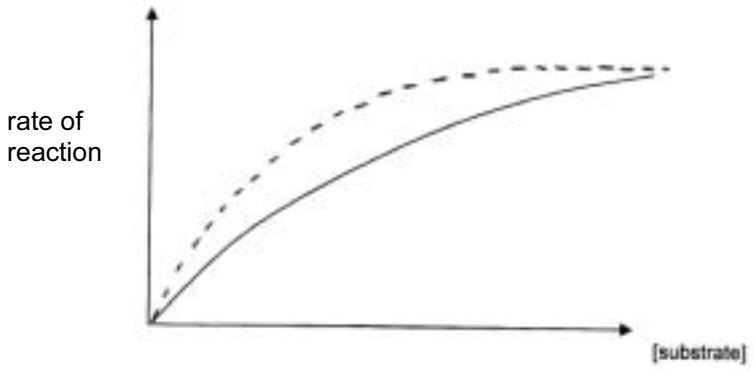
Section B

7 (a) (i) Metals such as Hg, Ag, Cd, Pb, Cu (identified – NOT just "heavy metals")
(allow names, atomic symbols or ions, names or formulae of salts – e.g. $Pb(NO_3)_2$)
or penicillin *or* organophosphorus insecticide etc. [1]

(ii) The ion / inhibitor binds to a part of the enzyme molecule away from the active site *or* to an allosteric site [1]
This changes the shape of the active site *or* denatures the enzyme [1]
OR
the inhibitor forms a **covalent / permanent** bond with the active site [1]
blocking entry of the substrate [1]

(iii)



[1]
[4]

(b) (i) (DNA) ⟶ **mRNA** ⟶ **ribosome** ⟶ **tRNA** ⟶ (Protein) [2]

(ii) stop codon / it is used to stop the growth of a protein chain
(allow: used at the start of protein synthesis) [1]
[3]

(c) (i) Adenosine diphosphate (ADP) *or* AMP **and** (inorganic) phosphate/P_i/PO_4^{3} /H_3PO_4 [1]

(ii) Any two of –
muscle contraction
transport of ions / molecules *or* active transport *or* exocytosis *or* Na / K pump
synthesis of new compounds / proteins etc.
movement of electric charge in nerve cells
bioluminescence
non-shivering thermogenesis
DNA synthesis / reproduction 2 × [1]
[3]

[Total: 10]

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8 **(a)** NMR **and** radiowaves (*or* VHF / UHF *or* 40 – 800 MHz) [1]
[1]

(b) NMR: protons have (nuclear) spin
or (*s*pinning) proton produces magnetic moment / field *or* two spin states
or protons can align with or against an applied magnetic field [1]

there is insufficient electron density / cloud around H atoms for X-ray crystallography [1]
[2]

(c) Sulfur, because it has the highest electron density [1]
[1]

(d) **(i)** $\frac{4.5}{1.5} \quad \frac{100}{1.1} \times n$

$n \quad \frac{100 \times 0.15}{4.5 \times 1.1} \quad 3.03 \quad \mathbf{3}$ (calculation must be shown) [1]

(ii) the –OH peak (broad singlet) at δ 4.6 [1]

(iii) 3 (three) [1]

(iv) **Q** has peak at 11.7δ. [1]
which is due to $-CO_2H$ [1]
(This can only be formed by oxidising a *primary* alcohol.)

or **P** has 4 peaks in its NMR spectrum, not 3 [1]
in a secondary alcohol with 3 carbons, two (methyl) groups will be in the same chemical environment (or wtte) [1]

or analysis of the splitting pattern in **P**: the peaks at δ 0.9 and 3.6 are triplets, [1]
so each must be adjacent to a $-CH_2-$ group. (hence $-CH_2-CH_2-CH_3$) [1]

(v) $CH_3CH_2CO_2H$ (**structure** needed, not name) [1]
[6]

[Total: 10]

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9 (a) (i) diamond and graphite [1]

(ii) any three from

	graphite	**diamond**
colour	black	transparent / colourless
electrical conductivity	good conductor	non-conductor
hardness	soft / slippery	hard / non slippery
density	less dense than diamond	more dense than graphite
melting point	lower	higher

3 × [1]
[4]

(b) Because each carbon is only bonded to 3 others *or* is unsaturated / doubly-bonded / sp^2 *or* has 3 bonding locations
(NOT forms only 3 *bonds*) [1]

$C_{60}H_{60}$ [1]
[2]

(c) (i) Number of atoms carbon present = $0.001 \times 6.02 \times 10^{23} / 12 =$ **5.02×10^{19}** [1]

(ii) Number of hexagons present = $5.02 \times 10^{19} / 2 = 2.51 \times 10^{19}$

Area of sheet = $690 \times 2.51 \times 10^{19} =$ **1.73×10^{22} nm^2** [1]

(iii) Graphene: Yes, since it has free / delocalised / mobile electrons [1]

Buckminsterfullerene: No, (although there is delocalisation within each sphere)
it consists of separate / simple / discrete molecules / spheres / particles,
(so no delocalisation from one sphere to the next)
or electrons are trapped within each molecule / sphere [1]
[4]

[Total: 10]

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