MARK SCHEME for the October/November 2013 series

9701 CHEMISTRY

9701/42   Paper 4 (A2 Structured Questions), maximum raw mark 100

1 (a)
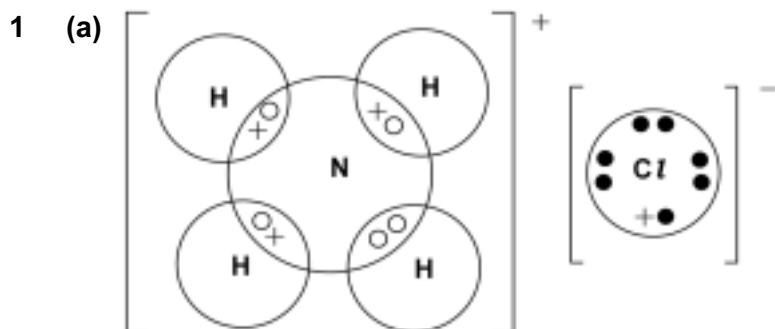

8 e⁻ around chlorine	[1]
1 H–electron (+) on the Cl^- ion	[1]
3 covalent (ox) and one dative (oo) around N	[1]

[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]

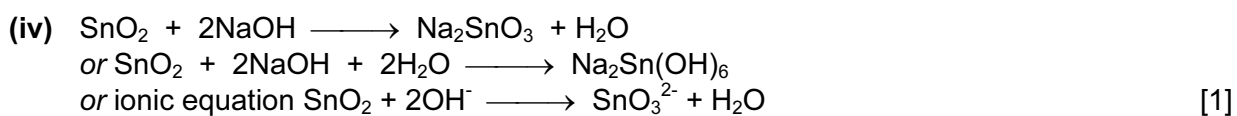thus causing less polarisation/distortion
of the anion/NO_3^-/N-O bond [1]

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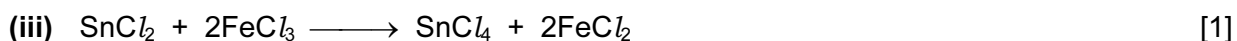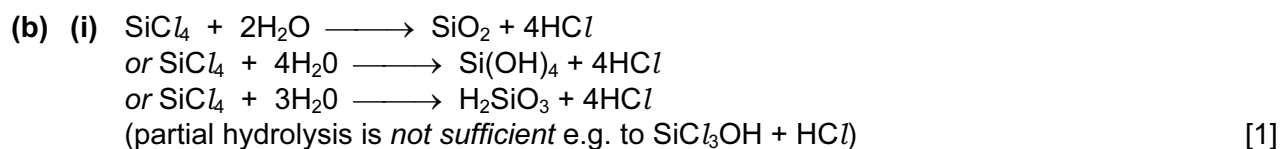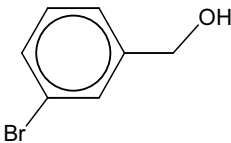
(b) (i) $SiCl_4 + 2H_2O \longrightarrow SiO_2 + 4HCl$
or $SiCl_4 + 4H_2O \longrightarrow Si(OH)_4 + 4HCl$
or $SiCl_4 + 3H_2O \longrightarrow H_2SiO_3 + 4HCl$
(partial hydrolysis is *not sufficient* e.g. to $SiCl_3OH + HCl$) [1]

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

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

[3]

(d) Cl-CH_2CH_2-CO_2H [1]
HO-$CH_2CH_2CH_2$-Cl [1]

[1]

[3]

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

(ii) (free) radical substitution [1]

(iii) ΔH = E(C-H) – E(H-Cl) = 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 $\longrightarrow$ **2Cl•** [1]
CH_3CH_2• + **Cl_2** $\longrightarrow$ **CH_3CH_2Cl + Cl•** [1]
CH_3CH_2• + Cl• $\longrightarrow$ 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**s** are formed
　　　　　 or double bond breaks and forms single bonds with other monomers [1]

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　 [3]

　　 (b) propenoic acid [1]

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　 [1]

　　 (c) **(i)**
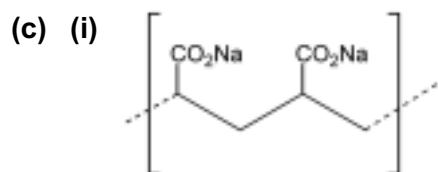
　　　　　 carbon chain **and** CO_2H [1]
　　　　　 at least one sodium salt [1]

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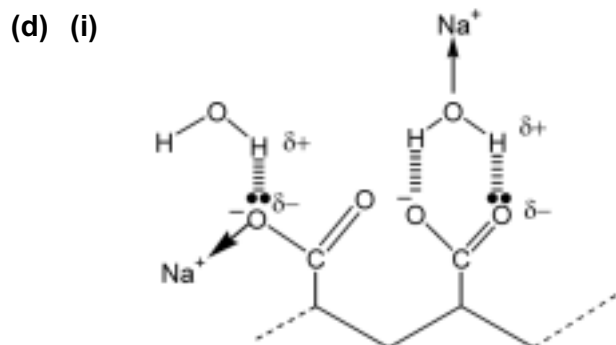　　　　　 due to the change from a trigonal/sp^2 carbon to a tetrahedral/sp^3 carbon [1]

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　 [4]

　　 (d) **(i)**

　　　　　 Any four:
　　　　　 hydrogen bond **labelled**
　　　　　 water H-bonded to O through H atom
　　　　　 $\delta+/\delta-$ 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)
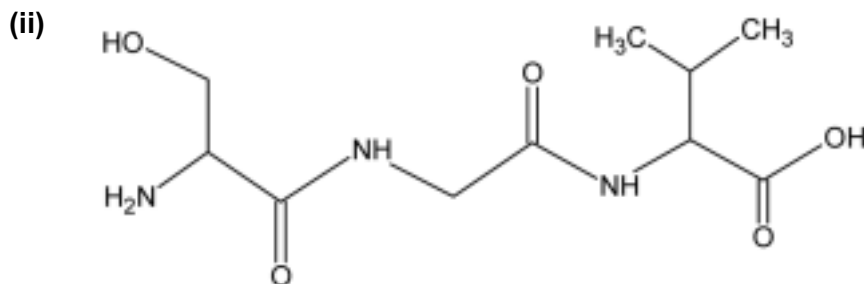
two **displayed** peptide bonds [1]
correct formula of peptide [1]
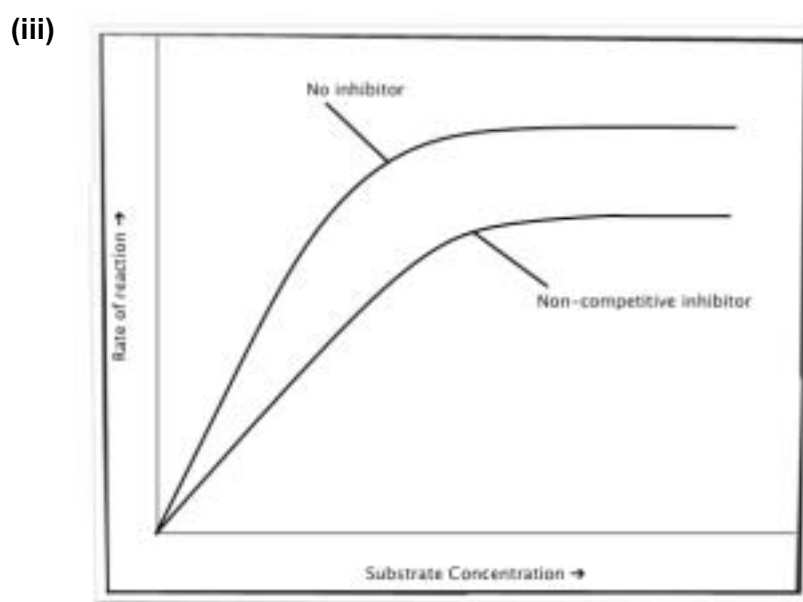
(iii) valine (**allow** glycine) [1]

(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]

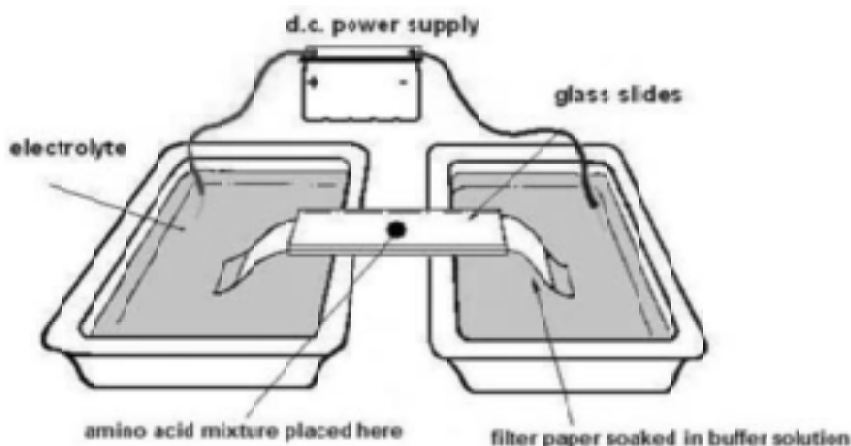**(ii)** binds with enzyme **and** changes shape/3D structure (of enzyme/active site) [1]

(iii)

[1]

[4]

[Total: 10]

7 **(a)**

d.c. power supply

glass slides

electrolyte

amino acid mixture placed here

filter paper soaked in buffer solution

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]

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 $SO_2 + \frac{1}{2}O_2 + H_2O \longrightarrow H_2SO_4$ [1]

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

[2]

[Total: 9]