Assessment Schedule – 2011

Chemistry: Describe properties of aqueous systems (90700)

Evidence Statement

<table>
<tr><th>Question</th><th>Evidence</th><th>Achievement</th><th>Merit</th><th>Excellence</th></tr>
<tr><td>ONE
(a)</td><td>NH_3 weak base
NaCl neutral
NH_4Cl weak acid
HF weak acid</td><td rowspan="4">TWO of:
• THREE from part (a) correct.

• Correct equation.
OR
• Correct rank for b(i) or b(ii)

EITHER
• K_a correct.
OR
• Correct $[H_3O^+]$.</td><td rowspan="4">THREE from part (a) correct.

AND

• Correct equation AND correct order of species for BOTH (b)(i) and (b)(ii).
OR
• Correct equation, order of species AND full explanation (all 4 species) for EITHER (b)(i) or (b)(ii).

AND
• Correct answer with minor error (incorrect sig. fig. or units).</td><td rowspan="4">ONE explanation to Merit level.

AND

ONE full explanation. (all 4 species).

AND

Correct answer with units, and appropriate number of sig. fig.</td></tr>
<tr><td>(b)(i)</td><td>$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

Equilibrium is to the left, so the greatest concentration of a species is NH_3. For each NH_3 that reacts equal amounts of NH_4^+ and OH^- are formed and are greater than the OH^- and H_3O^+ formed by the dissociation of water.

$NH_3 > OH^- \geq NH_4^+ > H_3O^+$</td></tr>
<tr><td>(ii)</td><td>$HF + H_2O \rightleftharpoons F^- + H_3O^+$

Equilibrium is to the left, so the greatest concentration of a species is HF. For each HF that reacts equal amounts of F^- and H_3O^+ are formed and are greater than the OH^- and H_3O^+ formed by the dissociation of water.

$HF > H_3O^+ \geq F^- > OH^-$</td></tr>
<tr><td>(c)</td><td>$K_a = 6.76 \times 10^{-4}$
$HF + H_2O \rightleftharpoons H_3O^+ + F^-$
Assume $[H_3O^+] = [F^-]$
$K_a = \frac{[H_3O^+]^2}{[HF]} \Rightarrow [HF] = \frac{[H_3O^+]^2}{K_a}$
$[H_3O^+] = 4.57 \times 10^{-3}$ mol L^{-1}
$[HF] = 0.0309$ mol L^{-1}</td></tr>
</table>

TWO (a)(i) (ii)	$Zn(OH)_2(s) \rightleftharpoons Zn^{2+}(aq) + 2OH^-(aq)$ $K_s = [Zn^{2+}][OH^-]^2$	TWO of: • Part (a) correct. • Method correct, but error in calculation. (Allow s^2 follow on from part (a) or $2s^3$error but if so, must have calculated s value correctly according to the candidates follow on.) • Recognises that $[OH^-]$ has increased. • Recognises equilibrium will shift to the left.		
(b)	Let s be solubility $K_s = 4s^3$ $s = \sqrt[3]{\frac{K_s}{4}}$ $s = 1.96 \times 10^{-6}$ mol L^{-1}		Solubility calculated correctly, (incorrect sig. fig.). AND ONE of: • Recognises that a complex ion will form and links this to either less solid remaining or equilibrium shifting to the right. • Identifies equilibrium shifting to the left due to additional OH^-. • Explains equilibrium shifting to the left in terms of the I.P. now exceeding K_s.	Solubility calculated correctly, 3 sig. fig. and s is defined. AND Complex ion forms, precipitate re-dissolves, as equilibrium shifts in the forwards direction / to RHS. This shift to the right will occur so more Zn^{2+} and OH^- will dissolve into solution so that the solution becomes saturated again.
(c)	Raising the pH will increase the concentration of OH^- ions. This will initially cause additional precipitate to form. Once the pH has been increased sufficiently (enough OH^- has been added) the formation of a complex ion with Zn^{2+} will occur, lowering OH^- ion concentration in solution. Thus the precipitate will redissolve as a complex ion and less precipitate will be at the bottom of the test tube.			

THREE (a) (b)	$HG + H_2O \rightleftharpoons G^- + H_3O^+$ OR $HOCH_2COOH + H_2O \rightleftharpoons HOCH_2COO^- + H_3O^+$ $K_a = \dfrac{[G^-][H_3O^+]}{[HG]}$ (must have equilibrium arrow)	TWO of: • Part (a) and (b) correct.		
(c)	$[H_3O^+] = \sqrt{K_a} \times [HG]$ $K_a = 1.50 \times 10^{-4}$ $[H_3O^+] = 9.99 \times 10^{-3}$ mol L^{-1} pH = 2.00	• EITHER Correct value for K_a OR Correct rearrangement of K_a expression to make $[H_30^+]$ subject.	Correct answer with minor error. AND	Correct answer with appropriate number of sig. fig. AND
(d)	$[H_3O^+] = 1.00 \times 10^{-4}$ mol L^{-1} $[G^-] = \dfrac{K_a \times [HG]}{[H_3O^+]} = 1.48$ mol L^{-1} Thus in 200 mL = 0.2 × 1.48 = 0.296 mol *Alternative method* $pH = pK_a + \log_{10} \dfrac{[\text{weak base}]}{[\text{weak acid}]}$ $4.00 = 3.83 + \log_{10} \dfrac{[\text{base}]}{[\text{acid}]}$ $\log_{10}[\text{base}] = 0.17$ [base] = 1.48 mol L^{-1} Thus, in 200 mL = 00.2 × 1.48 = 0.296 mol	• EITHER Correct $[H_3O^+]$. OR K_a expression rearranged for $[G^-]$ or other appropriate method for $[G^-]$ stated and rearranged for $[G^-]$.	Correct $[G^-]$. OR Correct method for $[G^-]$ and $n(G^-)$ calculation but incorrect answer.	Correct $n(G^-)$ to 3 sig. fig.

FOUR (a)	**A** At point A, there is an equi-molar mixture of HEt and Et^-. On addition of OH^- ions, the acid part of the buffer neutralises the OH^- ions, by donating a proton. The acid reacts with the base: $HEt + OH^- \rightarrow Et^- + H_2O$ On addition of H_3O^+, the ethanoate will accept a proton from the hydronium ion: $Et^- + H_3O^+ \rightarrow HEt + H_2O$ Candidate may discuss equilibrium shift. $pK_a = pH = 4.76$ (accept 4.5 – 4.9)	ONE of: • Recognises that at point A there is a buffer solution. • States that equimolar amounts of acid / base conjugate are present at A. • States that pH will not change when small amounts of acid or base are added. • Correct pK_a / K_a AND	Describes how a buffer works (for when both acid AND base are added) by: EITHER • Giving equations for the specific buffer OR • Writing about how a buffer works in general terms OR • Links that due to equimolar HEt and Et^- thus $pK_a = pH$ AND	Shows recognition of equimolar HEt and Et^- thus $pK_a = pH$ and discusses how the buffer solution works and links to equations. AND
(b)	**B** At the equivalence point all the HEt has been neutralised by NaOH. $HEt + NaOH \rightarrow EtNa + H_2O$ The Et^- reacts further to a small extent with water. $Et^- + H_2O \rightleftharpoons HEt + OH^-$ Thus the pH of the equivalence point is above 7 due to presence of OH^-.	ONE of: • Recognises that all the HEt has been used up at B. • That the pH of equivalence point is greater than 7. (must have clearly indicated that point B is the equivalence point)	• Recognises that none of the original HEt remains as ithas all reacted with NaOH OR • That the pH of equivalence point is greater than 7 with a valid reason.	Uses two equations to explain why the pH is above 7. (One equation may be implied in the candidate's written answer.)

Judgement Statement

Achievement	Achievement with Merit	Achievement with Excellence
3 **A**	2 **M** + 1 **A**	2 **E** + 1 **A**