Salts, Buffers, and Titrations Practice

1. Calculate the pH of a 0.200 M NH_4NO_3 solution given $K_b = 1.8 \times 10^{-5}$.

$NH_4NO_3 + H_2O \rightarrow NH_4^+ + NO_3^-$

R) $\boxed{NH_4^+ + H_2O \rightarrow NH_3 + H_3O^+}$ ✓ strong acid ✗ $NO_3^- + H_2O \rightarrow HNO_3 +$

I 0.200   0   0

C $-x$ $+x$ $+x$

E $0.200-x$ x x

$\frac{K_w}{K_b} = K_a = \frac{x^2}{0.200-x}$

$\frac{1.0\times10^{-14}}{1.8\times10^{-5}} = \frac{x^2}{0.200-x}$ $x = 1.05 \times 10^{-5}$, $\boxed{pH = 4.98}$

2. For the solution created using 20 mL of 0.10 M HF and 0.050 g of NaF, calculate the pH assuming the K_a of HF is 3.5×10^{-4}.

$MW_{NaF} = 41.988173$ g/mol

$0.050\,g\ NaF \left| \frac{1\ mol\ NaF}{41.988173\,g} \right. = 0.00119$ moles NaF $= 1.19$ mmoles NaF

$20\,mL(0.10\,M) = 2$ mmol HF

$\boxed{pH = pK_a + \log\left(\frac{1.19}{2}\right) = 3.23}$

3. Calculate the pH of the solution resulting from titrating 30 mL of 0.10 M HOBr with 24 mL of 0.10 M NaOH assuming the K_a of HOBr is 2.0×10^{-9}.

$\boxed{pH = pK_a + \log\left(\frac{2.4}{0.6}\right) = 9.30}$

3 mmol HOBr, 2.4 mmol NaOH

0.6 mmol HOBr $\rightarrow$ 2.4 mmol $^{\ominus}$OBr

4. Sketch a titration curve for the titration of 30 mL of the 0.25 M diprotic acid HA with 0.25 M NaOH by calculating the following ($K_{a1} = 5.9 \times 10^{-2}$ and $K_{a2} = 6.4 \times 10^{-5}$):

(a) The initial pH

R) $H_2A + H_2O \rightarrow H_3O^+ + HA^-$

I 0.25   0   0

C $-x$ $+x$ $+x$

E $0.25-x$ x x

$K_{a_1} = \frac{x^2}{0.25-x}$, $x = 0.095$

$\boxed{pH = 1.02}$

(b) The pH of both equivalence points

$pK_{a_1} = 1.23$, $pK_{a_2} = 4.19$

$pH_{eq_1} = \frac{pK_{a_1} + pK_{a_2}}{2} = \frac{1.23 + 4.19}{2} = 2.71$

$\boxed{pH_1 = 2.71}$

pH_{eq_2}

R) $A^- + H_2O \rightarrow HA + OH^-$

I $\frac{7.5\,mmol}{90\,mL}$ 0   0

C $-x$ $+x$ $+x$

E $\frac{7.5}{90} - x$ x x

$K_{b_2} = \frac{x^2}{\frac{7.5}{90} - x}$

$x = 3.61 \times 10^{-6}$

$pOH = 5.44$

$pH = 14 - 5.44 = 8.56$

$\boxed{pH_2 = 8.56}$

(c) The pH of both half-equivalence point

$\boxed{\text{half-equivalence 1} = 1.23}$

$\boxed{\text{half-equivalence 2} = 4.19}$