1) $F^- + H_2O \rightleftharpoons HF + OH^-$

$NaF_{(s)} \rightarrow Na^+_{(aq)} + F^-_{(aq)}$ $\quad K_a = 3.5 \times 10^{-4}$

0.25 M $\quad$ 0.25 M $\quad K_b = 2.86 \times 10^{-11}$

$K_b = \dfrac{[HF][OH^-]}{[F^-]}$ $\quad$ Let $x = [OH^-] = [HF]$

$[F^-] = 0.25 - x \approx 0.25$ if x is small

$2.86 \times 10^{-11} = \dfrac{x^2}{0.25}$

$x = 2.67 \times 10^{-6}$ M $= [OH^-]$

pOH = 5.57

pH = 8.43

2) 5.5% acetic acid $\quad$ 0.100 M NaOH

10.0 mL

D = 1.05 g/mL

$5.5\% = \dfrac{\text{mass of acid}}{\text{mass of sample}} = \dfrac{x}{10.5\,g}$

mole:
~~mass~~ of acid = 0.5775 g / FW

= 0.5775 g / 60.0 g/mol

= 9.625×10^{-3} mol CH_3COOH = mol H^+ = mol OH^- = mol NaOH

$V = \dfrac{n}{M} = \dfrac{9.625 \times 10^{-3}\ \text{mol NaOH}}{0.100\ M} = 9.6 \times 10^{-2}$ L or 96 mL

3) $CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$ $\quad$ pH = 4.50

$K_a = \dfrac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]}$ $\quad [H_3O^+] = 3.16 \times 10^{-5}$ M

$K_a = 1.8 \times 10^{-5}$

$1.8 \times 10^{-5} = \dfrac{[CH_3COO^-]}{[CH_3COOH]} \times 3.16 \times 10^{-5}$

$0.5696 = \dfrac{[CH_3COO^-]}{[CH_3COOH]}$ $\quad \therefore \quad \dfrac{[CH_3COOH]}{[CH_3COO^-]} = 1.8$

4) 10.0 mL H_2SO_3 25.0 mL 0.100 M NaOH

$H_2SO_3 + 2\,OH^- \rightarrow SO_3^{2-} + 2\,H_2O$ diprotic acid

mol NaOH = 0.100 M × 25.0 mL = 2.5 mmol NaOH = mol OH^-

mol OH^- = mol H^+ = 2 (mol acid)

$$\text{mol acid} = \frac{\text{mol } H^+}{2} = \frac{2.5 \text{ mmol}}{2} = 1.25 \text{ mmol}$$

$$[H_2SO_3] = \frac{1.25 \text{ mmol}}{10.0 \text{ mL}} = 0.125 \text{ M}$$

5) a) 49.0 mL 0.100 M NaOH | 50.0 mL 0.100 M HCl.

∴ mol base added = 4.90 mmol ∴ original mol acid = 5.00 mmol

$$[H^+] = \frac{5.00 \text{ mmol acid} - 4.90 \text{ mol base added}}{99.0 \text{ mL}} = 1.01 \times 10^{-3} \text{ M}$$

pH = 2.996 (3 SF)

b) 51.0 mL 0.100 M NaOH – 50.0 mL 0.100 M HCl.

∴ mols base added = 5.10 mmol ∴ original mols acid = 5.00 mmol

$$[OH^-] = \frac{5.10 \text{ mmol base added} - 5.00 \text{ mmol acid}}{101.0 \text{ mL}} = 9.90 \times 10^{-4} \text{ M}$$

pOH = 3.004 pH = 10.996

6) 30.0 mL 0.150 M HCOOH formic acid 0.150 M NaOH

$HCOOH \rightleftharpoons HCOO^- + H_3O^+$

a) Let $x = [H_3O^+] = [HCOO^-]$ $K_a = 1.8 \times 10^{-4}$

$[HCOOH] = 0.150 - x \approx 0.150$ M if x is small.

$$K_a = \frac{[H_3O^+][HCOO^-]}{[HCOOH]}$$

$$1.8 \times 10^{-4} = \frac{x^2}{0.150} \qquad x = 5.196 \times 10^{-3} \text{ M} = [H_3O^+].$$

pH = 2.284

6) continued

b) all $HCOOH$ "used up" $\rightarrow$ $HCOO^-$ ($HCOOH + OH^- \rightarrow HCOO^- + H_2O$)

$HCOO^- + H_2O \rightleftharpoons HCOOH + OH^-$ $\quad K_a = 1.8 \times 10^{-4}$

$K_b = \dfrac{[HCOOH][OH^-]}{[HCOO^-]}$ $\quad K_b = 5.56 \times 10^{-11}$

$[salt] = \dfrac{4.50 \text{ mmol}}{60.0 \text{ mL}} = 0.0750 \text{ M}$

Let $x = [OH^-] = [HCOOH]$

$[HCOO^-] = 0.0750 \text{ M} - x \approx 0.0750$ if x is small.

$5.56 \times 10^{-11} = \dfrac{x^2}{0.0750}$ $\quad x = 2.04 \times 10^{-6} \text{ M} = [OH^-]$

pOH = 5.690 $\quad$ pH = 8.310

c) original mols acid $\quad 30.0 \text{ mL} \times 0.150 \text{ M} = 4.50 \text{ mmol}$

mols base added $\quad 10.0 \text{ mL} \times 0.150 \text{ M} = 6.00 \text{ mmol}$

$[OH^-] = \dfrac{6.00 \text{ mmol} - 4.50 \text{ mmol}}{70.0 \text{ mL}} = 0.0214 \text{ M}$

pOH = 1.669 $\quad$ pH = 12.331