Acid Base Worksheet No. 4

1a) $NH_3 + H_2O \longleftrightarrow NH_4^+ + OH^-$

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]} = \frac{K_w}{K_{a\,(NH_4^+)}} = \frac{1.00 \times 10^{-14}}{5.6 \times 10^{-10}} = 1.79 \times 10^{-5}$$

let $[OH^-] = x$, then $[NH_4^+] = x$

and $[NH_3] = 0.30M - x \approx 0.30M$ if x is small

$$1.79 \times 10^{-5} = \frac{x^2}{0.30} \qquad x = [OH^-] = \underline{2.3 \times 10^{-3} M}$$

b) $pOH = -\log(2.3 \times 10^{-3} M) = 2.636$

$pH = pk_w - pOH = 14.000 - 2.636 = \underline{11.36}$

c) $[H_3O^+] = \text{antilog}(-pH) = \text{antilog}(-11.36) = \underline{4.3 \times 10^{-12} M}$

d) $[NH_3] = 0.30M - 2.3 \times 10^{-3} M = \underline{0.30\ M}$

e) $\%\ \text{dissociation} = \frac{2.3 \times 10^{-3} M}{0.30\ M} \times 100 = \underline{0.77\ \%}$

2. $CH_3COO^- + H_2O \longleftrightarrow CH_3COOH + OH^-$

$$K_b = \frac{[CH_3COOH][OH^-]}{[CH_3COO^-]} = \frac{K_w}{K_{a\,(CH_3COOH)}} = \frac{1.00 \times 10^{-14}}{1.8 \times 10^{-5}} = \underline{\underline{5.6 \times 10^{-10}}}$$

3. $NH_3 + H_2O \longleftrightarrow NH_4^+ + OH^-$

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]} = \frac{K_w}{K_{a\,(NH_4^+)}} = \frac{1.00 \times 10^{-14}}{5.6 \times 10^{-10}} = 1.79 \times 10^{-5}$$

let $[OH^-] = x$, then $[NH_4^+] = x$ and $[NH_3] = 1.0M - x$

$[NH_3] \approx 1.0M$ if x is small

$$1.79 \times 10^{-5} = \frac{x^2}{1.0}$$

$x = [OH^-] = 4.23 \times 10^{-3} M$

$$[H_3O^+] = \frac{K_w}{[OH^-]} = \frac{1.00 \times 10^{-14}}{4.23 \times 10^{-3}} = 2.36 \times 10^{-12} M$$

$pH = -\log(2.36 \times 10^{-12})$

$\underline{\underline{pH = 11.63}}$

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4. $CN^- + H_2O \longleftrightarrow HCN + OH^-$

$$K_b = \frac{[HCN][OH^-]}{[CN^-]} = \frac{K_w}{K_{a\,(HCN)}} = \frac{1.00 \times 10^{-14}}{4.9 \times 10^{-10}} = \underline{\underline{2.0 \times 10^{-5}}}$$

5. Strychnine $\Rightarrow B^-$

$$B^- + H_2O \longleftrightarrow HB + OH^-$$

$$K_b = \frac{[HB][OH^-]}{[B^-]} = 1.8 \times 10^{-6}$$

Let $x = [OH^-]$, then $[HB] = x$ and $[B^-] = 0.15M - x$
$\approx 0.15M$ if x is small

$$1.8 \times 10^{-6} = \frac{x^2}{0.15}$$

$x = [OH^-] = 5.20 \times 10^{-4} M$ $\quad$ $pOH = -\log 5.20 \times 10^{-4} = 3.284$

$pH = pK_w - pOH = 14.000 - 3.284 = \underline{\underline{10.72}}$

6. $NH_3 + H_2O \longleftrightarrow NH_4^+ + OH^-$

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]} = \frac{K_w}{K_a} = \frac{1.00 \times 10^{-14}}{5.6 \times 10^{-10}} = 1.79 \times 10^{-5}$$

Let $x = [OH^-]$, then $[NH_4^+] = x$ and $[NH_3] = 0.10M - x \approx 0.10$
if x is sm...

$$\underline{1.79 \times 10^{-5}} = \frac{x^2}{0.10M} \qquad x = [OH^-] = 1.34 \times 10^{-3} M$$

$$\% \text{ dissociation} = \frac{1.34 \times 10^{-3}}{0.10M} \times 100 = \underline{1.3\%} \text{ dissociation.}$$

7. $pK_b = -\log K_b = -\log (2.0 \times 10^{-7} M) = \underline{\underline{6.70}}$

8. $CH_3COO^- + H_2O \longleftrightarrow CH_3COOH + OH^-$

$$K_b = \frac{[CH_3COOH][OH^-]}{[CH_3COO^-]} = \frac{K_w}{K_a} = \frac{1.00 \times 10^{-14}}{1.8 \times 10^{-5}} = \underline{\underline{5.56 \times 10^{-10}}}$$

Let $x = [OH^-]$, then $[CH_3COOH] = x$ and $[CH_3COO^-] = 0.25 - x \approx 0.25M$ if x is sm...

$$5.56 \times 10^{-10} = \frac{x^2}{0.25} \qquad x = [OH^-] = 1.18 \times 10^{-5} \qquad pOH = 4.929$$

$pH = 14.000 - 4.929 = 9.07$

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9. $NaF \longrightarrow Na^+ + F^-$ soluble

$$F^- + H_2O \longleftrightarrow HF + OH^-$$

$$K_b = \frac{[HF][OH^-]}{[F^-]} = \frac{K_w}{K_{a(HF)}} = \frac{1.00\times10^{-14}}{3.5\times10^{-4}} = 2.86\times10^{-11}$$

Let $[OH^-] = x$, then $[HF] = x$ and $[F^-] = 0.50M - x \approx 0.50M$ if x is small

$$2.86\times10^{-11} = \frac{x^2}{0.50} \qquad [OH^-] = x = 3.78\times10^{-6}M$$

$$pOH = -\log[OH^-] = -\log(3.78\times10^{-6}) = \underline{\underline{5.42}}$$

10. $B^- + H_2O \longleftrightarrow HB + OH^-$

$$K_b = \frac{[HB][OH^-]}{[B^-]}$$

$[OH^-] = \text{antilog} -(14.000 - 11.62)$
$= 4.17\times10^{-3}M$

$[HB] = [OH^-] = 4.17\times10^{-3}M$

$$K_b = \frac{(4.17\times10^{-3})^2}{9.58\times10^{-2}} = 1.81\times10^{-4} \qquad [B^-] = 0.10M - 4.17\times10^{-3}M = 9.58\times10^{-2}$$

$$K_a = \frac{K_w}{K_b} = \frac{1.00\times10^{-14}}{1.81\times10^{-4}} = \underline{\underline{5.5\times10^{-11}}}$$

11. $B^- + H_2O \longleftrightarrow HB + OH^-$

$[OH^-] = \text{antilog}(-2.567)$
$= 2.710\times10^{-3}M$

$$K_b = \frac{[HB][OH^-]}{[B^-]}$$

$[HB] = [OH^-] = 2.710\times10^{-3}M$

$[B^-] = 0.250 - 2.710\times10^{-3}M = 0.2473$

$$K_b = \frac{(2.710\times10^{-3})^2}{0.2473} = 2.97\times10^{-5}$$

12. $B^- + H_2O \longleftrightarrow HB + OH^-$

$[OH^-] = \text{antilog} -(14.000 - 10.45) = 2.82\times10$

$[HB] = [OH^-] = 2.82\times10^{-4}M$

$$K_b = \frac{[HB][OH^-]}{[B^-]}$$

$[B^-] = 0.20M - 2.82\times10^{-4}M = 0.200M$

$$K_b = \frac{(2.82\times10^{-4})^2}{0.200} = 4.0\times10^{-7}$$