Chapter 8

(1) $H_2O \rightleftharpoons H^+ + OH^-$

when HBr is added the H^+ from the strong acid pushes the equilibrium towards the reactants (H_2O)

(2) a. $HBr \longrightarrow H^+ + Br^-$

$[H^+] = 1.0 \times 10^{-3} M \Rightarrow pH = \boxed{3}$

b. $KOH \longrightarrow K^+ + OH^-$

$[OH^-] = 1.0 \times 10^{-2}$

$pOH = 2 \Rightarrow pH = \boxed{12}$

(3) Dilute strong acid, use systematic method

mass balance: $5.0 \times 10^{-8} = [ClO_4^-]$

charge balance: $[H^+] = [OH^-] + [ClO_4^-]$

equilibrium: $[H^+][OH^-] = 10^{-14}$

unknowns: $[H^+], [OH^-], [ClO_4^-]$ equations: 3

solve: $[OH^-] = \frac{10^{-14}}{[H^+]}$

$[H^+] = \frac{10^{-14}}{[H^+]} + 5.0 \times 10^{-8}$

$[H^+]^2 - 5.0 \times 10^{-8}[H^+] - 10^{-14} = 0$

$[H^+] = 1.28 \times 10^{-7} M$

$\frac{7.81 \times 10^{-8}}{1.28 \times 10^{-7}} \times 100 = \boxed{61\%}$

$H_2O \rightleftharpoons H^+ + OH^-$

amount of H^+ from H_2O

$[OH^-] = \frac{10^{-14}}{1.28 \times 10^{-7}} = 7.81 \times 10^{-8} M$

$\boxed{pH = 6.89}$

(5)

a. $C_6H_5CO_2H \rightleftharpoons C_6H_5CO_2^- + H^+$

b. $C_6H_5CO_2^- + H_2O \rightleftharpoons C_6H_5CO_2H + OH^-$

c. $C_6H_5NH_2 + H_2O \rightleftharpoons C_6H_5NH_3^+ + OH^-$

d. $C_6H_5NH_3^+ \rightleftharpoons C_6H_5NH_2 + H^+$

(6) $HA \rightleftharpoons A^- + H^+$

	HA	H^+	A^-
I	0.100	0	0
C	$-x$	$+x$	$+x$
E	$0.100-x$	x	x

$$\frac{[H^+][A^-]}{[HA]} = 1.00\times10^{-5}$$

$$\frac{x^2}{0.100-x} = 1.00\times10^{-5} \quad \text{(ignore } -x \text{ in denominator)}$$

$$x = 1.0\times10^{-3}$$

pH = 3

$$\alpha = \frac{1.0\times10^{-3}}{0.100} = 1.0\times10^{-2}$$

$= 1\%$

(8) $(CH_3)_3NH^+ \rightleftharpoons (CH_3)_3N + H^+$

$$\frac{[H^+][(CH_3)_3N]}{[(CH_3)_3NH^+]} = 1.59\times10^{-10}$$

$$\frac{x^2}{0.060-x} = 1.59\times10^{-10} \quad \text{(ignore } -x \text{ in denominator)}$$

	$(CH_3)_3NH^+$	H^+	$(CH_3)_3N$
I	0.060	0	0
C	$-x$	$+x$	$+x$
E	$0.060-x$	x	x

$$x = 3.09\times10^{-6}\,M = [H^+]$$

pH = 5.51

~~[H+]~~

$[(CH_3)_3N] = 3.09\times10^{-6}\,M$

$[(CH_3)_3NH^+] = 0.060\,M$

(13) $\frac{[H^+][A^-]}{[HA]} = 9.8\times10^{-5}$

a. $\frac{x^2}{10^{-2.00}-x} = 9.8\times10^{-5}$

$x^2 + 9.8\times10^{-5}x - 9.8\times10^{-7} = 0$

$x = 9.4\times10^{-4} = [H^+]$ $\boxed{pH = 3.03}$

$\alpha = \frac{9.4\times10^{-4}}{10^{-2.00}}\times100 = \boxed{9.4\%}$

b. To be the most precise use the systematic method - very difficult to solve in this case so assume $pH = \boxed{7.00} \Rightarrow [H^+] = 10^{-7}$

$[HA] = \frac{[H^+][A^-]}{9.8\times10^{-5}} = \frac{10^{-7}[A^-]}{9.8\times10^{-5}} = 1.02\times10^{-3}[A^-]$

$\alpha = \frac{[A^-]}{[A^-]+[HA]} = \frac{[A^-]}{[A^-]+1.02\times10^{-3}[A^-]} = \frac{1}{1+1.02\times10^{-3}}\times100 = \boxed{99.9\%}$

(19) $B + H_2O \rightleftharpoons BH^+ + OH^-$

$\frac{[OH^-][BH^+]}{[B]} = K_b = 1.00\times10^{-5}$

$\frac{x^2}{0.100 - x} = 1.00\times10^{-5}$ (square)

$x = 1.0\times10^{-3} = [OH^-]$

$\alpha = \frac{1.0\times10^{-3}}{0.100}\times100$

$= \boxed{1\%}$ or 1.0×10^{-2}

$[H^+] = \frac{10^{-14}}{1.0\times10^{-3}} = 1.0\times10^{-11}$

$\boxed{pH = 11.0}$

(20) $(CH_3)_3N + H_2O \rightleftharpoons (CH_3)_3NH^+ + OH^-$

$$\frac{[(CH_3)_3NH^+][OH^-]}{[(CH_3)_3N]} = \frac{10^{-14}}{1.59\times10^{-10}} = 6.3\times10^{-5}$$

$$\frac{x^2}{0.060-x} = 6.3\times10^{-5}$$

$$x^2 + 6.3\times10^{-5}x - 3.78\times10^{-6} = 0$$

$x = 1.91\times10^{-3}\,M = [OH^-]$ $\quad pH = -\log\frac{10^{-14}}{1.91\times10^{-3}} = \boxed{11.3}$

$\boxed{[(CH_3)_3NH^+] = 1.91\times10^{-3}\,M}$

$\boxed{[(CH_3)_3N] = 0.058\,M}$

(22) $CH_3CO_2^- + H_2O \rightleftharpoons CH_3CO_2H + OH^-$

$$\frac{[CH_3CO_2H][OH^-]}{[CH_3CO_2^-]} = \frac{10^{-14}}{1.75\times10^{-5}} = 5.71\times10^{-10}$$

$$\frac{x^2}{0.100-x} = 5.71\times10^{-10}$$

$x = 7.56\times10^{-6}$

$\alpha = \frac{7.56\times10^{-6}}{0.100} = \boxed{7.56\times10^{-5} = 0.00756\%}$

ignore

$$\frac{x^2}{1\times10^{-2}-x} = 5.71\times10^{-10}$$

$x = 2.39\times10^{-6}$

$\alpha = \frac{2.39\times10^{-6}}{1\times10^{-2}} = \boxed{2.39\times10^{-4} = 0.0239\%}$

For $1.00\times10^{-12}\,M$ follow example of problem 13

~~$[(CH_3)_3N]$~~ $= CH_3CO_2H = \frac{5.71\times10^{-10}[CH_3CO_2^-]}{1.0\times10^{-7}} = 5.71\times10^{-3}[CH_3CO_2^-]$

$$\alpha = \frac{5.71\times10^{-3}[CH_3CO_2^-]}{5.71\times10^{-3}[CH_3CO_2^-] + [CH_3CO_2^-]} = \boxed{5.68\times10^{-3} = 0.57\%}$$

$\boxed{\alpha \text{ increases with dilution}}$