Chapter 14 - Acids and Bases

14.54

$$HBr \longrightarrow H^+ + Br^-$$

$$HI \longrightarrow H^+ + I^-$$

$$n_{HBr} = [HBr] \times V_{HBr} = 0.05 \times 0.05 = 2.5 \times 10^{-3} \text{ mol}$$

$$n_{HI} = [HI] \times V_{HI} = 0.1 \times 0.15 = 1.5 \times 10^{-2} \text{ mol}$$

$$\Rightarrow n_{Br^-} = 2.5 \times 10^{-3} \text{ mol}$$

$$n_{I^-} = 1.5 \times 10^{-2} \text{ mol}$$

$$n_{H^+} = n_{H^+_1} + n_{H^+_2} = 2.5 \times 10^{-3} + 1.5 \times 10^{-2} = 1.75 \times 10^{-2} \text{ mol}$$

$$\Rightarrow [Br^-] = \frac{n_{Br^-}}{V_t} = \frac{2.5 \times 10^{-3}}{0.2} = 1.25 \times 10^{-2} \text{ M}$$

$$[I^-] = \frac{n_{I^-}}{V_t} = \frac{1.5 \times 10^{-2}}{0.2} = 7.5 \times 10^{-2} \text{ M}$$

$$[H^+] = \frac{n_{H^+}}{V_t} = \frac{1.75 \times 10^{-2}}{0.2} = 8.75 \times 10^{-2} \text{ M}$$

$$[OH^-] = \frac{K_w}{[H^+]} = \frac{10^{-14}}{8.75 \times 10^{-2}} = 1.14 \times 10^{-13} \text{ M}$$

14.66

0.56 g Benzoic Acid (BA), $C_6H_5CO_2H$, MW = 122.12 g/mol

$K_a = 6.4 \times 10^{-5}$

$\Rightarrow n_{BA} = \frac{0.56}{122.12} = 4.59 \times 10^{-3}$ mol $\Rightarrow [BA] = 4.59 \times 10^{-3}$ M

	$C_6H_5CO_2H$	+ H_2O $\rightleftharpoons$	$C_6H_5CO_2^-$	+ H_3O^+
	4.59×10^{-3}		0	0
	$-x$		$+x$	$+x$
	$4.59 \times 10^{-3} - x$		x	x

$$K_a = \frac{[C_6H_5CO_2^-][H_3O^+]}{[C_6H_5CO_2H]} = \frac{x^2}{4.59 \times 10^{-3} - x} \simeq \frac{x^2}{4.59 \times 10^{-3}}$$

we consider x is negligeable compared to 4.59×10^{-3}

$\Rightarrow x = 5.42 \times 10^{-4}$

By comparing x to the initial concentration of BA

$\frac{5.42 \times 10^{-4}}{4.59 \times 10^{-3}} = 0.118 = 11.8\%$ approximation not acceptable

$\Rightarrow \frac{x^2}{4.59 \times 10^{-3} - x} = K_a = 6.4 \times 10^{-5}$ Solve as quadratic eq.

$\Rightarrow x_1 = 5.11 \times 10^{-4}$

$x_2 = -5.75 \times 10^{-4}$

$\Rightarrow \quad [C_6H_5COO^-] = [H_3O^+] = 5.11 \times 10^{-4}\ M$

$[C_6H_5COOH] = 4.59 \times 10^{-3} - 5.11 \times 10^{-4} = 4.08 \times 10^{-3}\ M$

$[OH^-] = \dfrac{K_w}{[H_3O^+]} = \dfrac{10^{-14}}{5.11 \times 10^{-4}} = 1.96 \times 10^{-11}\ M$

$pH = -\log [H_3O^+] = 3.29$

14.95

$$(C_2H_5)_3N + H_2O \rightleftharpoons (C_2H_5)_3NH^+ + OH^-$$

$$0.2 \qquad\qquad 0 \qquad\quad 0$$

$$0.2-x \qquad\qquad x \qquad\quad x$$

$$K_b = \frac{[(C_2H_5)_3NH^+][OH^-]}{[(C_2H_5)_3N]} = \frac{x^2}{0.2-x} \simeq \frac{x^2}{0.2}$$

$\Rightarrow \quad x = 8.94 \times 10^{-3}$ (app. accepted 4.47%)

$\Rightarrow [OH^-] = 8.94 \times 10^{-3}\ M \qquad [H^+] = 1.12 \times 10^{-12}\ M \qquad pH = 11.95$

$$HONH_2 \rightleftharpoons HO^- + NH_3^+$$

$$0.2 \qquad\qquad 0 \qquad\quad 0$$

$$0.2-x \qquad\qquad x \qquad\quad x$$

$$K_b = \frac{[OH^-][NH_3^+]}{[HONH_2]} = \frac{x^2}{0.2-x} \simeq \frac{x^2}{0.2}$$

$\Rightarrow \quad x = 4.69 \times 10^{-5}$ (app. accepted 0.023%)

$\Rightarrow [OH^-] = 4.69 \times 10^{-5}\ M \qquad [H^+] = 2.13 \times 10^{-10}\ M \qquad pH = 9.67$

14.113

CH_3COOH $\quad K_a = 1.8 \times 10^{-5} \longrightarrow CH_3COO^-$ base

$HOCl$ $\quad K_a = 3.5 \times 10^{-8} \longrightarrow OCl^-$ base.

Larger $K_a \Rightarrow$ stronger acid $\Rightarrow$ the conjugate base is weaker $\Rightarrow$ CH_3COO^- is a weaker base than OCl^-.

$\Rightarrow$ OCl^- is the stronger base.

14.117

a.

$$\underset{\substack{0.1\\0}}{CH_3NH_3Cl} \longrightarrow \underset{\substack{0\\0.1}}{CH_3NH_3^+} + \underset{\substack{0\\0.1}}{Cl^-}$$

$$\underset{\substack{0.1\\0.1-x}}{CH_3NH_3^+} + H_2O \rightleftharpoons \underset{\substack{0\\x}}{CH_3NH_2} + \underset{\substack{0\\x}}{H_3O^+}$$

$$K_a = \frac{[CH_3NH_2][H_3O^+]}{[CH_3NH_3^+]} = \frac{x^2}{0.1-x} \simeq \frac{x^2}{0.1}$$

$$K_a = \frac{K_w}{K_{b(CH_3NH_2)}} = \frac{10^{-14}}{4.38\times10^{-4}} = 2.28 \times 10^{-11}$$

$$\Rightarrow \frac{x^2}{0.1} = 2.28\times10^{-11} \Rightarrow x = 1.51\times10^{-6}$$ app. accepted

$$\Rightarrow [H_3O^+] = 1.51\times10^{-6}\ M \Rightarrow pH = 5.82$$

14.119

$NaCN$ $NaC_2H_3O_2$ NaF $NaCl$ $NaOCl$

the 5 salts are in the form NaA.

$pH = 8.07 \Rightarrow [H_3O^+] = 10^{-8.07} \Rightarrow [OH^-] = \frac{10^{-14}}{10^{-8.07}} = 1.17 \times 10^{-6}\ M$

NaA	$\longrightarrow$	Na^+	$+ A^-$
0.1		0	0
0		0.1	0.1

A^-	$+ H_2O$	$\rightleftharpoons$	HA	$+ OH^-$
0.1			0	0
0.1 − x			x	x

$$K_b = \frac{[HA][OH^-]}{[A^-]} = \frac{[OH^-]^2}{[A^-]} = \frac{(1.17 \times 10^{-6})^2}{0.1} = 1.37 \times 10^{-11}$$

$$K_a = \frac{K_w}{K_b} = \frac{10^{-14}}{1.37 \times 10^{-11}} = 7.3 \times 10^{-4}$$

Let us now compare the K_a calculated to what exists in the table 14.2 in your book.

HCN $K_a = 6.2 \times 10^{-10}$

$HC_2H_3O_2$ $K_a = 1.8 \times 10^{-5}$

HF $K_a = 7.2 \times 10^{-4}$

HCl strong acid

$HOCl$ $K_a = 3.5 \times 10^{-8}$

$\Rightarrow$ the salt is NaF