

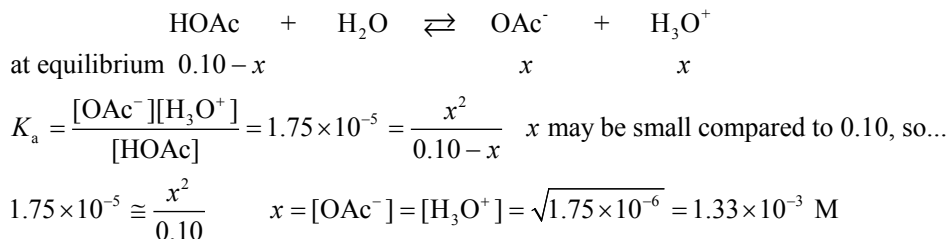
Equilibrium III: Basic Acid-Base Equilibrium

1. What are the species (equilibrium) concentrations of H_3O^+ , OH^- , and Cl^- in 0.10 M hydrochloric acid?

$$[\text{H}_3\text{O}^+] = [\text{Cl}^-] = 0.10 \text{ M} \quad \text{pH} = -\log(0.10) = 1.0$$

$$[\text{OH}^-] = \frac{K_w}{[\text{H}_3\text{O}^+]} = \frac{1.0 \times 10^{-14}}{0.10} = 1.0 \times 10^{-13} \text{ M}$$

2. What are the concentrations of each species in a solution prepared to be 0.10 M acetic acid (CH_3COOH)? $K_a = 1.75 \times 10^{-5}$



Check to see if assumption is acceptable: $\frac{0.00133}{0.1} \times 100 = 1.3\% (< 5\%, \text{ so accept assumption})$

$$[\text{HOAc}] = 0.10 \text{ M} - 0.00133 \text{ M} = 0.099 \text{ M}$$

$$[\text{OH}^-] = \frac{1.0 \times 10^{-14}}{0.00133} = 7.6 \times 10^{-12} \text{ M}$$

3. What is the approximate pH of 0.075 M formic acid? $K_a = 1.7 \times 10^{-4}$

This problem is virtually identical to problem 2.

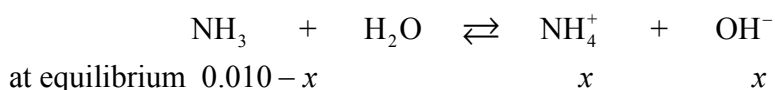
4. What is the K_a of nitrous acid if a 0.050 M solution has a pH of 2.34?

$$[\text{H}_3\text{O}^+] = 10^{-2.34} = 4.57 \times 10^{-3} \text{ M} \quad (= [\text{NO}_2^-])$$

$$C_{\text{HNO}_2} = 0.050 \text{ M} \quad [\text{HNO}_2] = 0.050 \text{ M} - 4.57 \times 10^{-3} \text{ M} = 0.0454 \text{ M}$$

$$K_a = \frac{(4.57 \times 10^{-3})^2}{0.0454} = 4.6 \times 10^{-4}$$

5. What is the pH of 0.010 M ammonia? $K_b = 1.8 \times 10^{-5}$



$$K_b = \frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_3]} = 1.8 \times 10^{-5} = \frac{x^2}{0.010 - x} \quad x \text{ is small compared to } 0.010, \text{ so...}$$

$$1.8 \times 10^{-5} \cong \frac{x^2}{0.010} \quad x = [\text{NH}_4^+] = [\text{OH}^-] = \sqrt{1.8 \times 10^{-7}} = 4.24 \times 10^{-4} \text{ M}$$

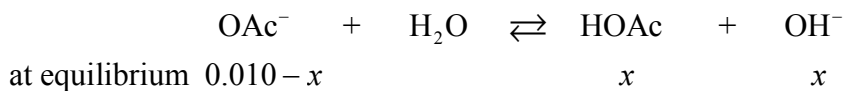
(Demonstrate yourself that x is small compared to 0.010 M)

$$[\text{NH}_3] = 0.010 \text{ M} - 4.24 \times 10^{-4} \text{ M} = 9.6 \times 10^{-3} \text{ M}$$

$$[\text{H}_3\text{O}^+] = \frac{1.0 \times 10^{-14}}{4.24 \times 10^{-4}} = 2.36 \times 10^{-11} \text{ M} \quad \text{pH} = -\log(2.36 \times 10^{-11}) = 10.6$$

6. Assuming that $K_a = 1.75 \times 10^{-5}$ for acetic acid, what is K_b for acetate ion? What is the pH of 0.010 M sodium acetate?

$$K_b = \frac{K_w}{K_a} = \frac{1.0 \times 10^{-14}}{1.75 \times 10^{-5}} = 5.71 \times 10^{-10}$$



$$5.71 \times 10^{-10} = \frac{[\text{HOAc}][\text{OH}^-]}{[\text{OAc}^-]} = \frac{x^2}{0.010 - x} \cong \frac{x^2}{0.010}$$

$$x = [\text{HOAc}] = [\text{OH}^-] = 2.4 \times 10^{-6} \text{ M} \quad \text{pOH} = 5.62$$

$$\text{pH} = 14 - \text{pOH} = 8.38$$