Acid base equilibria 2

The ionization constant for NH_4OH is 1.8×10^{-5}. Calculate the concentration of OH^- ions in a 1.0 molar solution of NH_4OH.

Solution:

The ionization constant (K_b) is defined as the concentration of OH^- ions times the concentration of the conjugate acid ions of a given base divided by the concentration of an unionized base. For a base (BA),

$$K_b := \frac{(B^-) \cdot (A^+)}{(BA)}$$

Where K_b is the ionized constant, (B^-) is the concentration of ionized base ions, (A^+) is the concentration of the conjugate acid, and (BA) is the concentration of the unionized base. The K_b for NH_4OH is stated as

$$K_b = \frac{(NH_4^+) \cdot (OH^-)}{NH_4OH} = 1.8 \times 10^{-5}$$

When NH_4OH is ionized, one NH_4^+ ion is formed and one OH^- ion is formed,

$$NH_4OH \rightleftharpoons NH_4^+ + OH^-$$

The concentrations of each ions are equal.

$$(NH_4^+) = (OH^-)$$

The concentration of the unionized base is decreased when ionization occurs. The new concentration is equal to the concentration of OH^- subtracted from the concentration of NH_4OH.

$$(NH_4OH) = 1.0 - (OH^-)$$

Since (OH^-) is small relative to 1.0, one may assume that $1.0 - (OH^-)$ is approximately equal to 1.0.

$$(NH_4OH) = 1.0 - (OH^-) \approx 1.0$$

Using the assumption and the fact that $(ON^-) = (NH_4^+)$, K_b can be rewritten as

$$K_b = \frac{(OH^-) \cdot (OH^-)}{1.0} = 1.8 \times 10^{-5}$$

Solution for (OH^-):

$$\frac{(OH^-) \cdot (OH^-)}{1.0} = 1.8 \times 10^{-5}$$

$$(OH^-)^2 = 1.8 \times 10^{-5}$$

$$(OH^-) = \sqrt[2]{1.8 \times 10^{-5}} = 4.2 \times 10^{-3}$$