

## Acid base equilibria 2

The ionization constant for  $\text{NH}_4\text{OH}$  is  $1.8 \times 10^{-5}$ . Calculate the concentration of  $\text{OH}^-$  ions in a 1.0 molar solution of  $\text{NH}_4\text{OH}$ .

### Solution:

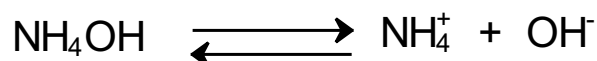
The ionization constant ( $K_b$ ) is defined as the concentration of  $\text{OH}^-$  ions times the concentration of the conjugate acid ions of a given base divided by the concentration of an unionized base. For a base (BA),

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

Where  $K_b$  is the ionized constant,  $(\text{B}^-)$  is the concentration of ionized base ions,  $(\text{A}^+)$  is the concentration of the conjugate acid, and  $(\text{BA})$  is the concentration of the unionized base. The  $K_b$  for  $\text{NH}_4\text{OH}$  is stated as

$$K_b = \frac{(\text{NH}_4^+) \cdot (\text{OH}^-)}{\text{NH}_4\text{OH}} = 1.8 \times 10^{-5}$$

When  $\text{NH}_4\text{OH}$  is ionized, one  $\text{NH}_4^+$  ion is formed and one  $\text{OH}^-$  ion is formed,



The concentrations of each ions are equal.

$$(\text{NH}_4^+) = (\text{OH}^-)$$

The concentration of the unionized base is decreased when ionization occurs. The new concentration is equal to the concentration of  $\text{OH}^-$  subtracted from the concentration of  $\text{NH}_4\text{OH}$ .

$$(\text{NH}_4\text{OH}) = 1.0 - (\text{OH}^-)$$

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

$$(\text{NH}_4\text{OH}) = 1.0 - (\text{OH}^-) \approx 1.0$$

Using the assumption and the fact that  $(\text{OH}^-) = (\text{NH}_4^+)$ ,  $K_b$  can be rewritten as

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

Solution for  $(\text{OH}^-)$ :

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

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

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