Weak Bases and Ionization Constants

The treatment of the ionization of weak bases is similar to the ionization of weak acids. When a base (B) is dissolved in water, it undergoes equilibrium reaction that is represented by

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

The equilibrium constant expression for this reaction is given by

$$K = \frac{[BH^+][OH^-]}{[B][H_2O]}$$

We can treat $[H_2O]$ as a constant and combine it with K and rewrite the above equation to yield the base ionization constant **K_b ,** which is *equilibrium constant expression for the ionization reaction of base.*

$$K_b = Kx[H_2O] = \frac{[BH^+][OH^-]}{[B]}$$

The subscript b in K_b indicates the base to distinguish it from the acid and any other substance.

Strength of Weak Base

At a given temperature, the strength of a base is measured by the magnitude of K_b; larger the K_b, the stronger the base. The following table lists few weak bases and their K_b values at 25^0C in order of decreasing base strength.

Base name	**Base formula**	**K_b**
Ethylamine	$C_2H_5NH_2$	5.6×10^{-4}
Methylamine	CH_3NH_2	4.4×10^{-4}
Caffeine	$C_8H_{10}N_4O_2$	4.1×10^{-4}
Ammonia	NH_3	1.8×10^{-5}
Pyridine	C_5H_5N	1.7×10^{-9}
Aniline	$C_6H_5NH_2$	3.8×10^{-10}
Urea	$(NH_2)_2CO$	1.5×10^{-14}

Example

Arrange the following acids in order of decreasing base strength.

(a) urea ($K_b = 1.53 \times 10^{-14}$)

(b) ethylamine (K_b= 5.6 x10^{-4})
(c) ammonia (K_b = 1.8 x 10^{-5})
(d) aniline (K_b=3.8 x 10^{-10})
(e) caffeine (K_b= 4.1 x 10^{-4})

Answer

Strength of a base is determined by the magnitude of K_b; higher the K_b, stronger the base. We arrange the above given bases from high K_a to low K_b for decreasing order. Thus,

ethylamine > caffeine > ammonia > aniline > urea

Example

Ammonia (NH_3) is a weak base, the equilibrium reaction of which with water is given by

$$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-$$

Which of the following statements are true for 1.0 M ammonia solution at equilibrium?

(a) [NH_4+] = 1.0 M
(b) [NH_4^+] < 1.0 M
(c) [NH_4^+]= [OH^-]
(d) [NH_3] = [NH_4^+]
(e) [OH^-] =1.0 M

Answer

(a) not true
(b) true
(c) true
(d) not true
(e) not true