Name:_____

Blk:_____Date:_____

Chemistry 12
ACID BASE LESSON #9
THE RELATIONSHIP BETWEEN K_a and K_b FOR A CONJUGATE PAIR

Experimentally it is found that the ACID IONIZATION equation:

$$NH_4^+(aq) + H_2O(l) \leftrightarrows NH_3(aq) + H_3O^+(aq)$$

Has the acid ionization constant of:

$$K_a = \frac{[NH_3][H_3O^+]}{[NH_4^+]} = 5.6 \cdot 10^{-10}$$ ← table

While the BASE IONIZATION eqaution:

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

Has the BASE IONIZATION CONSTANT of:

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]} = ? = 1.8 \cdot 10^{-5}$$

Since both equations involve both NH_3 & NH_4^+, the following relationship exists between the K_a and K_b for CONJUGATE PAIRS

$$K_a \times K_b = K_w \rightarrow \frac{[NH_3][H_3O^+]}{[NH_4^+]} \cdot \frac{[NH_4^+][OH^-]}{[NH_3]} = [H_3O^+][OH^-]$$

$K_w = 1.00 \cdot 10^{-14}$

Conclusion: for A CONJUGATE PAIR:

K_a (conjugate acid) x K_b(conjugate base) = Kw

$1.00 \cdot 10^{-14}$

Recall that the table of Relative Strengths of Acids and Bases is set up with only K_a values. You can use the above equation to solve for the K_b.

$$K_b(\text{conjugate base}) = \frac{K_w}{K_a(\text{conjugate acid})} \rightarrow \frac{1.00 \cdot 10^{-14}}{5.6 \cdot 10^{-10}}$$

Example 1. What is the K_b for $H_2PO_4^-$?

equation: $H_2PO_4^- + H_2O(l) \rightleftharpoons H_3PO_4 + OH^-$

($H_2PO_4^-$: base; H_2O: acid; H_3PO_4: c. acid)

expression: $K_b = \frac{[H_3PO_4][OH^-]}{[H_2PO_4^-]} \Rightarrow \frac{K_w}{K_a(\text{c. acid})} = \frac{1.00 \cdot 10^{-14}}{7.5 \cdot 10^{-3}} = \boxed{1.3 \cdot 10^{-12}}$

Example 2. What is the K_b for HS^- ?

equation $HS^- + H_2O(l) \rightleftharpoons H_2S + OH^-$ (H_2S: Ka)

expression $K_b = \frac{[H_2S][OH^-]}{[HS^-]} = ?$ $\quad \frac{Kw}{Ka(H_2S)} = \frac{1.00 \cdot 10^{-14}}{9.1 \cdot 10^{-8}}$

$= \boxed{1.1 \cdot 10^{-7}}$

Example 3. Given that the Kb for N_4H_6 is 2.14×10^{-12}, what is the Ka for $N_4H_7^+$?

(Ka) equation: $N_4H_7^+ + H_2O(l) \rightleftharpoons N_4H_6 + H_3O^+$

($N_4H_7^+$: acid; N_4H_6: base)

expression $K_a = \frac{[N_4H_6][H_3O^+]}{[N_4H_7^+]} = \boxed{4.67 \cdot 10^{-3}}$

$\frac{Kw}{K_b(N_4H_6)} \rightarrow \frac{1.00 \cdot 10^{-14}}{2.14 \cdot 10^{-12}} = 4.67 \cdot 10^{-3}$

SEATWORK/HOMEWORK: Exercises 35-37 in Hebden
PLO's: M1-M2 and M4