Name: Key
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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:

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

Has the acid ionization constant of:

$$K_a = \frac{[NH_3][H_3O^+]}{[NH_4^+]} = 5.6 \times 10^{-10}$$ on the table

While the BASE IONIZATION eqaution:

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

Has the BASE IONIZATION CONSTANT of:

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]} = ?$$ not directly on the table.

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

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

Conclusion: for A CONJUGATE PAIR:

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

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.

$\therefore$ Kb(conjugate base)= $\frac{Kw\ (1.00 \times 10^{-14})}{Ka(\text{conjugate acid})}$

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

1. Write out base equation

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

2. Write out Kb Base

$$K_b = \frac{[H_3PO_4][OH^-]}{[H_2PO_4^-]} = Kb(H_2PO_4^-) = \frac{Kw}{Ka(H_3PO_4)}$$

$\therefore \frac{1.00 \times 10^{-14}}{7.5 \times 10^{-3}} = \boxed{1.3 \times 10^{-12}}$

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

1. $HS^- + H_2O(\ell) \rightleftharpoons H_2S + OH^-$ (acid)

2. $K_b = \frac{[H_2S][OH^-]}{[HS^-]} = K_b(HS^-) = \frac{K_w}{K_a(H_2S)} = \frac{1.00 \times 10^{-14}}{9.1 \times 10^{-8}}$

$K_b = \frac{[H_2S][OH^-]}{[HS^-]} = \boxed{1.1 \times 10^{-7}}$

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

$\boxed{K_a(\text{conjugate acid}) \times K_b(\text{conjugate base}) = K_w}$

$\therefore K_a = \frac{K_w}{K_b(\text{conjugate base})}$; $K_b = \frac{K_w}{K_a(\text{conjugate acid})}$

$\therefore K_a(N_4H_7^+) = \frac{1.00 \times 10^{-14}}{2.14 \times 10^{-12}} = \boxed{4.67 \times 10^{-3}}$

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