

Name: _____

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Chemistry 12
ACID BASE LESSON #9

THE RELATIONSHIP BETWEEN K_a and K_b FOR A CONJUGATE PAIR

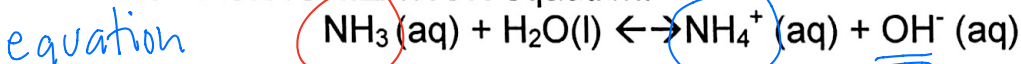
Experimentally it is found that the ACID IONIZATION equation:

$$\text{NH}_4^+(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{NH}_3(\text{aq}) + \text{H}_3\text{O}^+(\text{aq})$$

Has the acid ionization constant of:

expression $K_a = \frac{[\text{NH}_3][\text{H}_3\text{O}^+]}{[\text{NH}_4^+]} = 5.6 \cdot 10^{-10} \leftarrow \text{table}$

While the BASE IONIZATION equation:



Has the BASE IONIZATION CONSTANT of:

expression $K_b = \frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_3]} = ? = 1.8 \cdot 10^{-5}$

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

$$K_a \times K_b = K_w \rightarrow \frac{[\text{NH}_3][\text{H}_3\text{O}^+]}{[\text{NH}_4^+]} \cdot \frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_3]} = [\text{H}_3\text{O}^+][\text{OH}^-]$$

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

Conclusion: for A CONJUGATE PAIR:

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

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 .

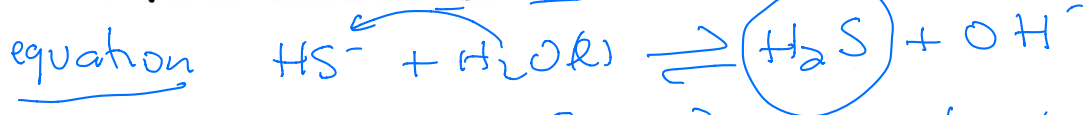
$$K_b(\text{conjugate base}) = \frac{K_w}{K_a(\text{conjugate acid})} \rightarrow \frac{1.00 \cdot 10^{-14}}{5.6 \cdot 10^{-10}}$$

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



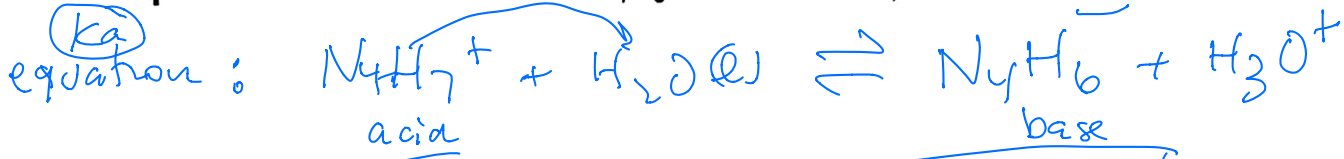
expression:
$$K_b = \frac{[\text{H}_3\text{PO}_4][\text{OH}^-]}{[\text{H}_2\text{PO}_4^-]} = \frac{K_w}{K_a(\text{c. acid})} = \frac{1.00 \cdot 10^{-14}}{7.5 \cdot 10^{-3}} = 1.3 \cdot 10^{-12}$$

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



expression $K_b = \frac{[H_2S][OH^-]}{[HS^-]} = \frac{K_w}{K_a(H_2S)} = \frac{1.00 \cdot 10^{-14}}{9.1 \cdot 10^{-8}} = 1.1 \cdot 10^{-7}$

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



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

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