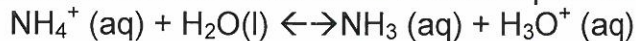


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Chemistry 12
 ACID BASE LESSON #9
 THE RELATIONSHIP BETWEEN K_a and K_b FOR A CONJUGATE PAIR

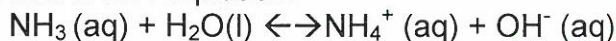
Experimentally it is found that the ACID IONIZATION equation:



Has the acid ionization constant of:

$$K_a = \frac{[\text{NH}_3][\text{H}_3\text{O}^+]}{[\text{NH}_4^+]} = \underline{5.6 \times 10^{-10}} \text{ on the table}$$

While the BASE IONIZATION equation:



Has the BASE IONIZATION CONSTANT of:

$$K_b = \frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_3]} = ? \text{ not directly on the table}$$

Since both equations involve both $\text{NH}_3 + \text{NH}_4^+$, the following relationship exists between the K_a and K_b for CONJUGATE PAIRS

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

Conclusion: for A CONJUGATE PAIR:

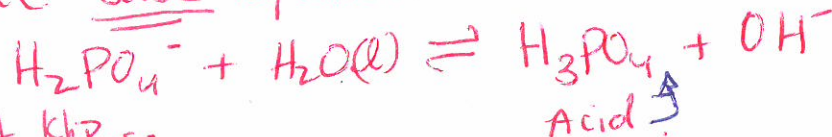
$$\boxed{K_a (\text{conjugate acid}) \times K_b (\text{conjugate base}) = K_w}$$

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 .

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

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

1. Write out base equation



2. write out K_b Base

$$K_b = \frac{[\text{H}_3\text{PO}_4][\text{OH}^-]}{[\text{H}_2\text{PO}_4^-]} = K_b (\text{H}_2\text{PO}_4^-) = \frac{K_w}{K_a (\text{H}_3\text{PO}_4)}$$

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

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



2. $K_b = \frac{[\text{H}_2\text{S}][\text{OH}^-]}{[\text{HS}^-]} = K_b(\text{HS}^-) = \frac{K_w}{K_a(\text{H}_2\text{S})} = \frac{1.00 \times 10^{-14}}{9.1 \times 10^{-8}}$

$K_b = \frac{[\text{H}_2\text{S}][\text{OH}^-]}{[\text{HS}^-]} = \boxed{1.1 \times 10^{-7}}$

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^+ ?

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

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

$\therefore K_a(\text{N}_4\text{H}_7^+) = \frac{1.00 \times 10^{-14}}{2.14 \times 10^{-12}} = \boxed{4.67 \times 10^{-3}}$