

## CONCEPT: $K_a$ AND $K_b$

- $K_a$  and  $K_b$  are equilibrium \_\_\_\_\_ for acids and bases, respectively.

-  $K_a$  and  $K_b$  are used to measure the \_\_\_\_\_ of weak acids and bases

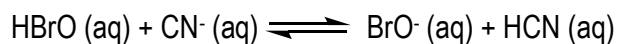
Equilibrium Constant ( $K$ )	Example Equilibrium Expressions	Acid-Base Strength
<b><math>K_a</math>:</b> acid dissociation (ionization) constant	$\text{HF (aq)} + \text{H}_2\text{O (l)} \rightleftharpoons \text{F}^- \text{ (aq)} + \text{H}_3\text{O}^+ \text{ (aq)}$ $K_a = \frac{\text{products}}{\text{reactants}} = \text{_____} = 6.3 \times 10^{-4}$	<ul style="list-style-type: none"><li>• Stronger Acid: _____ <math>K_a</math></li><li>• Weak Acid: <math>K_a</math> 1</li><li>• Strong Acid: <math>K_a</math> 1</li></ul>
<b><math>K_b</math>:</b> base dissociation (ionization) constant	$\text{NH}_3 \text{ (aq)} + \text{H}_2\text{O (l)} \rightleftharpoons \text{NH}_4^+ \text{ (aq)} + \text{OH}^- \text{ (aq)}$ $K_b = \frac{\text{products}}{\text{reactants}} = \text{_____} = 1.8 \times 10^{-5}$	<ul style="list-style-type: none"><li>• Stronger Base: _____ <math>K_b</math></li><li>• Weak Base: <math>K_b</math> 1</li><li>• Strong Base: <math>K_b</math> 1</li></ul>

- \_\_\_\_\_ acids and bases have a dissociation constant associated with them as well

**EXAMPLE:** Identify the strongest acid from the following list of weak acids based on their  $K_a$  values. Assume temp is 25°C.

- a) HCN  $K_a = 4.9 \times 10^{-10}$       b)  $\text{H}_2\text{O}$   $K_a = 1.0 \times 10^{-14}$       c)  $\text{HNO}_2$   $K_a = 4.6 \times 10^{-4}$       d)  $\text{HC}_3\text{H}_5\text{O}_3$   $K_a = 1.4 \times 10^{-4}$

**PRACTICE:** Hypobromous acid ( $K_a = 2.8 \times 10^{-9}$ ) and hydrocyanic acid ( $K_a = 4.9 \times 10^{-10}$ ) are both weak acids. Determine if reactants or products are favored in the following reaction.



- a) reactants      b) products      c) both directions are favored equally      d) neither direction is favored

**PRACTICE:** Identify a Bronsted-Lowry acid with **weakest** conjugate base.

- a)  $\text{H}_3\text{BO}_3$   $K_a = 5.4 \times 10^{-10}$   
b) HF  $K_a = 3.5 \times 10^{-4}$   
c)  $\text{HNO}_2$   $K_a = 4.6 \times 10^{-4}$   
d) HClO  $K_a = 2.9 \times 10^{-8}$

## CONCEPT: $K_a$ AND $K_b$

### $K_a$ & $K_b$ Relationship

- $K_a$  and  $K_b$  are related through the following formulas and can only be used for \_\_\_\_\_ pairs

$K_a$ & $K_b$ Formulas	
$K_w = K_a \times K_b$	$14 = pK_a + pK_b$

$pK_a$ & $pK_b$		
Acids	$pK_a = -\log \text{_____}$ $K_a = 10\text{_____}$	<input type="checkbox"/> Stronger Acid: ___ $K_a$ , ___ $pK_a$ <ul style="list-style-type: none"><li>• Strong Acid: <math>K_a</math> 1; <math>pK_a</math> 1</li><li>• Weak Acid: <math>K_a</math> 1; <math>pK_a</math> 0</li></ul>
Bases	$pK_b = -\log \text{_____}$ $K_b = 10\text{_____}$	<input type="checkbox"/> Stronger Base: ___ $K_b$ , ___ $pK_b$ <ul style="list-style-type: none"><li>• Strong Base: <math>K_b</math> 1; <math>pK_b</math> 1</li><li>• Weak Base: <math>K_b</math> 1; <math>pK_b</math> 0</li></ul>

**EXAMPLE:** Aspirin, also known as acetylsalicylic acid ( $K_a = 3.3 \times 10^{-4}$ ), is a medication used to reduce pain, fever, and inflammation. Calculate the  $K_b$  of acetylsalicylate ( $C_9H_7O_4^-$ ).

**PRACTICE:** Identify which of the compounds is the strongest species.

- a) Iodic acid  $pK_a = 0.80$       b) Acetic acid  $pK_b = 9.24$       c) Formic acid  $pK_a = 3.75$       d) Ammonium  $pK_b = 4.75$

**PRACTICE:** Determine the  $pK_a$  given the  $K_b$  of the following bases:

i)  $NH_3$        $K_b = 1.76 \times 10^{-5}$ ;  $NH_4^+$        $pK_a = \text{_____}$

ii)  $C_6H_5NH_2$        $K_b = 3.9 \times 10^{-10}$ ;  $C_6H_5NH_3^+$        $pK_a = \text{_____}$