

Weak Acids and Bases

K_a

- * Ionization of weak acids is not complete, as shown by the reversible arrow.
- * $\text{CH}_3\text{COOH}_{(\text{aq})} + \text{H}_2\text{O}_{(\text{l})} \rightleftharpoons \text{H}_3\text{O}^+_{(\text{aq})} + \text{CH}_3\text{COO}^-_{(\text{aq})}$
- * The extent of ionization can be represented using an equilibrium constant.
- * K_a is called an acid ionization constant

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]}$$

Measuring Strengths of Weak Acids

- * Stronger acids have large K_a
- * Weaker acids have smaller K_a

Percent Ionization

- * K_a is one measure of acid strength.
- * % ionization is another measure of acid strength.

$$\% \text{ Ionization} = \frac{[\text{H}^+] \text{ at equilibrium}}{\text{initial concentration}} \times 100$$

Example

* Propanoic acid, $\text{CH}_3\text{CH}_2\text{COOH}$, is a weak acid. 0.10 mol/L solution of propanoic acid had a pH of 2.96. Calculate the percent ionization for the acid.



Solution



I	0.1	0	0
C	-x	+x	+x
E	0.1-x	x	x

Solution

* Calculate the $[\text{H}_3\text{O}^+]$ using pH

* $[\text{H}_3\text{O}^+] = 10^{-\text{pH}}$

* $[\text{H}_3\text{O}^+] = 10^{-2.96}$

* $[\text{H}_3\text{O}^+] = 1.1 \times 10^{-3} \text{ mol/L}$

* Since H_3O^+ is formed by the ionization of propanoic acid, this would be the equilibrium concentration

Solution



I	0.1	0	0
C	-x	+x	+x
E	$0.1 - 1.1 \times 10^{-3}$	1.1×10^{-3}	1.1×10^{-3}

Solution

* Calculate K_a

$$K_a = \frac{[C_2H_5OO^-][H_3O^+]}{[C_2H_5OOH]}$$

$$[C_2H_5OOH]$$

$$K_a = \frac{[1.1 \times 10^{-3}]^2}{[0.1 - 1.1 \times 10^{-3}]}$$

$$[0.1 - 1.1 \times 10^{-3}]$$

$$K_a = 1.2 \times 10^{-5}$$

Solution

* Calculate the percent ionization

$$\text{Percent Ionization} = \frac{[\text{C}_2\text{H}_5\text{COO}^-]_{\text{ionized}}}{[\text{C}_2\text{H}_5\text{COOH}]_{\text{initial}}} \times 100$$

$$\text{Percent Ionization} = \frac{1.1 \times 10^{-3} \text{ M}}{0.1 \text{ M}} \times 100$$

$$\text{Percent Ionization} = 1.1\%$$

Measuring Strengths of Weak Bases, K_b

- * The equilibrium constant is given the subscript "b" to indicate that the equilibrium involves base ionization K_b is called base ionization constant.

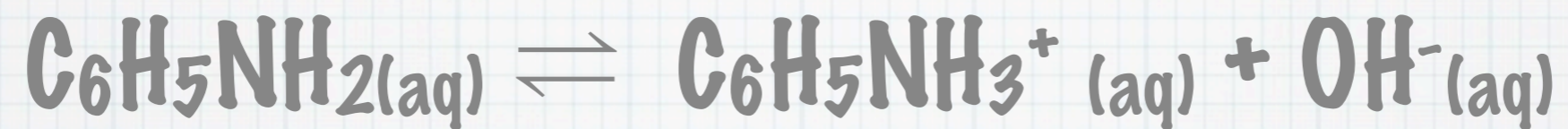
Measuring Strengths of Weak Bases, K_b

- * Stronger bases have large K_b
- * Weaker bases have smaller K_b

Example

- * Aniline, $C_6H_5NH_2(l)$ is used in the manufacturing of dyes. When dissolved in water it becomes a weak base. When a solution containing 0.0537 mol/L of aniline is prepared, the pH was determined to be 8.68 . What is the K_b for aniline?

Solution



I	0.0537	0	0
C	-x	+x	+x
E	0.0537-x	x	x

Solution

* Calculate the $[\text{OH}^-]$ using pH

* $\text{pOH} = 14 - 8.68$

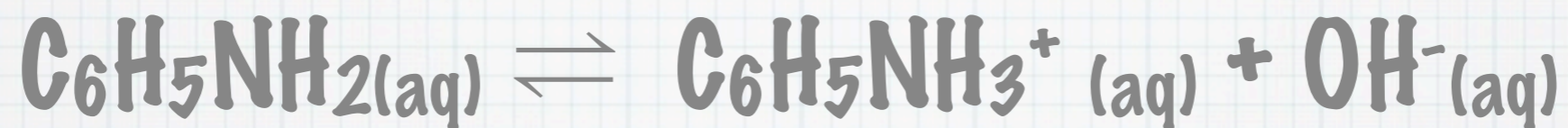
* $\text{pOH} = 5.32$

* $[\text{OH}^-] = 10^{-\text{pOH}}$

* $[\text{OH}^-] = 10^{-5.32}$

* $[\text{OH}^-] = 4.79 \times 10^{-6} \text{ mol/L}$

Solution



I	0.0537	0	0
C	-x	+x	+x
E	$0.0537 - 4.79 \times 10^{-6}$	4.79×10^{-6}	4.79×10^{-6}

* Since the change is so small, you can assume the hundreds rule

Solution

* Calculate K_b

$$K_b = \frac{[C_6H_5NH_3^+][OH^-]}{[C_6H_5NH_2]}$$

$$K_b = \frac{[4.79 \times 10^{-6}]^2}{[0.0537]}$$

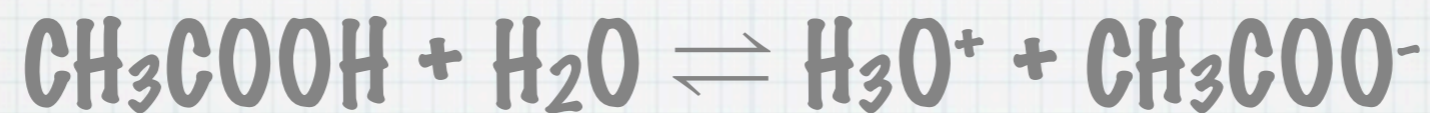
$$K_b = 4.27 \times 10^{-10}$$

K_a , K_b , and K_w

- * The relationship of an acid's K_a and its conjugate base, K_b can be described as follows:

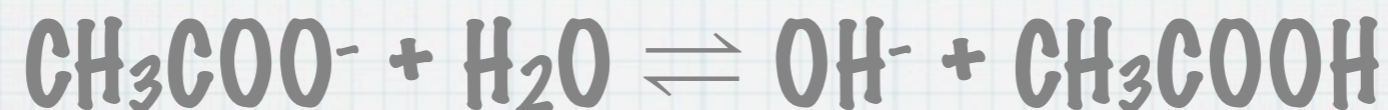
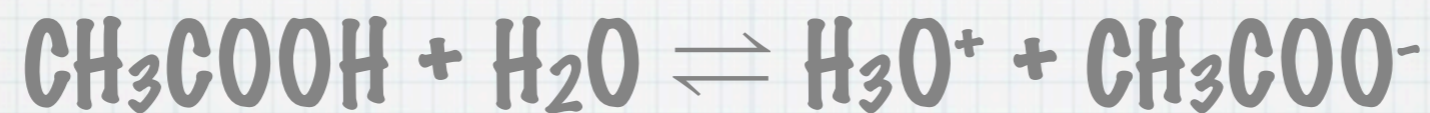
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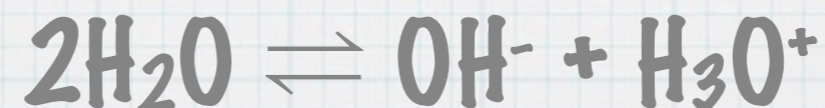
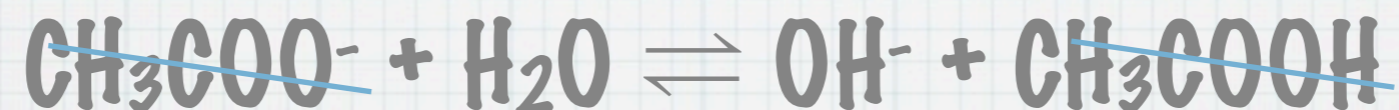
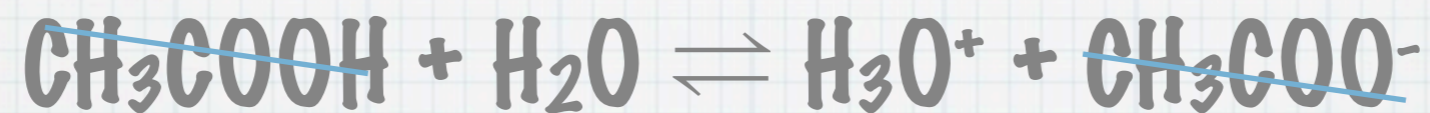
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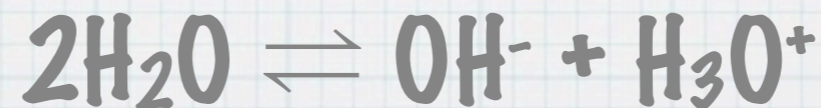
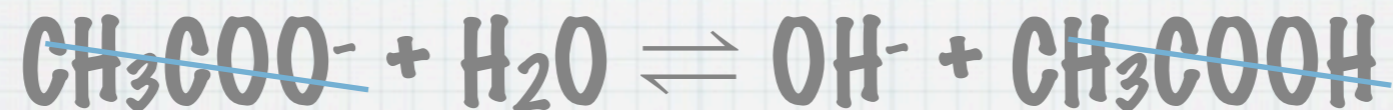
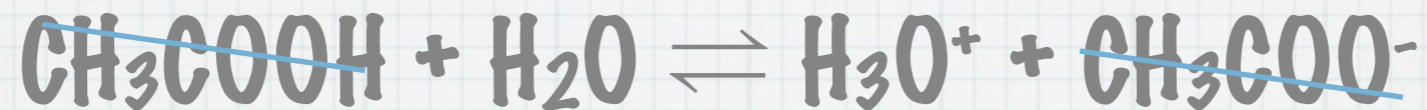
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K_a , K_b , and K_w

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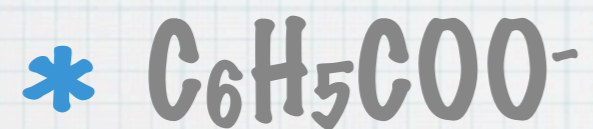
$$K_a K_b = K_w$$

Example

- * Calculate the K_b for the conjugate base of benzoic acid, C_6H_5COOH .

Solution

* Determine the conjugate base



Solution

* Look up the K_a value of benzoic acid

* $K_a = 6.3 \times 10^{-5}$

Solution

* Solve for K_b

* $K_b = K_w / K_a$

* $K_b = 1.0 \times 10^{-14} / 6.3 \times 10^{-5}$

* $K_b = 1.6 \times 10^{-10}$

Homework

* p. 512 # 48

* p. 523 # 72

* p 526 # 83, 84

