Exercise 18.3a(H)

Ka & Kb

Name: _____

Date: _____ Per: _____

K_a & Kb

Strong acids and bases ionize completely (or almost completely) in water. This means that essentially 100% of the acid or base forms products (the arrow in the chemical equation points one direction only). Weak acids & bases, however, only ionize partially before reaching a dynamic equilibrium (double arrows should be used in their formation equations). The equilibrium position of a weak acid/base can be expressed using an equilibrium expression. These expressions are called either acid (or base) ionization expressions. Like an equilibrium expression, it is written with products over reactants using only gases and aqueous solutions. The expressions will commonly take these forms:

Acid

$$\mathbf{HA(aq) + H_2O(l) \rightleftarrows H_3O^+(aq) + A^-(aq)}$$

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

Base

$$\mathbf{B(aq) + H_2O(l) \rightarrow BH^+(aq) + OH^-(aq)}$$

$$K_b = \frac{[BH^+][OH^-]}{[B]}$$

A critical step when completing these problems is calculating the equilibrium concentration of the original acid or base. This concentration will be equal to the original concentration of the acid or base minus the equilibrium concentration of the H_3O^+ for acids or OH^- for bases. ICE tables may be used to calculate equilibrium concentrations.

DIRECTIONS: Answer the following in the space provided.

1. Write the equations (acid ionization equations) representing the ionization of each of these acids in aqueous solution.
   a. HCNO (weak acid)
   b. HCl (strong acid)
   c. HNO_3 (strong acid)
   d. $H_2C_2O_4$ (weak diprotic acid)

2. Write the equations (base dissociation equations) representing the dissociation of each of these bases in aqueous solution.
   a. NaOH (strong base)
   b. NH_3 (weak base)
   c. CH_3NH_2 (weak base)
   d. KOH (strong base)

3. Write the acid ionization expression for each of the following.
   a. HCNO (weak acid)
   b. H_2S (weak acid)

4. Write the base dissociation expression for each of the following.
   a. CN^- (weak base)
   b. NH_3 (weak base)

Answers: 5a) 1.9×10^{-5} 5b) 0.29 5c) 3.4×10^{-4} 6a) 1.80×10^{-5} 6b) 1.7×10^{-6} 6c) 5.92×10^{-4}

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K_a & K_b with ICE Tables

The $[H_3O^+]$ of a 0.1000 M solution of acetylsalicylic acid (aspirin-"HAsp") was found to be $1.2x10^{-4}$. Determine the value of Ka, the ionization constant for acetylsalicylic acid. The formula for acetylsalicylic acid is $CH_3CO_2C_6H_4COOH$, but we use "HAsp" as an abbreviation.

	HAsp(aq)	+	$H_2O(l)$	⇄	$H_3O^+(aq)$	+	$Asp^-(aq)$
I	**0.1000**				0		0
C	$-1.2x10^{-4}$				$+1.2x10^{-4}$		$+1.2x10^{-4}$
E	0.9988				**$1.2x10^{-4}$**		$1.2x10^{-4}$

$$K_a = \frac{[H_3O^+][Asp^-]}{[HAsp]}$$

$$K_a = \frac{[1.2x10^{-4}]\,[1.2x10^{-4}]}{0.9988} = 1.1x10^{-8}$$

5. Calculate the K_a for each of the following weak acids.
   a. A 0.00100 *M* acetic acid ($HC_2H_3O_2$) solution with $[H_3O^+] = 1.27 \times 10^{-4}$ *M*.

   b. A 0.100 *M* HCN solution with $[H_3O^+] = 7.85 \times 10^{-2}$ *M*.

   c. A 0.100 *M* sample of acetylsalicylic acid (a monoprotic acid) solution with $[H_3O^+] = 0.00570$ *M*.

6. Calculate the K_b for each of the following weak bases.
   a. A 0.00700 *M* NH_3 solution with $[OH^-] = 3.46 \times 10^{-4}$ *M*

   b. A 0.15 *M* hydrazine solution (N_2H_4) with $[OH^-] = 5.01 \times 10^{-4}$ *M*.

   c. A 1.50 *M* Dimethylamine solution ($(CH_3)_2NH$) with $[OH^-] = 0.0295$ *M*.

Answers: 5a) 1.9×10^{-5} 5b) 0.29 5c) 3.4×10^{-4} 6a) 1.80×10^{-5} 6b) 1.7×10^{-6} 6c) 5.92×10^{-4}