Lab: Determination of Ionization Constant, Ka, of a Weak Acid

According to the Bronsted-Lowry acid-base theory, the strength of an acid is related to its ability to donate protons. All acid-base reactions are then competitions between bases of various strengths for these protons. For example, the strong acid HCl reacts with water according to:

$$HCl_{(aq)} + H_2O_{(l)} \longrightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$$

This is a strong acid and is completely dissociated (in other words, 100 percent dissociated) in dilute aqueous solution.

Consequently, the $[H_3O^+]$ concentration of a 0.10 M HCl solution is 0.10 M . Thus HCl is a stronger acid than water and completely donates a proton to water to form H_3O^+.

However, acetic acid, CH_3COOH, is a weak acid and is only slightly ionized, as shown in

$$H_2O_{(l)} + CH_3COOH_{(aq)} \rightleftharpoons CH_3COO^{-1}_{(aq)} + H_3O^{+1}_{(aq)}$$

Its acid ionization constant, as shown below:

$$K_a = \frac{[CH_3COO^{-1}][H_3O^{+1}]}{[CH_3COOH]} = 1.8 \times 10^{-5}$$

Acetic acid only partially ionized in aqueous solution, and an appreciable quantity of undissociated acetic acid remains in solution. FOR MOST WEAK ACIDS, THE PERCENT OF ACID THAT IONIZES IS LESS THAN 5 %.

THE VALUE OF THE EQUILIBRIUM CONSTANT, K_a, INDICATES THE EXTENT TO WHICH THE REACTION OCCURS.

IT IS A NUMERIC REPRESENTATIVE OF THE RELATIVE PROTON TRANSFER FOR THAT SUBSTANCE, OR THE LIKELIHOOD OF THAT COMPOUND DONATING A PROTON.

THE GREATER THE VALUE OF $\mathbf{K_a}$, THE STRONGER THE ACID, AND THE GREATER THE AMOUNT OF IONIZATION.

Acetaminophen is an acidic drug with a Ka of 1.2×10^{-10}, and is thus much less likely to ionize in aqueous solution than aspirin (acetyl salicylic acid) which has a Ka of 3.27×10^{-4}.

Often it is cumbersome to deal with exponential forms, so another expression of a compound's acid strength may be used. The pKa may be used to describe the tendency of a weak acid to ionize. The following equation should be used to calculate the pKa of a substance.

$$pK_a = -\log K_a$$

Note the relationship to pKa and acid strength: **The smaller the pKa, the stronger the acid.**

It is just the opposite of the relationship to the Ka.

Recall that pH is defined as:

$$pH = -\log [H_3O^+]$$

Recall that % ionization may be determined form the following:

$$\% \text{ ionization} = \frac{[H_3O^{+1}]}{[CH_3COOH]} \times 100$$

This experiment is designed to determine the K_a, pK_a values and the % ionization for a weak monoprotic acid.

OBJECTIVE: **TO DETERMINE THE K_a, pK_a VALUES AND THE % IONIZATION FOR A WEAK MONOPROTIC ACID.**

PROCEDURE:

1.Obtain a small sample,5 mL, of the weak acid provided in a 100 mL beaker.
2.Record the concentration of the weak acid in the Data Collection.
3.By means of the pH meter record the pH of the weak acid in the Data Collection.
4.Perform the necessary calculation as shown in the Data Processing.
5.Identify the acid from the table of acid ionization constants Ka provided.

Data Collection:

1. Qualitative observations:
2. Concentration of weak monoprotic acid:
3. pH of the weak monoprotic acid:
4. Room Temperature:

Data Processing

1.Abbreviate the weak acid by using $HA_{(aq)}$. Write the equation for the ionization of the weak acid, include state symbols:

2.What is the ratio of molecules and ions formed when the weak acid ionizes?

3.If you know the $[H_3O^{+1}]$ in the weak acid solution, how can you determine the $[A^{-1}]$?

4. From steps 2 and 3 above, how can you determine the concentration of the undissociated acid?
(What assumption is made for the ionization of a weak acid in calculations?)

5.Determine the $[H_3O^{+1}]$ from the pH of the weak acid determined in the lab:

6. Write the mathematical equation calculating the Ka for the weak acid in water:
Ka ==

7. Calculate the numerical value of the Ka for the weak acid in water, at ____^{O}C, knowing the initial concentration and the $[H_3O^{+1}]$:

8.Determine the pKa of the weak acid at ____^{O}C:

9.Determine the % ionization of the weak acid:

10.Determine the identity of the weak acid provided:

11.Compare the experimental value you obtained for the Ka for the weak acid with that obtained by one of your classmates who used the solution with the same concentration. How should the Ka's compare?

12. Compare the pH of the acid at 1. M, 0.20 M, .10 M, what is the effect of dilution on the pH of the acid?