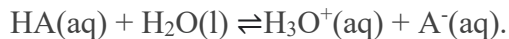


Introduction to Strong and Weak Acid Ionization

The ionization of an acid, HA, in water is depicted in the chemical equation shown below:



The equilibrium constant for the ionization of an acid in water is called “ K_a ”:

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{A}^-]}{[\text{HA}]}$$

The higher the K_a of an acid, the stronger the acid and the more it tends to ionize in water to form H_3O^+ and its conjugate base.

1. Why is $\text{H}_2\text{O}(\text{l})$ not included in the K_a expression?
2. At equilibrium, the following concentrations of species are found in a sample of the acid HF. $[\text{HF}] = 0.10 \text{ M}$, $[\text{H}_3\text{O}^+] = 8.0 \times 10^{-3} \text{ M}$, $[\text{F}^-] = 8.0 \times 10^{-3} \text{ M}$
Based on these values, calculate the K_a of HF at this temperature.

3. The hydronium ion, H_3O^+ , is the strongest acid that exists in water. Acids that are stronger than H_3O^+ are called strong acids. **Strong acids are assumed to completely ionize in solution to generate hydronium ions and their conjugate base.** For example, HCl is a strong acid. If 1M HCl is dissolved in water, it will completely ionize to produce 1M $\text{H}_3\text{O}^+(\text{aq})$ and 1M $\text{Cl}^-(\text{aq})$, and no intact HCl will remain in solution.
 - a. Write out the chemical equation for the ionization of HCl in water.
 - b. What is the K_a value for a strong acid such as HCl?
 - c. Suppose 5 molecules of HCl are dissolved in water. In the beaker below, show the number of H_3O^+ , Cl^- , and HCl particles in the solution.

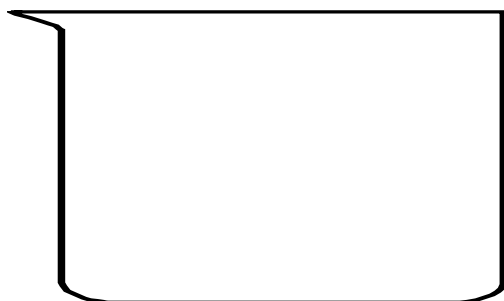


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- d. Suppose 0.10 M HCl is dissolved in water. What will the concentrations of H_3O^+ , Cl^- , and HCl be in solution?
- e. $\text{pH} = -\log[\text{H}_3\text{O}^+]$. If 0.10 M HCl is dissolved in water, what is the pH of the solution?
- f. If 0.50 M HCl is dissolved in water, what is the pH of the solution?
- g. HNO_3 is another strong acid. If 0.50 M HNO_3 is dissolved in water, what species will be present, and what is the pH of the solution?

4. **Weak acids only partly ionize in water to generate hydronium ions and their conjugate base. The higher the K_a of the acid, the more it will ionize in solution.** Because weak acids only partly ionize in solution, RICE tables are useful tools to keep track of the changes in concentrations when a weak acid solution comes to equilibrium.

- a. The make-believe acid HX has $K_a=0.25$. Suppose 5 molecules of HX are dissolved in water. In the beaker below, show the number of H_3O^+ , X^- , and HX in the solution. (*Hint: From the reaction $\text{HX}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_3\text{O}^+(\text{aq}) + \text{X}^-(\text{aq})$, H_3O^+ and X^- will be formed in a 1:1 ratio, so assume these are equal to each other for now. What ratio of products to reactants will give $K_a=0.25$?*)



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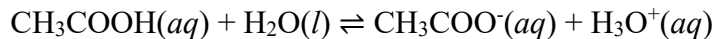
- b. Suppose 0.10 M HX ($K_a=0.25$) is dissolved in water. Fill in the RICE table below, then use the K_a value to determine the concentrations of H_3O^+ , X^- , and HX in solution at equilibrium. Assume H_3O^+ and X^- are not present initially.

Reaction				
I (M)				
C (M)				
E (M)				

- c. What is the pH of the 0.10 M HX solution?
How does it compare to the pH of the 0.10 M HCl solution? [3e, on p. 2]
Why do the pH values of the solutions differ?

Introduction to Strong and Weak Acid Ionization

5. Acetic acid (CH_3COOH), the acid in vinegar, is another weak acid, with $K_a = 1.8 \times 10^{-5}$. The ionization reaction is shown below:



- a. Before doing any calculations, how would you expect the $[\text{H}_3\text{O}^+]$ and pH of a 0.10 M aqueous acetic acid solution to compare to the 0.10 M HCl and 0.10 M HX solutions?
- b. Suppose 0.10 M CH_3COOH is dissolved in water. What will the concentrations of H_3O^+ , CH_3COO^- , and CH_3COOH be in the solution at equilibrium? Assume no H_3O^+ or CH_3COO^- are initially present. (*Since the equilibrium constant is very small, what approximation might you try to simplify the calculation?*)
- c. What is the pH of the 0.10 M CH_3COOH solution? Was your prediction from b correct?

Introduction to Strong and Weak Acid Ionization

6. The percent ionization of a weak acid is the ratio of the concentration of the ionized acid to the initial acid concentration, times 100:

$$\% \text{ ionization} = \frac{[\textit{conjugate base}]_{\textit{eq}}}{[\textit{acid}]_{\textit{initial}}} * 100\%$$

What is the percent ionization of the 0.10 M CH₃COOH(aq) solution in Question 5?

7. A solution is prepared by dissolving 0.250 mole acetic acid in enough water to make a 0.500 L solution. Use a RICE table to calculate the equilibrium concentrations, then determine the pH of the solution and the percent ionization of the acid at equilibrium.

8. In the acetic acid solutions above, how do the (1) pH of the solution and (2) percent ionization of the acid change as the concentration of the weak acid in solution increases?