CHEMISTRY
The Complete Course

Lesson Twenty Nine
Weak Acids and Bases

KA8529

Worksheet

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ANSWERS

1. $K_a = [H^+][X^-]/[HX]$

2. The Ka of a strong acid is essentially infinity because the ionization reaction goes to completion. The Ka of a weak acid is usually less than 1 because the formation of HX is favored over the formation of the ions.

3. HCN is weaker because it has a smaller K_a.

4. $K_a = [H^+][F^-]/[HF]$

5. $3.53 \times 10^{-4} = x^2/0.1$ so $x = 5.9 \times 10^{-3}$ M.
Therefore, [HF] = 0.1 M because the amount of ionization is quite small, $[H^+] = [F^-] =$ 5.9×10^{-3} M, and the $[OH^-] =$ $1 \times 10^{-14}/5.9 \times 10^{-3} = 1.7 \times 10^{-12}$.

6. pH = 2.2 and % ionization =
$(5.9 \times 10^{-3}/0.1)(100\%) = 5.9\%$.

7. $3.53 \times 10^{-4} = x^2/0.001$ so $x = 5.9 \times 10^{-4}$ M.
The pH = $-\log(5.9 \times 10^{-4}) = 3.2$ and % ionization = $(5.9 \times 10^{-4}/0.001)(100\%) = 59\%$.
Notice how much more ionization occurs in the more dilute solution of the aqueous solution. This solution will obviously conduct electricity more efficiently than the 0.1 M solution of HF. Because the % ionization is so high for this solution there is an error introduced by assuming $0.001-x = 0.001$ when solving for x.

8. $Ka = [H^+][CN^-]/[HCN]$

9. $4.93 \times 10^{-10} = x^2/0.1$ so $x = 7.0 \times 10^{-6}$ M.
Clearly, the assumption that $0.1 - x = 0.1$ is okay. Therefore, [HCN] = 0.1 M because the amount of ionization is quite small, $[H^+] =$ $[CN^-] = 7.0 \times 10^{-6}$ M, and the $[OH^-] =$ $1 \times 10^{-14}/7.0 \times 10^{-6} = 1.4 \times 10^{-9}$.

10. pH = 5.2 and % ionization =
$(7.0 \times 10^{-6}/0.1)(100\%) = 0.007\%$.

I. VIDEOTAPE FOLLOW-UP QUESTIONS

I. Weak acids are acids that are only slightly ionized in aqueous solution.
   A. They can be contrasted to the six common strong acids, which are essentially 100% ionized in aqueous solution.
   B. Most acids are weak acids.
   C. Even though most acids are "weak" acids, they still differ from each other in their relative strengths.
      1. The best way to compare the relative strengths of weak acids is to compare the numerical value for their ionization constants, K_a.
         a. For a general weak acid, HX, $K_a = [H^+][X^-]/[HX]$.
         b. The smaller the numerical value of K_a the weaker the acid.
      2. Chemists have prepared and published tables that compare the relative strengths of acids according to the numerical values for their ionization constants.
   D. The "classic" weak acid problem involves determining the concentrations of all molecular and ionic species, the pH, pOH, and % ionization in a solution of a weak acid of known concentration.

II. Several weak acid problems are presented and solved.

III. Weak base problems can be solved in the same manner as weak acid problems.
   A. The only common weak base generally encountered in a 1st year high school chemistry course is ammonia, NH_3.
      1. Ammonia ionizes according to the equation $NH_3 + H_2O$ <-------> $NH_4^+ + OH^-$.
      2. The ionization constant for ammonia, $K_b = 1.8 \times 10^{-5}$.
   B. When solving problems involving solutions of ammonia, you should remember that the "x" that is solved for represents the concentration of hydroxide ion, not hydrogen ion.

II. SUPPLEMENTARY EXERCISES

1. What is the general equilibrium expression for a weak acid?
2. What is the difference between the K_a of a weak acid and a strong acid?
3. HF and HCN are weak acids. The K_a's are 3.53×10^{-4} and 4.93×10^{-10}, respectively. Which acid is considered weaker?
4. Write the equilibrium expression for the ionization of HF in water.
5. What is the concentration of HF, F^-, H^+, and OH^- in a 0.1 M solution of HF?
6. What is the pH and % ionization of a 0.1 M solution of HF?
7. What is the pH and % ionization of a 0.001 M solution of HF?
8. Write the equilibrium expression for the ionization of HCN in water.
9. What is the concentration of HCN, CN^-, H^+, and OH^- in a 0.1 M solution of HCN?
10. What is the pH and % ionization of a 0.1 M solution of HCN?