IV. 14, 15

Period 42

- Quiz on Bronsted-Lowry Acids and Bases

- Go over Ka worksheet #1

1 Calculation of Ka values

If we are given the [H+] concentration and the concentration of the acid solution, we can easily calculate the Ka value for the acid.

Example #1 :

An unknown weak acid, HW, is found to have a $[H^+]$ of 1.5×10^{-5} M when we mix a 2.5 M solution of the acid. Calculate Ka for this acid.

Answer #1 :

$$HW_{(aq)} \Longleftrightarrow H^+_{(aq)} + W^-_{(aq)}$$

$$Ka = \frac{[H+][W-]}{[HW]} = \frac{(1.5 \times 10^{-5})(1.5 \times 10^{-5})}{(2.5 - (1.5 \times 10^{-5}))}$$

$$= \frac{(1.5 \times 10^{-5})^2}{(2.5)}$$

$$= 9.0 \times 10^{-11}$$

Example #2 :

Another weak acid, HZ, has a 1.8×10^{-8} M $[OH^-]$ in a 0.025 M solution of the acid. Calculate the Ka of HZ.

Answer #2 :

$$HZ_{(aq)} \Longleftrightarrow H^+_{(aq)} + Z^-_{(aq)}$$

If $[OH^-] = 1.8 \times 10^{-8}$ M the $[H^+] = 5.6 \times 10^{-7}$ M

$$Ka = \frac{[H^+][Z^-]}{[HZ]} = \frac{(5.6 \times 10^{-7})(5.6 \times 10^{-7})}{(0.025 - (5.6 \times 10^{-7}))}$$

$$= \frac{(5.6 \times 10^{-7})^2}{(0.025)}$$

$$= 1.2 \times 10^{-11}$$

- Assignment :

  - Ka worksheet question #2

  - Read sections 20-6, 20-7, 20-8

p.554 (not calculation)

Period 41

- Go over worksheet

- Quiz tomorrow on worksheet

2 Ka Calculations

Q1 : What is the $[H^+]$ in a 0.50 M HCl solution ?

A1 : Because HCl is a strong acid, it completely dissociates as per the following equation :
$HCl\ (aq) \longrightarrow H^+_{(aq)} + Cl^-_{(aq)}$
The ratio between HCl and H^+ is one to one therefore the $[H^+]$ will be 0.50 M.

Q2 : What is the $[H_3O^+]$ in a 15.0 M HNO_3 solution ?

A2 : $[H_3O^+] = 15.0$ M

Q3 : What is the $[H^+]$ in a 0.50 M CH_3COOH solution ?

A3 : Because CH_3COOH is a weak acid, it will not completely dissociate but will set up an equilibrium as follows :

$$CH_3COOH_{(aq)} \Longleftrightarrow H^+_{(aq)} + CH_3COO^-_{(aq)}$$

According to our chart, the equilibrium constant for this reaction is 1.8×10^{-5}.

$$Keq = \frac{[H^+][CH_3COO^-]}{[CH_3COOH]} = 1.8 \times 10^{-5}$$

Like with solubility, the equilibrium expression involving an acid is used so frequently, we give it its own name : the ACID CONSTANT and call it Ka. Ka in fact is nothing more than a specialized Keq expression. Now, back to our question. When we dissolve an acid into water, we are setting up an 'ICE' problem.

	CH^3COOH	$\Longleftrightarrow$	H^+	+	CH_3COO^-
I	0.50		0		0
C	-X		+X		+X
E	0.50-X		X		X

$$Keq = \frac{[H^+][CH_3COO^-]}{[CH_3COOH]}$$

$$1.8 \times 10\text{-}5 = \frac{(X)(X)}{(0.50-X)}$$

As we can see, this will work out quite quickly into an absolutely messy quadratic equation to solve for X. However, there is an easier method.

Look at the denominator : (0.50-X) . Because the Ka value is very low, the amount of dissociation is insignificant compared to the original concentration. We can therefore ignore the X in the denominator.

$$1.8 \times 10^{-5} = \frac{(X)(X)}{(0.50-X)} \quad \text{<----/ assume X is insignificant}$$

$$1.8 \times 10^{-5} = \frac{(X)(X)}{(0.50)}$$

$$9.0 \times 10^{-6} = X^2$$

$$3.0 \times 10^{-3} = X$$

The $[H^+] = 3.0 \times 10^{-3}$ M

NOTE : if we were to have calculated the question via the quadratic formula, we would have got 2.99×10^{-3} M. Either way, when we make a subtraction from 0.50 M (keeping in mind the rules for significant figures) the amount of dissociation is indeed insignificant compared to the original concentration.

Q4 : What is the $[H_3O^+]$ in a 3.0 M solution of benzoic acid ?

A4 : $C_6H_5COOH \Longleftrightarrow H^+ + C_6H_5COO^-$ $Ka = 6.6 \times 10^{-5}$

$$Ka = \frac{[H^+][C_6H_5COO^-]}{[C_6H_5COOH]}$$

$$6.6 \times 10^{-5} = \frac{(X)(X)}{(3.0 - X)} \quad \text{<-----/ X is insignificant}$$

$$6.6 \times 10^{-5} = \frac{(X)(X)}{(3.0)}$$

$$1.98 \times 10^{-4} = X^2$$

$$1.4 \times 10^{-2} = X$$

$[H_3O^+] = 1.4 \times 10^{-2}$ M

Note: Similar calculations for Kb (Kb must be calculated)