Lesson: Weak Acids (pK_a)

Weak Acids – dissociate incompletely (~20%)

Strong Acids – dissociate completely (~100%)

$$A_{(g)} + 2\,B_{(g)} \rightleftharpoons 3\,C_{(g)} + D_{(g)}$$

Equilibrium constant (K_{eq}) = $\frac{[Products]}{[Reactants]}$ $K_{eq} = \frac{[C]^3[D]}{[A][B]^2}$ LeChatelier's (lu-SHAT-el-YAY's)

Example Problems: Pg 521 (black book) & pg 519 (transparency)

IONIZATION CONSTANTS for ACIDS

$$HC_2H_3O_{2(aq)} \rightleftharpoons H^+_{(aq)} + C_2H_3O_2^{1-}{}_{(aq)}$$

Equilibrium constant $K_{eq} = \dfrac{[H^+][C_2H_3O_2^{1-}]}{[HC_2H_3O_2]} = K_a =$ Acid dissociation constant

$K_a = 1.8 \times 10^{-5}$ @ 25 ^oC

$$K_a = \frac{[H^+][C_2H_3O_2^{1-}]}{[HC_2H_3O_2]}$$

$$1.8 \times 10^{-5} = \frac{[H^+][C_2H_3O_2^{1-}]}{[HC_2H_3O_2]}$$

	K_a
$HCl \longrightarrow H^+ + Cl^{1-}$	very large
$HNO_3 \longrightarrow H^+ + NO_3^{1-}$	very large
$H_2SO_4 \longrightarrow H^+ + HSO_4^{1-}$	large
$HC_2H_3O_2 \rightleftharpoons H^+ + C_2H_3O_2^{1-}$	1.8×10^{-5}
$H_2S \rightleftharpoons H^+ + HS^{1-}$	9.5×10^{-8}

Sample 1)

One gram of concentrated sulfuric acid (H_2SO_4) is diluted to a 1.0 dm^3 volume with water. What is the molar concentration of the hydrogen ion in this solution?
What is the pH?

Solution)

First determine the number of moles of H_2SO_4

$$x \text{ mol } H_2SO_4 = 1 \text{ g } H_2SO_4 \frac{(1mol)}{(98g)} = 0.010 \text{ mol } H_2SO_4$$

$$H_2SO_4 \longrightarrow H^+ + HSO_4^{1-} \quad \& \quad HSO_4^{1-} \longrightarrow H^+ + SO_4^{2-}$$

OVERALL:

$H_2SO_4 \longrightarrow 2\ H^+ + SO_4^{2-}$ in dilute solutions...occurs ~100%

0.010 M 0.020 M

pH = - log $[H^+]$ substitute into equation pH = - log [0.020 M]

pH = 1.69

A volume of 5.71 cm^3 of pure acetic acid, $HC_2H_3O_2$, is diluted with water at 25 ^oC to form a solution with a volume of 1.0 dm^3. What is the molar concentration of the hydrogen ion, H^+, in this solution?

(The density of pure acetic acid is 1.05 g/cm^3.)

Step 1) Find the mass of the acid

Mass of acid = density of acid x volume of acid
= 1.05 $g/\cancel{cm^3}$ x 5.71 $\cancel{cm^3}$
= 6.00 g

Step 2) Find the number of moles of acid. (From the formula of acetic acid, you can calculate that the molar mass of acetic acid is 60 g / mol).

x mol acetic acid = 6.00 g acetic acid $\frac{(1mol)}{(60g)}$ = 0.10 mol acetic acid (in 1 L)

Molarity: M = mol / L Substitute into equation M = 0.10 mol / 1 L

M = 0.1 molar

Step 3) Find the $[H^+]$

$K_a = \frac{[H^+][C_2H_3O_2^{1-}]}{[HC_2H_3O_2]}$ Substitute into equation: $1.8 \times 10^{-5} = \frac{[x][x]}{[H_2C_2H_3O_2]}$

$1.8 \times 10^{-5} = \frac{x^2}{0.10}$

$x^2 = 1.8 \times 10^{-6}$

$x = 1.3 \times 10^{-3}$ molar

H^+ Concentrations

Moles of Acid used to form 1 L of solution	H^+	pH	
0.010 mol H_2SO_4	0.0200	1.7	Strong acid
0.100 mol $HC_2H_3O_2$	0.0013	2.9	Weak acid

Note: although the sulfuric acid is 10x less concentrated than the acetic acid...it produces > 10x more H^+

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

Practice Problems:

1a) What is the molar hydrogen ion concentration in a 2.00 dm^3 solution of hydrogen chloride in which 3.65 g of HCl is dissolved?

1b) pH

2a) What is the molar concentration of hydrogen ions in a solution containing 3.20 g of HNO_3 in 250 cm^3 of solution?

2b) pH

3a) An acetic acid solution is 0.25 M. What is its molar concentration of hydrogen ions?

3b) pH

4) A solution of acetic acid contains 12.0 g of $HC_2H_3O_2$ in 500 cm^3 of solution. What is the molar concentration of hydrogen ions?

ANSWERS:

1a) 0.0500 M **2a) 0.203 M**
1b) pH = 1.3 **2b) pH = 0.7**
3a) 2.1×10^{-3} M **3b) pH = 2.7**
4) 2.7×10^{-3} M