Strong Acids

A strong acid is one that ionizes completely

NO EQUILIBRIUM

Examples:

hydrochloric acid $HCl \rightarrow H^{+}_{(aq)} + Cl^{-}_{(aq)}$

nitric acid $HNO_3 \rightarrow H^{+}_{(aq)} + NO_3^{-}{}_{(aq)}$

chloric acid $HClO_3 \rightarrow H^{+}_{(aq)} + ClO_3^{-}{}_{(aq)}$

Notice that the reaction only goes one way, there is **NO EQUILIBRIUM**.

Strong Base

A strong base is one that ionizes completely

NO EQUILIBRIUM

Examples:

sodium hydroxide $NaOH \rightarrow Na^{+}_{(aq)} + OH^{-}_{(aq)}$

potassium hydroxide $KOH \rightarrow K^{+}_{(aq)} + OH^{-}_{(aq)}$

calcium hydroxide $Ca(OH)_2 \rightarrow Ca^{2+}_{(aq)} + 2OH^{-}_{(aq)}$

Notice that the reaction only goes one way, there is **NO EQUILIBRIUM**.

Weak Acids

Weak acids only ionize partially

THERE IS EQUILIBRIUM

Examples:

acetic acid $HC_2H_3O_2 \leftrightharpoons H^+{}_{(aq)} + C_2H_3O_2^-{}_{(aq)}$

carbonic acid $H_2CO_3 \leftrightharpoons H^+{}_{(aq)} + HCO_3^-{}_{(aq)}$

Notice that the reaction goes both ways, there is equilibrium.

Weak Bases

Weak bases only ionize partially

THERE IS EQUILIBRIUM

Example:

ammonium hydroxide

$NH_4OH \leftrightharpoons NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$

Notice that the reaction goes both ways, there is equilibrium.

Weak Acids and Bases

Because there is equilibrium for weak acids and bases we must write equilibrium expressions and use equilibrium expression to determine the hydrogen ion or hydroxide ion concentration **before** we calculate pH or pOH.

What is the pH of a 0.00542 M solution of acetic acid? $K_a = 1.8 \times 10^{-5}$

Step 1 – write the equation for the ionization of acetic acid

$$HC_2H_3O_{2\,(aq)} \leftrightharpoons H^+_{(aq)} + C_2H_3O_2^-{}_{(aq)}$$

Step 2 – write the equilibrium expression

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

Step 3 – determine the equilibrium concentrations.

$HC_2H_3O_2$ started at 0.00542 M **but some** reacted (not all). At equilibrium it will be 0.00542 M – *x*.

H^+ started at 0 M but some will be produced. At equilibrium it will be *x*. 1:1 mole ratio

$$\frac{X \text{ moles } HC_2H_3O_2}{1\text{L}} \text{ x } \frac{1 \text{ mole } H^+}{1 \text{ mole } HC_2H_3O_2} = X \text{ M } H^+$$

$C_2H_3O_2^-$ started at 0 M but some will be produced. At equilibrium it will be *x*. 1:1 mole ratio

$$\frac{X \text{ moles } HC_2H_3O_2}{1\text{L}} \text{ x } \frac{1 \text{ mole } C_2H_2O_2^-}{1 \text{ mole } HC_2H_3O_2} = X \text{ M } C_2H_2O_2^-$$

Step 4 – substitute the amounts into the equilibrium expression: K=$1.8x10^{-5}$, $[H^+]$ =x, [C2H3O2$^-$]=x, $[HC_2H_3O_2]$ = .00542-x

$$1.8x10^{-5} = \frac{[x][x]}{[0.00542-x]}$$

Multiply both sides by 0.00542-x …

$$(0.00542-x)\ (1.8x10^{-5}) = x^2$$

Distribute the $1.8x10^{-5}$ …

$$9.76x10^{-8} - 1.8x10^{-5}x = x^2$$

Move all terms to the right side by adding $1.8x10^{-5}$x to both sides and subtracting $9.76x10^{-8}$ from both sides

$$0=x^2 + 1.8x10^{-5}x - 9.76x10^{-8}$$

We now have a quadratic equation in the form of $0 = Ax^2 + Bx + C$

The solution for a quadratic equation is:

$$x= \frac{-B \pm \sqrt{(B^2-4AC)}}{2A}$$

So from our equation: $0 = x^2 + 1.8\text{x}10^{-5}x - 9.76\text{x}10^{-8}$

$A = 1$

$B = 1.8\text{x}10^{-5}$

$C = -9.76\text{x}10^{-8}$

$x = 3.03539\text{x}10^{-4}$ M or $-3.21539\text{x}10^{-4}$ M

Concentration cannot be negative so

$[H^+] = 3.035\text{x}10^{-4}$M

$[H^+] = 3.035\text{x}10^{-4}M$

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

$pH = -\log [3.035\text{x}10^{-4}]$

$pH = 3.52$