# Acids and Bases:

## Bronsted/Lowry Theory

**acid- Proton donor.**

**base- Proton acceptor.**

**The strength of an acid or base depends on their ability to donate or accept protons.**

**Where $H_3O^+$ same as $H^+(aq)$.**

# Strong Acids:

**Ex: Strong Acid**

| | | | | | | |
|---|---|---|---|---|---|---|
| **HCl** | **+** | **$H_2O(l)$** | **$\rightarrow$** | **$H_3O^+$** | **+** | **$Cl^-$** |
| **acid1** | | **base2** | | **acid2** | | **base1** |

**HCl dissociates completely.**

**Also written as:**

$$HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$$

# Weak Acids:

$HC_2H_3O_2 + H_2O(l) \rightleftharpoons H_3O^+ + C_2H_3O_2^-$

acid1 base1 acid2 base2

$HC_2H_3O_2$ dissociates slightly.

Also written as:

$HC_2H_3O_2(aq) \rightleftharpoons H^+(aq) + C_2H_3O_2^-(aq)$

# Strong Base:

**Typical Strong Base is NaOH.**

$$NaOH(s) \xrightarrow{H_2O} Na^+(aq) + OH^-(aq)$$

**Hydroxide Ion: $OH^-(aq)$**

$$OH^-(aq) + H^+(aq) \rightarrow H_2O(l)$$

# Weak Base:

$$NH_3 + H_2O(l) \rightleftharpoons NH_4^+ + OH^-$$

| | | | |
|---|---|---|---|
| base | acid | acid | base |

# The Self Ionization of Water:

$$2H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$

**or**

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$$

$$K = [H_3O^+(aq)][OH^-(aq)]$$

**or**

$$K = [H^+(aq)][OH^-(aq)]$$

## $K_w$: Ion product of water:

At 25 °C $[H^+(aq)] = [OH^-(aq)] = 1.0\times10^{-7}$ M thus

$$K_w = [H^+(aq)][OH^-(aq)] = 1.0\times10^{-14}$$

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$$

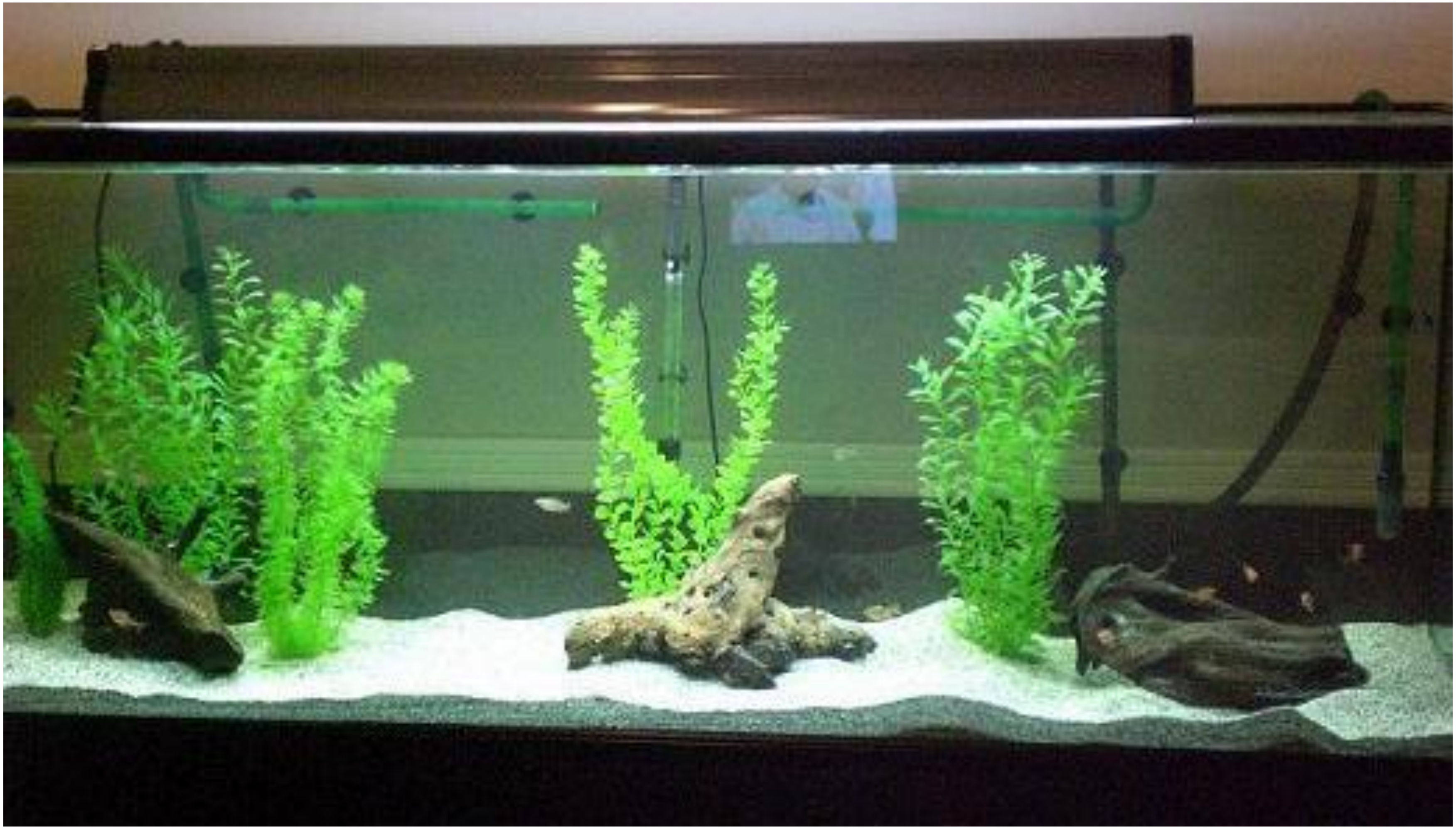
If $[H^+(aq)]$ increases, $[OH^-(aq)]$ decreases.

# Importance of $H^+$ Concentration:

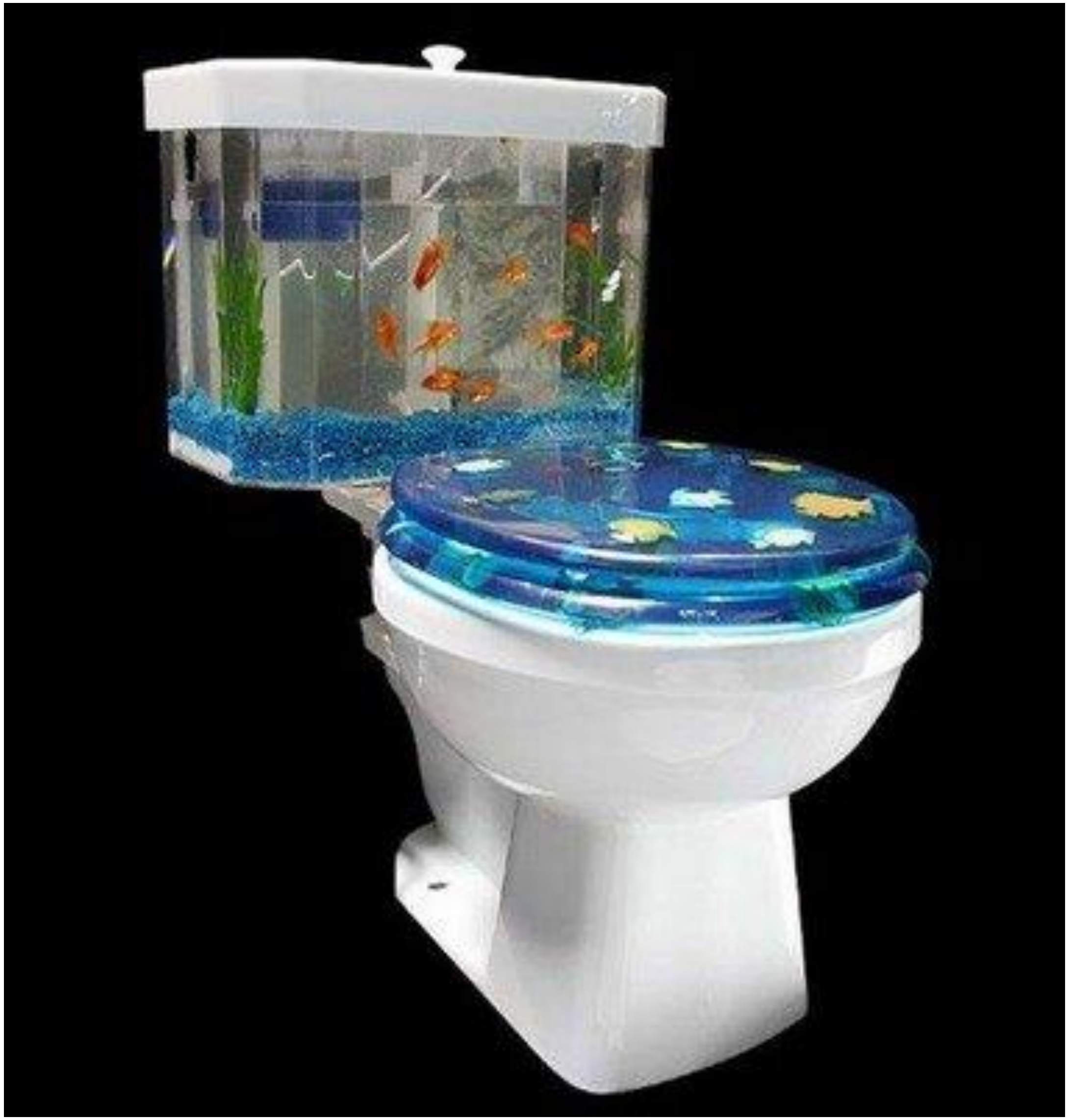
**Knowing the concentration of $H^+$ very important.**

**Ex: aquarium, pools, etc.**

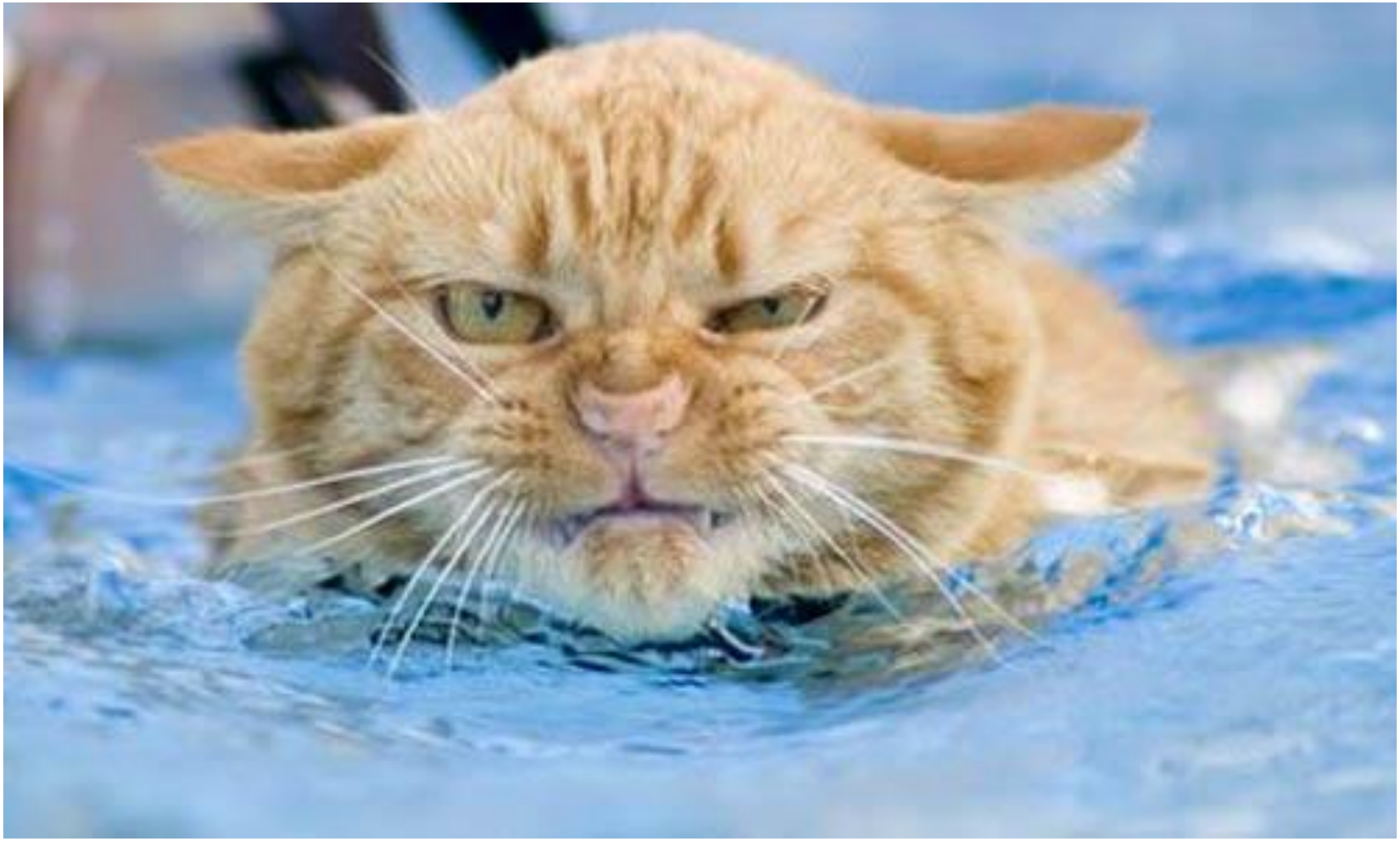
# Fishtank



# Aquarium in Toilet



# Pool



# pH Scale:

**pH is a logarithmic scale of $H^+$ concentration.**

$$pH = -Log[H^+(aq)] \quad \text{or} \quad pH = -Log[H_3O^+(aq)]$$

**The pH scale ranges from 0(very acidic) to 14(very basic). Pure water has a pH of 7.**

**Likewise,**

$$pOH = -Log[OH^-(aq)]$$

$$pH + pOH = 14$$

# Examples:

**Ex: Calculate the pH of a 0.025 M HCl solution.**

**Ex2: Calculate the [$H^+$(aq)], [$OH^-$(aq)], and pOH of rainwater with a pH of 4.35.**

**Ex3: At 25 °C a 0.100 M solution of acetic acid is 1.34% ionized. Calculate the pH.**

# Acid Ionization Constant($K_a$):

**For a weak acid HA.**

**$HA(aq) \rightleftharpoons H^+(aq) + A^-(aq)$**

$$K_A = \frac{[H(aq)^+][A^-(aq)]}{[HA(aq)]}$$

**$K_A$ values indicate relative acid strength.**

**Ex: Calculate the $K_A$ of 0.1 M acetic acid. Acetic acid is 1.34% ionized.**

**Examples:**

**Ex: What is the pH of a 0.00250 M $HNO_2$ solution?**

$K_A = 7.20 \times 10^{-4}$

# Diprotic and Polyprotic Acids:

**Acids with two or more ionizable protons.**

**Example of a Diprotic Acid**

$$H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

$$K_{A1} = \frac{[H(aq)^+][HCO_3^-(aq)]}{[H_2CO_3(aq)]}$$

$$HCO_3^-(aq) \rightleftharpoons H^+(aq) + CO_3^{2-}(aq)$$

$$K_{A2} = \frac{[H(aq)^+][CO_3^{2-}(aq)]}{[HCO_3^-(aq)]}$$

# Example of Triprotic Acid:

**Phosphoric acid: $H_3PO_4$**

**Ex:**

**Calculate $[H^+(aq)]$, $[H_2PO_4^-(aq)]$, $[HPO_4^{2-}(aq)]$, and $[PO_4^{3-}(aq)]$ for a 3.0 M $H_3PO_4$ solution.**

**$K_{A1} = 7.1\times10^{-3}$, $K_{A2} = 6.3\times10^{-8}$, $K_{A3} = 4.2\times10^{-13}$**

# Base Dissociation Constant($K_B$):

**For a weak base.**

$$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

$$K_B = \frac{[NH_4^+(aq)][OH^-(aq)]}{[NH_3(aq)]}$$

**Relationship between $K_A$ and $K_B$.**

$$K_A \cdot K_B = K_W = 1\times10^{-14}$$

# Hydrolysis:

**Hydrolysis is the reaction between an ion and water.**

**Adding NaCl to water.**

$$Na^+ + H_2O(l) \rightarrow \text{no reaction}$$

$$Cl^- + H_2O(l) \rightarrow \text{no reaction}$$

**Adding $NH_4Cl$.**

$$NH_4^+ + H_2O(l) \rightleftharpoons NH_3 + H_3O^+$$

**Salts of weak acids and bases affect pH.**

**If ion has $K_A$ or $K_B$, hydrolysis occurs.**

# Lewis Acids and Bases:

**Lewis acid-base theory relates acid-base behavior of molecules to their molecular structure.**

**Lewis acid- A species that is an electron pair acceptor.**

**Lewis base- A species that is an electron pair donor.**