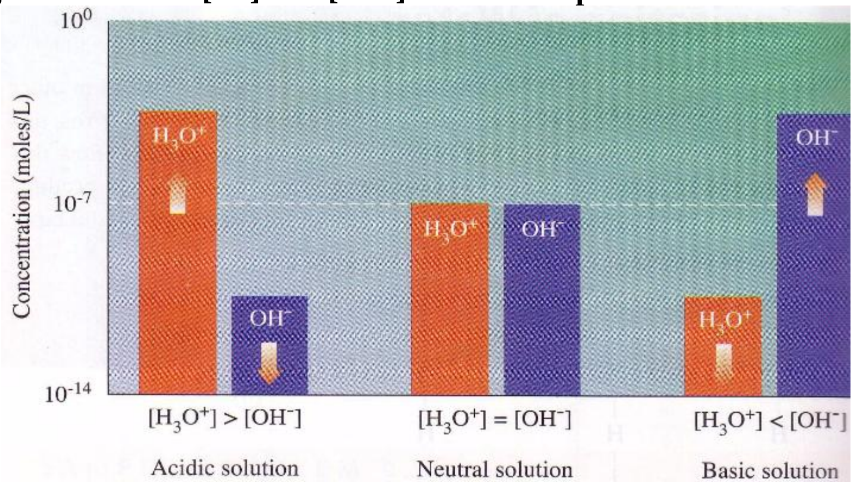
Unit I – Problem 3 – Biochemistry: pH and Buffers

- **Electrolytes:**
  - **Definitions**: they are substances which give ions when dissolved in water.
  - Electrolytes are divided into acids, bases and salts sense they produce ions when dissolved in water.
  - Electrolytes are able to conduct electricity as a result of the mobility of positive (cations) and negative (anions) ions.
  - **While water is a very weak electrolyte, auto-ionization of pure water is represented by:**
    - ✓ $H_2O = H^+ + OH^-$
  - **Electrolyte in body fluids:**
    - ✓ The primary electrolytes required in body fluids are:
      - ❖ *Cations*: calcium, potassium, sodium and magnesium.
      - ❖ *Anions*: chloride, carbonates, aminoacetates, phosphates and iodide.
- **pH:**
  - **pH = -log $[H_3O^+]$ = log $\frac{1}{[H_3O^+]}$**
    - ✓ Hydronium cation (H_3O^+):
      - ❖ It is a positively-charged polyatomic ion with the chemical formula H_3O^+
      - ❖ It is formed by protonation of water.
  - **pH (at 25 C) of:**
    - ✓ Neutral solution = -log (1.0×10^{-7}) = 7.00
    - ✓ Acidic solution: < 7.00
    - ✓ Basic solution: > 7.00
  - **Physiologic pH range**: 7.35 – 7.45 (notice that the pH of gastric juice is 1-3).
  - **The image below shows $[H^+]$ and $[OH^-]$ in different pH:**



- **Dissociation of strong and weak acids:**
  - **HCl is a strong acid which will dissociate completely in water:**
    - ✓ $HCl \rightarrow H^+ + Cl^-$
  - **CH_3COOH is a weak acid which will exist in aqueous solution in equilibrium of protonated and deprotonated states:**
  - $CH_3COOH \leftrightarrow CH_3COO^- + H^+$
- **Ionization of water:**
  - **Water is essentially a neutral molecule but ionizes slightly:**
    - ✓ $H_2O + H_2O \leftrightarrow H_3O^+ + OH^-$
  - **The equilibrium of the autoionization of water is given by ion product constant of water (Kw), which at 25 C is:**
    - ✓ $K_w = [H^+] \times [OH^-] = 1.0 \times 10^{-14}\ M^2$ (and it is always maintained).

- **Buffers:**
  - A mixture of a weak acid or a weak base and its salt that resist changes in pH when small amounts of an acid or a base are added.
  - Maximum buffering occurs at pKa ± 1 pH unit.
  - **Physiological buffering systems:**
    - ✓ Bicarbonate/ carbonic acid.
    - ✓ Phosphate.
    - ✓ Protein.
- **Handerson-Hasselbalch equation:**
  - **pH = pKa + log $[A^-]$ / [HA]**
    - ✓ [HA]: concentration of the undissociated weak acid.
    - ✓ $[A^-]$: concentration of the unconjugate base of [HA].
    - ✓ pKa = 6.1
    - ✓ In normal blood, the $[HCO_3^-]/[H_2CO_3]$ ratio is 20:1 (log 20 = 1.3)
  - **Therefore, in normal blood:**
    - ✓ pH = 6.1 + log [20/1]
    - ✓ pH = 6.1+ 1.3
    - ✓ pH = 7.40