Acids and Bases

Introduction: What Are Acids and Bases?

- **Everyday Examples:** Acids and bases are everywhere!
  - **Acids:** Vinegar (acetic acid), lemon juice (citric acid), car batteries (sulfuric acid).
  - **Bases:** Soap, baking soda, drain cleaner (sodium hydroxide).
- **Common Properties:** They are defined by their distinct chemical behaviors in water.

Common Properties of Acids

- **Taste:** Sour (e.g., lemons, unripe apples).
- **Touch:** Can feel sharp or burning; strong acids are corrosive.
- **Effect on Litmus Paper:** Turn blue litmus paper **red**.
- **Reaction with Metals:** React with most active metals to produce **hydrogen gas** .

Common Properties of Bases

- **Taste:** Bitter (e.g., strong coffee, tonic water).
- **Touch:** Feel **slippery** or soapy (due to reacting with fats in the skin); strong bases are corrosive.
- **Effect on Litmus Paper:** Turn red litmus paper **blue**.
- **Reaction:** Bases react readily with fats and oils (saponification).

The Arrhenius Concept: Introduction (1884)

- **The First Formal Definition:** Developed by Svante Arrhenius. This concept is simple and focuses on the behavior of substances when dissolved in water (aqueous solutions).
- **Limitation:** It only works for compounds dissolved in water.

- **Arrhenius Definition of an Acid**
- **Rule:** An **Arrhenius Acid** is a substance that, when dissolved in water, increases the concentration of **hydrogen ions** or **protons.**

The Brønsted-Lowry Concept: Introduction (1923)

- **Wider Scope:** Developed independently by Johannes Brønsted and Thomas Lowry. This definition does not require water as the solvent.
- **Focus:** It focuses on the **transfer of protons** between reacting species.

- **Brønsted-Lowry Definition of an Acid**
- **Rule:** A **Brønsted-Lowry Acid** is a substance that can **donate a proton**
  - Acids are **Proton Donors.**

- **Brønsted-Lowry Definition of a Base**
- **Rule:** A **Brønsted-Lowry Base** is a substance that can **accept a proton**
  - Bases are **Proton Acceptors.**

Conjugate Acid-Base Pairs

- **Definition:** When an acid donates a proton, the remaining ion or molecule is capable of accepting a proton, and is called the **conjugate base.**
- **Similarly:** When a base accepts a proton, the resulting ion or molecule is capable of donating a proton, and is called the **conjugate acid.**
- **The Relationship:** Every Brønsted-Lowry acid has a conjugate base, and every base has a conjugate acid.

Amphoteric Substances

- **Definition:** A substance that can act as both a **Brønsted-Lowry acid** (proton donor) and a **Brønsted-Lowry base** (proton acceptor).
- **Water :** The most common example.

The Lewis Concept: Introduction (1923)

- **Wider Scope Still:** Developed by Gilbert N. Lewis. This is the broadest definition and is not restricted to proton transfer or water.
- **Focus:** It focuses on the **transfer of electrons** (specifically, non-bonding electron pairs).

Lewis Definition of an Acid

- **Rule:** A **Lewis Acid** is a substance that can **accept a pair of non-bonding electrons.**
  - Lewis Acids are **Electron Pair Acceptors.**
- **Characteristic:** Often an atom that has an incomplete valence shell (like).

- **Lewis Definition of a Base**
- **Rule:** A **Lewis Base** is a substance that can **donate a pair of non-bonding electrons.**
  - Lewis Bases are **Electron Pair Donors.**
- **Characteristic:** Must have a lone pair of electrons available to donate .

Summary of the Three Acid-Base Theories

Concept	Acid Definition	Base Definition
Arrhenius	Produces H^+ in water	Produces OH^- in water
Brønsted-Lowry	Proton (H^+) Donor	Proton (H^+) Acceptor
Lewis	Electron Pair Acceptor	Electron Pair Donor

Strong Acids vs. Weak Acids

- **Strong Acid:** An acid that **ionizes completely** in water. All molecules break apart to release ions.
  - *Examples:* (Hydrochloric), (Sulfuric).
- **Weak Acid:** An acid that **ionizes only partially** (less than) in water. Most molecules remain intact.
  - *Example:* (Acetic Acid/Vinegar).

The Significance of Strength

- **Strength is not Concentration:** A dilute solution of a strong acid can be less dangerous than a concentrated solution of a weak acid.
- **Key Concept:** Strength refers to the extent of **ionization** (how many ions are formed). Concentration refers to the **amount** of acid or base dissolved in a given volume of solution.

The Concept of PH

- **Purpose:** A scale developed to express the wide range of H^+ concentrations in a simple, compact way.
- **Definition:** pH is the negative logarithm (base 10) of the hydronium ion concentration.

$$\mathrm{pH} = -\log[\mathrm{H_3O^+}]$$

- **The Log Scale:** Because it's a logarithmic scale, a change of one pH unit represents a tenfold ($10\times$) change in acidity.

The Scale Range

- **Neutral:** Pure water has a pH of **7** (where $[\mathrm{H_3O^+}] = [\mathrm{OH^-}]$).
- **Acidic:** Solutions with a pH **less than 7** (where $[\mathrm{H_3O^+}] > [\mathrm{OH^-}]$).
- **Basic (Alkaline):** Solutions with a pH **greater than 7** (where $[\mathrm{H_3O^+}] < [\mathrm{OH^-}]$).
- **Maximum Range:** Typically ranges from 0 to 14.

Calculating PH

- Example: If $[H_3O^+] = 1.0 \times 10^{-4}\,\mathrm{M}$:

$$\mathrm{pH} = -\log(1.0 \times 10^{-4}) = 4.0$$

- Conclusion: This solution is acidic because $\mathrm{pH} < 7$.

Neutralization Reaction

- **Definition:** The reaction between an acid and a base to form a **salt** and **water**.
- **Essential Feature:** The net result is the combination of H^+ (or H_3O^+) from the acid and OH^- from the base.

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

Example of Neutralization

- **Reaction:** Hydrochloric acid and Sodium Hydroxide.

$$\mathrm{HCl\ (aq) + NaOH\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (l)}$$

- **Products:** NaCl (Sodium Chloride) is the salt, and $\mathrm{H_2O}$ is water.
- **General Rule:** The solution becomes closer to a neutral pH of 7.

Salts

- **Definition:** An ionic compound formed when the negative ion (anion) from an acid combines with the positive ion (cation) from a base.
- **Types of Salts:**
  - **Neutral Salts:** Formed from a strong acid and a strong base .
  - **Acidic Salts:** Formed from a strong acid and a weak base .
  - **Basic Salts:** Formed from a weak acid and a strong base .

Acid-Base Indicators

- **Definition:** Weak organic acids or bases that change color depending on the of the solution.
- **Mechanism:** They exist in two forms (acidic and basic) that have different colors. The color change occurs within a narrow range.
- **Examples:**
  - **Litmus:** Red (acidic) to Blue (basic).
  - **Phenolphthalein:** Colorless (acidic) to Pink (basic).

Thank you

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