# SNS COLLEGE OF PHARMACY AND HEALTH SCIENCES
# Coimbatore -641035

COURSE NAME: BP102T-PHARMACEUTICAL ANALYSIS (Theory)

I YEAR / I SEMESTER

SUB TOPIC: UNIT II -ACID BASE TITRATION

# Acid-Base Titration:

## 1. Theories of Acid-Base Indicators

- Ostwald’s Theory – Ionization of weak acid/base indicators
- Quinonoid Theory – Structural change between quinonoid & benzenoid forms

### Acid-Base Titration:

## 2. Classification of Acid-Base Titrations

- Strong Acid vs Strong Base – Sharp end point (e.g., HCl vs NaOH)
- Strong Acid vs Weak Base – Acidic end point (e.g., HCl vs $NH_4OH$)
- Weak Acid vs Strong Base – Basic end point (e.g., $CH_3COOH$ vs NaOH)
- Weak Acid vs Weak Base – No sharp end point, rarely used

# Acid Base Titration:

- The Arrhenius theory of acids and bases states that “an acid generates H* ions in a solution whereas a base produces an OH— ion in its solution”.
- The Bronsted-Lowry theory defines “an acid as a proton donor and a base as a proton acceptor”.

Acid    Base+ H*

- Finally, the Lewis definition of acids and bases describes “acids as electron-pair acceptors and bases as electron-pair donors .

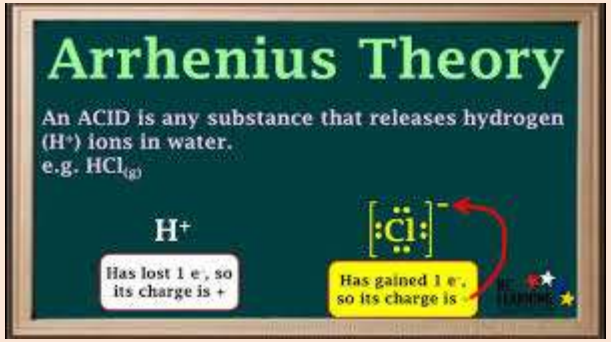
## Arrhenius Theory

- The Arrhenius Theory. It defines acids and bases based on their behavior in aqueous solutions, specifically their ability to produce hydrogen ions ($H^+$) or hydroxide ions ($OH^-$). Below is a concise overview of the Arrhenius Theory, its principles, examples, and limitations.

- **Acid:** Produces $H^+$ in water

  $HCl \rightleftharpoons H^+ + Cl^-$
- **Base:** Produces $OH^-$ in water

  $NaOH \rightleftharpoons Na^+ + OH^-$

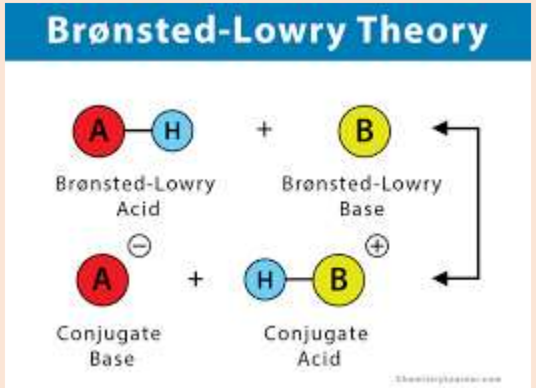


## *Bronsted-Lowry theory:-*

The **Bronsted-Lowry theory** defines acids and bases based on proton ($H^+$) transfer:

**Acid**: A substance that donates a proton ($H^+$) to another substance.

**Base**: A substance that accepts a proton ($H^+$) from another substance.



# Lewis definition :-

The **Lewis definition** of acids and bases focuses on electron pair transfer, proposed by Gilbert Lewis.

**Acid**: A substance that accepts an electron pair to form a coordinate covalent bond.

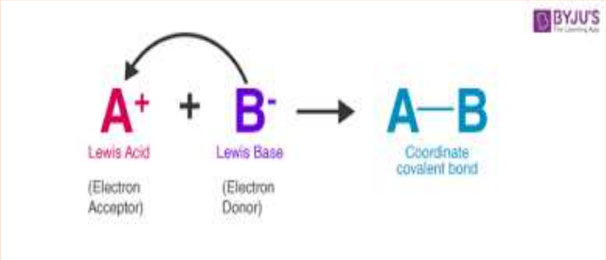
**Base**: A substance that donates an electron pair to form a coordinate covalent bond

## Examples:

**Lewis Acid**: Electron-deficient species like $BF_3$, $AlCl_3$, or metal cations (e.g., $Fe^{3+}$)

that can accept an electron pair.

**Lewis Base**: Electron-rich species with lone pairs, like $NH_3$, $H_2O$, or $OH^-$, that can donate an electron pair.



## Ostwarld Theory:-

Based on the query "Ostwarld Theory," it appears to be a misspelling or autocorrect error for Ostwald Theory, referring to the Ostwald's Theory. It explains the color changes observed in acid-base indicators during titrations. Below, I'll outline the theory, its principles, examples, and limitations. If this isn't what you meant (e.g., Ostwald's Dilution Law or Ostwald's Rule of Stages), feel free to clarify!

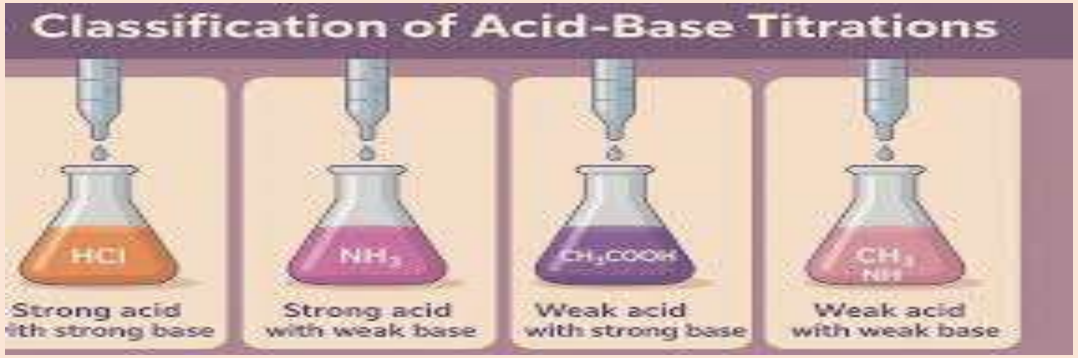
## Quinonoid theory:-

The Quinonoid Theory explains the color changes of acid-base indicators during pH-dependent reactions, such as titrations, by proposing that indicators exist in two tautomeric forms with distinct structures and colors.

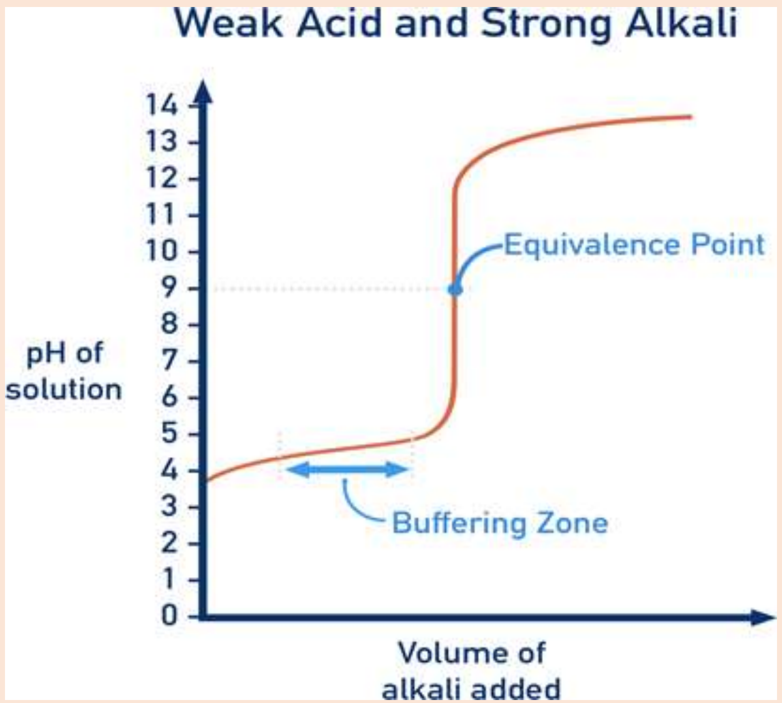
Proposed by Adolf Hantzsch in the early 1900s as a refinement to Wilhelm Ostwald's ionization-based theory, it addresses limitations in explaining complex indicator behavior. Below is a concise explanation of the theory, its principles, examples, and comparison with Ostwald's theory.

# Classification of acid base Titration:-

1. Titration of strong acid with strong base
2. Titration of weak acid with Strong base
3. Titration of weak base with strong acid
4. Titration of weak base with weak acid
5. Titration of polybasic acid with strong base



# 1 .Strong Acid-Strong Base Titration:-




**Title**:

Strong Acid vs. Strong Base

**Content**:

Examples: HCl vs. NaOH, $HNO_3$ vs. KOH.

**Characteristics:**

Complete ionization of acid and base.

Sharp pH change at equivalence point (pH ≈ 7).

Easy endpoint detection with indicators (e.g., phenolphthalein).

Applications: Standardization of solutions, quality control.

# 2. Titration of weak acid with Strong base:-

**Title**:

Weak Acid vs. Strong Base

**Content**:

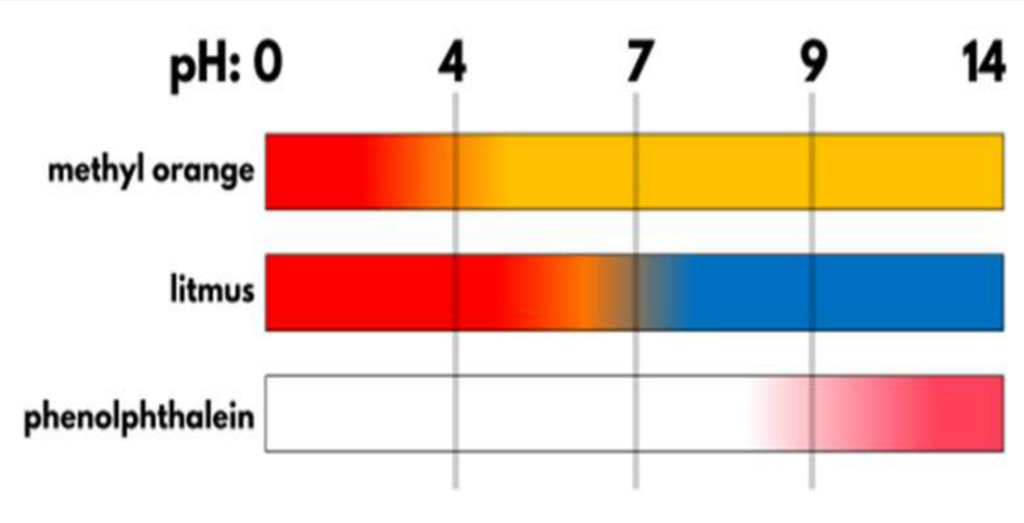
Examples: $CH_3COOH$ (acetic acid) vs. NaOH.

**Characteristics:**

Partial ionization of weak acid.

Equivalence point at pH > 7 (basic).

Gradual pH change, requiring specific indicators (e.g., phenolphthalein).




Applications: Analysis of organic acids, Pharmaceuticals.

# 3.Titration of weak base with strong acid:-


**Title**:

Strong Acid vs. Weak Base

**Content**:

Examples: HCl vs. $NH_3$ (ammonia).

**Characteristics:**

Partial ionization of weak base.

Equivalence point at pH < 7 (acidic).

Gradual pH change, indicators like methyl orange used.

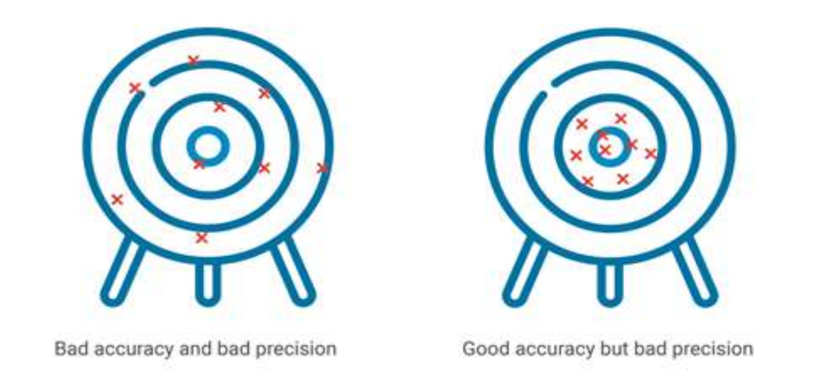
Applications: Analysis of weak bases, environmental samples.

## 4 .Titration of weak base with weak acid :-

**Title**: Weak Acid vs. Weak Base.

**Content**: Examples: $CH_3COOH$ vs. $NH_3$.

**Characteristics:**




- Both acid and base partially ionize.
- No sharp pH change, making endpoint detection difficult.
- Rarely used due to poor precision; requires specialized equipment.

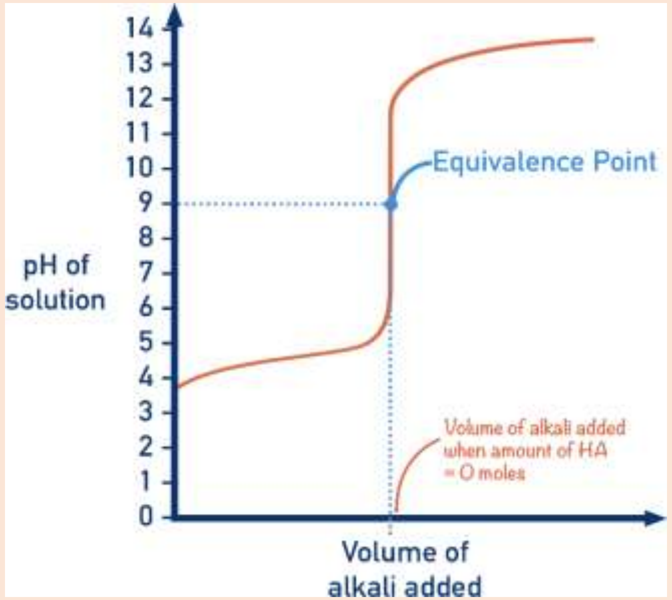
Applications: Limited, used in specific biochemical analyses.

# 5 .Titration of polybasic acid with strong base:-

Titrating a polybasic acid (an acid with multiple ionizable protons, like $H_2SO_4$ or $H_3PO_4$) with a strong base (e.g., NaOH) involves a stepwise neutralization process, with distinct equivalence points corresponding to each proton dissociation.

**Polybasic Acid**: Has multiple dissociation constants ($K_{a1}$, $K_{a2}$, etc.), each associated with the loss of one proton. For example, for phosphoric acid ($H_3PO_4$):

$$H_3PO_4 \rightleftharpoons H_2PO_4^- + H^+ \ (K_{a1})$$
$$H_2PO_4^- \rightleftharpoons HPO_4^{2-} + H^+ \ (K_{a2})$$
$$HPO_4^{2-} \rightleftharpoons PO_4^{3-} + H^+ \ (K_{a3})$$



**Neutralization curve:-**

Neutralization curve represents the neutralization reaction between acid & base in neutralization titration. It is plotted between the Ph and volume of acid or base added.

The following information derived from neutralization curve

- The curve is useful in studying the neutra(ination process by studying the change in hydrogen ion concentration during titration.
- It represent the progress of acid base titration.
- It indicate the end point of titration.
- It indicate the sensitivity of titration & chances of error.
- selection of indicator for particular titration is made.


**Objective Met**:

Acid-base titration accurately determines the concentration of an acid or base.

**Key Process**:

Neutralizes acid with base, tracking pH changes to identify equivalence points.

**Polybasic Acids**:

Show multiple equivalence points (one per proton) if $pK_a$ values are distinct, reflecting stepwise dissociation.

**Titration Curve**:

Visualizes initial pH, buffer regions, equivalence points, and final pH.

# Case Study:

**Case:**

You are working as a quality control analyst in a pharmaceutical company. During the standardization of **0.1N Sodium Hydroxide solution**, you used **0.1N Oxalic Acid** as a primary standard. After performing three concordant titrations, you got slightly varying burette readings.

**Questions:**

1. Explain the **importance of using a primary standard** for standardization.
2. Describe the **procedure for standardization** of NaOH using oxalic acid.
3. What types of **errors** might have caused variation in readings?
4. Suggest **methods to minimize these errors**.
5. Comment on the **accuracy and precision** of the titration results.

# ASSESSMENT:

Choose the most appropriate answer.

**1. Which of the following is a primary standard?**

a) Sodium hydroxide b) Hydrochloric acid

c) Oxalic acid d) Sodium thiosulphate

**2. Which of the following expresses concentration in terms of moles of solute per liter of solution?**

a) Normality b) Molarity

c) Molality d) % w/v

**3. Which type of error occurs due to defective apparatus or calibration?**

a) Personal error b) Systematic error

c) Random error d) Gross error

**4. Which Indian Pharmacopoeia edition is currently followed in India?**

a) IP 1985 b) IP 1996

c) IP 2018 d) IP 2020

**5. Which of the following is a source of impurity in drugs?**

a) Manufacturing process b) Storage condition

c) Raw materials d) All of the above

## Reference:

1. A.H. Beckett & J.B. Stenlake's, Practical Pharmaceutical Chemistry Vol I & II, Stahlone Press of University of London.

2. A.I. Vogel, Text Book of Quantitative Inorganic analysis.

3. P. Gundu Rao, Inorganic Pharmaceutical Chemistry.

4. Bentleyand Driver's Textbook of Pharmaceutical Chemistry.

5. John H. Kennedy, Analytical chemistry principles.

6. Indian Pharmacopoeia.


Thank You!