

FIRST STAGE II

# Volumetric Analysis

The First Lecture

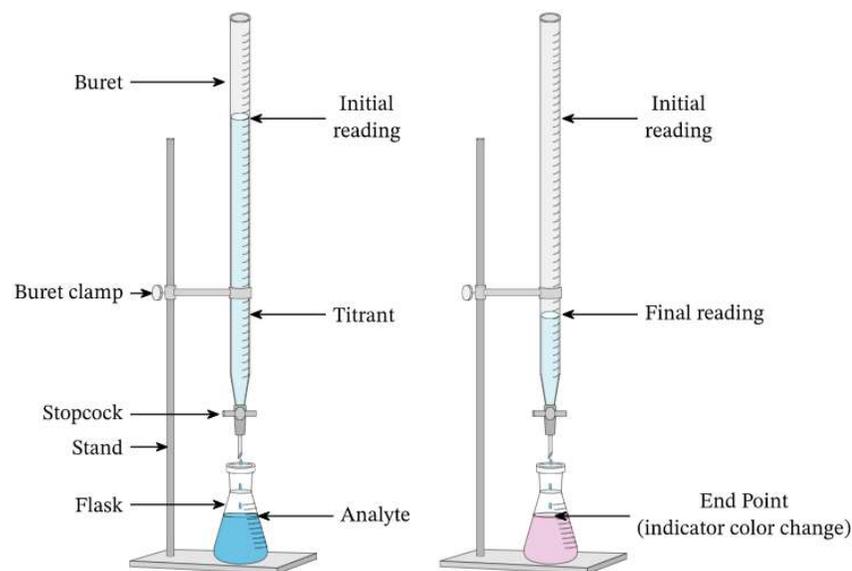
## Lecture Objective

- Volumetric Analysis method
- Some definitions
- Important of primer solutions (standard solutions)
- Calculations of Volumetric analysis
- Examples
- Equilibrium in acid base solution
- Acids & Bases classification

## Volumetric Analysis

Volumetric analysis is a quantitative analytical method of determining the amount of substance contained in a sample solution by gradually adding a **standard solution (Titrant)** of known concentration and measuring the volume at the time of reaction.

The standard solution is a solution containing a **precisely** known concentration of a substance, **called a titrant**, and this process is **called titration**.

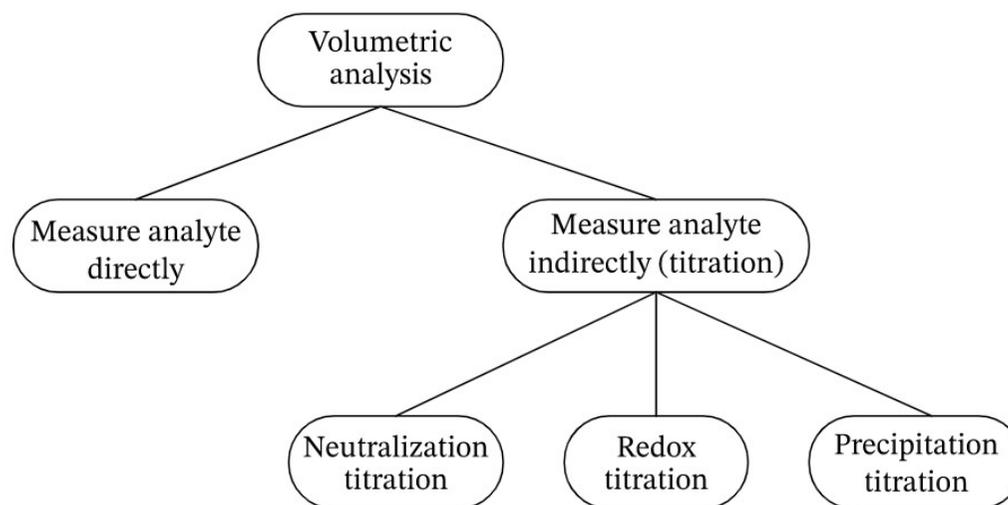


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## Volumetric Analysis

There are various types of titrations with different procedures that can be classified as:

- **DIRECT TITRATIONS**
- **INDIRECT TITRATIONS**
  - Neutralization titration (acid-base titration)
  - Redox titration, (oxidation–reduction)
  - Precipitation titration
  - Complexometric titrations



## Volumetric Analysis

### *SOME Definition:*

**Volumetric analysis:** is a quantitative analytical method that measures the volume of the **titrant (KNOW CONCENTRATION)** that reacts with the **analyte**.

**Titrimetric (titration) analysis:** is a quantitative analytical method used to determine the concentration of an analyte using a known concentration of a **titrant** solution.

Or Titration is the process in which the standard reagent (titrant) is added to a solution of an analyte until the reaction between the analyte and titrant (reagent) is complete.

**Indicators:** are often added to analyte solution in order to give an observable physical change (usually colour) end point at or near the equivalence point. Like phenolphthalein & methylene red indicators

## Volumetric Analysis

### *SOME Definition:*

**Analyte:** is the substance in a sample that is being investigated.

### **Equivalence point :Theoretical point**

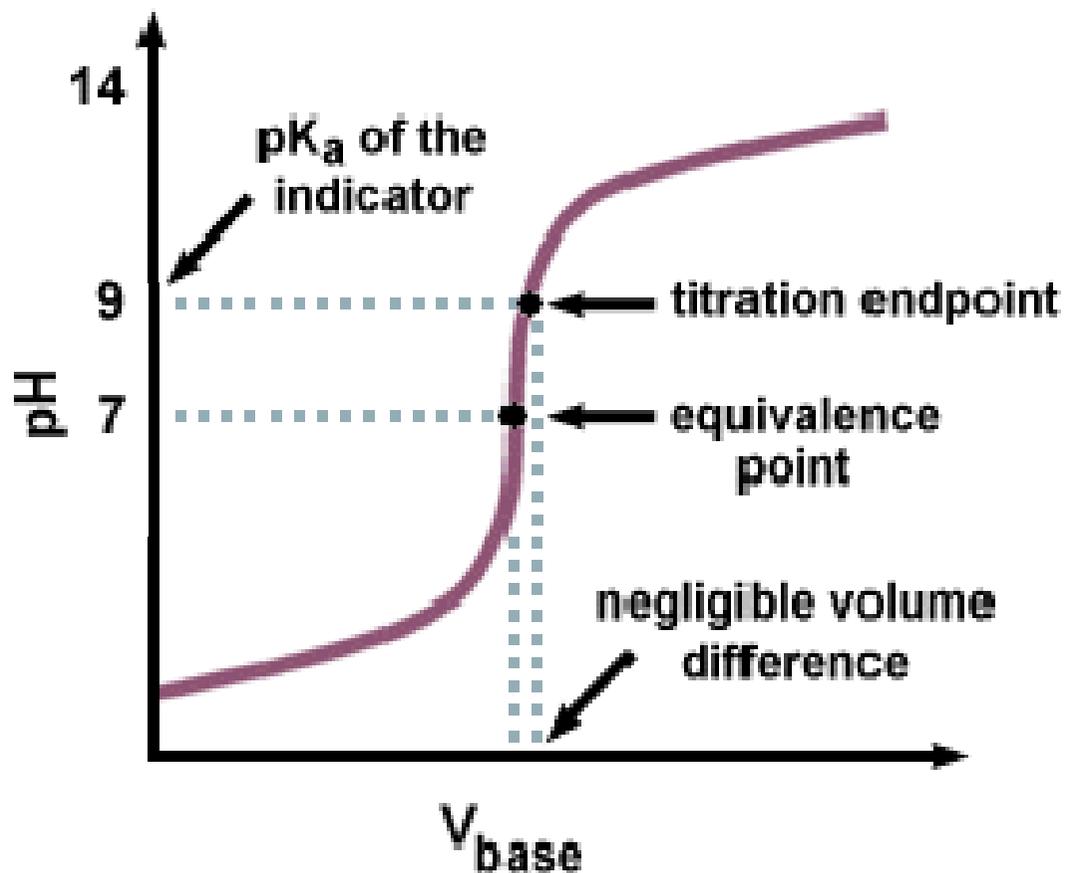
Called the Equivalence point when the number of moles of titrant equals the number of moles of analyte in the balanced chemical equation. In other words, exactly enough titrant has been added to react with all of the analyte. **indicates the completion of reaction It usually occurs a few milliseconds prior to the endpoint.**

### **End point : Experimental point**

An endpoint is a point in a titration that signifies the completion of the titration by a change in the colour or intensity of the solution. The endpoint occurs instantly after the equivalence point.

**the endpoint and equivalence point may occur concurrently.**

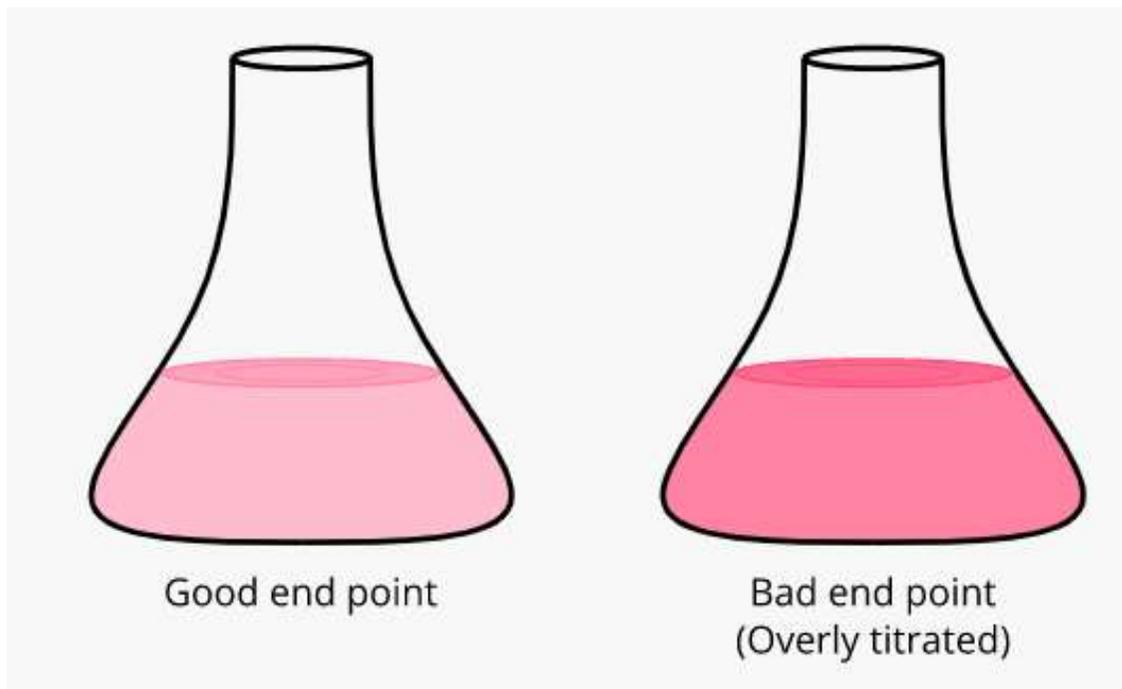
# Volumetric Analysis



## Volumetric Analysis

**Titration error:** The difference between the observed end point and the true equivalence point in a titration.

$$TE = V_{ep} - V_{eq}$$



## Primary Standards (titrant)

all chemicals with Accurately known concentrations are termed standard in chemistry. Primary standards are taken as reference chemicals for finding concentrations of analytes. Like calcium hydroxide  $\text{Na}_2\text{CO}_3$  , borax ( $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ ), and  $\text{NaCl}$ .

### The requirements of the primary standard

1. Low reactivity
2. High stability
3. High purity
4. Cheap in cost, Readily available
5. Non-Hygroscopic (stable under open atmosphere)
6. Non-toxic
7. High molecular weight

## Primary Standards (titrant)

**High molecular weight** is Very important thing in choosing the standard material for example,

**Which is better??** hydroxide  $\text{Na}_2\text{CO}_3$  **Or** borax ( $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ ) and why?

**Solution:**

The equivalent weight of  $\text{Na}_2\text{CO}_3 = 53 \text{ g/mol}$

And borax ( $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ ) = 191 g/mol

When preparing 0.1 N solution from both chemicals we need **1.325 g**  $\text{Na}_2\text{CO}_3$  and **4.775 g**  $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$ ..

If an error of 0.02 g is occurred in weighing. Thus, the percentage of error equal:

$$\frac{0.02}{1.325} \times 100 = 1.6\% \quad \text{and} \quad \frac{0.02}{4.775} \times 100 = 0.4\% \text{ respectively}$$

## Primary Standards (titrant)

**Ex.** Show by calculation how could you prepare 2 liters of 0.2 M NaOH solution from solid NaOH?? And Can we consider this chemical as a primary standard material?why?

**Solution:**

The equivalent weight of NaOH = 40 g/mol

$$\text{Wight of NaOH} = \text{eq.wt} \times M \times \frac{V}{1000}$$

$$\text{Wt} = 40 \times 0.2 \times \frac{2000}{1000} = 16 \text{ g}$$

This solution is not standard since NaOH is not primary material because

1. It absorbs water from atmosphere & dissolves in it
2. It reacts with CO<sub>2</sub> from atmosphere & forms thin layer of Na<sub>2</sub>CO<sub>3</sub> surrounding NaOH, thus NaOH is not pure.

## Titration Calculations

At the equivalence point in a neutralization, the moles of acid are equal to the moles of base.

**Moles of Acid = Moles of Base**

Recall that the molarity (M) of a solution is defined as the moles (m) of the solute divided by the liters of solution (L)

$$M = m/L$$

So the moles(m) of solute are therefore equal to the molarity of a solution multiplied by the volume in liters (L)

$$m = M \times L$$

$$\text{Moles of acid} = M \times V$$

$$\text{Moles of base} = M \times V$$

## Titration Calculations

We can then set the moles of acid equal to the moles of base.

**Moles of Acid = Moles of Base**

$$M_A \times V_A = M_B \times V_B$$

While  $M_A$  is the molarity of the acid, while  $M_B$  is the molarity of the base.  $V_A$  and  $V_B$  are the volumes of the acid and base, respectively

## Titration Calculations

**Ex1** Suppose that a titration is performed and 20.70mL of 0.5M NaOH is required to reach the end point when titrated against 15.00mL of HCl of unknown concentration. The above equation can be used to solve for the molarity of the acid.

### Solution

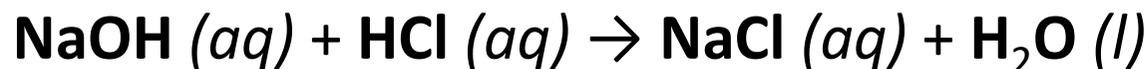
**Step 1:** List the known values and plan the problem

Volume of NaOH = **20.70 mL**

Molarity of NaOH = **0.5 M**

Volume of HCl = **15.00 mL**

**Step 2:** Write the balanced chemical equation



**Step 3:** Apply the dilution law to solve the question

$$M_A \times V_A = M_B \times V_B$$

$$M_A = \frac{M_B \times V_B}{V_A}$$

$$M_A = \frac{0.5 \text{ M} \times 20.70 \text{ mL}}{15 \text{ mL}} = 0.690 \text{ M}$$

## Titration Calculations

**Ex1** In a titration of sulfuric acid against sodium hydroxide, 32.20mL of 0.250M NaOH is required to neutralize 26.60mL of H<sub>2</sub>SO<sub>4</sub>. Calculate the molarity of the sulfuric acid.

### Solution

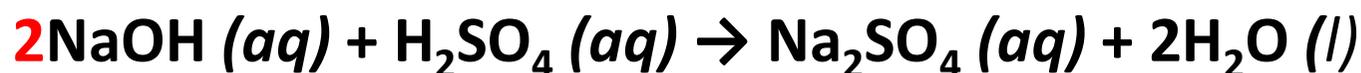
**Step 1:** List the known values and plan the problem

Volume of NaOH = **32.20mL**

Molarity of NaOH = **0.25 M**

Volume of HCl = **26.60 mL**

**Step 2:** Write the balanced chemical equation



**Step 3:** Apply the formula of **Moles of Acid = Moles of Base**

- **remember the m/L**

$$\begin{aligned} \text{m of base} &= \frac{32.20\text{mL}}{1000} \times 0.25 \text{ M} = 8.05 \times 10^{-3} \text{ mol NaOH} \\ \text{m of acid} &= \mathbf{1/2} \text{ m of base} \\ &= 4.025 \times 10^{-3} \text{ mol H}_2\text{SO}_4 \end{aligned}$$

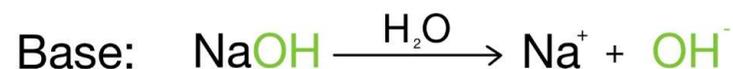
$$\text{Molarity} = \text{m}/V_L = 4.025 \times 10^{-3} / 0.0266 \text{ L} = 0.151 \text{ M H}_2\text{SO}_4$$

## Acid-Base Equilibrium

### Arrhenius

-An acid is a substance that, when dissolved in water, increases the concentration of hydrogen ions.

-A base is a substance that, when dissolved in water, increases the concentration of hydroxide ions.



## First Lecture

Volumetric Analysis

Primary Standards

Titration Calculations

Equilibrium

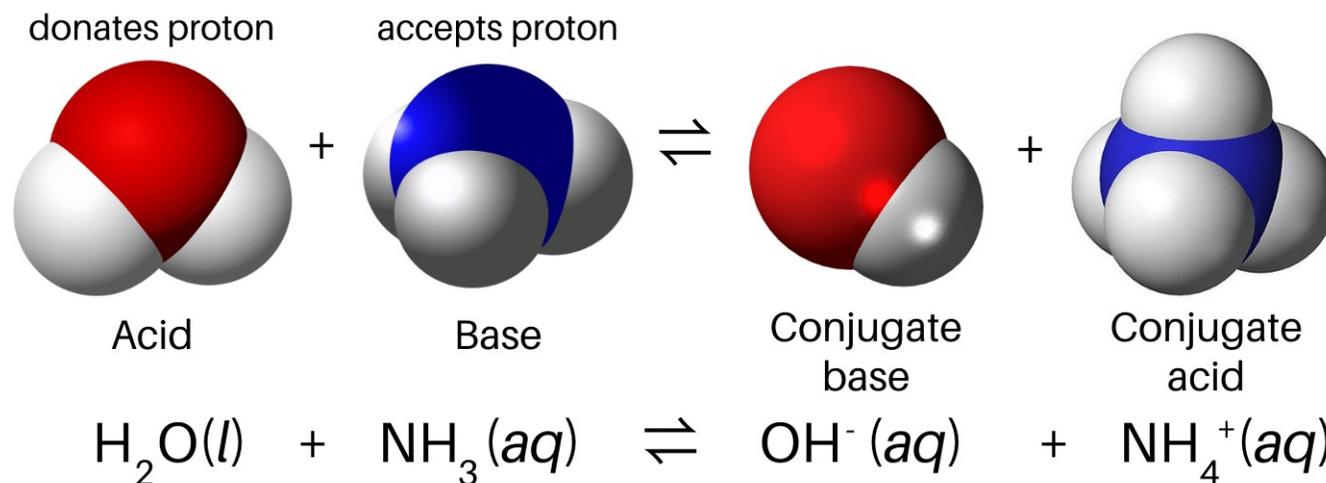
Acids-Bases

# Acid-Base Equilibrium

## Brønsted-Lowry

-An acid is a proton donor.

-A base is a proton acceptor.



## First Lecture

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Equilibrium

Acids-Bases

# Acid-Base Equilibrium

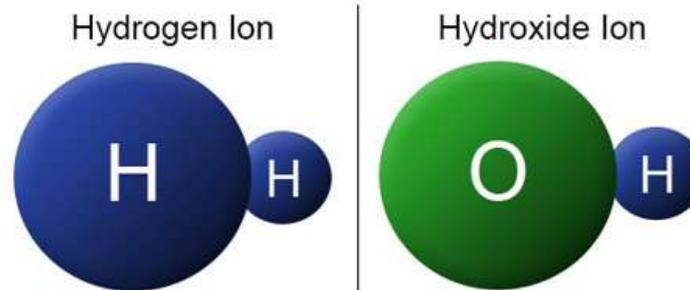
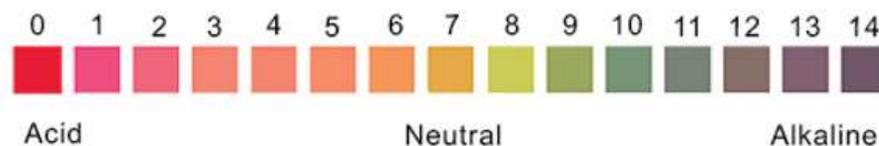
In any acid-base reaction, the equilibrium will favor the reaction that moves the proton from acid to the base.

This equilibrium constant is referred to as the ion-product constant for water,  $K_w$ . At 25°C,

$$K_w = 1.0 \times 10^{-14} \text{ Water is amphoteric.}$$

In pure water, some molecules act as bases and some as acids..

## The pH Scale



## First Lecture

Volumetric Analysis

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Equilibrium

Acids-Bases

# Acids-Bases

Acids and bases that are completely ionized when dissolved in water are called **strong acids** and **strong bases**

Strong Acids		Strong Bases	
Hydrobromic acid	HBr	Barium hydroxide	Ba(OH) <sub>2</sub>
Hydrochloric acid	HCl	Calcium hydroxide	Ca(OH) <sub>2</sub>
Hydroiodic acid	HI	Lithium hydroxide	LiOH
Nitric acid	HNO <sub>3</sub>	Potassium hydroxide	KOH
Perchloric acid	HClO <sub>4</sub>	Sodium hydroxide	NaOH
Sulfuric acid	H <sub>2</sub> SO <sub>4</sub>	Strontium hydroxide	Sr(OH) <sub>2</sub>

Weak acids		Weak bases	
Acetic acid	CH <sub>3</sub> COOH	Ammonia	NH <sub>3</sub>
Carbonic acid	H <sub>2</sub> CO <sub>3</sub>	Diethylamine	(CH <sub>3</sub> CH <sub>2</sub> ) <sub>2</sub> NH
Formic acid	CHOOH	Methylamine	CH <sub>3</sub> NH <sub>2</sub>
Hydrocyanic acid	HCN	Sodium bicarbonate	NaHCO <sub>3</sub>
Hydrofluoric acid	HF		
Phosphoric acid	H <sub>3</sub> PO <sub>4</sub>		