Practical Work N°1

Acid- Base Titration (Titration Colorimetric Strong Acid by Strong Base).

I- Titration of Strong Acid by Strong Base:

1- Introduction:

Titration is a laboratory technique used to determine the concentration of a substance in a solution. It involves the controlled addition of a solution of known concentration (titrant) to a solution of the substance being analyzed (analyte) until the reaction between the two is complete. The point at which the reaction is just complete is called the equivalence point, and it is often detected using an indicator or by monitoring a physical property, such as pH.

The key principle behind titration is that the amount of titrant needed to reach the equivalence point is stoichiometrically equivalent to the amount of analyte present. By measuring the volume of titrant required, one can calculate the concentration of the analyte.

Titration is commonly used in various fields, including chemistry, biology, and environmental science, for quantitative analysis of acids, bases, and other substances in solution. It is a versatile and precise method for determining the concentration of a substance in a sample.

2- Definition:

2-1- A strong acid is a substance that completely dissociates or ionizes in water, producing a high concentration of hydronium ions (H_3O^+). The dissociation is essentially 100%, meaning that every acid molecule donates its proton to water. As a result, strong acids have a very low pH. Examples of strong acids include hydrochloric acid (HCl), sulfuric acid (H_2SO_4), and nitric acid (HNO_3).

2-2- A strong base, on the other hand, is a substance that completely dissociates or ionizes in water, yielding a high concentration of hydroxide ions (OH^-). Similar to strong acids, the dissociation of strong bases is nearly 100%. Strong bases typically have a very high pH. Examples of strong bases include sodium hydroxide (NaOH), potassium hydroxide (KOH), and calcium hydroxide ($Ca(OH)_2$).

In summary, strong acids and strong bases are substances that undergo complete dissociation in water, leading to the formation of a high concentration of hydronium ions (H_3O^+) for acids or hydroxide ions (OH^-) for bases.

3- Principle of Titration:

Titration is based on the principle of reacting a solution of known concentration (the titrant) with a solution of unknown concentration (the analyte) to determine the concentration of the analyte. The reaction is usually a chemical reaction with a stoichiometric ratio between the titrant and analyte. The endpoint of the titration is reached when the reaction is complete, often indicated by a color change or other observable change.

4- Different Types of Titrations:

These are just a few examples of the various types of titration methods, each tailored to specific types of reactions and analytes. The choice of titration method depends on the nature of the substances being analyzed and the information sought from the analysis.

a- Redox Titration:

Principle: Involves a redox (reduction-oxidation) reaction between the titrant and analyte. The endpoint is determined by a change in oxidation states.
Examples: Titration of a reducing agent with a known oxidizing agent or vice versa.

b- Precipitation Titration:

Principle: Formation of a precipitate by the reaction between the titrant and analyte. The endpoint is reached when the precipitate just starts to form or disappears.
Examples: Titration of chloride ions with silver nitrate to form silver chloride precipitate.

c- Complexometric Titration:

Principle: Formation of a complex between the titrant and analyte. The endpoint is determined by the formation or disappearance of a colored complex.
Examples: Titration of metal ions with EDTA (ethylenediaminetetraacetic acid) as the titrant.

d- Alkalimetry and Acidimetry:

Principle: Specific types of acid-base titrations where the titrant is either a strong acid (acidimetry) or a strong base (alkalimetry).
Examples: Determination of the acidity of a solution using a strong base or the alkalinity using a strong acid.

e- Iodometric and Iodimetric Titration:

Principle: Involves the redox reaction between iodine and other substances. Iodometric titration uses iodine as the titrant, while iodimetric titration uses iodide ions.
Examples: Titration of reducing agents with iodine or titration of iodine with thiosulfate.

f- Titration with Potentiometric Detection:

Principle: Involves measuring the potential difference between a reference electrode and an indicator electrode (usually a pH electrode) during the titration.
Examples: Potentiometric titration of strong acids or bases.

g- Colorimetric titration

Colorimetric titration is a technique that combines the principles of titration and colorimetry. In colorimetric titrations, the endpoint of the titration is determined by a visible color change rather than a pH change or other physical property. This method is particularly useful when the reaction between the titrant and analyte produces a noticeable change in color.

5- Acid-Base Titration:

Acid-base titration is a fundamental analytical technique employed to determine the concentration of an acid or a base in a solution. **The principle** underlying acid-base titration is the neutralization reaction between an acid and a base, where the number of moles of the acidic species is equated to the number of moles of the basic species ($\mathbf{C_AV_A=C_BV_B}$). In a typical acid-base titration, a solution of known concentration (the titrant) is incrementally added to a solution of the substance with an unknown concentration (the analyte). The endpoint of the titration is reached when the stoichiometric equivalence point is achieved, marked by a significant change in pH. Commonly used indicators or pH meters are employed to detect this endpoint. The data collected during the titration, including the volume of titrant added and the corresponding pH values, allow for precise calculations to determine the concentration of the analyte. Acid-base titrations are widely used in various fields, including chemistry, biology, and environmental science, providing essential quantitative information about acidic or basic substances in solution.

6- Colour indicator:

In colorimetric titrations, colored indicators are substances that change color as the titration progresses, allowing for the visual detection of the endpoint. These indicators are chosen based on their ability to form a colored complex with one of the reacting species at or near the equivalence point. The color change is used to signal that the stoichiometric amount of titrant has reacted with the analyte.

Here are a few examples of colored indicators commonly used in colorimetric titrations:

Phenolphthalein:

Color Change: Phenolphthalein is colorless in acidic solutions but turns **pink** or red in basic solutions. It is often used in acid-base titrations, where the endpoint is close to neutralization.

Application: Commonly used in titrations involving strong acids and strong bases.

Methyl Orange:

Color Change: Methyl **orange** is **red** in acidic solutions and changes to **yellow** in basic solutions.

Application: Suitable for titrations involving weak acids and strong bases.

Bromothymol Blue:

Color Change: Bromothymol **blue** is **yellow** in acidic solutions, **green** in neutral solutions, and **blue** in basic solutions.

Application: Useful in titrations where the pH range extends beyond the neutral point.

Crystal Violet:

Color Change: Crystal **violet** changes from **violet to** colorless in acidic solutions.

Application: Applied in titrations involving weak acids and strong bases.

Starch-Iodine Complex:

Color Change: Starch forms a **blue** complex with iodine.

Application: Commonly used in iodometric titrations, such as the titration of vitamin C with iodine.

Eriochrome Black T (EBT):

Color Change: Eriochrome **Black** T changes from **wine-red** to **blue** in the presence of metal ions, particularly calcium and magnesium.

Application: Used in complexometric titrations.

It's important to note that the choice of indicator depends on the specific titration being conducted, the pH range of the reaction, and the nature of the analyte and titrant. The indicator should have a color transition that aligns with the expected equivalence point of the titration to ensure accurate endpoint detection. Additionally, some indicators are more suitable for certain types of titrations (e.g., acid-base, redox, complexometric), so their selection is based on the specific requirements of the analysis.

II- Objectif:

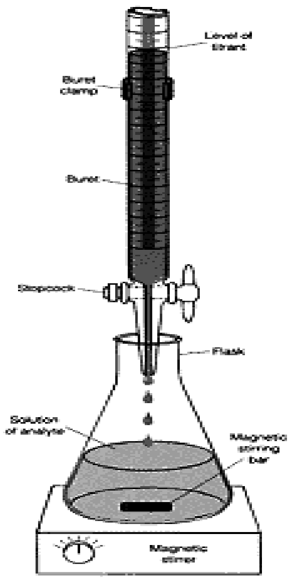
- Understand the principles involved in titration, such as equivalence point, titration, analysis, and stoichiometry of the reaction.
- Determining the normality and pH of hydrochloric acid (HCl)

III- Experimental Part:

1- Colorimetric Titration of Hydrochloric Acid with Sodium Hydroxide.

Materials: Burette, Erlenmeyer flask, beaker, graduated cylinder, wash bottles, NaOH solution (**0.3 N**),HCl solution and coloured indicators.

Titration with **Bromothymol blue**:

1- Rinse the equipment. Burette, Erlenmeyer flask, etc.	
2- Acquire a 50 mL or 25 mL burette, and fill it to the 0-line with **0.3 N** NaOH.	
3- Take (V_A=**4 ml**) the solution to be dosed (HCl) and pour it into an Erlenmeyer flask.	
4- Add 2 to 3 drops of colored indicator (**Bromothymol blue**).	
5- Pour the soda (NaOH) slowly into the Erlenmeyer flask (drop by drop and stirring) until the color changes.	
6- Record the volume V_B of (NaOH) added.	
7- Repeat the process three times	

IV- <u>Results</u>:

1 - Complete (Fill) the table below:

NaOH solution *(mL)*	***Essay 1(mL)***	***Essay 2(mL)***	***Essay 3(mL)***
Initial Reading of the Burette			
Final Reading of the Burette			
Volume of NaOH solution used			
Concordant Reading $(V_1+V_2+V_3)/3$			