Experiment-3 : **Acid/base titration using colorimetric reagents**

Introduction

Titration, also known as **titrimetry** or **volumetric** analysis, is a method used to determine the concentration of a solution by reacting it with a solution of known concentration.

Types of titration

There are several types of titration methods, each type of titration uses a specific indicator or method to signal the equivalence point, depending on the nature of the reaction.

- **Acid-Base titration** : Determines the concentration of an acid or base by neutralization.
- **Redox Titration** : Involves oxidation-reduction reactions to determine the concentration of a substance.
- **Complexometric titration** : Uses complexation reactions, commonly with metal ions and chelating agents, to measure concentrations.
- **Precipitation titration** : Involves a reaction that forms an insoluble precipitate to find the

Acid/base titration using colorimetric reagents

Acid-base titration using colorimetric reagents employs indicators that change color at specific pH levels, providing a visual signal for the equivalence point.

Color indicators

Color indicators are substances that exhibit a distinct change in color at specific pH levels, allowing them to be used as visual cues to determine the acidity or alkalinity of a solution. Typically composed of weak acids or bases, these indicators undergo reversible chemical reactions in response to changes in pH.

$$HInd_{(aq)} + H_2O \rightleftharpoons Ind^-_{(aq)} + H_3O^+_{(aq)}$$

Where :

HInd represents the acidic form of the color indicator, while Ind^- represents its basic form.

Table 1. Some indicators and their color change range

Indicator	Color change range	Color in acidic state	Color in basic state
Thymol Blue	1.2 - 2.8	Red	Yellow
Methyl Orange	3.1 - 4.4	Orange	Yellow
Phenol Red	6.6 - 8.0	Yellow	Red
Bromothymol Blue	6.0 - 7.6	Yellow	Blue
Phenolphthalein	8.3 - 10	Colorless	Pink

Principle

The principle of acid-base titration in aqueous solutions is based on the neutralization reaction between an acid and a base. During the titration process, an acid (HA) donates protons (H^+) while a base (BOH) provides hydroxide ions (OH^-). The resulting reaction produces water (H_2O) and a salt (AB).

$$HA + BOH \rightarrow AB + H_2O$$

The equivalence point occurs when the color changes at the end of the titration, indicating that the moles of acid are equals to the moles of base.

$$n_{Acide} = n_{Base} \Leftrightarrow C_{acide} . V_{acide} = C_{base} . V_{base}$$

$$C_{acide} = \frac{(C_{base} . V_{base})}{V_{acide}}$$

Objective of the experiment

1. To understand the tools and equipment used in titration and how to operate them.
2. To learn how to determine the concentration of the strong acid (HCl) using a strong base (NaOH).
3. To learn how to determine the concentration of the weak acid (CH_3COOH) using a strong base (NaOH).

Materials

- Burette with Burette stand and clamp.
- Graduated cylinder
- Erlenmeyer flask
- Funnel

Chemicals

- HCl solution of unknown concentration
- CH_3COOH with unknown concentration
- NaOH solution with a concentration of 0.1 mol/L
- Color reagents (bromothymol blue and phenolphthalein).

Procedure

Experiment 1

Titration of strong acid **HCl** of unknown concentration with a strong base **NaOH** of 0.1 mol/L.

- Begin by filling the burette with a 0.1 mol/L NaOH solution and calibrate it to zero.
- Measure 10 mL of the HCl solution of unknown concentration using a graduated cylinder.

- Transfer it to a 250 mL Erlenmeyer flask.
- Add a few drops of **bromothymol blue** indicator to the flask.
- Position the Erlenmeyer flask under the burette and begin the titration.
- When a color change is observed, close the burette valve and record the volume of NaOH used.

Experiment 2

Titration of a weak acid, acetic acid (CH_3COOH), with a strong base, sodium hydroxide (NaOH) at a concentration of 0.1 mol/L.

- Fill the burette with a 0.1 mol/L NaOH solution and calibrate it to zero.
- Use a graduated cylinder to measure 10 mL of the CH_3COOH solution of unknown concentration and transfer it to a 250 mL Erlenmeyer flask.
- Add a few drops of **phenolphthalein** indicator to the solution.
- Position the Erlenmeyer flask under the burette and begin the titration process.
- Once a color change occurs, close the burette valve and record the volume of NaOH used.