Practical Work N° 5. Determination of chloride (Cl^-) by the Mohr method

1. Introduction

Chloride ions are among the most important negative ions found in natural waters. When they combine with sodium ions to form sodium chloride (table salt), they give the water a salty taste. Chloride salts are highly soluble in water, and elevated concentrations can be toxic. The recommended limit for chloride concentration in water intended for human consumption is 250 mg/L.

2. Mohr method

The Mohr method (German pharmacist Karl Friedrich Mohr), is a classical titration technique used to determine the concentration of chloride ions (Cl^-) in a solution. It is a type of precipitation titration in which silver nitrate ($AgNO_3$) serves as the titrant and potassium chromate (K_2CrO_4) is used as the indicator.

3. Principle

3.1. Precipitation reaction: Chloride ions react with silver nitrate to form insoluble silver chloride (**AgCl**), which is white in color. Silver chloride precipitates first because its solubility product (**Ks**) is lower than that of silver chromate, as described by the following equation:

$$AgNO_3 + NaCl \rightarrow AgCl + NaNO_3 \quad \text{(white)} \quad (1)$$

3.2. End point detection: Once all the chloride ions are precipitated, any excess silver ions react with the potassium chromate indicator to form the red precipitate of silver chromate **(Ag_2CrO_4)**, indicating the end point of the titration.

$$2AgNO_3 + K_2CrO_4 \rightarrow Ag_2CrO_4 + 2KNO_3 \quad \text{(red precipitate)} \quad (2)$$

At the equivalence point :

$$n_{AgNO_3} = n_{NaCl} \rightarrow C_{AgNO_3} . V_{AgNO_3} = C_{NaCl} . V_{NaCl}$$

$$C_{NaCl} = \frac{C_{AgNO_3} . V_{AgNO_3}}{V_{NaCl}}$$

4. Objective

The primary objective of the Mohr experiment is to determine the **concentration of chloride ions (Cl^-)** in a given sample using **precipitation titration**. The method can also be applicable to the determination of other halide ions, such bromide (Br^-) and cyanide (CN^-).

6. Materials and chemicals

Materials	Chemicals
- Burette with stand and clamp - Graduated cylinder - Erlenmeyer flask - Funnel	- 0.01 M Silver Nitrate ($AgNO_3$) solution - 10% Potassium Chromate (K_2CrO_4) solution - Tap, Rain or Distilled water.

7. Procedure

1. Rinse all materials with distilled water before use.
2. Fill the burette with a 0.01 mol/L $AgNO_3$ solution and adjust the level to zero.
3. Using a graduated cylinder, measure 50 mL of water and transfer it to an Erlenmeyer flask.
4. Add 5 drops of K_2CrO_4 indicator to the flask and mix thoroughly.
5. Place the Erlenmeyer flask under the burette and begin the titration, adding the silver nitrate solution drop by drop while stirring continuously.
6. When a persistent red precipitate appears and does not disappear upon stirring, close the burette and record the volume of silver nitrate ($AgNO_3$) used (Veq).
7. Repeat the titration twice more and take the average value.

8. Answer the questions

1. Write the reaction equations.
2. Calculate the molar concentration of chloride in the water.
3. Calculate the mass concentration of chloride in water (mg/L).
4. Is this water suitable for human consumption? Justify your answer.