Essential Theory

Objective

Determine the unknown concentration of a strong acid (**HCl**) using titration against a strong base (**NaOH**) of known concentration.

Reaction

$$\mathrm{H_3O^+}(aq) + \mathrm{OH^-}(aq) \rightarrow 2\mathrm{H_2O}(l)$$

Key Points

- **Equivalence Point**: Moles of $\mathrm{H_3O^+}$ = Moles of $\mathrm{OH^-}$.
- **Endpoint**: Indicated by a color change of phenolphthalein from colorless to pink.

pH Monitoring

$$\mathrm{pH} = -\log[\mathrm{H_3O^+}]$$
$$\mathrm{pOH} = -\log[\mathrm{OH^-}]$$

At 25°C:

$$K_w = [\mathrm{H_3O^+}][\mathrm{OH^-}] = 10^{-14}, \quad \mathrm{pH} + \mathrm{pOH} = 14$$

Titration Curve Phases:

1. **Before Equivalence**: Acid dominates, pH increases gradually.
2. **At Equivalence**: Neutral solution, pH = 7.
3. **After Equivalence**: Base dominates, pH increases steeply.

Indicator

Phenolphthalein changes color at pH ∼9. The indicator's endpoint closely approximates the equivalence point for strong acid/base titrations.

Procedure

Preparation

1. Rinse burette with DI water, then with NaOH.
2. Prepare 50 mL of HCl analyte in a clean Erlenmeyer flask. Add 2-3 drops of phenolphthalein.

Pilot Titration

1. Add NaOH in large increments (∼2 mL) until a permanent pink color appears.
2. Record the approximate endpoint volume.

Full Titration

1. Add 80% of the pilot volume quickly.
2. Near the endpoint, add NaOH in 0.2 mL increments until the solution turns permanently pink.

Titration with pH Monitoring

1. Use a pH meter to record pH at intervals of added NaOH.
2. Collect data points before and after the endpoint to construct a titration curve.

Post-Experiment

- Discard waste solutions, clean all glassware, and ensure proper storage of the pH probe.

Materials

- **Glassware**: 50 mL graduated cylinder, 50 mL burette, 250 mL Erlenmeyer flasks.
- **Reagents**: 0.100 M NaOH, HCl (unknown concentration), phenolphthalein indicator.
- **Equipment**: pH meter, funnel, white paper for better visualization.

Safety Information

Hazards

- **Sodium Hydroxide (NaOH)**: Corrosive, causes severe skin and eye irritation.
- **Hydrochloric Acid (HCl)**: Corrosive, can cause burns and respiratory irritation.
- **Phenolphthalein**: Toxic if ingested, a strong laxative.

Precautions

- Always wear gloves, goggles, and a lab coat.
- Immediately rinse skin with cold water if contact occurs.
- Wash hands thoroughly after handling reagents.

SDS Highlights

- **NaOH**:
  - **Health Hazard**: Severe burns on skin/eyes.
  - **Handling**: Use in a well-ventilated area.
- **HCl**:
  - **Health Hazard**: Irritates respiratory tract and skin.
  - **Handling**: Avoid inhaling vapors.
- **Phenolphthalein**:
  - **Toxicity**: Ingestion can cause severe gastrointestinal distress.