Chemistry Lab Report Example

Determining the Molarity of an Unknown Hydrochloric Acid Solution Using Standardized Sodium Hydroxide

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1. Title Page

Experiment Title: Determining the Molarity of an Unknown Hydrochloric Acid (HCl) Solution Through Acid–Base Titration
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Course: CHEM 101 – General Chemistry I
Instructor: Dr. Smith
Date of Experiment: October 15, 2024
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2. Abstract (106 words)

The purpose of this experiment was to determine the concentration of an unknown hydrochloric acid solution using titration with standardized 0.100 M sodium hydroxide. A phenolphthalein indicator was used to detect the equivalence point. Three trials were conducted, and the average volume of NaOH required to neutralize 25.0 mL of HCl was 22.45 mL. Using the balanced equation and titration calculations, the molarity of the unknown HCl was found to be 0.0898 M. The results indicate that the acid solution was moderately dilute and consistent across trials. Minor variations likely resulted from endpoint detection errors and slight inconsistencies in dropwise addition.

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3. Introduction

Acid–base titrations are fundamental analytical techniques used to determine the concentration of a solution by reacting it with a solution of known molarity. In this experiment, hydrochloric acid (HCl), a strong acid, is neutralized by sodium hydroxide (NaOH), a strong base. Because both ionize completely in water, the reaction follows a simple 1:1 stoichiometric ratio, making titration an efficient way to determine unknown acid concentration.

Previous studies and standard analytical chemistry procedures demonstrate that accurate titration results depend heavily on precise endpoint detection and correct preparation of the standard solution. Phenolphthalein is widely used as an indicator for strong acid–strong base titrations because its color transition (colorless → pink) occurs in the appropriate pH range near the equivalence point.

The primary question addressed in this experiment is: *What is the molarity of an unknown HCl solution when titrated with standardized NaOH?* Determining unknown concentrations is important in real-world applications such as pharmaceutical formulation, water quality testing, and industrial acid/base monitoring.

Based on the balanced reaction and typical volumes used in freshman chemistry labs, it was hypothesized that the HCl solution would have a molarity between 0.08 and 0.12 M. It was predicted that NaOH volumes would be consistent across trials, and that the resulting molarity values would fall within ±5% of each other.

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4. Materials and Methods

Materials

- Unknown HCl solution
- 0.100 M NaOH solution (standardized)
- Phenolphthalein indicator (3 drops per trial)
- 50 mL burette
- 25 mL pipette and pipette filler
- 250 mL Erlenmeyer flask
- Distilled water
- White paper background (to help see the color change)

Procedure

1. The burette was rinsed with distilled water and then conditioned with 5 mL of the 0.100 M NaOH solution.
2. The burette was filled with standardized NaOH and initial volume recorded.
3. Using a 25 mL pipette, 25.0 mL of the unknown HCl solution was transferred into a clean Erlenmeyer flask.
4. Three drops of phenolphthalein indicator were added to the flask.
5. NaOH was added from the burette into the flask while swirling continuously.
6. Near the endpoint, NaOH was added dropwise until a faint pink color persisted for 30 seconds.
7. Final burette volume was recorded and NaOH volume used was calculated.
8. Steps 3–7 were repeated for three trials. All trials used fresh acid and indicator.

This procedure allowed for consistent and accurate measurement of titrant volume needed to reach the neutralization point.

5. Results

Table 1: Titration Data for Determining HCl Molarity

Trial	Volume of NaOH (mL)	NaOH Molarity (M)	Moles of NaOH	Moles of HCl	HCl Molarity (M)
1	22.60	0.100	0.002260	0.002260	0.0904
2	22.30	0.100	0.002230	0.002230	0.0892
3	22.45	0.100	0.002245	0.002245	0.0898

Average HCl Molarity: 0.0898 M

Observations

- The pink endpoint appeared faint and lasted 30 seconds in each trial.
- Color transitioned quickly as the equivalence point approached.
- No visible impurities or precipitation occurred.

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6. Discussion

The main finding of this experiment was that the molarity of the unknown HCl solution was determined to be **0.0898 M**. This value was consistent across the three trials, with a variation of less than 1.4%, indicating good precision.

The results align with theoretical expectations for titrations involving strong acids and bases. Because HCl and NaOH fully dissociate in aqueous solution, the stoichiometric 1:1 molar ratio simplifies calculations. The close agreement among trials suggests that the titrant delivery and endpoint detection were performed carefully.

Compared to typical student titration results found in academic literature, these outcomes fall within acceptable ranges of precision and accuracy. Small differences between trials may be explained by slight overshooting of the endpoint due to human perception of the color change. Another limitation is that phenolphthalein does not change color instantaneously, potentially introducing an uncertainty of 1–2 drops of NaOH.

Further improvements could include using a pH meter instead of an indicator for more precise endpoint detection or repeating additional trials to reduce statistical error. Future work may involve titrating weak acids, which require different indicators and demonstrate buffer behavior and non-linear pH curves.

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7. References

American Chemical Society. *Quantitative Chemical Analysis of Acid–Base Titrations*. ACS Publications, 2019.

Brown, T., LeMay, H., Bursten, B. *Chemistry: The Central Science*. 14th ed., Pearson, 2018.

Zumdahl, S. and Zumdahl, S. *Introductory Chemistry*, 6th ed., Cengage Learning, 2020.