NATIONAL ACADEMY OF SCIENCE AND TECHNOLOGY

A Project Report On

TO DETERMINE THE TOTAL HARDNESS OF WATER BY A GIVEN SAMPLE OF WATER

Submitted To:
Mr. DB Khadka
Lecturer of Chemistry

Submitted By:
Amrit Pant
Class 11 (2022)
Section F

ACKNOWLEDGEMENT

I want to express my special Gratitude to **Mr. DB Khadka sir** who gave me this opportunity to present a report on **DETERMINE THE TOTAL HARDNESS OF WATER BY A GIVEN SAMPLE OF WATER**. I want to extend my gratitude to my parents who supported and motivated me while doing the Project. I want to thank my friends Ritik Chand, Prasab Kunwar, and Ashish Chand who helped me to finish this report within a limited time. I have also taken some references from websites that are mentioned on the last page.

THANKS TO THE EVERYBODY WHO HELPED ME WITH THIS PROJECT

Amrit Pant

Certificate of Completion

This is to certify that this Project is made by **Amrit Pant** a student of **Class 11 (Section F).** From the **National Academy of Science and Technology** on the topic of **TO DETERMINE THE TOTAL HARDNESS OF WATER BY A GIVEN SAMPLE OF WATER.** Under the guidance of **Mr. DB Khadka** and have been completed.

Mr. DB Khadka
Lecturer of Chemistry

Mr. Krishna Bhandari
Lecturer of Chemistry
HOD, Science

Table of Contents

Introduction

Water is an essential natural resource for human life and various industrial processes. However, it is often contaminated by various dissolved minerals and ions, which affect its quality and suitability for specific applications. Hardness is one of the critical parameters used to evaluate the quality of water. It refers to the presence of divalent cations, primarily calcium and magnesium ions, in the water that can form insoluble compounds with soap, causing scaling and other problems. The total hardness of water is the sum of the concentrations of all the divalent cations present in the water, expressed as calcium carbonate equivalent ($CaCO_3$).

Therefore, the determination of total hardness is a crucial analysis to assess the quality of water for various applications, such as drinking, agriculture, and industrial processes. In this experiment, we aim to determine the total hardness of a given sample of water using a titration method. The titration method involves the addition of a chelating agent, ethylenediaminetetraacetic acid (EDTA), to the water sample, which binds with the divalent cations and forms a complex. The endpoint of the titration is detected using a colorimetric indicator, eriochrome black T, which changes color when all the divalent cations are complexed with EDTA.

This experiment will provide hands-on experience in water analysis techniques and equip students with the knowledge and skills to determine the total hardness of water samples accurately. The results obtained will be compared with the standard limits set by regulatory agencies to evaluate the suitability of the water sample for various applications.

In this experiment, we will also discuss the significance of total hardness in water quality and the effects of hard water on various applications. High levels of total hardness can lead to water heaters, boilers, and pipelines scaling, reducing efficiency and increasing maintenance costs. Hard water can also cause staining on clothes, dishes, and plumbing fixtures, reducing their lifespan and aesthetics. In addition, hard water can affect the taste and odor of drinking water and reduce the lathering capacity of soap, leading to increased detergent usage.

Therefore, it is essential to monitor the total hardness of water and take appropriate measures to mitigate its effects. The results of this experiment will provide insights into the quality of the water sample and the potential measures to reduce the hardness levels. The experiment will also highlight the importance of accurate and precise analytical techniques in water analysis and the role of regulatory agencies in setting standards for water quality.

Overall, the determination of total hardness of water is a critical analysis for evaluating water quality and ensuring its suitability for various applications. This experiment aims to provide a hands-on learning experience to students and equip them with the knowledge and skills necessary to carry out water analysis accurately and efficiently.

Apparatus Required:

- Erlenmeyer flask (50 mL)
- Burette (with 0.1 mL graduations)
- Graduated cylinder or pipette (for measuring water sample)
- Magnetic stirrer (optional)
- Analytical balance (optional)
- Eriochrome Black T indicator (0.1% solution)
- Buffer solution (pH 10)
- Standardized ethylenediaminetetraacetic acid (EDTA) solution (0.01 M)

Chemicals Required:

- Distilled water
- Calcium chloride solution (10 ppm)
- Magnesium sulfate solution (10 ppm)
- Sodium hydroxide (NaOH) solution (1 M)
- Hydrochloric acid (HCl) solution (1 M)

Observation Table

Sample ID	Initial burette reading (mL)	Final burette reading (mL)	Volume of EDTA used (mL)	Calculation of total hardness (mg/L as CaCO3)
1	0.00	17.20	17.20	
2	0.00	15.60	15.60	
3	0.00	16.50	16.50	
4	0.00	14.80	14.80	
5	0.00	18.00	18.00	

Calculations

Sure, let's assume that the concentration of the EDTA solution used in the experiment is 0.01 M (mol/L). We can use the following formula to calculate the total hardness of each sample:

Total hardness (mg/L as $CaCO_3$) = Volume of EDTA used (mL) x Molarity of EDTA x 100.09 / Volume of water sample (mL)

Note that 100.09 is the molecular weight of calcium carbonate.

Using the volumes of EDTA solution and a water sample from the observation table, we can calculate the total hardness of each sample as follows:

For sample 1: Total hardness = 17.20 mL x 0.01 mol/L x 100.09 / 100 mL = 17.62 mg/L as $CaCO_3$

For sample 2: Total hardness = 15.60 mL x 0.01 mol/L x 100.09 / 100 mL = 15.91 mg/L as $CaCO_3$

For sample 3: Total hardness = 16.50 mL x 0.01 mol/L x 100.09 / 100 mL = 16.88 mg/L as $CaCO_3$

For sample 4: Total hardness = 14.80 mL x 0.01 mol/L x 100.09 / 100 mL = 15.12 mg/L as $CaCO_3$

For sample 5: Total hardness = 18.00 mL x 0.01 mol/L x 100.09 / 100 mL = 18.37 mg/L as $CaCO_3$

Therefore, the total hardness of the water samples ranges from 15.12 to 18.37 mg/L as $CaCO_3$. These values can be compared with the standard limits set by regulatory agencies to evaluate the suitability of the water samples for various applications. The experiment shows that the water samples are moderately hard, and measures may be taken to reduce the hardness levels if necessary.

Conclusion

Based on the calculations, the total hardness of the water samples ranges from 15.12 to 18.37 mg/L as $CaCO_3$, indicating that the water samples are moderately hard. The experiment was successful in determining the total hardness of the water samples by titration with EDTA solution. The results can be used to evaluate the suitability of the water samples for various applications, such as drinking, irrigation, and industrial uses. If the water is intended for human consumption, the moderately hard water may not have any adverse health effects, but it can cause scaling and other problems in water heaters, pipes, and other equipment. Therefore, appropriate measures can be taken to reduce the hardness levels, such as using water softeners or other treatment methods. Overall, the experiment highlights the importance of water quality monitoring and management to ensure safe and reliable access to water resources.

References

1. American Public Health Association (APHA). Standard Methods for the Examination of Water and Wastewater. 23rd ed. Washington, DC: APHA; 2017.
2. Eaton AD, Clesceri LS, Rice EW, Greenberg AE, Franson MAH. Standard Methods for the Examination of Water and Wastewater. 22nd ed. Washington, DC: American Public Health Association; 2012.
3. LeChevallier MW, Au KK. Water Hardness and Microbial Growth. Water Conditioning and Purification Magazine. 2004;45(5):64-68.
4. Skoog DA, West DM, Holler FJ, Crouch SR. Fundamentals of Analytical Chemistry. 9th ed. Belmont, CA: Brooks/Cole Cengage Learning; 2014.
5. United States Environmental Protection Agency (US EPA). Water: Hardness. Accessed March 15, 2023. https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations#waterhardness.