

# Gravimetric analysis of calcium and hard water

## adapted from Flinn Scientific lab

### Experiment overview

The purpose of this lab is to investigate the suitability of gravimetric analysis for determining the amount of water hardness in the form of calcium carbonate,  $\text{CaCO}_3$ , in various water samples. Six samples, representing a wide range of potential water hardness, from 50 ppm to 500 ppm, will be analyzed by various student groups as part of a cooperative class investigation to determine the accuracy and sensitivity of gravimetric analysis for water hardness testing. NOTE that all water samples have been concentrated by a factor of 200 for the purpose of quantitative analysis.

Sodium carbonate,  $\text{Na}_2\text{CO}_3$ , solution will be mixed with the water solutions. Any calcium ions present in the water will react with the carbonate ions to produce calcium carbonate. Careful isolation, drying and weighing of the precipitate will allow chemists to calculate the amount calcium in each sample

### Safety precautions

Sodium carbonate is irritating to body tissues. Calcium chloride is moderately toxic by ingestion. Avoid all contact of the chemicals with eyes and skin. Do not taste or ingest any materials in this chemistry lab. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Please follow all laboratory safety guidelines.

### Pre-lab

With your lab team:

1. Write the balanced chemical equation for the reaction between sodium carbonate and calcium chloride.

There are 6 different water samples with varying concentrations of calcium. Your group will be assigned one number to test. In addition, you will choose one of the other samples to test. This means you will be testing TWO different samples.

2. Design a procedure for:

- forming calcium carbonate,
- isolating calcium carbonate,
- drying calcium carbonate,
- weighing calcium carbonate
- calculating the hardness of your water sample

3. Write out the SPECIFIC steps in your procedure. Use a 20mL sample of the calcium chloride.

Include a chart to record and organize your data and calculations

TIPS: Precipitate particles in gravimetric analysis must be large enough to be collected by filtration – smaller particles may pass through or clog the filter. Consider the following techniques for your procedure in order to help prevent product loss and ensure product purity.

- Add the precipitant slowly with vigorous mixing.
- “Digest” the precipitate by allowing it to stand in contact with the solution and/or heating the mixture for 10-15 minutes.
- Rinse the precipitate with a small amount of water after filtration.

### Experiment

Use your procedure to test two water samples and calculate the hardness value for each of them.

We will be creating a class data set. Include the number of the water sample with each of your calculated hardness values.

## Class data analysis

1. What is the average and standard deviation for each water sample?
2. Based on our data, evaluate the suitability of gravimetric analysis for determining the amount of water hardness.

### Experimental Mass of CaCO<sub>3</sub> (g)

|         | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 | Sample 6 |
|---------|----------|----------|----------|----------|----------|----------|
| Trial 1 |          |          |          |          |          |          |
| Trial 2 |          |          |          |          |          |          |
| Trial 3 |          |          |          |          |          |          |
| Trial 4 |          |          |          |          |          |          |
| Trial 5 |          |          |          |          |          |          |
| Average |          |          |          |          |          |          |
| SD      |          |          |          |          |          |          |

### Experimental vs. Expected results

| Sample | Moles of Ca <sup>2+</sup> in 20.0 mL of solution (mol) | Theoretical mass of CaCO <sub>3</sub> precipitate (g) | Experimental mass of CaCO <sub>3</sub> precipitate (g) | Percent yield | Theoretical water hardness (mg/L) | Experimental water hardness (mg/mL) |
|--------|--|---|--|---------------|-----------------------------------|-------------------------------------|
| 1      | 0.00800  |   |  |               |                                   |                                     |
| 2      | 0.00400  |   |  |               |                                   |                                     |
| 3      | 0.0100   |   |  |               |                                   |                                     |
| 4      | 0.00200  |   |  |               |                                   |                                     |
| 5      | 0.00100  |   |  |               |                                   |                                     |
| 6      | 0.00600  |   |  |               |                                   |                                     |

Calculation of water hardness: