CHEM109L
Introduction to Chemistry
Revision 1.0

Lab Exercise: moles Ca^{2+} in Hard Water

In this laboratory exercise, we will analyze a Tap Water sample for its Calcium Ion (Ca^{2+}) content. Calcium Ion, along with Magnesium Ion (Mg^{2+}), is one of the major cations present in Tap Water. The concentration of Calcium Ion plus Magnesium Ion is generally referred to as the "hardness" of the water. While both metals are nutrients that are needed for good human health, high concentrations of these cations in Water can cause deposits to form in bathrooms and kitchens, and cause the formation of "soap scum." Therefore, very "hard" water is undesirable for use as Tap Water.

Hard Water Deposits in a Tap Water Pipe

To determine the Calcium content in a Water sample, we will "titrate" the sample with a "standard" aqueous solution of Ethelyenediaminetetraacetic Acid (EDTA), in other words add incremental volumes of the EDTA solution, until the EDTA completely complexes with the Ion present.

$$Ca^{2+}(aq) + EDTA^{2-}(aq) \longrightarrow Ca{\bullet}EDTA^{2-}(aq)$$

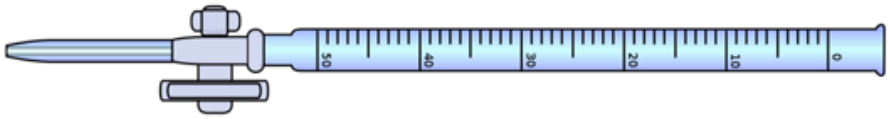
If we know the number of moles EDTA added to complete this reaction, then the reaction stoichiometry allows us to determine the number of moles Ca^{2+} present. This, in turn, allows us to determine the mass of Ca^{2+} present in the Water saample.

$$\text{mass } Ca^{2+} = \text{moles EDTA} \times (1 \text{ mol } Ca^{2+} / 1 \text{ mol EDTA}) \times \text{Molar Mass } Ca^{2+}$$

The number of moles EDTA is determinable from the total volume of EDTA solution added to complete the above complexation reaction and the known concentration of the EDTA solution. This later value will be provided by your always helpful laboratory instructor.

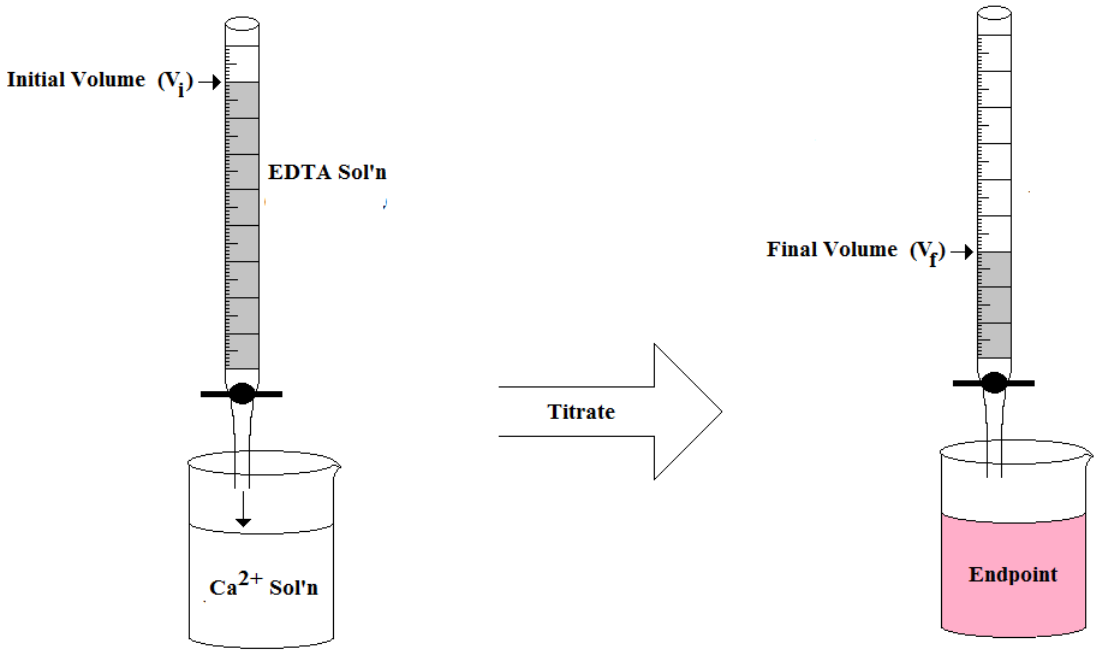
mole EDTA = volume EDTA Added [L] x (moles EDTA / L solution)

A Buret is the volume measuring device we will use to deliver the EDTA solution into the Water Sample.



This device is constructed such that it can be read with a high degree of precision and your laboratory instructor will demonstrate how to use it correctly.

Finally, the completion of the reaction can be detected using an appropriate "indicator." Calmagite (3-hydroxy-4-(2-hydroxy-5-methylphenylazo) naphthalene-1-sulfonic acid) is a triprotic organic acid that is red in color when in the presence of free Ca^{2+} and is blue otherwise. So, a change in the color of the added indicator will signal the "endpoint" of the reaction.



The "hardness" of Water is then graded as below:

Grade	Ca^{2+} Concentration [mg/L]
Soft	0 - 20
Mod. Soft	20 - 40
Slightly Hard	40 - 60
Mod. Hard	60 - 80
Hard	80 - 120
Very Hard	> 120

Procedure

1. Obtain a 100 mL sample of Water to be tested.

2. Pipette 25 mL of the sample into a 125 mL Erlenmeyer flask.

3. Add 2.5 mL of triethanolamine (TEA) and 2.5 mL of Ammonia buffer solution. Swirl to mix. (This regulates the pH of the sample and allows the EDTA to correctly bind to the Calcium Ion.)

4. Add 4-5 drops of the calmagite indicator solution. Swirl to mix.

5. Make an initial volume reading. Titrate with the EDTA titrant solution to a blue endpoint with no hint of red. Make a final volume reading. Be sure to note the concentration of the EDTA solution.

6. Repeat the titration with another 25 mL sample of Water.

Data Analysis

1. Determine the number of moles EDTA delivered during each titration.

2. Determine the mass Ca^{2+}, in milligrams, present in your Water sample for each trial.

3. Determine the concentration of Ca^{2+} [mg Ca^{2+} / L sol'n] in your Water sample for each trial. Average the results for each trial.

4. Grade your Water sample according to its hardness.