EDTA Titration Calculations

The hardness of water is due in part to the presence of Ca\(^{2+}\) ions in water. The concentration of Ca\(^{2+}\) ions is usually expressed as ppm CaCO\(_3\) in the water sample. This is equivalent to 1 gram of CaCO\(_3\) in 10\(^6\) grams of sample. In the lab 1 ppm CaCO\(_3\) is expressed as 1 mg CaCO\(_3\) per 1 Liter of sample or ppm is mg CaCO\(_3\) per L of sample.

Calcium ions can be analyzed by titration with EDTA using an appropriate indicator. EDTA is ethylene diamine tetraacetic acid or H\(_4\)C\(_{10}\)H\(_{12}\)N\(_2\)O\(_4\). EDTA itself is not very water soluble so the disodium salt is used, Na\(_2\)H\(_2\)C\(_{10}\)H\(_{12}\)N\(_2\)O\(_4\). For the purpose of simplicity, Y will stand for C\(_{10}\)H\(_{12}\)N\(_2\)O\(_4\). The EDTA we use is thus Na\(_2\)H\(_2\)Y. The part that reacts with calcium ions is H\(_2\)Y\(^{2-}\) according to the following equation.

\[
H_2Y^{2-} + Ca^{2+} \rightarrow CaY^{2-} + 2H^+
\]

The procedure is done in 3 steps 1) Preparation of a standard Ca\(^{2+}\) solution, 2) Standardization of EDTA with the standard calcium solution and, 3) Analysis of an unknown Ca\(^{2+}\) sample with the standardized EDTA solution.


0.405 g of CaCO\(_3\) is dissolved in HCl and diluted to a volume of 250.00 mL. What is the molarity of calcium ions in the solution?

\[
\text{Molarity of Ca}^{2+} \left( \frac{0.405gCaCO_3}{100.09gCaCO_3} \right) \left( \frac{1\text{molCa}^{2+}}{1\text{molCaCO}_3} \right) = 0.004505 \text{ mol Ca}^{2+} \text{ ions}
\]

Molarity of Ca\(^{2+}\) = \[ \frac{0.00405\text{molCa}^{2+}}{0.250L} = 0.0162 \text{ M Ca}^{2+} \text{ ions} \]

2. Standardization of EDTA.

A 25.00 mL aliquot (a portion or part) of the standard calcium solution reacts with 27.25 mL of the EDTA solution. What is the molarity of the EDTA?

\[
\left( \frac{0.0162\text{molCa}^{2+}}{L} \right) \left( \frac{0.02500L}{1} \right) \left( \frac{1\text{molEDTA}}{1\text{molCa}^{2+}} \right) = 0.000405 \text{ mol EDTA}
\]

Molarity of EDTA = \[ \frac{0.000405\text{molEDTA}}{0.02725L} = 0.0149 \text{ M EDTA} \]
3. Ca\(^{2+}\) concentration in an unknown solution CaCO\(_3\) reported as ppm CaCO\(_3\).

A 50.00 mL unknown solution requires 25.55 ml of the standardized EDTA solution for complete reaction. What is the Ca\(^{2+}\) concentration in the unknown reported as ppm CaCO\(_3\)?

\[
\left( \frac{0.0149 \text{ mol EDTA}}{L} \right) \left( \frac{0.02555 L}{1} \right) \left( \frac{1 \text{ mol Ca}^{2+}}{1 \text{ mol EDTA}} \right) = 0.000381 \text{ mol Ca}^{2+}
\]

\[
0.000381 \text{ mol Ca}^{2+} \left( \frac{1 \text{ mol CaCO}_3}{1 \text{ mol Ca}^{2+}} \right) \left( \frac{100.09 \text{ g CaCO}_3}{1 \text{ mol CaCO}_3} \right) = 0.0381 \text{ g CaCO}_3
\]

\[
\text{ppm CaCO}_3 = \frac{mg \text{ CaCO}_3}{LSolution} = 0.0381 \text{ g CaCO}_3 \left( \frac{1000 \text{ mg CaCO}_3}{1.000 \text{ g CaCO}_3} \right) \left( \frac{1}{0.05000 \text{ LSolution}} \right) = 762
\]