Hardness of Water by EDTA Titration

Student Handout

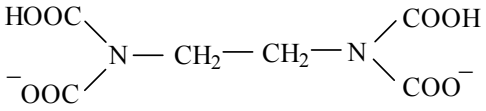
Purposes

1. To determine the concentrations of $Ca^{2+}(aq)$ and $Mg^{2+}(aq)$ ions in a commercial sample of bottled mineral water.
2. To compare experimental results with the concentrations of the metal ions claimed by the manufacturer.

Introduction

The ions involved in water hardness, i.e. $Ca^{2+}(aq)$ and $Mg^{2+}(aq)$, can be determined by titration with a chelating agent, ethylenediaminetetraacetic acid (EDTA), usually in the form of disodium salt (H_2Y^{2-}). The titration reaction is:

$$Ca^{2+}(aq) + H_2Y^{2-}(aq) \longrightarrow CaY^{2-}(aq) + 2H^+(aq)$$



EDTA (anionic form)

Eriochrome Black T is commonly used as indicator for the above titration. At pH 10, $Ca^{2+}(aq)$ ion first complexes with the indicator as $CaIn^+(aq)$ which is wine red. As the stronger ligand EDTA is added, the $CaIn^+(aq)$ complex is replaced by the $CaY^{2-}(aq)$ complex which is blue. The end point of titration is indicated by a sharp colour change from wine red to blue.

Titration using Eriochrome Black T as indicator determines total hardness due to $Ca^{2+}(aq)$ and $Mg^{2+}(aq)$ ions. Hardness due to $Ca^{2+}(aq)$ ion is determined by a separate titration at a higher pH, by adding NaOH solution to precipitate $Mg(OH)_2(s)$, using hydroxynaphthol blue as indicator.

Safety

Avoid skin contact with chemicals. Clothing contaminated with NaOH solution should be carefully removed. Spillage adhering to skin should be immediately washed with plenty of water.

Materials and Apparatus

50% w/v NaOH solution (50 g in 100 cm^3 solution)

Eriochrome Black T indicator

pH 10 NH_3-NH_4Cl buffer, hydroxynaphthol blue indicator, 0.01 M EDTA (disodium salt)

Commercial sample of bottled mineral water, apparatus required for titration, 5 cm^3 measuring cylinder.

Experimental Procedures

Part A: Determination of total hardness

1. Pipette 50 cm^3 mineral water into a conical flask.
2. Add 2 cm^3 buffer solution followed by 3 drops of Eriochrome Black T indicator solution.
3. Titrate with 0.01 M EDTA until the solution turns from wine red to sky blue with no hint of red (save the solution for colour comparison).
4. Repeat the titration to obtain two concordant results.

Part B: Determination of concentration of $Ca^{2+}(aq)$ ions

1. Pipette 50 cm^3 of mineral water into a conical flask.
2. Add 30 drops of 50% w/v NaOH solution, swirl the solution and wait for a couple of minutes to completely precipitate the magnesium ions as $Mg(OH)_2(s)$.
3. Add a pinch of hydroxynaphthol blue (exact amount to be decided by the intensity of the resulting coloured solution) and titrate with 0.01 M EDTA until it changes to sky blue (save the solution for colour comparison).
4. Repeat the titration to obtain two concordant results.

Results

Part A: Determination of total hardness

	Trial	1	2
Final burette reading/cm^3			
Initial burette reading/cm^3			
Volume used/cm^3			
Average volume of 0.01 M EDTA used/cm^3			

Part B: Determination of concentration of $Ca^{2+}(aq)$ ions

	Trial	1	2
Final burette reading/cm^3			
Initial burette reading/cm^3			
Volume used/cm^3			
Average volume of 0.01 M EDTA used/cm^3			

Calculation

1. From the results in Part A, determine the total concentration of $Ca^{2+}(aq)$ and $Mg^{2+}(aq)$ ions in the mineral water sample in mol dm^{-3}.
2. From the results in Part B, determine the concentration of $Ca^{2+}(aq)$ ions in the mineral water sample in mg dm^{-3}, or ppm.
3. Hence, calculate the concentration of $Mg^{2+}(aq)$ ions in the mineral water sample in mg dm^{-3} or ppm. Compare with the corresponding values displayed on the label of the bottle.

Discussion Questions

1. Why are two indicators used in the experiment? Can the first indicator be used for the second titration?
2. What are the limitations of the EDTA Titration in determining metal ion concentrations?
3. Comment on the pros and cons in drinking mineral water.