3.2 Activity: Using Titration to Calculate the Unknown [Cl^-] In A Sample of Seawater (Mohr Titration)

Question

What is the concentration of Cl^- in seawater?

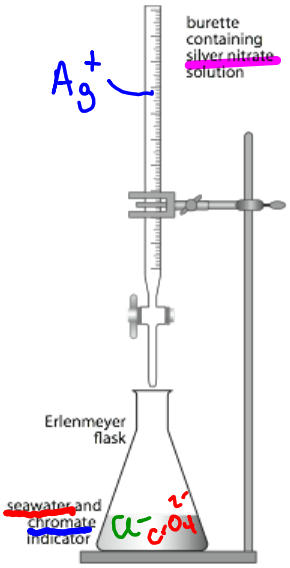
Background

Titration is an analytical method used to determine the unknown amount of a substance in a sample by reacting it with a measured amount of another substance. You will become more familiar with titration in the acid-base and redox chapters later in this textbook.

Seawater contains a significant amount of salts, largely sodium chloride. In this activity, a sample of seawater is titrated against a standardized solution of silver nitrate. The silver ions cause the chloride ions in the seawater to form a white precipitate. The concentration of chloride ion can be determined by measuring the amount of silver ions required to completely precipitate out the chloride ion. An indicator of potassium chromate is used. When almost all of the chloride ions in the sample have precipitated, any added silver ion will react with the chromate ion, causing a red precipitate to form. The equivalence point is reached once the solution begins to turn reddish.

Procedure

1. A 25.0 mL sample of seawater was diluted to 250. mL. From this diluted solution, a 25.0 mL sample was measured out and placed in the Erlenmeyer flask.
2. A few drops of potassium chromate were added to the flask to act as an indicator.
3. A burette was filled with 0.10 M silver nitrate solution. An initial burette reading was taken. The silver nitrate solution was slowly added to the flask. A white precipitate formed. After a few more drops of silver nitrate were added, the precipitate turned a reddish colour. At this point, no more silver nitrate was added. A final burette reading was recorded.



$AgCl_{(s)}$ $K_{sp} = 1.8 \times 10^{-10}$

$Ag_2CrO_{4(s)}$ 1.1×10^{-12}

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$AgCl_{(s)} \rightleftharpoons Ag^+ + Cl^-$ (s, s)

$K_{sp} = [Ag^+][Cl^-] = s^2$

$s = \sqrt{1.8 \times 10^{-10}} = 1.3 \times 10^{-5}$ mol/L

$Ag_2CrO_{4(s)} \rightleftharpoons 2Ag^+ + CrO_4^{2-}$ (2s, s)

$K_{sp} = [Ag^+]^2[CrO_4^{2-}]$

$= 4s^3$

$s = \sqrt[3]{\frac{1.1 \times 10^{-12}}{4}} = 6.5 \times 10^{-5}$ mol/L

4. Procedure steps 1 to 3 were repeated in two more trials, and the data below was recorded.

	Trial 1	Trial 2	Trial 3
Initial burette reading (mL)	0.00	14.70	28.60
Final burette reading (mL)	14.70	28.60	42.35
Volume $AgNO_3$ added (mL)	14.70	13.90	13.75
Average volume $AgNO_3$ used (mL)	13.83		

5. Complete the data table above by subtracting the initial volume from the final volume in each trial to determine the volume of silver nitrate added.
6. The average volume of silver nitrate added is calculated by taking the average of the closest two trials. Calculate the average volume of silver nitrate added, and record it in the data table.

Results and Discussion

1. Write a balanced net ionic equation that represents the reaction between silver ion and chloride ion.

$$Ag^+ + Cl^- \rightarrow AgCl_{(s)}$$

2. Calculate the moles of silver nitrate reacted in the titration using the average volume and concentration of the silver nitrate.

3. Using the mole ratio from the balanced net ionic equation, calculate the moles of chloride ion present in the sample.

$$13.83\ mL \times \frac{0.10\ mol\ AgNO_3}{1000\ mL} \times \frac{1\ mol\ Ag^+}{1\ mol\ AgNO_3} \times \frac{1\ mol\ Cl^-}{1\ mol\ Ag^+} = 0.00138\ mol$$

4. Using the volume of the *diluted* sample and the moles of chloride calculated above, calculate the concentration of chloride ion in the diluted sample.

$$[Cl^-] = \frac{0.00138\ mol}{0.0250\ L} = 0.055\ mol/L$$

5. Calculate the concentration of chloride ion in the original sample of seawater.

$$0.055\ mol/L \times 10 = 0.55\ mol/L$$

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