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Titration of a Newtown Creek Environmental Water Sample to Determine the Amount of Chloride Ions [Chemistry]

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SCC 201 Experiment- Titration of a Newtown Creek Environmental Water Sample to Determine the Amount of Chloride Ions

Competency: Global Learning

Communication Ability: Writing

Learning objectives:

To analyze and calculate the amount of chloride ions in an environmental sample by precipitation titration

To determine the equivalence point by visual observation

To become familiar with using pipettes and burettes for quantitative measurements

Introduction:

The chloride ion is an inorganic anion that is naturally occurring in environmental waters. Seawater contains 1.94% chloride and can be commonly found in varying forms, such as potassium chloride (KCl), sodium chloride (NaCl) and magnesium chloride ($MgCl_2$), with these salts all being water soluble (1). The Environmental Protection Agency has set a standard for the chloride concentration in drinking water to be 250 mg/L (2). Although chloride is non-toxic to humans, high levels of chloride can affect plants and corrode away infrastructure, such as roads and pipes. Possible sources that increase the chloride concentration include industrial processes, sewage, road salts, and fertilizers.

Titration is a technique involving the addition of a measured quantity of one solution to a known concentration (titrant) to a known volume of another solution of unknown concentration (analyte). The goal of this process is to determine the concentration of the unknown using the stoichiometry of the chemical reaction between analyte and titrant. In this experiment, a precipitation titration will be conducted where the reaction of the analyte and titrant will give ionic compounds with limited solubility.

Specifically, in the following experiment, the amount (or concentration) of chloride in water from Newtown Creek will be determined by titrating the chloride analyte with silver nitrate solution, the titrant, and using potassium chromate as an indicator. The titrant is slowly added to the environmental water sample whereby the silver ions react with chloride ions in a 1:1 ratio to form a silver chloride precipitate:

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

The end point of the titration occurs when all of the chloride ions have precipitated out of solution (as solid AgCl) and the free silver ions begin to react with the chromate ions (CrO_4^{2-}) to give a brown-red precipitate. Knowing the volume/concentration of the titrant used to attain the equivalence point and stoichiometry of the chemical reaction, the amount of chloride ions can be calculated. Ideally, the titration should be carried out at a pH between 7 and 9. A low pH environment will cause the chromate anion to protonate, which lowers the chromate concentration such that an endpoint cannot be detected. Conversely, a high pH will lead to the formation of a brown silver hydroxide compound which again inhibits the observation of the endpoint.

Pre-Laboratory Exercise

1. Define the terms equivalence point, endpoint, indicator, analyte and titrant?

2. What are the chloride ion limits for drinking water secondary standards set-forth by the Environmental Protection Agency?

Experimental Procedure

1. Using a 10 mL volumetric flask, place 10 mL of a filtered Newtown Creek water sample in an Erlenmeyer flask and measure the pH. The pH value should be in the range of 7-9. If your environmental sample has a pH value outside this range, adjust the acidity with nitric acid or sodium hydroxide.

2. Add 3-4 drops of potassium chromate indicator to the Erlenmeyer flask. A light yellow color solution should appear.

3. Set up a 50 mL burette:

    a) Obtain a burette, burette tip, burette clamp, accompanying ring stand and assemble. A magnetic stirrer device will be used as a base for the apparatus set-up.
    b) Clean the burette and burette tip with distilled water then discard. Afterwards, pre-rinse the burette with a few mL portion of standard $AgNO_3$ solution to remove any remaining water droplets.
    c) Place a funnel at the top of the burette and fill the burette with standard $AgNO_3$ solution to the 0.00 mL mark. Allow a few mL to run (to remove air bubbles) and refill up to the 0.00 mL mark. **(NOTE: You should only need to fill up the burette once)**

4. Place a stir bar in the Erlenmeyer flask, turn on the magnetic stirrer so that a gentle swirl of solution is reached.

5. Record the concentration of $AgNO_3$

6. Titrate with $AgNO_3$ solution. A white precipitate will initially form. The endpoint will be identified by the first appearance of a permanent brownish-red precipitate (with the accompanying white precipitate). Record the volume of silver nitrate used. (Note: The first trial should be used as a “rough” titration)

7. Repeat the titration until the volume of titrant used for different trials are in agreement.

8. Calculate the chloride ion concentration (Molarity, mg/L and parts per million)

Data Sheet: Experiment 6 - Titration of a Newtown Creek Environmental Water Sample to Determine the Amount of Chloride Ions

Student: _____ Lab Partner: _____

Instructor and Section: _____ Date: _____

Instructor's Signature: _____

Data:

pH of water sample:_____ Molarity of $AgNO_3$ standard: _____

	Trial 1	Trial 2	Trial 3
Volume of water sample added (mL)			
Initial volume of $AgNO_3$ (mL)			
Final volume of $AgNO_3$			
Volume of $AgNO_3$ used (mL)			
Average volume of $AgNO_3$ used (mL)			

Moles of $AgNO_3$ used: _____

Moles of Cl^- ions added to Erlenmeyer flask: _____

Volume of analyte sample added (L): _____

Concentration of Chloride Ion (M): _____

Concentration of Chloride Ion (mg/L): _____

Concentration of Chloride Ion (ppm): _____

Questions to Address in the Lab Report:

Show all calculations to find moles and concentrations of chloride.

Write the relevant chemical equation(s) associated with silver ions. What is the purpose of chromate ions in chloride determination?

What are some possible sources of error in this lab? (Note- this is not a pure water sample)

What are some of the concerns with high levels of chloride ions in environmental waters? Does the measured chloride concentration from Newtown Creek exceed the Secondary Standard limits set-forth by the Environmental Protection Agency?

In theory, if the chloride concentration in the titrated water sample is too high, what method(s) could be employed to reduce the amount of chloride ions?

What are some factors (natural or artificial) that could influence the amount of chloride in Newtown Creek?

What is a superfund and why is Newtown Creek a superfund site?

What are the implications of the pollution to the people who reside near Newtown Creek?

References

1. Balasubramanian, A. (November 2016) *Properties of Seawater*. Retrieved from URL: https://www.researchgate.net/profile/A_Balasubramanian/publication/309785723_Properties_of_Seawater-Documentary/links/582363e208ae7ea5be71fa4b.pdf?origin=publication_detail

2. Environmental Protection Agency (February 2017). Retrieved from URL: https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-nuisance-chemicals