PREPARATION FOR CHEMISTRY LAB: MEASUREMENT OF FLUORIDE IN WATER

When needed, you may assume the density of the solution is the same as the density of water: 1.00 g/mL.

1. Write the formula for both a fluorine molecule and a fluoride ion. How are they different?

2. An aqueous fluoride solution is labeled 142 ppm fluoride. How many micrograms (micro-, \( \mu \), \( \times 10^{-6} \)) of fluoride are in 71.6 g of the solution?

3. A calibration curve is prepared by plotting the absorbances of 5 different aqueous solutions containing the fluoride ion. Absorbance is plotted on the y-axis and the concentration, in ppm fluoride in each solution, on the x-axis. On the computer printout, the slope of the curve is 4.03\( \times 10^{-2} \) A/ppm and the y-intercept is 3.51\( \times 10^{-2} \) A. The absorbance of an unknown solution was 1.74 A. What is the fluoride ion concentration of the unknown solution in ppm? Show your calculations.

4. Perform the calculations and complete the table in the lab on fluoride ion concentration (that is, calculate the fluoride ion concentration in ppm = (mg F)/(L solution) for each solution). Show a sample calculation here.
MEASUREMENT OF FLUORIDE IN WATER

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INTRODUCTION

Earlier this semester, you had an opportunity to practice pipeting and preparing serial dilutions. You have also had an opportunity to explore the relationship between the absorbance of a species in solution and the concentration of that species. This week you will employ these techniques and concepts to measure the fluoride concentration in water samples using the same general principles.

Fluoride is used at very low levels in some municipal water supplies and in toothpastes to help prevent dental decay and as a treatment for osteoporosis. Fluoride ions are colorless (i.e., do not absorb in the visible region) in aqueous solutions and therefore cannot be measured directly by absorbance. However, if we react the fluoride ions with a highly colored complex of zirconium ions and a dye (represented as ZrIn) we can indirectly get an accurate measurement of the fluoride concentration. The following simplified reaction represents the reaction of the ZrIn complex and fluoride ions:

\[
\text{ZrIn} + \text{F}^- \rightarrow \text{ZrF} + \text{In}^-
\]

Green light is absorbed by solutions that contain ZrIn. When fluoride is added to a solution containing ZrIn, it reacts according to the above equation. **This reaction causes the absorbance of the solution to decrease with increasing fluoride concentration;** this is the expected behavior since you are removing the absorbing species by the addition of the fluoride. The net result is that as fluoride concentration increases, absorbance decreases. Think about how this indirect measurement of the fluoride ion concentration will affect your absorbance versus concentration graph (calibration curve).

Read the paragraph on parts per million that is on pages 329 and 330 in your textbook.

THE “PARTS PER MILLION” (ppm) UNIT

When we use percent, we are actually working with parts per hundred (parts) and use the % symbol rather than pph.

When we are able to detect fairly small quantities of solutes in solution, it is often more convenient to use parts per million, ppm, rather than percent.

For liquid solutions, ppm is usually based on mass: a 1 ppm solution contains 1 g of solute per 10^6 grams of solution. Or, for dilute aqueous solutions, 1 ppm = 1 mg (solute)/L (solution).

For example, a 20 ppm aqueous NaCl solution contains 20 mg of NaCl per liter of solution.
PROCEDURE

Since the fluoride concentration in our water samples ranges from 0 to 3 ppm, great care will be needed in measuring. Also, glassware has to be scrupulously clean and dry. Your results depend on it. Data that are less than 98% correlated will not be accepted.

Here is an overview of what you and your lab partner will do:

Make dilute solutions with water from an aqueous stock solution of fluoride (3.0 ppm, made from soluble NaF).

Pipet duplicate samples of an unknown fluoride solution into TT.

Add the color tag (ZrIn) from an automatic dispenser.

Measure the absorbance of the calibration solutions and generate a calibration curve with line characteristics (slope, intercept).

Measure the absorbance of the unknown solution.

Calculate the concentration of fluoride in the unknown.

Prepare the Dilutions:

1. Load a 25 mL buret with DI water.

2. Use a 25 mL buret to deliver the following volumes of FLUORIDE STOCK SOLUTION (3.0 ppm). Deliver the exact volumes of stock solution and water shown in the Table below into large test tubes (TT) marked with the letters A through G.

3. Calculate the fluoride concentration in each TT after the addition of water.

4. Using a mohr pipet, deliver 3.0 mL of an unknown fluoride solution into each of two TT labeled U (unknown).

5. Go to the COLOR REAGENT DISPENSER. Gently lift, then depress the plunger to deliver the preset volume (5.0 mL) of reagent into each TT.
6. Mix the contents of each tube well without spilling.

7. Check for cloudiness and proceed only if the solutions are clear.

**Take Measurements with Photometer:**

1. **USE DEIONIZED WATER IN THE PHOTOMETER CELL FOR A BLANK**

2. Measure the absorbance of the calibration solutions and generate a calibration curve with line characteristics (slope, intercept).

3. Measure and record the absorbance of the unknown solution.

**Contents of report:**

1. Computer-generated graph, with curve characteristics,

2. Estimated concentration of fluoride from your curve.

3. Calculation of the concentration of your unknown fluoride sample. Be sure that you show all work.

4. Postlab questions