Experiment 16: Analysis of Westhampton Lake Water (Yuck)

Prelab Lecture

What is this lab about?

We're putting together a number of techniques that we've learned in the past weeks to do a fairly complete chemical analysis of the amounts of "normal" constituents of water. I call these "normal" because all of the constituents that we'll be testing for are also present in something as common as bottled water. These include the concentration of H^+, calcium and magnesium ions, chloride ions, bicarbonate ions (HCO_3^-), and total dissolved solids.

Why do we care about the concentration of H^+ in water?

To check for acid rain, and its usual consequences.

Why do we care about calcium and magnesium ions?

They're a measure of the so-called "Hardness" of water. Hard waters often make it hard to wash clothes, or hair (they reduce the ability of soap to make suds), and (as a result of reactions with carbonates dissolved with water) can deposit large amounts of solids in water heaters, shortening their lives. These ions typically come from water passing over minerals containing the ions, which dissolve into the water.

Why do we care about the chloride concentration?

It's a measure of human impact on water sources. Normally fresh water sufficiently far away from tidal basins has a low concentration of chloride ion, so higher concentrations are a good measure of human impact on water.

Why do we care about the bicarbonate concentration?

It represent's the ability of water to neutralize acid, and is therefore important in understanding the ability of a body of water to resist acid rain (in some places lakes that have been damaged by acid rain have large amounts of bicarbonate added to them to help raise the pH back to healthy levels.

What about total solids?

This just tells us how many things are dissolved in the water. If the total solids we measure are significantly greater than the sum of the masses of the other things we've measured it's an indication that further tests are necessary.

Five different measurements! This seems like a lot. Isn't this going to be awfully hard?

Not too bad actually. First of all, you're going to be working in groups of 4, with each person doing a different task. Second of all each of the techniques you're going to use are techniques that you've used before.

Really? What are they?

For the concentration of H^+, you'll use a pH meter. For the concentrations of calcium and magnesium; of chloride and of bicarbonate, you'll use titration. For the total dissolved solids, you'll just boil away a small amount of water and weigh the residue.

What reaction do we use for titrating the calcium and magnesium?

The substance we use to titrate the ions is called EDTA, which is short for ethylene diamine tetraacetic acid. The EDTA originally comes bound to two protons, and when it binds to the metal ion, the two protons are released. The reaction is

$$Ca^{+2} + H_2EDTA^{-2} \rightarrow CaEDTA^{-2} + 2H^+$$

How do we know we've reached the endpoint?

As usual, by using an indicator. This one is called calgamite. It is red or purple in the presence of the metal ions, but will turn blue at the endpoint.

Do we need to standardise the EDTA concentration the way it says in experiment 14?

No, we've provided EDTA with a known concentration, so you only have to do the titration of the metal ions in the lake water.

Do we do the calculations described in experiment 14 or the ones in experiment 16?

Do the ones in experiment 16, using equation 1 to calculate the molarity of the ions, and then the calculation in part a) on the bottom of page 112 to calculate the concentration in parts per million.

What reaction do we use for titrating the chloride ion?

We react the chloride ion with silver nitrate, forming insoluble silver chloride.

$$AgNO_3(aq) + Cl^-(aq) \rightarrow AgNO_3(s) + NO_3^-(aq)$$

The reaction is complete when we've added enough $AgNO_3$ to react with all the chloride ion.

How do we detect the endpoint?

We use an indicator called sodium chromate. The sodium chromate starts out as yellow. When all of the chloride is consumed, the next drop of silver nitrate that we add produces an excess of silver in the solution. The excess silver reacts with the chromate ion to produce a red precipitate that turns the mixture red-orange.

$$2Ag^{+}(aq) + CrO_4^{-2}(aq) \rightarrow Ag_2CrO_4(s)$$

Won't a yellow to orange transition be sort of hard to see?

It might. It will help if you put distilled water and indicator in one well next to your titration so you have something to compare to.

How do we do these calculations?

Do the calculations exactly as stated in experiment 15, on page 107. The equations you'll be using will be equation 5 (which should look very familiar after last week) and equation 6.

What reaction do we do when we titrate the bicarbonate?

This is a special case of neutralization (the bicarbonate is a mild base) in which the neutralization produces carbon dioxide and water.

$$HCO_3^{-}(aq) + HCl(aq) \rightarrow H_2O(l) + CO_2(g) + Cl^{-}(aq)$$

Do we use phenolphthalein as an indicator?

No. The pink to clear color transition is not particularly easy to see. We'll use an indicator called methyl orange in which the transition is from yellow to orange.

Yellow to orange? Isn't that hard to see, too?

It's not too bad if you keep just indicator and distilled water in one of your wells for a comparison.

How do we do these calculations?

Calculate the molarity using equation 2 on page 114, and then calculate the concentration in ppm using the equation on the next line.

How many times should we do each titration?

Do it at least three times. If your three measurements do not agree to within + or – 2 drops, then you should do one or two additional titrations.

Are there any tips for this experiment?

1. The HCl is caustic. Take care and make sure you have your eye protection on.
2. The $AgNO_3$ while not particularly dangerous, does have the potential to leave black stains on your skin and clothes. Take care.
3. For the calcium and magnesium ion titration use 40 drops of water.
4. Keep the buffer solution for the calcium and magnesium ion titration in the hood when not in use.
5. For the chloride ion titration use 20 drops of the lake water.
6. Use 20 drops of water for the bicarbonate titration.
7. For both the chloride ion titration and the bicarbonate titration, it helps to have a sample of water + indicator in one your wells for comparison.

What do we do for a report?

Tabulate the pH, the concentrations of metal ions, chloride ion, and bicarbonate in parts per million, and the total dissolved solids. Present this orally to the class along with any perceived sources of error or improvements.