Environmental and Green Analysis of Nitrate or Phosphate Ions in Surface Water

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Chemical Concepts
Measurement/Analysis, Separation Science, Ion Analysis,

Environmental Concepts
Fertilizers, Eutrophication, Greenhouse Gases

Laboratory Techniques
Volumetric Analysis, Liquid Chromatography, Calibration Curves

Green Chemistry Principles
Avoid Chemical Derivatives, Minimize the Potential for Accidents, Prevent Waste, Use Safer Solvents/Reaction Conditions

Estimated Time:
Prelab Lecture (~0.5 -1.5 hr) highly variable depending upon instructor’s enthusiasm for details and what is covered in lecture. We do two prelab assignments to engage students.
Laboratory (3 hr slot) – all students are easily finished during this time period.
Calculations (1.5 hr) – We use laboratory time to do the EXCEL template, but could be a homework assignment. Well prepared students finish within 10 min, but we budget 1.5 hr

Synopsis:
This highly flexible laboratory uses ion chromatography to teach environmental and green chemistry along with analytical chemistry to an undergraduate introductory chemistry audience. These laboratories are designed to be self-contained within the content of a traditional introductory lecture course so they include primers on any information not normally covered in a typical text book.

Materials List:
Equipment:
- Erlenmeyer flasks and beakers
- Buret with ring stand and clamps (1 set per pair)
- Volumetric flasks (1 L can be shared between groups): 1-1 L and 2- 250 mL
- DI water – free of ions of interest.
- Disposable pipets (1 per group)
- 5 - IC vials and caps (these can be reused if well rinsed)
- Sharpie, labeling tape, Parafilm pieces
- Good quality DI water
- Ion Chromatograph [Dionex 1500, isocratic, AS9-HC column with 9.0 mM carbonate eluent at 1 mL/min flow, suppressor at 43 mA.

Chemicals:
- 100 ppm NO₃⁻⁻ – 100 ml/student pair. (make up & dilute 10,000 ppm nitrate – 32.613g of KNO₃ in 2 L DI water)
- 100 ppm PO₄³⁻ – 100mL/student pair, (make up & dilute 10,000 ppm phosphate – 80.046g of Na₃PO₄ in 2 L DI water)
- Surface water samples (unknowns to students) with nitrate and phosphate. In town, we find little water with phosphate and nitrate. Farm country is easier. As a compromise, we collect the water from recently fertilized office plants. Students could bring their own plants or fertilizers. Household fertilizers have lots of phosphate, but not much nitrate.
**Safety Precautions:**
All these solutions are safe to use, obviously no one drinks any of the materials. All wastes can be disposed of down the drain.

**Implementation Ideas:**
This experiment is significantly simplified since we use this in the third week of General Chemistry laboratory in the fall. There are many ways to make this experiment more rigorous for higher level students. Students could:

a. Calculate the standard series  
b. Use transfer pipets instead of a buret  
c. Make their own EXCEL spreadsheet and graphs rather than inputting data into our EXCEL template.  
d. Compare greenness of alternative analytical methods for nitrate and phosphate. Search standard analytical method data bases. Use the NEMI standards and the NEMI web site as a start.

**Companion (supporting) Web sites:**
- Fertilizing the Earth with Nitrogen, National Earth Science Teachers Association  
  www.windows2universe.org/earth/climate/nitrogen_fertilizer.html

  http://www.epa.gov/greenchemistry/pubs/pgcc/past.html

- National Environmental Methods Index www.nemi.gov includes link to greenness monitoring of analytical chemistry
**Pre-lab Lecture**

**Environmental Ideas:**
1. **Introduce nitrate and phosphate in water** – **Sources:** Human and animal waste, residential and agricultural fertilizer runoff, some industrial processes.
   a. Eutrophication: algal blooms, oxygen deprivation of aquatic animal life, etc.
   b. Mississippi dead zone
2. **Greenhouse gases:** N₂O created by bacteria in water and soil (fertilized rice paddies). N₂O is a strong greenhouse gas due to a long environmental lifetime (120 yrs) and high heat retention ability (310x greater than CO₂). As CFC’s are reduced, the concern for nitrous oxide increases. More information at EPA: [http://www.epa.gov/nitrousoxide/scientific.html](http://www.epa.gov/nitrousoxide/scientific.html)  
   Accessed March 2012

**Green ideas:** Fixing the fertilizer problem is a very green issue
1. **12 Principles**
2. Presidential Green Chemistry Challenge Award
3. Related but not used by us (National Environmental Methods Index & their greenness ratings)

**Analytical ideas:**
1. **Introduce chromatography:** Mixtures travel through a tube where some chemicals stick, slowing down progress and others make it through faster by not sticking. Things are detected at the end, which leads to a signal on a chromatograph. The signal is proportional to the concentration but you need a calibration curve to know exactly how.
   This first time we will use the IC as a black box with more understanding being developed as the course continues.
2. **Standard Series & Calibration Curves**
   a. **Dilution calculation:** \( M_1V_1 = M_2V_2 \). Go over this calculation.
   b. Introduce ppm as a concentration unit.
   c. Introduce the calibration curves (linear regression analysis) from standards to determine unknown concentrations using IC.

**Experimental Details:** each pair of students will prepare four standards by diluting a stock solution using a buret. The unknown requires no sample preparation.
1. **Glassware use:** Buret use and volumetric flask (record volumes to 0.01 mL, record concentration of stock solution)
2. **Demo buret use** (read to nearest 0.01 mL, rinse, bubble in tip, etc.), parafilm (stretch and wrap to seal), wash bottle (must have DI water), IC vial and cap (filter end of cap down, top of cap flush with top of vial).

**Water Sampling Instructions**
- Rinse container three times with water to be sampled. Do not pour the rinse water back in body of water in case contaminant is present in bottle.
- Fill container completely full with water to be sampled. Cap tightly. Keep cool.
- Label with the following information:
  - Name, date, and time
  - Name and/or location of body of water (be specific)
  - Describe surroundings (wooded, industrial, livestock area, plants, rotting logs, rusty pipe, etc.)
  - Recent weather if known (drought, rain, etc.)
Introduction to Chromatography

Ion Chromatography and Gas Chromatography

**Introduction:** Separation of complex mixtures is a vital step for the identification and quantification of chemicals. Chromatography is the separation of chemicals based on their relative affinity for a mobile phase versus a stationary support. Simply put, some chemicals stick to the stationary support, increasing the time it takes to travel a fixed distance (by getting off the path), and others do not stick at all.

This can be represented by an equilibrium where $A_M$ is the concentration of A in the mobile phase and $A_S$ is the concentration of A in the stationary phase.

In general, mixtures are added to the top of a column containing a mobile phase in close contact with a stationary support, usually coated onto the sides of the column. This “shot” of multiple chemicals then travels with the mobile phase through the column (10 cm to 600 m). On the column, the chemicals separate from each other based on their “stickiness” so they arrive at the end at different times. If A is sticky, it spends some time on the stationary phase, and B is not sticky at all, then B arrives at the end first since A “dawdles” on the stationary phase rather than making forward progress by staying in the mobile phase.

At the end of the column there is a detector that indicates the arrival of the mobile phase with “stuff” in it. The results are plotted against time. This is called a chromatogram. For this example the chromatogram could look like the picture below.

Chromatography can take many forms. The most common are gas chromatography (GC), used to identify small volatile organics, (typical of urine and blood analysis), high performance liquid chromatography (HPLC) and ion chromatography (IC), which analyzes for ions in aqueous solutions. We will be using ion chromatography (IC) to separate the ions in water and a standard curve to quantify the amounts of nitrate or phosphate.

In our first chromatography experiment, we will separate simple ions ($\text{NO}_3^-$ and $\text{PO}_4^{3-}$) from a complex sample of surface water by ion chromatography. The mobile phase is an aqueous carbonate/bicarbonate buffer ($\sim 10^{-3}$ M) while the stationary support is a long chain quaternary ammonium salt $\text{NR}_4^+$. 
Phosphate and Nitrate in Surface Water
Background & Technical Notes

Phosphates (PO$_4^{3-}$) and nitrates (NO$_3^-$) are environmentally important ions, vital to the health of surface water systems. Phosphates and nitrates enter the water system from agricultural efforts, animal waste *i.e.* poultry and hog farms, fertilizer run off, and water treatment facilities in urban and suburban areas. These anions are limiting nutrients for aquatic plants and algae. Nitrate is the limiting reagent for freshwater plants, while phosphate is the limiting reagent for marine plants. An excess of either, causes algal blooms. Although it is unsightly (algae turns the water green) it is the decomposition that causes the environmental problem. Bacterial decomposition of the algae consumes the majority of the dissolved oxygen in the water, suffocating all animal life. In fresh water systems this process is called eutrophication. A marine example is the spreading dead-zone at the mouth of the Mississippi River. In this area, no animal life, fish, shrimp etc. is found.

To control the amount of phosphate and nitrate, the government regulates the drinking water quality through the Safe Drinking Water Act (SDWA) and the individual states are responsible for local surface water standards. In Arkansas, the maximum phosphorous output is based on the water flow through a facility, but is in the range of 1-5 ppm PO$_4^{3-}$ (from the ADEQ: Arkansas Department of Environmental Quality). Unfortunately, Oklahoma has set their limit at 0.037 ppm PO$_4^{3-}$ for scenic rivers. This is a particular problem in northwest Arkansas where the Illinois River in Oklahoma is fed by the Arkansas watershed. This has spurred much debate between the states of Arkansas and Oklahoma. Even though the phosphorous flowing into the Illinois River from the Arkansas watershed has dropped dramatically in the past few years, Oklahoma continues to insist on much lower limits, which requires expensive water treatment. This is a real and present problem. After mediation between the State of Oklahoma and 14 poultry companies failed in August 2005, the Oklahoma Attorney General announced he would pursue legal action against the poultry industry in Arkansas for violations of the Solid Waste Disposal Act.$^1$ The targeted firms include Tyson Foods. At present, 2009 this is still an issue as some native Americans want to join in the class action suit.

Nitrate and nitrite (NO$_2^-$) are also monitored in nutrient surplus areas as designated by the ADEQ. The EPA drinking water standard is 10 ppm nitrate. In this laboratory, we will investigate the concentrations of nitrate and phosphate in a sample of ground water. Ion Chromatography will be used for the detection of these anions.

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$^1$ “Oklahoma AG to continue legal action against poultry firms,” The Log Cabin Democrat of Conway Arkansas, August 21, 2005.
Introduction to Ions in Surface Water
Technical Notes

Analyte(n) – chemical species of analytical interest, nitrate or phosphate herein.

Parts-per million - easy answer. This unit is often applied to very dilute solutions. Molarity gets a little awkward when concentrations are very low such as $10^{-5}$ M. \( \text{ppm} \approx \text{mg} \cdot \text{A}^- \cdot \text{L}^{-1} \cdot \text{solution} \).

Buret Care and Feeding

The analytical quality buret is a standard tool for delivering precise amounts of a solution, not just used for titration. To set-up a buret:

1. Acquire a ring stand and a butterfly buret clamp.
2. Get a buret to use. The buret should be clean, dry is not necessary. If it looks dirty, rinse it once with DI water (use your water bottle) to insure some level of cleanliness and to make sure solutions run smoothly through the tip.
3. Rinse the buret (use a funnel) with two to three small (10-15 mL) portions of the filling solution. (This improves cleanliness but more importantly prevents dilution of the filling solution if the buret is wet.) Run some solution through the tip. Put the buret in the clamp.
4. Fill the buret, using a funnel. Run solution through the buret tip. Make sure there are no air bubbles between the stopcock and the tip. If you can’t get a bubble out, call the laboratory instructor or a TA for assistance. (Note: Do not spend any time trying to fill the buret to 0.00 mL. It’ll take you forever and a simple subtraction will take care of that. Initial readings of 0.00 mL will be viewed with suspicion.) BTW- Did you record the \text{exact} concentration of the filling solution in your notebook?
5. Read the buret carefully to two digits to the right of the decimal. Measure volumes at the bottom of the meniscus and put your eye level with the reading to prevent parallax error.
6. Be sure to record data accurately into your laboratory notebook. The notebook should include initial buret reading, final reading, as well as the difference (the actual volume you added).

Standards

Standard solutions of known concentration are used to calibrate equipment and are usually created from a more concentrated stock solution.

Why calibrate? Instruments respond differently to analytical signals over time. Thousands of little things cause the instrument to give a slightly different signal response. We calibrate instruments by using a standard series of solutions with known analyte concentrations (e. g. 1, 2, 5, 10 ppm). This standard series of solutions is used to make a calibration curve.

Calibration Curves

Analytical standards are used to create a calibration curve. Ideally, there is no “curve” involved since we almost exclusively work with linear signal to analyte relationships. We use the equation of a line, \( y = m \cdot x + b \), to model the instrument response (signal) to the analyte.

Generally, \( x \) is related to the analyte concentration, and \( y \) is the instrument signal. We derive slope, \( m \), and the \( y \)-intercept by doing a linear regression on the data, AKA linear analysis, least squares, trend line, or best-straight line.
Phosphate and Nitrate Ion in Surface Water

PRELAB Analytical Questions

Herein we start to use a new concentration unit – ppm (aka parts per million, mg NO₃⁻/L solution). This unit is analogous to molarity, M.

Dilution calculations are usually done using: \( C_1V_1 = C_2V_2 \).

1) Calculate the mL of 100 ppm nitrate (NO₃⁻) stock solution necessary to create 250 mL of a standard solution that is 15.00 ppm.

\[ \text{ml nitrate stock necessary} \]

2) Clever Karl, captain of the Green-SWAT team, made up a PO₄³⁻ standard by adding 37.5 mL of 100 ppm PO₄³⁻ stock into a 250 mL flask. What was the concentration of the final phosphate standard? [In this case, 37.50 mL of 100 ppm describes the initial condition and 250 mL represents the final volume with an as yet, unknown concentration.]

\[ \text{ppm PO}_4^{3-} \]

3) In this laboratory you will need to make up a series of standard solutions for your calibration curve by diluting a stock solution. The stockroom will provide you with a stock solution of approximately 100 ppm. Calculate the amount of this solution you need to create the following solutions using the indicated volumetric flask. Problem 1 should seem related to this.

<table>
<thead>
<tr>
<th>Standard Number</th>
<th>Volumetric size (mL)</th>
<th>Final Concentration (ppm)</th>
<th>mL of 100 ppm stock solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1000</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>250</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>250</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>250</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

Note: These are not the same targets you will be using for your experiment.

Learning Targets:
- Dilution Series Calculations
- Stock solutions & Standards
- Nitrates and Phosphates in surface water

Experimental Techniques:
- Buret & Volumetric glassware
- Ion Chromatography
- Educator and EXCEL introduction
Phosphate and Nitrate Ion in Surface Water

PRELAB Green Questions

Fertilizers are a critical component of modern life. Use reliable internet resources to answer the following questions.

1) Give three costs associated with industrial fertilizer production, include web site and site date.

2) Using the EPA web site for the Presidential Green Chemistry Award entrees, search “fertilize”.
   a. Find two different methods proposed to make fertilizers more green.
   b. Which of the 12 Principles of Green Chemistry are illustrated by these methods.

3) Make one proposal for improving fertilizers that uses green chemistry principles.

Learning Targets:
- Importance of fertilizers
- Fertilizer impacts: financial, environmental, human
- Presidential Green Chemistry Challenge Awards
- Green approaches to improving fertilizer impact
Scenario: Officials in Arkansas and Oklahoma are arguing, again, about the amounts of phosphate and nitrate allowed in the watersheds that they share. The ADEQ (Arkansas Department of Environmental Quality) has asked you to find the real amounts of these anions in the water. The state legislatures of Arkansas and Oklahoma are waiting for your results before they file their suits and countersuits in federal court.

Problem: Measure nitrate or phosphate, in ppm, in a surface water sample.

Method: An ion chromatograph (IC) will provide sample separation and measurement of the amount of the ions in solution. A standard series will be used to create a calibration curve to find the actual concentrations in the surface water sample.

Procedure: Each pair of students will create a series of nitrate or phosphate standards. These and one surface water sample will be analyzed by ion chromatography.

Standard Solutions – To make your nitrate or phosphate standard solutions, add a known amount of stock solution from your buret into a volumetric flask. Be sure to prepare the standards very carefully, as carelessness at this point will affect the quality of the final answer. The stock solution provided by the stockroom will be approximately 100 ppm. Use DI water for all solutions.

1. Prepare and fill a buret Use a clean and dry beaker to acquire ~125 mL of stock solution of your anion. If using a wet beaker, rinse twice with stock solution before transferring 125 mL. Prepare the buret to dispense the stock solution according to Buret Care and Feeding in the technical notes. Record the exact concentration of the stock solution you used in order to accurately calculate the concentration of the standards you prepare.

2. Make four standard solutions by delivering approximately the target volume via buret into the indicated volumetric flask. Target volumes are listed in Table I. Remember, you will not add exactly the amount listed, but you need to know exactly what you add to the nearest 0.01 mL.

Create a table (see below) to record your data. Be sure to write down the initial and final buret readings directly into your notebook using two significant figures to the right of the decimal. Write down zeros, i.e. 3.5 ≠ 3.50 mL.

<table>
<thead>
<tr>
<th>Standard Number</th>
<th>Volumetric Size</th>
<th>Target ppm</th>
<th>~100 ppm stock (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1000</td>
<td>1</td>
<td>10.00 mL</td>
</tr>
<tr>
<td>2</td>
<td>250</td>
<td>5</td>
<td>12.50 mL</td>
</tr>
<tr>
<td>3</td>
<td>250</td>
<td>10</td>
<td>25.00 mL</td>
</tr>
<tr>
<td>4</td>
<td>250</td>
<td>15</td>
<td>37.50 mL</td>
</tr>
</tbody>
</table>

Label glassware. Be sure to not cross contaminate solutions.
a. Finish the dilution by filling each flask to the mark (hairline mark on the neck) on the volumetric flask with DI water. Use a wash bottle (with DI water) and a clean disposable pipet to fill the flask exactly to the hairline mark. The bottom of the meniscus should just touch it. Cover the flask with parafilm, hold in place with your thumb, and mix by inverting 15-20 times.

3. Calculate the actual, exact concentration of your standards, ppm, based on the actual volume of stock solution delivered to the 250 mL volumetric flask. Put this calculation in your notebook in a Calculations section. Have another group check your numbers and your group should check theirs. Make your errors in private rather than fighting it out when you get the spreadsheet!

4. Once your standards are ready, go to the indicated area to fill the IC vials. Bring all your labeled standards, your unknown if you brought one, and your notebook. A laboratory assistant will be there to help you.

5. Obtain five IC vials. Before putting solutions in the vials, use a Sharpie (vials with tape on them will NOT fit in the instrument and will not be analyzed) to label four of them along the length of the vial, NOT around the top (the cap will obscure writing there). Write directly on the vial your sample name as follows:

   Student A initials-Student B initials-exact concentration-anion (nitrate or phosphate).

   For example: Mrs. Bradley worked with Mr. Fuller to make a standard exactly 1.67 ppm NO$_3^-$, it would be labeled: SB-DF-1.67NO$_3$.

6. Create a second table in your notebook for your IC analysis data as illustrated below.

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Sample Name</th>
<th>Exact Standard Concentration (x)</th>
<th>µS·min IC reading (y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SB-DF-1.32 NO$_3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>SB-DF-4.85 NO$_3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>SB-DF-10.87 NO$_3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>SB-DF-15.39 NO$_3$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>unknown</td>
<td>SB-DF-BFcreek</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. Choose a surface water sample – Record which unknown you chose in your laboratory notebook (or the data for you own if you brought one) and label the unknown vial as directed above. Include any information listed on the bottle about the unknown in your notebook.

8. Fill IC Vials ½ full with the appropriate solution. Shake the unknown bottle well before using. Insert a black filter cap into each vial with the filter side down. The skinny part should be pointing up. Push the cap down until the top of the cap is flush with the top of the vial. There is a tool that will help you do this. Ask the lab assistant if you have problems.

9. Once your samples and unknown are capped and in labeled tubes, present them to the lab assistant, place them in the numbered slots on the tray, and stay until the samples are logged into the sign-in sheet. Leave them to be analyzed. Your results will appear on EDUCTOR next week.

Stop here

Come prepared for the calculations with your IC data (retrieved and recorded in your notebook), laboratory notebook, laptop, and calculator.

**Make sure you match the IC signal to the correct sample**
Anion Data Analysis

Meet in your pre-laboratory room to discuss the calculations and insights into problems. You will need your laboratory notebook and the data in it. Acquire the IC data for your solutions before you arrive. Feel free to start your calculations before we reconvene, a head start will get you out of laboratory sooner.

**Calibration Curve** – You will use your known solutions to create a calibration curve to standardize the instrument. In many cases, instrument signals are linear in response to the analyte concentration. This means that you are actually doing a linear regression (aka: best fit line, trend line, linear least squares) on the x,y data pairs created from your standard solutions and the instrument signal.

The linear regression will result in a line with the general equation: \( y = mx + b \).

- \( y = \) signal       signal from the IC instrument, in \( \mu \text{S} \cdot \text{min} \)
- \( x = \) anion concentration (ppm) sample concentration from the standard series
- \( b = \) y intercept collects unidentified background signal
- \( m = \) the slope an amplification factor, related to the sensitivity

You will use this line equation to calculate the anion concentration in your unknown. (Here you know \( y \), the instrument signal, and need to calculate \( x \), the anion concentration.) There is a spreadsheet in EXCEL to help you with the linear regression, but you have to provide the data and calculate the unknown concentration.

**Calculations** – Record calculations in your notebook on a new page with an appropriate title. Here, a major new task is the linear regression analysis.

- **Input your data**: \( x, y \) data and stock solution volumes into the *colored* boxes, on the spreadsheet. This includes the ml stock solution used by you, concentrations of the standards, and the area \((\mu \text{S} \cdot \text{min})\) readings for the unknowns. Do not include units.

Notice the spreadsheet automatically checks your calculation of the Anion concentration in your standards. If you do not get an “OK” on your calculations, make sure the numbers you used in your calculation are the ones in the spreadsheet. If so, then, ask for help. *(Getting to “OK” takes time.)*

- The spreadsheet automatically does the linear analysis of your standards. This regression line, also known as the trend line, best line, or linear least squares, is the calibration curve. Record the result of the linear regression analysis, for example: \( y = (0.482) x - 0.316 \), in your calculations section. Be sure to mention it is from an EXCEL spreadsheet.

- Record the spreadsheet’s calculation for the anion concentration of your unknown. This’ll work as a calculation check when you try it by hand in a minute. Follow the instructions on the next page.

- **Print** a copy of the spreadsheet and **graph** and include it with your experiment. One copy per pair of students.

- Calculate your anion concentration and show this in your laboratory notebook. Using the linear regression from your data (you recorded this in your notebook earlier), convert the \( \mu \text{S} \cdot \text{min} \) reading for your unknown, “\( y \)”, to ppm of your anion. Be sure you get the same answer as the spreadsheet did.
The calculation check spreadsheet will look very similar to this.

<table>
<thead>
<tr>
<th>Name(s)</th>
<th>Drs. Gron, Dequant, &amp; Hatch</th>
<th>stock concentration</th>
<th>Anion ID</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>99.87</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ml stock solution</th>
<th>flask size</th>
<th>Standard's ppm</th>
<th>Stnd Calc check</th>
<th>Area (µS·min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.31</td>
<td>250</td>
<td>2.10</td>
<td>OK</td>
<td>0.2482</td>
</tr>
<tr>
<td>10.10</td>
<td>250</td>
<td>4.10</td>
<td>OK</td>
<td>1.7180</td>
</tr>
<tr>
<td>25.01</td>
<td>250</td>
<td>10.00</td>
<td>OK</td>
<td>4.6900</td>
</tr>
<tr>
<td>36.25</td>
<td>250</td>
<td>14.40</td>
<td>OK</td>
<td>7.5000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Anion Concentration</th>
<th>Unknown Signal</th>
<th>Slope</th>
<th>Intercept</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.94</td>
<td></td>
<td>0.54</td>
<td>-0.65</td>
</tr>
</tbody>
</table>

Anion analysis by Ion Chromatography

\[
y = 0.5385x - 0.6468
\]

\[
R^2 = 0.9951
\]

Results –
1) linear regression equation of your standards and
2) the amount of your anion in your unknown, include name, location or source of the unknown.

Discussion – Describe one possible error in lab and its effect on the final data. This is your chance to link lab work with theory, and results. Very important!

More detailed description of your discussion assignment: List one possible source of error from the laboratory in this analysis. This does not have to be an error you actually made. (e.g. used tap water in the samples? Spilled ½ the stock in one of the standards before you diluted it, etc). Very importantly, discuss the impact it would have on the concentration of your anion in the unknown – too high, too low, alter the calibration curve to give too high or too low and answer.

Sign and date
Turn in before leaving lab