Objective: Today, you will prepare several leaves for a future experiment concerning their decomposition. You will also take part in your first journal club, during which you will read published literature about the role of nitrogen as related to the decomposition of organic matter.

Preparations for next week’s lab:

Each student will need to obtain three airtight containers labeled A, B, and C. You will also need three 50-mL beakers and several leaves without stems. Transfer 25 ml of standardized NaOH into each beaker.

For Containers A and B: record the mass of the empty containers in your notebook. Add four leaves each to Containers A and B, and record the mass of the containers and leaves in your notebook. Determine the mass of the leaves in each container. To Container A, use a disposable pipet to sprinkle 4 mL of deionized water on the leaves. To Container B, sprinkle 4 mL of 1% sodium nitrate on the leaves. Carefully place a 50-mL beaker containing the standardized NaOH in both containers A and B, making sure that there is no direct contact between the leaves and the NaOH solution.

Transfer another 25 mL NaOH into the third beaker, and place it into Container C. This container will act as a control. Carefully seal the containers with their lids and label them with your name. Place them in a location designated by your instructor.

Journal Club

Your instructor will give you more information on how to be well-prepared for Journal Club. Materials for this week and the pre-lab assignment will be posted on Moodle.
Week 11: Decomposition of Tree Leaves

Objectives: In this experiment you will use selective precipitation and titration to determine the amount of CO₂ released per day from the decomposition of leaves. You will also study the effect of nitrate ions on this process.

Over the past several decades, scientists have become concerned about the increasing amount of CO₂ in our atmosphere. Carbon dioxide is a greenhouse gas that traps infrared radiation in the earth’s atmosphere leading to global warming. The increase in carbon dioxide in our atmosphere is primarily due to the burning of fossil fuels such as oil and coal.

The process by which carbon moves through the atmosphere, biosphere, and geosphere is called the carbon cycle and is illustrated in the figure below:

Figure 1. This carbon cycle diagram shows the storage and yearly changes of the carbon between the atmosphere, hydrosphere and geosphere in Gigatons - or billion tons - of Carbon (GtC).

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6 From http://earthobservatory.nasa.gov/Library/CarbonCycle/carbon_cycle4.html
In this experiment, you will be investigating the role that plants play in the carbon cycle. Plants use the process of photosynthesis to convert carbon dioxide, water, and sunlight into glucose and oxygen gas.

\[
6 \text{CO}_2 + 6 \text{H}_2\text{O} + \text{hv} \text{(light energy)} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{O}_2 \quad (1)
\]

The glucose is converted to form other organic compounds that are used as building materials for the plant. When plants decompose, bacteria and fungi break down the leaves and release CO\(_2\) in the atmosphere. Scientists want to know the rate of this decomposition process so that they can better understand how increased amounts of CO\(_2\) in the atmosphere are impacting the carbon cycle.

You will be studying the amount of CO\(_2\) released by a sample of leaves over the period of one week. To determine the amount of CO\(_2\) released by the plants, you will place the leaves in an airtight storage container that also contains 25.00 mL of NaOH that you standardized the previous week. The CO\(_2\) will react with NaOH as shown in the following equation:

\[
2 \text{NaOH(aq)} + \text{CO}_2(g) \rightarrow \text{Na}_2\text{CO}_3(aq) + \text{H}_2\text{O(l)} \quad (2)
\]

After one week, your solution should be a mixture of the Na\(_2\)CO\(_3\) and excess NaOH. As in the experiment last week, you will need to do a back titration with HCl to determine the amount of NaOH remaining in solution, and then calculate the amount of CO\(_2\) that reacted with the original NaOH solution.

But in this experiment, there is an additional complication. The Na\(_2\)CO\(_3\) that was formed in solution can also act as a base and would react with the HCl in the back titration reaction. You must first remove the Na\(_2\)CO\(_3\) before performing the back titration. This can be done by selectively precipitating the CO\(_3^{2-}\) ions while leaving the OH\(^-\) ions in solution. This is not a trivial task since both carbonate ions and hydroxide ions tend to easily form precipitates. You will need to do some preliminary testing with a variety of cations to find a suitable cation that will form a precipitate with carbonate but not with hydroxide.

Since you only have one chance to do your titration on your leaf sample, you will test out your protocol using a test solution containing a mixture of NaOH and Na\(_2\)CO\(_3\). Once you are confident in your ability to accurately detect the amount of these species in solution, you can begin working on the leaf solutions.

Nitrates are often used in fertilizers to increase plant growth. They also increase the growth of algae and bacteria which can disrupt the oxygen levels in aquatic ecosystems. To study the effect of nitrates on the rate of leaf decomposition, you also made up a leaf sample containing 4 mL of 1% nitrate, but otherwise identical to your other sample. The third sample contains only the sodium hydroxide solution in the airtight container and will be used as a control sample for comparison or point of reference.
Prelab questions: (Answer the following in your notebook in a section labeled Prelab questions)

1. If there is any Na₂CO₃ remaining in the solution, it will neutralize some of the HCl used in the back titration. Write a balanced equation for the reaction that would occur between HCl and Na₂CO₃. Write both the molecular equation and the net ionic equation.

2. To determine which cation will precipitate carbonate ion but not hydroxide ion, you will be given 0.1 M solutions of Na₂CO₃, NaOH, AgNO₃, KNO₃, Sr(NO₃)₂, and Mg(NO₃)₂. Devise a series of reactions you and your partner can perform to do this determination. You will run these experiments in small test tubes. For each reaction you will do, write out the net ionic reaction that would occur if a precipitate were to form.

3. What effect do you think nitrate ion will have on the decomposition rate of the leaves? Defend your hypothesis in two or three sentences.

4. Begin writing out your procedure section and data tables in your lab notebook. Make a table in your data section to record the results of the reactions you described in Question 2.

In class:

Part I

Begin by performing the test experiments you devised in pre-lab Question 2 with your partner. You only need to use 5-10 drops of each solution for each reactant. Record your results of these reactions in your laboratory notebook in the data section. All solutions containing Ag or Sr should be disposed of in a waste bottle in the hood. All other solutions can go down the sink.

Part II.A

Once you have found the cation you will use for your precipitation reaction, your instructor will give you an unknown test solution containing a mixture of 1.0 M solutions of NaOH and Na₂CO₃. Each group member will be given a different solution to analyze. Record the letter corresponding to your unknown solution in your notebook. Begin by accurately transferring a known volume of the solution to an Erlenmeyer flask and adding phenolphthalein indicator. The indicator should be pink since the solution is basic. Titrate the solution with standardized HCl until the solution just turns colorless and record the volume of HCl at the endpoint. Remember that in your actual sample you will not have the opportunity to do a rough titration, so be careful in your titration. Since the phenolphthalein color will fade on its own over time due to a reaction in O₂, you should add an additional drop of indicator when you have finished titrating to confirm you have reached the equivalence point; if you have, the solution will remain colorless.
Part II.B

Transfer a second sample of the unknown solution into a clean flask but this time add an excess of the metal cation you earlier determined as suitable for the selective precipitation of carbonate. To determine how much would be an excess of the solution, assume the solution is completely 1.0 M Na₂CO₃ and then calculate what volume of the cation solution you would need to react with all of the carbonate ion. Record your observations in your notebook. After the precipitate has formed in the solution, titrate the sample with HCl using the phenolphthalein indicator as described earlier.

Calculate the molarity of NaOH in your unknown mixture and the percentage by volume of NaOH in the mixture. Check your answer with your instructor. If you are not within 5% of the actual value, repeat the analysis with a new sample.

Part III

Once you have successfully characterized the unknown solution, you are ready to analyze your leaf samples. Using your results from the earlier trials, devise a procedure to analyze the amount of NaOH that reacted with CO₂ in each of the three containers. Remember to run the analysis on the control sample (without leaves) in an identical manner as the other two.

Finally you will need to calculate the mass of CO₂ produced per day per gram of leaves in each of the two experimental samples. Remember that even without the decomposing leaves there is some CO₂ in the container, but you need to determine the amount of CO₂ that was produced due only to the leaf decomposition.

Outline of Experiment

I. Determine the cation that will selectively precipitate carbonate but not hydroxide ion.

II. Determine the amount of NaOH in unknown solution containing NaOH and Na₂CO₃.
   a. Titrate sample with HCl.
   b. Precipitate the carbonate ion in a second sample and then titrate with HCl.
   c. Calculate the molarity and % by volume of NaOH in solution.
   d. Compare to actual value provided by your instructor.

III. Determine Amount of CO₂ given off by leaves
   a. Analyze sample with leaves, sample with leaves and nitrate, and control.
   b. Determine amount of CO₂ in each sample.
   c. Calculate the mass of CO₂ produced per day per gram of leaves in each sample.
Laboratory notebook outline:

**Heading:** Title, Date, Lab partners

**Prelab questions:** Answer the questions in complete sentences or chemical equations.

**Procedure:** Write out a detailed stepwise procedure for your measurements. Be sure to include the specific glassware and measuring devices you will use and the amount of reagents. Remember to include the procedure for preparing your samples from last week.

**Data:** Make a data table for your observations in the precipitation study. You also will need data tables for each of your titrations. Be sure that you always record the final and initial buret readings for your volume measurements. You should also include any observations of precipitation reaction that occur in your analysis of the unknown solution and the leaf samples.

**Calculations and Results:** Show your calculations. Be sure to give any formulas you used and clearly define variables. You should be sure to include your calculations for the molarity and % volume of NaOH and Na₂CO₃ in your unknown solution, the amount of CO₂ in each of the three containers, and the mass of CO₂ produced per day per gram of leaves in the sample containing leaves with water and the sample containing leaves with nitrate. These calculations may have several parts so be sure to show them all in your laboratory notebook. Circle and clearly label your results for each of the three sections outlined above. Also include a class data table which gives the amount of CO₂ produced in leaf samples with and without added nitrate.

**Conclusions:**

1. Describe how your results compare numerically to those of your classmates. Explain any differences you observe.

2. What effect did the nitrate ion have on leaf decomposition? Is this what you would have expected?

3. If leaves are approximately 44.5% carbon, how many days would it take for all of the carbon to be converted to CO₂ using the class average rate calculated.

4. If you were to do an expanded study on this topic, give four other variables you could study. How do you think these variables change the results of your experiment?
Writing a Scientific Laboratory Report

At the end of Module 2, you will turn in a typed laboratory report detailing your results from the leaf decomposition lab (Week 7). Your paper for this lab project is due at the beginning of your lab period the week of November 6. The format is as follows:

Title Sheet
This cover page should include a title, lab section, date, and names of the investigators involved.

Abstract
Give a concise summary of the project in one single-spaced paragraph (all other sections should be double-spaced). What were you trying to accomplish in this laboratory project? What was the result?

Introduction
Give an overview of the background information necessary for the reader’s understanding of the significance of the experiment. This includes an introduction to any experimental techniques used, as well as a discussion of the relevance of this study. Describe the theory behind any method used in the experiment. In this case you will want to discuss titration and selective precipitation as well as why scientists would care about the amount of CO₂ in the atmosphere and the effects of nitrate. In this section you must use outside sources and should cite any references used.

Experimental Procedure
Describe in detail the investigations you did with your lab partner(s). This should be double-spaced and in paragraph form. Give the procedure you used, but not the results at this time. Give all materials and reagents used. Be sure you include the procedure for setting up the leaf samples from the previous week. If you perform a reaction, give a balanced equation. An investigator should be able to duplicate your procedure from this description. This section should be a narrative of what you did in the lab. It should be written in the past tense and in passive voice.

Results and Observations
This should give the results of your experiments and not be a discussion of why they occurred. You also need to explain the procedure you used to determine your final values from your raw data. In this case you need to explain how you determined the g of CO₂ released per g of leaves per day for each sample beginning with the volume of HCl in your titration. For the investigations you did, you should detail your results and any observations or problems you encountered. You should include tables for all of the data collected.
Discussion
In this section you will discuss your results. Were your results as you anticipated? If not explain why. From your results, how did you determine the proper precipitating agent? You also need to compare your result to those of your classmates and explain any overall trends or differences you observe. Are there any experimental problems that give error in the experiment (human error is not an acceptable response here)? Be as specific as possible about any assumptions you have made in your analysis of results.

Conclusion

How does all of the information presented above lead you to meeting the outcome desired for the lab project? Summarize the final outcomes you obtained.

A well-written report should be at least 8-10 pages.

Notes:

• Students should review the definition of plagiarism in the BSC Honor Code. If you are uncertain, ask for help at the writing center or from your instructor. Ignorance is not an excuse. You may not look at lab reports of other students (former or present) in preparing your report. Your report will be submitted to Turnitin.com to check for similarities between papers.

• All tables included in your paper should be numbered (i.e. Table 1) and have a meaningful title shown above the table. Graphs and figures should also be numbered and have a detailed caption below the figure. Equations or reactions should be indicated with a number in parenthesis on the right side. All tables, graphs, and figures should be referred to in the body of the paper and should not be broken by a page break. The reader should be able to independently read the table or graph and get all the information needed without having to read the laboratory report. Refer back to pages 30-31 for examples.

• References should be presented in American Chemical Society format. Refer to pages 31 and 32 for more information.