CHEM 116 Final Course Project Option 2
Prof. Sevian, Fall 2020

For each numbered part, write out your observations or answers to questions. For example, write down your observations and include photos of the colored solutions you will get as data. You will turn in one project report that includes your answers, observations, data, photos, etc., that is collaboratively written by both of you. It may be easiest to create your report in a shared Google doc or OneDrive doc, so that you both can add to it simultaneously as you work together. Remember to include both of your names on the document that you will submit. There are no formatting requirements other than to organize your project report into numbered parts. If you use resources from the internet, cite them using any citation style you prefer. Since you are digital natives, you will be able to find ways to label any photos that you may want to write on to emphasize or indicate something, and then you can add those to your shared project report that you will submit. You will upload your project report in Blackboard. Decide which one of you will upload the project report for you both, and make sure to give the other person evidence as assurance that it was successfully submitted. The first appendix is to help you with safety, and the second appendix is the rubric.

Household Acids and Bases

1. Make an acid-base indicator solution using red cabbage.

Both partners must do the experiments. Find a procedure on the internet for making an acid-base indicator solution using red cabbage. Red cabbage contains an anthocyanin. This is a class of substances that exist in some plants, and there is a large amount of anthocyanin in red cabbage. Because it is contained in cells, you have to use a procedure of extracting it that involves breaking cell walls, so you will either need to chop it up or boil it. Lots of people have posted ways of making red cabbage juice indicator.

Take a photo of yourself making the red cabbage juice acid-base indicator (either a selfie or have someone in your home or your project partner take the photo) to provide evidence that you did this. Include the photo in your report. No one other than Dr. Sevian or the TAs who will grade the final reports will see the photo unless you give permission.

2. Measure the pH of at least five different household acids and bases.

Set aside some of your red cabbage indicator for a later step. Now, set up several (at least five) cups or glasses (transparent so that you can see the colors), plus one more which will be your control. Add the same amount of water to each one (use a measuring cup), and add the same amount of red cabbage juice indicator solution to each. Record the amounts so that you can repeat it later if needed.

Find a chart on the internet (there is probably one in the procedure you used for making the indicator) that gives you a way to read the color of the indicator to measure the pH of a solution. Take a picture or include a screenshot of the chart you are using in your report. If you and your partner use different charts, include both of them and write which of you is using which chart.

Find five different household substances that are definitely acids or bases. Try to get at least one acid and at least one base. You will find lots of ideas online for what you could test. Take photographs, label them, and identify the pH of each solution using the color and your chart. Both partners will have at least 5 photos to add to your report.

3. **Find a medicine that is an acid or base.**

   Find a medicine tablet in your home. It has to be a tablet, not a gel capsule. It will need to be something that you can crush into a powder (in the next step). You need to know the identity of the chemical in it (look for something with only one medication in it) and the mass of the chemical in it (check the container to find these). Both partners must do this and it's likely you will have different medicines (or at least different brands if you are using the same medication).

   Look up the medicine in PubChem or DrugBank and get the molecular structure and the molecular formula of it. Figure out if it is an acid or a base. If it is neither, then pick a different medicine. Either PubChem or DrugBank will tell you the pK_a of the strongest acid or the pK_b of the strongest base on it, and you should also be able to look at the structure to figure out if it's an acid or base.

   Once you decide what medicine you will use (the process in the previous paragraph might cause you to choose a different one than you originally planned), write in your report the following information:

   - Name of medicine
   - Name of the chemical that the medicine is (it might be the same as name of the medicine)
   - Chemical formula of the medicine
   - Mass of the medicine in one tablet (usually this is given in mg)
   - Molecular weight of the medicine (you'll also find this in PubChem or DrugBank)
   - pK_a (if it's an acid) or pK_b (if it's a base)
   - Get the line structure of the molecule (you can copy/paste this from PubChem or DrugBank), then label what you think could be the acidic site on the molecule (if it's an acid) or the basic site on the molecule (if it's a base)

   Again, both of you will probably have different medicines, and you will each record this information for your own medicines.

4. **Make a solution of your medicine and predict the pH of the solution.**

   Decide on a volume of water that you will use to dissolve your medicine. You will need a measuring cup, and you probably will need to find an online converter if your measuring cup is in English/imperial units (e.g., fractions of a cup, or ounces). Convert the volume of water to mL or L. Record the volume. Then add the water to a cup.

   Crush the medicine tablet in a way that you lose as little powder as possible. For example, you could crush it between two metal spoons inside a wax paper square that you fold up. Or you could place it inside folded wax paper and crush it using an object that you can use to press on it.

   Add the powder to the water in the cup. Use a spoon and stir until the medicine is dissolved.

   Use the mass of the tablet, the molecular weight, and the volume of water to calculate the molarity of the medicine solution that you have made.

   Now use the value of pK_a (if acid) or pK_b (if base) that you found for this medicine to predict the pH of the solution. Start by assuming that it is ok to make the assumption that the amount of acid or base that dissociated is much smaller than C_o. Report your predicted pH. Also check that C_o/K_a or $C_o/K_b > 400$ to judge whether the assumption is valid. You do not need to use the quadratic formula to do the long calculation, your approximation for pH will be good enough since the measurement of pH by the cabbage juice indicator is not very precise. Report pH predictions from both people.

5. **Compare your pH prediction to experimental measurement.**

   Measure the same volume of your medicine solution as you did of your water in part 2. Add the same amount of red cabbage juice indicator to that medicine solution as you did with your water in part 2. Then, use your color scale and determine the pH of the solution. Take a photo of the solution because you will need to compare this side-by-side with the photo after you make a modification in the next part.

   Record your measured pH values (for both partners). How do your measured pH values compare to your predicted pH values? Are there any surprises? If so, try to give some possible reasons why.

   If you both have the same medicine, did the pH turn out the same? Why or why not? If you have different medicines, how are the pH values that you measured different? Does it make sense that they differ in this way?

6. **Altering the amount of acid or base present.**

   Propose three different changes you could make to your solution to control (change) the pH of the solution (e.g., adding something, etc., think about the many examples we discussed in class).

   Pick one of your proposed modifications that it would be possible to test, and first make a prediction using a kinetic (rates) or thermodynamic (Q vs. K) argument to predict why the reaction should become more reactant- or product-favored if your proposed modification is not a temperature change. If you propose changing the temperature, you will need to make an argument for the sign of ΔH (kinetic) or ΔS (thermodynamic), however in most cases, $\Delta S < 0$ because creating ions causes water molecules to organize more around the ions so this decreases the number of possible configurations. Record this argument in your report.

   Then try the modification. Take a photo of the solution after your modification. Place it side by side with the "before" photo that you took in the previous step. Does the measurement of pH change? Did it change in the direction you expected? Record your experimental results (for both individuals) of approximate pH, as measured by the color chart.

7. **What did you learn from the experience of doing this project?**

   Each of you should write a brief paragraph to answer this question. Include your name with your paragraph.

The two appendices begin on the next page.

Appendix 1: Safety and cleanup

It is unlikely that the medicine would be strong enough to harm you if it gets on your skin, but if it does, wash the affected area with warm water. Be very careful not to get any medicine in your eyes.

To clean up, wash the solutions down the sink drain. Solid materials (wax paper, leftover cabbage) can be placed in the garbage.

Appendix 2: Rubric (same for both projects)

Points possible	Area of competence	What high quality looks like
10	Experimental work	Photos demonstrating that all aspects of the expected experimental work were carried out and that both individuals participated
10	Mathematical work	Correct usage of the mathematical models related to the project
10	Conceptual work	Accurate, clear, and logical explanations of chemical ideas (either acid-base or redox) with correct usage of chemical terminology (e.g., conjugate acid/base, pH, oxidation numbers, anode & cathode)
10	Application work	Appropriate application of chemistry models to explain how (mechanism) and/or why (causal explanation) the behavior or function of a chemical system can be controlled and/or optimized
10	Collaborative work	Clear evidence that the work was shared between the individuals who collaborated on this project, including evidence that both individuals contributed in substantial ways