

Experiment 18: Open Ended Projects II

You will carry out another open-ended project as you did in Experiment 10. The laboratory instructor will assign new groups. Read the introduction to Experiment 10 if you are unclear as to the intent of the open-ended project and to review tips for working in a group. For this project, in addition to the individual written reports which each student will prepare, each group will be required to prepare and present an oral report.

Schedule and assignments for the open-ended sessions

Projects will be assigned to the groups based on lists of preferences submitted by each group to the TA. Group members will then meet to devise an experimental plan for the project. The experimental plan, plus two copies of a list of materials needed (p. 7), will be submitted to the TA one week before work on the project is to begin.

At the beginning of the first open-ended lab period, you will be given a cumulative quiz on laboratory techniques. It will include four or five questions which cover all of the techniques that you have learned over the course of the year. Questions covering knowledge of lab hazards and safety precautions may be included as well.

As usual, your TA will collect the yellow copies of your data and observations sheets at the end of each lab period during the open-ended sessions. In addition, after each lab period, *each student* will write a "progress report". The final lab report is due on the last lab period of the semester and *each member of the team* will write *his or her own final report*. During this last lab period, each group will also present their results and conclusions in the form of a short oral report.

Schedule for the Open-Ended Sessions

2 weeks prior to Session 1	Choose project
1 week prior to Session 1	Submit list of materials needed Submit project design
Session 1	Cumulative quiz Assign tasks to group members and begin work
Session 2	Progress reports for Session 1 submitted Work on project continues
Session 3	Progress reports for Session 2 submitted Group Meeting is held
Session 4	Final written reports are submitted Group presents oral report

You may find as you work on the project that modifications to the original procedure must be made. If you require additional items for the second lab period that were not listed in the initial request for chemicals and equipment, submit a new request to your TA before the second lab period.

The Group Meeting

During session 3, your group will meet in the laboratory to discuss the results of the experiments and to plan for the oral report. You will not be allowed to perform experiments during this lab period. To prepare for the meeting, you should:

- a) outline what you want to accomplish during this lab period (data analysis, organization of the oral report, etc.).
- b) perform calculations and plot graphs that you feel will be necessary for analyzing the data.
- c) review the chemical principles related to the project in your textbook by Tro.

Grading policies

The open ended project will be worth a total of 15 points, three times that of a "regular" laboratory report. The distribution of the 15 points will be as follows:

Project design	0.2
Progress reports	
for Session 1	0.4
for Session 2	0.4
Final report	
Introduction	0.2
Data analysis	0.3
Discussion	0.5
Oral report	
Individual's presentation	0.5
Overall presentation	0.5
Total	3.0

For most sections of the report, students will be graded on an individual basis. The exceptions to this are the grades for the "Project design" and the "Overall presentation" (Oral report), which will be "group" grades. All members of a group will receive the same grade for both these sections.

As usual, the TA will give a numerical grade from 1-5 for each section, and each section of the report will be multiplied by the appropriate weighting factor according to the numbers listed above. Thus, a final numerical grade out of 15 (3.0×5) for the lab report will be calculated based on the section scores and their weighting factors.

Performance grade

The final performance grade for the semester will be based on your performance during the weeks of the open-ended project. This grade will be arrived at through *peer evaluation* by the members of your group. The contribution of each group member will be rated by every other member of the group using the sheet on p. 8. These ratings should be based on a student's effort and cooperation in the group, creativity and contribution to the project, effort outside of the laboratory and attendance at meetings. This peer evaluation will be strictly confidential. Fill out and bring p. 8 to the last period and hand it in to your TA. The TA will arrive at a final performance grade for each student based on these peer evaluations as well as his/her own insight on a student's performance.

Make-up policy

The open-ended project cannot be used as a "dropped" grade. If a student misses one or more lab periods during the weeks of the open ended project, the group can decide as a whole how that student's work should be "made up". He/she might be assigned to do

extra data analysis, computer work, library research or other assignments which may be completed outside of the laboratory. In other cases, she/he may need to come to a different lab period to complete experimental work. If a student needs to make up work during a different lab period, s/he must make arrangements for this through the Laboratory Director, Prof. O'Connell, room 125D.

Project design

The project design should include the following:

1. A statement of the purpose of the project and the chemical principle(s) being studied. You may want to refer to your textbook (Tro).
2. An outline or description of the proposed procedures. You should refer to earlier experiments as well as the Techniques section of the manual/notebook. When designing the experiments, use the following questions as a guide:
 - a. What techniques will be used?
 - b. What independent variables will be manipulated?
 - c. What dependent variables will be observed and measured?
 - d. What method(s) will be used to measure the values of the variables?
 - e. In what units will the variables be expressed?
 - f. How often should measurements be obtained?
 - g. How many data points should be obtained?
Note: When trying to observe a trend, two data points is not sufficient. Obtain three to five data points.
 - h. What variables should be kept constant?
 - i. What should be the sample size and/or concentrations of the solutions?
3. Discuss significant hazards which will be encountered and describe special precautions that will be taken to avoid them. See p. 6 for information regarding safety references.
4. Fill out and attach 2 copies of the sheet provided on p. 7.

Progress reports

The progress reports will describe the procedures that were carried out and the data and observations that were obtained during each lab period. They should include the following:

1. *Details of the experiments that were performed.* Provide step by step instructions of the procedures that were followed using the past tense and the third person, passive voice. Examples follow:
correct: A 50 mL portion of 6 M hydrochloric acid was added to the solution.
incorrect: I added 50 mL of 6 M hydrochloric acid to the solution.
incorrect: Add 50 mL of 6 M hydrochloric acid to the solution.
2. *Modifications to the procedure.* You may find as you proceed that changes to the original procedure must be made. These modifications and the reasons for them should be noted in the appropriate progress reports.

3. *A summary of the outcome of the experiments (data and observation sheets).* As usual, your TA will collect the yellow copies of your laboratory notebook sheets, and these will constitute part of the progress report. The data on these sheets should be presented in appropriate forms (lists, tables, etc.). Include all observations which were made during the course of the experiments.

Each progress report should be one to two pages in length, not including the data and observation sheets from the notebook. *Each student* will hand in two progress reports. The progress reports should not attempt to analyze or interpret the data obtained and thus should not unnecessarily repeat information which will be presented in the final report.

Final written report

The final report should include the following three sections. Write the appropriate heading at the beginning of each section (Introduction, Data analysis or Discussion).

Introduction Introduce the reader to the problem that your group set out to solve. Explain what chemical principles were being investigated. Describe the approach that your team chose to take in tackling the problem and why this approach was chosen.

Data analysis Include calculations and graphs to show how the data was analyzed. If appropriate, summarize results in a table.

Discussion Provide an interpretation of the results and draw conclusions. Discuss what the experimental data proved or failed to prove and why. Review the chemical principles involved and explain whether or not your team's results fit the accepted theories. Describe problems encountered in performing the experiments and how these problems may have affected the final results. List any limitations of the experimental procedures and discuss sources of error. Discuss ways in which the procedures could have been improved.

The final report must be typed (calculations may be written by hand). Use double spacing, a one inch margin and a 12 point font size. The length of the Introduction and Discussion sections *together* should not exceed **three** pages. *Each student* will hand in a final report. The final report should not discuss details of the procedures followed in lab and thus should not unnecessarily repeat information which was presented in either of the progress reports.

As with all laboratory reports, the progress and final reports must be written *in your own words*. If identical reports are handed in by two or more members of a group, these reports will be given scores of zero for all the identical sections.

Oral report

The oral presentation is a group effort, and the material should be divided up so that each member of the group speaks for a few minutes. A possible division of topics follows:

1. Introduction, background information, an explanation of the rationale behind the plan of attack.

2. Experimental procedures and set-ups. Changes which were made to the procedures as the project progressed.
3. Observations and results which were obtained.
4. Conclusions and discussion of the results. Were the results what you expected? What would you do next if you could continue the project?

The preceding is just a suggestion and may be modified as you see fit.

You can, and should, use visual aids in your oral report. A portable LCD projector will be available if you would like to give a Power Point presentation; in this case, you must bring your own laptop computer and any necessary adapter(s). Alternatively (or additionally), you can print text or paste enlarged diagrams on poster boards which can be held up during the presentation. A blackboard will also be available. Some groups may also wish to provide handouts for members of the audience.

The presentation must not be longer than 15 minutes. Your audience will consist of your lab TA and your laboratory classmates. The audience will have an opportunity to ask questions when the presentation is over.

The group will be graded on the overall organization of the presentation as well as on the content. The material should be explained in a clear and interesting fashion. Individuals will be graded on their comprehension and ability to communicate.

Materials available in the laboratory

The following chemicals and equipment will be available in the labs at all times during the weeks scheduled for the open ended projects and should not be included on your list of requested chemicals and equipment. You must dilute the solutions provided to prepare solutions of varying concentrations.

1 M HCl	1 M NH ₃	filter paper	plastic cuvetts
1 M NaOH	1 M HNO ₃	plastic pipets	weighing paper
1 M acetic acid	solid NaHCO ₃	red litmus paper	spectrophotometers
1 M H ₂ SO ₄	solid NaCl	blue litmus paper	

Note that the concentrations given for the above solutions contain only one significant figure. If you need to know the concentration of a particular solution more precisely, you will have to standardize the solution. Any solution that is to be standardized must have a concentration which is less than 1 M in order for the result to be accurate. Dilute the stock solution to the desired concentration *before* performing the standardization. The concentrations of the solutions in the "common" bottles may change slightly from one week to the next. For this reason, once a solution has been standardized, pour as much as you think might be needed into a bottle, label it (include the names of the group members) and store it in one of the lab cabinets until the next week. Bottles will be provided for this purpose, if requested.

Use potassium acid phthalate and the technique in Experiment 7 to standardize a strong base solution. To standardize a strong acid solution, sodium carbonate should be used. You should request *dried* sodium carbonate for this purpose. Use methyl red indicator and titrate until the solution just begins to change from a yellow to a red color. Boil the solution gently for 2-3 minutes; the solution should become yellow again. Cool

to room temperature (you may use an ice bath), continue to titrate until the color again changes to red at which point the endpoint has been reached and the volume may be recorded. Note that at the endpoint of the titration, *two* moles of protons are neutralized for every *one* mole of sodium carbonate reacted.

Weak acid and weak base solutions must be standardized using a strong base or acid and thus cannot be standardized with sodium carbonate and potassium acid phthalate. If you need to standardize a weak acid or base solution, you must first standardize a strong base or acid solution (such as NaOH or HCl); then the weak acid or base solution is titrated against an aliquot of this standardized solution.

Safety precautions

1. Know the hazards of the chemicals that you are using. Look them up in the resource material listed below.
2. Perform all chemical reactions on a *small scale* first (1-2 mL of liquids and 10-20 mg of solids). If the reaction appears to be very vigorous, do not perform it on a large scale.
3. The “common” chemicals that are provided during these lab periods (see list on previous page) may be disposed of down the sink. Check with your TA regarding the proper disposal of *all other* chemicals which you choose to use in your project.

Safety references

These and other books on lab safety can be found in the library:

Merck Index of Chemicals and Drugs, Merck & Co.: New Jersey.
Fundamentals of Laboratory Safety; W. Mahn; Van Nostrand Reinhold, New York.
Handbook of Laboratory Safety; A. K. Furr, Ed.; CRC Press: Boca Raton, FL.
Guide For Safety in the Chemical Laboratory; Manufacturing Chemists Association; Van Nostrand Reinhold, New York.

A vendor is required by law to provide a Material Safety Data Sheet (MSDS) for every chemical sold. These sheets impart information regarding the hazards associated with a chemical, the precautions to take when working with the chemical, as well as some physical data. At the following website, you will find links to sites with MSDS's:

<http://www.ilpi.com/msds/#Internet>

You should check the MSDS's for a few chemicals with which you are familiar to get an idea of the kind of information that is provided. For instance, find the MSDS's for sodium chloride, hydrochloric acid and acetone.

The Boston College library has created a Chemical Laboratory Safety and Methods website:

<http://libguides.bc.edu/labsafety>

as well as a page for Chemical and Physical Property Data:

<http://libguides.bc.edu/chemdata>

Names of group members _____

Lab period _____ TA _____

Materials needed for the project

List the reagents and solutions needed (other than those listed on p. 5).

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

List the equipment which you will require (other than equipment provided in your drawers and that listed on p. 5).

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Each group must hand in two copies of this list to their instructor.

Peer Evaluation Form for the Performance Grade

Allocate 100 points among the members of your group in proportion to their contribution. Include yourself in the list. **This form will be kept strictly confidential and will not be shown to any members of your group.** Bring this sheet with you to the last lab period of the semester and give it to your TA.

	Points
1. _____	_____
2. _____	_____
3. _____	_____
4. _____	_____
Total	100 points

----- Fold here and staple or tape closed.-----

Open-Ended Project Topics

The titles of the open-ended projects are:

1. Preparing a Buffer for an Antiperspirant
2. A Study of the Spectrophotometric Properties of a Dye
3. Understanding the Acid Content of Wines
4. Determination of the Phosphoric Acid Content of Cola Beverages
5. A Study of the Effects of Concentration on the Rate of a Reaction
6. A Study of the Effects of Temperature on the Rate of a Reaction

Background information and hints for these projects are provided on the following pages. Each group in a laboratory will work on a different project. For this reason, the TA will obtain from each group a list of the top three topics that they wish to pursue in order of preference. After reviewing the lists, the TA will assign the topics.

Projects 1, 2, 3 and 4. Acids, Bases and Buffers

Project 1: Preparing a Buffer for an Antiperspirant

The company you work for is formulating a new antiperspirant that must be ready for pre-market testing by the end of the fiscal year. One aspect of the product's specifications which must be carefully adjusted is the acidity. It is very important that the pH be accurately regulated and maintained for proper function. You and your co-workers have been given the responsibility of finding and studying an appropriate buffer that can be used in the preparation of this antiperspirant. You must present a full report of the findings to the company.

You will be given a sample of an antiperspirant that is currently on the market. Mix a portion of the antiperspirant with water and determine its pH and buffering capacity. Not all of the material will be water soluble, however, the buffering components will be dissolved in the water.

Choose an appropriate buffer system from those listed on page 11 to match the anti-perspirant. Prepare buffer solutions using different ratios of $[A^-]:[HA]$. Perform as many of the following experiments as time permits:

- a) Compare the resulting pH's of the solutions.
- b) Test the buffering capacities of the solutions using both a strong acid and a strong base. For comparison, you might want to test the buffering capacity of water.
- c) Study the effects that diluting a buffer has on both the pH of the buffer and the buffering capacity. The dilution can be done in one of two ways:
 1. Prepare the buffer as instructed on p. 12, then add a quantity of water to it. Measure the pH and the buffering capacity.
 2. Prepare the buffer solution, remove a portion of it and dilute this portion with a quantity of water. Measure the pH and buffering capacity.

Would you expect these two dilution methods to produce the same effects on the pH and buffering capacity? Try both methods and compare the results.

- d) Prepare a buffer which simulates the pH and buffering capacity of the antiperspirant that you have been given.

Project 2: A Study of the Spectrophotometric Properties of a Dye

An organic chemist in your company has synthesized a new dye that can be used for coloring a variety of food products which are in development. A property of this dye is that its color depends on the pH of the solution. In order to fully assess the applications of this dye in food coloring, your group needs to study the relationship between the color and the pH and present a full report of the findings to the company. The synthetic chemist will provide you with a 0.01 M stock solution of the dye in a 50/50 water/ethanol mixture. The molar mass of the dye compound is 382.43 g/mol.

- a) Determine the pH range over which this dye changes color.

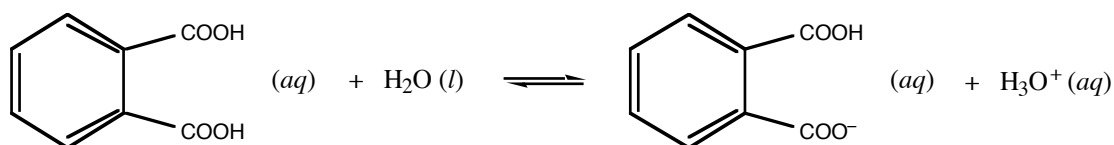
- b) Prepare buffer solutions of varying pH's using different ratios of $[A^-]:[HA]$. Choose a buffer system from those listed below that will allow you to prepare solutions having pH's in the range over which the dye changes color. Use these solutions to dilute the dye stock solution, and measure the absorbance of the solutions at **575 nm**. Plot the relationship between absorbance and pH.

Note: When using the spectrophotometer, it is best to prepare dilute solutions such that the absorbance measured is less than 1.000.

- c) The dye is a weak acid. Determine the pK_a of the dye. [Hint: Review the determination of pK_a for acetic acid in Experiment 17.]

Suggestions for buffer systems to use for Projects 1 and 2

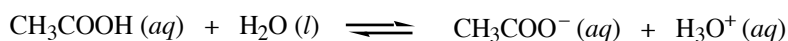
1. Phthalic acid/phthalate buffer system (**note:** in preparing a 0.100 M solution of phthalic acid, some heat may be required to dissolve the solid)



$$pK_{a1} = 2.93; pK_{a2} = 5.41$$

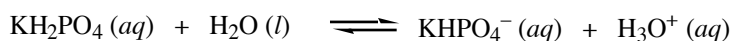
$$\text{molar mass of phthalic acid} = 166.13 \text{ g/mol}$$

2. Acetic acid/acetate buffer system



$$pK_a = 4.76$$

3. Phosphate buffer system



$$pK_{a1} = 7.18; pK_{a2} = 12.3$$

Project 3. Understanding the Acid Content of Wines

Acidity is very important to the quality and stability of wine. Having just purchased a winery along with a few of your colleagues, you want to fully understand the acid content of various wines. The two most important acids that are present in wines are tartaric and malic acids.

- a) Find the pK_a 's of tartaric and malic acids experimentally. [Hint: Review the determination of pK_a for acetic acid in Experiment 17. The molar mass of tartaric acid is 150.09 g/mol, and the molar mass of malic acid is 134.09 g/mol.]
- b) Prepare tartaric acid/tartrate and malic acid/malate buffer solutions using different ratios of $[A^-]:[HA]$. Compare the resulting pH's of the solutions. Test the buffering capacities of the solutions using both a strong acid and a strong base.

- c) Find the concentration of acid in the wines provided.
- d) What happens to the acidity of the wine if it is heated?
- e) Winemakers sometimes adjust the acidity of wine with sodium bicarbonate. Determine how much sodium bicarbonate would need to be added to the wine to raise the pH level by 0.5.

Hints and other important information for Projects 1, 2 and 3

When using the Logger Pro data collection system, first plug the pH electrode into the interface box, then start the Logger Pro program.

How to prepare a buffer:

1. Dispense 20.0 mL of a 0.1 M solution of a weak acid into a clean, dry beaker.
2. Add 20.0 mL of 0.1 M NaOH solution to the solution in the beaker, producing 40.0 mL of a 0.05 M solution of the sodium salt of the weak acid.
3. Dispense another 20.0 mL of a 0.1 M solution of a weak acid into a clean, dry beaker and add 20.0 mL of water, producing 40.0 mL of a 0.05 M solution of the weak acid.
4. Combine varying portions of the salt and acid solutions to produce buffers of various pH's. Mix thoroughly.

To produce an effective buffer, the ratio of $[A^-]:[HA]$ should not be less than 0.1 or greater than 10.

Pertinent equations for Projects 1, 2 and 3

Henderson-Hasselbalch equation:

$$pH = pK_a + \log \frac{[\text{conjugate base}]}{[\text{weak acid}]}$$

Buffer capacity: number of moles of acid or base required to change the pH of the buffer by 1 unit per liter.

$$\text{buffer capacity} = \frac{(\text{number of moles of acid or base consumed})}{(\text{change in pH}) \times (\text{volume of buffer, L})}$$

When determining the buffering capacity, the observed change in pH should be approximately 1.2 pH units. Use a 0.1 M solution of a strong acid or base and add it dropwise to the buffer with stirring.

Equipment and chemicals which are available that might be of use include:

- pH electrodes for the Logger Pro interface
- pH 4 and pH 7 buffers (for calibrating the pH electrode)
- 25 mL burets
- 1, 2, 4, 5, 10 and 25 mL pipets
- 50 mL, 100 mL and 250 mL volumetric flasks
- phthalic acid (solid)
- potassium dihydrogen phosphate (solid)

tartaric acid (solid)
malic acid (solid)

Project 4. Determination of the Phosphoric Acid Content of Cola Beverages

Cola beverages contain phosphoric acid, H_3PO_4 , which contributes to their tangy flavor. You are a member of the quality control group of a company that makes soft drinks. Your group needs to develop a method for accurately and efficiently determining the phosphoric acid content of the company's cola drink in order to be assured of a consistent product. The list of possible analytical methods to use for this purpose has been narrowed down to two: spectrophotometry or potentiometric titration. Your group must decide which is the better method and present a full report of the findings to the company.

a) *Spectrophotometry*

While phosphoric acid is not colored, it can be reacted with the compound ammonium vanadomolybdate, which forms a colored complex with the phosphate ion, PO_4^{3-} . The ammonium vanadomolybdate serves the same purpose that the compound 1,10-phenanthroline did in Experiment 6 when you determined the amount of iron ion present in a vitamin tablet. The phosphate complex which is produced absorbs light at **400 nm**.

To make standard solutions for the calibration curve, you can use KH_2PO_4 as a source of phosphate ions. Make solutions of this salt with varying concentrations of phosphate ion on the order of 10^{-4} to 10^{-5} M. Mix 5 mL of the ammonium vanadomolybdate solution provided with 10 mL of each phosphate solution and measure the absorbances.

The cola must be diluted until it is almost colorless. Mix 5 mL of the ammonium vanadomolybdate with 10 mL of the diluted cola and measure the absorbance.

Think carefully about what solution to use as a blank.

b) *Titration*

Use your results from the spectrophotometric determination to decide what concentration of base you should use for the titration. Determine the pK_a 's (as many as possible) of phosphoric acid from your data. [Hint: Review the determination of the pK_a for acetic acid in Experiment 17.]

Hints and other important information for Project 4

Before analyzing the cola, you must remove the dissolved carbon dioxide by heating just below the boiling point for about 20 minutes. Note that some water could be lost during this process due to evaporation, which must be accounted for in some way.

When using the spectrophotometer, it is best to prepare dilute solutions such that the absorbance measured is less than 1.000.

When analyzing your spectrophotometric data, remember that the salt, KH_2PO_4 , is serving as a source of phosphate ions in the standard solutions. The cola actually contains phosphoric acid, H_3PO_4 .

When using the Logger Pro data collection system, first plug the pH electrode into the interface box, then start the Logger Pro program.

Pieces of equipment and chemicals which are available that might be of use include:

pH electrodes for the Logger Pro interface
 pH 4 and pH 7 buffers (for calibrating the pH electrode)
 25 mL burets
 5 mL, 10 mL and 25 mL pipets
 50 mL, 100 mL and 250 mL volumetric flasks

Projects 5 and 6: Kinetics

The FD&C Blue #1 dye, which is commercially available in solution as "food coloring", will react with sodium hypochlorite, NaOCl, which is the major component of household bleach. During this reaction, the blue color fades to give a colorless or pale yellow solution:



The progress of the reaction can be studied spectrophotometrically by following the disappearance of the blue reactant at **630 nm**.

The rate equation for the reaction is:

$$-\frac{d[\text{Blue \#1}]}{dt} = k[\text{Blue \#1}]^x[\text{NaOCl}]^y$$

Eq. 1

However, if sodium hypochlorite is present in a large excess, its concentration can be assumed to remain constant, and it is possible to find the "pseudo" order of the reaction with respect to Blue #1:

$$-\frac{d[\text{Blue \#1}]}{dt} = k_1[\text{Blue \#1}]^x$$

Eq. 2

When using the spectrophotometer, it is best to prepare dilute solutions such that the absorbance measured is less than 1.000. Prepare a Blue #1 solution of appropriate concentration by diluting drops of the food coloring in water. Determine the concentration of the resulting solution using Beer's law, given that the length of the absorption cell is 1.00 cm and the molar absorptivity of Blue #1 is $1.38 \times 10^5 \text{ M}^{-1}\text{cm}^{-1}$.

You will be provided with a 6% solution of bleach (6 g of NaOCl per 100 g of solution). Mix 5.25% NaOCl solution with the Blue #1 solution that you have prepared in such a ratio that the blue color fades at a measurable rate. [Note: Because the bleach solution will be much more concentrated than your Blue #1 solution, the sodium hypochlorite will be present in large excess.]

Project 5. A Study of the Effects of Concentration on the Rate of a Reaction

Determine the rate constant, k_1 , and the order of the reaction between Blue #1 and bleach using the method employed in Experiment 14.

Vary the initial concentration of Blue #1 and determine the effect that this has on the initial rate of the reaction. Determine the rate order and rate constant from this data (see

Tro, section 13.3). Does varying the initial concentration of Blue #1 have an effect on either the order of the reaction or the rate constant?

Looking at the rate equations for the reaction, **Eq. 1** and **Eq. 2**, we can conclude:

$$k_1 = k[\text{NaOCl}]^y$$

Determine y , the order of the reaction with respect to NaOCl, by changing the concentration of NaOCl and measuring the rate of the reaction. How does this change affect k_1 ?

Other food dyes will also react with bleach. Compare the rate of reaction of Yellow #5 with bleach to the rate of the Blue #1 and bleach reaction. The yellow absorbance can be measured at **425 nm** and the molar absorptivity is $2.83 \times 10^4 \text{ M}^{-1}\text{cm}^{-1}$. Green food dye is a combination of Blue #1 and Yellow #5. Does the bleaching reaction rate change for either dye when they are present together in this mixture?

Project 6. A Study of the Effects of Temperature on the Rate of a Reaction

Determine the rate constant, k_1 , and the order of the reaction between Blue #1 and bleach using the method employed in Experiment 14.

Examine the effect of temperature on the rate of the reaction. Determine the energy of activation, E_A , and the frequency factor, A (see Tro, section 13.5). This analysis should include a plot.

If there is time, examine the effect of temperature on the rate of reaction of Yellow #5 with bleach. The yellow absorbance can be measured at **425 nm** and the molar absorptivity is $2.83 \times 10^4 \text{ M}^{-1}\text{cm}^{-1}$.

The reaction may be placed in a water bath of constant temperature and removed periodically to quickly measure the absorbance. The reaction should be immediately returned to the water bath after the absorbance is recorded. To obtain a constant temperature for the bath, water is heated to the desired temperature and then ice can be added as needed to maintain the temperature of the bath over time.

Hints and other important information for Projects 5 and 6

When using the Logger Pro data collection system, first plug the temperature probe into the interface box, then start the Logger Pro program.

Pieces of equipment and chemicals which are available that might be of use include:

- thermometers and/or temperature probes
- thermometer clamps
- 5 mL, 10 mL and 25 mL pipets
- 50 mL, 100 mL and 250 mL volumetric flasks
- 25 mL burets
- large Styrofoam buckets