1) Out of your drawer you are going to need a clean 125 ml Erlenmeyer flask and a clean 50 ml graduated cylinder. If these are not clean, clean them now. Also, quickly rinse your 100 ml volumetric flask with distilled water (I have cleaned this for you).

2) There are two stations, one per hood, where you can make your bleach solution. You will find in each hood a labeled beaker filled with bleach. Using the 5-ml volumetric pipet in the hood, pipet 5.00 ml of the bleach into your volumetric flask, take the flask back to your station, and dilute to the mark with distilled water. Cover the flask with parafilm and mix well.

3) Pour 30 ml of the diluted bleach solution into your 50 ml graduated cylinder, and using the 25ml volumetric pipet, pipet 25 ml of the solution into your clean Erlenmeyer flask.

4) Have one member of your lab group weigh out approximately 2.00 g of KI. The exact mass is not important, but near 2.00 g.

5) Go to the hood and add the KI you just measured along with approx. 25 ml of distilled water. Slowly, with stirring, add 2.0 ml of 3M HCl. Record your observations.

Observations:

6) Place your Flask under your buret. Titrate with the 0.10 M thiosulfate solution until the iodine color becomes “morning-urine” yellow. Add 2-3 drops of starch solution, which should cause the solution to become dark blue. Continue the titration until **one drop** makes the solution clear. Record the final volume of the buret.

7) Repeat the titration until you have two consistent titrations. **Note: you only have 4 shots to get this right because you only have 100 ml of solution.**

Data Table:

<table>
<thead>
<tr>
<th></th>
<th>Trial I</th>
<th>Trial II</th>
<th>Trial III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume of Diluted Bleach Used:</td>
<td>25.00 ml</td>
<td>25.00 ml</td>
<td></td>
</tr>
<tr>
<td>Mass of KI used:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial Buret Reading (.01 ml)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Buret Reading (.01 ml)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Notes on Lab Write-up:  
Analysis of bleach (due Thurs)

This is a simple, quick writeup. You want to do the following:

Calculations:

The reactions that occurred were as follows:

**Iodide is oxidized by bleach presence of acid:**

\[ 2H^+ (aq) + \text{ClO}^- (aq) + 2\text{I}^- (aq) \rightarrow \text{Cl}^- (aq) + \text{I}_2 (aq) + \text{H}_2\text{O} (aq) \]

Iodine, being nonpolar, is not very water soluble. However, it will react, or complex with excess iodide ion to form **triiodide ion**.

\[ \text{I}_2 (aq) + \text{I}^- (aq) \rightarrow \text{I}_3^- (aq) \]

The triiodide ion is what you actually saw, as it was what imparted the yellow-red color to the solution. Without the excess iodide, the iodine would have precipitated out of the solution, and the titration would have been much more difficult.

As the triiodide ion was titrated with the thiosulfate, the following reaction occurred:

\[ \text{I}_3^- (aq) + 2\text{S}_2\text{O}_3^{2-} (aq) \rightarrow 3\text{I}^- (aq) + \text{S}_4\text{O}_6^{2-} (aq) \]

As the last reaction occurred, the red-brown color of the triiodide faded to yellow, and would have ultimately gone clear. However, it is very difficult to tell when a yellow solution ultimately goes clear. Hence, the starch was added to form a reversible blue complex which is a much more precise method for determining the endpoint. Consequently, if you know the amount of thiosulfate that reacted, you can determine the amount of bleach initially in the solution.

What you need to do is as follows:

1) Determine the amount of bleach pipetted into your Erlenmeyer flask based on the amount of thiosulfate that reacted. (do this for each trial and avg the results)

2) Calculate the molarity of your diluted bleach

3) Calculate the molarity of the commercial bleach, using the fact you took 5 ml of the commercial bleach and diluted it to 100 ml to make your dilute solution.

4) Assuming the density of the commercial bleach solution is 1.09 g/ml, calculate the percent by mass of NaClO in the bleach.

5) Clorox reports that the percent by mass of the bleach is 8.25%. Assuming this is correct, calculate the percent error.

Discussion:

Two things need to be mentioned in your discussion section. You should state both redox reactions and identify what is oxidized and what is reduced, using oxidation
numbers to support your argument. In addition, you should distinguish between the concepts of equivalence point and endpoint, as they apply to titrations.

**Error:**
You will need to discuss sources of error if your concentrations calculated in each trial are significantly different. Also, discuss why the amounts of acid and iodide did not need to be precisely known.

Finish the lab with a standard conclusion.
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(Before Or After Performing An Experiment)
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<th>Page</th>
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<td>Instructions for Linear Regression</td>
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<td>307</td>
</tr>
</tbody>
</table>
Preface to the 2015 Edition:
As we are constantly trying to improve upon our lab manual we have added several new labs: 1. What is Mystical about *Mystical Fire* that asks students to analyze the colors observed in a flame and to formulate and test their hypotheses on the system, 2. Analysis of a Mixture, a follow-up to the lab that analyzes a Hydrate, and several “dry-labs” that are designed to allow students to perform lab type activities while the Chemistry Teacher, you, are not present in the classroom. We trust that you will find these additions worthwhile.

Preface to the 2014 Edition:
Welcome to this “mini update” to our inquiry lab manual. We have all survived the first year of the new AP Chemistry curriculum, and, as we theorized, the ability to interpret and analyze laboratory data were heavily scrutinized skills on the 2014 AP Chemistry exam. As every question on the exam must combine content with one of the seven science practices as outlined in the curriculum framework, we know that students who can plan an investigation, experiment, and reflect on data will certainly have an excellent foundation for both the AP examination and future work in the sciences.

There are few changes to the manual from the 2013 edition. In addition to the never-ending process of editing and correction, we present one new laboratory in the manual, Mass Spec Madness, that should really cement student understanding of mass spectra. Spectroscopy and spectrometry are the lynchpins of modern chemical analysis, and students in a modern chemistry program must have exposure to these techniques. As always, we hope the laboratories presented here continue to ease the planning for teachers in incorporating inquiry based labs while providing students with fertile experiences in chemical experimentation.

Preface to the 2013 Edition:
It is hard to believe that it has been over four years since the inception of this manual. Since that time, we have been humbled by the positive response received from participants at numerous workshops and from many friends we have made through email and social media. We are pleased that students throughout the country have been able to be exposed to the excitement and challenge offered by our inquiry model of laboratory work.

This year brings big changes to the AP examination in chemistry. Any time significant core changes are made to a class such as this, there will obviously be a lot of uncertainty and trepidation for those of us responsible for delivering the course to our students. The new curriculum framework designed by the College Board does a commendable job of outlining the changes and distributing exemplar question types for the new examination, and we have been hard at work making sure this manual continues to align with the needs of AP Chemistry teachers around the world.

We are extremely fortunate that, in terms of the laboratory component, the College Board seems to have “read our minds”, as the new emphasis on inquiry aligns perfectly with the core philosophy of this manual. *Inquiry* is a heated buzzword in the AP Chemistry community of late, and the exact definition of what distinguishes one level of inquiry from the next will easily vary from person to person. Several resources ranging from established research journals, to the Internet, to the recent AP Chemistry lab manual published by the College Board, will each give their own exemplars. Indeed, even as you read this manual we bet that you have your own definitions. We are excited that these discussions are active as they can only improve instruction for our students.
As you look at the organization of this edition of the manual, we want to point out three significant changes:

- All labs are now organized around the six “Big Ideas” that are fundamental to the new AP Chemistry course. This will allow you to quickly choose among labs that pique your and your student’s interests while also fulfilling the curricular requirements of the course.
- All experiments have been correlated to a primary learning objective(s) and science practices as outlined in the College Board Curriculum Framework for AP Chemistry. These correlations are listed on pages 8 and 9 of this manual.
- An appendix now lists additional questions (with answers) teachers can ask students either during a pre-lab session or a post-lab analysis.
- Finally, the table on pages 8 and 9 will also list an Inquiry Level (IL) for the lab. We list three IL’s in the manual:
  - Level 2 – A lab that many would consider “Guided Inquiry” in which the student is presented with a laboratory problem and must come up with their own procedure to solve this question.
  - Level 1 – A lab many would consider “Structured Inquiry” in which the student is presented with a laboratory problem but is given a procedure to help solve the problem.
  - Level 0 – A lab many would consider “Verification” which is often critical in the chemistry laboratory to teach technique and develop the higher order skills needed to successfully complete Level 1 and Level 2 labs at a later time.

Some of the labs will also be labeled as a Capstone experiment (**). Capstone labs will be Level 2 labs that will really push your students and may be more appropriate in some years rather than others. These labs are also designated in the correlation table. We are certain that the diversity of experiments coupled with multiple layers of inquiry will give you tremendous flexibility from year to year in selecting appropriate and exciting laboratory experiences for your students.

Although the new curricular requirements for AP Chemistry have lowered the number of mandatory laboratory experiences from 22 to 16, many new experiments make their appearance in this edition to ensure adequate support for all required laboratory experiences. Specifically, you will find new topics in laboratory techniques and precision, thermodynamics, kinetics, and equilibrium. In addition, in order to successfully complete the AP audit for Chemistry, each instructor must list the title of each lab with the associated SP(s) for that experiment. We hope that by including this information for each of the labs in the manual, it will help you both decide which experiments to perform as well as aid you in completing curricular requirements 5, 6, and 7 of your syllabus.

Several of the LO’s in the new curriculum framework address specific laboratory experiences. Other LO’s consistently support these primary-learning objectives. Listed below are the descriptions of the primary learning objectives addressed in this manual. As stated above, a correlation table does list the primary LO number(s) of the lab experience. Please use the list below to cross-reference the details of that LO. In addition, we provide a list of all the Science Practices for AP Chemistry as an appendix to the manual.

<p>| LO 1.3 | The student is able to select and apply mathematical relationships to mass data in order to justify a claim regarding the identity and/or estimated purity of a substance. |
| <strong>LO 1.4</strong> | The student is able to connect the number of particles, moles, mass, and volume of substances to one another, both qualitatively and quantitatively. |
| <strong>LO 1.6</strong> | The student is able to analyze data relating to electron energies for patterns and relationships. |
| <strong>LO 1.14</strong> | The student is able to use data from mass spectrometry to identify the elements and the masses of individual atoms of a specific element. |
| <strong>LO 1.15</strong> | The student can justify the selection of a particular type of spectroscopy to measure properties associated with vibrational or electronic motions of molecules. |
| <strong>LO 1.16</strong> | The student can design and/or interpret the results of an experiment regarding the absorption of light to determine the concentration of an absorbing species in a solution. |</p>
<table>
<thead>
<tr>
<th>LO</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LO 1.19</strong></td>
<td>The student can design, and/or interpret data from, an experiment that uses gravimetric analysis to determine the concentration of an analyte in a solution.</td>
</tr>
<tr>
<td><strong>LO 1.20</strong></td>
<td>The student can design, and/or interpret data from, an experiment that uses titration to determine the concentration of an analyte in a solution.</td>
</tr>
<tr>
<td><strong>LO 2.6</strong></td>
<td>The student can apply mathematical relationships or estimation to determine macroscopic variables for ideal gases.</td>
</tr>
<tr>
<td><strong>LO 2.10</strong></td>
<td>The student can design and/or interpret the results of a separation experiment (filtration, paper chromatography, column chromatography, or distillation) in terms of the relative strength of interactions among and between the components.</td>
</tr>
<tr>
<td><strong>LO 2.22</strong></td>
<td>The student is able to design or evaluate a plan to collect and/or interpret data needed to deduce the type of bonding in a sample of a solid.</td>
</tr>
<tr>
<td><strong>LO 3.3</strong></td>
<td>The student is able to use stoichiometric calculations to predict the results of performing a reaction in the laboratory and/or to analyze deviations from the expected results.</td>
</tr>
<tr>
<td><strong>LO 3.4</strong></td>
<td>The student is able to relate quantities (measured mass of substances, volumes of solutions, or volumes and pressures of gases) to identify stoichiometric relationships for a reaction, including situations involving limiting reactants and situations in which the reaction has not gone to completion.</td>
</tr>
<tr>
<td><strong>LO 3.5</strong></td>
<td>The student is able to design a plan in order to collect data on the synthesis or decomposition of a compound to confirm the conservation of matter and the law of definite proportions.</td>
</tr>
<tr>
<td><strong>LO 3.9</strong></td>
<td>The student is able to design and/or interpret the results of an experiment involving a redox titration.</td>
</tr>
<tr>
<td><strong>LO 3.10</strong></td>
<td>The student is able to evaluate the classification of a process as a physical change, chemical change, or ambiguous change based on both macroscopic observations and the distinction between rearrangement of covalent interactions and noncovalent interactions.</td>
</tr>
<tr>
<td><strong>LO 3.12</strong></td>
<td>The student can make qualitative or quantitative predictions about galvanic or electrolytic reactions based on half-cell reactions and potentials and/or Faraday's laws.</td>
</tr>
<tr>
<td><strong>LO 3.13</strong></td>
<td>The student can analyze data regarding galvanic or electrolytic cells to identify properties of the underlying redox reactions.</td>
</tr>
<tr>
<td><strong>LO 4.1</strong></td>
<td>The student is able to design and/or interpret the results of an experiment regarding the factors (i.e., temperature, concentration, surface area) that may influence the rate of a reaction.</td>
</tr>
<tr>
<td><strong>LO 4.2</strong></td>
<td>The student is able to analyze concentration vs. time data to determine the rate law for a zeroth-, first-, or second-order reaction.</td>
</tr>
<tr>
<td><strong>LO 4.7</strong></td>
<td>The student is able to evaluate alternative explanations, as expressed by reaction mechanisms, to determine which are consistent with data regarding the overall rate of a reaction, and data that can be used to infer the presence of a reaction intermediate.</td>
</tr>
<tr>
<td><strong>LO 5.6</strong></td>
<td>The student is able to use calculations or estimations to relate energy changes associated with heating/cooling a substance to the heat capacity, relate energy changes associated with a phase transition to the enthalpy of fusion/vaporization, relate energy changes associated with a chemical reaction to the enthalpy of the reaction, and relate energy changes to $\Delta H/\Delta V$ work.</td>
</tr>
<tr>
<td><strong>LO 5.7</strong></td>
<td>The student is able to design and/or interpret the results of an experiment in which calorimetry is used to determine the change in enthalpy of a chemical process (heating/cooling, phase transition, or chemical reaction) at constant pressure.</td>
</tr>
<tr>
<td><strong>LO 5.8</strong></td>
<td>The student is able to use LeChatelier's principle to predict the direction of the shift resulting from various possible stresses on a system at chemical equilibrium.</td>
</tr>
<tr>
<td><strong>LO 5.9</strong></td>
<td>The student is able to use LeChatelier's principle to design a set of conditions that will optimize a desired outcome, such as product yield.</td>
</tr>
<tr>
<td><strong>LO 6.13</strong></td>
<td>The student can interpret titration data for monoprotic or polyprotic acids involving titration of a weak or strong acid by a strong base (or a weak or strong base by a strong acid) to determine the concentration of the titrant and the $pK_a$ for a weak acid, or the $pK_b$ for a weak base.</td>
</tr>
<tr>
<td><strong>LO 6.16</strong></td>
<td>The student can identify a given solution as being the solution of a monoprotic weak acid or base (including salts in which one ion is a weak acid or base), and calculate the $pH$ and concentration of all species in the solution and/or infer the relative strengths of the weak acids or bases from given equilibrium concentrations.</td>
</tr>
<tr>
<td><strong>LO 6.17</strong></td>
<td>The student can, given an arbitrary mixture of weak and strong acids and bases (including polyprotic systems), determine which species will react strongly with one another (i.e., with $K &gt; 1$), and what species will be present in large concentrations at equilibrium.</td>
</tr>
<tr>
<td><strong>LO 6.18</strong></td>
<td>The student can design a buffer solution with a target $pH$ and buffer capacity by selecting an appropriate conjugate acid-base pair and estimating the concentrations needed to achieve the desired capacity.</td>
</tr>
</tbody>
</table>
With the emphasis on data collection and analysis in the new AP Chemistry curriculum, we feel, more that ever, that the experiences available to your students in this manual will position your students for success in their studies. If you have any questions, please contact Jesse Bernstein (bernsteinj@miamicountryday.org), or Jeff Bracken (brackenchem@gmail.com), or Paul Price (pricep@trinityvalleyschool.org) at any time. We welcome your comments!

Preface to the 2011 Edition:
The College Board has Twenty-Two (22) recommended laboratory experiments from which the A.P. Chemistry Exam takes its laboratory question(s). This laboratory manual addresses those experiments in a manner different from most every other laboratory manual. That is, we have taken the traditional experimental procedure and changed the problem such that the student is expected to have to think logically about how to accomplish the task of either answering a question posed or solving a problem. Few of the laboratory experiments included herein might be considered as traditional laboratory experiments. However, the ability for students to reason through a laboratory situation, as opposed to simply completing a “cookbook lab”, is critical when students encounter a laboratory question that may not be identical to the lab they have performed. Since several laboratory performance goals can be accomplished in a myriad of ways, we have included more than one lab for certain suggested experiments Thus, you have a choice as to which lab you wish to have your students work on in a particular year. In addition, we have included for each of the experiments a teacher’s guide that includes a suggested introduction of the experiment, instructions on how to prepare the chemicals required for each lab, possible source(s) of error that a student might make, a sample set of data and calculations, and a rubric for labs that have a specific outcome. In addition, we have included some laboratory experiments that we think are just plain neat but do not fit into a specific recommended laboratory experiment. In addition, we have added experiment #40, Investigating Electrochemical Cells, to complement experiment #39, The Electrolysis of Salt Solutions. This new version, Exp. 40, can be used instead of or in addition to Exp. 39.

Each experiment contained in this manual contains a sample rubric or “skill categories” that attempts to add humor to the students’ laboratory experience. For some of our experiments, a specific error range and grading scale that we use in our own classroom has been included. For example, “What Volume Do You Want?” and “The Great Buffer Challenge” each show complete rubrics with the humorous skill categories. It is important to note that these ranges for experimental error were created based on instructor error as well as reviewing student results over multiple classes. The acceptable error range is solely based on YOUR own situation (precision of electronic balances, purity of laboratory chemicals, accuracy of stockroom solutions, etc.). Teachers may wish to allow for greater error when using these experiments in their own classrooms to ensure that a perfect laboratory score is realistically achievable. Teachers will need to perform these experiments for themselves to establish their own rubrics to create fair assessment strategies. It is important for students to view these scoring standards as being reasonable.

The experiments that follow use certain equipment on a regular basis. Although we do not endorse one science supply company, we have included the 2015 Flinn catalog numbers for clarification purposes. The following items are commonly used throughout this laboratory manual:

Micro-tip pipets: Flinn catalog number AP1517 (for the box of 500)
Straight stem pipets: Flinn catalog number AP1444 (for box of 500)
Combination well plates: Flinn catalog number (AP8567)

**Leaning Objectives Laboratory Correlations**

<table>
<thead>
<tr>
<th>Lab #</th>
<th>Lab Title</th>
<th>Inquiry Level</th>
<th>Primary LO</th>
<th>Science Practice(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What is Mystical About <em>Mystical Fire</em></td>
<td>2</td>
<td>1.16</td>
<td>2,4,5</td>
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<tr>
<td>2</td>
<td>Colorimetry, An Introduction</td>
<td>1</td>
<td>1.16</td>
<td>2,4,5</td>
</tr>
<tr>
<td>3</td>
<td>The Case of The Late Grape</td>
<td>1</td>
<td>1.16</td>
<td>2,4,5</td>
</tr>
<tr>
<td>4</td>
<td>The Case of the Drowned Faculty Member</td>
<td>1</td>
<td>1.16</td>
<td>2,4,5</td>
</tr>
<tr>
<td>5</td>
<td>Driving Under the Influence</td>
<td>0</td>
<td>1.16</td>
<td>2,4,5</td>
</tr>
<tr>
<td>6</td>
<td>Studying the Emission Spectra of Atoms</td>
<td>0</td>
<td>1.15, 1.6</td>
<td>2,4,5</td>
</tr>
<tr>
<td>7</td>
<td>Aegean Formula 55</td>
<td>0</td>
<td>1.19</td>
<td>2,4,5,6</td>
</tr>
<tr>
<td>8</td>
<td>Avogadro's Number by Monomolecular Film</td>
<td>0</td>
<td>1.4</td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td>The Average or Apparent Mass of an Element</td>
<td>0</td>
<td>1.3, 1.14</td>
<td>1,2,4,5,6</td>
</tr>
<tr>
<td>10</td>
<td>Mass Spec Madness**</td>
<td>2</td>
<td>1.14</td>
<td>1,2,4,5,6</td>
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<tr>
<td>11</td>
<td>Standardization of an Acid with a Base</td>
<td>2</td>
<td>1.20, 6.13</td>
<td>2,4,5,6</td>
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<tr>
<td>12</td>
<td>Molarity of Vinegar</td>
<td>2</td>
<td>1.20, 6.13</td>
<td>2,4,5,6</td>
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<tr>
<td>13</td>
<td>Peter Piper’s Pickles</td>
<td>1</td>
<td>1.20, 6.13</td>
<td>2,4,5,6</td>
</tr>
<tr>
<td>14</td>
<td>When Good Wine Goes Bad</td>
<td>1</td>
<td>1.20, 6.13</td>
<td>2,4,5,6</td>
</tr>
<tr>
<td>15</td>
<td>Titration of a Weak Base</td>
<td>1</td>
<td>1.20, 6.13</td>
<td>2,4,5,6</td>
</tr>
<tr>
<td>16</td>
<td>Titration of Household Ammonia**</td>
<td>2</td>
<td>1.20, 6.13</td>
<td>2,4,5,6</td>
</tr>
<tr>
<td>17</td>
<td>Titration of Aspirin</td>
<td>1</td>
<td>1.20, 6.13</td>
<td>2,4,5,6</td>
</tr>
<tr>
<td>18</td>
<td>The Formula of a Metal Hydroxide**</td>
<td>2</td>
<td>1.20, 6.13</td>
<td>2,4,5,6</td>
</tr>
<tr>
<td>19</td>
<td>Building Industry Group</td>
<td>1</td>
<td>1.20, 3.3</td>
<td>2,4,5,6</td>
</tr>
<tr>
<td>20</td>
<td>Equal Growers Group</td>
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** Capstone Laboratory Experiments
Lab 13: Peter Piper's Pickles

A.P. Chemistry Class
Name of Your School
Address of Your School
City, State Zip Code

Dear A.P. Chemistry Students,

The process of adding vinegar, salt and spices to pickles to produce a quality of taste and crunch has always been taken for granted. Lately, the pickles being produced have been of a lesser quality. It is important to our industry that the standards that have been set over the many years are continued. Thus, we would ask for your help. Please determine if the amount of vinegar that is present in the brine is within the range set by our industry (0.05 – 0.30 M Acid).

Sincerely,

Dillbert Verjuice

Encl.: suggested procedure
Lab 13: Peter Piper's Pickles

Problem:
Recently the process that produces the famous Peter Piper Pickles has not yielded the same crunchy pickles consumers have come to expect. Something is wrong. The process of pickle manufacturing involves adding a hot brine of vinegar, salt and spices. Alum and calcium chloride are also added to produce a firm pickle. The vinegar’s acidity prohibits bacterial growth and provides a longer shelf life.

We believe that checking the acidity of the brine will give us information that we can then use to produce quality pickles once again. Two problems present themselves:
- What concentration of base, 0.500 M, 0.100 M should be used for vinegar analysis (to at least 2 sig. Figs), and
- The pickle brine at this concentration in the jar might interfere with the phenolphthalein indicator. If the sample is diluted, should the NaOH also be diluted?

Materials Available:
- Erlenmeyer Flask, 25 or 50 mL
- 100 mL beaker
- NaOH, 1.0 M, 0.50 M, 0.10 M
- micro-tip pipets
- phenolphthalein indicator
- distilled water
- Peter Piper Pickle Juice

Safety Concerns:
Students should wear safety goggles and laboratory aprons throughout this experiment. Students should exercise care when working with the chemicals. Clean up all spills as soon as possible. Students should wash their hands after completing this experiment.

Suggested Procedure:
1. Add at least 50 drops (micro-tip pipet dropper) of Pickle Juice to the Erlenmeyer flask.
2. Add some distilled water to reduce the color of the pickle juice.
3. Add one or two drops of phenolphthalein indicator.
4. Titrate the pickle juice with the NaOH solution that you have chosen.
5. Repeat as necessary.

Lab Report:
Your lab report should consist of the following:
- Experimental procedure
- Data table summarizing your results
- Calculations showing the concentration of acetic acid (vinegar) in mole/Liter in the pickle brine
- Letter to Mr. Dilbert Verjuice indicating what you determined regarding the pickles
Lab 13: Peter Piper's Pickles  
(Teacher’s Notes)

Prerequisite Concepts:
- Titrations
- Acid-base concepts
- Use of Indicators
- Mole concept
- Dilution of a solution

Prerequisite Laboratory Skills:
- Titrations

Materials Available:
- Erlenmeyer Flask, 25 or 50 mL
- 100 mL beaker
- NaOH, 1.0 M, 0.50 M, 0.10 M
- micro-tip pipets
- phenolphthalein indicator
- Peter Piper Pickle Juice
- distilled water

Suggested Introduction:
Pickle juice consists of a number of substances including vinegar. One should be able to titrate the vinegar (dilute acetic acid) using an indicator as long as the color of the juice does not interfere with the color of the indicator.

Common Student Errors:
Some sources of error include the miscounting of drops, having difficulty seeing the color change of the indicator (for a number of reasons including not diluting the juice with sufficient distilled water) and going past the end point because of titrating too quickly.

Successful Strategy:
To a small Erlenmeyer Flask (25 mL), add 50 drops (micro-tip dropper; 60 dp/mL) of Peter Piper Pickle juice. Add distilled water to the 10 mL mark. Add 2 drops of phenolphthalein indicator. Titrate with 0.50 M NaOH

Clean Up: Discard all solutions in the sink while the water is running.

Sample Data and Calculations:
Drops Pickle Juice: 50 dps   Drops NaOH: 12 dps

12 drops x (1 mL/60 drops) x (1L/1000 mL) x (0.50 M NaOH/1 L) x (1 mole Acetic Acid/1 mole NaOH) = 1.0 x 10^{-4} mole Acetic Acid

50 dp juice x (1 mL/60 dp juice) x (1 L/1000 mL) = 8.33 x 10^{-4} L juice
= 1.0 x 10^{-4} mole Acetic Acid / 8.33 x 10^{-4} L juice = 0.12 M Acetic Acid in Pickle juice

Notes: The pickles were obtained from a local super market. The name used is the actual brand (coincidentally).
Rubric: Peter Piper's Pickles

10 pts – You crunched the numbers beautifully!

9 pts – Either way you slice it, you missed by a slight bit.

8 pts – Back to raising cucumbers for you

7 pts – Now who’s in a pickle?

6 pts – I needed an Indicator? The Pickle Juice already had a color to it!