Bridging the Gap Between First and Second Semester General Chemistry: A Laboratory Exercise

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Abstract: A simple yet challenging exercise that reviews many fundamental chemical concepts and laboratory techniques from first semester general chemistry is offered for use in the first laboratory period of the second semester general chemistry course. This exercise is easy to do and involves a minimal amount of equipment and reagents. Students at the author's school like this exercise because they get good results, yet feel challenged because they have to think for themselves.

Here at Harper College, the first laboratory period of our second semester general chemistry course is devoted to equipment and locker check-in and a safety orientation. These activities require about an hour, so we usually have at least two-thirds of our three-hour lab period left. Most of our students have indicated they appreciate a good review before proceeding to the new material, so we have developed a simple exercise to fill this left-over time in their first laboratory period. We call it "Laboratory Review Challenge" because it reviews important, fundamental concepts from the first semester of general chemistry and challenges the students to think for themselves rather than follow a detailed recipe procedure. This exercise provides students the opportunity to practice and review most, if not all, of the following:

1) weighing techniques
2) dilution techniques
3) separation techniques
4) reading a meniscus
5) writing and balancing equations
6) writing net ionic equations
7) classifying chemical reactions
8) reaction stoichiometry
9) solution stoichiometry and concentration units
10) acid–base indicators
11) electrolytes and conductivity

In the laboratory, students are first asked to write and balance an equation for the double substitution reaction between calcium hydroxide and hydrochloric acid. They then practice their weighing and dilution techniques by preparing the reactants. To begin, each student is asked to weigh a sample of solid calcium hydroxide within a suggested range (between 0.5 and 1.0 g) and then dilute any one of several available stock HCl solutions to 0.7 M. By doing these things, students review how to operate a balance, perform dilution calculations, and use a volumetric flask properly. A range of calcium hydroxide masses is suggested and at least two stock solutions of HCl (3 M and 6 M) are set out so that students will have different data and results, depending on their own personal choices.

Students are then asked to use the balanced chemical equation they wrote to calculate how much of their 0.7 M hydrochloric acid solution is necessary to react completely with their sample of calcium hydroxide. Performing this calculation affords students the opportunity to review the concepts of solution stoichiometry and limiting reactant.

Next, students dissolve their calcium hydroxide in 50–100 mL of water and add a couple drops of phenolphthalein to the solution. This step reviews acid–base indicators and color changes. The indicator is used as a check for the students when they mix their reactants to see if their calculations were correct. They are asked to measure and see how much of their previously calculated volume of dilute hydrochloric acid solution is necessary to change the color of the indicator in their calcium hydroxide solution. If their calculations were correct, the volume of HCl they have used should be close to the volume they calculated. (Using a graduated cylinder introduces some error, and undissolved calcium hydroxide in the reaction beaker can also be a common source of error.)

After the students have successfully obtained an indicator color change by mixing the proper amounts of reactants, they are asked to think about the products of the reaction they just performed. What substances are now present in the reaction vessel? What are the products of the reaction? Are any reactants left over? Should the solution conduct electricity? Students decide yes or no, and then use a conductivity apparatus to determine whether their decision was correct. Writing a net ionic equation for the double substitution reaction pinpoints which substances are responsible for the conductivity.

To end the exercise, students are challenged to devise a way to separate the products of their reaction mixture. Most students select evaporation. Recovery of ionic salts using this technique isn't an easy task because of spattering problems. The instructor should ensure that students use the proper equipment and technique to prevent this problem. If time permits, students can be asked to calculate the theoretical yield of salt formed from their reaction and calculate a percent yield.

In summary, this lab exercise is short, simple in design, and easy to do. It involves the review and application of many fundamental chemical concepts and provides an excellent opportunity for students to prepare themselves for the second semester of general chemistry. Students have an opportunity to get off to a good start when they do this exercise. They are encouraged if they get good results, yet they feel challenged because they have to think for themselves. There are many possibilities for variation of the procedure or inclusion of thought-provoking questions as they do the experiment. For example, “Why doesn’t it matter how much water you use to dissolve the calcium hydroxide before you mix it with the hydrochloric acid?” or “Could another indicator be used to signal the end of the reaction?”

Laboratory Review Challenge

This exercise will test how well you’ve mastered several important concepts including: electrolytes, molar concentration, dilution of solutions, and stoichiometric calculations. Your success will also depend on how well you’ve mastered important laboratory techniques such as: handling liquids, measuring and recording volumes, handling solids, measuring and recording mass, and performing separations.

Instructions in the procedure below are minimal; part of the challenge is to perform your own calculations and decide how you want to accomplish the various activities you’re asked to do.

Procedure:

1) Begin by writing and balancing the chemical equation for the double substitution reaction between aqueous calcium hydroxide and aqueous hydrochloric acid.
2) Use a volumetric flask to prepare 100 mL of 0.7 M hydrochloric acid solution. Do this by diluting one of the stock hydrochloric acid solutions that have been set out for you to use. (Remember always to add acid to water, not the other way around. Fill your volumetric flask about half full with water, add the appropriate volume of stock acid solution, and then complete the dilution.) **WARNING! Hydrochloric acid will cause burns. Handle carefully.**
3) Weigh between 0.5 and 1.0 gram of solid calcium hydroxide. Dissolve your calcium hydroxide sample in about 50-100 mL of water (the resulting solution might be somewhat cloudy).
4) Add 4 or 5 drops of phenolphthalein indicator to the calcium hydroxide solution. (Acid color is colorless; basic color is magenta.)
5) Using the balanced chemical equation you wrote, calculate the volume of your diluted hydrochloric acid solution that will be necessary to react completely with the amount of calcium hydroxide in your sample.
6) Using either a graduated cylinder or a buret, slowly add the amount of hydrochloric acid you calculated in step 5 to your calcium hydroxide sample until the indicator color changes. Record the volume of your acid solution that’s actually necessary to cause a complete reaction (the indicator color will change permanently when all the calcium hydroxide has reacted). If you see some undissolved calcium hydroxide residue in the beaker, crush it with your stirring rod to ensure a complete reaction. If you did everything correctly, the indicator color will have changed when you’ve added the amount of acid you calculated in step 5 (±1 or 2 mL, allowing for experimental error). If your calculated and experimental volumes differ by more than 3 mL, check your calculations and try again.
7) Do you think the contents of the beaker after reaction has occurred will conduct electricity? Use the conductivity apparatus to check.
8) Devise a way to separate the products of this reaction, and do so. **Check with your instructor before you actually do this, to ensure that your method is safe.** Show your instructor the results of your separation and keep the results for step 9.
9) Calculate the theoretical yield of the salt that should have formed in your reaction and compare it to your actual yield. Calculate the percent yield. Can you think of one or more reasons why the two yields might be different?

Acknowledgment. The author wishes to thank her colleagues Julie Ellefson Kuehn and Barbara Q. Weil for their encouragement and suggestions.