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#17 Determining the Accuracy of Selected Laboratory Glassware

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Introduction

Description

By using the density formula, students will calculate the volume of a specific mass of water placed in selected pieces of common laboratory glassware. Students will then determine the accuracy of the volumetric measurement for selected pieces of laboratory glassware.

Student Audience

This experiment is designed for high school honors or advanced placement chemistry students, as well as freshman college chemistry students. This experiment might also be done at the beginning of an Analytical Chemistry course by adding some additional statistical analysis.

Goals for the Experiment

The main goals for this experiment are for students to:

- become familiar with the various pieces of laboratory glassware and the proper techniques for use, as well as other common laboratory tools such as balances, ring stands, burette holders, etc.;
- observe that some pieces of laboratory glassware have greater volumetric accuracy than other pieces;
- use the density formula to calculate the volume of a specific mass of a liquid; and
- calculate the percent error for each piece of laboratory glassware used within the experiment.

Recommended Placement in the Curriculum

This experiment should be conducted near the beginning of the term so that students may carry their observations and knowledge gained from this experiment to future experiments.

STUDENT HANDOUT

Determining the Accuracy of Selected Laboratory Glassware

Objectives

1. Use various volumetric glassware.
2. Use the density formula.
3. Determine which volumetric glassware contains or delivers the most accurate volume.
4. Determine the percent error.

Discussion

Choosing the most accurate measuring device for a particular type of measurement is a decision that a chemist must make when selecting equipment to perform an experiment. This is especially true when using volumetric glassware. The time required to use a more sophisticated and expensive piece of equipment must be balanced against the accuracy required for the experiment. It is important for the chemist to determine what step(s) of the procedure is the least accurate and what step(s) in the procedure does not require extremely accurate measurements. These steps will dictate the accuracy required by the measuring device.

In this experiment, you will determine the accuracy of several pieces of common laboratory volumetric glassware. **Listen to the instructions regarding the use of each of these pieces of glassware.**

Procedure

- A. Measure the mass of a clean, dry, empty 50-mL beaker. Carefully fill this beaker to the 20-mL mark (using the markings on the side of the beaker) with deionized (distilled) water. Determine the final mass of the beaker and water. Use the density formula to determine the exact volume of the water. **Repeat this procedure twice more.** (Consider the importance of temperature.)
- B. Perform step A for the following beakers: 100-mL, 250-mL and 400-mL. Fill the 100-mL beaker to the 50-mL mark, the 250-mL beaker to the 100-mL mark, and the 400-mL beaker to the 200-mL mark. **Repeat this procedure twice more for each beaker.**
- C. Measure the mass of a clean, dry, empty 25-mL Erlenmeyer flask. Carefully fill this flask to the 20-mL mark (using the markings on the flask) with deionized water. Measure the final mass of the beaker and water and calculate the mass of the water. **Repeat this procedure twice more.**
- D. Perform step C for the following flasks: 50-mL, 250-mL and 500-mL. Fill the 50-mL flask to the 20-mL mark, the 250-mL flask to the 100-mL mark, and the 500-mL flask to the 200-mL mark. **Repeat this procedure twice more for each flask.**

E. Determine the mass of a dry, empty 50-mL beaker. Using a 5-mL pipette, pipette 5 mL of deionized water into the beaker and measure the new mass. After determining the mass of the water delivered, calculate the exact volume of the water added to the beaker. **Repeat this procedure two more times by pipetting an additional 5 mL of water to the beaker each time.**

F. Repeat step E using a 10-mL pipette and then a 25-mL pipette.

NOTE: When using the 25-mL pipette, you will need to empty, dry, and reweigh the beaker prior to each delivery.

G. Determine the mass of a dry, empty 10-mL graduated cylinder. Fill the graduated cylinder to the 10-mL mark and reweigh. Determine the mass and the exact volume of the water contained in the graduated cylinder. **Repeat this procedure two more times.**

H. Determine the mass of a dry, empty 50-mL graduated cylinder. Fill the 50-mL graduated cylinder to the 25-mL mark with deionized water. Determine the mass and exact volume of the water contained in the graduated cylinder. Fill the graduated cylinder to the 50-mL mark by **adding** more water. **Determine the mass and exact volume of this additional amount of water. Repeat this procedure twice more.**

I. Fill a clean 25-mL burette to the zero mark with deionized (distilled) water. Deliver 10 mL of deionized (distilled) water to a clean, dry, empty, and previously-massed 50-mL beaker. Measure the mass of the beaker and 10 mL of water and determine the exact volume delivered. Continue adding more water from the burette to the 50-mL beaker in 10-mL increments, measuring the mass of the beaker and water and determining the exact volume delivered at the end of each 10-mL increment. Perform this procedure until a **total** of 40 mL has been added. **Repeat this entire process one more time.**

NOTE: Before you add the third 10-mL increment, you will need to refill the buret!!!

HINT FOR THE FUTURE

NEVER deliver more than 25 mL from a 25-mL buret. The space below the 25-mL mark is not calibrated. There may be times this year that you will need to deliver more than 25 mL of liquid from the burette. In these cases you should 1) record the amount of titrant that you have delivered so far, 2) remove the receiving container from under the buret, 3) refill the buret, 4) record the new starting position, 5) reposition the receiving flask, and 6) continue the titration.

When you have collected all the data and determined the exact volume for each of the above steps, compare the results of the exact volume with the volume you thought you added to or delivered from each piece of glassware. Calculate the percent error for each piece of volumetric glassware that you used. (% error = $(\text{Observed} - \text{Exact} / \text{Exact}) \times 100\%$)

NOTE: When doing more than one trial, average the results of these trials to obtain an **average error**.

Questions

1. Which piece of laboratory glassware is the most accurate?
2. Which piece of laboratory glassware is the least accurate?
3. What trend in accuracy do you observe when using the beakers?
4. What trend in accuracy do you observe when using the pipettes?
5. What trend in accuracy do you observe when using the flasks?
6. What trend in accuracy do you observe when using the burettes?
7. What effects will differences in temperature cause?
8. Why is it important to know the accuracy and precision of glassware?
9. What are some of the sources of error in these measurements?

Disposal

All liquids (water) can be disposed by flushing them down the sink.

INSTRUCTOR NOTES

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Time Required

- Performed by an individual student: 4–5 hours
- Performed by a group of two students: 2–3 hours
- Performed by a group of four students: 1½–2 hours

Materials Needed

- deionized (distilled) water at room temperature
- 50-, 100-, 250-, and 400-mL beakers
- 25-, 50-, 250-, and 500-mL flasks
- 10- and 50-mL graduated cylinders
- 5-, 10-, and 25-mL pipettes
- 25-mL burette
- pipette bulbs
- balances with centigram precision and capacity to 300 grams

Note: You may want to include different grades of glassware (i.e., disposable vs. Grade “A”).

Information You Will Want to Supply

You should give your students the density of water at room temperature. You may wish to give this from the **Handbook of Chemistry and Physics**, which gives the value in units of kg/m^3 . Alternatively, students can measure the temperature of the water and look up the correct density to use in the **Handbook of Chemistry and Physics**, or you could provide a table to reference.

Pre-Lab Discussion

You will want to show your students how to properly use

- balances,
- pipettes and pipette bulbs, and
- burettes.

You will also want to perform several example calculations. HINT: You could do this in the form of a handout given at the beginning of the laboratory session or the class meeting prior to performing this experiment. You will certainly want to spend some time going through the conversion calculation of changing the density of water from kg/m^3 to g/mL .

You will also want to show your students how to carry items to the balances that are going to be weighed. You will want to show them that fingerprints do indeed have mass and how touching the items that are being weighed with their fingers will cause errors in their final results. You may also want to discuss significant figures and define accuracy and precision.

Post-Lab Discussion

You will want to emphasize the inaccuracy of the beakers and flasks as volumetric measuring devices. You should emphasize when it would be appropriate to use these two pieces of glassware to measure the volumes of reagents used in an experiment.

You will also want to emphasize the accuracy of graduated cylinders, pipettes, and burettes and when it is desirable to use these pieces of laboratory equipment for volumetric measurements.

Finally, you will want to solicit from your students what they feel are the sources of errors. Then discuss with them how these errors could have been avoided. You will want to show how proper laboratory techniques could have avoided some of these errors. Don't be afraid to admit to your students that some of the errors are inherent and cannot be avoided. If time permits, you may want to enter into a discussion of the different types of errors.

Hints for Modifications

You may wish to modify this experiment due to time and/or equipment constraints. To reduce the amount of repetition, you can reduce the number of trials for each piece of laboratory glassware used. If this is desirable, I would suggest performing two trials instead of three. You may also reduce the number of beakers and flasks used. If this is desirable, I would suggest using the larger beakers and flasks as they will produce larger errors.

Additional Exercises

I have found that this is a very good experiment to have the students present their data using a spreadsheet. Not only will your students become familiar with the spreadsheet, but they will also quickly learn to use the copy and paste functions. Your students will learn a valuable lesson as to the time-saving capabilities of using spreadsheets, especially when performing repetitive calculations. In my classes at Harper College, I require students to use spreadsheets to present their quantitative data in all laboratory experiments.

Another extension would be to take two pipettes of different grades and make at least five deliveries and then determine the standard deviations.