Reading Volumes

A Significant Figures Demonstration

Introduction

Do you believe everything you read? When you read a newspaper or magazine article, do you consider the source before deciding whether or not to believe what's written? We know how to read a newspaper or magazine. But how do we "read" volume measurements in the laboratory?

Chemical Concepts

- Significant figures
- Uncertainty
- Accuracy
- Precision

Materials

Beaker, 100-mL

Buret, 50-mL

Erlenmeyer flask, 125-mL

Graduated cylinders, 100- and 500-mL

Water and food coloring

Safety Precautions

Although the materials in this demonstration are considered nonhazardous, follow all normal laboratory safety guidelines.

Preparation

Add several drops of food coloring to about 200 mL of water to prepare a colored water solution. Fill a buret to the 0-mL line with colored water. *(Look closely, this is at the top of the buret, NOT at the bottom!)*

Procedure

1. Dispense water from the buret into a 100-mL graduated cylinder until the water level in the buret is exactly on the 50.00-mL line.

2. Ask a student to "read" the volume of water in the graduated cylinder and to estimate, based on the scale divisions, how well she "knows" this number (±10 mL, ±1 mL, ±0.5 mL, etc.). If students are unsure of how to estimate the "plus-or-minus" range, invite classroom participation until consensus is reached.

3. Record the volume and "plus-or-minus" estimate on the board.

4. Ask another student to come forward and read the buret volume to determine how much water was transferred from the buret to the graduated cylinder. Again, ask the student to estimate how well he knows this number. Record the values on the board.

5. Invite discussion. Are the numbers the same or different? What factors could account for the difference, if any? Which "reading" is more precise? More accurate? *Note:* We don't know the accuracy yet!

6. Pour the water from the graduated cylinder into a 100- or 150-mL beaker. Again, ask a student to read the volume of water in the beaker and to estimate the precision. Record the values.

7. Pour the water from the beaker into a 500-mL graduated cylinder. Record the volume and estimate the precision.

8. Pour the water from the graduated cylinder into a 125-mL Erlenmeyer flask. Record the volume and estimate the precision.

9. Review the results of these volume measurements with the class and discuss their "significance." Have students rank the different types of laboratory glassware in order from most precise to least precise.

10. Ask students to derive the rule for estimating *significant figures* in measurements.

11. Invite discussion of how the accuracy of these volume measurements could be determined. What else must be known in order to measure accuracy?

12. Assuming that the volume of liquid dispensed from the buret in step 1 is accurate—that is, the "true" volume is 50.00-mL—ask the students to rank the other types of lab glassware in order from most accurate to least accurate.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. Flush the colored water down the drain according to Flinn Suggested Disposal Method #26b.

Tips

- Liquid transfer is an obvious source of error in this demonstration. Carefully transfer liquids as completely as possible in order to reduce experimental error. Review with students the procedure for reading a meniscus.

- Volumes can be read from any type of glassware in any order. This procedure alternates precise and imprecise volume readings to keep the students guessing.

- The accuracy of volume measurements is traditionally determined by measuring the mass of water and dividing by the density to determine the "true" volume. Consider doing this if time permits after reviewing density calculations.

Discussion

Typical volume measurements (in order from step 1 to step 8).

Buret	50.00 ±0.05 mL
Graduated cylinder (100-mL)	49.0 ±0.2 mL
Beaker (150-mL)	55 ±2 mL
Graduated cylinder (500-mL)	50 ±1 mL
Erlenmeyer flask (125-mL)	50 ±10 mL

Precision

Buret > Graduated cylinder (100-mL) > Graduated cylinder (500-mL) > Beaker >> Erlenmeyer flask.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

> ***Unifying Concepts and Processes: Grades K–12***
> Constancy, change, and measurement
> ***Content Standards: Grades 5–8***
> Content Standard A: Science as Inquiry
> Content Standard B: Physical Science
> ***Content Standards: Grades 9–12***
> Content Standard A: Science as Inquiry
> Content Standard B: Physical Science

Reference

Flinn ChemTopic™ Labs, *Vol. 1 Introduction to Chemistry* Flinn Scientific: Batavia, IL, 2002.

Materials for *Reading Volumes—A Significant Figures Demonstration* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP6253	Flinn ChemTopic™ Labs, Vol. 1 Introduction to Chemistry
GP1090	Buret, Borosilicate Glass with Teflon® Stopcock

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