INTRODUCTION TO QUANTITATIVE MEASUREMENT: DENSITY DETERMINATION

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The study of chemistry involves not only observing changes in matter, but also measuring these changes. In fact, most chemical principles cannot be fully understood without obtaining and analyzing some quantitative data. The techniques of data collection, data analysis, and measurement are an important part of chemistry.

Careful attention should be given to the degree of uncertainty in your measurements. Use only those digits which are significant in your calculations in this experiment and in all of the other quantitative experiments that follow. (See page 4 for a discussion of significant digits.)

The precision of your methods can be reported with your results in terms of percent of error. The percent error in calculations and measurements is a comparison of the differences between experimental results and theoretical values, expressed as a percentage. Percent error can be determined as follows.

$$\%\ error = \frac{|experimental\ value - theoretical\ value|}{theoretical\ value} \times 100\%$$

A useful way of comparing two substances is to compare their densities. By carefully measuring the mass and volume of two substances, their densities can be calculated as follows.

$$density = \frac{mass}{volume}$$

In conducting this experiment, you will make several mass and volume measurements and use these measurements to determine the density of water, an unknown liquid, and an unknown solid. You will then determine the precision of your results by calculating percent error.

Objectives

In this experiment, you will

- determine the density of different substances from mass and volume measurements; and,
- calculate the percent error in your results.

EQUIPMENT

2 graduated cylinders (10 mL and 50 or 100 mL)
balance
beaker (100 or 250 mL)
string

PROCEDURE

Prepare a table for your data as directed in the Analysis.

A. Density of Water

1. Measure the mass of a 100 mL or 250 mL beaker to the nearest 0.01 g. Check with your teacher if you are in doubt about reading the balance.
2. Use the balance to be sure you have added exactly 50.00 g of distilled water to the beaker.
3. Pour the 50.00 g of water into a 50 mL or 100 mL graduated cylinder. Read the bottom of the meniscus as shown in Figure 3-1. Record the volume to the nearest 0.5 mL.

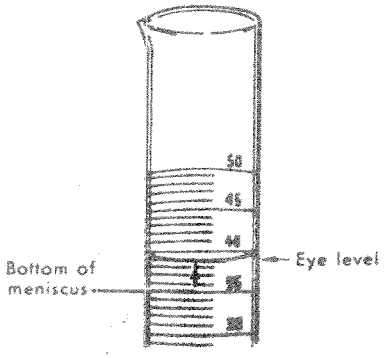

FIGURE 3-1. Reading liquid volume.

B. Density of an Unknown Liquid

1. Measure the mass of a 10 mL graduated cylinder.
2. Fill the graduated cylinder to about the 9 mL mark with the unknown liquid. CAUTION: *Some liquids are harmful to the skin, do not spill or get on hands.* Read the volume to the nearest 0.2 mL.
3. Measure the mass of the cylinder and its contents carefully and record.
4. Return the unknown liquid to a container designated by your teacher.

C. Density of a Solid

1. Obtain a solid object from your teacher and measure its mass to the nearest 0.01 g.
2. Fill a 100 mL graduated cylinder about one-half full of tap water and read the volume to the nearest 0.5 mL.
3. Carefully immerse the solid in the water in the cylinder as shown in Figure 3-2. Record the new volume to the nearest 0.5 mL.

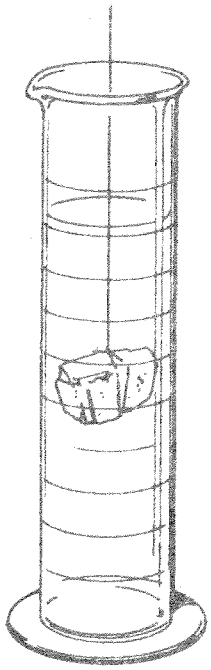

FIGURE 3-2. Water displacement method for determining the density of an irregular solid.

4. Return the solid to a container designated by your teacher and pour the water into the sink.

ANALYSIS

1. Prepare a table for your data, using Table 3-1 as a guide. Use the data collected in Parts A, B, and C to calculate the mass per unit volume (density) for water, the unknown liquid, and solid.

Table 3-1

Material	Mass	Volume	Density
beaker		×	×
beaker + water		×	×
water			
graduated cylinder		×	×
cylinder + liquid		×	×
liquid			
water	×		×
water + solid	×		×
solid			

2. Once you have completed your measurements, obtain the names of the two unknowns from your teacher. Use a chemical handbook to find the theoretical densities of the three substances you tested.

CONCLUSIONS

1. Describe briefly a general method that could be used to determine the density of a solid and a liquid.
2. Calculate the percent error of your results. What were the major sources of error in your methodology.
3. The method used to find the density of a solid, Part C, will not work for all solids. Why not? Suggest a method for determining the density of these solids.
4. Water is often used as a standard in making comparisons between substances. Based on your observations suggest a reason for using water as a standard.