Name ____________________________ Class ___________ Date ___________

Core Skill Lab

Accuracy and Precision in Measurements

In this experiment, you will determine the volume of a liquid in two different ways and compare the results. You will also calculate the density of a metal, using your measurements of its mass and volume.

$$D = \frac{m}{V}$$

You will compare your result with the accepted value provided by your teacher. The experimental error and percentage error in each part of the experiment will be calculated.

The *experimental error* is calculated by subtracting the accepted value from the observed or experimental value, as follows:

$$\textit{Experimental error} = \textit{Experimental value} - \textit{Accepted value}$$

The *percentage error* is calculated according to the following equation:

$$\textit{Percentage error} = \frac{\textit{Experimental value} - \textit{Accepted value}}{\textit{Accepted value}} \times 100$$

The sign of the experimental error and the percentage error may be either positive (the experimental result is too high) or negative (the experimental result is too low).

You will determine the average value for the density of a metal by averaging the values obtained by the entire class. Using this value, you will calculate the experimental error and percentage error in the class average.

OBJECTIVES

Use experimental measurements in calculations.

Organize data by compiling it in tables.

Compute an average value from class data.

Recognize the importance of accuracy and precision in scientific measurements.

Relate the reliability of experimental data to uncertainty and percent error.

MATERIALS

- 15 cm plastic ruler
- 25 mL graduated cylinder
- 100 mL beaker
- 100 mL graduated cylinder
- balance
- metal shot (aluminum, copper, lead)
- thermometer, nonmercury, 0–100°C

Procedure

After completing each part of the experiment, record your observations in the appropriate data table. Recording data anywhere else increases the probability of recording an inaccurate value.

PART 1

1. Examine the centimeter scale of the plastic ruler. What are the smallest divisions?

2. You can estimate a measurement to one-tenth of the smallest division on a measuring apparatus. To what fraction of a centimeter can you estimate with your plastic ruler?

3. The uncertainty in a measurement is ± one-half of the smallest division. What is the uncertainty in a measurement made with your plastic ruler?

4. Using the ruler, measure the inside diameter of the 100 mL graduated cylinder. Similarly, measure the inside height of the cylinder to the 50 mL mark. Record these measurements in **Data Table 1.**

Data Table 1	
Inside diameter of graduated cylinder	
Inside height of graduated cylinder	

PART 2

5. Examine the gram scale of the balance. What are the smallest divisions?

To what fraction of a gram can you estimate with a centigram balance?

6. Examine the graduations on a 25 mL graduated cylinder, and determine the smallest fraction of a milliliter to which you could make a measurement. Does this match the *uncertainty* of a measurement made with a 100 mL graduated cylinder?

7. Using the balance, measure the mass of the dry 25 mL cylinder. Record the mass in **Data Table 2.**

8. Fill the beaker half full of water, and measure its temperature to the nearest degree. Look up the density of water for this temperature in your textbook, and record in **Data Table 2** both the temperature and water density.

9. Fill your graduated cylinder with water to a level between 10 and 25 mL; accurately read and record the volume. Measure the mass of the water plus the cylinder. Record this value in **Data Table 2.** Save the water in the graduated cylinder for use in **Part 3.**

Data Table 2	Value	Unit
Mass of empty graduated cylinder		g
Temperature of water		°C
Density of water		g/cm^3
Volume of water		mL
Mass of graduated cylinder + water		g

PART 3

10. Add a sufficient quantity of the assigned metal shot (aluminum, copper, or lead) to the cylinder containing the water (saved from **Part 2**) to increase the volume by at least 5 mL. Measure the volume and then the mass of the metal shot, water, and cylinder. Record your measurements in **Data Table 3.**

Data Table 3	Value	Unit
Volume of water (from **Part 2**)		mL
Mass of water + graduated cylinder (from **Part 2**)		g
Volume of metal + water		mL
Mass of metal + water + graduated cylinder		g

DISPOSAL

11. Clean up all apparatus and your lab station. Return equipment to its proper place. Wash your hands thoroughly with soap before you leave the lab and after all work is finished.

Analysis

Show all your calculations.

Part 1

1. **Organizing Data** Calculate the volume of the cylinder to the 50.0 mL graduation ($V = \pi \times r^2 \times h$).

2. **Inferring Conclusions** Assume the accepted value for the volume of the cylinder is 50.0 cm^3. Calculate the experimental error and percentage error.

Part 2

3. **Organizing Data** Calculate the mass of water as measured by the balance.

4. **Organizing Data** Calculate the mass of the water from its measured volume and its density ($m = D \times V$).

5. **Inferring Conclusions** Using the mass of water determined by the use of the balance as the *accepted value,* calculate the experimental error and percentage error in the mass determined using the volume and density.

Part 3

6. **Organizing Data** Determine the volume of the metal, using your measurement of the volume of water displaced by the metal.

7. **Organizing Data** Using your measurements in **Data Table 3,** determine the mass of the metal.

8. **Organizing Data** Calculate the density of the metal.

9. **Inferring Conclusions** In a handbook, your textbook, or on-line, look up the density of the metal you used. (In SI, the density of liquids and solids is equal to the specific gravity.) Calculate the experimental error and percentage error for the density of the metal shot you determined in item **8.**

Part 4

10. **Organizing Conclusions** Record in the table below five values obtained by you and your classmates for the density of the *same metal.*

Group number	Density (g/cm^3)

11. Evaluating Conclusions Calculate the average density (D) of the five results.

12. Inferring Conclusions Calculate the experimental error and the percentage error for the average density of the metal shot.

13. Evaluating Methods What value of a measurement must be known if the accuracy of an experimental measurement is to be determined?

14. Evaluating Methods What are the possible sources of experimental errors in this experiment?

Conclusions

1. Evaluating Conclusions Sarah and Jamal determined the density of a liquid three times. The values they obtained were 2.84 g/cm^3, 2.85 g/cm^3, and 2.80 g/cm^3. The accepted value is known to be 2.40 g/cm^3.

a. Are the values that Sarah and Jamal determined precise? Explain.

b. Are the values accurate? Explain.

c. Calculate the percentage error for each density.