

### Lab 1: Measurement and Density

#### Objectives:

- Determine the relative **precision** and **accuracy** of different glassware items.
- Determine the **density** of a solid sample by two methods

#### Skills:

- Practice basic measurement techniques of masses and volumes
- Review accuracy and precision in measurement

#### Useful formulae:

$$\text{percent error} = \frac{|\text{experimental value} - \text{reference value}|}{\text{reference value}} \times 100$$

$$\text{percent difference} = \frac{|\text{high experimental value} - \text{low experimental value}|}{\text{average value}} \times 100$$

#### Pre-lab questions:

Read **both** parts of the procedure; then answer these questions on a **separate sheet of paper** *before* coming to class on Thursday; turn them in at the beginning of class. This is an assignment that may be done by each lab partnership (in other words, one sheet for each lab partnership).

- The 10 mL graduated cylinder is marked with graduations in tenths of a mL. To how many decimal places should you record (how many are significant)?
- Why is it best to determine the mass of the metal *before* placing it into the graduated cylinder of water rather than *after*?
- Would your accuracy be better if you used a very small amount of metal, compared to a larger amount of metal? Justify your answer.
- Which formula in the “useful formulae” section will you use in this lab? What do the symbols “| |” mean in either formulae?

#### Materials needed:

- Prepared graph paper (see prelab)
- 100 mL beaker
- small beaker
- distilled water (**not** tap water)
- thermometer
- two different metal cylinders
- data sheet (print this out as a separate document)
- 10 mL graduated cylinder
- 50 or 100 mL (“large”) graduated cylinder
- 10 mL volumetric pipet and suction device
- electronic balance
- calipers or rulers

**Remember:** • Measure water volume at the bottom of the **meniscus**.

- Use the **same balance** for the entire lab.

**Procedure** (work in pairs, but each person should turn in their own data sheet):

*Part One — the density of water*

1. Obtain a 100 mL beaker, a 10 mL graduated cylinder and a 50 or 100 mL graduated cylinder and record the **dry** mass for each on the **data sheet**. The weighing step can be avoided by using the “tare” function on the balance.
2. As best as you can, put 10 mL of distilled water in each glassware item. Do not use the 10 mL graduated cylinder to measure water for each container or transfer the same water from container to container. You want to measure the water using the marking on the container. Record the **measured** volume for each one, remembering that you should estimate one place past the markings. Don't forget **trailing zeroes**. The 10 mL volumetric pipet has a precision of thousandths of a mL.
3. Weigh and record the **mass** of the glassware plus water for each item. Again, this step can be avoided by using the “tare” function on the balance.
4. Calculate (or write down) the **mass** of the water from each piece of glassware.
5. Measure the water **temperature**. Consult a reference book, such as the **CRC Handbook**, or a reference site, such as the Frostburg (MD) State University chemistry site <http://antoine.frostburg.edu/chem/senese/javascript/water-density.html> to determine the **density** of water at your observed temperature.
6. Complete the calculation for the **calculated** volume of water in each piece of glassware, then the **percent error** between the measured and calculated volumes for each piece of glassware.

*Part Two — the density of a metal*

7. Weigh and record the mass and letter of a **metal cylinder**. The metal pieces should fit into your 10 mL graduated cylinder and have a volume between 1.00 mL and 3.00 mL.
8. Measure and record the **diameter** and **height** of the cylinder. Calculate the volume of the cylinder based on these dimensions (recall that radius = half of the diameter). Then calculate the **density** of the metal cylinder using this *calculated* volume.
9. Place enough water in the 100 mL graduated cylinder so the water has about the same height as the metal cylinder. Record the water **volume**. Tilt the graduated cylinder and *gently* slide the metal cylinder down inside it. Record the **volume** of water plus metal cylinder. The difference between these two measures is the volume of the metal cylinder. This technique is called **water displacement**. Remove and dry the metal cylinder and return it to the lab cart. Then calculate the **density** of the metal cylinder using this *measured* volume.

10. Find out the identity of the metal in the cylinder and look up and record the **literature value** of the density of that metal.

11. Calculate the **percent errors** between the literature value and each of the two densities for the metal cylinder.

12. Repeat the measurements for a different letter metal cylinder.

**Analysis and Questions** (Please use your own paper for the answers of these questions, but number them the same way. Attach this to the data sheet to turn in. Errors in *significant figures* or *missing units* will be docked a half point):

1. For each piece of glassware, determine the **mass of the water**, then use the **density** of water at the measured classroom temperature to find the *calculated* volume of the water. Clearly, you should enter this information into the data table, 2<sup>nd</sup> to last line, but show the details of *one* such calculation.

2. Which is more **precise**, the *measured* volume or the *calculated* volume? Why?

3. Which is more **accurate**, the *measured* volume or the *calculated* volume? Why? Hint: This should **not** be the same reason as the one you gave in question 2.

4. Calculate the **percent error** for each piece of glassware, using the more accurate in each pair as the **true** value. Use the formula for percent error given in class or in the text. **Rank** the glassware items in order of decreasing accuracy.

5. Calculate the **density** of the metal cylinder using the cylinder dimensions and the formula for the **volume** of a regular cylinder. Of course, enter the information in the data table, but show the *details* of your calculation.

6. Calculate the **density** of the metal cylinder using the **water displacement** method. Again, show the details of your calculation.

7. Which method is more **precise**, using the cylinder dimensions or water displacement? Why?

8. Which method is more **accurate**, using the cylinder dimensions or water displacement? Why? Hint: This should **not** be the same reason as the one you gave in question 7.

9. Calculate the **percent error** of the metal cylinder density for both the cylinder calculation and water displacement methods, using the density value obtained from a reputable source, such as the textbook.

10. Why won't this technique work to measure densities of materials that are less than 1 g/mL?