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MASS, VOLUME, AND DENSITY

PURPOSE

To determine the densities of unknown metals.

BACKGROUND

An old riddle asks "Which is heavier, a pound of feathers or a pound of lead?" The question is nonsensical, of course, since a pound of feathers and a pound of lead both weigh the same, one pound. Nevertheless, there is a clearly something different about a small lead brick and a large bag of feathers, even though they weigh the same. The key to answering the riddle is understanding the relationship that exists between a substance's mass and the volume it occupies. This relationship is expressed by the physical property called density. *Density* is defined as the ratio of a substance's mass to the volume it occupies.

$$\text{Density} = \frac{\text{mass of substance (g)}}{\text{volume of substance (mL)}}$$

In this experiment, you will measure the mass and volume of several unknown materials. You will then use your data to explore the relationship between the mass and volume of the materials and to calculate their density.

After performing this lab, if someone asks you the riddle about feathers and lead, you can explain to them the difference between weight and density.

MATERIALS (PER PAIR)

safety goggles
centigram balance
25-mL graduated cylinder
ruler
metal samples
paper towels

SAFETY FIRST!

In this lab, observe all precautions, especially the ones listed below. If you see a safety icon beside a step in the Procedure, refer to the list below for its meaning.

Caution: Wear your safety goggles. (All steps.)

Note: Your teacher will properly dispose of the materials.

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PROCEDURE

As you perform the experiment, record your data in Data Tables 1 and 2.

1. Determine the mass of two different unknown metal samples to the nearest 0.01 gram, using a centigram balance. Record the masses in Data Tables 1 and 2.
2. Find the volume of each metal sample by water displacement. Fill a 25-mL graduated cylinder about half-full with water, measure the volume, and record as "volume of water alone" in Data Table 1. Tilt the graduated cylinder and carefully slide one of the metal samples down the side. Make sure the metal sample is completely submerged in the water. Measure the volume and record the measurement as "volume of water + metal" in Data Table 1.

3. Repeat Step 2, using the other metal sample. Dry both samples and return them to your teacher.

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OBSERVATIONS

DATA TABLE 1: INDIVIDUAL DATA AND CALCULATIONS

	Metal A	Metal B	Additional Metal Sample
mass (g)			
volume of water alone (mL)			
volume of water + metal (mL)			
volume of metal (mL)			
density of metal (g/mL)			

All sample data is for aluminum (Metal A) and brass (Metal B).

DATA TABLE 2: CLASS DATA: MASS AND VOLUME OF METAL SAMPLES

	Metal A		Metal B		Additional Metal Sample	
Lab Pair	mass (g)	volume (mL)	mass (g)	volume (mL)	mass (g)	volume (mL)
1						
2						
3						
4						
5						
6						
7						
8						
9						

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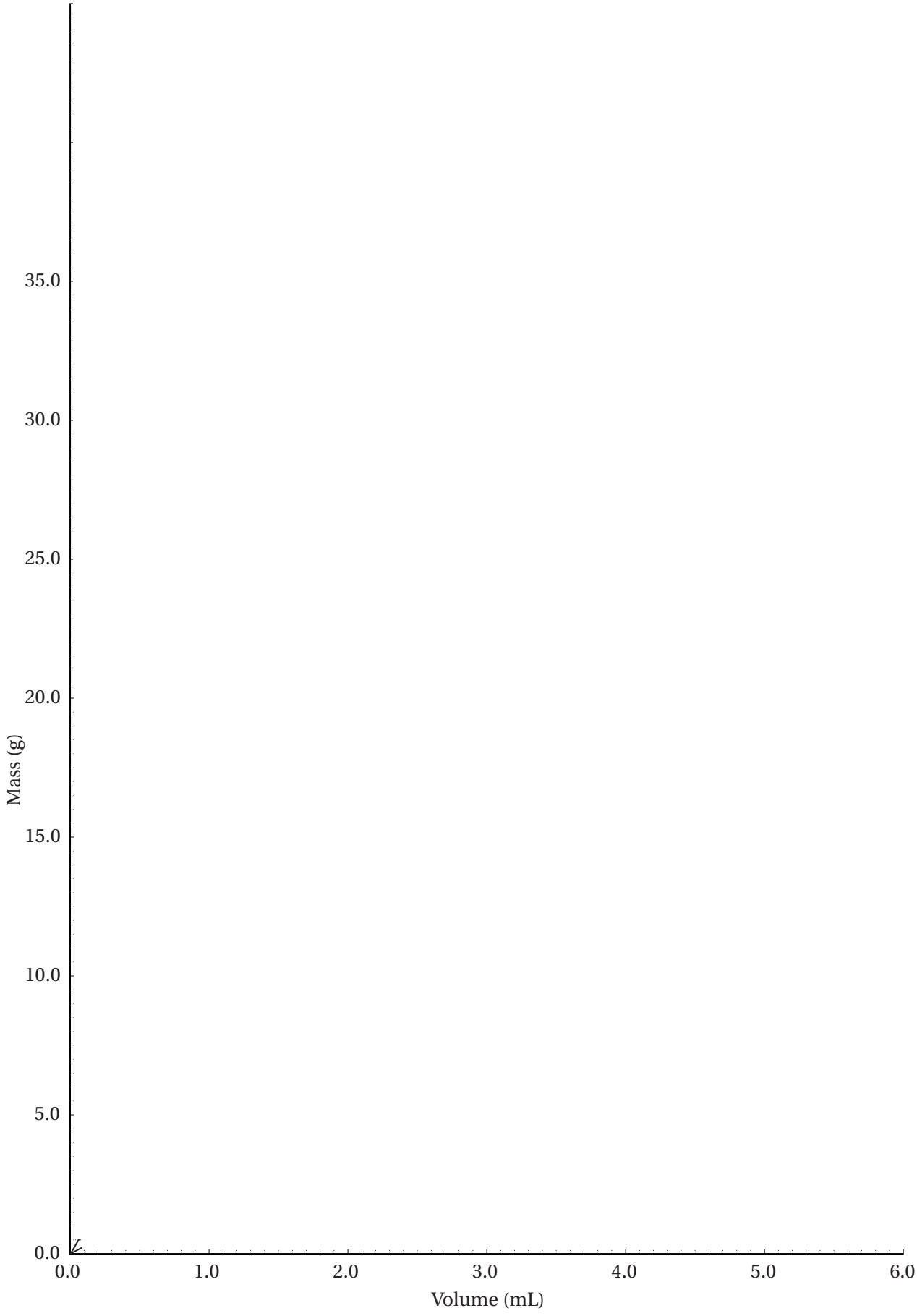

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ANALYSES AND CONCLUSIONS

1. Compute the volume of each metal sample, using data from Data Table 1. Compute the density of each metal sample, showing your work (including units), in Data Table 1. Remember,

$$\text{density} = \frac{\text{mass (g)}}{\text{volume (mL)}}.$$

2. Complete Data Table 2 by recording the mass and volume data collected by you and your classmates.

3. Using the class data, plot a graph of mass versus volume. Represent the plotted points for each metal with a different symbol. Draw a "best fit" straight line through each group of plotted points.

4. Determine the slope of each of the lines on your graph. Record the slope of each line and your method of calculation in Data Table 3. (**Hint:** The general equation for a line is $y = mx + b$ where m is the value for the slope and b is the value for the y-intercept.) Pay special attention to the units of the slope.

DATA TABLE 3: DENSITY CALCULATIONS FROM CLASS DATA (SLOPES)	
Metal A	Metal B

5. What does the slope of the line for each metal represent? (**Hint:** Look back at Data Table 1.)

6. Looking at your graph, what does this experiment demonstrate about the density of a metal? What does it demonstrate about the densities of different metals?

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7. Calculate the percent error in the density calculations for the two samples. (See Analyses and Conclusions, Step 1.) Your teacher will provide the accepted value for the density of each metal.

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

Densities of suggested metals

Al - 2.70 g/mL

Brass - 8.44 g/mL

Zn - 7.10 g/mL

Fe - 7.86 g/mL

Stainless Steel - 7.75 g/mL

8. Calculate the percent error in the values of density obtained from the slopes of the lines in your graph. (See Analyses and Conclusions, Step 4.)

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9. Look back at the percent errors calculated in problems 7 and 8. Generally, the slope of the line will give a more accurate value for density than a single sample. Explain why this is usually true.

10. Can you identify a metal if you know its density? Explain your answer. Try to identify the metals used in this experiment by referring to tables of density.

11. Do you think that determining the volumes of your metal samples by measuring their dimensions and calculating would be more accurate or less accurate than determining these volumes by water displacement? Explain. Would measuring the dimensions of a solid always be possible? Explain.

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12. How would you modify this experiment to determine the density of table sugar, wood chips, and milk?