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Predicting the Density of an Element

Density is a useful property for identifying and classifying elements. In this exploration, you will determine the densities of three elements in Group 4A—silicon, tin, and lead. Then, you will use your data to predict the density of another element in Group 4A—germanium.

Problem Can the densities of elements within a group be used to help predict the density of another element in the group?

Materials

- unlined white paper
- scissors
- metric ruler
- balance
- forceps
- silicon
- tin
- lead shot
- 50-mL graduated cylinder
- graph paper
- periodic table

Skills Measuring, Observing, Using Graphs, Calculating

Procedure

Part A: Measuring Mass

DATA TABLE

Element	Mass of Paper (g)	Mass of Paper and Element (g)	Mass of Element (g)	Volume of Water (cm^3)	Volume of Water and Element (cm^3)	Volume of Element (cm^3)	Density of Element (g/cm^3)
Silicon							
Tin							
Lead							

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1. Cut out three 10-cm × 10-cm pieces of paper from a sheet of unlined white paper. Label one piece of paper Silicon, the second Tin, and the third Lead. Find the mass of each piece of paper and record it in the data table.
2. Using forceps, place the silicon onto the paper labeled Silicon. Find the mass of the silicon and the paper. Record this mass in the data table. Then, subtract the mass of the paper from the mass of the silicon and paper. Record the mass of silicon in the data table. Set the paper containing the silicon aside for now.
3. Repeat Step 2 to find the masses of tin and lead.

Part B: Measuring Volume

4. Place 25 mL of water in the graduated cylinder. Measure the volume of the water to the nearest 0.1 mL. Record the volume (in cm^3) in the data table. (*Hint:* 1 mL = 1 cm^3)
5. Tilt the graduated cylinder and carefully pour the silicon from the paper into the graduated cylinder. Make sure that the silicon is completely covered by the water. Measure and record the volume of the water and silicon in the data table. Then, subtract the volume of water from the volume of the water and silicon. Record the result in the data table.
6. Repeat Steps 4 and 5 to find the volumes of tin and lead.

Part C: Calculating Density

7. To calculate the density of silicon, divide its mass by its volume.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

   Record the density of silicon in the data table.
8. Repeat Step 7 to find the densities of tin and lead.
9. Make a line graph that shows the relationship between the densities of silicon, tin, and lead and the periods in which they are located in the periodic table. Place the number of the period (from 1 to 7) on the horizontal axis and the density (in g/cm^3) on the vertical axis. Draw a straight line that comes as close as possible to all three points.
10. Germanium is in Period 4. To estimate the density of germanium, draw a dotted vertical line from the 4 on the horizontal axis to the solid line. Then, draw a dotted horizontal line from the solid line to the vertical axis. Read and record the density of germanium.

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11. Wash your hands with warm water and soap before you leave the laboratory.

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Analyze and Conclude

1. **Classifying** List lead, silicon, and tin in order of increasing density.

2. **Comparing and Contrasting** How does your estimate of the density of germanium compare with the actual density of germanium, which is 5.5 g/cm^3?

3. **Calculating** Use the formula for percent error (PE) to calculate a percent error for your estimate of the density of germanium.

$$PE = \frac{\text{Estimated value} - \text{Accepted value}}{\text{Accepted value}} \times 100$$

4. **Drawing Conclusions** How does the density of the elements change from silicon to lead in Group 4A?