Density: An Intensive Property of Matter

A Carolina Essentials™ Investigation

Student Worksheet

Overview

Ping pong balls and golf balls are about the same size. Ping pong balls have a diameter of about 40 mm and golf balls have a diameter of about 43 mm, but their masses are very different. A ping pong ball has a mass of 2.7 g and a golf ball's mass is 46 g. Think about this: If you filled your bag with ping pong balls and your friend filled the exact same type of bag with golf balls, how would the two stuffed bags compare?

This example illustrates the concept of density. Density is an intensive property of matter that relates mass and volume. That means the density of a substance is not dependent on the amount of substance at hand. Can you stuff the same number of ping pong balls or golf balls in a lunch box as in a bag? The volume of the container changes and so does the number of balls the container can hold. Did the properties of the individual balls change?

The relationship between a substance's mass and volume is constant and remains constant while temperature remains constant. Analyzing data on mass and volume to establish a relationship is the topic of this investigation.

Essential Question

How can characteristic properties of substances be related to their structure?

Investigation Objectives

1. Analyze and interpret data to develop a mathematical relationship between mass and volume.
2. Using particle diagrams, construct a model for density that represents the relative densities for all substances tested.

Safety Precautions

Make certain you are slowly dropping each sample into the cylinder. Tilt the cylinder and let the sample slowly slide down the wall of the cylinder to avoid breakage or water splashing out. Do not force a sample into a graduated cylinder. Use safety goggles, gloves, and apron. Wash hands with soap and water when finished.

Procedures

1. Obtain 4 or 5 samples of the same element or pure substance.
2. Mass each sample.
3. Find the volume of each sample by displacement of water or calculation. If your samples are regularly shaped geometric solids, like cylinders, spheres, cubes, or rectangular solids, then calculate the volume using the appropriate formula.
4. Record all measurements.
5. Graph the data with volume on the x-axis and mass on the y-axis.
6. Draw the line of best fit.
7. Calculate the slope of the line.
8. Calculate the density of each sample.
9. Calculate the average density of all samples for a substance.

Disposal

Dry all samples after use and return them to the designated location.

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SAFETY REQUIREMENTS

MATERIALS

Samples of the same element or pure substance (4 or 5)

Ruler with millimeter marks

Graduated cylinder with 1 mL, 0.2 mL, or 0.1 mL graduations

Electronic balance

Weigh boat

Data and Observations

Arrange your data in a table that includes sample number, mass, volume, and calculated density. Remember to include labels and units.

Sample	Mass (g)	Volume by displacement (mL)	Volume by calculation (cm^3) optional	Calculated density (g/mL)

Analysis and Discussion

1. How do the densities of each sample compare? Use your data to support or refute the statement that density is an intensive property of matter.

2. How does the average density compare to the slope of the line? Use your data to construct a model for density.

3. Translate the slope equation into the density equation. Show the steps with all units. How are the slope and formula for density related?

4. Your teacher will give you the standard value for the density of the metal or other substance you used. Calculate the percent error using the slope. Calculate the percent error using the average. Compare the two values.

5. Sketch a particle diagram that models the concept of density for each substance.