MASS, VOLUME AND DENSITY OF A SOLID

Problem:

What is the relationship between mass and volume of different geometric solids made of the same material?

Background and Inquiry:

Density is the ratio of the mass of a substance to the volume occupied by the object:
Density = mass/volume

Mass is found using a balance. To find volume there are 3 methods, the first two are displacement methods,

1. Drop an object into a graduated cylinder partially filled with water. Observe the displacement or change in volume is (use this method only for small objects).
2. Use an overflow bucket to measure the volume of displaced liquid.
3. Use the geometric formula.

The unit of density varies depending upon the material measured. Density is grams per cubic centimeter (g/cm^3) for solids; grams per milliliter (g/mL) for liquids; and grams per liter (g/L) for gases.
The density of aluminum is given as 2.7 g/cm^3 (2.7 g Al/1.0 cm^3 Al).
This means that a 1 cm x 1 cm x 1 cm cube of aluminum would weigh 2.7 g.

The number of **Significant Figures** in measured numbers shows the uncertainty of the measuring device. Significant figures are the digits in any measurement that are known with certainty plus one more digit which is estimated.

Significant Figures in Calculations-Addition and Subtraction

The answer may not have any more **decimal places** than the least accurate number
For example: 91. + 4.00 = 95.
This is the least accurate number (least number of decimal places). The answer has 2 significant figures

Multiplication and Division

The answer contains the same number of sig. fig. as the measurement with the **least number** of sig. fig.

For example: 23 x 2.00 = 46
The answer has 2 sig figs.

Accuracy (how close you are to the correct value) may be improved by carrying out several determinations and then computing an average value. The significance of the error in any given measurement depends on the magnitude of the error compared to that of the measurement.
An error of one foot in measuring the height of a person is a relatively large error, whereas an error of one foot in determining the distance to Mars is a relatively small error. This relative error is usually expressed as a percentage of the measurement and is called percent error.

$$\%\text{Error} = |(\text{Theoretical Value} - \text{Experimental Value})/\text{Theoretical Value}| \times 100$$

Chemistry is an experimental science, observations and making accurate measurements are very important. In this experiment you will measure mass, volume, length and temperature. From these measurements you will perform calculations to obtain other values.

Volume of a cube = $(\text{side})^3$
Volume of a rectangular solid = length x width x height
Volume of a triangular prism = 1/2 bh (of triangle) x height of the prism
Volume of a cylinder = (3.14) $(\text{radius of cylinder})^2$ x height of cylinder
Volume of a sphere = (3.14) $(\text{radius of sphere})^3$

Background Questions:

1. Define density. Give an example showing how to find the density of an object.
2. What do you expect will happen to the mass of an object if the volume is increased?
3. If the volume is doubled what would happen to the mass?
4. Describe three ways you could find the volume of a small sphere.
5. A cube has a side of 3.0 cm. And a mass of 56 g what is the density of the cube?
6. A sphere has a diameter of 5.00 cm. What is the radius? What is the volume?
7. Explain what the slope of a graph is. How do you find it?

Practice Problems - Show all work and significant figures.

1. What is the mass, in g, of a sample of 2.00 liters gold if the density of gold is 19.3 g/cc?
2. Water has a density of .998 g/ml. What is the volume, in ml, of .35 kg of water?
3. 7.72×10^{-2} g of a substance is put into 20.0 ml of water in a graduated cylinder. The new volume reading was 23.9 ml. Find the density of the substance in g/cm^3.
4. Lead has a density of 11.34 g/cm^3, what is the volume of 25.1 grams of lead?
5. Tell how many significant figures are in the following:
    a. 0.74
    b. 720.0
    c. 0.0409
    d. 0.0010700 sig.figs
6. Tell **how many sig figs** you should report in each answer.
    a. 0.74 x 31.5 x 22.4
    b. 16.3 + 9.27 + 4.025
    c. [61.5 - 57.3)/57.3] x 100) = % error
    d. 25.65 - 18.47
7. Convert 1125 cm to yards

Experiment #1-

Materials: triple beam balance, Plexiglas solids, graduated cylinder, overflow bucket, beakers

Procedure:

1. Find the mass of each of the objects, from smallest to largest. Measure each mass three times and calculate the average mass.
2. Find the volume of each object using both the geometric method and displacement method (using the overflow bucket as described in class or graduated cylinder for the smallest cubes). Calculate the average volume.
3. Calculate the density of each object.

Results:

Solid Name	**M, (Mass,g)**	**Volume, cm^3. (*Geometric Method)***	**Volume, cm^3 (*Displacement Method*)**	**Average Volume cm^3 (using both methods)**	**Density g/cm^3 (Mass/Avg.Volume)**
A					
B					
C					
D					
E					
F					
G					

Graphing: Draw a graph plotting mass on the y-axis and average volume on the x-axis. Make sure to label your graph. *Find the slope of the graph.*

Experiment #2

Density of an irregular shaped object.

1. Obtain two size # 2 rubber stoppers and a 100 ml graduated cylinder.
2. Mass the rubber stoppers together and record to + 0.01 g.
3. Pour approximately 40 ml (somewhere between 35-50 ml) of water into the cylinder. Record the exact volume (measured to the nearest 0.1 ml).
4. Tilt (slightly) the graduated cylinder and carefully slide in the two rubber stoppers (Don't splash!)
5. Record the new volume.
6. Perform the experiment three times and calculate the average density

Experiment #3

Density of an unknown liquid

1. Obtain a 50 ml graduated cylinder.
2. Find the mass of the empty 50 ml graduated cylinder and record.
3. Measure approximately 20 ml of unknown liquid into the graduated cylinder. Record the exact volume.
4. Mass the graduated cylinder plus unknown liquid and record.
5. Add approximately 5 more ml of unknown liquid record exact volume
6. Mass the graduated cylinder and record.

CALCULATIONS:

1. Calculate the mass of the unknown for both runs, using the mass of the empty graduated cylinder.
2. Calculate the density for both runs.
3. Calculate an average of the two runs.
4. Calculate the % error

Discussion:

Be sure to include the following:

1. What are the variables used in this experiment?
2. How are the variables changing with relationship to each other?
3. What were some factors or conditions that you held constant while doing this experiment?
4. What type of relationship does your graph demonstrate?
5. Make sure to discuss the meaning of the slope of the graph.

Classification is an important skill in science. Biologists classify organisms to better understand their characteristics. A pathologist classifies diseases to see if they have similar causes. Chemists classify different materials in order to understand and predict their properties. In this lab you will classify several materials as compounds elements or mixtures.

PROCEDURE

Classifying compounds elements, heterogeneous and homogeneous mixtures by appearance
On the reagent bench are several samples of various materials. Write the name of the material, a brief description of its state, color and any other pertinent observation, state if the material appears homogeneous or heterogeneous and finally classify it as a compound element or mixture.

MATERIAL	DESCRIPTION	HOMOGENOUS OR HETEROGENEOUS	CLASSIFICATION: Compound, element, homogenous mixture or heterogeneous mixture