2-1 What is density?

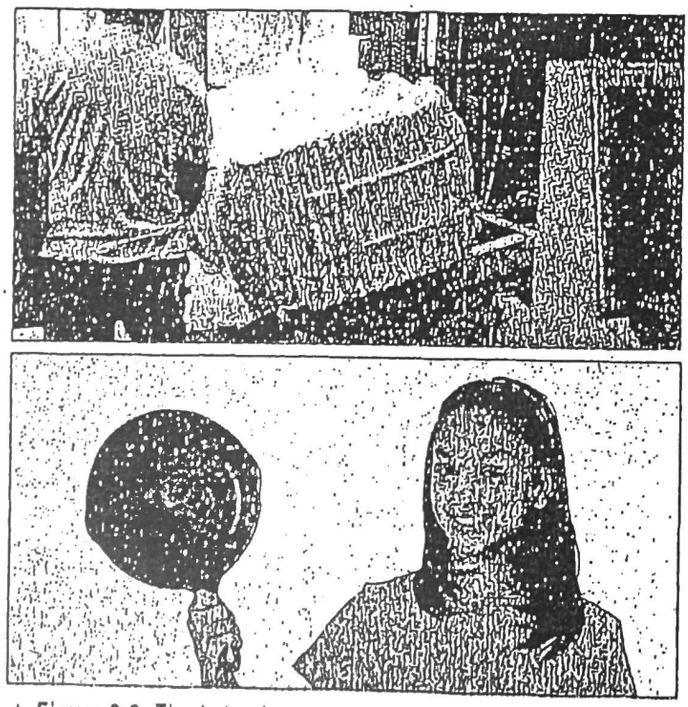
Objective

Define density.

Key Term

density (DEHN-suh-tee): mass per unit volume

Density Which do you think is heavier, a kilogram of cotton or a kilogram of iron? You may already know the answer to this riddle. They both weigh the same amount. However, a kilogram of cotton takes up a greater amount of space, or volume. A kilogram of iron is small enough to hold in your hand. A kilogram of iron takes up less space because iron has a much greater density than cotton does. Density is the mass per unit volume of a substance. Substances that are very heavy for their volume are called dense substances.



▲ Figure 2-2 The bale of cotton at the top has a mass of 1 kg. The iron frying pan below it also has a mass of 1 kg.

1 DEFINE: What is density?

Units of Density You can find the density of a substance by finding the mass of a unit volume of the substance. Units of density include units of mass and volume. Mass is measured in grams. Tl volume of solids is measured in cubic centimeter The volume of liquids can be measured milliliters. One milliliter is equal to one cut centimeter. Therefore, the density of any substan can be given in grams per cubic centimeter, g/cm^3. For example, water has a density of 1 g/cr One gram of water takes up one cubic centimet of space. The densities of some comm substances are listed in Figure 2-3.

DENSITIES OF SOME COMMON SUBSTANCES	
Substance	Density (g/cm^3)
Air	0.0013
Alcohol	0.8
Aluminum	2.7
Cork	0.2
Gold	19.3
Iron	7.9
Lead	11.3
Mercury	13.6
Silver	10.5
Steel	7.8
Water	1.0

▲ Figure 2-3

2 IDENTIFY: In what units is density measured?

Using Density Density is a physical property matter. Every kind of matter has a density that c be measured. The density of a pure substance always the same. For example, the density of le is always 11.3 g/cm^3. The density of mercury always 13.6 g/cm^3. Density does not depend on t size or shape of the substance.

Density can be used to help identify differe kinds of matter. Suppose two metals look simil You know that one may be silver and the oth aluminum. If you know the density of ea sample, you can identify them. The sample with density of 10.5 g/cm^3 is silver. The sample with density of 2.7 g/cm^3 is aluminum.

2-2 How is density measured?

Objective

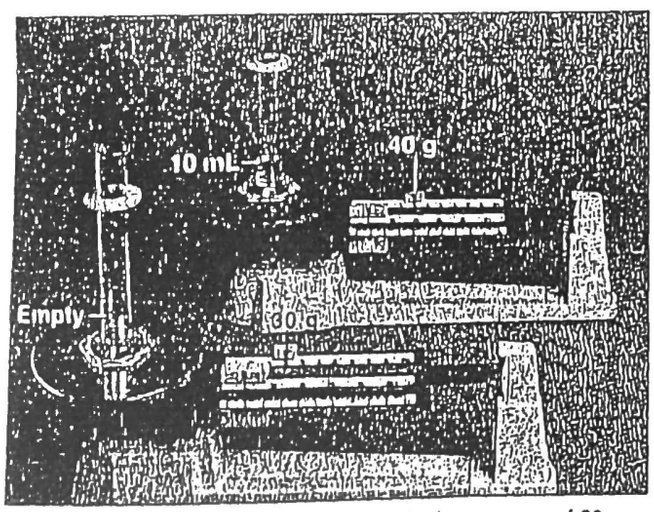
Explain how to find the density of a solid or a liquid.

Finding Density To find the density of a material, you must measure both mass and volume. You can find density by dividing the mass by the volume. Remember that mass is measured in grams. Volume is measured in cubic centimeters or milliliters, so density is expressed in grams per cubic centimeter or grams per milliliter.

1. IDENTIFY: What measurements must you make before you can calculate the density of a material?

Density of a Liquid You can find the density of a liquid using a graduated cylinder and a balance.

- Find the mass of the graduated cylinder. Record your measurement.
- Pour some of the liquid you want to measure into the graduated cylinder. Write down the volume of the liquid.
- Place the graduated cylinder with the liquid on the balance. Record the mass.
- Find the mass of the liquid by subtracting the mass of the empty graduated cylinder from the mass of the graduated cylinder with the liquid.



▲ Figure 2-6 The empty graduated cylinder has a mass of 30 g. With the liquid the mass is 40 g, so the water has a mass of 10 g.

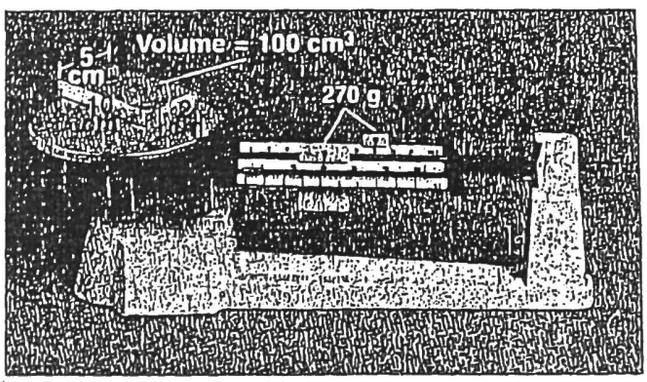
Now you are ready to calculate the density of the liquid. Look at the example shown. The mass of the liquid is 10 g. The volume is 10 mL. To find the liquid's density, divide its mass by its volume.

density = mass ÷ volume
density = 10 g ÷ 10 mL
density = 1 g/mL

Notice that in this example, density is expressed in grams per milliliter. One milliliter is equal in volume to one cubic centimeter. The density of a liquid can be measured in grams per milliliter or grams per cubic centimeter.

2. EXPLAIN: Why can density be measured either in grams per cubic centimeter or in grams per milliliter?

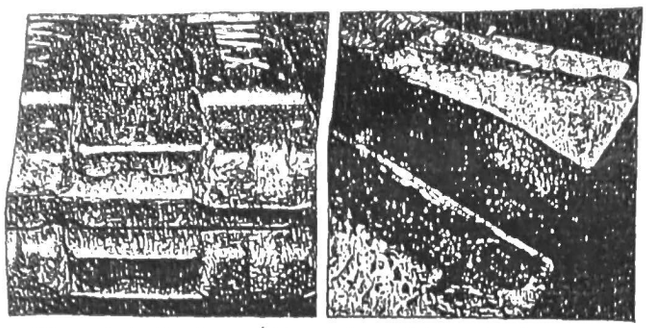
Density of a Solid You can find the density of any solid if you know its mass and its volume. You can use a balance to find the mass of a solid. You can find the volume of a rectangular solid by multiplying its length by its width by its height. Look at the aluminum bar in Figure 2-7. Its mass is equal to 270 g. Its volume is equal to 10 cm × 5 cm × 2 cm, or 100 cm^3. To find the density of the aluminum bar, divide its mass by its volume.



▲ Figure 2-7 An aluminum bar of volume 100 cm^3 has a mass of 270 g.

density = mass ÷ volume
density = 270 g ÷ 100 cm^3
density = 2.7 g/cm^3

3. DESCRIBE: How can you find the volume of a rectangular solid?



▲ Figure 2-4 Aluminum (left) and silver (right) look alike but have different densities.

IDENTIFY: What kind of property is density?

CHECKING CONCEPTS

1. Density is the _____ per unit volume of a substance.
2. When a substance has a high density, a large mass fits into a _____ volume.
3. The units of _____ are grams per cubic centimeter.
4. Density is a physical _____ of all matter.
5. The density of silver is always _____.

THINKING CRITICALLY

6. CALCULATE: What is the density of a metal block that has a mass of 525 g and a volume of 50 cm^3?
7. PREDICT: How large a container would be needed to hold 800 g of water?
8. SEQUENCE: List the following substances in order from lowest density to highest density: iron, gold, steel, water, air, silver, and aluminum.

DESIGNING AN EXPERIMENT

Design an experiment to solve the following problem. Include a hypothesis, variables, a procedure, and a type of data to study.

PROBLEM: How can you determine the density of chalk?

CHECKING CONCEPTS

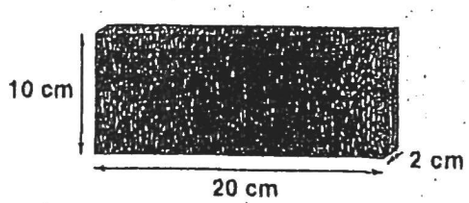
1. What measurements must be known in order to find the density of a substance?
2. What are the units of density for a liquid?
3. What equipment do you need to find the density of a liquid?
4. What three measurements must you make when finding the density of a liquid?
5. How can you find the density of a solid with a regular shape?

THINKING CRITICALLY

6. CALCULATE: If 5 mL of a liquid has a mass of 10 g, what is the density of the liquid?
7. EXPLAIN: When finding the density of a liquid, why must you first find the mass of the container holding the liquid?

BUILDING MATH SKILLS

Calculating Density Use Figure 2-8 to answer the following questions.



▲ Figure 2-8

8. What is the volume of the bar?
9. If the bar has a mass of 500 g, what is its density? Show your work.
10. How would the density of the bar be different if its mass was 4,520 g? What would the bar be made of?

Answers

Density

Textbook definition

Mass per unit volume.

Unit for Density:

g/cm^3

Density of Water:

$1\ g/cm^3$

Density is a physical property of matter.

Densities of Common Substances	
Substance	**Density (g/cm^3)**
•Air	0.0013
Alcohol	0.8
Aluminum	2.7
Cork	0.2
•Gold	19.3
•Iron	7.9
Lead	11.3.
Mercury	13.6
Silver	10.5
•Steel	7.8
•Water	1.0

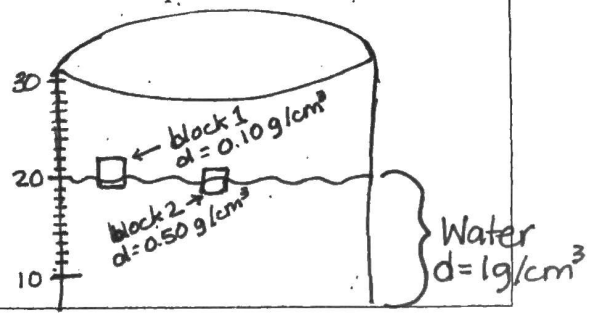
How is density represented in a formula?

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

OR

$$D = \frac{M}{V}$$

How is density represented in a picture?



List the following substances in the correct order from the lowest density to the highest density – iron, gold, steel, water, air

1. Air
2. Water
3. Steel
4. Iron
5. Gold

How is density useful in identifying substances?

The higher the density of a substance the more mass per volume it has. You can identify an unknown substance by measuring its density and

How can you determine if an object will float if you place it in water?

If the density of an object is less than $1\ g/cm^3$, then it will float in water because it is less dense than water.

$D =$ ass / olume