Name: _____

Skill Sheet 17-A — Density

The density of a substance is a measure of how much mass is "packed" into a certain volume of the substance. Substances with a high density, like steel, have molecules that are packed together tightly. Substances with a low density, like cork, have fewer molecules packed into the same amount of space.

The density of a substance can be found by dividing its mass by its volume. As long as a substance is homogeneous, the size or shape of the sample of the substance doesn't matter. The density will always be the same. This means that a steel paper clip has the same density as a steel girder used to build a bridge.

1. Finding density

You can use the formula below to find the density of a substance.

$$Density = \frac{mass}{volume}$$

For example, you have a block of aluminum with a volume of 30.0 cm^3 and a mass of 81.0 grams. To find its density, divide the mass (81.0 grams) by the volume (30.0 cm^3).

$$Density = \frac{81.0\,g}{30.0\,cm^3}$$

The density of aluminum is 2.70 g/cm^3.

A note regarding units for density: Because one milliliter takes up the same amount of space as one cubic centimeter, density can be expressed in units of g/mL or g/cm^3. Liquid volumes are most commonly expressed in milliliters, while volumes of solids are usually expressed in cubic centimeters.

Try these problems on your own:

a. A solid rubber stopper has a mass of 33.0 grams and a volume of 30.0 cm^3. What is the density of rubber?

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b. A chunk of paraffin (wax) has a mass of 50.4 grams and a volume of 57.9 cm^3. What is the density of paraffin?

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c. A marble statue has a mass of 6200 grams and a volume of 2296 cm^3. What is the density of marble?

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2. Using density to find mass

If you know the density of a substance and the volume of a sample, you can calculate the mass of the sample. To do this, rearrange the equation above to find mass:

$$Density = \frac{mass}{volume}$$

$$volume \times Density = \frac{mass}{volume} \times \frac{volume}{1}$$

$$volume \times Density = mass$$

Here's an example: The density of iron is 7.9 g/cm^3. If you have an iron horseshoe with a volume of 89 cm^3, what is the mass of the horseshoe?

To solve the problem, multiply the volume of the horseshoe by the density of iron.

$$89.0\,cm^3 \times 7.90\frac{g}{cm^3} = mass$$

The mass of the horseshoe is 703 grams.

Try these problems on your own:

a. The density of ice is 0.92 g/cm^3. An ice sculptor orders a one cubic meter block of ice. What is the mass of the block? Hint: 1 m^3 = 1,000,000 cm^3.

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b. The density of platinum is 21.4 g/cm^3. A disk of pure platinum has a volume of 113 cm^3. What is the mass of the disk?

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c. The density of seawater is 1.025 g/mL. What is the mass of 1.00 liter of seawater? (Hint: 1 liter = 1,000 mL)

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3. Using density to find volume

If you know the density of a substance and the mass of a sample, you can find the volume of the sample. This time, you will rearrange the density equation to find volume.

$$volume \times Density = mass$$

$$\frac{1}{Density} \times Density \times volume = mass \times \frac{1}{Density}$$

$$volume = \frac{mass}{Density}$$

Sample problem: The density of lead is 11.3 g/cm^3. Find the volume of a 525-gram block of lead.

To solve this problem, divide the mass of the block by the density of lead.

$$volume = \frac{525 g}{11.3 \frac{g}{cm^3}}$$

The volume of the block is 46.5 cm^3.

Try these problems on your own:

a. The density of cork is 0.24 g/cm^3. What is the volume of a 240-gram piece of cork?

b. The density of gold is 19.3 g/cm^3. What is the volume of a 575-gram bar of pure gold?

c. The density of mercury is 13.6 g/mL. What is the volume of a 155-gram sample of mercury?

4. Using density to solve problems

Knowing the density of a substance can help you solve problems. Recycling centers, for example, use density to help sort and identify different types of plastics so that they can be properly recycled. The chart below shows common types of plastics, their recycling code, and density.

Plastic name	Common uses	Recycling code	Density (g/cm^3)
PETE	2-liter soda bottles	1	1.38-1.39
HDPE	milk cartons	2	0.95-0.97
PVC	plumbing pipe	3	1.15-1.35
LDPE	trash can liners	4	0.92-0.94
PP	yogurt containers	5	0.90-0.91
PS	cd "jewel cases"	6	1.05-1.07

Use the table on the previous page to solve the following problems:

a. A recycling center has a 125,000 cm^3 box filled with one type of plastic. When empty, the box had a mass of 755 grams. The full box has a mass of 120.8 kg (120,800 g). What is the density of the plastic? What type of plastic is in the box?

b. A truckload of 2-liter soda bottles was finely shredded at a recycling center. The plastic shreds were placed into 55-liter drums. What is the mass of the plastic shreds inside one of the drums? Hint: 55 liters = 55,000 milliliters = 55,000 cm^3.

c. A recycling center has 100 kilograms (100,000 grams) of shredded plastic yogurt containers. How many 10-liter (10,000 mL) containers do they need to hold all of this plastic?

d. A solid will float in a liquid if it is less dense than the liquid, and sink if it is more dense than the liquid. If the density of seawater is 1.025 g/mL, which types of plastics would definitely float in seawater?