DENSITY Key

Density is the **ratio** of the **mass** of a substance to the **volume** of the substance at a given temperature. Density has the units of g/cm^3 or g/mL for liquids and solids. The density of a gas is expressed as g/L. NOTE: $1\ cm^3 = 1\ mL$

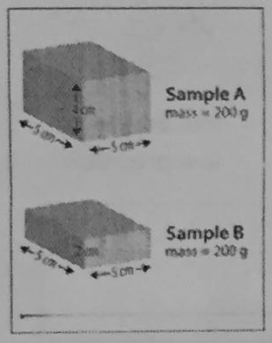
$$\text{Density} = \frac{mass}{volume} \quad \text{or} \quad D = \frac{m}{V}$$

*Note the equation for density is on Table T of the Reference Tables.

Density is an ***intensive*** property. However, density does vary with temperature.

The volume of a sample of matter can be found using mathematical calculations for regular shaped objects. If an object is irregularly shaped and the substance it is made of does not react with water, the method of water displacement can be used to determine the volume of the object.

Example #1: Two silver metal blocks were measured and observed in the lab. The recorded measurements are represented in the box below. Determine the density of each sample and then determine if sample A and sample B are the same substance. Support your statement using evidence from your calculations.



Sample A

mass = 200g

vol. = 5cm x 5cm x 4 cm = 100 cm^3

$d = \frac{m}{V} = \frac{200g}{100\ cm^3} = \boxed{2\ g/cm^3}$

Sample B

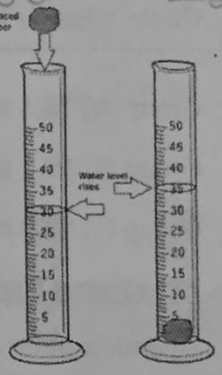
mass = 200 g

vol. = 5cm x 5cm x 2cm = 50 cm^3

$d = \frac{m}{V} = \frac{200g}{50\ cm^3} = \boxed{4\ g/cm^3}$

A + B are not the same substances since they have different densities.

Example #2: A student is trying to find the density of a rock. The mass is measured on a balance to be 13.25 g. The volume of the rock is found using water displacement as shown in the diagram. First calculate the volume and then determine the density of the rock.



volume = 35.0mL - 30.0mL = 5.0mL

mass = 13.25g

$d = \frac{13.25\ g}{5.0\ mL} = \boxed{2.7\ g/mL}$

Practice Problems: All work must be shown to receive credit.

1) Diamonds have a density of 3.5 g/cm^3. What is the volume of a diamond with a mass of 0.10 g?

$d = \frac{m}{V}$ $\quad 3.5\ g/cm^3 = \frac{0.10\ g}{x}$ $\quad \frac{(3.5\ g/cm^3)(x)}{3.5\ g/cm^3} = \frac{0.10\ g}{3.5\ g/cm^3}$

$\boxed{x = 0.029\ cm^3}$

2) Different types of wood have different densities. The density of oak wood is generally 0.7 g/cm^3. If a 35 cm^3 piece of wood has a mass of 25 g, is the wood likely to be oak? Why or why not?

$d = \frac{m}{V} = \frac{25g}{35\ cm^3} = 0.70\ g/cm^3$; the wood may be oak since it has the same density as oak.

3) A graduated cylinder is filled with water to a level of 40.0 mL. When a piece of copper is lowered into the cylinder, the water level rises to 63.4 mL. Find the volume of the copper sample. If the density of copper is 8.9 g/cm^3, what is the mass of the sample?

vol = 63.4 mL - 40.0 mL = 23.4 mL

$d = \frac{m}{V}$ $\quad 8.9\ g/cm^3 = \frac{x}{23.4\ mL}$

$x = 208.26$ to 2 sf = $\boxed{210\ g}$

ACCURACY AND PRECISION

✱use textbook pg. 34 to help you

When taking **quantitative measurements** in the lab it is important that scientists maintain a high degree of accuracy and **precision.**

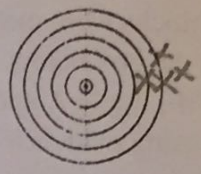
Accuracy **is related to how close a measured value is to an accepted value.**

Precision **is related to how close a series of measurements are to one another.**

PRACTICE: **Given the four targets below, place four dots per target in indicate the degree of accuracy and precision indicated. A successful hit is a bullseye.**

high accuracy
high precision

high accuracy
low precision



low accuracy
high precision

low accuracy
low precision

APPLY: A measurement was taken three times by three different groups of students.
The correct(accepted value) measurement is 68.1 mL.
Circle whether the set of measurements is accurate, precise, both, or neither.

Group A) 78.1 mL, 43.9 mL, 2 mL — accurate — precise — both — (neither)

Group B) 68.1 mL, 68.2 mL, 68.0 mL — accurate — precise — (both) — neither

Group C) 98.0 mL, 98.2 mL, 97.9 mL — accurate — (precision) — both — neither

Expressing Errors in Measurements

Scientists often express their uncertainty and error in measurements by calculating percent error.

$$\text{Percent error} = \frac{\text{measured value} - \text{accepted value}}{\text{accepted value}} \times 100$$

EXAMPLE: While doing a lab a student found the density of a piece of pure aluminum to be 2.85 g/cm^3 (measured). The accepted value for the density of aluminum is 2.70 g/cm^3 (accepted). What is the student's percent error?

$$\%\text{ error} = \frac{2.85 - 2.70}{2.70} = \frac{0.15}{2.70} \times 100\% = 5.5555\ldots = 5.6\%$$

↑ 2 sf

PRACTICE: A sample of iron has a mass of 28.5 g. It is added to a graduated cylinder containing 45.5 mL of water. The water level rises to the 49.1 mL mark. Using the information provided, calculate the density of the sample.

$$d = \frac{m}{V} = \frac{28.5\text{g}}{(49.1 - 45.5\text{ mL})} = \frac{28.5\text{ g}}{3.6\text{ mL}} = 7.9166\ldots = 7.9\text{ g/mL}$$

↑ 2 sf

If the accepted density for iron is 7.87 g/mL (accepted). Determine the student's percent error. ✱Don't worry about sf for

$$\%\text{error} = \frac{(7.9 - 7.87)}{7.87} = \frac{0.03}{7.87} \times 100\% = 0.38\%$$