

ANSWER KEY

Name _____

Lab: It's All About Density

Background:

Density is defined as the amount of matter that occupies a given unit of space; it can also be thought of as the "compactness" of a substance. Dense materials (such as lead or gold) are very heavy for their size whereas less dense substances (such as a big bag of feathers or a filled balloon) are light for their size.

Density is equal to a substance's mass per unit volume, where *mass* is the amount of matter in an object (measured in grams) and *volume* is the amount of space that an object occupies (measured in milliliters or cubic centimeters). The equation to calculate density is as follows:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} \quad \text{OR} \quad D = \frac{M}{V} \quad (\text{in g/mL or g/cm}^3)$$

Density is an intrinsic physical property of matter – that is, it is a property unique to a specific substance (at a specified temperature) no matter what size the sample. A substance's density varies with temperature and pressure changes. The benchmark for comparing density is water which, at 4°C, has a density of 1.00 g/mL. Substances that float in water are less dense than water, while substances that sink are more dense than water.

Table 1:




Shape of Solid Object		Volume (in cm ³)
Cube or Rectangle		$V = L \times W \times H$
Cylinder		$V = \pi \times r^2 \times h$
Sphere		$V = \frac{4}{3} \times \pi \times r^3$

Table 2:

Densities of Common Substances			
Substance	Density (g/cm ³)	Substance	Density (g/cm ³)
Helium	0.0002	Sulfur	2.07
Air	0.001	Silicon	2.33
Balsa Wood	0.11-0.14	Glass	2.4-2.8
Cork	0.22-0.26	Aluminum	2.70
Maple Wood	0.65-0.75	Calcium carbonate	2.93
Ethanol	0.789	Rubber	1.34
Mineral oil	0.86-0.93	Iron	7.86
Polyethylene plastic	0.92	Copper	8.92
Water	1.000	Lead	11.3
Polystyrene plastic	1.06	Mercury	13.6
Fool's Gold (FeS ₂)	5.0	Gold	19.3

Procedures:

- Determine the mass and volume of each of the following seven materials using the appropriate method as outlined in the background section.
 - Station 1 – Clear Liquid I
 - Station 2 – Clear Liquid II
 - Station 3 – White block
 - Station 4 – Foam block
 - Station 5 – Rubber stopper
 - Station 6 – Glass sphere
 - Station 7 – Metal cylinder
- Record the mass and volume of each substance in the Density Data Table. Be sure to include the appropriate units.
- Calculate the density of each material.
- Determine the identity of the unknown metal cylinder by comparison with the actual values for density.

Pre-lab Questions:

Type of Material	M or V Data	Mass (grams)	Volume (mL or cm ³)	Density (g/mL or g/cm ³)	Identity of Solid
Rectangular Solid	L = 1.23 cm W = 2.34 cm H = 3.45 cm	10.6 g	$V = L \times W \times H$ $V = 9.93 \text{ cm}^3$	$D = \frac{10.6 \text{ g}}{9.93 \text{ cm}^3}$ $D = 1.07 \text{ g/cm}^3$	Polystyrene Plastic
Cylindrical Solid	h = 3.45 cm d = 1.12 cm	26.72 g	$V = \pi r^2 h$ $V = 3.40 \text{ cm}^3$	$D = \frac{26.72 \text{ g}}{3.40 \text{ cm}^3}$ $D = 7.86 \text{ g/cm}^3$	Iron
Irregular Solid	Vol water = 25.2 mL Vol water + solid = 37.4 mL	61.1 g	$V = 37.4 \text{ mL} - 25.2 \text{ mL}$ $V = 12.2 \text{ mL}$	$D = \frac{61.1 \text{ g}}{12.2 \text{ mL}}$ $D = 5.01 \text{ g/mL}$	Fool's Gold
Liquid	Mass empty cylinder = 40.1 g Mass cylinder + liquid = 93.2 g	$m = 93.2 \text{ g} - 40.1 \text{ g}$ $m = 53.1 \text{ g}$	67.2 mL	$D = \frac{53.1 \text{ g}}{67.2 \text{ mL}}$ $D = 0.790 \text{ g/mL}$	Ethanol

Lab Data:

* Class Data Set * Class Data Set

Station	Name of Object	Mass (g)	Volume (mL of cm ³)	Density (g/mL or g/cm ³)
1	Clear Liquid I	Cylinder + liquid = 183.93g Cylinder = 122.63g Liquid = 61.30g	61.8 mL	0.992 g/mL
2	Clear Liquid II	Cylinder + liquid = 48.70g Cylinder = 41.09g Liquid = 7.61g	8.8 mL	0.86 g/mL
3	White Block	39.66g	V = L x W x H L = 8.80 cm W = 4.19 cm H = 1.09 cm V = 69.7 cm ³	0.569 g/cm ³
4	Foam Block	2.74g	V = L x W x H L = 5.15 cm W = 4.44 cm H = 4.42 cm V = 101.1 cm ³	0.0271 g/cm ³
5	Rubber Stopper	14.40g	Water = 63.0 mL Water + stopper = 71.8 mL Glass = 8.8 mL	1.3 g/mL
6	Glass Sphere (Water displacement method)	22.04g	Water = 61.2 mL Water + glass = 69.9 mL Glass = 8.7 mL	2.53 g/cm ³
	Glass Sphere (Measurement method)	22.04g	V = 4/3 πr ³ d = 2.50 cm r = 1.25 cm V = 8.18 cm ³	2.69 g/cm ³
7	Metal Cylinder (Water displacement method)	18.03g	Water = 60.8 mL Water + metal = 66.9 mL Metal = 6.1 mL	3.0 g/mL
	Metal Cylinder (Measurement method)	18.03g	V = πr ² h d = 1.30 cm r = 0.65 cm h = 5.09 cm V = 6.75 cm ³	2.67 g/cm ³

Post-Lab Questions:

- Rank the materials tested in this lab in order from most dense to least dense

Metal Cylinder, glass sphere, rubber stopper, water, mineral oil, white block, foam block

- If the foam block was cut in half, would the density change? Explain

No, because density is an intrinsic physical property and does not depend on sample size.

- List the items in this lab that would float on water. How was this determined?

Mineral oil, white block, foam block

↳ Their densities are less than the density of water, 1.0 g/mL

- Consider the following six materials – water, mercury, mineral oil, cork stopper, rubber stopper, and a piece of lead. If these materials were added to a graduated cylinder, in water order would they be found from top to bottom?

Cork, mineral oil, water, rubber, lead, mercury

- Why is density an important factor to know about a material?

Density is a property unique to each substance and can help to determine the identity of the substance.

- Use the "Table of Densities of Common Substances" to identify Clear Liquids I & II.

* Clear Liquid I = Water (Distilled)

* Clear Liquid II = Mineral oil

- Observe the metal cylinder tested at Lab Station 7. Using the density you obtained and observations, identify the metal.

Aluminum Metal

- From your answer to question 7, which method for determining density did you find to be more accurate? Explain.

Measuring volume with a ruler was found to be more accurate than using the water displacement method because the metal cylinder was a regular shaped object.

- Explain how you would find the density of your own body.

① Determine body's mass in grams

② Determine body's volume by water displacement

③ Calculate $D = \frac{\text{mass}}{\text{volume}}$