Experiment 6
Measurements - Density

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Date:

Key Objectives

1. Understand the difference between Accuracy and Precision.
2. Make all measurements with the correct number of Significant Figures.
3. Calculate average, standard deviation, and percent error.
4. Measure density by calculating volume of a regular object.
5. Calculate density by volume displacement method.

Discussion

The density of an object is the ratio of the mass to volume, and is unique for any given compound or element. By measuring the density of an object, it is often possible to determine the nature of an unknown compound. A discussion of density can be found in Hein Ch. 2.9 (p. 37), Chang Ch. 1.7 (p. 18), or McMurry 1.10 (p. 16).

Density is defined as the ratio of an objects mass to its volume. Mathematically we can use the equation below where D = Density(in g/mL), M = mass (in grams) and V = volume (in mL).

$$D = \frac{M}{V} \tag{1}$$

While the equation form is useful and is taught in many schools, we should try to think of Density as simply another conversion factor that allows one to convert between mass and volume. Using Density as a conversion factor will also help us if a problem is given in non-standard units, for instance lb/ft^3.

For example we can ask what is the volume of 25.0 grams of gold. Using the equation method we would solve:

$$19.3\ \mathrm{g/mL} = \frac{25.0\ \mathrm{g}}{X\ \mathrm{mL}} \tag{2}$$

If instead we think of it as a conversion factor we would solve:

$$\frac{25.0\ \mathrm{g}}{1} \times \frac{1\ \mathrm{mL}}{19.3\ \mathrm{g}} = 1.30\ \mathrm{mL} \tag{3}$$

The mass of an object is relatively easy to measure using a balance. Volume is more difficult and is generally measured in two ways. Regular objects (such as cubes, cylinders, and spheres) can be measured with a ruler and the volume calculated mathematically as shown in Figure 6.1. The volume

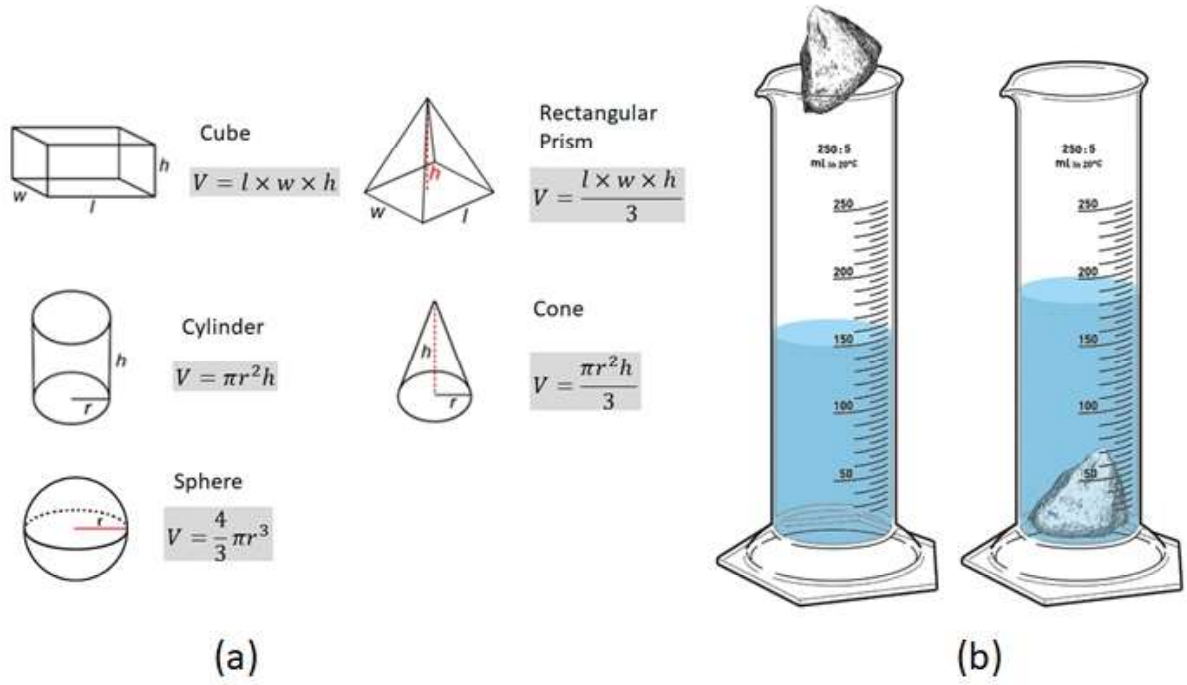

Figure 6.1: (a) Formula's for finding volume of regular objects. (b) Method of water displacement for finding volume of irregular objects. credit: (a) Author (b) `https://en.wikipedia.org/wiki/Displacement_(fluid)`

of irregular objects is generally measured by the water displacement method, the object is submerged in water and the change in volume of the water is the volume of the object. In this lab both methods will be used.

Because most substances change in volume when heated or cooled due to expansion or contraction, the density of an object is also temperature-dependent. Usually the variance is quite small for instance, the density of water at 3.98 ℃ is 1.0000 g/mL which decreases to 0.99987 g/mL at 0 ℃. We will generally assume the density of water is 1.00 g/mL at room temperatures.

The density of the samples used in class can be found in the table below. Additional values can be found on the back of your Cheat Sheet.

Object	**Density (g/ml)**	**Object**	**Density (g/mL)**
Water (4 ℃)	1.000	Aluminum	2.70
Copper	8.96	Lead	11.34
Mercury	13.55	Gold	19.3
Brass	8.5	Iron	7.86
Nickel	8.90	Steel	7.8
Tin	7.28	Manganese	7.20
Zinc	7.10	Woods Alloy	9.63

Table 6.1: Density of Common Metals

Procedure

Density of a regular object

1. Obtain a regular shaped object from your laboratory instructor. Record its identity.
2. Weigh the object, record your result.
3. Measure the objects length, width, and height.
4. Calculate the volume of the object. Be sure to show your calculation.
5. Calculate the density of the object. Be sure to show your calculation.

Density of an irregular object

1. Obtain an irregular shaped object from your laboratory instructor. Record its' identity.
2. Weigh the object and record your result.
3. Fill a burret half full of water. Record the volume.
4. Carefully (slide it down the side of the tube, do not drop it in) place your irregular object in the burret and record the volume.
5. Calculate the volume of the item.
6. Calculate the density of the item using the appropriate formula.
7. Compare the density of the item with the value given by your instructor, if your measurement is within 0.2 g/mL of the correct value move onto the next section, if not, redo this section.

Density of an unknown object

1. Obtain an unknown object from your instructor. Record its identity.
2. Determine the density of the object using the methods described above.
3. Do 3 trials and average your result.
4. Compare your experimental density with the density of the known elements provided in the discussion section.
5. Write down the identity of the known element which most closely matches your measured density.

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Results

Density of a regular object

1. Identity of regular object: _____
2. Mass of regular object: _____
3. Length of regular object: _____
4. Height of regular object: _____
5. Width of regular object: _____
6. Calculate the volume of the regular object, show the formula used and the calculation: _____
7. Calculate the density of the regular object: (Show formula and work) _____
8. Correct value for density of regular object (ask instructor) _____
9. Your answer should be within 0.05 g/mL of the correct answer. If your answer is not, redo steps 1-8.
10. Calculate the Percent Error in your measurement using the following formula: $|\frac{\text{Actual Density} - \text{Measured Density}}{\text{ActualDensity}}| * 100\ \%$ _____

Density of an irregular object

1. Identity of irregular object: _____
2. Mass of irregular object: _____
3. Initial volume of water in the buret: _____
4. Final volume of water in the buret after adding irregular object: _____
5. Calculate the volume of the irregular object. (Show work): _____
6. Calculate the density of the irregular object (Show work): _____
7. Correct value for density (obtained from cheat sheet): _____
8. Your answer should be within 0.2 g/mL of the correct answer. If your answer is not inform your instructor, redo steps 1-8.
9. Calculate the Percent Error in your measurement: _____

Density of an unknown object (3 Trials)

		Trial 1	Trial 2	Trial 3
1.	Identity of unknown object:	_____	_____	_____
2.	Mass of unknown object:	_____	_____	_____
3.	Initial volume of water in the burret:	_____	_____	
4.	Final volume of water in the burret after adding unknown object:	_____	_____	_____
5.	Volume of unknown object (show work):	_____	_____	_____
6.	Measured density of unknown object (show work):	_____	_____	_____
7.	Average density of unknown object:		_____	
8.	Standard Deviation:		_____	
9.	Using Table 1, what metal is the unknown object?		_____	
10.	What is the percent error in your measurement?		_____	

Questions

1. The density of a zinc block is 7.10 g/mL. What is the volume of a zinc block weighing 120.5 grams? 1. _____

2. A zinc fishing weight displaces 13.50 mL of water. What is the mass (in milligrams) of the zinc weight? 2. _____

3. A bar of lead weighs 250 lbs. What is its volume in ft^3? 3. _____

4. An empty graduated cylinder weighs 82.450 g. When filled to 50.0 mL with an unknown
liquid it weighs 110.810 g. What is the density of the unknown liquid? 4. _____

5. Five liquids (Ethyl Alcohol, Glycerin, Sulfuric Acid, Vegetable Oil, and Water,) are poured into a large beaker and given time to separate. What is the order of the liquids in the beaker from bottom to top. Sketch and label a picture for your answer.

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