Density

Names: ________________________________

Exercise #1: Measuring Masses, Volumes and Densities

Fill in column #2 ("Mass") of Table 1 by measuring the masses of your ten objects. **(10 points)**

Fill in columns 3 and 4 (again, remember for column #4, that 1 ml = 1 cm^3). **(10 points)**

Fill in the Density column in Table 1. **(5 points)**

1. Think about the process you used to determine the volume. How accurate do you think it is? Why? How could we improve this technique? **(5 points)**

Table 1: The Masses, Volumes, and Densities of the Different Objects.

Object Column #1	**Mass (g)** #2	Volume of Water (ml) **#3**	**Volume** cm^3 **#4**	**Density** g/cm^3 **#5**
Obsidian				
Gabbro				
Pumice**				
Silicon				
Magnesium				
Copper				
Iron (Steel)				
Zinc				
Mystery				
Aluminum				

**It is tricky to measure the volume of Pumice, but find a way to *submerge* the entire stone.

Fill in Table 2. Copy the mass measurements from Table 1 for the five metal "cubes". Calculate the volumes of these "cubes" using the caliper. **(5 points)**

Table 2: The Masses, Volumes, and Densities of the Metal Cubes.

Object	**Mass (g)**	$l \times w \times h \quad =$	**Volume** cm^3	**Density** g/cm^3
Copper				
Iron (Steel)				
Zinc				
Mystery				
Aluminum				

2. Compare the two sets of densities you found for each of the five metal cubes. How close are they? Assuming the second method was better, which substance had the biggest error? Why do you think that happened? **(5 points)**

3. One of the objects in our table was labeled as a "mystery" metal. This particular substance is composed of two metals, called an "alloy." You have already measured the density of the two metals that compose this alloy. We now want you to figure out which of these two metals are in this alloy. Note that this particular alloy is a 50-50 mixture! So its mean density is (Metal A + Metal B)/2.0. What are these two metals? Did its color help you decide? **(3 points)**

Exercise #2: Using Density to Understand the Composition of Planets.

4. You measured the densities of (pure) silicon, iron and magnesium in Exercise #1. Compare the density of Gabbro and Obsidian to that of pure silicon. Can you tell that there must be some iron and/or magnesium in these minerals? How? Which of these two elements *must* dominate? Were your density measurements good

enough to demonstrate that Gabbro has less silicon than Obsidian? **(4 points)**

Table 3: Densities of the Earth and Moon

Object	Density g/cm^3
Earth	5.5
Moon	3.3
Earth's Crust	3.0

5. Compare the mean densities of the Earth's crust and the Moon. The leading theory for the formation of the Moon is that a small planet crashed into the Earth 4.3 billion years ago, and blasted off part of the Earth's crust. This material went into orbit around the Earth, and condensed to form the Moon. Do the densities of the Earth's crust and the Moon support this idea? How? **(4 points)**

6. If you were asked "What are the main elements that make-up the Moon?", what would your answer be? Why? **(2 points)**

7. Given that the mean density of the Earth's crust is 3.0 g/cm^3, and the mean density of the whole Earth is 5.5 g/cm^3, what (common) element do you suppose is partially responsible for the higher mean density of the whole Earth? If we guess, and say that the Earth is a 50-50 mixture of this element, and the crust material, what density do you calculate? Does the resulting density compare with that for the whole Earth? **(4 points)**

8. If Pumice has the same basic composition as Gabbro, how might it have such a low density? [Hint: think about a boat. As you have found out, cubes of pure metals do not float. But then how does a boat made of iron (steel) or aluminum actually float? What is found in the boat that fills most of its volume?] **(2 points)**

9. Dry air has a density of 0.0012 g/cm^3, let's make an estimate for how much air must be inside Pumice to give it the density you measured. Note: this is like the alloy problem you worked on above, but the densities of one of the two components in the alloy is essentially zero. **(6 points)**

   You measured the volume of the piece of Pumice along with its mass, and then calculated its density. We stated that density = mass/volume. But you could re-arrange this equation to read volume = mass/density.

Assume that the density of the material that comprises the solid parts of Pumice is the same as that for Gabbro.

a) What would be the volume of a piece of Gabbro that has the same mass as your piece of Pumice?

$$\text{Volume(Gabbro)} = \text{Mass(Pumice)/Density(Gabbro)} = \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_} \quad \text{cm}^3$$

b) Now take the value of the volume you just calculated and divide it by the volume of the Pumice stone that you measured:

$$r = \text{Volume(Gabbro)/Volume(Pumice)} = \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_} \ \%$$

This ratio, "r", shows you how much of the volume of Pumice is occupied by **rocky material**. The volume of Pumice occupied by "air" is:

$$1 - r = \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_} \ \%$$