EXPERIMENT 1 Pre-laboratory Questions:

Name__________________________ Lab Section_______________

- **Please read the experiment before attempting this assignment.**
- ***THESE QUESTIONS MUST BE COMPLETED PRIOR TO ATTENDING LAB.***
- ***THEY WILL BE COLLECTED AT THE BEGINNING OF LAB.***

1. Calculate the volume of a cylinder with the following dimensions:
   diameter = 2.25 cm height = 4.46 cm

Answer_________________

2. A student collected the following data in attempting to determine the density of an unknown liquid by the pycnometer method:

Mass of dry pycnometer and stopper:	32.4345 g
Mass of pycnometer + stopper + water:	58.0558 g
Temperature of the water:	23.0 °C
Mass of the pycnometer + stopper + unknown liquid:	52.8734 g

a) Find density of water at 23.0 °C *(Use the CRC Handbook of Chemistry and Physics located in the HELP! OFFICE SQU 502, the balance room between SQU 418 & 416, or the Library.)*

Answer_________________

b) Calculate the volume of the pycnometer. *(show work)*

Answer_________________

c) Determine the density of your unknown liquid. *(show work)*

Answer_________________

d) If the accepted density of your liquid is 0.8000 g/mL, what is the percent error between your value and the accepted value?

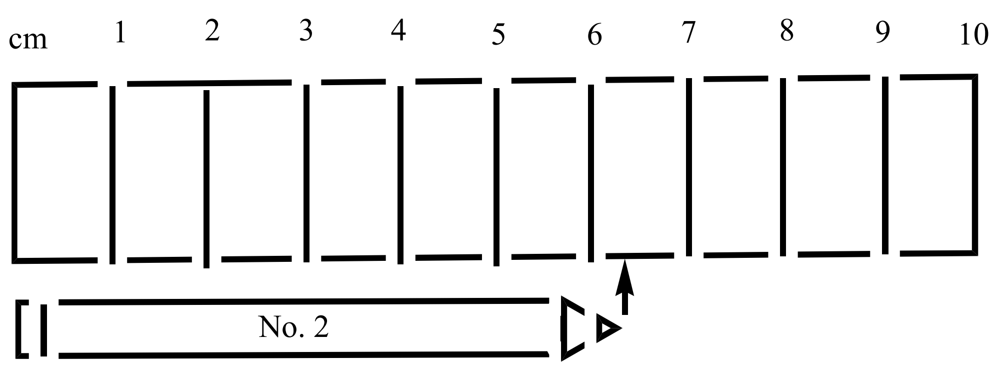
$$\text{Percent Error} = \frac{|\text{Experimental Value - Accepted Value}|}{\text{Accepted Value}} \times 100$$

Experiment 1: Density

Every substance has a unique set of properties or characteristics which allows us to distinguish it from other substances. The properties of many substances are tabulated in scientific books and handbooks, such as the *CRC Handbook of Chemistry and Physics (CRC Press)*. A copy of this useful handbook can be found in the HELP! Office (SQU 502). Some properties are physical properties, which can be measured without changing the identity or composition of the substance. When a number defines a property, it is called a quantitative property. A unit of measurement must always be associated with the numerical value in order for it to have meaning. For example, saying that the length of a desk is 150 is meaningless. However, saying the desk is 150 cm long properly specifies the length.

When making quantitative measurements, the uncertainty in our number is partially determined by the precision of the instrument or equipment used. For example, weighing an object on a top loading balance, which weighs to the nearest 0.01 gram is less precise and contains more uncertainty than weighing the object on an analytical balance capable of weighing to the nearest 0.0001 gram. The number of significant figures provided by the instrument and subsequently recorded by the user provides an estimate of the uncertainty associated with the measurement. It is generally assumed that the last significant digit in a number is assumed to have an uncertainty of at least 1. For example when the mass of a sample is recorded as 15.34 grams, we are implying that the object was weighed in such a way that there is no question that the mass is at least 15.3 grams and less than 15.4 grams. The value in the hundredths place is thought to be 4, but there is some uncertainty associated with this last digit. As a result, we should conclude that there is an uncertainty of at least 0.01 gram in the value 15.34 grams. The number 15.34 grams has four significant digits, three of which are completely certain (15.3) and one that has some uncertainty associated with it (4). We can see that the correct use of significant figures in recording measurements can summarize the minimum level of uncertainty associated with a value (+/- 0.01 grams in the above example).

On balances in our lab, a digital readout generally provides the value. However, for many other types of measurements and measurement devices, the user is required to estimate the last digit. For example, the figure of the ruler below shows divisions of cm. The object being measured is between 6 and 7 cm long. We can estimate an extra digit, although this digit is uncertain since the ruler is not calibrated with mm lines. I would estimate the length of the pencil to be 6.3 cm.

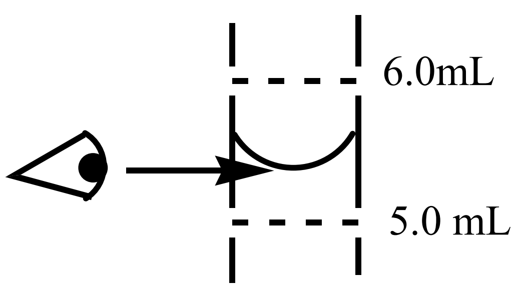


The density of a substance is a very useful intensive property which is defined as the amount of mass per unit volume of the substance.

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

The densities of solids and liquids are commonly expressed in units of grams per cubic centimeter (g /cm^3) or grams per milliliter (g /mL). Since the volumes of most substances change when heated or cooled, densities are temperature dependent. Therefore, when reporting densities, the temperature should be documented with the value.

The density of a substance or object can be experimentally determined by making a measurement of its mass and the volume that it occupies. The mass of an object can be easily determined by weighing it on a balance. The volume can be determined a number of different ways depending on the state of the substance and its physical form. In explanation, the volume of a liquid is easily measured in a graduated cylinder or a special type of glassware called a pycnometer. When measuring the volume of a liquid, be sure to read the volume at the bottom of the meniscus. The figure below illustrates the correct method to read the volume of a liquid with a meniscus. I would read the volume as 5.4 mL. Often it is helpful to place a piece of paper with a dark mark drawn upon it behind the graduated cylinder and under the meniscus. This serves to sharpen the image of the meniscus and make it easier to read the volume. Your lab instructor will illustrate this useful trick for you.



The volume of a regularly shaped solid, such as a cube, can be determined by measuring the length of one of its sides and using the equation for the volume of a cube ($V = l^3$). However, an irregularly shaped solid may not have a simple equation defining its volume, and as a result does not lend itself to this method. Alternatively, we can use a displacement method in which the amount of liquid volume displaced by the object is used to determine its volume.

Objectives: The skills acquired and topics you should understand upon completion of this exercise include:

1. The ability to use and understand the differences associated with a top loading balance and an analytical balance.

2. The ability to correctly read the liquid volume in a graduated cylinder and in a thermometer.

3. Determine that the precision of a measurement is dependent upon the scientific methods and instrumentation utilized.

4. Experimentally determine the density of a liquid and solid.

5. Use the *CRC Handbook of Chemistry and Physics* to locate the density of a substance.

6. Calculate the percent error between your experimentally determined value and a tabulated value.

Experimental Procedure. A. Density of a Known Liquid.

1. Graduated cylinder method: Clean and dry your 10.0 mL graduated cylinder with soap and water and then rinse with a small amount of acetone. Shake as much of the acetone out as possible by gently tapping it on a paper towel. When you can no longer smell the acetone in your graduated cylinder, it is ready to use. Weigh the dry and empty graduated cylinder on the top loading balance. Record the mass on your data sheet. In the weighed graduated cylinder, obtain approximately 5 mL of one of the known liquids in the hood. Read the volume and record the value on your data sheet. Weigh the graduated cylinder and known liquid and record the value. Measure the temperature of the liquid.

2. Pycnometric method: Obtain a pycnometer and glass stopper from your lab instructor. Carefully clean the glassware with soap and water and then rinse with a small amount of acetone as described above. Weigh the dry flask and stopper on the analytical balance in the balance room. Determine the exact volume of your pycnometer by filling it fully with water, inserting the stopper, and tapping the sides gently to remove the air bubbles. Dry the sides and weigh the full pycnometer on the analytical balance. Measure the temperature of the water. Use the known density of water located in the CRC handbook to determine the volume of water contained in the full pycnometer flask. Be certain to use the known density value at the correct temperature. Record all the values on your data sheet. Empty and dry your pycnometer before filling it with the same known liquid you used in part one. Use the same technique to make sure the pycnometer is full of your known liquid. Dry the outside carefully and weigh the full pycnometer. Record the mass values. Be sure to record the identity of your known liquid.

B. Density of a solid cylinder.

Obtain solid samples from your lab instructor and record its number. Also obtain a ruler.

1. Volume Calculation Method. Weigh the large solid sample on a top loading balance and record its mass on your data sheet. Use the ruler to make measurements which will allow you to calculate the volume of your cylinder. Describe and record the values on your data sheet. Be sure to make these measurements to the greatest precision possible.

2. Graduated Cylinder Method. Clean and dry a 50 mL graduated cylinder with soap and water and then acetone. Place about 20 mL of deionized water in the graduated cylinder and read the value as precisely and accurately as possible. Record the value. Very gently slide your large solid cylinder into the graduated cylinder, being careful not spill any of the water. Read and record the new value of the water in the graduated cylinder.

3. Pycnometric Method. Weigh the small solid samples on the **analytical balance**. Record the value. Place the solid sample in the pycnometer and fill completely with water as described in part A-2. Weigh and record the mass.

Please clean the glassware when you are finished and return the solid samples and the pycnometer to the lab instructor.

<u>Density Experiment Data Sheet.</u> Name: ______________________________

(Turn in only this and the following pages.)

Lab Section: ________________________

A. Density of a Known Liquid: Identity of Known Liquid________________________

Part 1. Graduated cylinder method:

Mass of empty graduated cylinder _________________

Mass of graduated cylinder and known liquid _________________

Mass of known liquid in the graduated cylinder _________________

Volume of known liquid _________________________ Temperature____________

Density of known liquid _________________________

Show your work:

Part 2. Pycnometric method: *Calibration of pycnometer using water*

Mass of clean dry pycnometer and stopper _________________

Mass of pycnometer + stopper + water _________________

Mass of water in pycnometer _________________

Temperature of water _________________

Known density of water (CRC Handbook) at the above temperature______________

Volume of water (volume of pycnometer) _________________

Show your work:

Instructor Initials & Date: ____________________

Part 2. Pycnometric method *(cont.)*: *Density of a Known Liquid*

Mass of known liquid + pycnometer + stopper ____________________

Mass of known liquid in pycnometer ____________________

Temperature_______________ Density of known liquid ____________________

Known density of known liquid (CRC handbook) ____________________

Show your work:

B. Density of a Solid Solid sample number _____________________

Part 1. Direct Volume Calculation Method.

Radius of cylinder _____________ Length of cylinder_____________

Volume of cylinder_____________

Show your work:

Mass of cylinder _________________ Density of cylinder ___________________

Show your work:

Instructor Initials & Date: _____________________

Part 2. Graduated cylinder method. *Water Displacement*

Initial Volume of water in graduated cylinder ____________________

Final Volume of water after adding metal cylinder ____________________

Volume of water displaced by metal cylinder ____________________

Density of metal cylinder ____________________

Show your work:

Part 3. Pycnometric method:

Mass of small solid sample + pycnometer + stopper ____________________

Mass of solid sample ____________________

Show your work:

Mass of solid sample + pycnometer + stopper + water ____________________

Mass of water surrounding the solid ____________________

Volume of water surrounding the solid ____________________

Volume of the solid ____________________

Density of the solid ____________________

Known density of the solid (CRC Handbook) ____________________

Show your work:

Instructor Initials & Date: ______________________

Post Lab Questions:

1. From your results in measuring the density of the **known liquid** using the two different techniques, calculate the percent error between your density values and the value obtained in the *CRC handbook of Chemistry and Physics*:

A.	**Part 1:**	Your value	__________________
		Known Density	__________________
		Percent error	__________________
	Part 2:	Your value	__________________
		Percent error	__________________

Show your work:

2. Explain thoroughly the difference you observed in the above results. Please use complete sentences, nouns etc...