EXPERIMENT 1 Pre-laboratory Questions:[1]

Name: ___________________________ Score: _______ /10
Lab Section: _______

1. Calculate the volume of a cylinder with the following dimensions: (show work)

diameter = 2.25 cm
height = 4.46 cm

Answer_________________

2. Find density of water at 23.0 °C, report to six sig.figs. *(Use the CRC Handbook of Chemistry and Physics in the HELP! OFFICE SQU 502, the instructor desk in SQU 418 & 416, or online on the chem. 1A Lab webpage.)*

Answer_________________

3. A student collected the following data 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
Mass of the pycnometer + stopper + unknown liquid:	52.8734 g
Temperature of the water:	23.0 °C

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

Answer_________________

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

Answer_________________

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

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

Answer_________________

[1] Please read the experiment before attempting this assignment.
THESE QUESTIONS MUST BE COMPLETED PRIOR TO ATTENDING LAB. THE ASSIGNMENT IS DUE AT THE BEGINNING OF LAB.
All work must be shown for credit.
Significant figures and units count, there will be points deducted for such errors.

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), the Library and in the chem. 1A balance room. 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. When massing (weighing) an object on a top loading balance, which with an uncertainty of ± 0.01 grams, the mass is less precise and contains more uncertainty than obtained by weighing the object on an analytical balance with an uncertainty ± 0.0001 grams. 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, one should conclude that there is an uncertainty of at least 0.01 grams 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 (the 4^{th}). One 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).

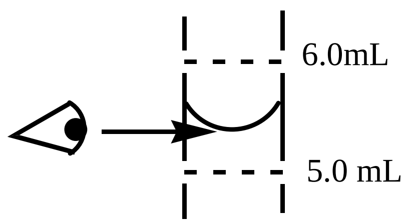
On balances in this lab, a digital readout generally provides the value. However, for many other types of measurements and measurement devices, the user is required to estimate the last digit. Look at the figure of the ruler below shown in divisions of cm. The line measured is between 8 and 9 cm long. One can estimate an extra digit, although this digit is uncertain since the ruler is not calibrated beyond mm lines. You should estimate the length of the line to be 8.4 cm. (2 significant figures)

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.

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

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 metal sample, 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 metal sample 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 precision 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 metal sample.

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.

WATCH YOUR SIGNIFICANT FIGURES! POINTS WILL BE DEDUCTED FOR ERRORS!

Experimental Procedure.
Determining the density of a known liquid

1. **Graduated cylinder method**

- Inspect your 10.0 mL graduated cylinder, if it is not clean, use a small amount of soap, water and your test tube brush to clean it. Rinse well with deionized water (di–H_2O). To dry the cylinder, rinse with a little bit of acetone, dispose of the acetone in the waste jugs. Quietly blow air into the cylinder to remove the last of the acetone.
- Weigh the graduated cylinder on a top loading balance to ± 0.01g after the acetone has dissipated.
- Record the mass on your data sheet.
- Add ~ 5mL of a known organic liquid from the auto dispensers in the fume hood to your graduated cylinder. (Pull the plunger up once, the push down with the opening of the graduated cylinder under the dispenser tip.)
- Record the volume on your data sheet to ± 0.1 mL
- Weigh the graduated cylinder and known liquid on the same top loading balance you used previously.
- Record the mass on your data sheet to ± 0.01g.
- Calculate the density of the known liquid and record on your data sheet.

2. **Pycnometric method:** ***Calibration using water***

- Check out a pycnometer and glass stopper from the stockroom. ***You will be responsible for returning this at the end of the period. Do not leave it in your locker!***
- Clean, rinse and dry the glassware as before with soap, water and acetone.
- Weigh the pycnometer and glass stopper on an analytical balance in the balance room to ± 0.0001g after the acetone has evaporated. ***If you don't know how to use the balance, see your instructor!***
- Record the mass of the empty pycnometer and glass stopper on your data sheet.
- Fill the pycnometer with deionized water and slowly insert the glass stopper while gently tapping the sides of the pycnometer to remove air bubbles.
- Dry the exterior of the pycnometer with a paper towel and weigh the glassware on the same analytical balance you used previously.
- Record the mass of the pycnometer and glass stopper filled with water on your data sheet.
- Remove the glass stopper and measure the temperature of the water using the thermometer in your drawer. Record the temperature of the water on your data sheet.
- Look up the density of water at the measured temperature. Record the density on your data sheet.
- Determine the volume of water that occupies the pycnometer using the mass and density of water.
- Record the volume on your data sheet.
- Empty the water from the pycnometer, rinse and dry as before with a little bit of acetone. (no soap)
- Allow the acetone to evaporate before beginning the next step.

3. Density of known liquid using a pycnometer

- Fill the pycnometer with the same known organic liquid that was used in the graduated cylinder method.
- Just as before, determine the mass of the pycnometer, glass stopper and known liquid on the same analytical balance used previously. Record the mass on your data sheet.
- Determine the density of the known liquid from the mass of liquid and the volume of the pycnometer (***<u>IT IS NOT 25.00 mL</u>***)and record the value on your data sheet.
- Look up the density of the known in the CRC Handbook. Record the literature value of your known liquid on your data sheet.
- Calculate the experimental error of the density and record on your data sheet.

Density of a known metal sample:

1. Direct measurement Method

- Obtain a metal sample from your instructor. There will be two samples, on large and one small. Record the identity of the metal on your data sheet.
- Measure the mass of the larger piece on a top loading balance, record the mass to ± 0.01g on your data sheet.
- Measure the length and radius (diameter × ½) to ± 0.1 cm (1 mm) using a ruler. Calculate the volume and record the value on your data sheet.
- Calculate the density of the metal sample and record the value in your data sheet.

2. Density of known metal sample using water displacement

- Fill a clean and dry a 50.0mL graduated cylinder with just enough di–water to completely immerse the larger of the two metal samples. Record the volume to ± 0.5 mL.
- Gently slide the metal sample sample into the graduated cylinder so water does not splash out.
- Record the new volume of the water in the graduated cylinder on your data sheet to ± 0.5 mL.
- Determine the density of the sample using the mass recorded in part 1.

3. **Density of known metal sample using a pycnometer**

- Place the metal sample in the pycnometer. Weigh on the same analytical balance used previously, record the mass to ± 0.0001 g.
- Fill the pycnometer containing the metal sample completely with water and then insert the glass stopper avoiding trapped air bubbles as before. Gently tap the sides of the pycnometer to remove air bubbles. Dry the exterior of the pycnometer off thoroughly.
- Weigh and record the mass of the pycnometer, glass stopper, metal sample and water on the same analytical balance to ± 0.0001 g.
- Determine the density of the metal sample as per your lab instructor's pre–lab discussion and record the value on your data sheet.
- Rinse the pycnometer with deionized water then **return it to the stockroom.**

All data must be recorded neatly and legibly. Do not erase errors or use white out. Simply draw a line through the error and write the correct value directly bellow:

Example: Mass Object: ~~2.3466g~~
2.4366g

Density Experiment Data Sheet. Name: ____________________________Sec. #: _____

(Turn in only this and the following pages. Place the Data Summary Page on top, followed by the Questions)

Density of a Known Liquid (not water!): Identity of Known Liquid__________________________

Part 1. Graduated cylinder method:

Mass of empty graduated cylinder ___________________ g

Mass of graduated cylinder and known liquid ___________________ g

Mass of known liquid in the graduated cylinder ___________________ g

Volume of known liquid ___________________ mL

Density of known liquid ___________________ g/mL

Show your work (for credit):

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

Mass of clean dry pycnometer and stopper ___________________g

Mass of pycnometer + stopper + water ___________________g

Mass of water in pycnometer ___________________g

Temperature of water ___________________^{o}C

Density of water (Instructor Desk) at the above temperature ___________________g/mL

Volume of water = volume of pycnometer ___________________mL

Show your work (for credit):

Instructor Initials & Date: ______________________

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

Mass of known liquid + pycnometer + stopper ____________________g

Mass of known liquid in pycnometer ____________________g

Density of known liquid: ___________________g/mL

Density of known liquid (CRC handbook): ___________________g/mL

Show your work (for credit):

Density of a Metal Metal Identity: _____________________

Part 1. Direct Volume Calculation Method.

Radius of cylinder _____________cm Length of cylinder ____________cm

Volume of cylinder_____________ mL

Show your work (for credit):

Mass of cylinder _________________g Density of cylinder ___________________g/mL

Show your work (for credit):

Instructor Initials & Date: _____________________

Part 2. Graduated cylinder method. *Water Displacement*

Initial Volume of water in graduated cylinder ____________________mL

Final Volume of water after adding metal cylinder ____________________mL

Volume of water displaced by metal cylinder ____________________mL

Density of metal cylinder ____________________g/mL

Show your work (for credit):

Part 3. Pycnometric method:

Volume of your pycnometer (from p. 6) __________________ mL

Mass of small metal sample + pycnometer + stopper __________________ g

Mass of clean dry pycnometer + stopper (see page 6) __________________ g

Mass of metal sample __________________ g

Mass of metal sample + pycnometer + stopper + water __________________ g

Mass of water surrounding the metal sample __________________ g

Volume of water surrounding the metal sample __________________ mL

Volume of the metal sample __________________ mL

Density of the metal sample __________________ g/mL

Accepted density of the metal (CRC Handbook) __________________ g/mL

Show your work (for credit):

Instructor Initials & Date: ______________________

Data Summary Page (to be placed on top of your data pages) Name:____________________________

Fill in this sheet from your calculations.

Section: __________

All work shown must have the proper units and must be completed using dimensional analysis. There will be point deductions if this is not the case!

Density of a Known Liquid:

Identity of Known Liquid

____

Density of known liquid (CRC handbook):

___________________ g/mL

Part 1: Density from Graduated Cylinder Method ___________________ g/mL

Part 2: Density From Pycnometer Method ___________________ g/mL

% Error part 1: _____________________

% Error part 2: _____________________

Density of a Known Metal sample:

Identity of Known Metal

____

Density of known Metal (CRC handbook):

___________________ g/mL

Part 1: Density from Direct Measurement ___________________ g/mL

Part 2: Density From Water Displacement Method ___________________ g/mL

Part 3: Density From Pycnometer Method ___________________ g/mL

% Error part 1: _____________________

% Error part 2: _____________________

% Error part 3: _____________________

Post Lab Questions: (Place this as your second page on top of your data sheets)

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*:

Part 1: ***Show your work:*** Percent error __________________

Part 2: ***Show your work:*** Percent error __________________

2. From your results in measuring the density of the **known metal** 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*:

Part 1: ***Show your work:*** Percent error __________________

Part 2: ***Show your work:*** Percent error __________________

Part 3: ***Show your work:*** Percent error __________________

3. Based on your results, which method in each case appears to be the most accurate? Do you feel that the results reflect your expectations as to which method you'd expect to be the most accurate? Please explain why or why not.