Measuring Density

Background

In Part A, you will use two methods to determine the density of an unknown liquid and compare the precision of the two methods.

In Part B, you will determine the density of a solid using three methods. Again you will determine which method is the most precise. You will also perform calculations to determine the reasonable range of experimental density values for one of the methods.

Graphing is a method often used to determine regularities in data. In Part C of this experiment you will be graphing mass vs. volume data for two metals. Then based on the graphs, you will be looking for regularities.

Equipment

From the stockroom
- 10.00 mL volumetric pipet
- 1 pipet bulb
- ~~set of metal cylinders for Part C~~
- caliper ~~x~~ plus yellow cm ruler

From your drawer
- 100 or 50 mL graduated cylinder

Save the vial the liquid unknown comes in to use in Part B.

Procedure

Part A–Density of a Liquid

Obtain an unknown (a vial of aqueous sodium chloride solution) from your instructor. Be sure to **record its unknown number** on the data sheet.

Method 1

1. Weigh your clean, dry 100– or 50–mL graduated cylinder (referred to as "graduate" below) and record the mass to 0.01 g (that means read to two decimal places) under both the Trial 1 and Trial 2 headings on the report form.
2. Pour the entire unknown sample into the weighed graduate. Read the volume to the nearest 0.1 mL (see Figure 1 for reading the volume in the graduate cylinder). Record this volume and the mass of the graduate with its contents under Trial 1.

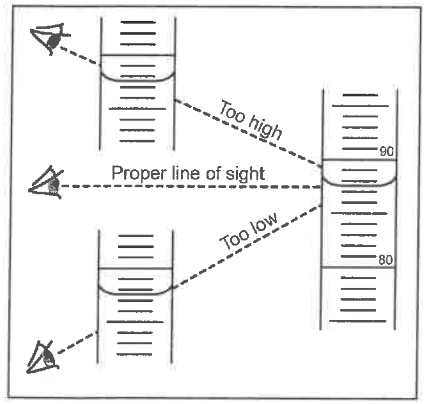

Figure 1: Using a graduate Cylinder

3. Now pour one-fourth to one-third of the liquid back into the unknown vial. Record the new volume in the graduate under Trial 2. Weigh the graduate with its contents again and record under Trial 2.
4. Pour the rest of the unknown liquid back into the vial and keep for Method 2. ***Do not discard the liquid.***

Calculate both densities, showing on attached paper all your calculation setups. Be sure to report your answer to the correct number of significant figures. The two calculated densities should differ by from each other by no more than 0.03 g/mL. If the densities differ by more, dump the liquid back into the vial, wash and dry the graduate and repeat the procedure, recording the new data but not erasing the old. When you have two values for density in appropriate agreement, calculate the average.

Method 2

A volumetric pipet is a long glass tube with a bulge in the middle. The stem above the bulge has a line etched around it. The liquid to be used is drawn into the pipet using the suction from a pipet bulb. When the meniscus of the liquid is above the line on the stem, the bulb is replaced by your forefinger that is used to control the flow of liquid from the pipet. When the meniscus of the liquid is exactly on the line on the stem, the pipet is positioned over a receiving vessel and the finger removed. The liquid will flow out of the pipet. Do not blow out the last drop. A pipet will deliver the volume written on it good to three significant figures.

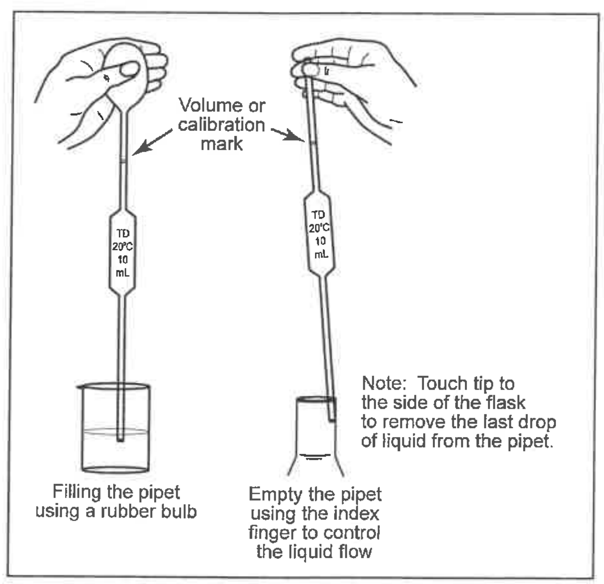

Figure 2: Using a Pipet

1. Determine the mass of a small beaker.
2. Rinse a 10.00 mL pipet with **small** amounts of the unknown liquid two times.
3. Pipet (See Figure 2) 10.00 mL of the liquid into the beaker and measure its mass. Record your results under Trial 1 on the data sheet.
4. Dump the liquid back into the graduate, wash and dry the beaker and redo the procedure for Trial 2.
5. Calculate the densities (of course to the proper number of significant figures). If the two densities do not agree within 0.02 g/mL or if Method 1 results do not agree with Method 2 results within 0.05 g/mL, redo the trials until they do. Rinse pipet with deionized water before returning to stockroom.

Part B–Density of a Solid

Obtain a cylindrical metal unknown from your instructor. Be sure to **record its number** (etched on the end of the unknown on the data sheet. Determine the mass of the cylinder and record it on the data tables for all three methods for the solid. Next you will determine its volume by three different methods and, using these volumes, make three independent calculations of its density.

Method 1–Volume by displacement of water in a graduated cylinder

1. Fill a 50 or 100 mL graduate cylinder about half full with water. Carefully read and record the volume, including one estimated digit.
2. ***Carefully*** slide the metal unknown into the graduate cylinder and record the volume. The volume of the water displaced equals the volume of the metal unknown.
3. Calculate the density of the metal.

Method 2–Volume by displacement of water in an ungraduated vial

1. Totally fill a large vial with deionized water and carefully replace the lid so that no air bubbles are trapped inside. Invert the vial to make sure there is no air bubble.
2. Weigh the vial and water and record the mass.
3. ***Carefully*** place the metal unknown in the vial allowing excess water to spill over. Make sure the vial is full to the top with water, then replace the lid without trapping any air bubbles (check by inverting the vial, again ***carefully***).
4. Wipe the vial dry on the outside, weigh it, and record the mass.
5. By subtraction, calculate the mass of water displaced by the metal unknown. Assuming that the density of water is 1.00 g/mL, this number will also be the volume of water displaced. Since the metal unknown displaces its own volume of water, it will also be the volume of the metal unknown. Calculate the density of the metal.

Method 3–Volume by measurement with calipers

1. Use the calipers or rulers to measure in cm the diameter and height of the cylindrical metal unknown.
2. Using the formula for the volume of a cylinder ($V = \pi r^2 h$), calculate the volume of the piece of metal.
3. Calculate the density of the metal.

Part C–Mass Versus Volume

1. For each metal cylinder, measure and record its mass. Measure and record the diameter and height of each metal cylinder in cm.
2. Calculate the volume of the object ($V = \pi r^2 h$). Make sure you write out the formula, write numbers and units in the formula, and write the answer with units and correct number of significant figures.
3. Repeat the above procedure with 2 different sized cylinders. Keep your three metal cylinders until the class data is graphed.
4. Obtain mass and volume data from the other members of your class. Be careful to keep pairs of data together.
5. Graph mass vs. volume (graph paper is in Appendix C). Plot mass on the vertical axis, and volume on the horizontal axis. Choose an appropriate scale so that you use most of the graph paper to plot your data. Label the axes, showing your units. Give the graph a title.
6. Draw lines on your graph to represent the mass–volume relations of each type of metal. Calculate the slope of each line. Be sure to include units. Extrapolate your lines through the y (vertical) axis.

REPLACEMENT PAGE FOLLOWS
(HANDOUT)

HANDOUT

Measuring Density (REPLACEMENT for Part-C page 19) = pg. 23

Part C-Mass Versus Volume

Select either Data Set for Metal A or Data Set for Metal B below to plot. You will do one and your partner will do the other Data Set.

Metal A

Volume (cm3)	Mass (g)
7.89	17.22
6.80	18.11
7.92	21.21
9.75	22.25
8.17	23.19
9.84	25.44
10.1	26.36
11.4	28.29
11.8	28.73
11.7	29.69

Metal B

Volume (cm3)	Mass (g)
6.63	53.90
6.45	54.53
6.42	57.15
6.61	57.34
7.97	69.15
8.40	69.43
7.98	72.24
9.65	84.84
9.65	86.14
9.84	87.67

1. Calculate the respective densities for the metals using an average of the Mass and Volume for each metal. (Report the values in the table on this page and attach it along with your graphs to the REPORT FORM pages and turn in.)
2. Graph the Mass (vertical axis) vs. Volume (horizontal axis) for your Data Set (graph paper is in Appendix C). Scale your graph to use as much of the graph paper as possible. Provide a Title, label the axes (include units), show each data point and draw the best possible straight line balancing the differences in the distance of the points on each side of the line using a ruler. Draw the line through the y-axis. Calculate the slope of the line, slope (m) = Δy / Δx, which equals the metal's density. (Report the values below.)
3. The respective metals are either aluminum, density = 2.64 g/cm^3 or copper, density = 8.94 g/cm^3. Using these as accepted values, identify A and B, then calculate and record the calculated % error in the experimental densities using the two methods.

	A	B
Metal *identified*		
Density (g/cm^3) *averaged*		
Error (%) *averaged*		
Density (g/cm^3) *graphed*		
Error (%) *graphed*		