Density & Specific Gravity (F 99)

Purpose

1) To learn how to use some common laboratory equipment
2) To learn how to measure the densities of unknown liquids and solids.

Introduction

From everyday experience it is known that substances differ in their intrinsic weights. For example, a piece of concrete is much heavier than a piece of wood assuming that both are the same size. This type of difference between materials can be expressed in terms of density. The density of a substance is defined as the mass per unit volume or

D = m / v

where D = density, m = mass, and v = volume. Common units of density are g/mL for liquids, and g/cm^3 for solids, and g/L for gases. Changes in temperature and pressure affect the density of liquids and gases and hence need to be specified. Water at 4.00 °C and 1.00 atmosphere pressure has a density of 1.00 g/mL. The density of water decreases with increasing temperature. The density of ice is 0.92 g/mL.

PROCEDURE PART A - DENSITY & SPECIFIC GRAVITY OF A LIQUID

In Part A a volume of liquid is measured using a pipet and this amount of liquid is weighed in a small container or vial. The density of the liquid can be calculated from the data obtained using the above equation or by using dimensional analysis.

Direct Measurement of Density

1) Obtain a clean and dry 50 mL beaker or 50 mL flask to use as a vial.
2) Weigh the empty vial to the nearest mg (0.001 g).
3) Add 20.00 ml of the unknown liquid into the vial using a volumetric pipet. If volumetric pipets are not available you can use a graduated pipet. You need to learn how to use the pipet bulb or pipet pump so that you don't have to use mouth suction. Be sure to record which unknown you have been assigned.
4) Reweigh the vial containing the liquid sample. Use the same balance.
5) Measure the temperature of the liquid in the container. Use correct significant figures.
6) Discard the liquid, rinse the vial with tap water and then deionized water, and place it on the drying rack.
7) Repeat the procedure. This would give you an idea of your precision (repeatability).

Measurement of Specific Gravity

8) Place a hydrometer into your assigned unknown liquid and read the specific gravity. This may already be set up for you on the demonstration table. Make sure the hydrometer is not touching the container walls. You may need help interpreting the scale on the hydrometer.

PROCEDURE PART B - DENSITY OF AN UNKNOWN SOLID

In Part B a metal sample is weighed and then its volume is determined. To determine the volume, the sample is poured into a graduated cylinder partially filled with water. The difference between the original water level and the water level after the sample is added is the volume of the metal sample.

1) Obtain a dry metal sample and record its identity.
2) Weigh the metal sample to the nearest mg (0.001 g).
3) Obtain a 50.0 mL graduated cylinder and add about 20.0 ml of deionized water.
4) Record the exact volume of water that you use to the correct number of significant figures. Read the bottom of the meniscus.
5) Carefully slide the sample down, with the cylinder at an angle, so the bottom of the cylinder is not broken. Is it necessary to completely submerge your sample? Make sure there are no air pockets.
6) Record the new water level.
7) Carefully decant (pour off) the water, rinse the metal sample with deionized water, and dry everything with paper towel and repeat procedure.
9) Check your data with the instructor.
10) Clean up your mess.

STUDY QUESTIONS

Exercises to aid you in your calculations and understanding of the experiment.

1) 35.7 g of ether has a volume of 50.0 mL. What is the density ?
(answer=0.714 g/mL)

2) 25.0 mL of a certain liquid weighs 32.5 g. What is the density ?
(answer=1.30 g/mL)

3) What is the mass of 20.0 mL of rubbing alcohol if its density is 0.785 g/mL ?
(answer=15.7 g)

4) Carbon tetrachloride (CCl_4) has a density of 1.59 g/mL and does not mix with water. If some water and CCl_4 are put together in a flask, which liquid floats on top of the other and why ?
(answer=water floats on top)

5) Ethyl alcohol has a density of 0.79 g/mL. What is the volume of 32 g of ethyl alcohol ?
(answer: 41 mL)

6) A metal bar has the following dimensions, length = 10.0 cm, width = 5.00 cm, and height = 1.20 cm. What is the volume of the bar ?
(answer: 60.0 cm^3)

7) A piece of metal has a weight of 13.50 g and a volume of 5.00 cc (cm^3) What is the density of the metal ? Refering to the periodic table, which metal is it ? (answer: 2.70 g/cm^3, aluminum)

8) A granular metal sample is poured into a graduated cylinder containing 54.3 mL of water. If the new water level is 75.2 mL after the addition of the metal, what is the volume of the water displaced ?
(answer: 20.9 mL)

9) Refer to problem 8, what is the volume of the metal sample in cm^3 ? (answer: 20.9 cm^3)

10) A granular metal sample is poured into a graduated. cylinder containing 50.0 mL of water and as a result the water level rose to 61.8 mL. What is the density of the metal if it originally weighed 92.748 g ?
(answer: 7.86 g/cm^3)

11) A student measured the specific gravity of a liquid as 1.345 at 25.5 °C. Calculate the density at this temperature. answer = From the previous experiment, we use the graph to obtain the density of water at 25.5 °C is 0.9969 g/mL. Then we solve for sample density as follows : D unknown = (sp. gr.)(D water) = (1.345)(0.9969 g/mL) = 1.341 g/mL

Name Tong Li Name of lab partner _____
Day of the week _____

Density and Specific Gravity

Part A Density and Specific of a liquid

Identification of the Unknown (A or B) _____

Method 1: Direct Measurement of Density

	Trial 1	Trial 2	Average value	# sig fig
Mass of vial + liquid	_____ g	_____ g		_____
Mass of empty vial	_____ g	_____ g		_____
Mass of the liquid	_____ g	_____ g	_____ g	_____
Volume of the liquid	_____ mL			

Direct Measurement of Density: (use the correct number of significant figures of above mL and average mass)

Density = $\frac{\text{\_\_\_\_\_ g}}{\text{mL}}$ = g/mL

Method 2: Calculation of Density from Specific Gravity

Temperature of the liquid _____ °C Determine the density of water at the Temperature from the sig fig lab (lab 2).

Specific Gravity (hydrometer reading) _____ # sig fig _____

Use the density of water at the temperature listed above (estimate from the graph of density vs. temperature in the previous lab) and the hydrometer reading of the liquid. Use the correct number of significant figures.

Density of the Unknown liquid = (hydrometer reading) x (density of water)

Density of the Unknown liquid = ( ) x (g/mL) = g/mL

Estimate the error in your density determinations by calculating the % difference between the above two methods (use significant figures and use the absolute value). Fill in the blanks with your experimental values:

$$\% \text{ Difference} = \left| \frac{\text{difference between the density values from the two methods}}{\text{average of the densities}} \right| \times 100$$

$$= \left| \frac{\text{\_\_\_\_\_ - \_\_\_\_\_}}{\text{[(+)/2]}} \right| \times 100 = \left| \frac{\text{\_\_\_\_\_}}{\text{\_\_\_\_\_}} \right| \times 100 = \text{\_\_\_\_\_ \%}$$

Part B Density of an Unknown Solid: (use significant figures)

Identification of the Unknown (A-D) _____

	Trial 1	Trial 2	Average value	# sig fig
Mass of metal	_____ g			_____
In the graduated cylinder:				
Volume of metal + H_2O	_____ mL	_____ mL		_____
Volume of H_2O alone	_____ mL	_____ mL		_____
Volume of H_2O displaced	_____ mL	_____ mL	_____ mL	_____
Volume of metal	_____ cm^3			_____
Density of metal	(_____ g) / (cm^3) = _____ g/cm^3			_____

Metals and their Densities:

Metal	Density (g/cm^3)
Copper	8.96
Lead	11.35
Aluminum	2.70
Brass	8.55
Zinc	7.14
Tin	7.31

Match the density of your metal with the list of possible metals given above.

The identity of your unknown metal is: _____

Determine the percent error by using the average value of the two trials and the actual value given above:

$$\% \text{ Error} = \left| \frac{\text{experimental density} - \text{actual density}}{\text{actual density}} \right| \times 100$$

$$= \left| \frac{\_\_\_\_\_ - \_\_\_\_\_}{(\qquad\qquad)} \right| \times 100 = \left| \frac{\_\_\_\_\_}{|\qquad\qquad|} \right| \times 100 = \qquad \%$$