Density Determinations

Introduction

In general, DENSITY is defined as the MASS of substance per unit VOLUME, or

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} \qquad \text{or} \qquad D = \frac{M}{V}$$

This definition and formula are true whether we are considering PURE SUBSTANCES (for example, a pure metal, such as iron), or SOLUTIONS of some solute in a solvent such as water (as we do in this experiment with a solution of sodium chloride). The RATIO of mass to volume, regardless of the nature of the substances involved, gives the density. In this experiment, we will determine each of these quantities (mass and volume) INDEPENDENTLY of each other, and then we will calculate the RATIO−the DENSITY.

For a PURE SUBSTANCE, the density at a given temperature is CHARACTERISTIC of the substance. For a solution, knowing the density and the concentration of the solution permits calculation of the amount of solute in a given amount of solution.

The first part of this experiment involves measuring the density of some irregularly shaped chunks of rock. Determining the MASS of the chunks is done directly with the lab balances. However, determining the VOLUME of the chunks of rock is somewhat less direct. We make use of Archimedes Principle: that is, an insoluble solid will DISPLACE a volume of water equal to its own volume. By adding the chunks of rock to a measured quantity of water in a graduated cylinder, we can determine the volume of the rock chunks by the EXTENT TO WHICH THE WATER LEVEL IN THE CYLINDER IS CHANGED BY THE ADDITION OF THE ROCKS.

The second part of the experiment involves first PREPARING a particular solution, and then MEASURING ITS DENSITY by determining the mass of a particular volume of the solution. Your lab instructor will ASSIGN you a SPECIFIC SOLUTION of sodium chloride (NaCl) to prepare, in terms of the PERCENT BY WEIGHT NaCl that the solution is to contain. By "percent by weight NaCl" is meant the weight of NaCl that would be contained in 100 g of solution. For example, a 35% by weight solution of NaCl would contain 35 g of NaCl per 100 g of solution. This solution could be prepared conceivably by adding 35 g of NaCl to 65 g of water (for a total solution weight of 100 g). Once the solution has been prepared, its density can be determined by WEIGHING a SPECIFIC VOLUME of the solution on the lab balance.

Summary

The density of some irregularly shaped chunks of rock is determined. The density of a solution of NaCl in water (of some assigned concentration) is determined. The composition of the solution made up must be within ± l.5% of the assigned value.

Supplies

NaCl that has been kept stored in an oven to prevent moisture from caking the solid; chunks of rock. THE CHUNKS OF ROCK SHOULD BE RETURNED TO THE WASTE BEAKERS AFTER USE: DO NOT POUR THEM INTO THE SINKS!

CAUTION! WEAR SAFETY GLASSES AT ALL TIMES!!

CHEMICALS INFORMATION

Sodium chloride−No major health risks

Procedure

(1) Density of Rocks

Add water to a 25 mL graduated cylinder to about the 15 mL mark (the bottom of the curved water surface should line up with the 15 mL mark). Measure the volume to the nearest 0.1 mL and record this value in your lab notebook.

Weigh an empty 50 mL beaker on the lab balance.

Measure out approximately 20 g of the available rocks into the weighed beaker, and reweigh carefully (to the nearest 0.001 g).

Add the rocks to the water in the graduated cylinder, being careful to exclude air bubbles (which would change the volume).

Determine the water level after adding the rocks (again reading across the bottom of the curved water surface) to the nearest 0.1 mL. The CHANGE in water levels represents the volume occupied by the rocks.

DO NOT THROW THE ROCKS INTO THE SINKS OR THE WASTEBASKETS: A beaker is provided for collecting the rocks.

Calculate the density of the rocks, to **three significant figures**.

(2) Density of NaCl Solution

(a) Preparing the solution:

Based on the percentage assigned to you by your lab instructor, calculate the amounts of NaCl and water you will need to make 100 g of your solution.

Weigh an empty 150 mL beaker on the balance to the nearest 0.01 g. (Do not use a 250 mL beaker.)

Never weigh any chemical directly on the balance pan. Use either weighing paper or filter paper.

Carefully add the required amount of NaCl and reweigh (see note 1 below).

Carefully add the amount of water required and reweigh (see note 1 below).

Thoroughly dissolve the NaCl in the water by stirring for several minutes; the solution must be homogeneous before determining its density.

Note 1: In weighing out the NaCl and water, it is not necessary to weigh exactly the amounts calculated. Your solution's concentration may be within ± l.5% of the assigned value: Quickly weigh as near as you can to the required amounts, but then use the actual amounts you weighed in calculating the exact percentage of your solution.

(b) Determining the density:

Weigh your empty, dry 25 mL graduated cylinder to the nearest 0.001 g.

Fill the graduated cylinder to exactly the 25 mL mark with a portion of your NaCl solution, and reweigh. THE DIFFERENCE IN WEIGHTS REPRESENTS THE MASS OF 25 mL OF YOUR SOLUTION.

Calculate the density of the solution, in g/mL, to **three significant figures**.

With your thermometer, determine the temperature of your solution. (The volume, and so the density, of a solution changes with temperature.) The temperature must be reported together with your density measurement.

Sodium chloride solutions can be poured down the drain.

REMEMBER TO TURN THE YELLOW COPY FROM YOUR LAB NOTEBOOK INTO YOUR TA.

Density Determinations
Report Sheet (40 points)

Name _____ Lab Day _____

Lab Instructor _____ Date _____

(Show calculations on the back of the page.)

1. Density of rock chunks

Weight of rocks	Volume before adding rocks	Volume after adding rocks	Volume of rocks	Density of of rocks
_____	_____	_____	_____	_____

2. Density of NaCl Solution Assigned Concentration: _____ %

(a) Preparation of Solution

Mass of NaCl needed _____ g

Volume of distilled water needed _____ mL

Weight of beaker _____ g

Weight of beaker plus NaCl _____ g

Weight of beaker plus NaCl plus water _____ g

Actual % NaCl _____% (if different from assigned)

(b) Density Determination

Weight empty graduate _____ g

Weight of graduate plus solution _____ g

Volume of solution _____ mL

Density _____ g/mL

Temperature of solution _____ ^{o}C

Density Determinations
Post-Lab Questions (30 points)

Name _____ Lab Day _____

Lab Instructor _____ Date _____

1. A chunk of rock weighs 15.8 g and causes the water level in a graduated cylinder to rise from 22.3 to 32.5 mL. Calculate the density of the rock.

2. Twelve grams of sodium chloride were dissolved in 52 mL (52 g) of distilled water, calculate the % sodium chloride in the solution.

3. True or False: The density of a solution is dependent on the temperature of the solution.

4. In this experiment, you were told to avoid getting air bubbles on the rock chunks while measuring your volume. Would air bubbles increase, decrease, or have no effect on the density of the rocks? Explain.

Density Determinations
Preliminary Questions (10 points)

Name _____ Lab Day _____

Lab Instructor _____ Date _____

(Show calculations on the back of the page.)

1. Ten grams of a sample of metal is added to 50.0 mL of water in a graduated cylinder. The final volume in the graduate is 52.8 mL. Calculate the density of the metal.

_____g/mL

2. Twenty-five grams of NaCl is dissolved in 175.0 g of water. Calculate the percent by weight of NaCl in the solution.

_____% NaCl

3. What is the proper disposal of your wet rocks?

4. A student is asked to make up a 16% sodium chloride solution. She makes the solution by weighing an empty beaker (which has a mass of 98.56 g). Sodium chloride is added to the beaker. The mass of the beaker and sodium chloride is 114.71 g. Lastly the student added 84 mL of distilled water to the beaker. Reweighing the beaker she finds that the mass of the beaker, sodium chloride, and distilled water is 196.14 g. What is the weight percentage of sodium chloride in this solution? (Use the back of this page to show your work, if needed).