Experiment Three

Density

Procedure

Part 1.The density of a solid

Obtain a solid unknown sample from your instructor. Write down the number of the unknown in your notebook. Determine the mass of your unknown by using the milligram balance and record the value. Use your 50 mL graduated cylinder and fill it up with water to a level that will cover your unknown sample. This is easy to do. Just place your sample beside your graduated cylinder and see how many mL it will take to cover it (Figure 1). This volume will be different depending on the size of your unknown. Record the volume of water you poured into the graduated cylinder. Gently and

Figure 1. Example of volume of water required for an unknown sample

Figure 2. How to put the unknown sample in your graduated cylinder

slowly place your solid unknown inside the graduated cylinder with water. Tilt the cylinder to facilitate this process (Figure 2). Read the new water volume inside the cylinder and record the observed value. Determine the volume of water displaced by subtracting the initial volume you read from the final volume you recorded after placing your solid unknown inside the cylinder. Assuming that no water is lost during the insertion of the solid and that there is no air trapped inside the unknown sample, the amount of water displaced is the volume of your sample. As you have learned in class 1 mL = 1 cm^3, so now you can record the volume of your unknown in both mL and cm^3.

Determine the density of your unknown by dividing the mass of the sample by its volume.

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

Mass is given in grams (g) and volume in cubic centimeters (cm^3). Compare your value with the values on the following table to determine the identity of your unknown.

Table of densities

Sample	Density (g/cm^3)	Sample	Density (g/cm^3)
Aluminum	2.70	Pyrex	2.23
Acrylic	1.18	PVC	1.45
Delrin	1.41	Copper	8.96
Tin	7.36	Rubber	1.61
Brass	8.55	PTFE	2.20
Iron (Steel)	7.87	Zinc	7.14

Part 2. The density of a liquid, pycnometer method

In this part of the experiment you will determine the density of pure water using a pycnometer (Figure 1, also known as a specific gravity bottle). Take a dry pycnometer and determine its mass using an analytical balance. Make sure it is dry. If it is not dry, ask your instructor to show you how to dry it using acetone. Once you have recorded the mass, proceed to fill it with pure water all the way to the top. Do not worry if it overflows. Insert its stopper, letting the excess liquid overflow from the tiny hole in the top of the stopper. Wipe dry any water on the outside of the bottle and determine its mass using the analytical balance again. Record the observed mass in your notebook.

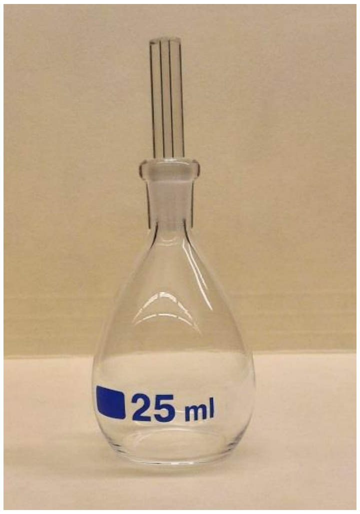

Figure 1. A pycnometer(Specific gravity bottle).

The mass of water contained inside your pycnometer is determined by subtracting the two observed masses, in other words

$$\textit{Mass of liquid sample} = \textit{(Mass of bottle with liquid)} - \textit{(Mass of empty bottle)}$$

Write your calculated value in your laboratory notebook and use this value to calculate the density of pure water. Recall that

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

In this case you calculated the mass and the volume is given by the size of the pycnometer you used. Record the value you calculated for the density of pure water.

Part 3. The density of a liquid and percent composition, graphing method

In this part of the experiment you will determine the density of an unknown liquid solution and find out its percent concentration by graphing the densities and concentrations of solutions with known concentrations

Determine the weight of a clean and dry 25 mL graduated cylinder to 0.01 g. Add approximately 20 mL of pure water to the graduated cylinder and record the volume. Weigh and record the mass of the graduated cylinder to 0.01 g. Determine the mass of the water and calculate its density. Recall that

$$Mass\ of\ liquid\ sample = (Mass\ of\ graduated\ cylinder\ with\ liquid) - (Mass\ of\ empty\ graduated\ cylinder)$$

and

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

Record the obtained values in your laboratory notebook.

Repeat the above procedure with solutions of 4.0%, 8%, 12% and 16% NaCl (sodium chloride). Start with the most dilute solution (the 4.0% solution) and rinse your graduated cylinder with the solution you will use next prior to performing the measurement. For example, when preparing to determine the density of the 4.0% solution, use 4 to 5 mL of the 4.0% solution of NaCl to rinse your graduated cylinder. Do this at least 2 times. After you have rinsed it you can add the 20 mL of the needed solution. Once you have completed all 5 readings (pure water and the 4 different concentrations), complete the following table, except for the unknown section.

Sample	Volume of the liquid sample	Mass of the liquid sample	Density of the sample (g/mL)
Pure water			
4.0% NaCl			
8.0% NaCl			
12.0% NaCl			
16.0% NaCl			
Unknown sample ______			

Make sure you write the above information in your laboratory notebook. Show the information to your instructor and if she or he indicates that the data seems reliable ask for an unknown sample. Record the unknown's sample number and determine the density of this unknown solution by the above procedure.

Plotting the Graph

You will need to use the information that you have in your table to plot a graph of the densities versus the concentrations. Your graph should fill most of your note book page.

Steps

1. Determine the scale required. Your concentrations will be plotted on the horizontal axis (x-axis) and the densities on the vertical axis (y-axis). Let's start with the horizontal axis. Your concentrations range from 0.0% to 16.0%. A simple way of labeling this axis is by counting the number the divisions along this axis, and then divide it by the division values, (in this case four; from 0.0% to 4.0%, from 4.0% to 8.0%, from 8.0% to 12.0% and from 12.0% to 16.0%) that you need. For example, if you used a ruler you could measure from 0 to 24 cm and make each division at every 6 cm, because 24 cm/4 sections = 6 cm/section. If you had graphing paper and you decide to use 32 squares, each division would have 8 squares because 32 squares/4 sections = 8 squares/section.
   The same procedure is used for the densities along the vertical axis. Your densities should range between 1.00 g/mL and 1.40 g/mL and you also have 4 divisions because these are determined by your concentrations. If you used a ruler, you could measure from 0 to 16 cm am make each division at every 4 cm because 16 cm/4 sections = 4 cm/section. The similar procedure applies if you use graphing paper.
2. Dertemine your starting points on each axis. In the case of your concentrartions your first value is 0.0%, so it follows that your initial value on the x-axis is 0.0% NaCl. As for the densities, the density of pure water (0.0%) should be the lowest of all five samples, so that would be a good point to start on the y-axis.
3. Mark your divisions along the y and x axis and label the axis accordingly. The x-axis should be labeled as denisty in g/mL and the y-axis should be labeled as % Concentration of NaCl.
4. Plot your points.
5. Draw a line that runs through all the points or as close as possible to all the points. Do not conect point to point. Your line should be a straight line
6. Title your graph. Make your title simple but informative.

Determining the concentration of your unknown graphically

You will need to use the graph you have made to determine the concentration of your unknown. Read on the vertical (y-axis) the value of density that you determined your unknown to have. Draw a horizontal line from where you took the reading on the densities axis to the straight line connecting your points on the graph. Mark the point where these two lines intersect. From this intersection point draw a straight vertical line that extends all the way to the x-axis. At the point this two lines intersect you will be able to read the concentration of your unknown solution. Record this percentage value. Make sure you record your unknown number so you will be graded appropriately.