Experiment 5

PHYSICAL MEASUREMENTS:
DENSITY AND CONCENTRATION OF SOLUTIONS

MATERIALS:

125 mL Erlenmeyer flask, 25 mL pipet, 25 mL graduated cylinder, 500 mL volumetric flask, 250 mL beaker, weighing boat, powder funnel, solid sodium chloride, thermometer.

PURPOSE:

This lab is designed to introduce the student to the nature of physical measurements, concentration of solutions, and the importance of accuracy, precision, significant figures, and proper units.

PROCEDURE:

Stock Solution Preparation:

Using the *top loading balance*, place between 50 and 100 g of sodium chloride in the weighing boat and record the measured mass of the boat and its contents in the *Data Section* of this document. Using a powder funnel, transfer the sodium chloride to a 500 mL volumetric flask. Record the mass of the empty weighing boat. Add enough water to the volumetric flask to fill it about three-fourths full and swirl it until the solid is completely dissolved; then add water until the bottom of the meniscus is level with the line on the flask. Stopper the flask and invert it several times to mix this stock solution thoroughly. Measure the temperature of this solution using the thermometer provided and record it in the *Data Section*. Do not discard this stock solution until this experiment has been completed.

Part A. Determination of Density and Concentration of a Sodium Chloride Solution by Two Different Methods

Method 1:

Carefully dry the outside of a 125 mL Erlenmeyer flask and weigh it on the top loading balance. Record this mass in the *Data Section*. Rinse a 250 mL beaker with a small amount of the sodium chloride stock solution and then fill it half full with that solution. Rinse a <u>clean</u> 25 mL pipet with the sodium chloride stock solution from the beaker by drawing approximately 10 mL of the solution into the pipet and rotating it to wet the walls completely with the solution. Discard this rinse solution in the sink. With the same pipet, transfer 25 mL of the sodium chloride solution from the beaker to the weighed flask and weigh the flask and solution on the *top loading balance*. Record all masses in the *Data Section*. Discard the 25 mL of sodium chloride solution and dry the outside of the flask.

Repeat this procedure to obtain a second set of data. Record the results in the *Data Section*. <u>Save the sodium chloride solutions</u> in the beaker.

Method 2:

The density of your sodium chloride stock solution will now be determined using a graduated cylinder, instead of a pipet, to measure volumes. Rinse the graduated cylinder with a few milliliters of the stock solution from the beaker and then add 20 to 25 mL of the solution to the cylinder. By reading the bottom of the meniscus, carefully determine the volume of the solution to the *appropriate number of significant figures*. Weigh the graduated cylinder and salt solution on the top loading balance. Discard the solution and weigh the graduated cylinder.

Repeat this procedure to obtain a second set of data. Record the mass measurements in the *Data Section* of this report.

Part B. Determination of the Density of a Solid by Two Different Methods

Obtain a metal slug from your instructor. Use the *top loading balance* to weigh the slug *(Fig. 1)*. Record the slug number and its mass in the *Data Section*.

Figure 1

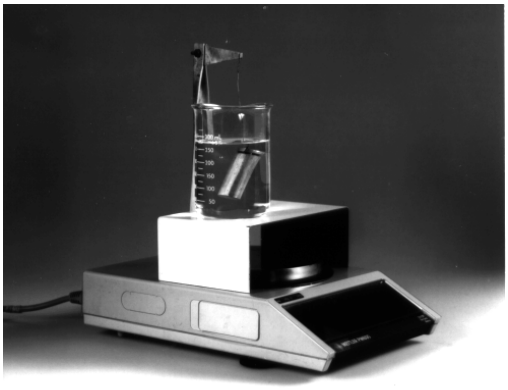
Method 1:

Add between 10 and 16 mL of water to the 25 mL graduated cylinder and record the volume with the *appropriate number of significant figures*. Measure and record the temperature of the water. Completely immerse the slug in the water (making sure that the slug is completely covered with water and that no air bubbles are trapped beneath it) and record the new position of the meniscus. The volume change upon immersion of the slug is equal to the volume of the slug.

Method 2:

Archimedes' Principle states that the apparent loss in mass of an immersed body is equal to the mass of the displaced fluid. Thus, it follows from Archimedes' Principle that the apparent loss in slug mass on immersion in a liquid is proportional to the density of the liquid. This principle can be used to determine the density of the slug. To accomplish this, fill the 250 mL beaker with water to within about one inch of the top. Measure the temperature of the water in the beaker and record this value in the *Data Section*. Place the beaker on the fixed support under the balance stirrup. Suspend the slug from the stirrup and completely immerse the slug in the water by adjusting the height of the support. Be sure the slug is not touching the bottom of the beaker *(Fig. 2)*. Record the mass of the totally immersed slug.

Figure 2



Part C. Determination of the Density of Sodium Chloride Solution by Archimedes' Principle

Fill the 250 mL beaker with the sodium chloride stock solution to within about one inch of the top.

Immerse the slug in the salt solution and determine its mass using the same procedure as used in Part B, method 2. Record the mass in the *Data Section*.

Name_____ **Section**_____

Partner_____ __ **Date**_____

DATA SECTION
Experiment 5

Record all data using the proper number of *significant figures* and the proper *units*.

Stock Solution Preparation:

Mass of weighing boat and sodium chloride	_____
Mass of weighing boat after transfer	_____
Total mass of sodium chloride in 500 mL of solution	_____
Temperature of sodium chloride stock solution	_____

Part A. Determination of Density and Concentration of a Sodium Chloride Solution by Two Different Methods

Method 1:	**Trial I**	**Trial II**
Mass of flask and 25 mL of sodium chloride solution	_____	_____
Mass of empty flask	_____	_____
Mass of 25 mL of sodium chloride solution	_____	_____

Method 2:	**Trial I**	**Trial II**
Volume of sodium chloride solution	_____	_____
Mass of cylinder plus sodium chloride solution	_____	_____
Mass of cylinder	_____	_____
Mass of sodium chloride solution	_____	_____

Part B. Determination of the Density of a Solid by Two Different Methods

Slug number _____

Method 1:

Mass of slug (in air) _____

Volume of water _____

Volume of water containing slug _____

Volume of water displaced (equals volume of slug) _____

Temperature of water _____

Method 2:

Mass of suspended slug in water _____

Part C. Determination of the Density of a Sodium Chloride Solution by Archimedes' Principle

Mass of suspended slug in sodium chloride solution _____

DATA TREATMENT
Experiment 5

Part A. Determination of Density and Concentration of a Sodium Chloride Solution by Two Different Methods

(A.1) Using the data collected via **Method 1**, calculate the density of the sodium chloride solution for each trial and calculate the average density (show a sample calculation).

	Trial I	**Trial II**
Density of sodium chloride solution	_____	_____
Average density of sodium chloride solution	_____	

(A.2) Using the data collected via **Method 2**, calculate the density of the sodium chloride solution for each trial and calculate the average density (show a sample calculation).

	Trial I	**Trial II**
Density of sodium chloride solution	_____	_____
Average density of sodium chloride solution	_____	

Which method gives more precise results? Explain your choice.

(A.3) The concentration of a solution is often expressed as molarity (M). The molarity of a solution is defined as the number of moles of *solute* dissolved in one liter of *solution*. Calculate the molarity of the 500 mL sodium chloride stock solution you prepared (show work).

(A.4) The concentration of a solution may also be expressed as molality (m). The molality of a solution is defined as the number of moles of *solute* dissolved in one kilogram of *solvent*. What is the molality of the 500 mL sodium chloride stock solution you prepared? (Hints: mass solution = mass solute + mass solvent. The density of the solution can be used to calculate the mass of solution.)

(A.5) The mass percent of a component in a solution is the *mass of that component* divided by the *total mass* of all components present in the solution multiplied by 100. Calculate the mass percent of sodium chloride in the 500 mL sodium chloride stock solution that you prepared remembering the solution consisted of sodium chloride and water.

(A.6) The mole fraction (X) of a component in a solution is the number of *moles of that component* divided by the *total number of moles* of all components present in the solution. Calculate the mole fraction of sodium chloride in the 500 mL sodium chloride stock solution you prepared. Note, the solution consisted of sodium chloride and water.

Part B. Determination of the Density of a Solid by Two Different Methods

(B.1) Calculate the density of the slug from the mass of the slug and the volume of water displaced upon placing the slug in the graduated cylinder.

(B.2) Archimedes' Principle states that the apparent loss in mass of an immersed body (mass of slug in air - mass of suspended slug in water) is equal to the mass of the displaced fluid.

Calculate the mass of the displaced water.

Using the mass of the displaced water and the density of water *at the temperature measured*, calculate the volume of the displaced water (which is equal to the volume of the slug). Densities of water are listed in Appendix K.

Calculate the density of the slug.

(B.3) Which method (water displacement in the graduated cylinder or Archimedes' Principle) gives more precise results on repeated determinations? Explain your choice.

(B.4) When weighing the slug in Part B, the mass of the wire attached to the slug was included. If the wire weighs 0.17 g, recalculate the density of the slug (via Archimedes' Principle) using the mass of the slug without the wire attached.

(B.5) Calculate the percent error caused by including the wire in the density calculation (via Archimedes' Principle).

Part C. *Determination of the Density of Sodium Chloride Solution by Archimedes' Principle*

(C.1) It follows from Archimedes' Principle that the apparent loss in slug mass on immersion in a liquid is proportional to the specific gravity of the liquid. The specific gravity of a liquid is the ratio of the density of that liquid to the density of a reference substance (usually water). The ratio of the loss in slug mass upon immersion in sodium chloride solution to the loss in slug mass upon immersion in water yields the specific gravity of the sodium chloride solution.
Calculate the specific gravity of the sodium chloride solution.

(C.2) Using the value of the density of water *at the temperature of your experiment*, calculate the density of the sodium chloride solution using the specific gravity determined above.

(C.3) Compare the value obtained in Part (C.2) to that obtained in Part (A.1). Do these values differ appreciably? Which one should be more precise? Explain your choice.

(C.4) In the preparation of the sodium chloride stock solution, it is important to make sure that the solid is completely dissolved before measuring its density. If there is undissolved solid in the stock solution, would the measured density be higher or lower than the true density? Why? Explain your answer.