Experiment 3: Density of Aqueous Sodium Chloride Solutions

(This experiment is adapted from Ross S. Nord and Stephen E. Schullery, Eastern Michigan University.)

Purpose: The purpose is to determine the concentration of an unknown sodium chloride solution. The density of this unknown solution will be experimentally determined and compared with a standard curve prepared from solutions of known density.

Background: The density of a solution is usually directly related to the solution's concentration. Because the density of a solution is easy to measure, this provides a convenient method of determining the concentration of the unknown sample.

$Density = mass \,/\, volume$

For a solution, the volume is readily determined using accurately graduated glassware. The mass is determined using a laboratory balance. Since the volume of a substance varies with temperature, it is important to record the temperature of density measurements. When comparing the densities of samples, the temperature should be held constant for all the density measurements.

The concentration of an aqueous solution can be expressed in many different ways, but the simplest is mass percent (also called weight percent).

$Mass\ \% = (\ mass\ solute \,/\, (\ mass\ solute + mass\ H_2O\ )\ )\ x\ 100\%$

The density of aqueous NaCl solutions is a nearly-linear function of the NaCl concentration (in mass percent). A linear relationship permits a reliable standard curve to be constructed. The best-fit line is added using linear regression. This line shows the relationship between density and % mass NaCl.

In this experiment, five standard solutions of known mass percent will be prepared and their densities determined. A standard curve will be constructed by plotting the density vs. mass % and the best-fit line will be determined via linear regression (use Excel or Google Sheets). The density of an unknown solution will be measured and its mass % concentration will be determined with the equation of the best-fit line.

Record measured and calculated values with correct units and the appropriate number of significant figures. All calculations should be clearly organized, make proper use of significant figures, and include the units.

Chemicals:
Deionized water
Sodium Chloride

Equipment:

Beakers (50 mL, 100 mL)	10 mL pipet & pipettor	glass stirring rod
Laboratory Balance	spatula	thermometer

Procedure:

Preparing the Standard Solutions

1. Weigh out the mass of NaCl for solution number 1 (given in Table 1 below).
   a) Place a clean, dry, 50-mL (or 100 mL) beaker on a balance, tare (zero) the balance.
   b) Use a spatula to add solid NaCl to the flask. The mass of solid does not need to be exactly the mass given in the table. But you do need to know exactly how much you measured out, so record the mass to the nearest .001 g.

2. Tare the balance again (while the beaker containing the salt is still on the balance). Remove the beaker from the balance. Then add approximately 30 mL of distilled water to the beaker and record the mass. (Use a graduated cylinder to roughly measure the amount of liquid.)

The %mass of the NaCl solution can be calculated with the information in steps 1 and 2.

(Return to your lab bench to finish preparing this solution. This will give the other students time to use the laboratory balance.)

3. Mix the solution by stirring with a glass stirring rod until all of the solid has dissolved.

4. Measure and record the temperature of the solutions (to the nearest 0.5 °C). All five standard solutions must have the same temperature. The temperature of a solution can be adjusted by holding the beaker under hot or cold running water (being careful not to splash any water into the flask).

5. Measure the mass of a 10.0 mL aliquot (portion) of the standard solution.
   a) Use a 50 mL beaker. Measure and record the mass of the dry, empty beaker. (Then return to your lab bench.)
   b) Use the pipet to add a 10.00 mL aliquot of the standard solution to the beaker.
   c) Place the beaker back on the balance and record the mass of the beaker and solution. *(Use the same balance you used in step 5a.)*

6. Repeat the above steps for standard solutions 2-5. For each solution, weigh out a mass of NaCl close to the amount in Table 1.

Table 1: Mass of NaCl for Standard Solutions

Standard Soln	**1**	**2**	**3**	**4**	**5**
Mass NaCl, (g)	1.0	2.0	3.0	4.5	6.0

Measuring the Unknown Sample's Density

7. Obtain approximately 20 mL of an unknown solution. Record your unknown number in your notebook.

8. Measure the temperature of the unknown. If necessary, adjust it to be the same temperature of the standard solutions measured earlier.

9. Measure the mass of a 10.0 mL aliquot of the unknown using the procedure described in step 5 above. Repeat this measurement two more times and then use the average value when calculating the density.

Calculations

1. Calculate the mass % NaCl in each of your five standard solutions. Show a sample calculation using solution 1.

2. Calculate the density for each of your five standard solutions. Show a sample calculation using solution 1.

3. Generate your standard curve and best-fit line using Excel or Google Sheets. *(There is a video in Blackboard to show you how to these programs.)* Density values are on the Y-axis and % mass NaCl values are on the X-axis. Put the best-fit line on the graph. Print the graph with the best-fit line, equation of the line, and R^2 value. Put this in your notebook.

4. Calculate the average density of your unknown solution. Show your density calculations. Use 10.0 mL as the significant figures for the pipet.

5. Calculate the concentration (% mass) of your unknown (to the proper number of significant figures) using its density (from calculation 4) and the equation of the best-fit line, y=mx+b. Y is the density of your unknown, and you are solving for x, which is the concentration. Show your calculations.