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 by calculating its density. The density of this unknown solution will be experimentally determined, and compared to a standard curve prepared from solutions of known density (a graph of density vs. concentration).

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.

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 concentration 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:
Part A: 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, empty 50-mL (or 100 mL) beaker on a balance, and record its mass.
   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 should be close. However, you do need to know exactly how much you measured out, so record the mass of the (beaker+ NaCl) from the lab balance. Record all the digits on the display.
   c) Repeat steps 1a and 1b for the other solutions in Table 1 (solutions 2 – 5).

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

2. Return to your lab bench with the five beakers of salt from steps 1 (a, b, c). Add 30 mL of distilled water to each of the beakers. (Use a graduated cylinder to roughly measure the amount of liquid.) Mix the contents of each beaker until the salt dissolves. Rinse and dry your glass stirring rod in between beakers so you don't contaminate any of them. There should now be a homogeneous mixture (a solution) in each beaker.

3. Bring your five solutions back to the same balance used in step 1. Measure the mass of each (beaker+salt+water) solution.

Part B: Determining the Density of the Standard Solutions and Unknown Solution

1. Bring six dry, clean, empty small beakers to the same balance you used in Part A. These beakers should already be labeled as solution 1 – 5, and unknown.
2. Measure and record the mass of each labeled beaker. Record all digits in the balance display.
3. Return to your lab bench. Pipet 10.0 mL of each solution (1 – 5, unknown) into its labeled beaker. (You will need to get approximately 20 mL of unknown solution from the bottle in the hood to pipet 10.0 mL of this solution. Record the ID number of the unknown.)
4. Bring these beakers back to the balance used in step 1. Measure and record the mass of each (beaker+10.0 mL solution). You should now have the mass of all solutions (1 – 5, unknown).

Calculations

1. Calculate the mass % NaCl in each of your five standard solutions. Show your calculations. Do not include the mass of the beaker in these calculations; subtract out the mass of the empty beaker from the mass NaCl and the (mass NaCl + mass H_2O)

$Mass$ % = ($mass$ NaCl / ($mass$ NaCl + $mass$ H_2O)) x 100%

2. Calculate the density for each of your five standard solutions and the unknown solution. Show your calculations. Use 10.0 mL as the significant figures for the volume. Subtract out the mass of the empty beaker before doing these calculations.

Density = ((mass of 10.0 mL solution) / (10.0 mL))

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 use 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. Attach a printout of this graph with your notebook worksheet.

4. Calculate the concentration (% mass) of your unknown using its density 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.