Name:_____
Date:_____

Making Solutions

PURPOSE:

In this experiment, you will learn how to **make a solution** and **calculate the concentration** of the solution in several different concentration units regularly used in chemistry and industry. The concentration units you will learn are percent mass ($\%_{mass}$), mole fraction (X_{mol}), molarity (**M**) and molality (***m***). You will also calculate density, which is used in some solutions to determine concentration empirically using density tables and a hydrometer (density meter).

MATERIALS:

- solid NaCl (salt)
- granulated sugar
- water
- 100 mL volumetric flask
- 10 mL graduated cylinder
- 50 or 100 mL graduated container.
- Balance or scale

PROCEDURE:

Weigh a clean, dry graduated cylinder. Record the weight in Table 1a, below. Add 10 mL of solid NaCl and re-weigh the cylinder. Calculate and record the mass of NaCl in the table.

Next weigh a clean, dry volumetric flask. Record the weight in Table 1b. Add the NaCl from the graduated cylinder to the flask and fill it to the halfway point with water. Swirl or gently shake the flask until all of the NaCl has dissolved. Then fill the flask to the 100 mL mark. You may need to use a dropper or pipette when you get close to the mark. Re-weigh the flask and record the information. Answer the questions below the tables.

Weight of dry, empty graduated cylinder	g
Weight of graduated cylinder with NaCl	g
Calculated weight of NaCl in cylinder	g

Table 1a

Weight of dry, empty volumetric flask	g
Weight of volumetric flask with NaCl solution	g
Calculated weight of solution in 100 mL flask	g

Table 1b

Question: What is the mass of the H_2O (water) in the solution? _____g

How do you know? SHOW YOUR WORK

Making Solutions (continued)

ANALYSIS:

Use your experimental data to answer the following questions. Record your answers in the Table 2

1. Percent by mass tells how many grams of solute are present per 100 grams of solution. You should use information from Table 1 for this calculation.

$$\%_{\text{mass}}\ \textbf{(NaCl)} = \frac{\text{mass of solute}}{(\text{mass of solute} + \text{mass of solvent})} \times 100\% = \frac{\text{mass of solute}}{\text{total mass of solution}} \times 100\%$$

Calculate: $\%_{\text{mass}}$ **(NaCl)** =

2. Mole fraction tells how many moles of solute there are for every total mole of solution. To calculate this, you must first calculate the number of moles present of both the solute and the solvent. You will need to calculate the gram formula weight (gfw) for both the solute and the solvent. "gram formula weight" is often called the "formula weight" or "molar mass" - they mean the same thing. Look up the mass of each element on the periodic table. For H_2O (water) the formula weight is 18 g/mole. Why? One oxygen (16 g/mol) + 2 hydrogen (1 g/mol) = 18 g/mol.

$$\text{moles solvent} = \left(\frac{\text{??? g water}}{1}\right) \times \left(\frac{\text{1 mol water}}{\text{18 g water}}\right) = \_\_\_\_\ \text{moles water}$$

$$\text{moles solute} = \left(\frac{\text{g solute}}{1}\right) \times \left(\frac{\text{1 mol solute}}{\text{??? gfw solute}}\right) = \_\_\_\_\ \text{moles solute}$$

Knowing the moles of both solute and solvent (in this case, water) you can now calculate the mode fraction of the solute, NaCl

$$\mathbf{X}_{\text{NaCl}} = \frac{\text{moles of solute}}{(\text{moles of solute} + \text{moles of solvent})} = \frac{\text{moles of solute}}{\text{total moles in solution}}$$

Calculate the mole fraction, $\mathbf{X}_{\text{NaCl}}$ =

What are the units for mole fraction? Explain.

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3. **Molality** (***m***) shows how many moles are present in each kilogram (1 kg) of solvent (not solution). Molality is often used when calculating boiling point elevations or freezing point depression for solutions.

   You will first have to calculate the number of kilograms of solvent. Use the number of grams solvent that you calculated on page 1 and convert.

   remember, 1 kg = 1000 g.

   $$\boldsymbol{m} = \left(\frac{\text{mol NaCl}}{\text{kg } H_2O} \right)$$

   Calculate the molality of your solution:

   $$\boldsymbol{m} =$$

4. **Molarity** (**M**) *is the **most common** concentration unit used in chemistry*. It tells how many moles of solute are dissolved in each liter (1 L) of total solution. Molarity is the concentration unit listed on bottles of chemicals that we use in the lab. It is ideal for calculating how much of a concentrated solution is necessary to make a dilute solution at some other concentration.

   $$\mathbf{M} = \left(\frac{\text{mol NaCl}}{\text{L solution}} \right)$$

   First calculate your liters of total solution (remember, 1000 mL = 1L)

   Now calculate the molarity of the solution:

   $$\mathbf{M} =$$

5. **Density** tells how many grams of solution are present in 1 mL of solution.

   $$\textbf{density} = \left(\frac{\text{g solution}}{\text{mL solution}} \right)$$

   Now calculate the density of the solution:

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PRACTICE:

1. Analyze It! Extract a sample of your NaCl solution and place it in a pre-weighed graduated container with a 50 mL mark. Weigh the bottle again to calculate the mass of solution you extracted. Dilute the solution to a total of 50 mL. On your own, figure out an equation to calculate the new concentration of your diluted solution in each of the units discussed above. *SHOW ALL OF YOUR WORK.*

2. Design It! Design and carry out an experiment to make a solution of table sugar quantitatively. This means taking the same measurements as you did for NaCl. Calculate the concentration of table sugar using the same units you used to calculate the concentration of the NaCl solution. *SHOW ALL OF YOUR WORK.*