

Experiment 16

The Solution is Dilution

OUTCOMES

Upon completion of this lab, the student should be able to

- proficiently calculate molarities for solutions.
- prepare a solution of known concentration.
- prepare a dilute solution from a more concentrated one.
- perform serial dilutions.
- use volumetric and Mohr pipets and a volumetric flask.

DISCUSSION

Solutions are an important part of chemistry. In this lab you will practice preparing solutions of different concentrations. The amount of solute that is dissolved in a given quantity of solvent is expressed as the concentration of the solution. A dilute solution contains only a small amount of solute in a given amount of solution. The units chemists use most often to describe concentration of solutions are molarity units. The molarity, M , of a solution is the number of moles of solute in one liter of solution. To determine the molarity of a solution, the following equation can be used:

$$\text{Molarity (M)} = \frac{\text{moles of solute}}{\text{Liters of solution}}$$

Example 1: How would 500.0 mL of a 0.6000 M NaCl solution be prepared?

Since NaCl is a solid, its mass must be measured on a balance. The first step is to calculate the mass of solute needed. The molar mass for NaCl is 58.44 g/mol.

$$500.0 \text{ mL solution} \times \frac{1 \text{ L solution}}{1000 \text{ mL solution}} \times \frac{0.6000 \text{ mol NaCl}}{1 \text{ L solution}} \times \frac{58.44 \text{ g NaCl}}{1 \text{ mol NaCl}} = \mathbf{17.53 \text{ g NaCl}}$$

Answer: Using a balance, measure out 17.53 g of NaCl into a small beaker and transfer it to a 500-mL volumetric flask. A funnel may be necessary to transfer the solid into the flask. Rinse the beaker and funnel with a small amount of deionized water into the flask. Then add deionized water to the flask until it is about $\frac{1}{2}$ full. Cap the flask and invert it several times to dissolve the solid. Next, add water until the liquid is just below the etched line on the neck of the flask. Bring the water to the line by adding the last few drops of water drop-by-drop using either a wash bottle or dropper. Again, cap and invert the flask several times to ensure proper mixing. The final volume of the solution is 500.0 mL. See **Figure 1** on the next page.

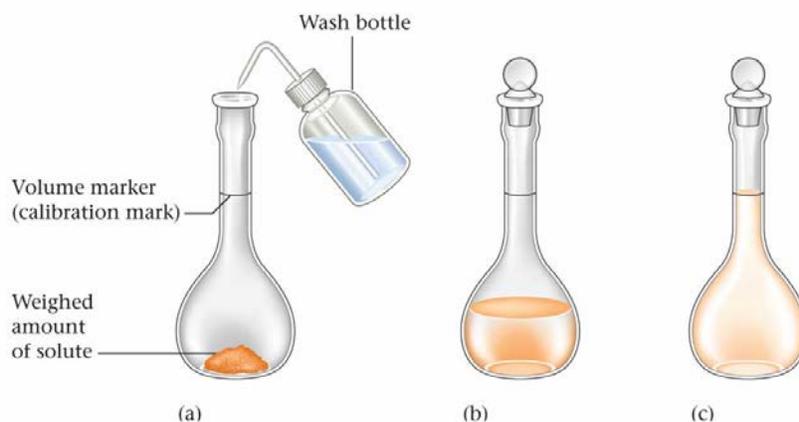


Figure 1. Preparing a solution of known concentration using a solid solute.

Experiments often require a solution that is more dilute than the stock solution or solution on hand. The following equation can be used to determine the amount of concentrated solution needed to carry out the dilution:

$$\text{Molarity}_{\text{concentrated solution}} \times \text{Volume}_{\text{concentrated solution}} = \text{Molarity}_{\text{dilute solution}} \times \text{Volume}_{\text{dilute solution}}$$

The equation is commonly written as: $M_1V_1 = M_2V_2$

Example 2: Suppose that an experiment required that 500.0 mL of a 0.200 M NaCl solution be prepared from the 0.6000 M NaCl solution prepared in the first example. What volume of the concentrated (0.6000 M) solution would be needed?

$$\frac{M_1V_1}{M_1} = \frac{M_2V_2}{M_1} \quad \text{or} \quad V_1 = \frac{M_2V_2}{M_1} = \frac{0.200 \text{ M NaCl} \times 500.0 \text{ mL}}{0.6000 \text{ M NaCl}} = \mathbf{167 \text{ mL}}$$

To prepare this solution, 167 mL of the 0.6000 M NaCl would be measured and transferred into a 500-mL volumetric flask. Deionized water would then be added up to the etched line on the neck of the flask and mixed thoroughly. See **Figure 2** to the right.

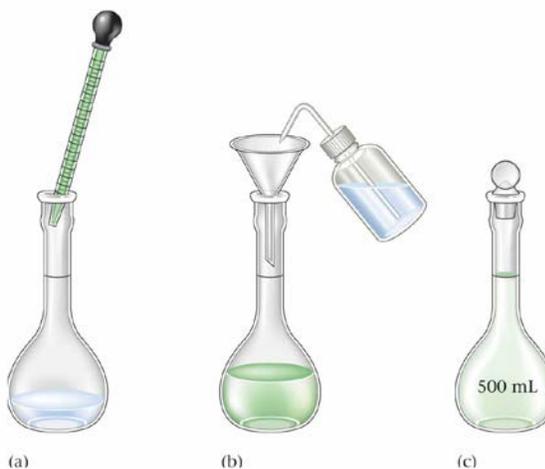


Figure 2. Diluting a solution.

The previous example is one kind of dilution. A serial dilution is a dilution where a series of dilutions are conducted, each one may be one-tenth as concentrated as the previous. This procedure is repeated until the desired concentration is reached. Serial dilutions are commonly used in microbiology where the solution being diluted contains bacterial colonies. See **Figure 3** below.

To prepare solutions through serial dilution, 1.00 mL of a stock solution is removed using a pipet and added to a 10 mL graduated cylinder. Water is added so that the final volume is 10.00 mL. The solution is mixed and then poured into test tube #2. To prepare the next solution, 1.00 mL of solution from test-tube #2 is removed using a pipet and added to a 10 mL graduated cylinder. Again, deionized water is added to the graduated cylinder until the final volume is 10.00 mL. The solution is mixed and then poured into test tube #3.

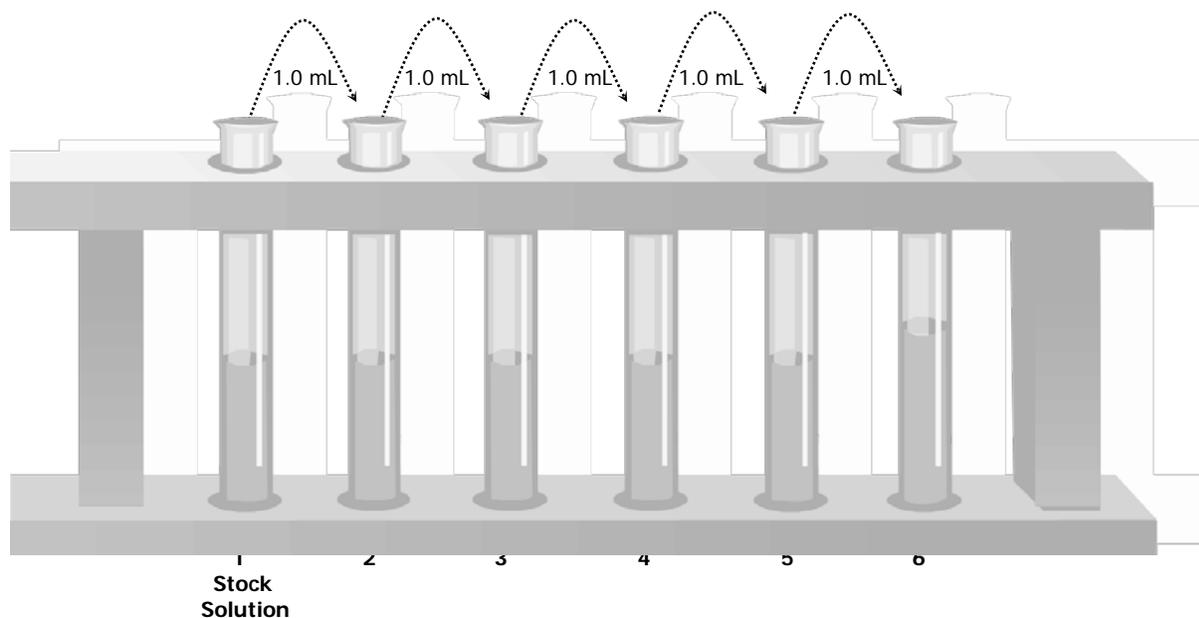


Figure 3. Serial Dilutions.

Note: Since volumes are not additive, you will **not** actually be measuring 9.0 mL of water to add to the concentrated solution. Instead, the correct procedure is to use a pipet to measure 1.00 mL of concentrated solution into a 10 mL graduated cylinder, then add deionized water to the graduated cylinder so that the final volume of the diluted solution is precisely 10.00 mL.

Recall the proper pipet procedure you learned in experiment 2. The pipet must be kept vertical at all times when it has liquid in it (to prevent liquid from getting into the pump). When dispensing from a pipet, you must either stop at a certain volume marking, or, on pipets with markings all the way down to the tip, you must allow the liquid to drain out by gravity only. In either case, forcing all of the liquid out of the pipet will dispense too much.

PROCEDURE

⚠ Eye protection, as directed by your instructor, must be worn for this experiment.

PART A. Preparing a 0.10 M sucrose solution in a volumetric flask.

1. Check your calculations from question #2 in the prelab exercises. Calculate the mass of sucrose, $C_{12}H_{22}O_{11}$, required to make 100.0 mL of a 0.10 M solution. Measure out the required amount of sucrose into a new plastic weighing boat.
2. Transfer the sucrose into a 100 mL volumetric flask, using a wash bottle to rinse any solid remaining on the weighing boat. Add water to the flask until it is one-half to two-thirds full. Add 10 drops of food coloring to the solution.
3. Cap the flask and invert the flask gently several times until the solid dissolves completely. Use your thumb or forefinger to secure the cap onto the flask while inverting. Do not shake the flask hard as the glass neck may break.
4. Continue (slowly) adding deionized water until the water level is near the etched line on the neck of the flask. Add water more carefully, drop-by-drop, until the bottom of the meniscus is on the etched line.
5. Cap the flask and invert the flask gently 3 to 4 more times. Do not shake the flask hard as the glass neck may break.
6. Once the solution is thoroughly mixed and all solid has been dissolved, transfer it to the labeled plastic bottle. Cap the bottle to prevent contamination or evaporation. This is the 0.10 M sucrose stock solution.

PART B. Preparing Serial Dilutions.

1. Place 5 clean, dry test tubes in a test tube rack and label the test tubes 1-5 with labeling tape.
2. Fill a 250-mL beaker about half full with deionized water. This water will be used to rinse the pipet after each use. This will ensure the pipet is clean and not a cause of contamination. Label this beaker as the "rinse beaker."
3. Pour your 0.10 M sucrose stock solution into a 10-mL graduated cylinder. The final volume of liquid in the graduated cylinder should be precisely 10.00 mL. Pour this solution into the first test tube. Rinse the graduated cylinder with deionized water. Invert the cylinder and try to get as much water out as possible.

⚠ Use a pipet pump or bulb to draw liquid into the pipet. Never pipet by mouth.

- Using a rinse beaker, rinse a 1 mL volumetric pipet, by drawing in water followed by a small amount of the solution that you intend to use and then discard it into a labeled “waste” beaker. This “seasons” the pipet with the liquid that you will be using and removes traces of the liquid previously in the pipet. Use this procedure for rinsing the pipet for the remainder of the lab. Be careful not to draw liquid up into the pipet bulb. Discard the contents of your waste beaker.
- Using the clean sucrose pipet, transfer 1.00 mL of sucrose solution to the 10 mL graduated cylinder. Add deionized water so that the final volume on the cylinder is 10.00 mL. Mix this solution by drawing a small amount of the solution into the pipet and returning the solution back to the cylinder, or alternatively, you may carefully use a clean stirring rod. Transfer this solution to test tube #2. Rinse the pipet in the rinse beaker and rinse the 10 mL graduated cylinder with deionized water.
- Repeat step 5 by adding 1.00 mL of the sucrose solution from test tube # 2 to the graduated cylinder. Add deionized water so that the final volume is 10.00 mL. Agitate the solution and add this newly mixed solution to test tube #3. Repeat the dilution process for test tubes #4 and #5. Don’t forget to rinse your pipet and graduated cylinder out between steps.
- Compare the color of the stock solution and each of the subsequent dilutions in test tubes 1-5. Rank these solutions in order of color intensity from the darkest to the lightest color (the most concentrated solution will have the highest number).

⚠ Empty each test tube into the designated waste container.

- Rinse each test tube with deionized water.

PART C. Preparing Solutions of a Given Molarity.

- Place the 5 labeled test tubes back into the test tube rack. Using the 10 mL graduated cylinder, pour 10.00 mL of the stock solution into test tube #1. Record the necessary data in the data table for test tube #1.
- Rinse a graduated Mohr pipet. Use this pipet to add 3.80 mL of the sucrose stock solution to the 10 mL graduated cylinder. Now fill the graduated cylinder to the 10 mL mark with deionized water. Mix the solution by agitating with the pipet or a clean stirring rod. Transfer this solution to test tube #2. Rinse the pipet and graduated cylinder as directed earlier. Record the necessary data in the chart for test tube #2.
- Again, using the graduated Mohr pipet, add 2.40 mL of sucrose stock solution to the 10 mL graduated cylinder. Now fill the graduated cylinder to the 10 mL mark with deionized water. Mix the solution by agitating with the pipet or a clean stirring rod. Transfer the solution to test tube #3. Rinse the pipet and graduated cylinder as directed earlier. Record the necessary data in the chart for test tube #3.

4. Using your calculations from question number 3 in the prelab, prepare 10.00 mL of a 0.050 M sucrose solution by dilution using the stock solution. Transfer this solution to test tube #4 and record the necessary data for test tube #4.
5. Using your calculations from question number 4 in the prelab, prepare 10.00 mL of a 0.015 M sucrose solution by dilution using the stock solution. Transfer this solution to test tube #5 and record the necessary data for test tube #5.
6. Compare the color of the stock solution and each of the subsequent dilutions in test tubes 1-5. Rank these solutions in order of color intensity from the darkest to the lightest color (the most concentrated solution will have the highest number).

⚠ Empty each test tube into the designated waste container.

7. After completing the data table, wash the test tubes and graduated cylinder, and rinse with deionized water. Invert the test tubes in the rack so that they dry for the next lab class. Make sure that you have washed and dried all your equipment (the insides of test tubes and graduated cylinders do not need to be dried) so that it is scrupulously clean for the next lab group. Make sure balances and surrounding bench areas are clean as well.

Name _____ Lab Section _____

Lab Partner's Name _____

DATA

Part B:

		Test tube # 1	Test tube # 2	Test tube # 3	Test tube # 4	Test tube # 5
M_1	Concentration of Concentrated Solution	0.10 M				
x						
V_1	Volume (in mL) of Concentrated Solution added	10.00 mL				
=						
M_2	Concentration of Dilute Solution	0.10 M (no water was added to this test tube)				
x						
V_2	Volume (in mL) of Dilute Solution	10.00 mL (no water was added to this test tube)				
Color observations Rank solutions 1-5 lightest = 1 darkest = 5						

Part C:

		Test tube # 1	Test tube # 2	Test tube # 3	Test tube # 4	Test tube # 5
M_1	Concentration of Concentrated Solution	0.10 M				
x						
V_1	Volume (in mL) of Concentrated Solution added	10.00 mL				
=						
M_2	Concentration of Dilute Solution	0.10 M (no water was added to this test tube)				
x						
V_2	Volume (in mL) of Dilute Solution	10.00 mL (no water was added to this test tube)				
Color observations Rank solutions 1-5 lightest = 1 darkest = 5						

POSTLAB QUESTIONS

1. Compare the concentrations of each of the serial dilutions to the color rankings. What is the relationship between concentration and color intensity?
2. Calculate the number of grams of potassium iodide (KI), needed to prepare 500.0 mL of a 0.125 M KI. Show your work.
3. Suppose you took 1.00 mL of the KI solution from question #2 above and diluted it to 50.0 mL, what would be the concentration of the new solution? Show your work.
4. 25.0 mL of 0.50 M solution of NaOH was diluted to a final volume of 200.0 mL. What is the new concentration of this solution?