The Right Solution Lab

Today is your first day of on the job training at Green Thumb Growers, a greenhouse operation that produces a variety of flower and vegetable seedlings for home and garden centers throughout the state. Your job involves watering plants and applying the correct amount of fertilizer solution. Your boss has given you and your coworker *The Right Solution Lab* exercise to help you understand measurements and dilution before you can begin working on your own. You have been instructed to read the directions and carry out the lab. Your boss encourages you to ask questions to clarify anything you don't understand since these types of tasks will be part of your daily work at the greenhouse.

Fertilizers are used to provide nutrients that are not present in soil (or other growing media) in amounts necessary to meet the needs of the growing crop. Fertilizers are available in several forms:

- Pre-mixed liquid concentrates that are then diluted with water
- Pre-mixed powder concentrates that are then diluted with water
- Made from "scratch"—many commercial growers buy the individual compounds and mix the nutrient solution themselves

In this example, the fertilizer concentrate is the solute and the water is the solvent. The two are mixed to create a homogeneous solution. Dilution is the process of making the solution weaker or less concentrated, and can be used to regulate the amount of nutrients applied. In this lab, we'll be diluting the original substance to a concentration of one part per million (ppm) and one part per billion (ppb).

Very small quantities of a substance can be measured in parts per million and parts per billion. The ability to measure substances in such minute amounts allows growers to strategically apply the specific nutrients a plant needs to grow. But what do parts per million and parts per billion actually mean? These are difficult numbers to comprehend. The following activity will help illustrate the terms ppm and ppb.

Procedure

1. Collect materials.
2. Fill three plastic cups about half full of water. Two cups will be used for cleaning the eye dropper, and one will be used for diluting. Label the cups so they don't get mixed up.
3. Label ice cube tray "cells" 1 to 10 with a permanent marker.
4. In cell #1, place 10 drops of food coloring. This represents a pure substance, or a concentration of 1 million parts per million.

The Right Solution Lab *(continued)*

5. Using an eye dropper, take one drop of food coloring from cell #1 and place it in cell #2. Return any excess food coloring back to cell #1.
6. Rinse the dropper in one of the plastic cups to remove all traces of food coloring. Then rinse again in the second cup you have reserved for rinsing.
7. Add 9 drops of clean water to cell #2 and stir the solution.
8. Take one drop of the solution from cell #2 and place it in cell #3. Return any excess solution back to cell #2.
9. Rinse the dropper in one of the plastic cups to remove all traces of food coloring.
10. Add 9 drops of clean water to cell #3 and stir the solution.

Continue repeating the procedure through cell #10, taking a drop of the solution from the previous cell and adding 9 drops of water. Remember to clean the dropper thoroughly between uses.

The Right Solution Data Collection

Name: _____

1. Determine the concentration of the solution for each cell and record it in the data table below.
   Example: In cell #2, one out of 10 drops was food coloring. The concentration of food coloring is 1/10 or .10, or 100,000 ppm.

Cell #	**Concentration** *(fraction and decimal)*	**ppm**	**Color** *(use colored pencils)*
1			
2	1/10 or .10	100,000	
3			
4			
5			
6			
7			
8			
9			
10			

2. Compare and contrast the solutions in each cell. In which cell is the color most intense? Why?

   _____

   _____

   In this activity, what agriculture concept does the solution in the first cell represent?

   _____

   _____

3. In which cell is the color least intense? Why?

   _____

   _____

   In this activity, what agriculture concept does the solution in the last cell represent?

   _____

   _____

The Right Solution Data Collection *(continued)*

4. Carefully examine your cells. Are there any cells where the liquid is colorless? _____ Is there any food coloring in these cells? _____ How do you know? _____

5. A fertilizer solution contains 1% nitrogen and 12% calcium. Write these percentages as concentrations in ppm.

   There is a factor of 10,000 between ppm and percentage; ppm stands for parts per million, whereas percent means per hundred, and there is a factor of 10,000 between one hundred and one million. To go from ppm to percentage divide by 10,000 and from percentage to ppm multiply by 10,000. For example: 1.5% would be 1.5 x 10,000 = 15,000 ppm and 0.12% would be 0.12 x 10,000 = 1,200 ppm

6. Which cell is closest to the concentration of nitrogen? Which cell is closest to the concentration of calcium?

7. Nitrogen, phosphorus, potassium, magnesium, and calcium are essential nutrients for plant growth. Deficiencies in these nutrients can be corrected by fertilizer application. **General recommended nutrient concentrations for cucumbers are listed below.** Convert the ppm concentrations to ppb. Which of your cells of food coloring is closest in concentration to each fertilizer concentration?

Nutrient	Concentration		Cell Number
Nitrogen (N)	230 ppm =	ppb	
Phosphorus (P)	40 ppm =	ppb	
Potassium (K)	315 ppm =	ppb	
Magnesium (Mg)	42 ppm =	ppb	
Calcium (Ca)	175 ppm =	ppb	

   Why do greenhouse growers use the process of dilution?

8. Explain at least two possible problems associated with applying a fertilizer solution that is too concentrated?

The Right Solution Data Collection *(continued)*

9. Explain at least two problems associated with applying a fertilizer solution that is too diluted.

_____

_____

_____

10. Your boss gives you a bag of fertilizer with the following chart and instructs you to prepare a fertilizer solution for the stock tank that will deliver 100 ppm nitrogen to the flower seedlings in one of the greenhouses. Your boss tells you that the injector ratio is set to 1:200.

Nitrogen ppm	**Injector Ratios**		
	1:100	***1:200***	***1:300***
50	3.38 oz	6.75 oz	10.13 oz
75	5.06 oz	10.13 oz	15.19 oz
100	6.75 oz	13.50 oz	20.25 oz
150	10.13 oz	20.25 oz	30.38 oz

a. Find the column that matches the type of injector you have with the row that matches the desired concentration of fertilizer in ppm. This will tell you how many ounces of fertilizer mix you need. Write the amount here: _____ oz of fertilizer mix needed per gallon of concentrated fertilizer solution.

b. Your boss tells you to make enough concentrated fertilizer solution for the 5 gallon stock tanks. How many ounces do you need to make 5 gallons? _____ oz.

c. You look for a way to measure out your dry fertilizer mix and notice that your scale is in grams. If 1 oz = 28.3 grams, how many grams should you weigh out for your 5 gallon mixture? _____ grams. What is your next step?