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Module 8; Making Solutions and Dilutions

Introduction

A solution is a homogeneous mixture, a mixture of molecule-sized particles of two or more substances. Air is a solution containing molecules of nitrogen, oxygen, water vapor, carbon dioxide, and air pollutants. Soda pop is a solution containing molecules of water, carbon dioxide, flavoring, and sweeteners.

Because the particles in solutions are very small, solutions look uniform. Usually, they are transparent like air or soda pop; sometimes they are opaque like metal alloys (brass, stainless steel etc). But they are never cloudy or nonuniform in appearance.

When chemists talk about solutions, they call the substance that is present in the greatest amount the solvent and they say that the other substances (the solutes) are dissolved in the solvent. When they are talking about air, they say that oxygen, water vapor, and carbon dioxide are dissolved in the solvent, nitrogen. When they are talking about soda pop, they say that carbon dioxide, flavorings, and sweeteners are dissolved in water, the solvent.

Scientists call the relative amounts of dissolved substance and solvent the concentration of the solution. They have many different ways of giving the concentration. Chemists usually use molarity, moles of dissolved substance per liter of solution, and they always abbreviate the molarity as M. So, when they write 6 M HCl on a label, they are saying that there are six moles of HCl dissolved in each liter of solution. Biologists often use mass/volume per cent or grams of dissolved substance per 100 milliliters of solutions. When they write 7.5 % on a label, they are saying that there are 7.5 grams of salt in every 100 milliliters of solution.

The procedures and protocols that scientists follow specify the concentration of each solution. So, scientists must know how to make up solutions of specific concentrations.

When a new solution is prepared by dilution of an existing solution the concentration of the new solution can be calculated using the relationship $V_1 C_1 = V_2 C_2$. The symbols represent:

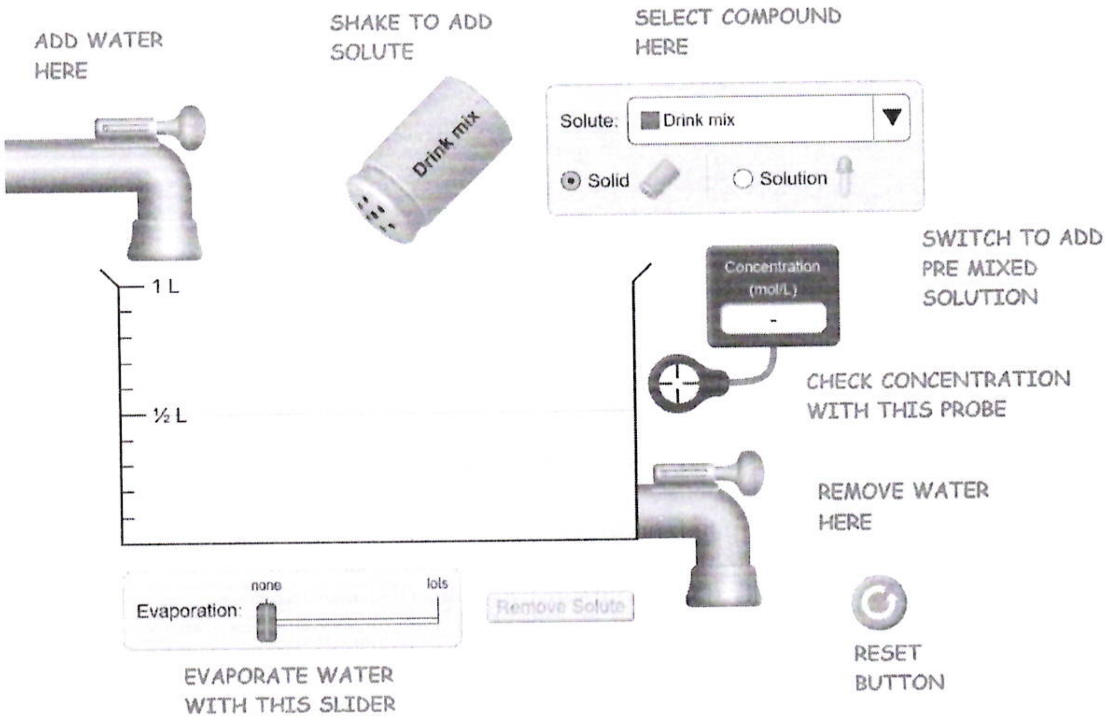
Previous volume	x	Previous concentration	=	New volume	x	New concentration

Pre-Lab Questions

QUESTION #1: How would you dilute 10 mL of a 1.2 M salt solution to make a .48 M salt solution? (complete the table below).	
First solve for V_2: To do this, write the formula. **Then plug in the numbers with units**. To solve for V2, you will need to divide both sides by C2 to isolate V2. Make sure your units cancel so you end up with mL.	$V_1 \times C_1 = V_2 \times C_2$ $10\ mL \times 1.2 M = V_2\ mL \times 0.48 M$ $\frac{10\ mL \times 1.2 M}{0.48 M} = V_2\ mL = 25\ mL$
Then to figure out how much water to add by subtracting: Do V_2 – 10 mL	$25\ mL - 10\ mL = 15\ mL$
Now explain how you would make the solution by filling in the blanks:	Mix __10__ mL of 1.2 M salt solution with __15__ mL of water to make __25__ mL of .48 M solution.
QUESTION #2 How many mL of water should you add to 200 mL of a 10% salt solution to make a 2% salt solution?	
First solve for V_2:	$V_1 \times C_1 = V_2 \times C_2$ $200 mL \times 0.1 = V_2 \times 0.02$ $\frac{200\ mL \times 0.1}{0.02} = V_2 = 1000\ mL$
Then to figure out how much water to add.	$1000\ mL - 200\ mL = 800\ mL$
Now explain how you would make the solution by filling in the blanks:	Mix 200 mL of 10% salt solution with 800 mL of water to make 1000 mL of 2% salt solution.

Procedures and Data

Use the following link to access an online simulation. I suggest you use a split screen so that you can follow directions while running the experiment. The simulation provided in the link does not really explain what the images do. Below is a still picture which labels the capabilities of each image. (The label that says "remove water" should actually say "remove solution").
https://phet.colorado.edu/sims/html/concentration/latest/concentration_en.html



PART 1 - Getting Familiar with the Simulation Features.

1. Click reset button on simulation (the image above is JUST an image – you need to open the simulator).
2. The beaker has water in it. You are going to shake in some drink powder to make a drink mix. To shake it in, click on the drink mix and "shake".
3. Now you can measure the concentration of your drink, Do that by putting the concentration probe into your beaker. Note the concentration on the "meter".
4. Now use the simulator to see what things will affect concentration. Hit the reset button and then use the simulator to complete the table here:

Action	Starting point – water only	Add a little drink mix	Add more drink mix	Add water	Remove some solution	Evaporate some water	Remove solute
Record concentration in mol/L	0.000	1.360	4.128	3.530	3.580	4.524	0.000
How did concentration change?	N.A.	1.360	2.768	-0.598	0.000	0.994	-4.524

PART 2 – Effect of Changing Amount of Solute/Solvent

1) Choose a solute from the dropdown menu. (The colored boxes let you know what color the solution will be when you mix the solute (a powder) with water. Complete the table below:

Name of chosen compound ➡	Cobalt (II) nitrate
Formula of chosen compound	$Co(NO_3)_2$
Class of chosen compound (covalent or ionic with fixed metal or ionic with variable metal)	Ionic with Variable Metal
What happens to the concentration as more solute is added?	It increases
What units are being used on the meter for measuring concentration?	Moles per Liter
What is the relationship between concentration and color?	Higher concentration = darker color
What happens to the color as more solute is added?	More solute = darker color

2) Now add water.

What happens to the concentration as the quantity of water increases?	It decreases
Explain why. (Mention what is happening to the quantity of solvent and solute)	The ratio of the solvent to the solute is increasing, causing the concentration to decrease.

3) Now Remove solution with the valve on the lower right.

What happens to the concentration as the quantity of solution decreases?	There is no change
Explain why. (Mention what is happening to the quantity of solvent and solute)	The ratio of the solute to the solvent is not changing as removing the whole solution removes both substances at an equal rate.

4) Now Remove water with the Evaporation Slider Bar on the bottom.

What happens to the concentration as the quantity of water decreases?	The concentration increases
Explain why. (Mention what is happening to the quantity of solvent and solute)	The ratio of the solute to solvent increases as the amount of solvent decreases without any change in solute.

PART 3 - Saturation

1) Press reset button. Choose $CuSO_4$ (Copper II sulfate) as your solute from the dropdown menu.

Create a saturated solution. How did you do it?	I kept shaking in increasingly more solute
How do you know when a saturated solution is created? (list both ways)	• The solute no longer dissolves in the solvent • The color of the solution is no longer changing

2) Move the Concentration Probe into the liquid. (At this time the solution should be saturated).

What is the concentration? (Include Units)	1.380 mol/L
Add more solute. What happens to the concentration? (Explain why)	The concentration does not change as the solute is no longer dissolving.

PART 4 – Adding Solutions to water (diluting)

1) Press Reset. Select Potassium Permanganate from the dropdown menu. Switch to the Eye dropper by selecting Solution in the upper right. This will add a solution (rather than a powder) to the water. Now use the simulator to see how concentration is affected. Complete the table.

Action	Starting point – water only	Add a little solution from the dropper	Add more solution from the dropper	Add water	Remove some solution	Evaporate some water
Record concentration in mol/L	0.000	0.017	0.031	0.028	0.028	0.033
How did concentration change?	N.A.	0.017	0.014	-0.003	0.000	0.005

2) Press Reset. Select any solute you want from the dropdown menu. Switch to the Eye dropper by selecting Solution in the upper right. Drain ALL the water out of the beaker so it is empty.
3) Determine the concentration in the eyedropper solution. To do this, move the probe so that it is just under the eyedropper. You will see the concentration as the solution drops over it.

Record the concentration of your solution:	5.000 mol/L

4) To determine the concentration a second way, add ½ L to the beaker of the solution in the dropper. Then drop the probe into the beaker.

Record the concentration of your solution:	5.000 mol/L

5) Without hitting reset, use the simulator to see how concentration of the solution is affected.

Action	Starting point – solution from dropper	Add a little more solution from the dropper	Add water	Remove some solution	Evaporate some water	Evaporate all water
Record concentration in mol/L	5.000	5.000	4.158	4.158	4.612	What do you see? 5.210
How did concentration change?	N.A.	0.000	-0.842	0.000	0.454	N.A,

→ It became super-saturated

PART 5 – Controlling the Concentration – Time for calculations!

Press Reset. Select nickel (II) chloride ($NiCl_2$).

1) Making a Solution at a certain concentration. Add enough powder to create a 0.4 Molar Solution in the ½ liter of water originally in the beaker. (If you overshoot the mark, use the "remove solute" button and try again).
   - Record the actual concentration that you got (as close to 0.4 M as you can get): 0.395 mol/L
   - Now calculate the number of moles of $NiCl_2$ that you shook into your beaker. Show your conversion below. Remember, you have ½ L solution (0.5 L) and your concentration is

Note: Moles and Molarity are not the same thing. The abbreviation for moles is mol. The abbreviation for molarity is M. To calculate moles: Use volume (in L) times M in (moles/L) The liters will cancel to give you moles:	Show calculation here. Include units. 0.395 mol/L · 0.5L = 0.198 mol $NiCl_2$

2) Dilute a Solution. Use $V_1C_1 = V_2C_2$ to predict what the concentration will be if you dilute the .5 L of your .4 M solution by adding water to make a 1L solution. Show your calculation set up and your answer:

Show calculation here: (Start with the formula. Plug in the numbers with units.) $V_1 \times C_1 = V_2 \times C_2$ $0.5\,L \times 0.4\,M = 1\,L \times C_2$ $\frac{0.5\,L \times 0.4\,M}{1\,L} = C_2$ $C_2 = 0.2\,M$	
See if you got the correct value. Do the dilution by adding water to the beaker up until the 1 L mark. What is the concentration according to the meter?	0.198 mol/L

3) Concentrate a Solution. Predict the concentration if the solution is now concentrated (by using evaporation) to a volume of .6 liters (one dash above the ½ L mark). Show the calculation of this concentration using the $V_1C_1 = V_2C_2$ formula.

Show calculation here: $V_1 \times C_1 = V_2 \times C_2$ $1\,L \times 0.198\,mol/L \quad 0.6\,L \times C_2$ $\frac{1\,L \times 0.198\,mol/L}{0.6\,L} = C_2$ $C_2 = 0.33\,mol/L$	
After you make the calculation: Evaporate water with Evaporation Slider Bar at the bottom until there is .6 liter of solution in the beaker. What is the concentration?	0.336 mol/L
From the volume and concentration, calculate the number of moles** of solute in the solution. Show your calculation with units.	$0.336\,mol/L \cdot 0.6\,L = 0.2016$ 0.2 mol
How does the # moles of solute compare to the # of moles of solute calculated in question 1. Explain why these numbers compare as they do.	It is nearly the exact same as the calculation and equal to ½ of the ideal 0.4 Molar solution. This shows that the total amount/moles of solute has stayed the same despite fluxuations in the concentration of the solution.