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Go to my website, [www.lhart.org](http://www.lhart.org), to the Chemistry Resources page.

OR go directly to <https://phet.colorado.edu/en/simulation/molarity>

OR go to [phet.colorado.edu](http://phet.colorado.edu), search “molarity” and select Molarity (HTML5)

Have you ever made lemonade or Kool Aid with powdered drink mix? Sometimes you make it too weak and sometimes it may turn out too strong!

Look at the simulation.

The first slider is the “**Solute Amount**”. This is the amount of the solid (powder) you’re adding.

The second slider is the “**Solution Volume**”. This is how much you’ll wind up with in your glass or pitcher.

The slider to the right is “**Solution Concentration**”. This is a good indication of if the Kool Aid is weak, strong or just right.

When you first open the simulation it gives you what looks like a pretty weak drink. What are two ways of making the drink stronger? Move just one slider to make a change that works, then hit the reset button and make a second change that works. Write your answers below:



1) \_\_\_\_\_

2) \_\_\_\_\_

In Chemistry, we often want to do numerical calculations, so first hit “reset”, then hit the “**Solution values**” checkbox. You should see that the Solute Amount (moles) = 0.500 mol, the Solution Volume (Liters) = 0.500 L, and the Solution Concentration (Molarity) = 1.000 M.

Play with the sliders and find other values for moles and Liters that will result in a Molarity of 1.000 M

Solute Amount (moles)	Solution Volume (Liters)	Solution Concentration (Molarity)
		1.000 M

What do you notice about the values?

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The concentration or strength of a solution is called its **Molarity** which is a ratio of the solute amount in moles divided by the solution volume in liters. We can write the formula:

$$\text{Solution Concentration (Molarity)} = \frac{\text{Solute Amount (moles)}}{\text{Solution Volume (Liters)}} \quad \text{or} \quad M = \frac{n}{V}$$

The units for molarity are moles per liter or  $\frac{\text{mol}}{\text{L}}$

This equation can be rearranged to solve for volume or for number of moles:

$$M = \frac{n}{V} \quad n = M \times V \quad V = \frac{n}{M}$$

Using the equations, determine the Solute Amount (moles) and the Solution Volume (Liters) that would create a 0.800 molar solution of drink mix in each situation below.

moles	Liters	Molarity	Show Calculations
<i>Example:</i> 0.500 mol		0.800 M	$V = \frac{N}{M} = \frac{0.500}{0.800} = 0.625 \text{ L}$
0.800 mol		0.800 M	
	0.256 L	0.800 M	
	0.661 L	0.800 M	
0.665 mol		0.800 M	

Now, check your answers using the simulation.

Looking at your data, for a given molarity, if you have more volume of solution, what happens to the number of moles of solute contained in that solution?

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## Molarity Practice Calculations

Calculate the missing values in the table:

$$M = \frac{\text{mol}}{L} \quad \text{mol} = M \times L \quad L = \frac{\text{mol}}{M}$$

moles	Liters	Molarity	Show Calculations
0.887 mol		1.590 M	
	0.830 L	0.360 M	
0.750 mol	0.295 L		
0.908 mol		1.552 M	
0.205 mol	0.880L		
0.205 mol		1.025 M	

Now, check your answers using the simulation.

Answer True or False:

T      F      Having more moles of solute definitely means a higher concentration (molarity) solution

Explain:

T      F      Having a greater volume definitely means a lower concentration (molarity) solution

Explain:

T      F      With a given number of moles of solvent, the solution will always have the same concentration

Explain:

## Calculating Grams

If you wanted to make 0.800 Liters of a 0.531 M solution of Nickel(II) chloride, NiCl<sub>2</sub>, how many grams of NiCl<sub>2</sub> would you need?

A problem like this first requires you to identify how many moles of NiCl<sub>2</sub> using a molarity formula, and then to convert that number of moles to grams using the molar mass of NiCl<sub>2</sub>.

First, identify your known variables (leave one blank):

$$M = \underline{\hspace{2cm}} \text{ M}$$

$$n = \underline{\hspace{2cm}} \text{ mol}$$

$$V = \underline{\hspace{2cm}} \text{ L}$$

Now, circle the version of the molarity equation that would be most easy to work with (with your unknown on the left):

$$M = \frac{\text{mol}}{L} \quad \text{mol} = M \times L \quad L = \frac{\text{mol}}{M}$$

Next, use that equation to solve for your unknown value. (show work)

Now that you know the number of moles, you will need the molar mass of NiCl<sub>2</sub> to calculate the grams of NiCl<sub>2</sub>.

Calculate the molar mass of NiCl<sub>2</sub> here, showing your work:

Now, use the unit cancelling method to determine the grams of NiCl<sub>2</sub> required:

$$\boxed{\hspace{2cm}} \text{ mol NiCl}_2 \times \frac{\boxed{\hspace{2cm}} \text{ g NiCl}_2}{\boxed{\hspace{2cm}} \text{ mol NiCl}_2} = \boxed{\hspace{2cm}} \text{ g NiCl}_2$$

In the simulation, switch the Solute from Drink Mix to Nickel(II) chloride by clicking on the box below the beaker. Adjust the sliders to check your answer with the simulation.

## Dilution

Reset the simulation and set the quantities at 0.250 mol of Drink Mix in 0.200 L of solution. Enter the molarity in the table below.

Now we are going to dilute the solution **only by sliding the second slider and changing the volume** (adding more water). Complete the first four columns of the table, indicating if the number of moles increased, decreased or remained the same.:

moles	Liters	Molarity	Did the moles increase, decrease or stay the same?	
0.250 mol	0.200 L			
	0.355 L			
	0.426 L			
	0.520 L			
	0.726 L			
	0.881 L			

Now multiply the liters (column 2) by the molarity (column 3) and enter that value in the last column.

What do you notice?

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The Molarity formula can be rearranged to solve for number of moles:  **$mol = M \times L$** .

Another way to express this is:  $n = M \times V$ , where  $n$  = number of moles and  $V$  = volume

Notice that diluting the solution results in the same number of moles. Therefore, since  $n$  remains the same, the quantity  $M \times V$  will remain constant.

Since this is the case, we can use the following formula for dilutions:

$$M_1 \times V_1 = M_2 \times V_2$$

The initial molarity times the initial volume equals the new molarity times the new volume.

$$M_1 \times V_1 = M_2 \times V_2$$

Calculate the missing quantities in the table

Initial Molarity ( $M_1$ )	Initial Volume ( $V_1$ )	Final Molarity ( $M_2$ )	Final Volume ( $V_2$ )
2.000 M	0.500 L		1.00 L
2.500 M	0.200 L	0.500 M	
0.215 M	0.785 L		0.897 L
1.941 M	0.306 L	0.832 M	
2.280 M	0.368 L		0.562 L

Now check your answers with the simulation

### Saturated Solutions

In the simulation, switch the Solute from Drink Mix to Copper(II) sulfate by clicking on the box below the beaker. Adjust both sliders to the bottom so that you have 0.000 moles and 0.200 L.

Slowly raise only the Solute Amount by (about) 0.070 moles and watch the Solution Concentration change.

moles	Molarity (M)
0.000	0.000
0.071	
0.140	
0.209	
0.280	
0.349	
0.420	

Does the molarity continue to change? Why or why not?

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What do you notice on the bottom of the container as you continue to add additional solute to the container?

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