



SCIENCE DISSECTED

Making Solutions of Known Molarity

Making solutions for the science classroom can be a cost-effective procedure. This issue will discuss how to make solutions from solid chemical solutes (substance being dissolved) and a liquid solvent (substance doing the dissolving). Usually water is the solvent, and sometimes alcohol is used as the solvent initially and then diluted with water.

Concentrations are usually given in one of two units. Molarity, symbolized M, is very commonly used in the chemistry laboratory. Molarity is the moles of solute per liter of solution. This can also be expressed as moles solute per decimeter cubed of solution. This can also be symbolized as

$$M = \frac{\text{moles solute}}{L \text{ solution}} = \frac{\text{moles solute}}{dm^3 \text{ solution}}$$

The other commonly used concentration unit is percent solute per one hundred grams solution. This is called a mass percent solution. The symbolism is

$$\% \text{ solute} = \frac{\text{grams solute}}{\text{grams solute} + \text{grams solvent}}$$

This issue will explain how to make up solutions of a known molarity. Percent solutions will be explained in a later issue.

To begin, we'll make up a fairly easy solution: 1.00 L of 6.0 M NaOH. Solid sodium hydroxide comes as NaOH. That means that there is 1 mol Na, 1 mol O, and 1 mol H atoms in each mole of NaOH. First, we need to determine the molar mass of NaOH. Here's how to do this calculation. Find the elements listed in the formula, determine how many moles of each, and the atomic mass of each element. The number of moles of each element is determined by the subscript in the formula, and the atomic mass is taken directly from the periodic table. Two decimal places for atomic mass are sufficient. Then multiply the number of moles of each element times the molar mass and add up to get the total molar mass.

Element	#moles		Atomic Mass		Molar Mass
Na	1	x	22.99	=	22.99
O	1	x	16.00	=	16.00
H	1	x	1.01	=	1.01
					40.00
					Molar Mass

This means that the molar mass of NaOH is 40.00 g. Mass out 40. g NaOH.

SPECIAL POINTS OF INTEREST:

- ◆ Electric stirrers, although very convenient, can cause a mess if due care is not taken. NEVER DROP the stirring magnet into the flask, always gently slide it into a tilted flask.
- ◆ Eye protection, gloves and an apron should always be worn when mixing chemicals.
- ◆ Make sure to properly label all storage containers with their contents WHEN they are filled. This will avoid the timely process of identifying an UNKNOWN substance.

Making Solutions of Known Molarity continued...

Remember to tare the mass of the weighing paper or container into the balance so that you get the correct mass of 40. g NaOH. Obtain a volumetric flask with a total volume of 1.00 L. Tilt it to one side and slide a magnetic stir bar into it gently, taking care not to break the volumetric flask. Add distilled water to fill it about $\frac{1}{4}$ full. Place the flask on a magnetic stirrer and turn it on to stir gently. Then carefully add the sodium hydroxide to the flask. You will need to use a powder funnel or make a funnel out of weighing paper to avoid spilling any of the solid. Add more water and allow the solid NaOH to completely dissolve. This particular solution process is exothermic. Allow the solution to cool to room temperature. Remove the magnetic stir bar and proceed to fill the volumetric flask so that the bottom of the meniscus is on the scratch mark on the neck. Reinsert the stir bar and stir for 5 to 10 minutes to completely mix the solution. Remove the stir bar and transfer the solution to the appropriate covered storage bottle(s).

You now have 1.00 L of 1.0 M NaOH.

Example #2

Let's try another solution. Let's say that we need to have 250. mL of a solution that is 2.00 M $\text{Cu}(\text{NO}_3)_2$. Again, you need to determine the molar mass of the solute. The bottle containing the solute must be examined to find the actual formula of the solute. Copper(II) nitrate usually is ordered with the formula $\text{Cu}(\text{NO}_3)_2 \cdot 8 \text{H}_2\text{O}$. This solute is usually shipped as a hydrate, a substance that has water molecules within its crystalline structure. The water then becomes part of the molar mass. To calculate molar mass,

$$\text{Cu } 1 \times 63.55 = 63.55$$

$$\text{N } 2 \times 14.01 = 28.02$$

$$\text{O } 6 \times 16.00 = 96.00$$

$$\text{H } 16 \times 1.01 = 16.16$$

$$\text{O } 8 \times 16.00 = \underline{128.00}$$

331.73 So, the molar mass is **331.73 g**

You need 250. mL of solution 2.00 M $\text{Cu}(\text{NO}_3)_2$. So, to determine how much solid to mass out, you need to calculate moles $\text{Cu}(\text{NO}_3)_2$, found by multiplying volume by molarity, and then convert the moles to mass. The volume is given in mL, which must be changed to L. Calculations are below.

$$\text{mass } \text{Cu}(\text{NO}_3)_2 = \frac{250. \text{ mL} \times 1 \text{ L}}{1000 \text{ mL}} \times \frac{2.000 \text{ mol } \text{Cu}(\text{NO}_3)_2 \cdot 8 \text{ H}_2\text{O}}{1 \text{ L}} \times \frac{331.73 \text{ g}}{1 \text{ mol}} = 165.9 \text{ g } \text{Cu}(\text{NO}_3)_2 \cdot 8 \text{ H}_2\text{O}$$

Begin by obtaining a 250 mL volumetric flask, sliding in the stir bar, and filling it about $\frac{1}{4}$ full with water. Turn on the stirrer. Mass out the 165.9 g $\text{Cu}(\text{NO}_3)_2 \cdot 8 \text{H}_2\text{O}$. Transfer it to the volumetric flask and add water almost to the neck. Allow the solute to dissolve. Make sure the solution is at room temperature. Then bring up to the correct volume and transfer to the appropriate covered storage bottles.

Frequently, the lab manuals will call for a solute that is a hydrate, but the number of moles of water in the formula may not be given in the materials list. It is very important to look at the manufacturer's formula on the bottle to determine if water is included. This will allow you to determine the correct mass of solute to get the desired concentration. Some solutes, such as phenolphthalein must be dissolved first in alcohol and then the entire solution must be diluted with water. This occurs very commonly with acid-base indicators. The instructor's lab manual is a great source of information on how to mix up these solutions. Also, consult a chemical order book for information on mixing solutions. Some are much better than others. Lastly, some manufacturers put the molar mass directly onto the storage bottle, an excellent time saver.

The same steps are always followed when making up any solution of known molarity, and they will soon become second nature to you.