Chemistry Lecture #77: Molarity

In chemistry, the common unit to describe the concentration of a solution is molarity (M). Molarity is the moles of solute dissolved in one liter of solution. It is calculated by dividing the total moles of solute by the volume of the solution in liters.

$$\text{Molarity} = M = \frac{\text{moles of solute}}{\text{liters of solution}}$$

What is the molarity if 2.00 moles of NaCl are dissolved in 0.500 L of solution?

$$M = \frac{\text{moles of solute}}{\text{liters of solution}}$$

$$M = \frac{2.00 \text{ moles NaCl}}{0.500 \text{ L}}$$

$$M = \frac{4.00 \text{ moles NaCl}}{\text{L}}$$

M = 4.00 molar NaCl or 4.00 M NaCl

If the amount of solute is given in grams, and the volume of the solution is given in mL or cm^3, you'll have to use the factor label method to convert grams to moles, and mL into liters. Remember that 1000 mL = 1 L.

What is the molarity of 80.0 g of $CuSO_4$ in 2.50×10^2 mL of solution?

Answer

We need to convert 80.0 g of $CuSO_4$ into moles. 1 mole of $CuSO_4$ has a mass of 160 g. We also need to convert 2.50×10^2 mL or 250 mL into liters. 1000 mL = 1 L.

$$M = \frac{80.0 \text{ g } CuSO_4}{250 \text{ mL}} \times \frac{\text{mole } CuSO_4}{160 \text{ g } CuSO_4} \times \frac{1000 \text{ mL}}{\text{L}}$$

$M = 2.00$ M $CuSO_4$

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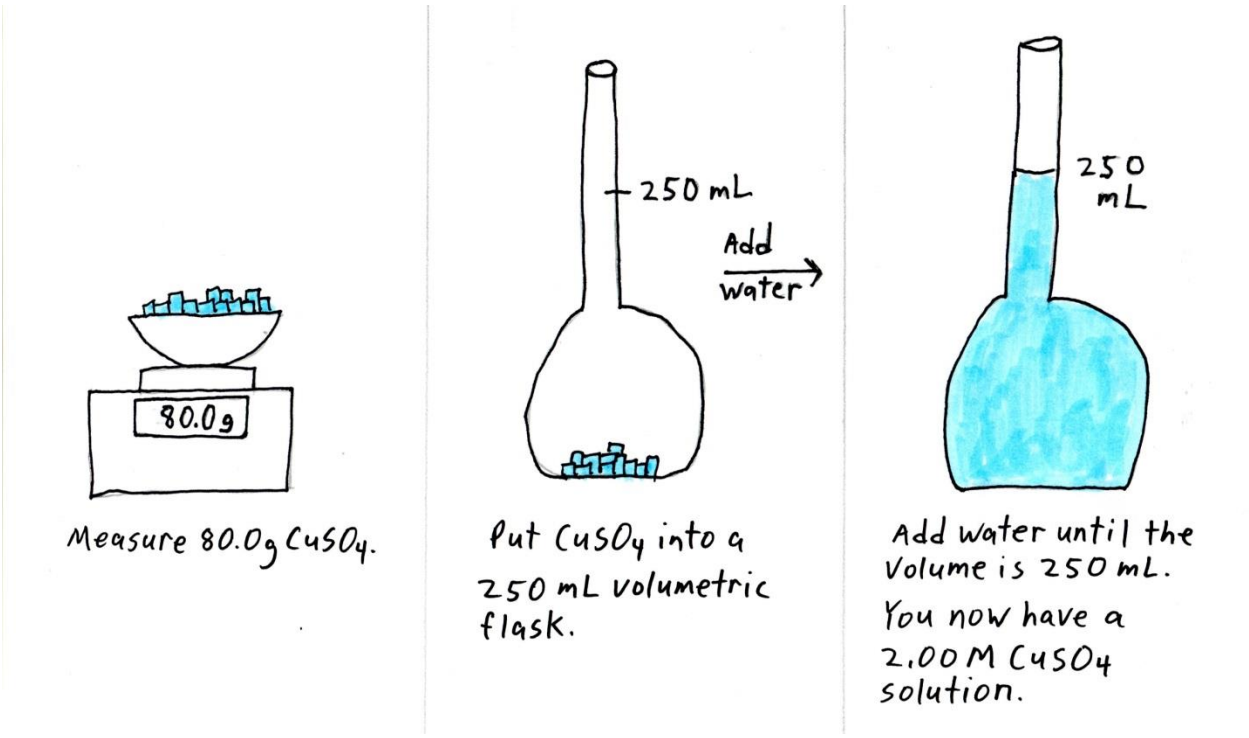
Molar solutions are prepared by measuring the grams of solute you need, adding the solute to a volumetric flask, then adding water until you've reached the desired volume.

For example, to prepare 250 mL of a 2.00 M $CuSO_4$ solution, you would measure out 80.0 g of $CuSO_4$, add it to a 250 mL volumetric flask, then add water to the flask until it reached the 250 mL line. Done in this fashion, you'll actually use a little bit less than 250 mL of water since the $CuSO_4$ takes up some of the total volume of the solution.



The next type of molarity problem asks you how to prepare a certain volume of a solution with a certain molarity. Indirectly, you are being asked how many grams of solute are in a certain volume of solution.

For these types of problems, you'll be converting mL into liters, liters into moles, then moles into grams.

mL → L → moles → grams

How would you prepare 4.00×10^2 mL of a 1.50 M $CaCl_2$ solution?

Answer

We'll convert 400 mL into L using 1000 mL = 1 L.

1.50 M means that 1 L of solution contains 1.50 moles of $CaCl_2$, so we'll convert L to moles using 1 L = 1.50 moles $CaCl_2$

1 mole of $CaCl_2$ has a mass of 111 g, so we'll use 1 mole $CaCl_2$ = 111 g $CaCl_2$.

mL ⇒ L ⇒ moles ⇒ grams

1000 mL = 1 L 1 L = 1.50 moles $CaCl_2$

1 mole $CaCl_2$ = 111 g $CaCl_2$

$$\frac{400 \text{ mL}}{1} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1.50 \text{ moles } CaCl_2}{1 \text{ L}} \times \frac{111 \text{ g } CaCl_2}{\text{mole } CaCl_2} =$$

$$66.6 \text{ g } CaCl_2$$

To prepare 400 mL of 1.50 M $CaCl_2$, add water to 66.6 g of $CaCl_2$ until the volume is 400 mL .