Concentration (Molarity)

Unit: Solutions

MA Curriculum Frameworks (2016): HS-PS2-7(MA)

Mastery Objective(s): (Students will be able to…)

- Calculate the concentration of a solution in $\frac{mol}{L}$.
- Calculate the final concentration of a solution after dilution.

Success Criteria:

- Solutions have the correct quantities substituted for the correct variables.
- Algebra and rounding to appropriate number of significant figures is correct.

Tier 2 Vocabulary: concentration, molar

Language Objectives:

- Explain how concentration is calculated.

Notes:

concentration: how much of something (solute) is dissolved in something else (solvent).

molarity (M): a unit of concentration equal to $\frac{\text{moles of solute}}{\text{L of solution}}$ or $\frac{\text{mol}}{\text{L}}$.

dilution: the process of decreasing the concentration of a substance by adding more solvent.

dilute: a solution that has a low concentration of solute dissolved in it.

There are three common types of problems involving molarity:

1. Find the molarity of a solution containing ___ grams/moles of solute with a volume of ___ L.
2. "How many moles/grams of a chemical would you need to make ___ L of a ___ M solution?" OR "What volume would you add to ___ moles/grams of a chemical to make a ___ M solution?"
3. What volume of ___ M solution would you add to water to make ___ L of a ___ M solution.

Use this space for summary and/or additional notes:

1. Determining Concentration

To calculate the molarity of a solution:

1. find the moles of solute
2. find the liters of solution
3. divide the moles by the liters

For example: Determine the molarity of a solution made by dissolving 0.25 mol of $CuSO_4$ in enough water to make a total volume of 500 mL (0.5 L) of solution.

$$\frac{0.25\,\text{mol CuSO}_4}{0.5\,\text{L solution}} = 0.5\,\frac{\text{mol CuSO}_4}{\text{L}} = 0.5\,\text{M CuSO}_4$$

(pronounced "0.5 molar copper sulfate").

2. Determining the mass of solute or the volume of water needed

To solve these problems, use the molarity as a conversion factor, rewriting M as $\frac{\text{mol}}{\text{L}}$ (for example, 1.75 M would be $\frac{1.75\,\text{mol}}{1\,\text{L}}$, or 1.75 mol = 1 L).

For example:

How many moles of $AgNO_3$ would you need to dissolve in water to make 100. mL (0.100 L) of an 0.50 M solution?

$$\frac{0.100\,\text{L}}{1} \times \frac{0.50\,\text{mol}}{1\,\text{L}} = 0.050\,\text{mol}$$

Note that if the question had asked for <u>grams</u> of $AgNO_3$, you would then need to convert moles of $AgNO_3$ to grams.

Use this space for summary and/or additional notes:

3. Dilution problems

The idea is that the moles of solute before dilution must equal the moles of solute after dilution. Because molarity times volume equals moles $\left(\frac{\text{mol}}{\text{L}} \times \text{L} = \text{mol}\right)$, this means $M_1V_1 = M_2V_2$, where M_1 and M_2 are the molarities before and after dilution, respectively, and V_1 and V_2 are the volumes before and after dilution.

For example:

How much 0.50 M HCl would you need to add to water to make 2.0 L of an 0.10 M solution?

$$M_1V_1 = M_2V_2$$
$$M_1 = 0.50\ \text{M}$$
$$V_1 = V_1$$
$$M_2 = 0.10\ \text{M}$$
$$V_2 = 2.0\ \text{L}$$
$$(0.50)V_1 = (0.10)(2.0)$$
$$V_1 = \frac{(0.10)(2.0)}{0.50} = 0.40\ \text{L}$$

Use this space for summary and/or additional notes:

Homework Problems

1. What is the molarity of a solution that contains 25.2 g of KNO_3 (F.W. = $101.1\frac{g}{mol}$) dissolved in enough water to make a total volume of 200. mL of solution?

   Answer: 1.25 M

2. What is the molarity of a solution that contains 22.5 g of NaI (F.W. = $149.98\frac{g}{mol}$) dissolved in enough water to make a total volume of 500. mL of solution?

   Answer: 0.300 M

Use this space for summary and/or additional notes:

3. How many grams of NaOH (F.W. = $40.00 \frac{g}{mol}$) would you dissolve in water to make 1.0 L of a 2.0 M solution?

Answer: 80. g NaOH

4. How many grams of KCl (F.W. = $74.55 \frac{g}{mol}$) would you dissolve in water to make 250. mL of 0.100 M solution?

Answer: 1.86 g KCl

5. How many mL of 12.0 M HCl would you add to water to make 500. mL of a 1.00 M solution?

Answer: 42.0 mL HCl

Use this space for summary and/or additional notes:

6. If you put two teaspoons (8.0 g) of sucrose ($C_{12}H_{22}O_{11}$) into 300. mL of coffee, what is the concentration of sugar in the resulting solution?

Answer: 0.078 M

Use this space for summary and/or additional notes: