7.3: Molarity, Molality & Dilution

Remember:

- Have your **7.3 notesheet** ready!
- You can **pause** the video anytime.
- You can **rewind** the video anytime.
- Write down **questions/comments** as you go for discussion in class.

Are you ready???

Part I: Molarity and Molality

- the concentration of a solution can be measured in a variety of ways.
  - the words "**concentrated**" and "**dilute**" can describe a sol'n **without** specific numerical values. These are **qualitative** descriptions.
  - **quantitative** descriptions of concentration (numerical values) can be calculated from specific information about the solution, such as moles of solute and either volume or mass of solvent. **Molarity** (M) and **molality** (m) are two such values.
- **Molarity** (**M**) = the number of **moles** of solute per 1 **liter** of total solution.

$$\textbf{Molarity}\ (M) = \frac{\text{moles of solute}}{\text{liters of solution}} = \frac{\textbf{mol}}{\textbf{L}}$$

  - Molarity involves a **molar** amount of solute, so if you are given something like grams, you must convert them into moles first.
  - Molarity also involves the **volume** (in **liters**) of total solution, so if you are given something like mL, you must convert them into liters first.

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- once you have moles of solute and liters of solution, just divide. **Molarity unit = M**
- steps in the calculation:

$$M = \frac{mol}{L}$$

1. set up a "**column of information**" that lists the **info given** in the problem, as well as which variable you are solving for (the ?)
2. decide which **rearrangement** of the formula you need to solve the problem
3. **convert** units given to those needed to match the units in the formula
4. **plug in** the values and **solve**!

Ex1 (Molarity): What is the Molarity of a 2.3 L solution containing 54.3 g of H_3PO_4?

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$$M = \frac{mol}{L}$$

Ex1 (Molarity): What is the Molarity of a 2.3 L solution containing 54.3 g of H_3PO_4?

M = ?

mol = 54.3 g → .554 mol

L = 2.3 L

$$54.3\ g\ H_3PO_4 \times \frac{1\ mol\ H_3PO_4}{98.00\ g\ H_3PO_4} = .554\ mol\ H_3PO_4$$

$$M = \frac{mol}{L} = \frac{.554\ mol}{2.3\ L} = \mathbf{.24\ M}$$

- **<u>molality</u>** (**m**) = the number of **moles** of **solute** per 1 **kilogram** of **solvent**.

$$\textbf{Molality}\ (m) = \frac{\text{moles of solute}}{\text{kilograms of solvent}} = \frac{\textbf{mol}}{\textbf{kg}}$$

  - molality involves a **molar** amount of solute, so if you are given something like grams, you must convert them into moles first.
  - molality also involves the **mass** (in **kilograms**) of solvent, so if you are given something like grams, you must convert them into kilograms first.
  - once you have moles of solute and kg of solvent, just divide. **Molality unit = m**
- the reason we have **two different forms** of concentration values is because of the tendency of a liquid to expand or contract with temperature or pressure fluctuations.
  - this affects the **volume** of the liquid, which, in turn, affects the **Molarity** value.

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  - this affects the **volume** of the liquid, which, in turn, affects the **Molarity** value.
  - therefore, if the temperature or pressure **remains the same**, Molarity is used as the measure of concentration.
  - however, **molality** does **not** involve volume, it involves **mass** (in kg), which does **not** fluctuate with changes in temperature or pressure.
  - therefore, if the temperature/pressure **changes**, molality is used as the measure of concentration.

Ex2 (molality): How many grams of NaCl were added to 1.48 kg of ethanol if the resulting solution was 3.7 m?

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$$m = \frac{mol}{kg}$$

<u>Ex2</u> (molality): How many grams of NaCl were added to 1.48 kg of ethanol if the resulting solution was 3.7 m?

m = 3.7 m
mol = ? (in g)
kg = 1.48 kg

$$m = \frac{mol}{kg}$$

$$m \bullet kg = mol$$

$$mol = m \bullet kg$$

mol = (3.7 m)(1.48 kg) = 5.476 mol

$$5.476 \text{ mol NaCl} \times \frac{58.44 \text{ g NaCl}}{1 \text{ mol NaCl}} = \textbf{320.02 g NaCl}$$

Part II: Dilution Calculations

- most acids, bases, and other chemical solutions are sold in very concentrated form to save on shipping costs and storage space (smaller volume and mass). (Think of frozen concentrated orange juice.)
- however, most experiments call for very diluted versions of these solutions.
- to dilute a solution, you combine distilled water with the concentrated solution until the proper, lower-concentration solution is formed.
- there are four parts to the **dilution equation**:

$$M_C V_C = M_D V_D$$

1. M_D = **Molarity** of the **diluted** (or desired) solution
2. M_C = **Molarity** of the **concentrated** (or stock) solution
3. V_D = **volume** of the **diluted** (or desired) solution
4. V_C = **volume** of the **concentrated** (or stock) solution

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  1. M_D = **Molarity** of the **diluted** (or desired) solution
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  3. V_D = **volume** of the **diluted** (or desired) solution
  4. V_C = **volume** of the **concentrated** (or stock) solution
  - in most cases, you need to calculate V_C, the **volume of the conc. sol'n**, so the formula will need to be rearranged like this:

$$M_C V_C = M_D V_D$$

$$V_C = \frac{M_D V_D}{M_C}$$

- in addition to the V_C, you will also need to know the **volume of distilled water** to use to dilute the concentrated solution. You can calculate this volume of water by using this equation:

$$V_W = V_D - V_C$$

Ex3 (Dilution): How many mL of 12 M HCl is needed to produce 1.5 L of a solution that is 3.8 M? Also, how many mL of distilled water must be used to make this 3.8 M solution?

1. set up a "**column of information**" that lists the **info given** in the problem, as well as which variable you are solving for (the ?)
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Ex3 (Dilution): How many mL of 12 M HCl is needed to produce 1.5 L of a solution that is 3.8 M? Also, how many mL of distilled water must be used to make this 3.8 M solution?

M_D = 3.8 M

M_C = 12 M

V_D = 1.5 L

V_C = ?

V_W = ?

$$V_C = \frac{M_D V_D}{M_C} = \quad V_C = \frac{(3.8\text{ M})(1.5\text{ L})}{12\text{ M}} = .475\text{ L}$$

$$.475\text{ L} \times \frac{1000\text{ mL}}{1\text{ L}} = \textbf{475 mL HCl}$$

$$V_W = V_D - V_C = 1500\text{ mL} - 475\text{ mL} = \textbf{1025 mL } \mathbf{H_2O}$$

- Make sure notesheet is **completely filled in**
- Preview the **funsheets** (7.3a and 7.3b)
- **Rewind and review** any parts that were not clear
- Bring both **notesheet** and **funsheet packets** to class