Conversions to Moles

Measurable property ⇌ Moles

Mass ⇌ Moles of pure substance

Volume of solution ⇌ Moles of solute

Molarity

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

- Converts between moles of solute and volume of solution

$$0.500\ \text{M}\ Na_3PO_4\ \text{means}\ \frac{0.500\ \text{mol}\ Na_3PO_4}{1\ \text{L}\ Na_3PO_4\ \text{solution}}\ \text{or}\ \frac{0.500\ \text{mol}\ Na_3PO_4}{10^3\ \text{mL}\ Na_3PO_4\ \text{solution}}$$

Calculating Molarity

- A silver perchlorate solution was made by dissolving 29.993 g of pure $AgClO_4$ in water and then diluting the mixture with additional water to achieve a total volume of 50.00 mL. What is the solution's molarity?

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$$= \frac{2.893 \text{ mol AgClO}_4}{1 \text{ L AgClO}_4 \text{ soln}} = \mathbf{2.893 \text{ M}} \text{ AgClO}_4$$

Calculating Molarity

- A silver perchlorate solution was made by dissolving 29.993 g of pure $AgClO_4$ in water and then diluting the mixture with additional water to achieve a total volume of 50.00 mL. What is the solution's molarity?

Molarity expressed with more specific units

Given amount of solute

Converts mass to moles

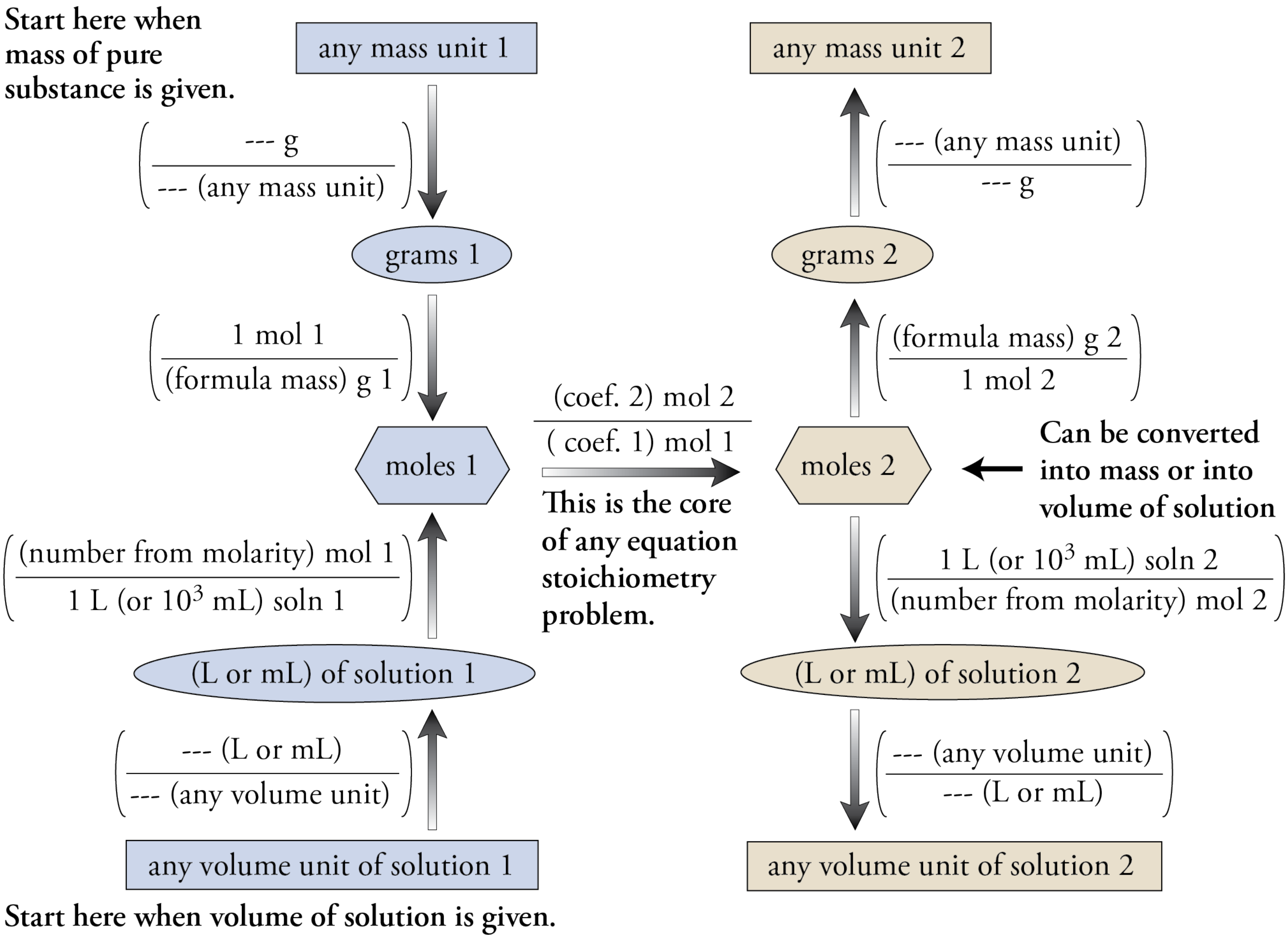
Converts the given volume unit into the desired volume unit

$$? \text{ M } AgClO_4 = \frac{? \text{ mol } AgClO_4}{1 \text{ L } AgClO_4 \text{ soln}} = \frac{29.993 \cancel{\text{g } AgClO_4}}{50.00 \cancel{\text{mL}}\ AgClO_4 \text{ soln}} \left(\frac{1 \text{ mol } AgClO_4}{207.3185 \cancel{\text{g } AgClO_4}}\right)\left(\frac{10^3 \cancel{\text{mL}}}{1 \text{ L}}\right)$$

Given amount of solution

$$= \frac{2.893 \text{ mol } AgClO_4}{1 \text{ L } AgClO_4 \text{ soln}} = \mathbf{2.893\ M}\ AgClO_4$$

Equation Stoichiometry



Equation Stoichiometry (2)

- **Tip-off -** The calculation calls for you to convert from amount of one substance to amount of another, both of which are involved in a chemical reaction.
- **General Steps**

1. If you are not given it, write and balance the chemical equation for the reaction.
2. Start your unit analysis in the usual way.

Equation Stoichiometry (3)

3. Convert from the units that you are given for substance 1 to moles of substance 1.
   - For pure solids and liquids, this means converting mass to moles using the molar mass of the substance.
   - Molarity can be used to convert from volume of solution to moles of solute.

Equation Stoichiometry (4)

4. Convert from moles of substance 1 to moles of substance 2, using the coefficients in the balanced equation.
5. Convert from moles of substance 2 to the desired units for substance 2.
   - For pure solids and liquids, this means converting moles to mass using the molar mass of substance 2.
   - Molarity can be used to convert from moles of solute to volume of solution.

Equation Stoichiometry (4)

6. If necessary, we convert from grams to the mass unit we want, or liters (or milliliters) to the volume unit we want.
7. Calculate your answer and report it with the correct significant figures (in scientific notation, if necessary) and unit.

Example 1

- How many milliliters of 6.00 M HNO_3 are necessary to neutralize the carbonate in 75.00 mL of 0.250 M Na_2CO_3?

$$\left(\frac{0.250 \text{ mol } Na_2CO_3}{10^3 \text{ mL } Na_2CO_3 \text{ soln}}\right) \qquad \left(\frac{10^3 \text{ mL } HNO_3 \text{ soln}}{6.00 \text{ mol } HNO_3}\right)$$

mL Na_2CO_3 soln → mol Na_2CO_3 → mol HNO_3 → mL HNO_3 soln

Example 1

How many milliliters of 6.00 M HNO_3 are necessary to neutralize the carbonate in 75.00 mL of 0.250 M Na_2CO_3?

- Before we can do our calculation, we need to get a balanced equation.
- HNO_3 is a strong acid and Na_2CO_3 as a weak base, so we follow the steps described in a previous lesson for writing double displacement equations for acid-base reactions.

$$2HNO_3(aq) + Na_2CO_3(aq) \rightarrow H_2O(l) + CO_2(g) + 2NaNO_3(aq)$$

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$$? \text{ mL } HNO_3 \text{ soln} = 75.00 \cancel{\text{mL } Na_2CO_3 \text{ soln}} \left(\frac{}{\cancel{\text{mL } Na_2CO_3 \text{ soln}}} \right)$$

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$$= \mathbf{6.25 \text{ mL } HNO_3 \text{ soln}}$$

Coefficients from balanced equation convert moles of one substance into moles of another substance.

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Molarity as a conversion factor converts liters into moles.

Molarity as a conversion factor converts moles into liters.

Example 2

- What is the maximum number of grams of silver chloride that will precipitate from a solution made by mixing 25.00 mL of 0.050 M $MgCl_2$ with an excess of $AgNO_3$ solution?

$$\left(\frac{0.050 \text{ mol } MgCl_2}{10^3 \text{ mL } MgCl_2 \text{ soln}}\right)$$

mL $MgCl_2$ soln → mol $MgCl_2$ → mol $AgNO_3$ → g $AgNO_3$

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What is the maximum number of grams of silver chloride that will precipitate from a solution made by mixing 25.00 mL of 0.050 M $MgCl_2$ with an excess of $AgNO_3$ solution?

- Before we can do our calculation, we need to get a balanced equation.
- This is a precipitation reaction, so we follow the steps described in a previous lesson for writing double displacement equations for precipitation reactions.

$$2AgNO_3(aq) + MgCl_2(aq) \rightarrow 2AgCl(s) + Mg(NO_3)_{2(}aq)$$

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$$= \mathbf{0.36\ g\ AgCl}$$