

## Concentration Units

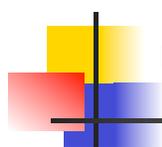
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Molarity: defined as moles of solute per liter of solution

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

The volume used is the total volume of the solution, not just the volume of the solvent

Usually the volume of the solute is negligible compared to the solvent volume



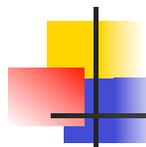
## Concentration Units

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Molality: defined as moles of solute per mass of solvent

$$m = \frac{\text{moles solute}}{\text{kilograms of solvent}} = \frac{\text{mol}}{\text{kg}}$$

In this case, the mass is only the mass of the solvent, not the total mass of the solution



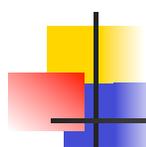
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Mole fraction: mole fraction is defined as the number of moles solute divided by the total number of moles of all species in the solution

$$X_A = \frac{\text{moles solute}}{\text{total moles in solution}} = \frac{n_A}{n_{\text{tot}}}$$

Mole fraction is a unitless number



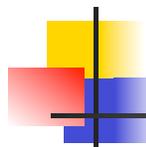
## Concentration Units

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Parts-per-million (ppm) and parts-per billion (ppb)

For dilute aqueous solutions, we can make the assumption that the density of the solution is 1.00 g/mL

ppm and ppb express the mass of a specific solute relative to the mass of the solvent



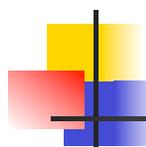
## Concentration Units

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### Parts-per-million (ppm) and parts-per billion (ppb)

$$\begin{aligned}\text{ppm} &= \mu\text{g solute/mL soln} \\ &= \text{mg solute/L soln}\end{aligned}$$

$$\begin{aligned}\text{ppb} &= \text{ng solute/mL soln} \\ &= \mu\text{g solute/L soln}\end{aligned}$$



## Concentration Units

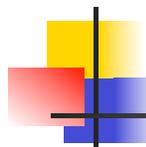
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### Parts-per-million (ppm) and parts-per billion (ppb)

When referring to gaseous mixtures, we usually compare the number of solute particles in a specific volume (not the mass of solute particles)

$$\text{ppmv} = \mu\text{mol solute/total mol in volume}$$

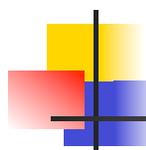
$$\text{ppbv} = \text{nmol solute/total mol in volume}$$



## Aqueous Solutions

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- A solution is composed of two parts: the solute and the solvent.
  - The solute is the minor component of the solution.
  - The solvent is the major component of the solution and is the liquid into which the solute is added.
- Aqueous solutions are those in which water acts as the solvent.



## Molarity

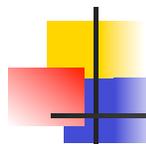
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Determine concentration of a solution in which 6.081 g  $\text{NaNO}_3$  is dissolved to a total volume of 843 mL.

1. Calculate moles of solute

moles of  $\text{NaNO}_3$

$$6.081 \text{ g} / 84.994 \text{ g mol}^{-1} = 7.155 \times 10^{-2} \text{ mol}$$



## Molarity

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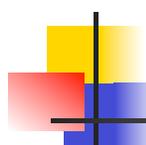
2. Calculate molarity of solution

a. convert volume to L

$$843 \text{ mL} = 0.843 \text{ L}$$

b. calc M

$$7.155 \times 10^{-2} \text{ mol} / 0.843 \text{ L} = 8.49 \times 10^{-2} \text{ M}$$

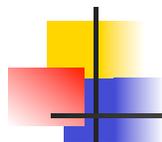


## Dilutions

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- When diluting a solution by adding more solvent, the amount of solute does not change (you do not add or take away the solute), only the concentration changes.

$$C_1 V_1 = C_2 V_2 \quad (C = \text{concentration} \\ V = \text{volume})$$



## Dilutions

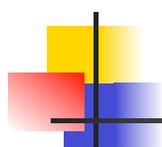
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50.0 mL of .650 M NaCl solution is diluted with 1000.0 mL of water. Determine concentration of final solution.

1.  $C_1V_1 = (0.650 \text{ M})(0.0500 \text{ L}) = 0.0325 \text{ mol NaCl}$

2. final volume =  $V_2 = 50.0 \text{ mL} + 1000.0 \text{ mL}$   
 $= 1050.0 \text{ mL}$

3.  $C_2V_2 = C_1V_1 = 0.0325 \text{ mol NaCl}$   
 $C_2 = C_1V_1 / V_2 = 0.0325 \text{ mol} / 1.0500 \text{ L}$   
 $= 3.10 \times 10^{-2} \text{ M}$



## Dilutions

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You prepare a Cu stock solution with a concentration of 209.5 ppm. You need to now prepare a standard solution with a concentration of 7.5 ppm in a 25 mL volumetric flask. How do you prepare the standard?

$C_1 = 209.5 \text{ ppm}$

$V_1 = ?$

$C_2 = 7.5 \text{ ppm}$

$V_2 = 25 \text{ mL}$

$$V_1 = \frac{C_2V_2}{C_1} = \frac{(7.5 \text{ ppm})(25 \text{ mL})}{(209.5 \text{ ppm})} = 0.895 \text{ mL}$$