



Concentration Units

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

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



Concentration Units

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

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

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

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

- 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.



Concentration Units

- *Molarity* (M) is a very commonly used unit of concentration.
molarity \equiv mol solute / L solution
- Units are mol L⁻¹
- Note that the denominator is L total solution (total volume of solution), not L solvent (volume of solvent added).



Molarity

Determine concentration of a solution in which 6.081 g NaNO_3 is dissolved to a total volume of 843 mL.

1. Calculate moles of solute

moles of NaNO_3

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



Molarity

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

- 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.

$$C_1V_1 = C_2V_2$$

(C = concentration
V = volume)



Dilutions

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

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?

$$C_1 = 209.5 \text{ ppm}$$

$$V_1 = ?$$

$$C_2 = 7.5 \text{ ppm}$$

$$V_2 = 25 \text{ mL}$$

$$V_1 = \frac{C_2 V_2}{C_1} = \frac{(7.5 \text{ ppm})(25 \text{ mL})}{(209.5 \text{ ppm})} = 0.895 \text{ mL}$$