Example: If a solution is 0.688 m citric acid, what is the molar concentration (M) of the solution? The density of the solution is 1.049 g/mL

$H_3C_6H_5O_7$: 192.125 g/mol "CA"

$$\frac{0.688 \text{ mol CA}}{\text{kg solvent}} \longrightarrow \frac{\text{mol CA}}{\text{L solution}}$$

definition of molality

definition of molarity

- ASSUME IN BASIS of 1 kg solvent. That means the moles of CA is 0.688 mol. Now all we have to do is find the volume (L) of solution.
- To find liters of solution, use the DENSITY of solution. FIrst, we'll need to find the mass of solution. We already know how much solvent we have (assumed 1 kg), so we just need to convert 0.688 moles of CA to mass to find out how much solute there is.

$$0.688 \text{ mol CA} \times \frac{192.125 \text{ g CA}}{\text{mol CA}} = 132.182 \text{ g CA}$$

mass solution = 1000 g solvent + 132.182 g CA = 1132.182 g solution

Use density ...

$$1132.182 \text{ g} \times \frac{\text{mL}}{1.049 \text{ g}} = 1079.296473 \text{ mL} = 1.079296473 \text{ L}$$

$$M = \frac{0.688 \text{ mol CA}}{1.079296473 \text{ L}} = \boxed{0.637 \text{ M CA}}$$

An aqueous solution is 8.50% ammonium chloride by mass. The density of the solution is 1.024 g/mL
Find: molality and molarity.

NH_4Cl : 53.491 g/mol H_2O: 18.016 g/mol

$$\frac{8.50\text{ g } NH_4Cl}{100\text{ g solution}} \longrightarrow \frac{\text{mol } NH_4Cl}{\text{kg } H_2O}$$

definition of mass percent   defintion of molality

Assume a basis of 100 g solution. That means we know the amount of ammonium chloride is 8.50 grams. Convert 8.50 grams of ammonium chloride to moles (use formula weight), and find the mass of water by subtracting the mass of ammonium chloride (8.50 grams) from the total mass of solution (100 grams).

$$8.50\text{ g } NH_4Cl \times \frac{\text{mol } NH_4Cl}{53.491\text{ g } NH_4Cl} = 0.158905236 4\text{ mol } NH_4Cl$$

$$100\text{ g solution} - 8.50\text{ g } NH_4Cl = 91.5\text{ g } H_2O = 0.0915\text{ kg } H_2O$$

$$m = \frac{\text{mol } NH_4Cl}{\text{k } H_2O} = \frac{0.1589052364\text{ mol } NH_4Cl}{0.0915\text{ kg } H_2O} = \boxed{1.74\text{ m } NH_4Cl}$$

An aqueous solution is 8.50% ammonium chloride by mass. The density of the solution is 1.024 g/mL
Find: molality and molarity.

NH_4Cl : 53.491 g/mol H_2O: 18.016 g/mol

$$\frac{8.50\text{ g } NH_4Cl}{100\text{ g solution}} \longrightarrow \frac{\text{mol } NH_4Cl}{\text{L solution}}$$

definition of mass percent

defintion of molarity

Assume a basis of 100 grams solution. That means we know the mass of ammonium chloride (like last time) is 8.50 grams. We already calculated moles of ammonium chloride, so all we have to find is the volume of solution. Use density to convert 100 grams solution to volume.

$$100\text{ g solution} \times \frac{\text{mL}}{1.024\text{ g}} = 97.65625\text{ mL} = 0.09765625\text{ L}$$

moles calculated on previous page of notes

$$M = \frac{\text{mol } NH_4Cl}{\text{L solution}} = \frac{0.158902364\text{ mol } NH_4Cl}{0.09765625\text{ L}} = \boxed{1.63\text{ M } NH_4Cl}$$

COLLIGATIVE PROPERTIES

- properties unique to solutions.

- depend only on the CONCENTRATION of a solution and not the IDENTITY of the solute**

**ionic solutes: Remember that they dissociate into MULTIPLE IONS!

1. Freezing point depression
   - The freezing temperature of a SOLUTION gets lower as the CONCENTRATION of a solution increases.
2. Vapor pressure lowering
   - The vapor pressure of a solution (pressure of sovent vapor over a liquid surface) goes DOWN as solution concentration goes UP
3. Boiling point elevation
   - The boiling temperature of a solution increases as the concentration of the solution increases.
4. Osmotic pressure
   - The pressure required to PREVENT the process of osmosis

FREEZING POINT DEPRESSION

$$\underline{\Delta T_f} = \underline{K_f} \times \underline{C_m}$$

concentration of solute (molality)

Freezing point depression constant (for SOLVENT)

Freezing point depression: The amount the freezing temperature is LOWERED by the solute.

- Applications: In chemistry, this effect is often used to determine the molecular weight of an unknown molecule.

A solution of 2.500g of unknown dissolved in 100.0 g of benzene has a freezing point of 4.880 C. What is the molecular weight of the unknown?

$K_{f,\,benzene} = 5.065\ ^\circ C/m$, $T_{f,\,benzene} = 5.455^\circ C$ (see p500 9th p509, 10th)

$$\Delta T_f = K_f \times C_m$$

$\Delta T_f = 5.455^\circ C - 4.880^\circ C = 0.575^\circ C$

$K_f = 5.065^\circ C/m$

$$C_m = \frac{\text{mol unknown}}{\text{kg benzene}}$$

Solving for Cm (molality) will allow us to calculate how many moles of unknown are dissolved in the benzene. Since we already know the mass of unknown, we'll then be able to find the molecular weight (grams/moles).

$$0.575^\circ C = 5.065\ ^\circ C/m \times C_m$$

$$C_m = 0.1135241856\ m \text{ unknown}$$