

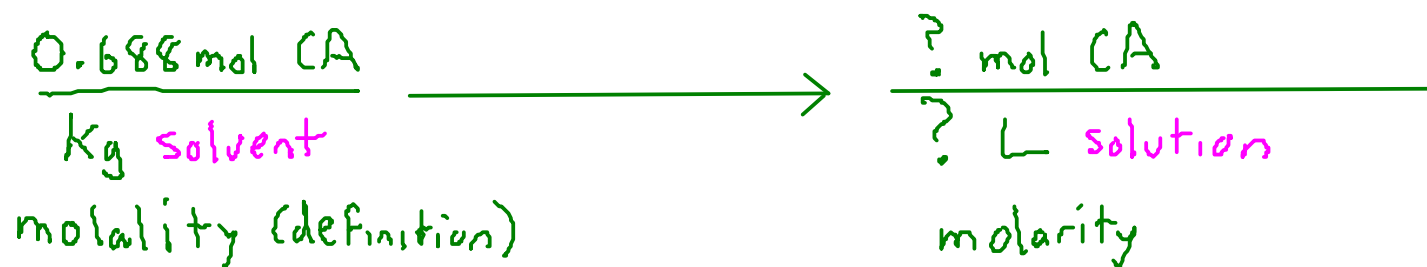
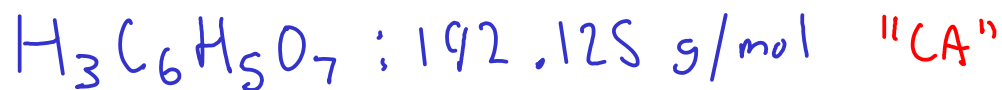
⁶⁴ MOLARITY and the other concentration units

- To convert between molarity and the other three concentration units we've studied, you have to know more about the solution. For example:

$$\frac{\text{molarity}}{\text{moles A}}{\text{L solution}} \longrightarrow \frac{\text{molality}}{\text{moles A}}{\text{kg solvent}}$$

- * To perform this conversion, you can assume a liter of solution, which will give you the number of moles present. But you've then got to have a way to convert the volume of SOLUTION to the mass of the SOLVENT. How?
- * You need DENSITY (which depends on temperature). The density of the solution will allow you to find the total mass of the solution.
- * If you subtract out the mass of the SOLUTE, then what you have left is the mass of the SOLVENT. Express that in kilograms, and you have all the information you need to find molality!
- * You'll run into the same situation when you use any of the other mass or mole based units. DENSITY is required to go back and forth between MOLARITY and these units.

⁶⁵ 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



1 - Assume a basis of 1 kg of solvent. In each kilogram of solvent, we know that there are 0.688 mol CA.

2- We need to find VOLUME of solution. We know the density of the SOLUTION, but at the moment we know the mass of the SOLVENT. To use the density, we need to know the mass of the SOLUTION. We need to add the mass of SOLUTE (CA) to the mass of the solvent to get the mass of solution.

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

$$\text{mass solution} = 1000 \text{ g solvent} + 132.182 \text{ g CA} = 1132.182 \text{ g solution}$$

Find volume (using density):

$$1132.182 \text{ g solution} \times \frac{\text{mL}}{1.049 \text{ g}} \times \frac{10^{-3} \text{ L}}{\text{mL}} = 1.079296 \text{ L}$$

Molarity = moles CA / L solution :

$$\frac{0.688 \text{ mol CA}}{1.079296 \text{ L}} = \boxed{0.637 \text{ M CA}}$$

An aqueous solution is 8.50% ammonium chloride by mass. The density of the solution is 1.024 g/mL

Find: molality, mole fraction, molarity.

$$\text{NH}_4\text{Cl} : 53.491 \text{ g/mol} \quad \text{H}_2\text{O} : 18.016 \text{ g/mol}$$

$$91.50 \text{ g H}_2\text{O} \times \frac{\text{mol H}_2\text{O}}{18.016 \text{ g H}_2\text{O}} = 5.078818828 \text{ mol H}_2\text{O}$$

$$X_{\text{NH}_4\text{Cl}} = \frac{0.1589052364 \text{ mol NH}_4\text{Cl}}{0.1589052364 \text{ mol NH}_4\text{Cl} + 5.078818828 \text{ mol H}_2\text{O}}$$

$$X_{\text{NH}_4\text{Cl}} = 0.0303$$

If we want to know X_{water} , $X_{\text{water}} = 1 - X_{\text{ammonium chloride}}$

Find molarity:

$$\frac{8.50 \text{ g NH}_4\text{Cl}}{100 \text{ g solution}} \xrightarrow{\text{mass percent}} \frac{\text{mol NH}_4\text{Cl}}{\text{L solution}} \text{ molarity}$$

We already know moles ammonium chloride from previous work, so we need to find out the VOLUME IN LITERS of that 100 g of solution.

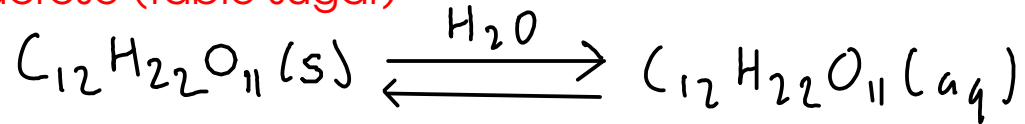
$$100 \text{ g solution} \times \frac{\text{mL}}{1.024 \text{ g}} \times \frac{10^{-3} \text{ L}}{\text{mL}} = 0.09765625 \text{ L}$$

$$\frac{0.1589052364 \text{ mol NH}_4\text{Cl}}{0.09765625 \text{ L}} = \underline{1.63 \text{ M NH}_4\text{Cl}}$$

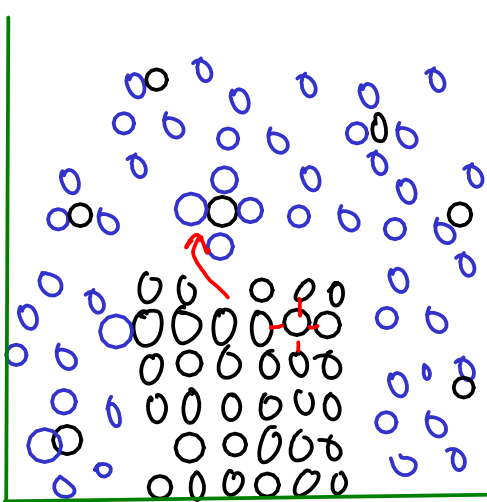
68 HOW THINGS DISSOLVE

- Let's look at how things dissolve into water, since aqueous solutions are quite common.

sucrose (table sugar)



... what happens?



- Water molecules pull the sugar molecules out of the sugar crystal and into solution.

- Attractions between sugar molecules and water allow this to happen.

- The solubility of the sugar depends on how well water and sugar interact (HYDRATION) versus how well the sugar molecules are held in the crystal (LATTICE ENERGY)

- "like dissolves like": Substances held together by similar (or at least compatible) kinds of attractive forces can dissolve in each other. Substances that are held together by very different kinds of attractive forces will not dissolve in one another!

- MOLECULAR solutions:

Contain MOLECULES dissolved in one another.

① - Any mixture of GASES

- all gases mix with one another, since gas molecules (effectively) do not interact with one another.

② - Liquids

- Liquids dissolve well in one another only if they are held together by similar kinds of forces

③ - Solids and liquids

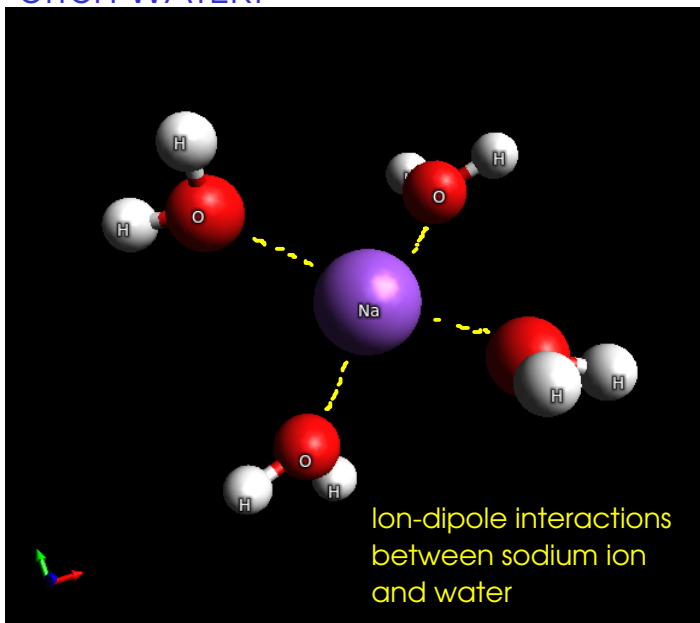
- MOLECULAR SOLIDS will dissolve well in liquids if they are held together by similar forces.

- IONIC SOLIDS will sometimes dissolve in POLAR liquids, but not in nonpolar liquids

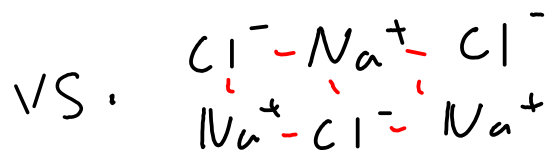
- COVALENT NETWORK solids don't generally dissolve well in other substances

IONIC solutions

- form when ions from IONIC SUBSTANCES interact with POLAR solvents - often WATER.



The charged ends of the water molecule HYDRATE the ions.



- The solubility of an ionic compound depends on whether HYDRATION (attraction of water molecules for an ion) is greater than LATTICE ENERGY - the attraction of ions in a crystal lattice for one another..
- SMALLER IONS are usually easier to enclose in water than larger ones, and ions with larger charges are attracted to water molecules.
- But solubility is also determined by LATTICE ENERGY - which holds the solid ionic compound together. Ions with high charges tend to be strongly attracted to other ions in a crystal, meaning lattice energy is high. Smaller ions also tend to have higher lattice energies. Lattice energy and hydroation are competing trends!