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"

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

molality (m) → molarity (M)

1 - Assume we have 1 kg of solvent. This makes the number of moles of CA = 0.688 mol
2 - We need to FIND the VOLUME of the solution. We can use density to convert mass to volume, but we have to be careful. The mass we know right now is not the mass of the SOLUTION; it's the mass of the SOLVENT. We must find the MASS OF SOLUTE to find the mass of the solution.

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

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

Now find the 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 / L solution

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

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.

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

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

mass percent   molality

Find moles of ammonium chloride using FW

$$8.50\text{ g } NH_4Cl \times \frac{\text{mol}}{53.491\text{ g}} = 0.15891\text{ mol } NH_4Cl$$

Find mass solvent (water) by subtracting out solute from total mass

$$100\text{ g solution} - 8.50\text{ g } NH_4Cl = 91.50\text{ g } H_2O = 0.09150\text{ kg } H_2O$$

Find molality

$$m_{NH_4Cl} = \frac{0.15891\text{ mol } NH_4Cl}{0.09150\text{ kg } H_2O} = \boxed{1.74\text{ m } NH_4Cl}$$

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

mass percent   mole fraction

0.15891 mol NH_4Cl (from previous calculation)

Find moles water. Convert the mass water (91.50 g) to moles using FW

$$91.50\text{ g } H_2O \times \frac{\text{mol}}{18.016\text{ g}} = 5.07881\text{ mol } H_2O$$

$$X_{NH_4Cl} = \frac{0.15891\text{ mol } NH_4Cl}{0.15891\text{ mol } NH_4Cl + 5.07881\text{ mol } H_2O} = \boxed{0.0303}$$

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.

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

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

0.15891 mol NH_4Cl (from previous calculation)

mass percent   molarity

Find volume of 100g of SOLUTION using density

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

Find molarity

$$\underline{M} = \frac{0.15891\text{ mol } NH_4Cl}{0.09765625\text{ L solution}} = \boxed{1.63\ \underline{M}\ NH_4Cl}$$

End of material for Test #1

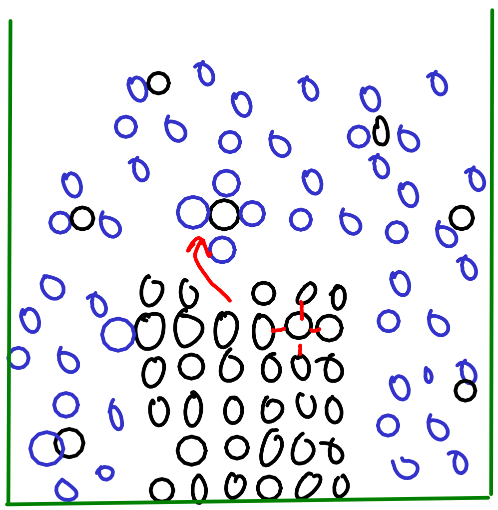
HOW THINGS DISSOLVE

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

sucrose (table sugar)

$$C_{12}H_{22}O_{11}(s) \underset{}{\overset{H_2O}{\rightleftharpoons}} C_{12}H_{22}O_{11}(aq)$$

... 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)

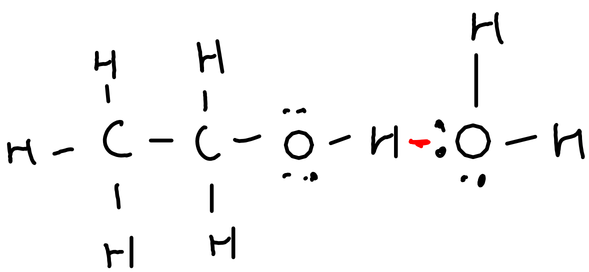
- "like dissolves like": Substances held together by similar (or at least compatible) kinds of attractive forces can dissolve in each other. Substances that are held together by very different kinds of attractive forces will not dissolve in one another!

Consider WATER:

HYDROGEN BONDS

↓

Water mixes well with other substances that can hydrogen bond, like ETHANOL!



POLAR

↓

Water can dissolve polar substances! (SUCROSE is polar!)

↓

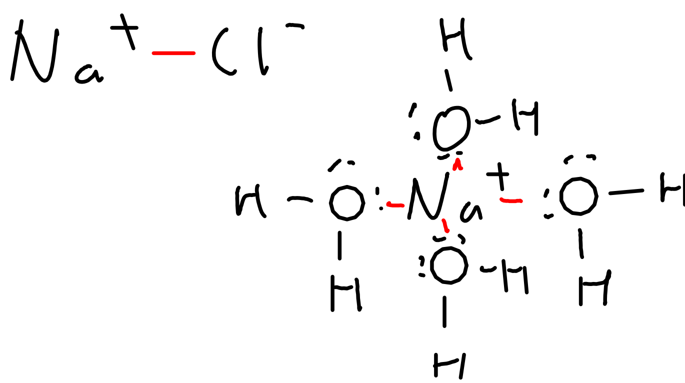
Since IONIC BONDS are also interactions between opposite charges (You can think of an ionic bond here as an extreme case of dipole-dipole interaction), many IONIC SUBSTANCES will also dissolve in water!

SMALL (little London force)

↓

large and/or nonpolar solutes do not dissolve well in water!

(example: OILS and WAXES)



"ion-dipole" interactions

MOLECULAR AND IONIC SOLUTIONS

- 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

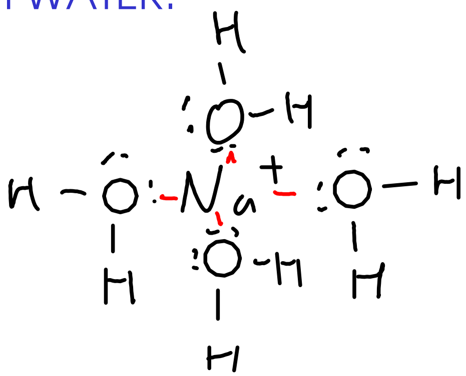
- Liquids dissolve well in one another only if they are held together by similar kinds of forces

(3) - Solids and liquids

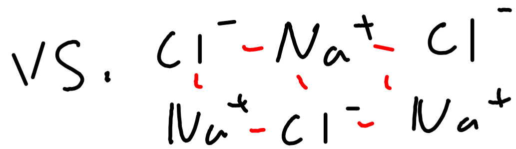
- MOLECULAR SOLIDs will dissolve well in liquids if they are held together by similar forces.
- IONIC SOLIDS will sometimes dissolve in POLAR liquids, but not in nonpolar liquids
- COVALENT NETWORK solids don't generally dissolve well in other substances

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 attrraction 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!