SOLUTIONS

- a SOLUTION is a HOMOGENEOUS MIXTURE.

Uniform properties throughout!

- parts of a solution:

① SOLUTE(S)

- component(s) of a solution present in small amounts.

② SOLVENT

- the component of a solution present in the GREATEST amount

- in solutions involving a solid or gas mixed with a LIQUID, the liquid is typically considered the solvent.

- solutions are usually the same phase as the pure solvent. For example, at room temperature salt water is a liquid similar to pure water.

SOLVENTS

- We traditionally think of solutions as involving gases or solids dissolved in liquid solvents. But ANY of the three phases may act as a solvent!

① GAS SOLVENTS

- Gases are MISCIBLE, meaning that they will mix together in any proportion.
- This makes sense, since under moderate conditions the molecules of a gas don't interact wth each other.
- Gas solvents will only dissolve other gases.

② LIQUID SOLVENTS

- Can dissolve solutes that are in any phase: gas, liquid, or solid.
- Whether a potential solute will dissolve in a liquid depends on how compatible the forces are between the liquid solvent and the solute.

③ SOLID SOLVENTS

- Solids can dissolve other solids, and occasionally - liquids.
- Solid-solid solutions are called ALLOYS. Brass (15% zinc dissolved in copper) is a good example.
- AMALGAM is a solution resulting from dissolving mercury into another metal.

CONCENTRATION

- When you discuss a solution, you need to be aware of:
    - what materials are in the solution
    - how much of each material is in the solution

- CONCENTRATION is the amount of one substance compared to the others in a solution. This sounds vague, but that's because there are many different ways to specify concentration!

- We will discuss four different concentration units in CHM 111:

① MASS PERCENTAGE

$$= \frac{\text{mass solute}}{\text{mass solution}} \times 100\% \qquad \%\ ,\ \%\ ^{w}/_{w}$$

② MOLARITY

$$= \frac{\text{moles solute}}{\text{L solution}} \qquad M \text{ or } \underline{M}$$

③ MOLALITY

$$= \frac{\text{moles solute}}{\text{kg solvent}} \qquad m$$

④ MOLE FRACTION

$$= \frac{\text{moles component A}}{\text{moles solution}} \qquad X_A$$

How would you prepare 455 grams of an aqueous solution that is 6.50% sodium sulfate by mass?

↓ solve for this!

$$\text{mass \%} = \frac{\text{mass solute}}{\text{mass solution}} \times 100\%$$

↑ 455g

↑ 6.50%

We know everytihng in this definition except for the mass of the solute (sodium sulfate). So, we plug the numbers we know into the definition, then solve.

$$6.50 = \frac{\text{mass } Na_2SO_4}{455} \times 100$$

① × 455

② ÷ 100

$$\frac{6.50 \times 455}{100} = \text{mass } Na_2SO_4 = \boxed{29.6\,g\ Na_2SO_4}$$

How about water? We know the total mass of the solution, and the amount of sodium sulfate. Subtract!

$$455g \text{ total} - 29.6g\ Na_2SO_4 = \boxed{425.4g \text{ water}}$$

Mix 29.6 g of sodium sulfate with 425 g water to make the solution.

What's the MOLALITY and MOLE FRACTION OF SOLUTE of the previous solution?

29.6 g Na_2SO_4, 425.4 g water ← previous solution

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

① Convert mass of sodium sulfate to moles! (Use FW)

② Convert grams of water to kg

$$X_{Na_2SO_4} = \frac{\text{moles } Na_2SO_4}{\text{moles total}}$$

① Convert mass of sodium sulfate to moles! (Use FW)

② Convert mass water to moles (using FW), then add to moles sodium sulfate to get total

Formula weight: $142.04\text{ g } Na_2SO_4 = \text{mol } Na_2SO_4$

Find molality...

① $$29.6\text{ g } Na_2SO_4 \times \frac{\text{mol } Na_2SO_4}{142.04\text{ g } Na_2SO_4} = 0.208392\text{ mol } Na_2SO_4$$

② $$425.4\text{ g } H_2O \times \frac{\text{kg}}{10^3\text{ g}} = 0.4254\text{ kg } H_2O$$

$$m = \frac{0.208392\text{ mol } Na_2SO_4}{0.4254\text{ kg } H_2O} = \boxed{0.490\ m\ Na_2SO_4}$$

$$X_{Na_2SO_4} = \frac{\text{moles } Na_2SO_4}{\text{moles total}}$$

① Convert mass of sodium sulfate to moles! (Use FW) : Already done! (0.208392 mol Na_2SO_4)

② Convert mass water to moles (using FW), then add to moles sodium sulfate to get total

$$\left.\begin{matrix} H: 2\times 1.008 \\ O: 1\times 16.00 \end{matrix}\right] 18.016 \text{ g/mol } H_2O$$

$$425.4 \text{ g } H_2O \times \frac{\text{mol } H_2O}{18.016 \text{ g } H_2O} = 23.612345 \text{ mol } H_2O$$

$$X_{Na_2SO_4} = \frac{0.208392 \text{ mol } Na_2SO_4}{0.208392 \text{ mol } Na_2SO_4 + 23.612345 \text{ mol } H_2O}$$

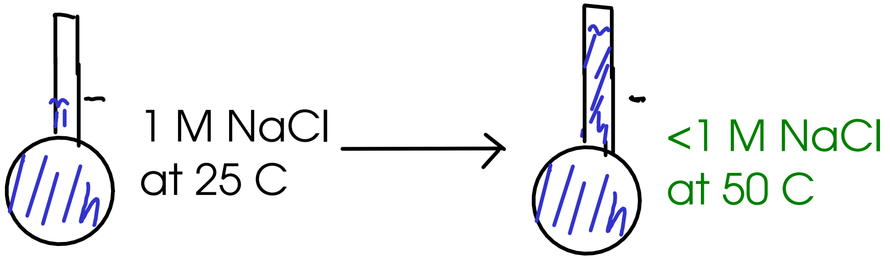
$$= \boxed{0.00875}$$

MOLARITY

- In the previous example, we converted between three of the four units that we discussed: mass percent, molality, and mole fraction.

- We didn't do MOLARITY, because the information given in the previous problem was not sufficient to determine molarity!

$$\underline{M} = \frac{\text{moles solute}}{\underline{\text{L solution}}}$$



Molarity is based on VOLUME, while the other three units are based on MASS. (moles and mass can be directly converted)

Volume depends on TEMPERATURE!

- If you HEAT a solution, what happens to CONCENTRATION?

$$\text{ex:}\quad \underbrace{5.00\ \text{mol}\ Na_2SO_4}_{\text{constant when heated}}\ \text{in}\ \underbrace{1\ \text{L solution}}_{\text{increases. (thermal expansion)}}$$

... the MOLAR CONCENTRATION decreases. (But the concentration in the other three units we discussed stays the same.)

- If you COOL a solution, the MOLAR CONCENTRATION increases. (The other three units stay the same!)