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

$$m = \frac{\text{mol } Na_2SO_4 \ (1)}{\text{kg } H_2O \ (2)}$$

definition of molality

1) Calculate the moles of sodium sulfate. Use FORMULA WEIGHT, then convert mass to moles.
2) Convert mass of water to kilograms.

Na_2SO_4: Na - 2 x 22.99
S - 1 x 32.07
O - 4 x 16.00
142.05 g Na_2SO_4 = mol Na_2SO_4

(1) $29.6 \text{ g } Na_2SO_4 \times \frac{\text{mol } Na_2SO_4}{142.05 \text{ g } Na_2SO_4} = 0.2083773319 \text{ mol } Na_2SO_4$

(2) $\text{kg} = 10^3 \text{ g}$

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

$\frac{0.2083773319 \text{ mol } Na_2SO_4}{0.4254 \text{ kg } H_2O} = \boxed{0.490 \ m \ Na_2SO_4}$

29.6 g Na_2SO_4, 425.4 g water ← previous solution

$$X_{Na_2SO_4} = \frac{\text{mol } Na_2SO_4 \quad (1)}{\text{mol } Na_2SO_4 + \text{mol } H_2O \text{ (total moles)} \quad (2)}$$

1) Calculate moles sodium sulfate by changing grams to moles. We already did that for finding molality, so let's just use the same number here.

2) We need to add moles sodium sulfate to moles water. To get moles water, we can just convert water's mass to moles using water's formula weight.

(1) 0.2083773319 mol Na_2SO_4

(2) H_2O: H - 2 x 1.008
O - 1 x 16.00

18.016 g H_2O = mol H_2O

$$425.4 \text{ g } H_2O \times \frac{\text{mol } H_2O}{18.016 \text{ g } H_2O} = 23.6123458 \text{ mol } H_2O$$

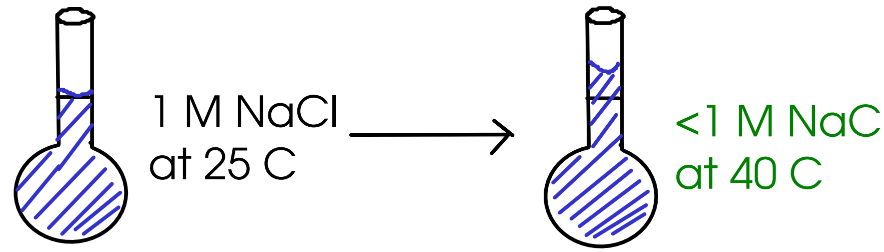
$$X_{Na_2SO_4} = \frac{0.2083773319 \text{ mol } Na_2SO_4}{0.2083773319 \text{ mol } Na_2SO_4 + 23.6123458 \text{ mol } H_2O} = \boxed{0.00875}$$

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!

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



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?

ex: 5.00 mol Na_2SO_4 in 1 L solution

5.00 mol Na_2SO_4 — constant when heated

1 L solution — increases, (thermal expansion)

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

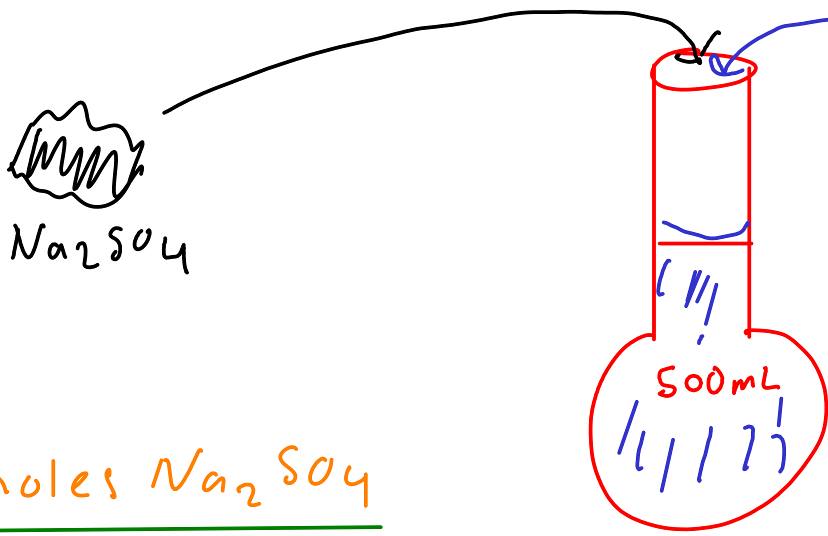
- If you COOL a solution, the MOLAR CONCENTRATION increases. (The other three units stay the same!)

... we use MOLARITY so much because it's easy to work with. It is easier to measure the VOLUME of a liquid solution than it is to measure mass.

Na_2SO_4: (142.05 g/mol)

Example: How would we prepare 500. mL of 0.500 M sodium sulfate in water?

Dissolve the appropriate amount of sodium sulfate into enough water to make 500. mL of solution.



A VOLUMETRIC FLASK is a flask that is designed to precisely contain a certain volume of liquid.

VOLUMETRIC FLASKS are used to prepare solutions.

$*500 mL = 0.500 L$

$$M = \frac{\text{moles } Na_2SO_4}{\text{L solution}}$$

definition of molarity

$M \rightarrow 0.500 M$; L solution $\rightarrow 0.500 L$

volumetric flask

Start by calculating moles sodium sulfate! (it's the only number we don't know already!)

$$0.500 M = \frac{\text{mol } Na_2SO_4}{0.500 L} \; ; \; \text{mol } Na_2SO_4 = 0.250 \text{ mol } Na_2SO_4$$

Convert 0.250 moles sodium sulfate to grams, since we need to weigh the sodium sulfate on a balance!

$142.05 g\ Na_2SO_4 = \text{mol } Na_2SO_4$

$$0.250 \text{ mol } Na_2SO_4 \times \frac{142.05 g\ Na_2SO_4}{\text{mol } Na_2SO_4} = 35.5 g\ Na_2SO_4$$

Add 35.5 grams sodium sulfate to a 500 mL volumetric flask and add water to the mark.

More on MOLARITY

To prepare a solution of a given molarity, you generally have two options:

1. Weigh out the appropriate amount of solute, then dilute to the desired volume with solvent (usually water)"

2. Take a previously prepared solution ("stock solution") of known concentration and DILUTE it with solvent to form a new solution

   - Use DILUTION EQUATION

The dilution equation is easy to derive with simple algebra.

$$M \times V$$

$$\frac{mol}{L} \times L = \text{moles solute}$$

... but when you dilute a solution, the number of moles of solute REMAINS CONSTANT. (After all, you're adding only SOLVENT)

$$M_1 V_1 = M_2 V_2$$

Since the number of moles of solute stays the same, this equality must be true!

$M_1 V_1$: before diution

$M_2 V_2$: after dilution

$$M_1V_1 = M_2V_2$$ ... the "DILUTION EQUATION"

M_1 = molarity of concentrated solution

V_1 = volume of concentrated solution

M_2 = molarity of dilute solution

V_2 = volume of dilute solution ←(TOTAL VOLUME, NOT the volume water added!)

The volumes don't HAVE to be in liters, as long as you use the same volume UNIT for both V_1 and V_2

Example: Take the 0.500 M sodium sulfate we discussed in the previous example and dilute it to make 150. mL of 0.333 M solution. How many mL of the original solution will we need to dilute?

$$M_1V_1 = M_2V_2$$

$M_1 = 0.500\ M$ $\quad M_2 = 0.333\ M$

$V_1 =$ $\quad V_2 = 150.\ mL$

$$(0.500\ M)(V_1) = (0.333\ M)(150.\ mL)$$

$$V_1 = 99.9\ mL$$

Measure out 99.9 mL of the 0.500 M sodium sulfate stock, then add enough water to it to get a total volume of 150 mL.

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:

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

* 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.

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

To solve this problem, we'll need to assume an amount of solution. (We call this ASSUMING A BASIS - it works since concentrations are ratios and we're just changing from one concentration unit to another!) We'll assume we have a kilogram of solvent. That means we already know how many moles of CA there are (.688 moles).

* TIP: Always assume your basis to be the "bottom" of your starting concentration unit!

Now we just need to find out the volume of the solution! How? We have density - so if we can figure out how much the solution weighs, we can find the volume! We calculate the mass of CA from moles, then add it to the kilogram of solvent to get the total mass!

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

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

Find volume using density

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

Find molarity

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