N31 - SOLUTIONS

Target: I can convert between different concentration units and can use concentration calculations to find helpful information like how many moles are present.

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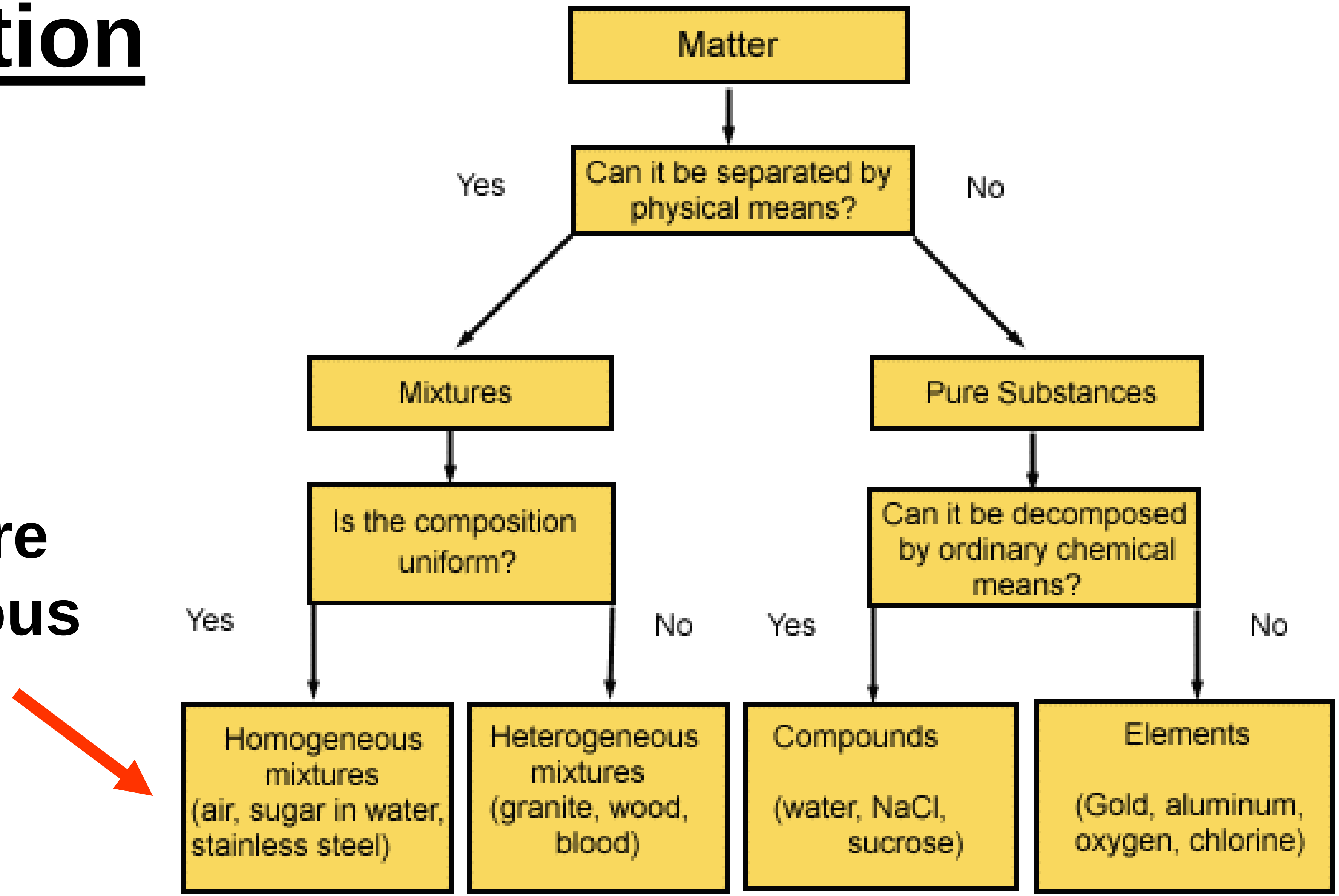
Concentration

Classification of Matter

Solutions are homogeneous mixtures



Solute

A solute is the dissolved substance in a solution.

Salt in salt water

Sugar in soda drinks

Carbon dioxide in soda drinks

Solvent

A solvent is the dissolving medium in a solution.

Water in salt water

Water in soda

Types of Solutions

Solution Phase	Solute Phase	Solvent Phase	Example
Gaseous Solutions	Gas Liquid *Solid**	Gas Gas *Gas**	Air (mostly N_2 and O_2) Humid air (H_2O droplets in air) *Moth balls**
Liquid solutions	Gas Liquid Solid	Liquid Liquid Liquid	Soda (CO_2 in H_2O) Rubbing Alcohol (alcohol in H_2O) Seawater (NaCl in H_2O)
Solid solutions	*Gas** Liquid Solid	*Solid** Solid Solid	*Gas Stove Lighter (H_2 and Pd)** Dental fillings and other Amalgams Brass Alloy (Zn in Cu)
*Combinations in italics and with a * are rare, very few "normal" examples. Most charts leave them off because there are so few examples – they are still possible, just rare*			

Molarity

Moles of solute per 1 liter of solution - Describes how many molecules of solute in each liter of solution

If a sugar solution concentration is 2.0 M,

- 1 liter of solution contains 2.0 moles of sugar
- 2 liters = 4.0 moles sugar
- 0.5 liters = 1.0 mole sugar

$$\boldsymbol{Molarity, M = \frac{moles\ of\ solute}{Liters\ of\ solution}}$$

Molality

Moles of solute per 1 kilogram of solvent

Careful! Defined in terms of amount of solvent, not the solution like most of the other calculations

Does not vary with temperature

- Because based on masses, not volumes

$$Molality, m = \frac{moles\ of\ solute}{kg\ of\ solvent}$$

Parts Solute in Parts Solution

Parts can be measured by mass or volume.

Parts are generally measured in the same units.

- **By mass in grams, kilogram, lbs, etc.**
- **By volume in mL, L, gallons, etc.**
- **Mass and volume combined in grams and mL**

Parts Solute in Parts Solution

Percentage = parts of solute in every 100 parts solution

- If a solution is 0.9% by mass, then there are 0.9 grams of solute in every 100 grams of solution (or 0.9 kg solute in every 100 kg solution).

Parts per million = parts of solute in every 1 million parts solution

- If a solution is 36 ppm by volume, then there are 36 mL of solute in 1 million mL of solution.

Mass Percent

Mass percent - the ratio of mass units of solute to mass units of solution, expressed

$$mass\ percent = \frac{mass\ of\ solute}{mass\ of\ solution} x100$$

Parts per Million - PPM

Grams of solute per 1,000,000 g of solution

- **mg of solute per 1 kg of solution**
- **1 liter of water = 1 kg of water**

For aqueous solutions we often approximate the kg of the solution as the kg or L of water. For dilute solutions, the difference in density between the solution and pure water is usually negligible.

$$PPM = \frac{amount\ of\ solute}{amount\ of\ solution} x10^6$$

Remember that the density of water is
1g/1mL
Same as 1000g/1L
Same as 1kg/1L

Parts per Billion - PPB

$$PPB = \frac{amount\ of\ solute}{amount\ of\ solution} x10^9$$

$$Parts\ per\ \ldots = \frac{amount\ of\ solute\ (PART)}{amount\ of\ solution\ (WHOLE)} x\ some\ factor$$

% = x 100

ppm = x 1,000,000 = $x10^6$

ppb = x1,000,000,000 = $x10^9$

Mole Fraction X_A

Mole fraction - **the fraction of the moles of one component in the total moles of all the components of the solution.**

- **Total of all the mole fractions in a solution = 1.**
- **No units**

$$X_A = \frac{n_A}{n_A + nB + \cdots}$$

Mole percentage - **the percentage of the moles of one component in the total moles of all the components of the solution.**

= mole fraction × 100%

$$X_A = \frac{n_A}{n_A + nB + \cdots} x\,100$$

Making Dilutions

When you take one more concentrated solution and take a small amount of it and dilute it down by adding more solvent.

$$M_1V_1 = M_2V_2$$

Volumetric Flasks

Very accurate marking for a specific volume. You can fill the flask with your strong V1 amount and then fill to the line to get the desired solution volume.

Converting Concentration Units

1. WRITE YOUR UNITS. SERIOUSLY.
2. Write the given concentration as a ratio.
3. Separate the numerator and denominator.
   - Think about each separately
   - Separate into the solute part and solution part
4. Convert the solute part into the required unit.
5. Convert the solution part into the required unit.
6. Use the definitions to calculate the new final concentration units.

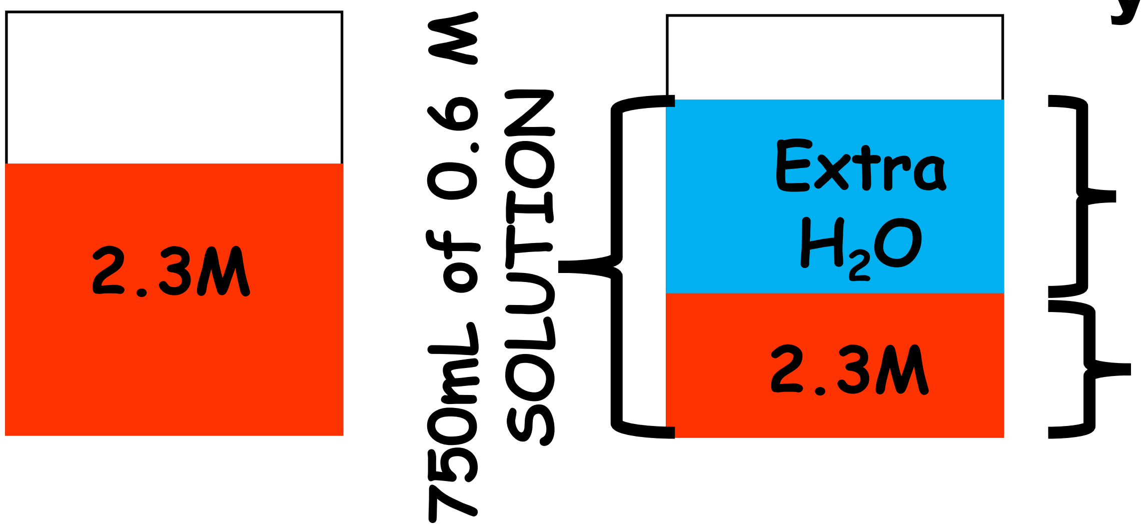
Practice

How much of a 2.3 M solution do you have to use in order to make 750mL of a 0.6 M solution?

$$(2.3M)(V_1) = (0.6M)(750mL)$$

$$V_1 = 195.65\ mL\ of\ the\ 2.3M\ solution\ is\ needed$$

How much water did you add???



750-195.65 =
554.35mL H_2O

195.65mL of the STRONGER STUFF

Find the mass percent of $CuSO_4$ in a solution whose density is 1.30 g/ml and whose molarity is 4.73 M.

A. 41.9%

B. 6.15%

C. 58.1%

D. 6.03%

E. None of these

$$mass\ percent = \frac{mass\ of\ solute}{mass\ of\ solution} x100$$

Find the mass percent of $CuSO_4$ in a solution whose density is 1.30 g/ml and whose molarity is 4.73 M.

- A. **41.9%**
- B. **6.15%**
- C. **58.1%**
- D. **6.03%**
- E. **None of these**

1 L solution = 4.73 mol $CuSO_4$

$$\frac{4.73\text{mol}}{} \left| \frac{159.62\text{g}}{1\text{mol}} \right. = \mathbf{755g\ solute}$$

$$1\text{ L} = \frac{1000\text{mL}}{} \left| \frac{1.30\text{g}}{1\text{mL}} \right. = \mathbf{1300g\ solution}$$

$$\frac{755\text{g}}{1300\text{g}} \times 100 = \mathbf{58.15\%}$$

What is the mole percent of ethanol (C_2H_5OH), which consists of 71.0 g of ethanol for every 14.3 g of water present?

A. 66.0%

B. 1.94%

C. 1.52%

D. 83.2%

E. 34.0%

$$X_A = \frac{n_A}{n_A + nB + \cdots} x\ 100$$

What is the mole percent of ethanol (C_2H_5OH), which consists of 71.0 g of ethanol for every 14.3 g of water present?

- A **66.0%**
- B 1.94%
- C 1.52%
- D 83.2%
- E 34.0%

$$\frac{71.0\text{g}}{} \left| \frac{1\text{mol}}{46.08\text{g}} \right. = 1.54 \text{ mol ethanol}$$

$$\frac{14.3\text{g}}{} \left| \frac{1\text{mol}}{18.02\text{g}} \right. = 0.794 \text{ mol water}$$

$$\frac{1.54\text{mol}}{(1.54\text{mol} + 0.794\text{mol})} \times 100 = 65.99\%$$

What is the molality of solution of 33.5 g propanol ($CH_3CH_2CH_2OH$) in 152 ml water, if the density of water is 1.00 g/ml?

- A 3.67 m
- B 0.00367 m
- C 0.273 m
- D 0.557 m
- E None of these

$$Molality, m = \frac{moles\ of\ solute}{kg\ of\ solvent}$$

What is the molality of solution of 33.5 g propanol ($CH_3CH_2CH_2OH$) in 152 ml water, if the density of water is 1.00 g/ml?

- **A** **3.67 m**
- **B** **0.00367 m**
- **C** **0.273 m**
- **D** **0.557 m**
- **E** **None of these**

33.5g	1mol
	60.11g

= 0.557 mol solute

$$\frac{0.557\text{mol}}{0.152\text{kg}} = \mathbf{3.67\ m}$$

A solution containing 481.6 g of $Mg(NO_3)_2$ per liter has a density of 1.114 g/ml. The molarity of the solution is:

- A. 3.247 M
- B. 2.915 M
- C. 9.740 M
- D. 3.617 M
- E. None of these

$$Molarity, M = \frac{moles\ of\ solute}{Liters\ of\ solution}$$

A solution containing 481.6 g of $Mg(NO_3)_2$ per liter has a density of 1.114 g/ml. The molarity of the solution is:

- A **3.247 M**
- B **2.915 M**
- C **9.740 M**
- D **3.617 M**
- E **None of these**

$$\frac{481.6\text{g}}{} \;\Big|\; \frac{1\text{mol}}{148.33\text{g}}$$

= 3.247 mol solute

= 3.247 mol/1L = 3.247 M

Density was just extra info! Very common in solutions problems to have more info than you need.

Link to YouTube Presentation

https://youtu.be/op8vqy3uxq8