N31 - SOLUTIONS

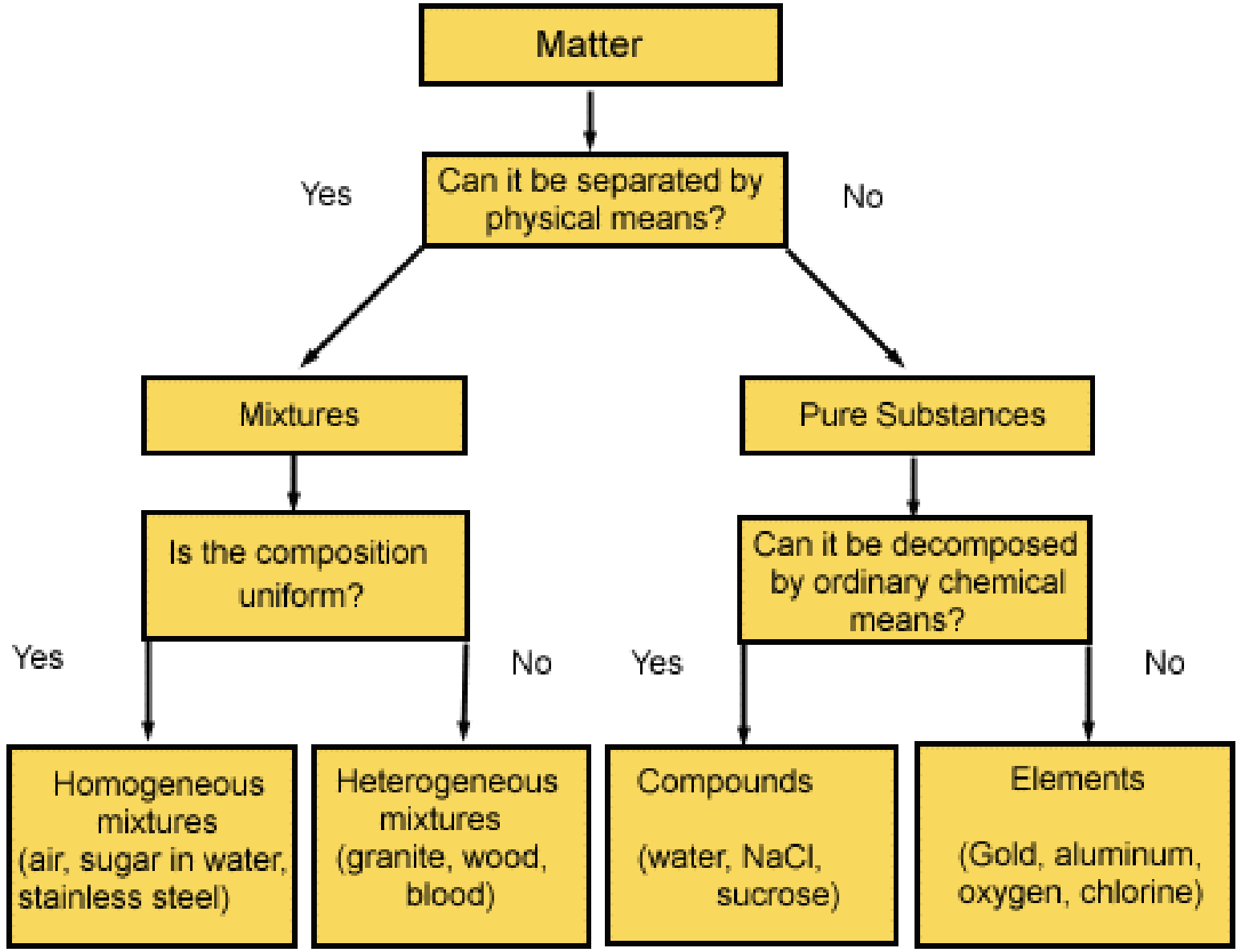
Target: I can convert between different concentration units and can use concentration calculations to find helpful information like how many moles are present.

N31 - SOLUTIONS

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

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

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

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**

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

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

= mole fraction × 100%

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

TABLE 12.5 Solution Concentration Terms

Unit	Definition	Units
Molarity (M)	$\frac{\text{amount solute (in mol)}}{\text{volume solution (in L)}}$	$\frac{\text{mol}}{\text{L}}$
Molality (m)	$\frac{\text{amount solute (in mol)}}{\text{mass solvent (in kg)}}$	$\frac{\text{mol}}{\text{kg}}$
Mole fraction (χ)	$\frac{\text{amount solute (in mol)}}{\text{total amount of solute and solvent (in mol)}}$	None
Mole percent (mol %)	$\frac{\text{amount solute (in mol)}}{\text{total amount of solute and solvent (in mol)}} \times 100\%$	%
Parts by mass	$\frac{\text{mass solute}}{\text{mass solution}} \times \text{multiplication factor}$	
Percent by mass (%)	Multiplication factor $= 100$	%
Parts per million by mass (ppm)	Multiplication factor $= 10^6$	ppm
Parts per billion by mass (ppb)	Multiplication factor $= 10^9$	ppb
Parts by volume (%, ppm, ppb)	$\frac{\text{volume solute}}{\text{volume solution}} \times \text{multiplication factor}^*$	

*Multiplication factors for parts by volume are identical to those for parts by mass.

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.**

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 $CuSO_4$

$$\frac{4.73\text{mol}}{1\text{mol}} \quad \frac{159.62\text{g}}{} = \textbf{755g solute}$$

$$1\text{ L} = \frac{1000\text{mL}}{1\text{mL}} \quad \frac{1.30\text{g}}{} = \textbf{1300g solution}$$

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

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%

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

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%**

$$\frac{71.0\text{g}}{46.08\text{g}} \times \frac{1\text{mol}}{} = \textbf{1.54 mol ethanol}$$

$$\frac{14.3\text{g}}{18.02\text{g}} \times \frac{1\text{mol}}{} = \textbf{0.794 mol water}$$

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

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**

$$\frac{33.5\text{g}}{60.11\text{g}} \times \frac{1\text{mol}}{} = \textbf{0.557 mol solute}$$

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

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**

$$\frac{481.6\text{g}}{148.33\text{g}} \times \frac{1\text{mol}}{} = 3.247 \text{ mol solute}$$

= 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