IX. DOUBLE UNIT CONVERSIONS:

Follow along and complete these notes as you view video "#9: Dimensional Analysis: Double Units" at https://edpuzzle.com.

A. Converting the Units

- Numbers such as 8.90 g/cm^3 or 2.998×10^8 m/s
- Must be set up correctly for proper use of conversion factors

1. Set up the starting units as a full fraction opposite the question mark and convert each unit separately:
   a. Put the number and the first unit in the numerator or top left corner of the grid.
   b. Put the second unit in the denominator or lower left corner of the grid with the number 1.
2. Start with either unit first, placing canceling units diagonally until you have the desired unit
3. ONCE YOU ARE THROUGH WITH THE FIRST UNIT, LEAVE IT ALONE AND BEGIN WORK ON THE SECOND UNIT in the same way.
4. Do the math (use the "zig-zag" method), then bring both of your units over for the final answer.
   - The final units can be stated as "per" units

Example: The speed of light is 2.998×10^8 m/s. How fast is this in km/hr?

1. The first unit is m and the second is s. Set up a full fraction opposite the question mark (show work below #4)
2. Convert one unit at a time. We'll start with m ⟶ km
3. Now we convert the remaining unit, s ⟶ hr
4. Now calculate the result with the zig-zag method

$$\underline{\ ?\ }\ \text{km/hr} = \frac{2.998\times10^8\ \text{m}}{1\ \text{s}} \times \frac{1\ \text{km}}{1\times10^3\ \text{m}} \times \frac{60\ \text{s}}{1\ \text{min}} \times \frac{60\ \text{min}}{1\ \text{hr}} = \boxed{1.079\times10^9\ \text{km/hr}}$$

Example. A level of 0.70 micrograms per milliliter (µg/mL) of lead in a child's bloodstream can cause severe damage in their body, and even lead to death. What is this amount in grams per liter (g/L)?

? g/L = 0.70 µg/mL 1 mL = 1×10^{-3} L 1 µg = 1×10^{-6} g

$$?\ \text{g/L} = \frac{0.70\ \mu\text{g}}{1\ \text{mL}} \times \frac{1\ \text{mL}}{1\times10^{-3}\ \text{L}} \times \frac{1\times10^{-6}\ \text{g}}{1\ \mu\text{g}} = \boxed{7.0\times10^{-4}\ \text{g/L}}$$

YOUR TURN

Example. Convert 2.178×10^{-19} J/bond to kJ/mol. Conversion factor: 6.022×10^{23} bonds = 1 mol.

$$?\ \text{kJ/mol} = \frac{2.178\times10^{-19}\ \text{J}}{1\ \text{bond}} \times \frac{1\ \text{kJ}}{1\times10^3\ \text{J}} \times \frac{6.022\times10^{23}\ \text{bonds}}{1\ \text{mol}} = \boxed{131.2\ \text{kJ/mol}}$$

Example. The bladder snail, an especially speedy snail, can reach a breakneck speed of 22.6 cm/s. What is this in km/hr?

$$?\ \text{km/hr} = \frac{22.6\ \text{cm}}{1\ \text{s}} \left| \frac{1\times10^{-2}\ \text{m}}{1\ \text{cm}} \right| \frac{1\ \text{km}}{1\times10^3\ \text{m}} \left| \frac{60\ \text{s}}{1\ \text{min}} \right| \frac{60\ \text{min}}{1\ \text{hr}} = \boxed{0.813\ \text{km/hr}}$$

B. Using double units as conversion factors

- Double units can also be used as conversion factors between the two quantities that their units represent.
  - E.g. the units for density are g/cm^3, so the numerical value represents a conversion factor between mass (g) and volume (cm3). Speed, with units of m/s, represents a conversion factor between distance (m) and time (s). We will encounter many such units during the course of this year.

1. As with conversions, write the number as a full fraction first with the number and first unit in the numerator and the second unit in the denominator with the value 1.
2. Set up the conversion with the desired unit and question mark on the left of the equals sign and the starting value and unit to the right.
   a. If needed, convert the starting unit to match the unit representing the same quantity in the double unit number.
3. Determine whether you need to multiply the starting quantity by the double unit or its reciprocal (inverse). You will need to use the reciprocal if the starting quantity is in the numerator of the double unit.
4. If needed, perform any conversions to get the new quantity into the desired unit.
5. Be sure all units except the final unit cancel, then perform the math.

Example: The density of mercury, a liquid metal, is 13.6 g/mL. What is the mass, in kg, of 250. mL of mercury?

1. Set up the double unit (density in this case) as a full fraction (Show work below)
2. Set up the conversion.
3. Since we are starting with mL, that unit goes into the denominator in the conversion factor.
4. Canceling the mL leaves the unit g, so convert g to kg
5. We now have he desired unit, calculate the result:

$$\frac{13.6\text{ g}}{1\text{ mL}} \Rightarrow ?\text{ g} = 250.\text{ mL} \times \frac{13.6\text{ g}}{1\text{ mL}} \times \frac{1\text{ kg}}{1\times10^3\text{ g}} = \boxed{3.40\text{ kg}}$$

Example: A cyclist is moving along at 12.5 m/s. How much time, in min, will she take to travel 25.0 km?

$$\frac{12.5\text{ m}}{1\text{ s}} \Rightarrow ?\text{ min} = 25.0\text{ km} \times \frac{1\times10^3\text{ m}}{1\text{ km}} \times \frac{1\text{ s}}{12.5\text{ m}} \times \frac{1\text{ min}}{60\text{ s}} = \boxed{33.3\text{ min}}$$

YOUR TURN

Example: A certain car has gas "mileage" of 17.0 km/L. What distance, in km, can it travel using 425 mL of gas?

$$\frac{17.0\text{ km}}{1\text{ L}} \Rightarrow ?\text{ km} = 425\text{ mL} \times \frac{1\times10^{-3}\text{ L}}{1\text{ mL}} \times \frac{17.0\text{ km}}{1\text{ L}} = \boxed{7.23\text{ km}}$$

Example: A salt water solution contains 6.58 g NaCl/L. What volume of solution, in mL, is needed to have 8.03 µg (micrograms) of NaCl?

$$\frac{6.58\text{ g}}{1\text{ L}} \Rightarrow ?\text{ mL} = 8.03\ \mu\text{g} \times \frac{1\times10^{-6}\text{ g}}{1\ \mu\text{g}} \times \frac{1\text{ L}}{6.58\text{ g}} \times \frac{1\text{ mL}}{1\times10^{-3}\text{ L}} = \boxed{1.22\times10^{-3}\text{ mL}}$$