CHAPTER 2 VIDEO NOTES — METRIC SYSTEM CONVERSIONS
CHEMISTRY 1 — DR. CASAGRANDE

VIII. METRIC SYSTEM CONVERSIONS:
Follow along and complete these notes as you view video "#8: Dimensional Analysis: Metric Conversions" at https://edpuzzle.com.

- The US is one of only 3 countries not using the Metric System
- Science uses SI units, based on the Metric System
  - Universally accepted and understood
  - Conversions between units of different sizes involve only **powers of 10**
    - Never have to memorize–always get conversion table
  - Prefix indicates **size of unit**
  - 1 is with the **prefix**, exponent is with the **base unit (Power to the Base!)**
    - Prefixes are **never used alone**
    - Examples:
      - **1 mL = 1×10^{-3} L**
      - **1 kg = 1×10^{3} g**
      - **1 ns = 1×10^{-9} s**

Unit Prefixes: Can be used with *any unit* (m, L, g, etc.)

Prefix	Meaning	Examples (with meters)
tera- (T)	1×10^{12}	1 Tm = 10^{12} m
giga- (G)	1×10^{9}	1 Gm = 10^{9} m
mega- (M)	**1×10^{6}**	**1 Mm = 10^{6} m**
kilo- (k)	**1×10^{3}**	**1 km = 10^{3} m (1000 m)**
–	1×10^{0}	***(1 m = 1 m)***
deci- (d)	1×10^{-1}	1 dm = 10^{-1} m *(10 dm = 1 m)*
centi- (c)	**1×10^{-2}**	**1 cm = 10^{-2} m *(10^{2} cm = 1 m)***
milli- (m)	**1×10^{-3}**	**1 mm = 10^{-3} m *(10^{3} mm = 1 m)***
micro- (μ)	**1×10^{-6}**	**1 μm = 10^{-6} m *(10^{6} μm = 1 m)***
nano- (n)	**1×10^{-9}**	**1 nm = 10^{-9} m *(10^{9} nm = 1 m)***
pico- (p)	1×10^{-12}	1 pm = 10^{-12} m *(10^{12} pm = 1 m)*
femto- (f)	1×10^{-15}	1 fm = 10^{-15} m *(10^{15} fm = 1 m)*

LET'S PRACTICE!!!!!!!!!!!!!!

A. ONE STEP CONVERSIONS

- Converting between a prefix and the base unit, only one step is needed
  - Use table to determine conversion factor from starting equality

Example. Current computer transistor gate oxides are approaching 32 nm (nanometers) in width. How many meters is this?

$$? \text{ m} = 32 \text{ nm} \qquad 1\text{nm} = 1\times10^{-9} \text{ m}$$

$$? \text{ m} = \frac{32 \text{ nm} \quad 1\times10^{-9} \text{ m}}{1 \text{ nm}} = \boxed{3.2\times10^{-8} \text{ m}}$$

Example. How many microliters (μL) are there in 4.56×10^{-3} liters?

$$? \text{ μL} = 4.56\times10^{-3} \text{ L} \qquad 1 \text{ μL} = 1\times10^{-6} \text{ L}$$

$$? \text{ μL} = 4.56\times10^{-3} \text{ L} \times \left(\frac{1 \text{ μL}}{1\times10^{-6} \text{ L}} \right) = \boxed{4.56\times10^{3} \text{ μL}}$$

CAUTION You MUST **show all your work** for full credit! CAUTION

B. Prefix to Prefix — REQUIRES TWO STEPS!

- Prefix-Prefix conversions require two steps
  - Use two conversion factors using the base unit tied to the starting and ending prefixes

Example. The Joule (J) is the SI unit of energy. How many kJ (kiloJoules) are equivalent to 367 mJ (milliJoules)?

$$? \text{ kJ} = 367 \text{ mJ} \qquad 1 \text{ mJ} = 1\times10^{-3} \text{ J} \qquad 1 \text{ kJ} = 1\times10^{3} \text{ J}$$

$$? \text{ kJ} = 367 \text{ mJ} \times \frac{1\times10^{-3} \text{ J}}{1 \text{ mJ}} \times \frac{1 \text{ kJ}}{1\times10^{3} \text{ J}} = \boxed{3.67\times10^{-4} \text{ kJ}}$$

Example. A Blu-ray player uses a blue laser beam with a wavelength of 405 nm. How many cm is this equal to?

$$? \text{ cm} = 405 \text{ nm} \qquad 1 \text{ nm} = 1\times10^{-9} \text{ m} \qquad 1 \text{ cm} = 1\times10^{-2} \text{ m}$$

$$? \text{ cm} = \frac{405 \text{ nm} \quad 1\times10^{-9} \text{ m} \quad 1 \text{ cm}}{1 \text{ nm} \quad 1\times10^{-2} \text{ m}} = \boxed{4.05\times10^{-5} \text{ cm}}$$

C. YOUR TURN!

Example. A student has a mass of 58.97 kg. How many grams does this represent?

$$? \text{ g} = 58.97 \text{ kg} \qquad 1\times10^{3} \text{ g} = 1 \text{ kg}$$

$$? \text{ g} = 58.97 \text{ kg} \times \left(\frac{1\times10^{3} \text{ g}}{1 \text{ kg}}\right) = \boxed{5.897\times10^{4} \text{ g}}$$

Example. Convert 6.99×10^{8} µg (micrograms) to cg.

$$? \text{ cg} = 6.99\times10^{8} \text{ µg} \qquad 1 \text{ µg} = 1\times10^{-6} \text{ g} \qquad 1\text{cg} = 1\times10^{-2} \text{ g}$$

$$? \text{ cg} = \frac{6.99\times10^{8} \text{ µg} \quad 1\times10^{-6} \text{ g} \quad 1 \text{ cg}}{1 \text{ µg} \quad 1\times10^{-2} \text{ g}} = \boxed{6.99\times10^{4} \text{ cg}}$$

D. New Method for Prefix Conversions

- In this method, prefixes are treated not as part of the unit but as part of the number.
- First the given prefix will be replaced by its exponent (value)
- Next we'll multiply by the definition (value) of the desired prefix and its inverse, effectively multiplying by 1.
- A simple regrouping of the exponents will then give us the value of the number with the new prefix.

Example: Prefix to Prefix: Convert 768 mg to µg ($10^{-3} \rightarrow 10^{-6}$)

1) Use the table to replace the prefix with its factor. m = 10^{-3}, so write: $768 \times \mathbf{10^{-3}}$ g
2) Find the factor for the desired unit and insert its inverse × itself before the unit, effectively multiplying by 1. µ = 10^{-6}, so write: $768 \times 10^{-3} \times \mathbf{(10^{6} \times 10^{-6})}$ g
3) Regroup the factors to have the desired factor alone with the unit: $768 \times \mathbf{(10^{-3} \times 10^{6})} \times 10^{-6}$ g
4) Perform the multiplication in the parentheses: $768 \times \mathbf{10^{3}} \times 10^{-6}$ g
5) Replace the numerical factor of the desired prefix with its prefix (10^{-6} = µ): 768×10^{3} **µg**
   - While this is not considered valid *scientific notation*, the value is correct. If you want to convert it to valid scientific notation (which you do not have to do), move the decimal point two to the left and increase the exponent by two: $\mathbf{7.68 \times 10^{5}}$ µg

Example: Prefix to Base: Convert 8.74×10^2 MHz to Hz $(10^6 \rightarrow \text{base})$

1) Change prefix to factor (M = 10^6): $8.74 \times 10^2 \times \mathbf{10^6}$ Hz
2) Going to the base unit there is no need to put in a factor and reciprocal
3) Multiply exponents (if needed): $8.74 \times \mathbf{10^8}$ Hz
   (rewrite if needed/wanted for proper scientific notation)

Example: Base to Prefix: Convert 3.28×10^{-2} L to mL $(\text{base} \rightarrow 10^{-3})$

1) Starting from the base unit there is no prefix to replace
2) Multiply by inverse of factor of new prefix and itself: $3.28 \times 10^{-2} \times \mathbf{(10^3 \times 10^{-3})}$ L
3) Regroup factors: $3.28 \times \mathbf{(10^{-2} \times 10^3)} \times \mathbf{10^{-3}}$ L
4) Multiply exponents (if needed): $3.28 \times \mathbf{10^1} \times 10^{-3}$ L
5) Replace factor with new prefix (10^{-3} = m): 3.28×10^1 **m**L
6) Rewrite if desired: 32.8 mL

E. Your Turn

Example: Convert 41.3 km to nm: $(10^3 \rightarrow 10^{-9})$

$41.3 \times \mathbf{10^3}$ m $\rightarrow 41.3 \times 10^3 \times \mathbf{(10^9 \times 10^{-9})}$ m $\rightarrow 41.3 \times \mathbf{(10^3 \times 10^9)} \times \mathbf{10^{-9}}$ m $\rightarrow$

$41.3 \times \mathbf{10^{12}} \times 10^{-9}$ m $\rightarrow 41.3 \times 10^{12}$ **n**m $= 4.13 \times 10^{13}$ nm

Example 5: Convert 548.2 ns to s: $(10^{-9} \rightarrow \text{base})$

$548.2 \times \mathbf{10^{-9}}$ s $= 5.482 \times 10^{-7}$ s

Example 6: Convert 254 J to kJ: $(\text{base} \rightarrow 10^3)$

$254 \times \mathbf{(10^{-3} \times 10^3)}$ J $\rightarrow 254 \times \mathbf{10^{-3} \times 10^3}$ J $\rightarrow 254 \times 10^{-3}$ **k**J $= 2.54 \times 10^{-1}$ J $= 0.254$ J