Part III: The Mole – It's Such a Gas!

- At STP, **one mole** of any ideal gas occupies a volume of 22.4 L.
  - STP: Standard temperature is 0°C (273K) and standard pressure is 1 atm = 760 mm Hg = 760 torr.
- Gases must have their quantitative properties calculated using temperatures in Kelvin.
- The ideal gas equation, $PV = nRT$, can be used to relate the properties [pressure (P), volume (V), number of moles (n), and *Kelvin* temperature (T)] of ideal gases to one another.
  - R = universal gas constant = 8.314 J mol^{-1} K^{-1} = 0.08206 L atm mol^{-1} K^{-1} = 62.36 L torr mol^{-1} K^{-1}
  - The numerical value of R is *dependent upon the units used.*
- A rhyme to help you remember! **When you're NOT at STP, use PV = nRT.**

5. ~~1.~~ Given 7.81 x 10^{22} molecules of chlorine gas (Cl_2):

   a. What is the volume of your sample at STP?

$$7.81E22 \text{ molec. } Cl_2 \times \frac{1 \text{ mol } Cl_2}{6.022E23 \text{ molec. } Cl_2} = 0.130 \text{ mol } Cl_2 \times \frac{22.4 \text{ L}}{1 \text{ mol}} = \boxed{2.91 \text{ L } Cl_2}$$

   b. What is the volume of your gas sample in Texas in late August? Let's say 1.00 atm and 38°C (about 100°F, sigh).

$$V = \frac{nRT}{P} = \frac{(0.130 \text{ mol})\left(0.08206 \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}}\right)\overbrace{(38°\text{C} + 273)}^{311 \text{ K}}}{(1.00 \text{ atm})} = \boxed{3.32 \text{ L } Cl_2}$$

2. Three identical containers are filled with a single gas each: the first container with O_2, the second with CO_2, and the last with N_2. All of the containers are at the same temperature and pressure.

   a. Which container has the greatest number of molecules?

   Trick question – they all have the same # of molec.!
   Same V, T, P ⇒ same n (b/c PV = nRT)

   b. Which container has the smallest mass?

   N_2, b/c all 3 have the same n (# mol), and N_2 has a smaller molar mass than O_2 and CO_2.