

Lecture 10C - Molar Volume

We have already learned 2 of the 3 "mole definitions"...

$$1 \text{ mole} = 6.02 \times 10^{23} \text{ particles}$$

$$1 \text{ mole} = \text{molar mass (grams)}$$

Now we will learn the last mole definition - the one that actually started all this mole stuff in the first place!

Amadeo Avagadro was doing experiments with gases, similar to the ones that LaVoisier and Dalton had done to determine ratios of reactants. Avagadro developed a key hypothesis:

"Equal volumes of gases, at the same temperature and pressure, have the same number of molecules".

Further work defined that exactly 1 mole of ANY gas at standard temperature and standard pressure (STP) has a volume of 22.4 liters.

$$1 \text{ mole} = 22.4 \text{ L (at STP)}$$

So... what is STP?

Standard Temperature = 0°C

Standard Pressure = 1 atm



Molar Volume Problems

Ex. 1: What is the volume at STP of 2.37 moles of helium gas?

$$\frac{2.37 \text{ moles He}}{1 \text{ mole He}} \times \frac{22.4 \text{ L He}}{1 \text{ mole He}} = \boxed{53.1 \text{ L He}}$$

Ex. 2: How many grams oxygen gas are in a 5.60 L container?

$$\frac{5.60 \text{ L O}_2}{22.4 \text{ L O}_2} \times \frac{1 \text{ mole O}_2}{1 \text{ mole O}_2} \times \frac{32.0 \text{ g O}_2}{1 \text{ mole O}_2} = \boxed{8.00 \text{ g O}_2}$$

We can even find the DENSITY of a gas using mole definitions!
But first, we need to review density...

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

Now for the cool part... what would happen if we had standard temperature and pressure conditions?

Hey - wait a minute! Then the "mass" above would be "molar mass" and the "volume" above would be "molar volume".

Ex. 3: What is the density of 1 mol of CO₂ at STP?

$$\begin{array}{rcl} \text{C:} & 1 \times 12.0 & = 12.0 \\ \text{O:} & 2 \times 16.0 & = 32.0 \\ & \hline & & 44.0 \text{ g CO}_2 \end{array}$$

$$\text{density} = \frac{44.0 \text{ g CO}_2}{22.4 \text{ L CO}_2}$$

$$\boxed{\text{density} = 1.96 \text{ g/L CO}_2}$$

$$1 \text{ mole CO}_2 = 22.4 \text{ L}$$