THE IDEAL GAS LAW

- Recall that the molar volume of an "ideal gas" is 22.4 L at STP conditions

- An ideal gas is a **hypothetical** gas that obeys the gas laws perfectly under ALL conditions. i.e. won't condense into a liquid when cooled, graphs are all perfectly straight lines, etc.

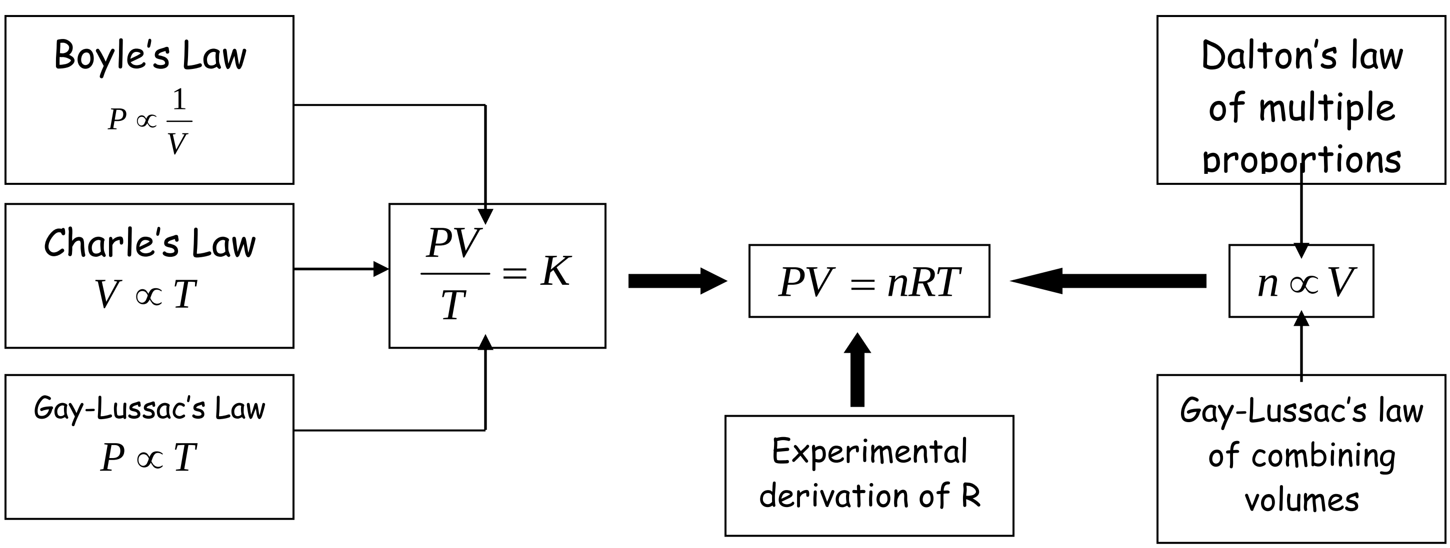
- According to the KMT of an ideal gas;
  - gas molecules have insignificant volume
  - there are no attractive forces between molecules
  - molecules move in perfectly straight lines
  - collisions are completely elastic (do not loose energy)

At STP most gases do behave like ideal gases, however, at high pressures and/or low temperatures, most gases no longer behave ideally.

Scientists that desire more accuracy in their experiments have adopted the **Ideal Gas Law** to reflect the behavior of real gases.

The **Ideal Gas Law** is a mathematical representation of the relationship between moles, pressure, volume, and temperature for an ideal gas.

CONCEPT ORGANIZER: The Evolution of the Ideal Gas law



- Ideal Gas Law is derived by combining the **Boyles's law**, **Charles's law** and **Avogadro's Law/Hypothesis**.

$V \propto n$ *and* $V \propto \frac{T}{P}$ combined becomes, $V \propto \frac{nT}{P}$

- Introducing a constant, k_4 the formula becomes, $k_4 = \frac{PV}{nT}$, *but what is k_4?*
- To find the value of R, we would substitute known values and solve for R. Example: At STP (101.3 kPa and 273.15K), 1.00 mol of an ideal gas would occupy a volume of 22.4L.

PV=nRT $\quad$ $R=\frac{PV}{nT}$ $\quad$ $R = \frac{101.325\text{kPa} \times 22.414\text{L}}{1.00\text{mol} \times 273.15\text{K}} = \mathbf{8.31\,4\ \frac{kPa \bullet L}{mol \bullet K}}$

- If the mass of gas was given, and not moles, we would have to calculate n first.

- The accurate value of 8.314 $\frac{kPa \cdot L}{mol \cdot K}$, determined experimentally, is known as the **universal gas constant,** and is given the symbol ***R***.

OR = 0.082606 L. atm/mol . K (see next page)

- Rearranging the formula to the usual form of the **IDEAL GAS LAW**:

$$PV = nRT$$

Recall, any gas that obeys this equation is called and "ideal gas".

NOTE: there is no such thing as an ideal gas, however at low pressures (~1 atm) and room temperature conditions, gases will behave like an ideal gas and obey PV=*n*RT

Guidelines for using the Ideal Gas Law

- Always convert the temperature to Kelvins (K).
- Always convert the masses to moles (mol).
- Always convert the volumes to litres (L).
- Using the ideal gas law will always be easier if pressure values are converted to kilopascals (kPa). Then the value of *R* that is required will always be 8.314 $\frac{kPa \cdot L}{mol \cdot K}$. *What can you do if you forget this value?*

Converting the units of the Universal Gas Constant, *R*

Rather than converting pressure to kilopascals, we can convert the units of *R*. If pressure is given in atmospheres, atm:

$$\frac{8.314\,kPa \cdot L}{mol \cdot K} \times \frac{1\,atm}{101.3\,kPa} = 0.08206\,\frac{atm \cdot L}{mol \cdot K}$$

If pressure is given in torr (or mm Hg):

$$\frac{8.314\,kPa \cdot L}{mol \cdot K} \times \frac{760\,mmHg}{101.3\,kPa} = 62.37\,\frac{mmHg \cdot L}{mol \cdot K}$$

Sample Problem

If 0.78g of hydrogen at 22ºC and 125kPa is produced, what volume of hydrogen would be expected?

Given: mass of H_2 = 0.78g T= 22 ^{0}C P= 125 kPa R = 8.314 $\frac{kPa \cdot L}{mol \cdot K}$

V= ?

Plan: Step 1: Find moles of hydrogen
Step 2: Use the Ideal Gas Law to find the volume of hydrogen expected.

Solution: Step 1: n=m/M = 0.78g/2.02g/mol = 0.39mol

Step 2: PV=nRT

$V_{H2} = \frac{nRT}{P}$

$V_{H2} = \frac{0.39mol \times 8.31kPA*L/mol*K \times 295K}{125kPa}$

V_{H2}= 7.6L

Paraphrase: Therefore the volume of hydrogen gas expected was 7.6L.

Practice Problem

What mass of neon gas should be introduced into an evacuated 0.88L tube to produce a pressure of 90. kPa at 30ºC? (A: 0.56 g Ne)