Lab You will need your [NaOH] for the next lab. Should be between 0.1M – 0.2M.

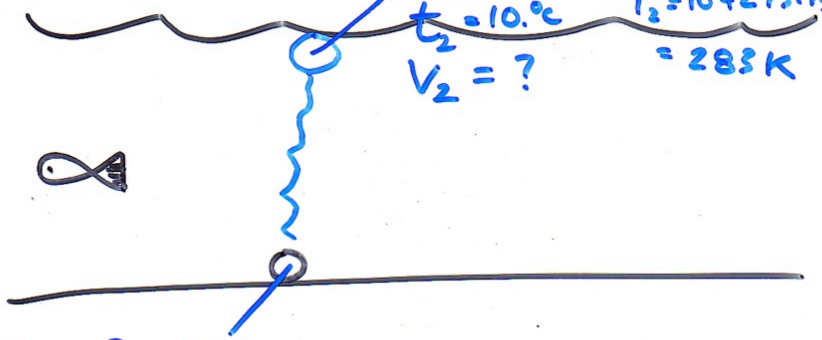
$pV = nRT$ ← ideal gas CONSTANT

$$\frac{P_1V_1}{n_1T_1} = R = \frac{P_2V_2}{n_2T_2}$$

n = # mol gas

if # mol gas is constant

$$\boxed{\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}}$$ Combined Gas Law.



$P_2 = 1.0\,atm$

$t_2 = 10.°C$ $T_2 = 10 + 273.15 = 283\,K$

$V_2 = ?$

$CH_{4(g)}$ $P_1 = 17\,atm$

$V_1 = 3.7\,mL$

$t_1 = -10.°C \Rightarrow T_1 = -10. + 273.15 = 263\,K$

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \Rightarrow V_2 = \frac{P_1V_1}{T_1} \times \frac{T_2}{P_2}$$

$$\Rightarrow V_2 = \frac{17\,atm \times 3.7\,mL \times 283\,K}{263\,K \times 1.0\,atm}$$

$= 68\,mL$ (≈ 20× larger!)

Gas Stoichiometry

- can find volume of gases made in rxns!

ex: $C_6H_{12}O_{6(s)} \xrightarrow{\text{Yeast}} 2C_2H_6O_{(aq)} + 2CO_{2(g)}$

let's calculate what vol. of CO_2 is formed from 454g of $C_6H_{12}O_6$ @ $t = 17°C$ and a $p = 1.01$ atm.

$T = 17 + 273.15 = 290.\,K$

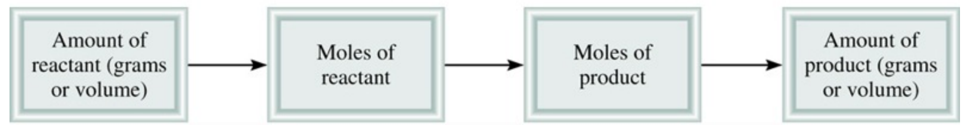
$$\frac{454g\ C_6H_{12}O_6}{} \left| \frac{1mol\ C_6H_{12}O_6}{180.2g\ C_6H_{12}O_6} \right| \frac{2\ mol\ CO_2}{1\ mol\ C_6H_{12}O_6}$$

$= 5.04$ mol $CO_2\ (g)$

$pV = nRT \Rightarrow V = \frac{nRT}{P}$

$$\Rightarrow V = \frac{5.04\ mol \times 0.08206 \frac{atm \cdot L}{mol \cdot K} \times 290.\ K}{1.01\ atm}$$

$= 119$ L



A 2.10-L vessel contains 4.65 g of a gas at 1.00 atm and 27.0 ˚C. What is the molar mass of the gas?

$$\mathcal{M} = \frac{dRT}{P} \qquad d = \frac{m}{V} = \frac{4.65\ \text{g}}{2.10\ \text{L}} = 2.21\frac{\text{g}}{\text{L}}$$

$$\mathcal{M} = \frac{2.21\frac{\text{g}}{\cancel{\text{L}}} \times 0.0821\frac{\cancel{\text{L}}\bullet\cancel{\text{atm}}}{\text{mol}\bullet\cancel{\text{K}}} \times 300.15\ \cancel{\text{K}}}{1\ \cancel{\text{atm}}}$$

$$\mathcal{M} = 54.5\ \text{g/mol}$$

Density (d) Calculations

$$d = \frac{m}{V} = \frac{P\mathcal{M}}{RT}$$

m is the mass of the gas in g

$\mathcal{M}$ is the molar mass of the gas

Molar Mass ($\mathcal{M}$) of a Gaseous Substance

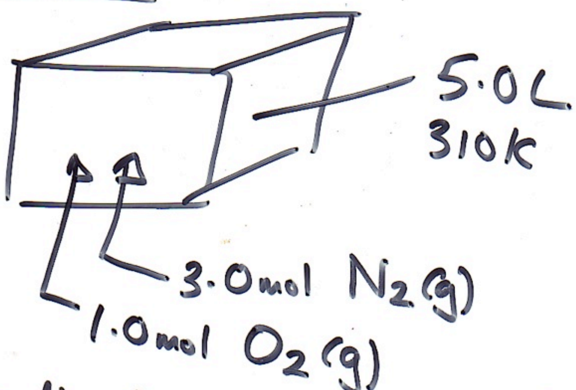
$$\mathcal{M} = \frac{dRT}{P}$$

d is the density of the gas in g/L

Section 5.4

density + molar mass of gases.

Section 5.5



Q. What's the pressure in the box?

$pV = nRT \Rightarrow p = \frac{nRT}{V}$

N_2

$P_{N_2} = \frac{3.0\,\text{mol} \times 0.08206\,\frac{\text{atm}\cdot\text{L}}{\text{mol}\cdot\text{K}} \times 310\,\text{K}}{5.0\,\text{L}}$

$= 15\,\text{atm}$

O_2

$P_{O_2} = \frac{1.0\,\text{mol} \times 0.08206\,\frac{\text{atm}\cdot\text{L}}{\text{mol}\cdot\text{K}} \times 310\,\text{K}}{5.0\,\text{L}}$

$= 5.1\,\text{atm}$

Dalton's law of Partial Pressures.

$P_{TOT} = \underbrace{P_1 + P_2 + P_3 + \ldots}_{\text{partial pressures}}$

- pressure that each gas will exert BY ITSELF!

$P_{TOT} = P_{N_2} + P_{O_2} = 15\,\text{atm} + 5.1\,\text{atm} = 20.\,\text{atm}$

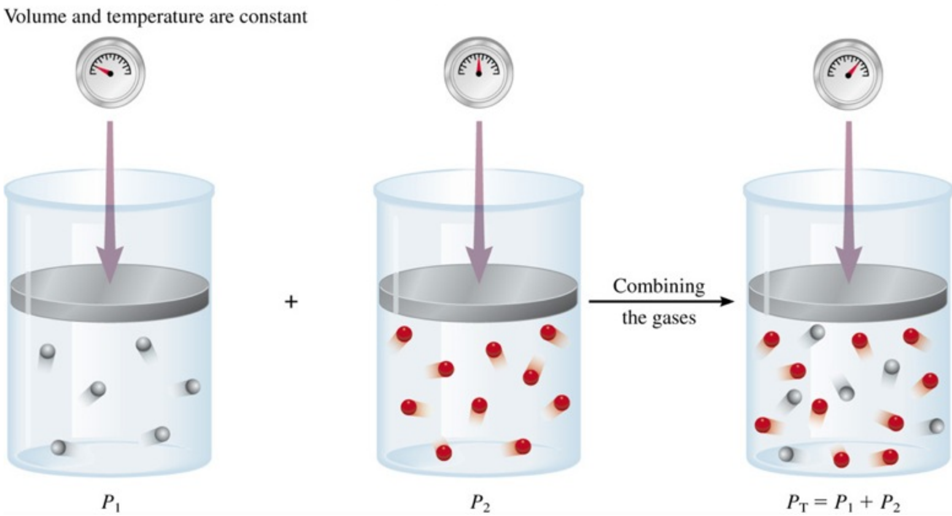
Mole Fractions

$x_A = \frac{n_A}{n_{TOT}}$

ex: $x_{N_2} = \frac{3.0\,\text{mol}}{3.0\,\text{mol} + 1.0\,\text{mol}} = 0.75$

$x_{O_2} = \frac{1.0\,\text{mol}}{4.0\,\text{mol}} = 0.25$

$1 = x_A + x_B + x_C + \ldots$



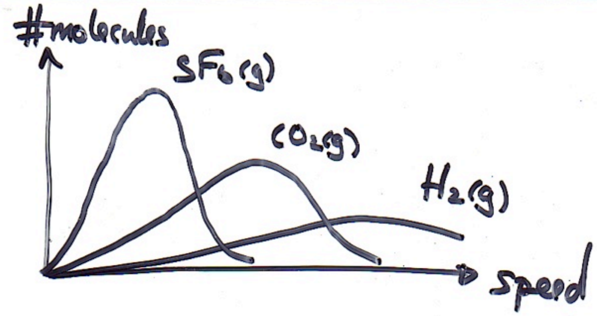
$P_A = x_A \cdot P_{TOT}$

ex: $P_{TOT} = 20.\text{ atm}$, $x_{O_2} = 0.25$ } $P_{O_2} = 0.25 \times 20.\text{ atm} = 5.0\text{ atm}$

ex: $P_{TOT} = 20.\text{ atm}$, $x_{N_2} = 0.75$ } $P_{N_2} = 0.75 \times 20.\text{ atm} = 15\text{ atm}$.

ex: What's P_{O_2} in air, if $P_{TOT} = 760\text{ mmHg}$ and $x_{O_2} = 0.21$

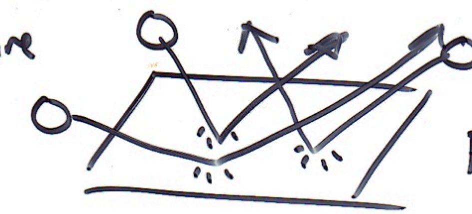
$P_{O_2} = 760\text{ mmHg} \times 0.21$
$= 160\text{ mmHg}$



Kinetic Molecular Theory of Gases

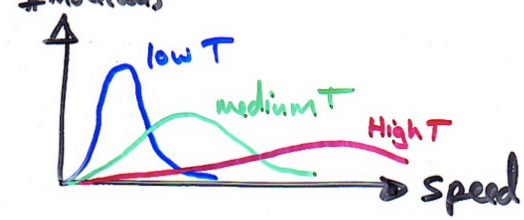
Kinetic: Movement
Molecular: small-particles

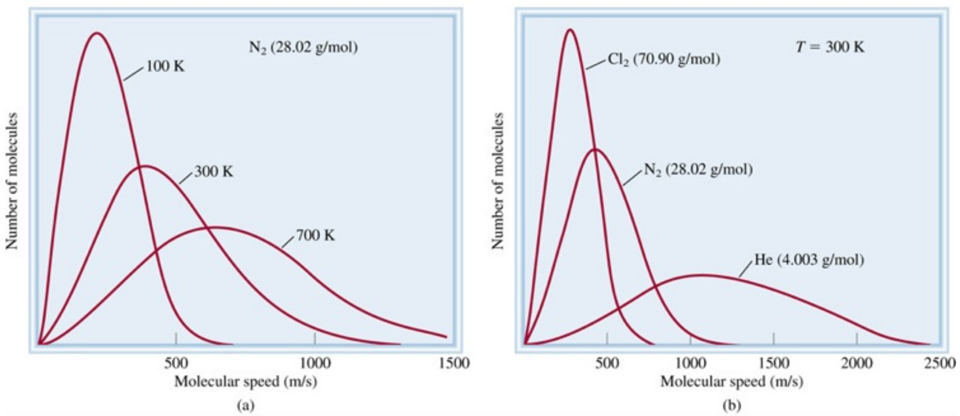
gases:
- molecules
- constant random motion!
- Kinetic Energy $\propto T(K)$
  energy of motion
- Pressure



$$P = \frac{F}{A}$$

Not all molecules are moving @ same speed. <u>Maxwell-Boltzmann Distribution</u>




N2 (28.02 g/mol)
100 K
300 K
700 K
Number of molecules
500
1000
1500
Molecular speed (m/s)
(a)
Cl2 (70.90 g/mol)
T = 300 K
N2 (28.02 g/mol)
He (4.003 g/mol)
Number of molecules
500
1000
1500
2000
2500
Molecular speed (m/s)
(b)