GAS LAWS

- were derived by experiment long before kinetic theory, but agree with the kinetic picture!

Boyle's Law:

$$PV = \text{constant}$$

True at constant temperature

$$P_1V_1 = \text{constant} \qquad P_2V_2 = \text{constant}$$

$$\boxed{P_1V_1 = P_2V_2}$$

True at constant temperature

Charles's Law:

$$\frac{V}{T} = \text{constant}$$

True at constant pressure, and using ABSOLUTE temperature

$$\boxed{\frac{V_1}{T_1} = \frac{V_2}{T_2}}$$

True at constant pressure, and using ABSOLUTE temperature

Combined gas law:

$$\frac{PV}{T} = \text{constant}$$

Must use ABSOLUTE temperature units!

$$\boxed{\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}}$$

Must use ABSOLUTE temperature units!

amount (moles) of gas must be constant!

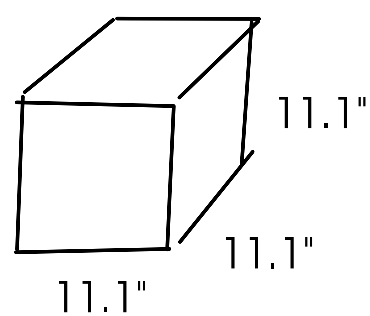
Avogadro's law:

- a mole of any gas at the same conditions has the same volume.

1 mol gas molecules @ 0°C and 1 atm

volume = 22.4 L

"STP"
Standard Temperature and Pressure



= 22.4 L

Ideal gas law:

$$\frac{PV}{T} = \text{constant}$$

... but this constant actually depends on the amount of gas!

$$= n \times \text{"}R\text{"}$$

The ideal gas constant.

$$0.08206 \ \frac{L \cdot atm}{mol \cdot K}$$

... combining these together ...

$$\frac{PV}{T} = nR$$

$$\boxed{PV = nRT}$$

P = pressure atm

V = volume L

T = ABSOLUTE temperature K

R = ideal gas constant

n = number of moles of gas molecules

A balloon is taken from a room where the temperature is 27.0 C to a freezer where the temperature is -5.0 C. If the balloon has a volume of 3.5 L in the 27.0 C room, what is the volume of the balloon in the freezer. Assume pressure is constant.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \quad \text{... since } P = \text{constant}, \quad \frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$V_1 = 3.5\,L$ $\quad V_2 = ?$

$T_1 = 27.0^\circ C = 300.2\,K$ $\quad T_2 = -5.0^\circ C = 268.2\,K$

$$\frac{3.5\,L}{300.2\,K} = \frac{V_2}{268.2\,K}$$

$$\boxed{V_2 = 3.1\,L \text{ in the freezer}}$$

2.25 L of nitrogen gas is trapped in a piston at 25.0 C and 1.00 atm pressure. If the piston is pushed in so that the gas's volume is 1.00 L while the temperature increases to 31.0 C, what is the pressure of the gas in the piston?

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$P_1 = 1.00\,atm$ $\quad P_2 = ?$

$V_1 = 2.25\,L$ $\quad V_2 = 1.00\,L$

$T_1 = 25.0^\circ C = 298.2\,K$ $\quad T_2 = 31.0^\circ C = 304.2\,K$

$$\frac{(1.00\,atm)(2.25\,L)}{(298.2\,K)} = \frac{P_2(1.00\,L)}{(304.2\,K)}; \quad \boxed{P_2 = 2.30\,atm}$$

Calculate the mass of 22650* L of oxygen gas at 25.0 C and 1.18 atm pressure.

$\leftarrow O_2$

*Volume of a 10'x10'x8' room

O_2: 32.00 g O_2 = mol O_2

Use the ideal gas equation, but it has no mass term. What will we calculate?

$$PV = nRT$$

$\rightarrow$ Find the number of moles, n ... then use the formula weight of oxygen gas to find the mass.

$$n = \frac{PV}{RT}$$

$P = 1.18\ atm$ $\qquad R = 0.08206\ \frac{L \cdot atm}{mol \cdot K}$

$V = 22650\ L$

$T = 25.0°C = 298.2\ K$

$$n_{O_2} = \frac{(1.18\ atm)(22650\ L)}{\left(0.08206\ \frac{L \cdot atm}{mol \cdot K}\right)(298.2\ K)} = 1092.222357\ mol\ O_2$$

$$1092.222357\ mol\ O_2 \times \frac{32.00\ g\ O_2}{mol\ O_2} = \boxed{35\bar{0}00\ g\ O_2}$$

(35.0 kg)

(~77 lb)