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

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

$$P_1V_1 = P_2V_2$$

True at constant temperature

Charles's Law:

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

True at constant pressure, and using ABSOLUTE temperature

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

True at constant pressure, and using ABSOLUTE temperature

Combined gas law:

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

Must use ABSOLUTE temperature units!

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

Must use ABSOLUTE temperature units!

amount (moles) of gas must be constant!

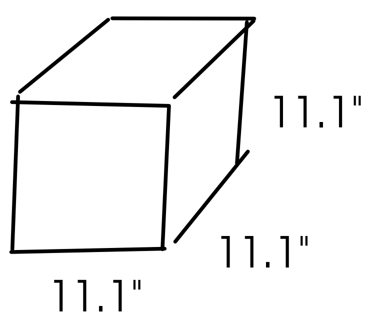
Avogadro's law:

- 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 ...

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

$$PV = nRT$$

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.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \text{ and } P_1 = P_2 \rightarrow \frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$V_1 = 3.5L$

$T_1 = 27.0°C = 300.2K$

$V_2 = ?$

$T_2 = -5.0°C = 268.2K$

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

$$3.1L = V_2$$

volume in 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?

$P_1 = 1.00\,atm$

$V_1 = 2.25L$

$T_1 = 25.0°C = 298.2K$

$P_2 = ?$

$V_2 = 1.00L$

$T_2 = 31.0°C = 304.2K$

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

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

$$2.30\,atm = P_2$$

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

← O_2

*Volume of a 10'x10'x8' room

O_2: 32.00 g O_2 = mol O_2

1) Find the MOLES of oxygen gas using the ideal gas equation, PV=nRT (n is moles)

2) Convert moles oxygen gas to mass using FORMULA WEIGHT.

$PV = nRT$ | $P = 1.18\,atm$

$n = \frac{PV}{RT}$ | $V = 22650\,L$

$T = 25.0°C = 298.2\,K$

$R = 0.08206\,\frac{L \cdot atm}{mol \cdot K}$

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

Convert moles to mass ...

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

35.0 Kg

~77 lb