Ideal gas law:

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

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

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

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.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \xrightarrow[P]{\text{constant}} \frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$V_1 = 3.5L$ $V_2 = ?$

$T_1 = 27.0°C = 300.2K$ $T_2 = -5.0°C = 268.2K$

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

$$3.1L = V_2$$

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 $P_2 = ?$

$V_1 = 2.25L$ $V_2 = 1.00L$

$T_1 = 25.0°C = 298.2K$ $T_2 = 31.0°C = 304.2K$

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

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

$$2.30\ atm = P_2$$

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

↖ O_2

O_2: 32.00 g O_2 = mol O_2

*Volume of a 10'x10'x8' room

1 - Calculate the moles of gas in the room using IDEAL GAS EQUATION.
2 - Convert moles gas (assuming it's all oxygen) to mass using FORMULA WEIGHT.

$PV = nRT$ Find the moles of gas by solving for 'n' ...

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

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

$V = 22650 L$ $T = 25.0°C = 298.2 K$

① $n_{O_2} = \frac{(1.18 \text{ atm})(22650 L)}{(0.08206 \frac{L \cdot atm}{mol \cdot K})(298.2 K)} = 1092.222357 \text{ mol } O_2$

② $32.00 \text{ g } O_2 = \text{mol } O_2$

$1092.222357 \text{ mol } O_2 \times \frac{32.00 \text{ g } O_2}{\text{mol } O_2} = \boxed{35\bar{0}00 \text{ g } O_2}$ 35.0 kg ~77 lb

CHEMICAL CALCULATIONS WITH THE GAS LAWS

$FW_{NaHCO_3} = 84.007\ g/mol$

$$H_2SO_4(aq) + 2NaHCO_3(s) \rightarrow 2H_2O(l) + 2CO_2(g) + Na_2SO_4(aq)$$

Given 25.0 g of sodium bicarbonate and sufficient sulfuric acid, what volume of carbon dioxide gas would be produced at 25.0 C and 0.950 atm pressure?

1 - Convert 25.g sodium bicarbonate to moles. Use FORMULA WEIGHT.
2 - Convert moles sodium bicarbonate to moles carbon dioxide. Use CHEMICAL EQUATION.
3 - Convert moles carbon dioxide to volume. Use IDEAL GAS EQUATION.

(1) $84.007\ g\ NaHCO_3 = mol\ NaHCO_3$ (2) $2\ mol\ NaHCO_3 = 2\ mol\ CO_2$

$$25.0\ g\ NaHCO_3 \times \underbrace{\frac{mol\ NaHCO_3}{84.007\ g\ NaHCO_3}}_{(1)} \times \underbrace{\frac{2\ mol\ CO_2}{2\ mol\ NaHCO_3}}_{(2)} = 0.297594248\ mol\ CO_2$$

$PV = nRT$

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

$n = 0.297594248\ mol\ CO_2$

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

$T = 25.0°C = 298.2\ K$

$P = 0.950\ atm$

$$V = \frac{(0.297594248\ mol\ CO_2)(0.08206\ \frac{L \cdot atm}{mol \cdot K})(298.2\ K)}{(0.950\ atm)} = 7.67\ L\ CO_2$$

7.67 L CO_2 at 25.0°C, 0.950 atm

What volume would the gas in the last example problem have at STP?

STP: "Standard Temperature and Pressure" (0 C and 1 atm)

Let's use the combined gas law to get the volume at STP:

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

$P_1 = 0.950$ atm $\quad P_2 = 1.00$ atm

$V_1 = 7.67$ L $\quad V_2 = ?$

$T_1 = 298.2$ K $\quad T_2 = 273.2$ K

$$\frac{(0.950 \text{ atm})(7.67 \text{ L})}{(298.2 \text{ K})} = \frac{(1.00 \text{ atm})\, V_2}{(273.2 \text{ K})}$$

Note: STP is a *defined* condition ... so the 1 atm and 0 C temperatures are EXACT.

$$6.67 \text{ L} = V_2$$

6.67 L CO_2 at STP

Alternate solution: Use PV=nRT a second time with STP as the temperature and pressure (since we already calculated moles in the previous problem.)