Got Gas?

Chemistry

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By end of this unit I can…

GS1: describe the Kinetic-Molecular Theory and explain how it accounts for observed gas behavior.

GS2: identify and describe the variables that define an ideal gas; Pressure, Volume, Moles, Temperature and Ideal Gas Constant.

GS3: calculate pressure using a manometer.

GS4: relate the variables of an ideal gas to changing conditions.

GS5: calculate for an unknown variable using the ideal gas formula for a static condition.

GS6: calculate the composition of a gas using Dalton’s law of partial pressures.

Basic Properties of Gasses

- 1 mole of any gas at 0-°C & 1-atm occupy the same volume.
  - 1-mol = 22.4-L at Standard Temp and Pressure
- Can be compressed.
- Expand to fill their container.
- Different gasses may move through each other.
- Constantly travel in random directions.
- Have a high amount of Kinetic Energy.
  - The amount of energy is proportional to the temperature of the gas.

Kinetic Theory

- When contained, gas molecules constantly hit the side of the container and other molecules.
  - The more molecules hit the side of the wall the more the pressure on the wall.
  - These impacts do not reduce the energy of the molecule (elastic collision).

Variables of gas: Pressure (P)

- Amount of contact with a container's walls.
- Some common conversions:
  - 1-atm = 101.3-kPa (kilo Pascal's)
  - 1-atm = 760 mm Hg (mm of Mercury)
  - 1-atm = 14.7 lb/in^2 (psi)
  - 1-atm = 1.013-bar
- Keep in mind:
  - Since all equal 1-atm they all equal each other.
    - 101.3-Kpa = 760-mm Hg

Pressure Problem Example

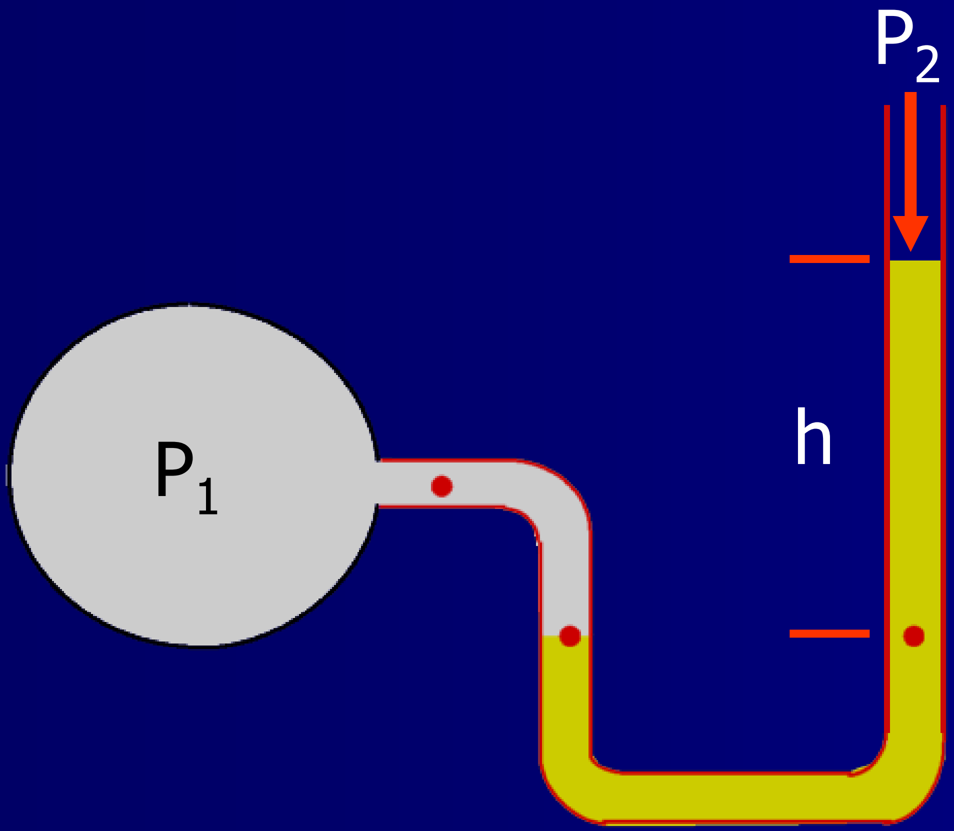
- Convert 6.25-atm to mm Hg.
  1. Write what you know.
  2. What you have: bottom.
  3. What you want: top.

$$6.25 - \cancel{atm} \; x \; \frac{760 - mm\,Hg}{1 - \cancel{atm}} = 4750 - mm\,Hg$$

4750.0-mm Hg

Using a Manometer

- Measures differences in pressure.



P_1 is closed

P_2 is open (1-atm)

P should be in mm Hg.

$|P_1-P_2|$ = h(eight) in mm.

The side with more pressure will be lower.

Manometer Example

- **A ball is hooked up to a manometer with the open end at sea level. If the height is 25-mm lower on the ball side, what is the balls pressure?**

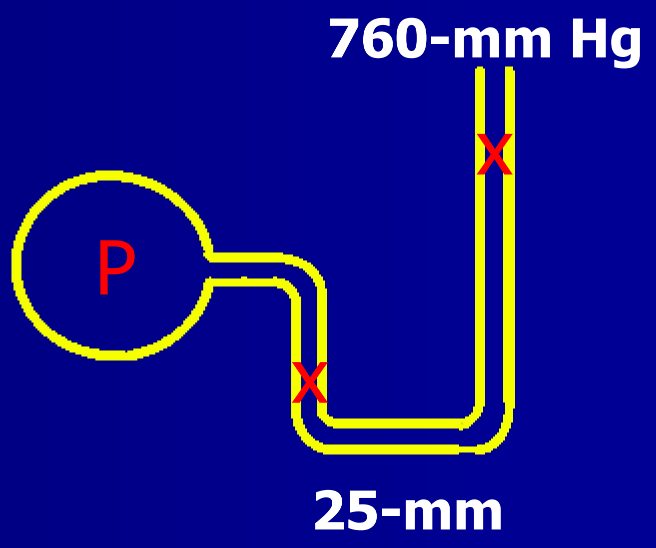
Draw a picture

Ball side height is lower… low side is always larger of the pressures.

To get a larger number add height.

P = 760-mm Hg + 25-mm Hg

P = 785.0-mm Hg



Variables of gas: Volume (V)

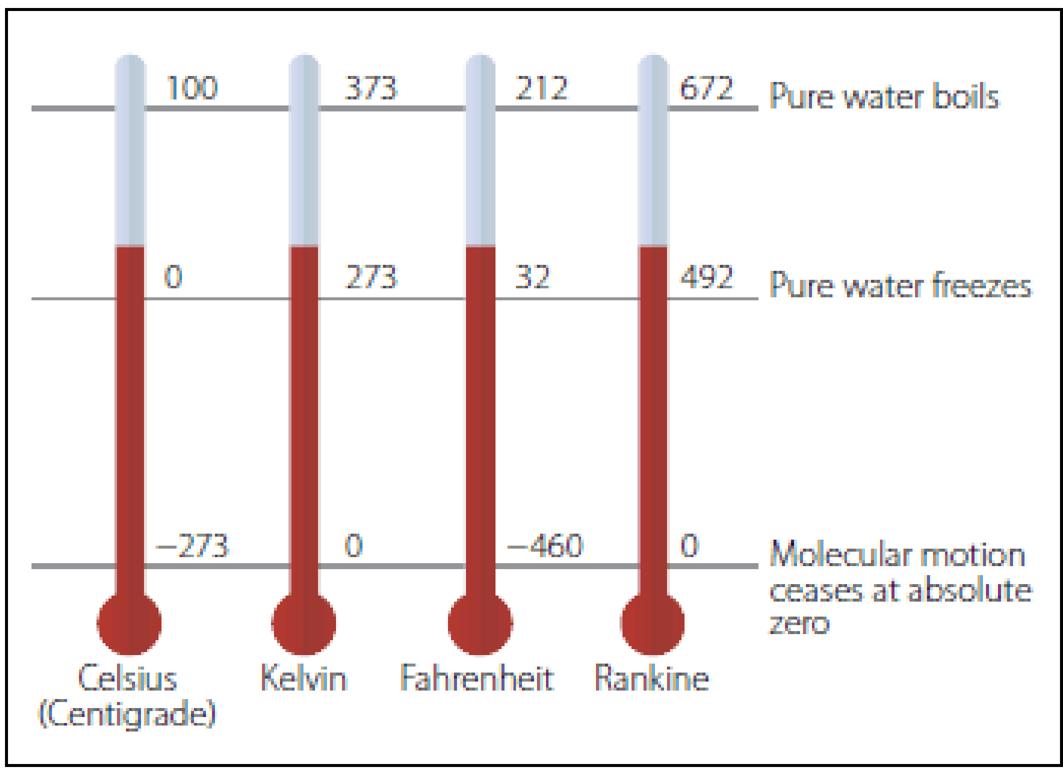
- A gas will fill its container
- 1-L = 1000-mL
- 1-L = .001-m^3
- 1-L = 1-dm^3
- 1-L = 1000-cm^3

Variables of gas: Moles (n)

- Remember the three ways to convert to moles.
  - Mass→ (molar mass-g)
  - Particles→ (Avogadro's Number)
  - Volume→ (22.4-L)
    - Remember this is only at a specific temperature (273.15-K) and pressure (1-atm).

Variables of gas: Temperature (T)

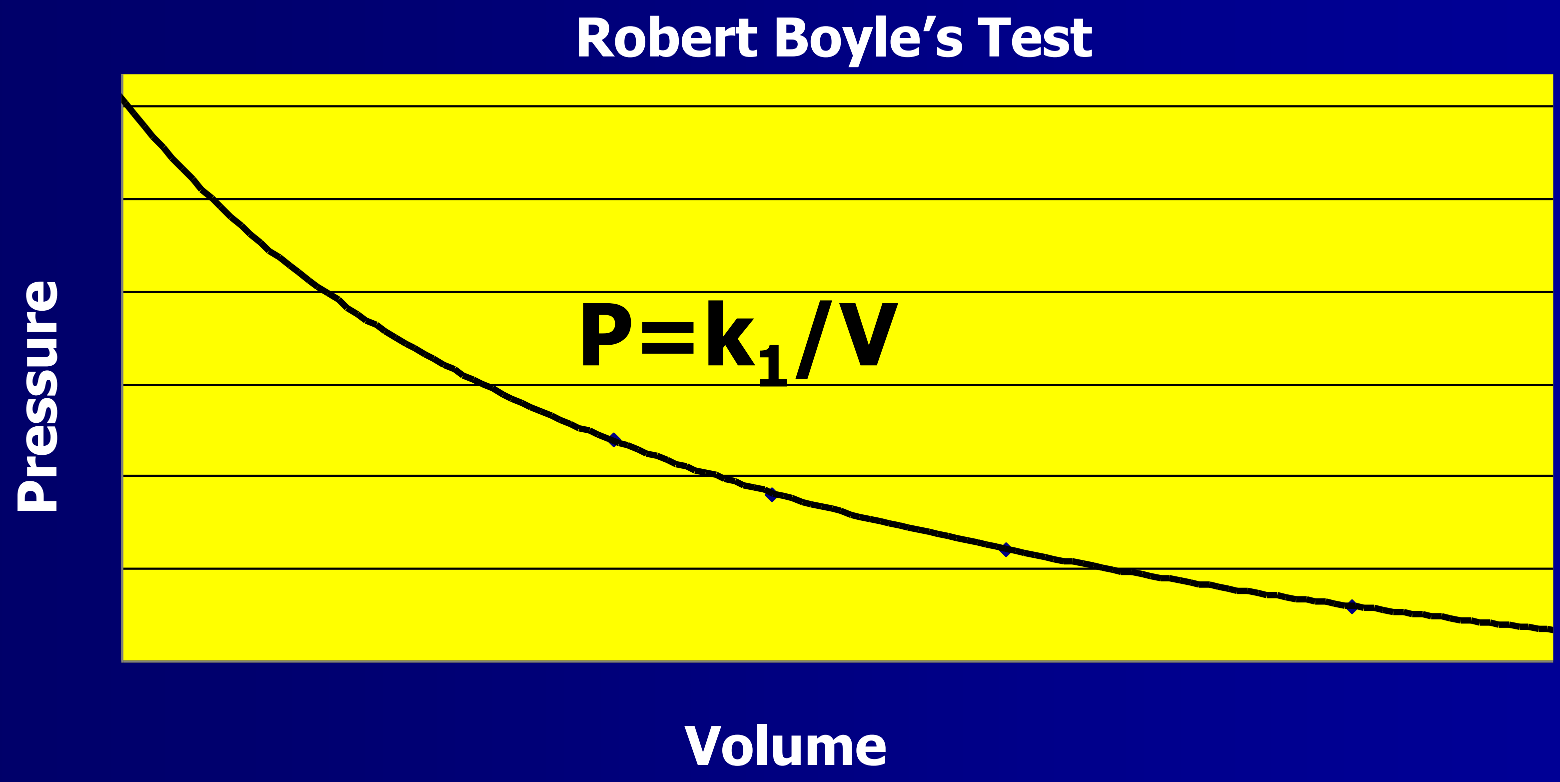
- Fahrenheit based on a salt-water solution.
  - Rankine ≅ Fahrenheit
  - Kelvin ≅ Celsius
- Kelvin should be used.
  - Never Negative.
  - $T_K = T_{°C} + 273.15$



Gas Laws: Boyle

(1627-1692)

- **While looking at gasses Boyle found that for any gas the following is true.**



Gas Laws: Boyle

- Doing this experiment multiple times, he found that P=k/V or PV=k.
  - This assumes a constant Temperature.
- For any sample of gas the following is true:

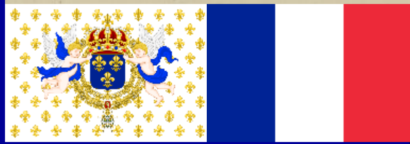
$P_1V_1=k_1$ and $P_2V_2=k_1$

so…

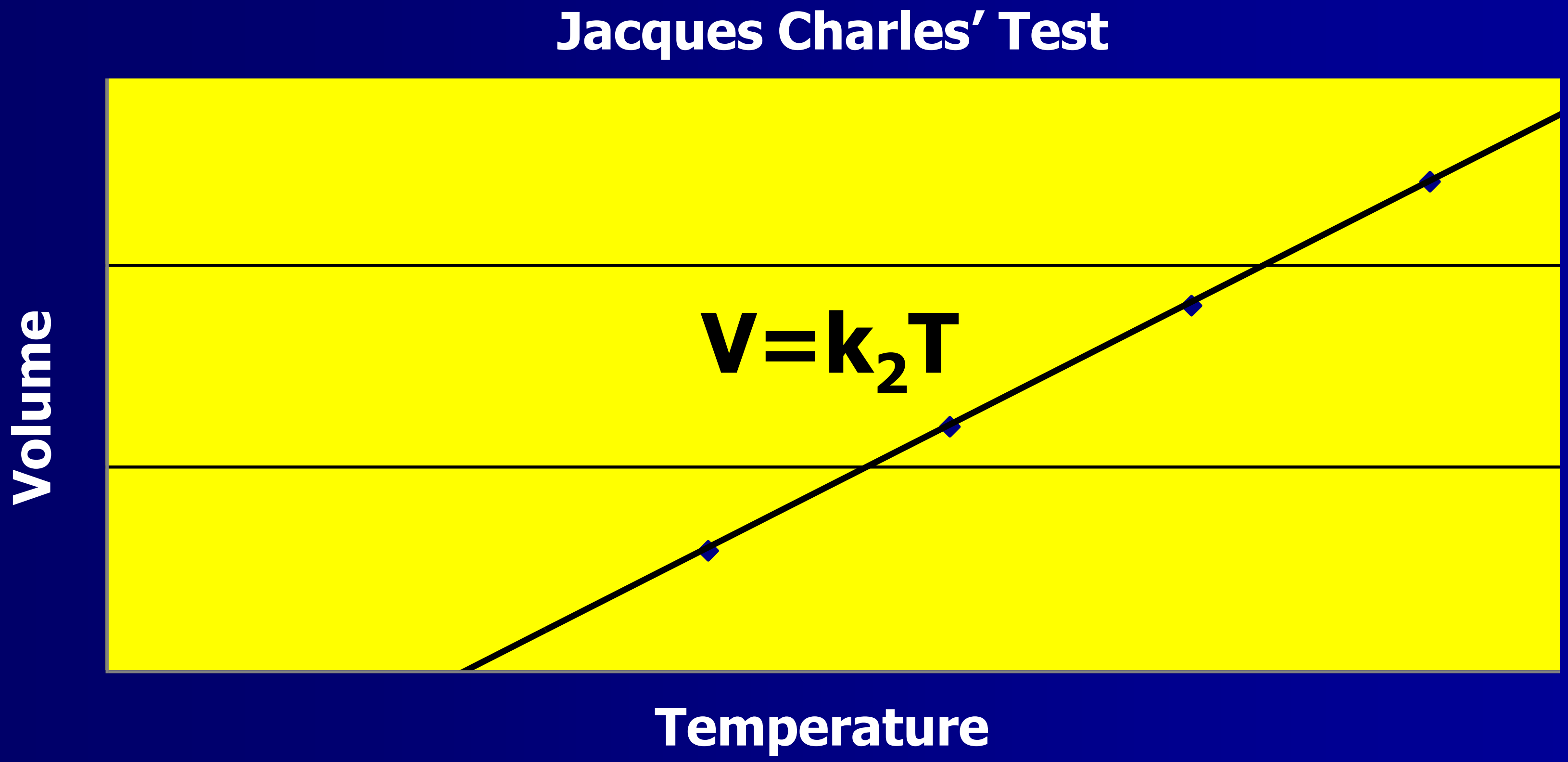
$$P_1V_1=P_2V_2$$

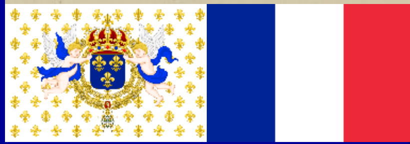
Gas Laws: Charles

- While looking at gasses it was found that for any gas the following is true.



(1746-1823)





Gas Laws: Charles

- Doing this experiment multiple times, he found that $V=k_2T$.
  - This assumes a constant Pressure.
- For any sample of gas the following is true:

$$V_1=k_2T_1 \qquad \text{and} \quad V_2=k_2T_2$$

so…

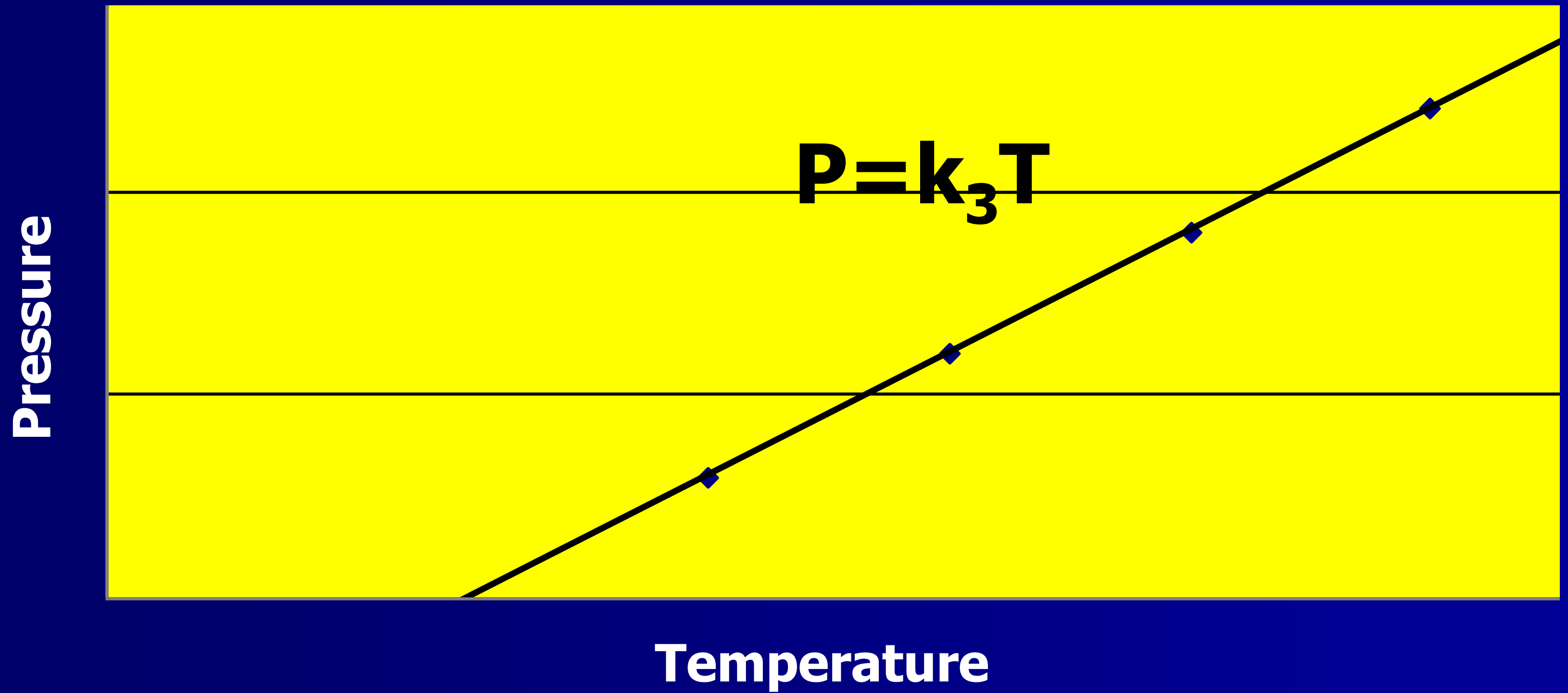
$$V_1/T_1=V_2/T_2$$

Gas Laws: Gay-Lussac

(1778-1850)

- **While looking at gasses it was found that for any gas the following is true.**

Joseph Louis Gay-Lussac's Test



Gas Laws: Gay-Lussac

- Doing this experiment multiple times, he found that $P=k_3T$.
  - This assumes a constant Volume.
- For any sample of gas the following is true:

$$P_1=k_3T_1 \quad \text{and} \quad P_2=k_3T_2$$

so…

$$P_1/T_1=P_2/T_2$$

Gas Laws: Avagadro

(1776-1856)

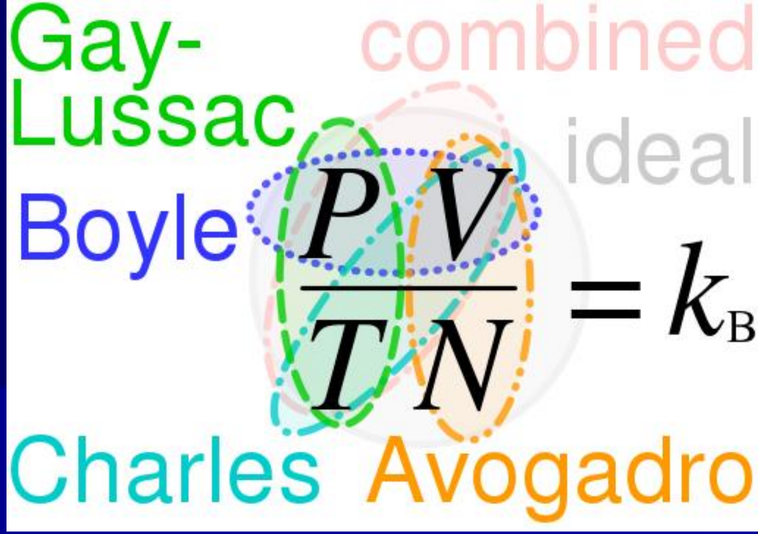
- **Avagadro already stated that at a constant pressure and temperature the Volume of any gas is proportional to the amount.**

$$V_1=k_4n_1 \qquad \text{and} \quad V_2=k_4n_2$$

so...

$$V_1/n_1=V_2/n_2$$

Gas Law's: Combined



PV=nRT

This is called the Ideal Gas Law.

R=.0821-atm·L/mol·K

R=8.314-Pa·m³/mol·K

R: Depends on the Pressure and Volume given (n→moles, T→K always)

If a gas changes condition ("then"):

Before = After

$$\frac{PV}{nT} = \frac{PV}{nT}$$

Gas Law Example: Combined

- At 300-K a balloon at 1.75-atm has a volume of 2-L. The temp drops to 250-K and then has a volume of 2.3-L. What is the new Pressure?

$$\frac{PV}{\cancel{n}T} = \frac{PV}{\cancel{n}T} \qquad \frac{1.75 - atm \cdot 2 - \cancel{L}}{300 - \cancel{K}} = \frac{P \cdot 2.3 - \cancel{L}}{250 - \cancel{K}}$$

$$.011667 - atm = .0092 \cdot P$$

$$1.26 - atm = P$$

1.3-atm

Gas Law Example: Ideal

- In a tire what volume does 6-moles of N_2 occupy at 1.5-atm and 16°-C?

$$PV = nRT$$

$$1.5 - \cancel{atm} \cdot V = 6 - \cancel{mol} \cdot .0821\,\frac{\cancel{atm} \cdot L}{\cancel{mol} \cdot \cancel{K}} \cdot 289.15 - \cancel{K}$$

$$1.5\,V = 142.43529 - L$$

$$V = 94.95686 - L$$

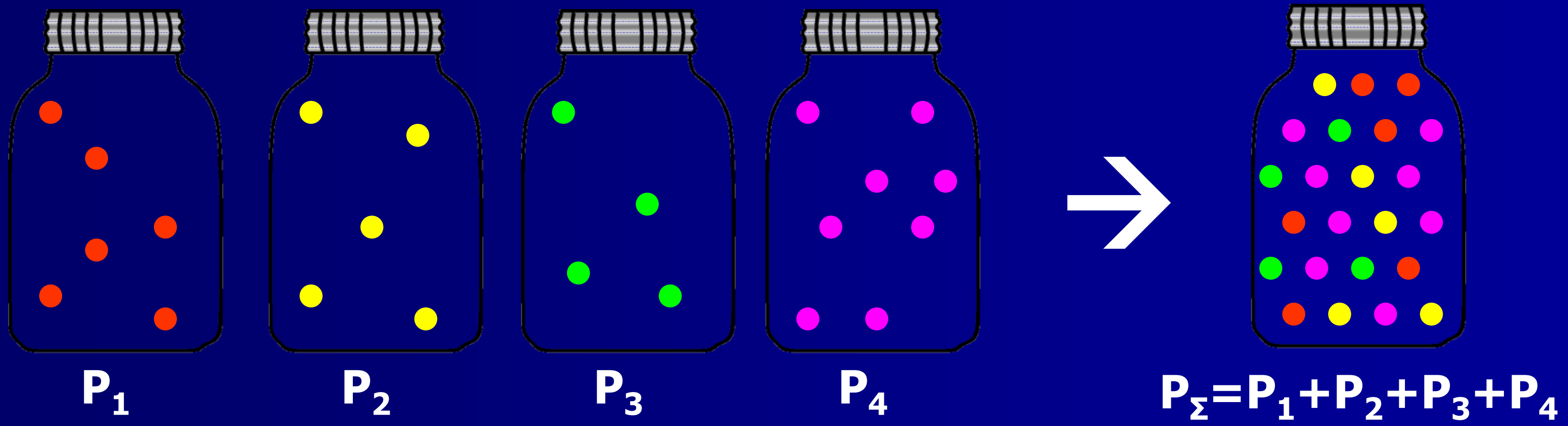
P = 1.5-atm
V = ?
n = 6-mol
R = .0821-atm·L/mol·K
T = 16 + 273.15 →
T = 289.15-K

95.0-L

Gas Law: Dalton

(1766-1844)

- John Dalton spent his time looking at Pressure. Dalton stated gasses with different Pressures…



- Put together in the same size container, the total Pressure is the sum the parts.