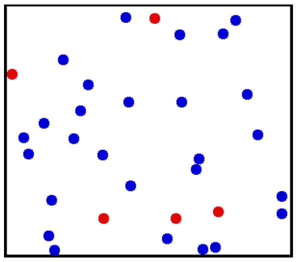
5.1 - 5.2 Gas Laws - Constant Amount

What keeps the hot air balloons up?

Gas Particles

Kinetic Molecular Theory - assumes that particles in a gas sample are far apart, so their size has little influence on the volume occupied by the gas (lots of space between them).

Each particle has kinetic energy - energy of motion. More on that later.



Box of Gas!

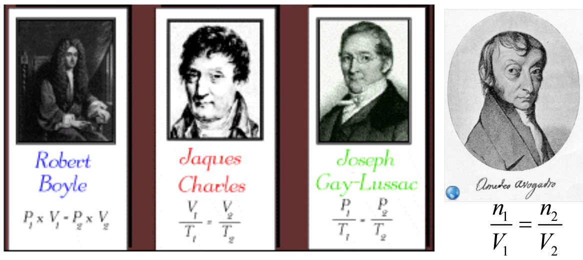
1. Pressure: A Can vs. Atmosphere

Watch this! What happens to the can, and why? Write down your observations.

Intro to Gases - 4 Laws

Gases respond predictably to changes in pressure, temperature, volume and number of particles.

For a fixed amount of gas, a change in one variable (pressure, temperature, volume) affects the others.



Pressure Details

Pressure: force per unit area:

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

System Pressure: pressure exerted on walls of container by an enclosed gas.

Air Pressure: pressure exerted in all directions from the particles in air.

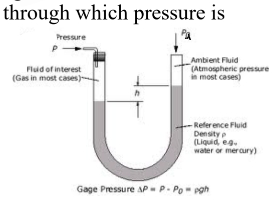
Absolute Pressure: sum of system pressure and air pressure.

Pressure Measurement

Several devices measure pressure.

You've probably used a spring-loaded tire gauge.

A manometer is a U-shaped tube open to the atmosphere on one end, and connected to a container of gas on the other.
A liquid in the tube acts a reservoir through which pressure is transmitted.
The pressure of the gas is balanced by the weight of the column of liquid and atmospheric pressure.



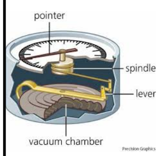
Manometer

Barometer

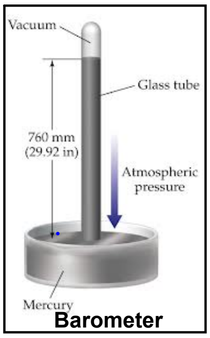
A closed tube of Hg is placed upside down in a dish.

Some of the Hg runs into the dish (creating a vacuum above the column), but atmospheric pressure prevents the rest from running out.

The column height is 760 mm Hg.



Aneroid barometers use a sensitive diaphragm enclosing a vacuum.



Pressure Units

Unit of pressure (for this class) is the atmosphere (atm). At sea level, 1.0 atm is the average pressure that the air exerts.

Other Units of pressure:
SI units: Newton/meter^2 = 1 pascal (Pa)
1 atm = 101,325 Pa

In honor of Evangelista Torricelli, the inventor of the barometer another unit is the torr.
1 atm = 760 mm Hg = 760 Torr

Temperature Details

Temperature must be in **Kelvin**!

Kelvin scale is an absolute scale → 0 K is the lowest possible temperature.

At this point, all molecular motion is stopped.

Celsius to Kelvin:
$Temp_K = °C + 273$

Kelvin to Celsius:
$Temp_{°C} = K - 273$

Boyle's Law - Constant Temperature

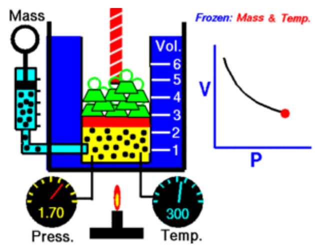
The volume of a gas is inversely proportional to its pressure at constant temperature and moles.
From condition 1 to condition 2:

Boyle's Law

$P_1V_1 = P_2V_2$	P = pressure V = volume

A note on units: they can be anything, as long as they're the same!

Construction Set Piston Demo.



2. Boyle's Law Example

A gas' volume at 9.9 atm is 300.0 mL. If pressure decreases to 3.4 atm, what is the new volume?

Data:

$P_1 = 9.9\,atm$
$V_1 = 300.0\,mL$
$P_2 = 3.4\,atm$
$V_2 = ?$

$$P_1V_1 = P_2V_2$$

$$V_2 = \frac{P_1 \bullet V_1}{P_2} = \frac{9.9\,atm \bullet 300.0\,ml}{3.4\,atm}$$

$$= 874\,ml$$

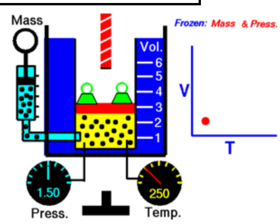
Charles' Law: Constant Pressure

The volume of gas is directly proportional to its Kelvin temperature (constant pressure).
From condition 1 to condition 2:

Charles' Law

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$	V = volume T = temperature (Kelvins)

Balloon on vol. flask demo.



The Quest for Absolute Zero

The relation of temperature vs. volume originally led to the idea of an absolute lowest temperature.

All gases at temperatures well above their condensation points expanded identically, and extrapolating a Temp. vs Volume graph to 0 volume yielded an approximation of absolute zero.

Original work was done on many gases at 0 °C and 100 °C, due to the ease of achieving these temperatures in a lab, and the first absolute zero value was proposed in 1848 by William Thompson, later known as Lord Kelvin.

3. Charles's Law Example

A balloon containing 1.30 L of air at 24.7°C is placed into a beaker containing liquid nitrogen at -78.5°C. What will the new volume of air be?

Data:

$V_1 = 1.30\,L$

$T_1 = 24.7\,^\circ C = 297.7\,K$

$T_2 = -78.5\,^\circ C = 194.5\,K$

$V_2 = ?$

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

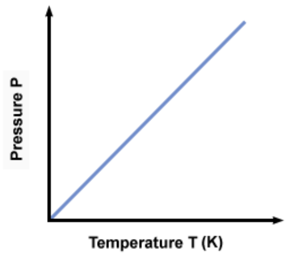
$$V_2 = \frac{T_2 \bullet V_1}{T_1} = \frac{194.5\,K \bullet 1.30\,L}{297.7\,K}$$

$$= \boxed{0.849\,L}$$

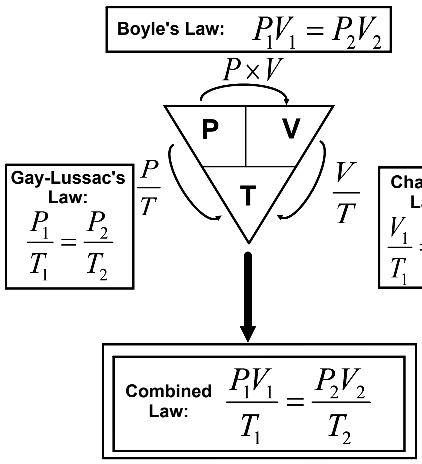
Gay-Lussac's Law: Constant Volume

The pressure of a gas is directly proportional to the Kelvin temperature (constant volume).

Gay-Lussac's Law	
$\frac{P_1}{T_1} = \frac{P_2}{T_2}$	P = absolute pressure T = temperature (Kelvins)



Pictorial Aid & Combined Law



4. Which Law?

A rigid steel container holds 1.00 L of methane gas at 6.6 atm when the temperature is 22 °C.

What's the pressure at 45 °C?

Which Law is useful? Gay-Lussac's.

Convert Celsius to Kelvin: 22.0 °C = 295 K
45 °C = 318 K.

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

$$P_2 = \frac{P_1 \bullet T_2}{T_1} = \frac{6.6\,atm \bullet 318\,K}{295\,K} = 7.1\,atm$$

Avogadro's Law: Constant T & P

The volume of a gas is directly proportional to the number of moles (constant temperature and pressure).

Avogadro's Law	
$\frac{n_1}{V_1} = \frac{n_2}{V_2}$	**n = number of moles** **V = volume**

5. If 2.45 mol of argon gas is 89.0 L, what volume will 2.10 mol Ar occupy (at same T and P)?

$$\frac{n_1}{V_1} = \frac{n_2}{V_2}$$

$$V_2 = \frac{V_1 \bullet n_2}{n_1} = \frac{89.0\,L \bullet 2.1\,mol}{2.45\,mol} = \boxed{76.3\,L}$$

Homework:

Read 5.3 in your book.

Complete 5.1 - 5.2 Problems
Due: Next Class