Chem Unit 11.1 Notes - Gas Laws

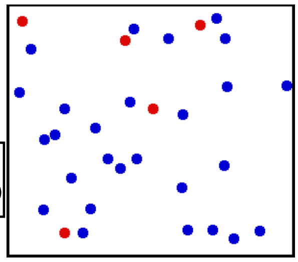
11.1 - Gas Laws

More

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:

$K = \frac{1}{2}mv^2$	m = mass (kg) v = velocity (m/s)

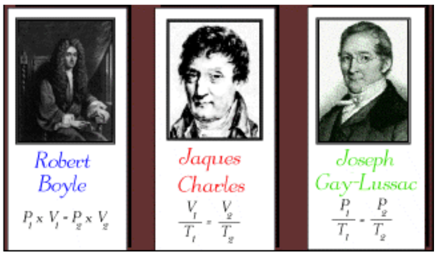
Intro to Gases - 3 Laws

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.

Meet the Ancient Gas Law Scientists!

Gases were studied extensively in the late 1600's into early 1700's, and the three major Laws were discovered by the following people:



A Note on Temperature

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:
$Temp_K = °C + 273$

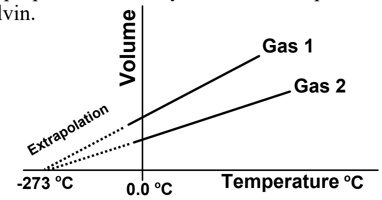
Kelvin to Celsius:
$Temp_{°C} = K - 273$

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.



Chem Unit 11.1 Notes - Gas Laws

1. Temperature Conversions

A. Convert 245 °C to Kelvins.

$Temp_K = °C + 273$
$= 245\ °C + 273$
$= 518\ K$

B. Convert 350 K to °C.

$Temp_{°C} = K - 273$
$= 350\ K - 273$
$= 77\ °C$

Pressure:

Definition: force per unit area.

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

Unit of pressure (for this class) is the atmosphere (atm).

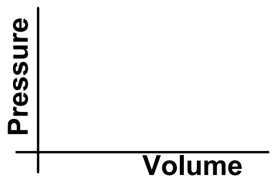
At sea level, 1.0 atm is the average pressure that the air exerts.

Pressure Gauge Exercise

Try This!

Develop a relation between pressure and volume for the construction set syringe system. When you mess with one, what happens to the other?

NEXT: Draw a crude sketch of pressure vs. volume:

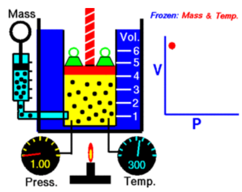


Boyle's Law - Constant Temperature

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

Boyle's Law	
$P_1V_1 = P_2V_2$	P = absolute pressure V = volume

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



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:

$P_1 = 9.9\, atm$

$V_1 = 300.0\, mL$

$P_2 = 3.4\, atm$

$V_2 = ?$

$$P_1V_1 = P_2V_2$$

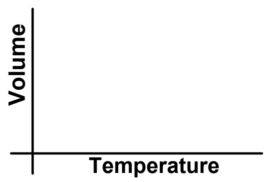
$$V_2 = \frac{P_1 \cdot V_1}{P_2} = \frac{9.9\, atm \cdot 300.0\, ml}{3.4\, atm}$$

$$= 874\, ml$$

Temperature Vs. Volume!

Observe the balloon, as I put the flask into the hot water bath. What happens?
Develop a relation between temperature and volume for this system. When you mess with one, what happens to the other?

NEXT: Draw a crude sketch of temperature vs. volume:



Chem Unit 11.1 Notes - Gas Laws

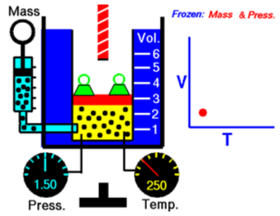
Charles' Law: Constant Pressure

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)

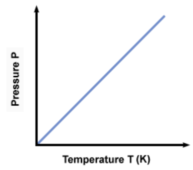


Gay-Lussac's Law: Constant Volume

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)



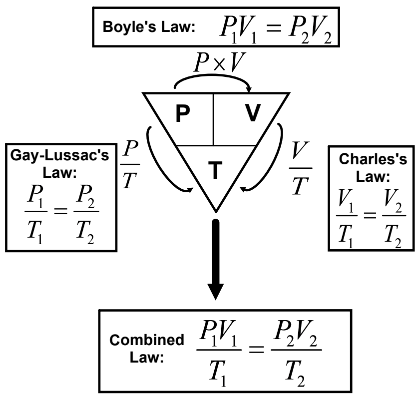
Combined Gas Law

Combined Gas Law: when more than one variable is changed for a fixed amount of gas:

Combined Law: $$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Remember: all these laws are for a fixed amount of gas.

Combined Gas Law: Pictorial Aid



3. 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.

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

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

Homework:

11.1 Problems
Due: Next Class