2.A.3 - Gas Laws Part 1: Constant Amount

Demo: Heating and Expanding Gas

Heat causes matter to expand by causing molecules to move faster.

Observe the balloon with lead shoes as the water heats it up.

If time/available): marshmallow in microwave.

Who's Heard of STP?

Not the Stone Temple Pilots (90's era grunge band).

Stands for: **S**tandard **T**emperature and **P**ressure

Defined: 0 degrees Celsius (273 K), and 1.0 atm (1.0 E 5 Pa) of pressure.

The utility of STP is that a lot of gas problems start at STP before changes occur (temp, pressure, volume, amount of gas).

Gas Laws

Different gases have different expansion properties, but at low densities, all gases behave the same.

To simplify calculations, we use Ideal Gases (a theoretical condition).

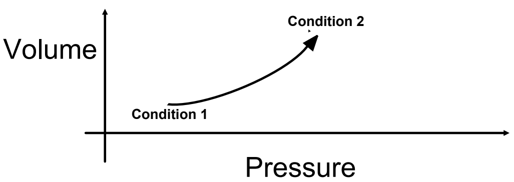
They have no:

- mass,
- electrostatic interactions
- volume,
- collisions with each other or the container.

Graphical Notes:

In graphing gaseous processes (going from one state to another in pressure vs. volume graphs), use these guidelines:

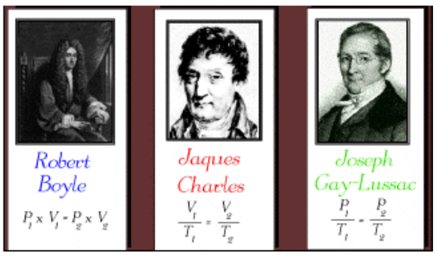
1. Process Arrows show direction.
2. Graphs shouldn't start at zero.
3. Different processes have specific shapes.



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.



Boyle's Law - Constant Temperature

The volume of a gas is inversely proportional to its pressure at constant temperature.

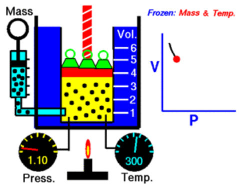
From condition 1 to condition 2:

$P_1V_1 = P_2V_2$	P = absolute pressure V = volume

Remember: Absolute pressure is gauge pressure plus atmospheric pressure.

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

Construction Set Syringe Demo.



1. Boyle's Law Example

The volume of a gas at 99.0 kPa is 30.0 m³. If the pressure is increased to 188 kPa, what will be the new volume?

Organize data first:

$P_1 = 99.0\,kPa$

$V_1 = 300.0\,mL$

$P_2 = 188\,kPa$

$V_2 = ?$

$$P_1V_1 = P_2V_2$$

$$V_2 = \frac{P_1 \bullet V_1}{P_2} = \frac{99.0\,kPa \bullet 30.0\,m^3}{188\,kPa}$$

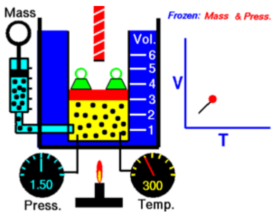
$$= 15.8\,m^3$$

Charles' Law: Constant Pressure

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

From condition 1 to condition 2:

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



Charles' Law Exercise: The Quest for Absolute Zero

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

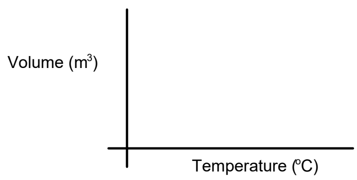
All gases at temperatures well above their condensation points expanded identically, and extrapolating a Temp. vs Volume graph to 0 volume yielded an approximation of absolute zero.

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.

2. The Quest for Absolute Zero

At 0 °C, a gas' volume is 0.0227 m³.

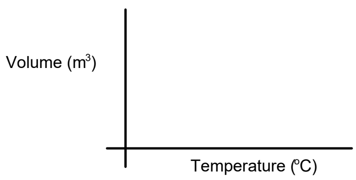
Determine the volume at 100 °C, then graphically determine a Celsius approximation of absolute zero using the two data points, where a hypothetical volume of zero m³ is reached.



Absolute Zero Answer

Determine the second volume:

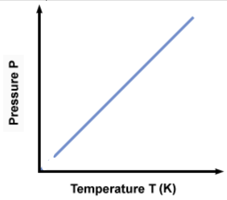
$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$



Gay-Lussac's Law: Constant Volume

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

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$	P = absolute pressure T = temperature (Kelvins)



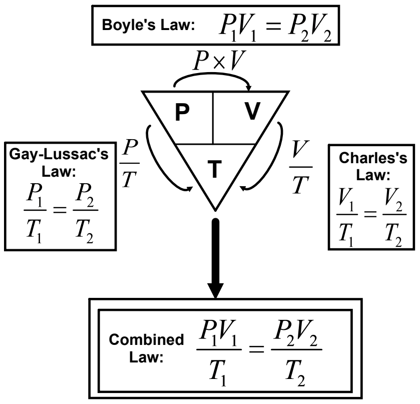
Combined Gas Law

When more than one variable is changed for a fixed amount of gas, use the Combined Gas Law:

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

Remember: these laws are for a <u>fixed amount</u> of gas.

Combined Gas Law: Pictorial Aid



3. Steel Container Example

A <u>rigid</u> steel container holds 1.00 L of methane gas at 660 kPa (abs.) 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.

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

$$P_2 = \frac{P_1 \cdot T_2}{T_1} = \frac{660\,kPa \cdot 318\,K}{295\,K} = 711\,kPa$$

Homework

Preview 2.A.4

2.A.3 Problems in your Booklets
Due: Next Class.