Gas Laws

Boyle's Law

In the mid 1600's, Robert Boyle studied the relationship between the pressure **P** and the volume **V** of a confined gas held at a constant temperature. Boyle observed that the product of the pressure and volume are observed to be nearly constant. The product of pressure and volume is exactly a constant for an **ideal gas**.

P x V = constant

This relationship between pressure and volume is called **Boyle's Law** in his honor.

Boyle's Law - P & V

- Boyle's law states that for a given mass of gas at constant temperature, the volume of the gas varies inversely with pressure.
- As one goes up the other goes down

Boyle's Law - P & V

$P_1 V_1 = P_2 V_2$

As pressure changes,
so does the volume of a gas
at constant temperature.

Sample Problem

A gas at STP with a volume of 5.0 L, is compressed from 760 mm Hg to 2,000 mm Hg.

If the temperature remains constant, what will be the new volume of the gas?

A) 1.9L B) 13L C) 3.0×10^5 D) none of these

Solution

$P_1 V_1 = P_2 V_2$

P_1 = ___ P_2 = ___

V_1 = ___ V_2 = ___

Solution

$P_1 = 760$ mm Hg $\quad P_2 = 2{,}000$ mm Hg

$V_1 = 5.0$ L $\quad V_2 = V$ L

$760 \text{ mm Hg} \cdot 5.0 \text{ L} = 2{,}000 \text{ mm Hg} \cdot V \text{ L}$

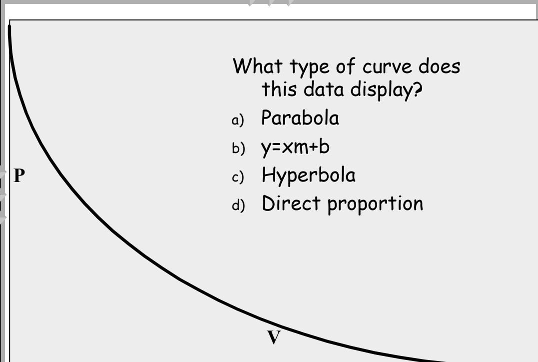
$$\frac{760 \text{ mm Hg} \cdot 5.0 \text{ L}}{2{,}000 \text{ mm Hg}} = V \text{ L} = 1.9\text{L}$$

Boyle's Law - P & V

(Temperature and number of particles remain constant.)

Create a graph that shows the data collected by the affect of pressure changes on volume.

Trial#	Pressure	Volume
1	200	0.5
2	100	1.0
3	50	2.0
4	40	2.5



What type of curve does this data display?

a) Parabola
b) y=xm+b
c) Hyperbola
d) Direct proportion

Boyle's Law - P & V

- Hyperbola curve relationship
- This means that pressure times volume will create a constant that we can use for any gas.

  $P \times V = k$

Charles Law

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

- 6-charleslaw.mov

Charles Law

- The volume of a gas at constant pressure is directly related to its Kelvin temperature.
- Absolute zero - lowest possible temp. = -273.15°C = 0 K
- 0 °C = 273 kelvins

Charles Law

Collect data and create a graph. Interpolate the data to the temperature where the volume of the sample gas is infinitely small.

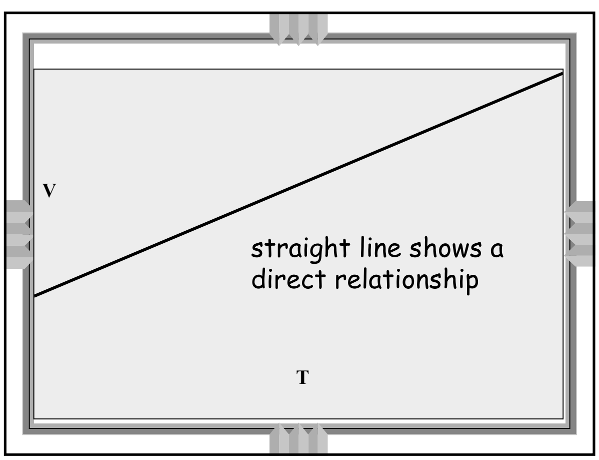
Volume of gas sample vs. Temperature

Volume	Temperature
	0° C
	100° C
	-45 °C

Charles Law

Volume of gas sample vs. Temperature

Volume	Temperature
8L	0° C
11L	100° C
6.6L	-45 °C



Notice that the four points are nearly collinear.

If we extend this line to where the volume is 0 we should find absolute zero.

Therefore, the relationship of temperature to volume is:

$k = V/T$

$k = V/T$

- If we take two measurements, they should each equal k.
- Therefore, the data in the equations will be equal.

$$V_1 / T_1 = V_2 / T_2$$

Sample Problem

A balloon inflated in a room at 24 °C has a volume of 4.00 L. The balloon is then heated to a temperature of 58 °C. What is the new volume if the pressure remains constant?

A) 348L B) 4.46L C) 1.65L

Solution

Temperature MUST always be expressed in Kelvin

$V_1/T_1 = V_2/T_2$

V_1 = ____ V_2 = ____

T_1 = ____ T_2 = ____

V_2 = 4.46 L

Tomorrow

Gay-Lussac's Law

Combined Gas Law