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**.

$$P \times V = \text{constant}$$

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 $P_2 = 2{,}000$ mm Hg

$V_1 = 5.0$ L $V_2 = V$ L

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

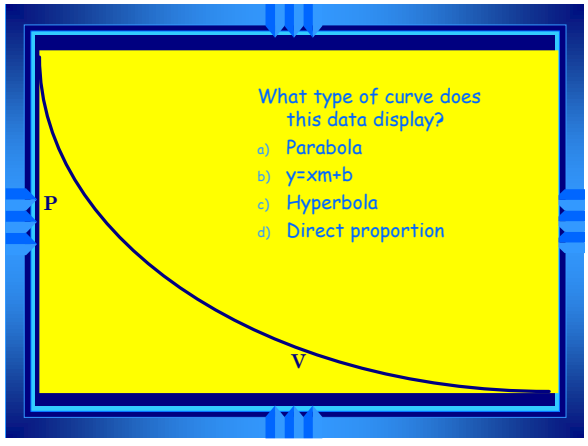
$$\frac{760 \text{ mm Hg} \cdot 5.0 \text{ L}}{2{,}000 \text{ mm Hg}} = V \text{ L} = 1.9 \text{L}$$

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 (kPa)	Volume L
1	200	0.5
2	100	1.0
3	50	2.0
4	40	2.5



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.

$$P \times V = k$$

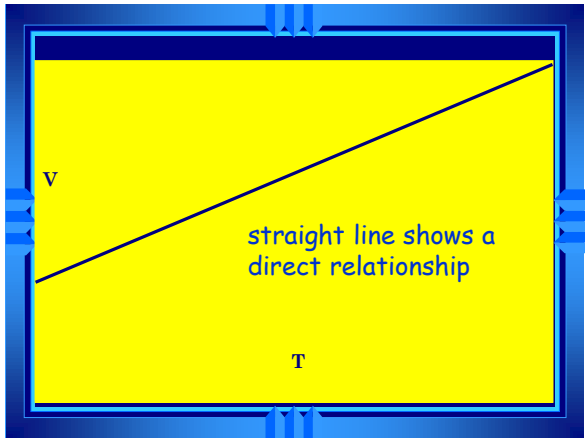
Charles Law

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

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



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

$V_1/T_1 = V_2/T_2$

$V_1 =$ 4 L $V_2 =$?

$T_1 =$ 297 K $T_2 =$ 331 K

$V_2 = 4.46$ L

Combined Gas Law

The Combined Gas Law

- Combining Boyle's Law and Charles' Law results in a new gas law, the ***Combined Gas Law***, which is used when pressure, volume and temperature all change while the number of gas molecules remain constant.

$$\frac{PV}{T} = k \quad \text{therefore} \quad \frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

The Combined Gas Law

- Example:

  Find the volume of a gas at 110.0 kPa and 35.0°C if its volume at 98.0 kPa and 15.0 0°C is 7.50 L ?

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} \quad \text{rearranges to} \quad V_2 = \frac{P_1V_1T_2}{T_1P_2}$$

$$V_2 = \frac{(98.0\ \text{kPa})(7.50\ \text{L})(308.2\ \text{K})}{(110.0\ \text{kPa})(288.2\ \text{K})} = 7.1\ \text{L}$$