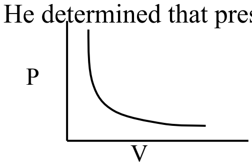
NS D.1 (pg 1 of 1) The Relationship Between the Four Variables P, V, T, n

Pressure and Volume – Boyles' Law

The first quantitative experiments on gases were performed by the Irish chemist Robert Boyle during the mid 1600's. Boyle measured the relationship between the pressure on a gas and its resulting volume. He determined that pressure and volume are inversely proportional.

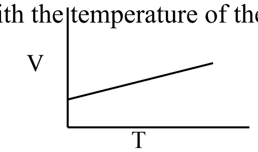


$P \alpha 1 / V$ which gives rise to the mathematical relationship,
$P * V = k$ where k is a constant at a particular temperature.

Since Boyles work in the 1600's more sophisticated measuring techniques have shown that this mathematical relationship holds only at lower temperatures and pressures. A gas that obeys Boyles law is called an ideal gas. For now, we will assume all gases are ideal gases, and reserve our discussion for deviations from the ideal until later.

Volume and Temperature – Charles' Law

In the late 1700's a French physicist, Jacques Charles (the first person to fill a balloon with hydrogen and who made the first solo balloon flight) determined that the volume of a gas at constant pressure increases linearly with the temperature of the gas. That is to say that the volume and temperature of a gas are directly proportional.

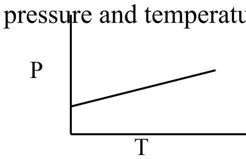


$V \alpha T$ which gives rise to the mathematical relationship,
$V / T = k$ where k is a constant at a particular pressure.

Again, a gas that obeys Charle's law is called an ideal gas. For now, we will assume all gases are ideal gases, and reserve our discussion for deviations from the ideal until later.

Pressure and Temperature – Gay-Lussac's Law

Jacques Charles (and a second French scientist Joseph Gay-Lussac, another balloonist) also determined that the pressure of a gas at constant volume increases linearly with the temperature of the gas. That is to say that the pressure and temperature of a gas are directly proportional.

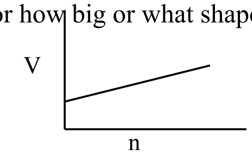


$P \alpha T$ which gives rise to the mathematical relationship,
$P / T = k$ where k is a constant at a particular pressure.

Again, a gas that obeys Gay-Lussac's law is called an ideal gas. For now, we will assume all gases are ideal gases, and reserve our discussion for deviations from the ideal until later.

Moles and Volume – Avogadro's Law

Amedeo Avogadro was an Italian chemist who proposed that the volume of a gas (at a particular temp and pressure) is completely dependent on how many moles of gas are in that container. It does not matter what gas it is or how big or what shape its molecules are. That is to say that the number of moles and volume of a gas are directly proportional.



$V \alpha n$ which gives rise to the mathematical relationship,
$V / n = k$ where k is a constant at a particular pressure.

Again, a gas that obeys Avogadro's law is called an ideal gas. For now, we will assume all gases are ideal gases, and reserve our discussion for deviations from the ideal until later.

Yikes, do I have to learn 4 separate laws???

NO, put P, V, T and n together into the single Combined Gas Law

We can use this law to solve any "before and after" type gas problems. If any one of the variables stays constant in the problem, it will simple cancel out..

$$\frac{P_1 V_1}{n_1 T_1} = \frac{P_2 V_2}{n_2 T_2}$$

The mathematical relationship only works when the temperature is in Kelvin.

Note the direct relationship between pressure and volume to temperature is only mathematically effective when the Kelvin scale is used. For instance when a gas in a rigid container at 300 mm pressure is heated from 20ºC to 40ºC, the pressure does not double. Instead in increases only by a factor of 1.07 (313 K / 293 K)

Standard Temperature and Pressure - STP

Standard Temperature = 0ºC (273 K) and Standard Pressure = 760 mm = 1 atm