The Gas Laws:

Pressure Volume Temperature Relationships

Boyle's Law: The Pressure-Volume Law

Boyle's law or the pressure-volume law states that the volume of a given amount of gas held at constant temperature varies inversely with the applied pressure when the temperature and mass are constant.

$$V \propto \frac{1}{P}$$

Another way to describing it is saying that their products are constant.

$PV = C$

When pressure goes up, volume goes down. When volume goes up, pressure goes down.
From the equation above, this can be derived:

$P_1V_1 = P_2V_2 = P_3V_3$ etc.

This equation states that the product of the initial volume and pressure is equal to the product of the volume and pressure after a change in one of them under constant temperature. For example, if the initial volume was 500 mL at a pressure of 760 torr, when the volume is compressed to 450 mL, what is the pressure?
Plug in the values:

$P_1V_1 = P_2V_2$

(760 torr)(500 mL) = P_2(450 mL)
760 torr x 500 mL/450 mL = P_2 844 torr = P_2
The pressure is 844 torr after compression.

Charles' Law: The Temperature-Volume Law

This law states that the volume of a given amount of gas held at constant pressure is directly proportional to the Kelvin temperature.

$V \propto T$

Same as before, a constant can be put in:

$V / T = C$

As the volume goes up, the temperature also goes up, and vice-versa. Also same as before, initial and final volumes and temperatures under constant pressure can be calculated.

$V_1 / T_1 = V_2 / T_2 = V_3 / T_3$ etc.

Gay-Lussac's Law: The Pressure Temperature Law

This law states that the pressure of a given amount of gas held at constant volume is directly proportional to the Kelvin temperature.

$\boldsymbol{P \propto T}$

Same as before, a constant can be put in:

$\boldsymbol{P / T = C}$

As the pressure goes up, the temperature also goes up, and vice-versa. Also same as before, initial and final volumes and temperatures under constant pressure can be calculated.

$\boldsymbol{P_1 / T_1 = P_2 / T_2 = P_3 / T_3}$ **etc.**

Avogadro's Law: The Volume Amount Law

Gives the relationship between volume and amount when pressure and temperature are held constant. Remember amount is measured in moles. Also, since volume is one of the variables, that means the container holding the gas is flexible in some way and can expand or contract. If the amount of gas in a container is increased, the volume increases. If the amount of gas in a container is decreased, the volume decreases.

$\boldsymbol{V \propto n}$

As before, a constant can be put in:

$\boldsymbol{V / n = C}$

This means that the volume-amount fraction will always be the same value if the pressure and temperature remain constant.

$\boldsymbol{V_1 / n_1 = V_2 / n_2 = V_3 / n_3}$ **etc.**

The Combined Gas Law

Now we can combine everything we have into one proportion:

$V \propto \frac{T}{P}$

The volume of a given amount of gas is proportional to the ratio of its Kelvin temperature and its pressure.
Same as before, a constant can be put in:

$\boldsymbol{PV / T = C}$

As the pressure goes up, the temperature also goes up, and vice-versa. Also same as before, initial and final volumes and temperatures under constant pressure can be calculated.

$\boldsymbol{P_1V_1 / T_1 = P_2V_2 / T_2 = P_3V_3 / T_3}$ **etc.**

The Ideal Gas Law

The previous laws all assume that the gas being measured is an *ideal gas*, a gas that obeys them all exactly. But over a wide range of temperature, pressure, and volume, real gases deviate slightly from ideal. Since, according to Avogadro, the same volumes of gas contain the same number of moles, chemists could now determine the formulas of gaseous elements and their formula masses. The idea gas law is:

$\boldsymbol{PV = nRT}$

Where n is the number of moles of the number of moles and R is a constant called the universal gas constant and is equal to approximately 0.0821 L-atm / mole-K.

Partial Pressures

Dalton's Law of Partial Pressures states that the total pressure of a mixture of nonreacting gases is the sum of their individual partial pressures.

$\mathbf{P_{total} = P_a + P_b + P_c + ...}$

or

$\mathbf{P_{total} = n_aRT / V + n_bRT / V + n_cRT / V + ...}$

or

$$P_{total} = (n_a + n_b + n_c + \ldots)RT / V$$