The relationship between Kelvin temperature and gas volume is known as Charles's law. **Charles's law** *states that the volume of a fixed mass of gas at constant pressure varies directly with the Kelvin temperature*. Charles's law may be expressed as follows:

$$V = kT \quad or \quad V/T = k$$

The value of T is the Kelvin temperature, and k is a constant. The ratio V/T for any set of volume-temperature values always equals the same k. The form of Charles's law that can be applied directly to most volume-temperature problems involving gases is as follows:

$$V_1/T_2 = V_2/T_2$$

$V_1$and T_1 represents initial conditions. V_2 and T_2 represent a different set of conditions. When three of the four values T_1, V_1, T_2, *and* V_2 are known, you can use this equation to calculate the fourth value for a system at constant pressure.

Gay-Lussac's Law: Pressure-Temperature Relationship

As before, pressure is the result of collisions of molecules with container walls. The energy and frequency of collisions depend on the average kinetic energy of molecules. For a fixed quantity of gas at constant volume, the pressure of a confined gas changes by 1/273 of the pressure at 0°C. Joseph Gay-Lussac is given credit for recognizing this in 1802. **Gay-Lussac's Law** *is the pressure of a fixed mass of gas at constant volume varies directly with the Kelvin temperature.*

$$P = kT \text{ or } P/T = k$$

The value of T is the temperature in kelvins, and k is a constant that depends on the quantity of gas and the volume. For a given mass of gas at constant volume, the ratio P/T is the same for any set of pressure-temperature values. Unknown values can be found using this form of Gay-Lussac's law.

$$P_1/T_1 = P_2/T_2$$

P_1 and T_1 represent initial conditions. P_2 and T_2 represent a different set of conditions. When values are known for three of the four quantities, the fourth value can be calculated for a system at constant volume.

The Combined Gas Law

A gas sample often undergoes changes in temperature, pressure, and volume all at the same time. When this happens, three variables must be dealt with at once. Boyle's law, Charles's law, and Gay-Lussac's law can be combined into a single expression that is useful in such situations. *The* **combined gas law** *expresses the relationship between pressure, volume, and temperature of a fixed amount of gas.*

$$PV/T = k$$

In this equation, k is constant and depends on the amount of gas. The combined gas law can be written as:

$$\mathbf{P_1V_1/T_1 = P_2V_2/T_2}$$

The subscripts in the equation about indicate two different sets of conditions, and T represents Kelvin temperature.

From this expression, any value can be calculated if the other five are known. Note that each of the gas laws can be obtained from the combined gas law when the proper variable is constant. For example, Boyle's law is obtained when the temperature is constant. Because $T_1 = T_2$, T_1 and T_2 will cancel out on both sides of the combined gas law equation, giving Boyle's law.

$$P_1V_1 = P_2V_2$$