CHARLES' LAW:

In 1787, the French physicist Jacques Charles measured the volumes of samples of various gases at different temperatures. He plotted his data on a graph of volume vs. temperature, and noted that the data points for each gas lay on a straight line. The lines for different gases had different slopes.

Charles drew the following conclusions from these results:

1) The volume of a sample of a gas is directly proportional to the temperature of the gas. As the temperature increases, the volume also increases. In equation form, Charles' law can be written as:

\[ V = (\text{constant}) \times T \]

where \( V \) is the volume and \( T \) is the Kelvin temperature of the sample of the gas.

2) The lines on the graph all converged at the point on the graph which corresponded to a volume of zero and a temperature of \(-273^\circ\text{C}\). This is the lowest possible temperature, called absolute zero (zero on the Kelvin scale).

Problem: A balloon has a volume of 750 mL in a freezer whose temperature is \(-10^\circ\text{C}\). If the balloon is removed from the freezer and allowed to warm to room temperature \((25^\circ\text{C})\), what will be its volume?

Solution: A convenient form of Charles' law to use in this case is:

\[ \frac{V_i}{T_i} = \frac{V_f}{T_f} \]

where "i" and "f" indicate the initial and final conditions, respectively. Using the above temperatures as written leads to a negative value for the new volume. This isn't physically possible -- there's no such thing as a "negative volume"!

Converting the Celsius temperatures into Kelvin temperatures solves this problem:

\[ -10 + 273 = 263 \text{ K} = T_i \quad 25 + 273 = 298 \text{ K} = T_f \]

\[ V_f = \frac{V_i T_f}{T_i} = \frac{(750 \text{ mL}) \times (298 \text{ K})}{(263 \text{ K})} = 850 \text{ mL}. \quad \text{(Note: The balloon expands.)} \]