9.6: Pressure and Temperature

Learning Objectives

- Learn and apply Gay-Lussac's Law.

Propane tanks are widely used with barbeque grills. But it's not fun to find out halfway through grilling that you have run out of gas. You can buy gauges that measure the pressure inside the tank to see how much is left. The gauge measures pressure and will register a higher pressure on a hot day than it will on a cold day. So you need to take the air temperature into account when you decide whether or not to refill the tank before your next cook-out.

Gay-Lussac's Law

When the temperature of a sample of gas in a rigid container is increased, the pressure of the gas increases as well. This is because the increase in kinetic energy at higher temperatures results in the molecules of gas striking the walls of the container with more force, resulting in a greater pressure. The French chemist Joseph Gay-Lussac (1778-1850) discovered the relationship between the pressure of a gas and its absolute temperature. **Gay-Lussac's Law** states that the pressure of a given amount of gas varies in direct proportion to the absolute temperature of the gas, when the volume is kept constant. Gay-Lussac's Law is very similar to Charles's Law, with the only difference being the type of container. Whereas the container in a Charles's Law experiment is flexible, it is rigid in a Gay-Lussac's Law experiment.

The mathematical expressions for Gay-Lussac's Law are likewise similar to those of Charles's Law:

$$\frac{P}{T} = \text{constant} \tag{9.6.1}$$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \tag{9.6.2}$$

On the simulator in Figure 9.6.1 below, click the $\boxed{\text{Gay} - \text{Lussac's Law}}$ button. Then click on the $\Uparrow$ and $\Downarrow$ arrows to vary the temperature and the pressure. Then click the $\boxed{\text{Add Data}}$ button to add up to 5 points on the graph.

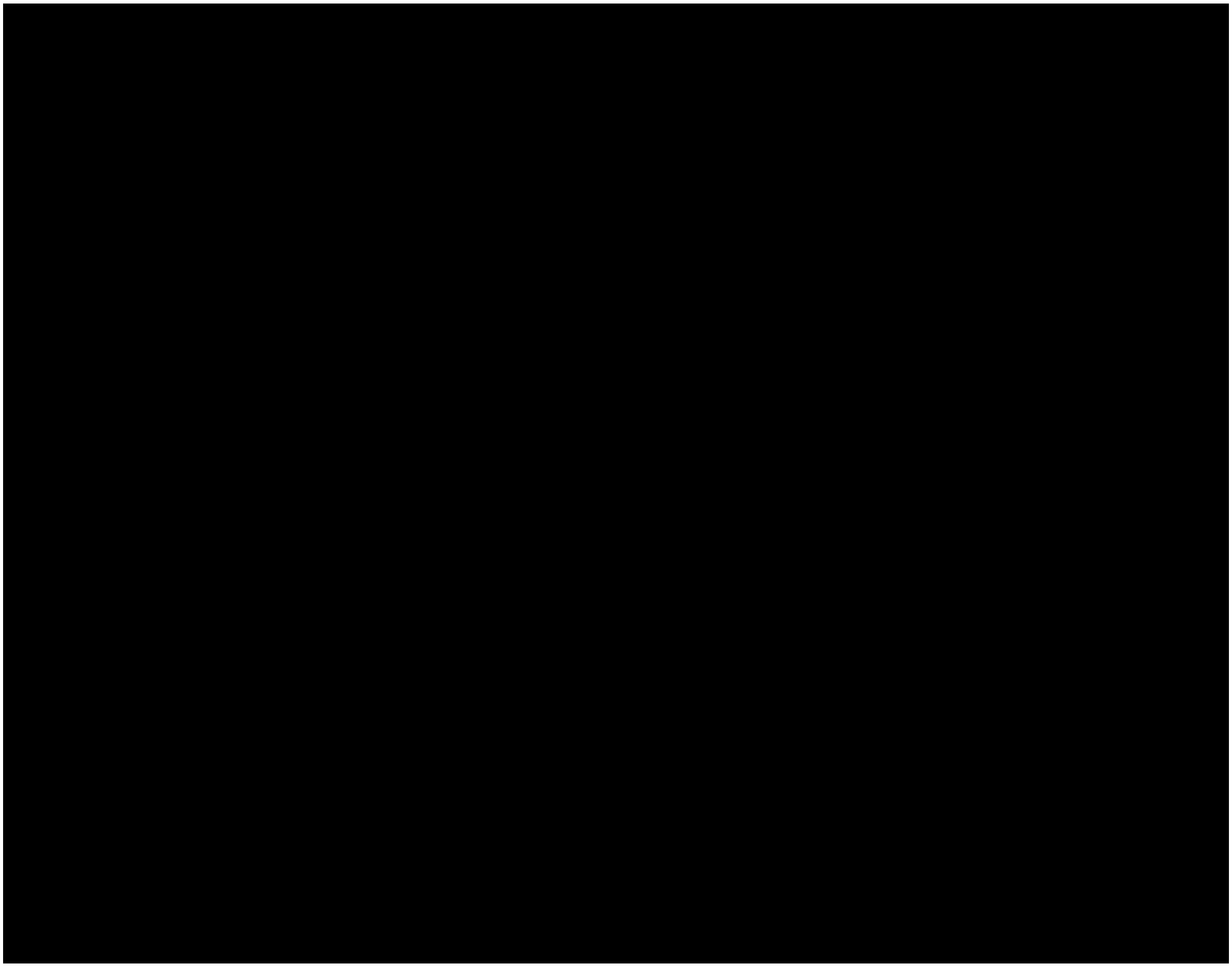

Figure 9.6.1: A gas laws simulator courtesy of teachchemistry.org.

Notice that the graph of pressure vs. temperature also illustrates a direct proportion. As a gas is cooled at constant volume, its pressure continually decreases until the gas condenses to a liquid.

✅ Example 9.6.1

The gas in an aerosol can is under a pressure of 3.00 atm at a temperature of 25ºC. It is dangerous to dispose of an aerosol can by incineration. Calculate the pressure in the aerosol can at a temperature of 845ºC.

Solution

Steps for Problem Solving	
Identify the "given" information and what the problem is asking you to "find."	Given: P_1 = 3.00 atm, T_1 = 25ºC = 298 K, T_2 = 845ºC = 1118 K Find: P_2 = ? atm

Steps for Problem Solving	
List other known quantities.	The temperatures were first converted to kelvins. $T_K = T_{°C} + 273.15$
Plan the problem.	Rearrange the equation to solve for P_2. $P_2 = \frac{P_1 \times T_2}{T_1}$
Calculate and cancel units.	Now substitute the known quantities into the equation and solve. $P_2 = \frac{3.00 \text{ atm} \times 1118 \cancel{\text{K}}}{298 \cancel{\text{K}}} = 11.3 \text{ atm}$
Think about your result.	The pressure increases dramatically due to a large increase in temperature.

Exercise 9.6.1

An incandescent lightbulb has an internal pressure of 13.9 psi at 20°C. It is designed to withstand an internal pressure of up to 41.7 psi. To what temperature, in °C, may the bulb be heated before it exceeds the maximum pressure it was designed to withstand?

Answer

606°C

Summary

- Pressure and temperature at constant volume are directly proportional.