

Demonstration 5

Adiabatic Expansion

An adiabatic process is one in which there is no loss or gain of heat. In an adiabatic expansion external work is done at the expense of the internal energy of the gas and results in lower temperature of the gas molecules.

According to the kinetic theory of gases, all gas molecules are in continuous motion and their kinetic energy is a measure of the absolute temperature of the gas. As the temperature increases, the molecules move faster. When a gas is expanded, as in the case of air being pumped from a vacuum system, the gas molecules will do work by expanding into vacated spaces in an attempt to equalize the pressure. The work to do this is obtained at the expense of the internal kinetic energy of the gas. The result is a decrease in the temperature of the gas molecules. If the expansion is so fast that very little heat energy can be transferred to the gas, it can be considered adiabatic.

The adiabatic expansion of a gas can be demonstrated in two ways with a simple vacuum system. The first way is to simply place a thermometer in a vacuum system and observe the temperature as the system is evacuated. If the pumping speed of the system is rapid, the temperature will drop by several degrees; however, it will begin to rise again as the system comes to thermal equilibrium. The second way to demonstrate adiabatic expansion is to produce a cloud chamber by introducing water vapor into a chamber and then pump it out. As the temperature of the air decreases, some of it condenses, since cooler air cannot hold as much moisture. Water droplets then form on the various nuclei present, e.g., dust particles, gas ions or molecules, depending on the amount of expansion. If the expansion is great enough water droplets form on the gas molecules, producing a cloud. The clouding effect can be made more dramatic by dimming the room lights and shining a light through the chamber during pumpdown.

Water can be introduced into the chamber by moistening the walls of the chamber before pumpdown or by introducing water vapor into an evacuated system. The latter can be achieved by placing a heavily moistened cloth over the up-to-air valve inlet for a few seconds when the system is partially evacuated and the pump turned off. Quickly close the valve, turn on the pump and observe the cloud formation.

