Measuring Pressure

A **barometer** *is a device used to measure atmospheric pressure.* The first type of barometer, illustrated in **Figure 3,** was introduced by Evangelista Torricelli during the early 1600s. Torricelli wondered why water pumps could raise water to a maximum height of only about 34 feet. He thought that the height must depend somehow on the weight of water compared with the weight of air. He reasoned that liquid mercury, which is about 14 times as dense as water, could be raised only 1/14 as high as water. To test this idea, Torricelli sealed a long glass tube at one end and filled it with mercury. Holding the open end with his thumb, he inverted the tube into a dish of mercury without allowing any air to enter the tube. When he removed his thumb, the mercury column in the tube dropped to a height of about 30 in. (760 mm) above the surface of the mercury in the dish. He repeated the experiment with tubes of different diameters and lengths longer than 760 mm. In every case, the mercury dropped to a height of about 760 mm.

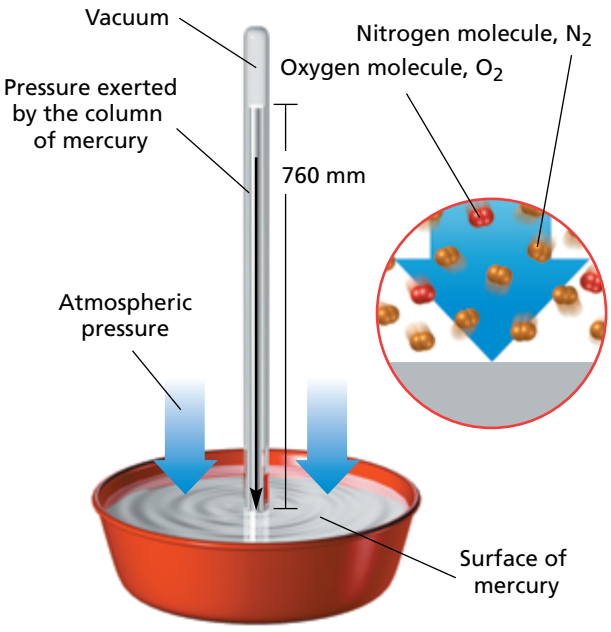

FIGURE 3 Torricelli discovered that the pressure of the atmosphere supports a column of mercury about 760 mm above the surface of the mercury in the dish.

The space above the mercury in such a tube is nearly a vacuum. The mercury in the tube pushes downward because of gravitational force. The column of mercury in the tube is stopped from falling beyond a certain point because the atmosphere exerts a pressure on the surface of the mercury outside the tube. This pressure is transmitted through the fluid mercury and is exerted upward on the column of mercury. The mercury in the tube falls only until the pressure exerted by its weight is equal to the pressure exerted by the atmosphere.

The exact height of the mercury in the tube depends on the atmospheric pressure, or force per unit area. The pressure is measured in terms of the mercury column's height in the barometer tube.

From experiments like Torricelli's, it is known that at sea level and at 0°C, the average pressure of the atmosphere can support a 760 mm column of mercury. The atmospheric pressure at any given place depends on the elevation and the weather conditions. If the atmospheric pressure is greater than the average at sea level, the height of the mercury column in a barometer will be greater than 760 mm. If the atmospheric pressure is less, the height of the mercury column will be less than 760 mm.

All gases, not only those in the atmosphere, exert pressure. A device called a manometer can be used to measure the pressure of an enclosed gas sample, as shown in **Figure 4.** The difference in the height of mercury in the two arms of the U-tube is a measure of the oxygen gas pressure in the container.

To understand gas pressure, consider a can that is filled with air. The atmosphere exerts a pressure against the outside of the can. The air inside the can pushes outward and balances the atmosphere's inward-pushing force. If a vacuum pump is used to remove the air from the can, the balancing outward force is removed. As a result, the unbalanced force due to atmospheric pressure immediately crushes the can.

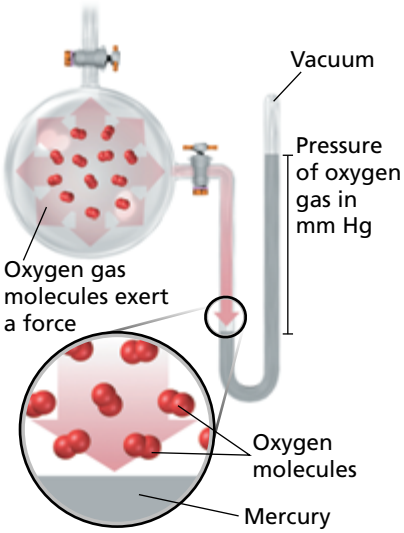

FIGURE 4 In the manometer above, the pressure of the oxygen gas in the flask pushes on the mercury column. The difference in the height of the mercury in the two arms of the U-tube indicates the oxygen gas pressure.