1.2: Pressure and Molar Volume

Italian physicist Evangelista Torricelli (1608 – 1647) (Evangelista Torricelli) was the inventor of an ingenious device that could be used to measure air **pressure**. Basically, he took a glass tube closed at one end, and filled it with mercury. He then inverted it, submerging the open end below the surface level in a pool of mercury. The mercury in the glass tube was then allowed to drain, leaving a vacuum (known as a "Torrocellian vacuum") in the open space at the closed end of the tube.

Figure 1.2.1: Evangelista Torricelli (1608 - 1647). Evangelista Torricelli portrayed on the frontpage of Lezioni d'Evangelista Torricelli. (Public Domain).

Remarkably, the tube did not drain completely! Torricelli, was able to use the residual column height to measure the pressure of the air pushing down on the surface of the pool of mercury. The larger the pressure pushing down on the exposed surface, the larger the column height is observed to be. The ambient air pressure can be computed by equating the force generated by the mass of the mercury in the column to the force generated by ambient air pressure (after normalizing for surface area). The resulting relationship is

$$p = \rho\, g\, h$$

where ρ is the density of the mercury (13.1 g/cm^3), g is the acceleration due to gravity, and h is the height of the column. Torricelli found that at sea level, the height of the column was 76 cm.

$$p = (13.1\, g/cm^3)(9.8\, m/s)(76\, cm)\left(\frac{100^2\, cm^2}{m^2}\right)\left(\frac{1\, kg}{1000\, g}\right)\left(\frac{1\, kg\, m/s^2}{N}\right)$$

$$100,000 N/m^2 = 1 \times 10^5\, Pa$$

A force of 1 N acting on an area of 1 m^2 is a Pascal (Pa). A standard atmosphere is 101,325 Pa (101.325 kPa), or 76.0 cm Hg (760 mm Hg.) Another commonly used unit of pressure is the bar:
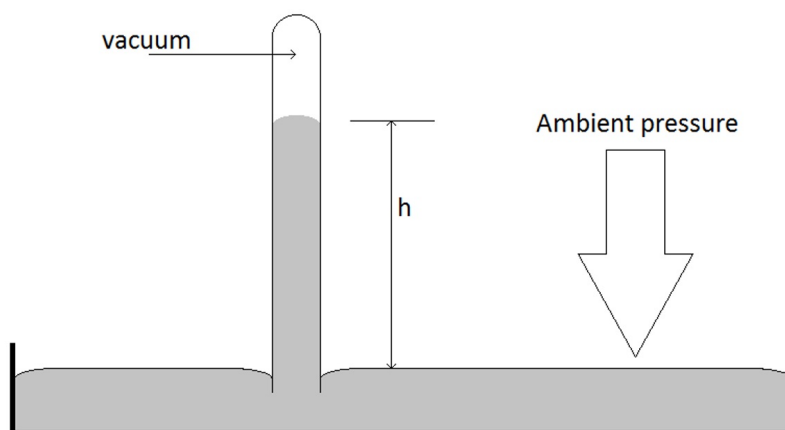
$$1\, bar = 100,000\, Pa$$

Figure 1.2.2: : Set up for the Torricelli barometer.

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