8.2: Ratio of the Heat Capacities of a Gas

The ratio of the heat capacities of a gas at constant pressure and at constant volume plays an important part in many calculations involving the expansion and contraction of gases. The ratio appears, for one example of many that could be chosen, in the theoretical expression for the speed of sound in a gas. The higher the ratio C_P/C_V, the faster the speed of sound. The ratio is generally given the symbol γ:

$$\frac{C_p}{C_v} = \gamma. \tag{8.2.1}$$

Apart from any other reason, one reason for its importance is that the ratio is easier to measure precisely than either heat capacity separately. For example, you could determine it from a measurement of the speed of sound, which is easier than adding heat to a sample of gas at constant pressure and again at constant volume and measuring the rise in temperature.

We have seen that, for gases that behave as we would like them to behave, the molar heat capacities C_V at constant temperatures for monatomic, diatomic and nonlinear polyatomic gases without molecular vibration are respectively $\frac{3}{2}R$, $\frac{5}{2}R$, and $3R$. And since, for an ideal gas, $C_P = C_V + R$, (equation 8.1.3), we expect the corresponding values for C_P to be $\frac{5}{2}R$, $\frac{7}{2}R$ and $4R$. and Thus the expected values of γ are 5/3, 7/5 and 4/3.