# 5.6: Entropy and Disorder

A common interpretation of entropy is that it is somehow a measure of chaos or randomness. There is some utility in that concept. Given that entropy is a measure of the dispersal of energy in a system, the more chaotic a system is, the greater the dispersal of energy will be, and thus the greater the entropy will be. Ludwig Boltzmann (1844 – 1906) (O'Connor & Robertson, 1998) understood this concept well, and used it to derive a statistical approach to calculating entropy. Boltzmann proposed a method for calculating the entropy of a system based on the number of energetically equivalent ways a system can be constructed.

Boltzmann proposed an expression, which in its modern form is:

$$S = k_b \ln(W) \tag{5.6.1}$$

This rather famous equation is etched on Boltzmann's grave marker in commemoration of his profound contributions to the science of thermodynamics (Figure 5.6.1).



Figure 5.6.1: Ludwig Boltzmann (1844 - 1906)

> ✔ **Example 5.6.1:**
>
> Calculate the entropy of a carbon monoxide crystal, containing 1.00 mol of $CO$, and assuming that the molecules are randomly oriented in one of two equivalent orientations.
>
> **Solution**
> Using the Boltzmann formula (Equation 5.6.1):
>
> $$S = nK \ln(W)$$
>
> And using $W = 2$, the calculation is straightforward.
>
> $$S = \left( 1.00 \, mol \cot \frac{6.022 \times 10^{23}}{1 \, mol} \right) (1.38 \times 10^{-23} \, J/K) \ln 2$$
> $$= 5.76 \, J/K$$