Entropy in Isolated System

\[ S = k_B \ln W \]

\# "ways"
1) a system can be found to exist
2) \# "microstates" available to a system

microstates configurations

2 particles

what is the probability of this microstate?

\[ \begin{align*}
W &= \frac{n!}{m!(n-m)!} \\
&= \frac{9!}{2!(9-2)!} \\
&= \frac{9!}{2! \cdot 7!} \\
&= 36
\end{align*} \]
\[ \mathcal{P}_{\text{dead}} = \frac{32}{36} \sim \text{close to 1} \]

\[ m = 2 \]

\[ N = 16 \]

\[ \omega = \frac{16!}{2 \cdot 14!} = 8 \times 15 = 120 \]

\[ \mathcal{P}_{\text{dead}} = \frac{60}{120} \sim 0.5 \]

\[ m = 10 \]

\[ N >>>>> m \]

\[ \mathcal{P}_{\text{dead}} \sim \text{infinitesimal} \]

non-zero, but "small"
$N$ changes

What about $m$ changes?

Think about how $W$ changes if $m$ changes.

$$ W = \frac{n!}{m! (n-m)!} $$

$m \rightarrow 2m$

$2m \rightarrow m$

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Entropy is **Probability**

**Isolated System**

$\rightarrow W$ ways

Probability of a particular microstate

$$ P_i = \frac{1}{W} $$

$$ \ln P_i = \ln \left(\frac{1}{W}\right) = -\ln W $$

? Average of $\ln(P_i)$?

$$ \langle \ln P \rangle = \frac{\sum_{i=1}^{W} P_i \ln(P_i)}{\text{average}} = -\ln W $$
\[ = - \sum_{i=1}^{w} \left( \frac{1}{w} \right) \ln w \]
\[ = -w \left( \frac{1}{w} \right) \ln w \]
\[ = - \ln w \]

\[ -k_b \sum_{i=1}^{w} \theta_i \ln(\theta_i) = k_b \ln W \]

9. Entropy is related to a probability distribution.