Introduced coupling to ext. energy sources (work):

\[
\frac{\Omega_{nm}}{\Omega_{mn}} = e^{-\beta(E_n - E_m - W_{nm})}
\]

\[Q_{nm}\] heat from environ. m \rightarrow n

Work supplied from outside to sys. in m \rightarrow n trans.

Go deeper into details of different kinds of \(W_{nm}\) terms:

- Work against pressure (common to biological systems)
- "Chemical" work

\[\Rightarrow\] idea of a chemical potential

Pressure:
m \rightarrow n \text{ transition (part of a bigger network)}

biomolecule in state m has volume $V_m$

$\Rightarrow$ $n \text{ has volume } V_n$

\[ \text{force } = P \, dA \]

\[ \text{pressure of outside water} \]

add up all contributions across whole surface area:

\[ \text{work } = \int P \, dA \, dx = \int P \, dV \]

\[ \text{area } \frac{dV}{dV} = P \, (V_n - V_m) \]

\[ \frac{\Omega_{nm}}{\Omega_{mn}} = e^{-\beta (E_n - E_m - W_{nm})} \]

$\Rightarrow W_{nm} = -P \, (V_n - V_m)$

when $V_n > V_m \Rightarrow W_{nm} \leq 0$
\( \Rightarrow \) sys does work on env. in the \( m \rightarrow n \) transition when it expands in volume