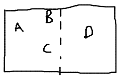
Most systems have a very large number of parts (1e23): statistical mechanics tells us how to deal with it

Averaging out irrelevant quantities

A lot of particles are more predictable en masse
Quantities like temperature, pressure, etc are averages over all particles in a system.

"Thermodynamic limit" : when number of particles in a system is large enough that this averaging process works well

N-> ∞

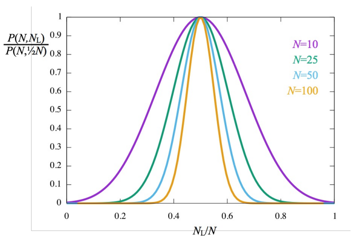


What is probability that the particles are evenly distributed: 2 on one side, 2 on the other?

ways to distribute the particles: 2^4 =16
ways that they are evenly distributed: 4 choose 2 = 4!/(2! 2!) = 6

Probability of even distribution: 6/16=37.5%
Probability of uneven distribution: 62.5%

$$P(N, N_L) = \frac{1}{2^N}\binom{N}{N_L}$$



As N gets really large, the most likely distribution becomes VERY likely, to the point of being almost guaranteed.
This is the "equilibrium state".
Systems tend toward equilibrium, just due to mathematics.

Each distribution of particles above is a "microstate": a complete description of the state of the system.

A MACROstate is a partial description of the state of the system
- "Half of the particles are on the left"
- "Temperature in this room is 20°C"
- "Particle A is on the right"

The MULTIPLICITY of a macrostate is the # of microstates that correspond to that macrostate. Often represented by Ω.

e.g. There are 16 microstates in the example above
The multiplicity of the "half of the particles are on the left" macrostate is 6.
Probability of a macrostate = Multiplicity of a macrostate/ # of microstates
This assumes all microstates are equally likely—often true, not always

The equilibrium macrostate is the one with the largest multiplicity

Multiplicity Ω has two problems with it:
    It's usually very very large. e.g. 2^(10^23)
    It's multiplicative
        If there are Ω=6 outcomes to rolling one die,
        then rolling two dice is Ω^2 = 36

Instead, we usually deal with ln Ω, which is additive and not quite so huge

S = k ln Ω   ENTROPY

The equilibrium state is the state with the largest entropy
Entropy tends to maximize (Second Law of Thermodynamics)

First Law of Thermodynamics: Energy is conserved, and heat is energy.