Lecture 17 review:

States of a System — microstate: Know all coordinates and momenta x_i + p_i of each particle i.

macrostate ← Know only the "state functions" like E, V, N, color, etc. which are measurable.

Same system, different macrostate: low T.

P_j = probability of being in state j. $p(x_i, p_i)$ or $|\psi(x_i)|^2$ if system specified by $x(p)$

$\sum p_j = 1$

Lecture 18: The Postulates of Statistical Mechanics

- Example system: N dice, total roll "E" (think of each die as molecule "i" with energy E_i, so $\sum_i^N E_i = E$.)
- Ensemble: all microstates of a system E, V, N... corresponding to a macrostate with state functions.
  - ex: N=2, E=5: [1][4], [4][1], [2][3], [3][2]
- Partition Function: # of microstates accessible to the system in the macrostate with E, V, N...
  - ex: W = 4 for dice system N=2, E=5
- Extensive state function: scales linearly with size
  - ex: [2] E=2 N=1 T=2 ↓ [2][2] E=4 N=2 T=2
- Intensive state functions: independent of system size
  - ex: $T = E/N$
- Goal in stat mech: For a given system, calculate average of any observable "A"
  - $\langle A \rangle = \bar{A} = A = \sum_j p_j A_j$ (analogous to QM $\langle A \rangle = \int dx\, \psi^* A \psi$)

- Postulates
- I: Microscopic laws (e.g. F=ma, $H\psi = E\psi$) also apply to an isolated macroscopic system specified by extensive state functions E, V, N..
- II: Principle of equal probabilities:
  - i) weak form: All the W microstates j=1,2,3 have equal probability (microcanonical ensemble)
    - ex: p_j for state [1][4] = p_j for state [2][3]
    - $p_j = \frac{1}{W} = \frac{1}{4}$ for N=2, E=5 (weak form)
  - ii) strong form: $\langle p_j \rangle_t = \langle p_j \rangle_E$

ex of average: N=1, allow all E

$\langle roll \rangle = \frac{1}{6}\cdot 1 + \frac{1}{6}\cdot 2 + \dots \frac{1}{6}\cdot 6 = \sum_i^6 p_j E_j = 3.5$

$= \sum_{j=1} \frac{1}{W} E_j = \frac{1}{W}\sum_j E_j$

S2.2: How many ways to distinguish 3 distinguishable molecules in a box of size 3. □△○

○△□
○□△
□△○
⋮

ways = 3·2 = 3!

if 2 are identical: ○△△ ... 3 ways; $\frac{3!}{2!1!}$