## CONCEPT: MICROSTATES AND MACROSTATES OF A SYSTEM

- So far, what we have been commonly referring to as the STATE of a system is properly referred to as a MACROSTATE
  - The macrostate of a system is defined by its measureable thermodynamic properties
  - For IDEAL GASSES, pressure and volume, and therefore temperature, define a system's microstate

- Something important to realize is that a single MACROSTATE is not unique for a system
  - A system can be in a single macrostate while have many, many different microscopic arrangements
  - For instance, two samples of gas can have the same temperature, but have different positions for their particles

- A MICROSTATE is a microscopic arrangement of a system that leads to a particular MACROSTATE
  - Macrostates typically have multiple microstates, but must have at least one
  - The number of microstates a particular macrostate has available to it is known as the MULTIPLICITY, $\Omega$

EXAMPLE 1: Consider 4 coins. A particular macrostate of this system could be 2 heads-up and 3 heads-down. How many different microstates are there in the given macrostate?

- The ENTROPY of a system can be defined in terms of how many microstates a particular macrostate has

$S =$ _____ where $\Omega$ is the multiplicity of a given macrostate

EXAMPLE 2: What is the entropy of the system of coins in the previous problem for a 2 heads-up macrostate?

## PRACTICE: ENTROPY PRODUCED BY A CHANGE IN MACROSTATES OF A COLLECTION OF COINS

The macrostate of a set of coins is given by the number of coins that are heads-up. If you have 100 coins, initially with 20 heads-up, what is $\Delta S$ when the system is changed to have 50 heads-up? Note that the multiplicity of k coins which are heads-up, out of N total coins, is $\Omega = \frac{N!}{k!(N-k)!}$. Does this change in macrostate satisfy the second law of thermodynamics?