Date _____

AP Chemistry Labette Entropy of Coins

Questions:

1. What happens to a system when it reaches maximum entropy?

Materials

3-20 coins Die 3-20 sided to match number of coins

Introduction—

Entropy (S) is a thermodynamic function that increases with the number of energetically equivalent ways (W) to arrange the components of a system to achieve a particular state.

$S = k \ln W$

Where k is the Boltzmann constant (Gas constant divided by Avogadro's number)

$k = 1.38 \text{ x } 10^{-23} \text{ J/K}$

In this activity, you will roll a die and flip corresponding coins. You will calculate the entropy (S) of the coin system and see how the entropy of the system changes over time.

Pre-Lab (answer the following)

1. On a separate piece of paper create a three-column data table with the following labels:

Number of	Number of	Number of
rolls (R)	heads (H)	tails (T)

Procedure

- 1. Place all coins heads up on your table.
- 2. Number each coin from 1-N (number of coins)
- 3. Record how many heads (H) and how many tails (T) are up after zero rolls (R) of the di.
- 4. Roll one die. Whatever number the die is, you flip over the corresponding coin. Record how many heads and tails are up after this roll.
- 5. Repeat step 4, 20-50 times.
- If you have time, you can repeat this activity with a different number of coins and die sides. It is worth it to see how number of coins affects the results. You need to do this to answer post-lab #9.

Post-Lab Questions:

- 1. Enter your data table into Excel or Google Sheets.
- 2. Create a table to calculate the *ways*, *(W)* of organizing your coins, this is the binomial coefficient for our 2 sided coins:

$$W = {}^{N}_{H}C = \frac{N!}{H!\,T!}$$

Where: N is the number of coins H is the number of heads T is the number of tails

- 3. Create a new column to calculate the natural log of the number of ways calculated in step 2. This is proportional to the entropy (S) of the system.
- 4. Create a plot of entropy (S) vs number of rolls (R).
- 5. What happens to the entropy of your coin system during the first few rolls?
- 6. What is the maximum entropy of your system?

7. How many rolls did it take to reach maximum entropy?

- 8. What happens to your system after it reaches maximum entropy?
- 9. Which has greater maximum entropy, a system of 10 coins or a system of 20 coins? Explain.