PRINT NEATLY *** **USE A BLACK PEN** *** **DO NOT STAPLE**

Course 565/665 Lecture Number ______ Date 2/17/03

Lecturer Dr. Silvia Cavagnero Note Taker Eric Fulmer

Last Time

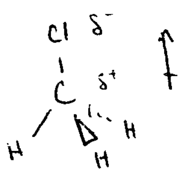
$$\frac{S}{kN} = -\sum_{i=1}^{t} p_i \ln p_i$$

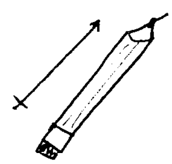
$$S = k_B \ln W$$

Example Objects with dipole moments:

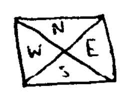
Magnets

Nonsymmetric Molecules





Lets think of a pencil as a macroscopic object with a "dipole" orientation.

Let us rotate the pencil N times on a surface that is divided into 4 quadrants, 

.

$$W = \frac{N!}{n_N!\, n_S!\, n_E!\, n_W!}$$

$$p_N = \frac{n_N}{N} \qquad p_S = \frac{n_S}{N} \qquad p_N + p_S + p_E + p_W = 1$$

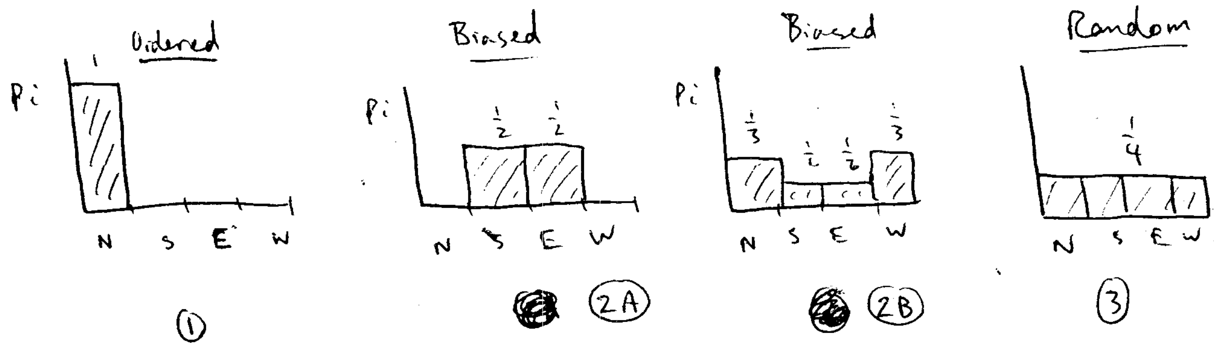
$$p_E = \frac{n_E}{N} \qquad p_W = \frac{n_W}{N}$$

PRINT NEATLY *** USE A BLACK PEN *** DO NOT STAPLE

Course 565/665 Lecture Number ______ Date 2/17/03

Lecturer Cavagnero Note Taker Fulmer

In the absense of any a priori knowledge about the probability distribution, let's take 4 ~~possibilities~~ possible working cases into consideration:



With the Random case, there is no preference or constraint on the system. All outcomes are equally likely.

Entropy for the above cases:

$S_N = \frac{S}{N}$

① $\frac{S_N}{k} = -1 \cdot \ln 1 = 0$

(2A) $\frac{S_N}{k} = -2\left(\frac{1}{2} \ln \frac{1}{2}\right) = 0.69$

(2B) $\frac{S_N}{k} = -2\left(\frac{1}{3} \ln \frac{1}{3}\right) - 2\left(\frac{1}{6} \ln \frac{1}{6}\right) = 1.33$

③ $\frac{S_N}{k} = -4\left(\frac{1}{4} \ln \frac{1}{4}\right) = -1.39$

PRINT NEATLY *** USE A BLACK PEN *** DO NOT STAPLE

Course 565/665 Lecture Number ______ Date 2/17/03

Lecturer Cavagnero Note Taker Fuhmer

Multiplicities for the Above Outcomes.

(1) $W = \frac{4!}{4!} = 1$

(2A) $W = \frac{4!}{2!\,2!} = 6$

(2B) $W = \frac{12!}{4!\,2!\,2!\,4!} = \frac{6!}{2!\,1!\,1!\,2!} =$

(3) $W = \frac{12!}{3!\,3!\,3!\,3!} = \frac{4!}{1!\,1!\,1!\,1!} = 24$

Observations

(1) More disorganized systems have higher S and higher W.

(2) $S \propto$ Disorder. More correctly, Entropy is proportional to the number of possibilities that the system has.

(3) Principle of maximum entropy: Events will tend to states in which have the highest multiplicity (largest number of possibilities), which maximizes the entropy.

PRINT NEATLY *** **USE A BLACK PEN** *** **DO NOT STAPLE**

Course 565/665 Lecture Number ______ Date 2/17/03

Lecturer Cavagnero Note Taker Fulmer

Entropy can be computed for any systems where the multiplicity can be determined, or where multiple configurations are possible.

<u>Example</u> Entropy of the class: Sock Colors.

Black	4
White	8
Blue	1
Grey	1
Yellow	1
Brown	1
total	16

$$\frac{S}{k_B} = -\frac{4}{16}\ln\frac{4}{16} - \frac{8}{16}\ln\frac{8}{16} \cdot 4\left(\frac{1}{16}\ln\frac{1}{16}\right)$$

$$\boxed{\frac{S_N}{k_B} = 1.38}$$