SYSTEMS TEND TOWARDS EQUILIBRIUM → WHICH IS THE STATE THAT MAXIMIZES THE NUMBER OF CONFIGURATIONS.
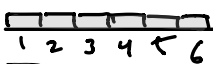
WE DEVELOPED AN IDEA OF THIS BEFORE FOR DICE USING A BINOMIAL DISTRIBUTION.
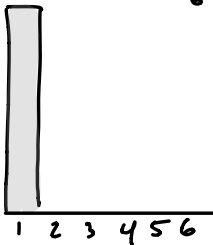
TODAY: A GENERAL DESCRIPTION OF ENTROPY:

$$S = -R \sum_{i}^{\omega} p_i \ln(p_i)$$

S

FAIR DICE: 6 BINS @ $p = 1/6$

$-6 \times \frac{1}{6} \ln\left(\frac{1}{6}\right) = 1.8R$

LOADED DICE: 1 BIN @ $p = 1$
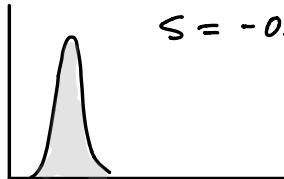
$-1 \ln(1) = \emptyset = \emptyset R$

HOW MUCH INFORMATION DO I NEED TO COMMUNICATE THE POSSIBLE OUTCOMES GIVEN WHAT I ALREADY KNOW?

THE MORE EVEN A DISTRIBUTION, THE HIGHER THE ENTROPY AND THE MORE PROBABLE.

THINK ABOUT:
$n = 100$
$k \in [0, 100]$
$p = 1/6$

$S = -0.0227 \text{ kJ} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$

ALL SIXES: $p = 1$

$S = \emptyset$

$\Delta S = -0.0227$
$T\Delta S = -6.8 \text{ kJ} \cdot \text{mol}^{-1}$

ASIDE: YOU MAY HAVE SEEN

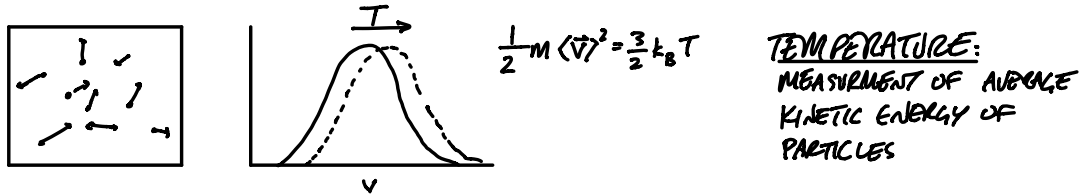$S = R \ln(\omega)$ WHERE ω IS # STATES

THIS IS A LIMITING CASE OF THE $S = -R \sum p \ln(p)$ FORM OF ENTROPY

IF ALL p ARE SAME, $p = 1/\omega$ WHERE ω IS # OF STATES.

$S = -R \sum_{i=1}^{\omega} \frac{1}{\omega} \cdot \ln\left(\frac{1}{\omega}\right) = -R \cdot \omega \cdot \frac{1}{\omega} \ln\left(\frac{1}{\omega}\right)$

$= -R \ln\left(\frac{1}{\omega}\right)$
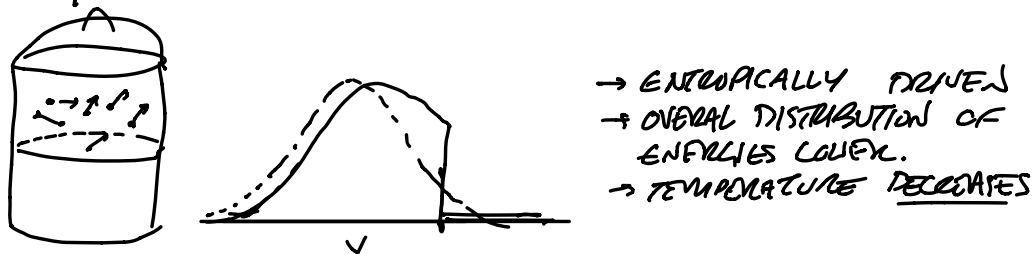
$= R \ln(\omega)$

SO WHAT DOES ANY OF THIS HAVE TO DO WITH HEAT?

GOING TO HAVE TO MOVE AWAY FROM DICE TO ACTUAL PARTICLES
UNLIKE DICE: CONTINUALLY JOSTLING WITHOUT ADDING EXCESS ENERGY.

$$\frac{1}{2} m \langle \vec{v} \rangle^2 = \frac{3}{2} k_B T$$

TEMPERATURE:
MEASUREMENT OF AVERAGE
KINETIC ENERGY OF
PARTICLES

THINK ABOUT PROCESS OF INCREASING TEMPERATURE:

→ ENTROPICALLY DRIVEN
→ OVERALL DISTRIBUTION OF
  ENERGIES HIGHER.
→ TEMPERATURE INCREASES.

COOLING:

→ ENTROPICALLY DRIVEN
→ OVERALL DISTRIBUTION OF
  ENERGIES LOWER.
→ TEMPERATURE DECREASES

JUST LIKE DICE, IF YOU PERTURB DISTRIBUTION, EQUILIBRATES TO
MAXIMALLY RANDOM STATE, FOR THE SAME REASON.

HOT   COLD

HEAT IS FLOW
OF ENERGY THAT
MAXIMIZES
ENTROPY OF SYSTEM.

(q)
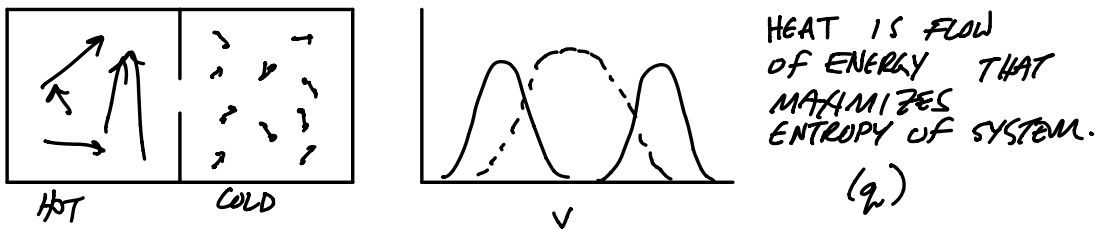
$$dS = \frac{\delta q}{T}$$ BOTH MEASURABLE.

KEY IDEAS:

→ ENTROPY IS MEASURE OF DISORDER

$$S = -R \sum_i^\omega p_i \ln(p_i)$$

→ TEMPERATURE IS A MEASURE OF KINETIC ENERGY OF PARTICLES [Mol pp 254-255]

→ HEAT IS THE TRANSFER OF ENERGY TO OR FROM A THERMODYNAMIC SYSTEM.

→ LEADS TO A REDISTRIBUTION OF PARTICLE KINETIC ENERGIES TO MAXIMIZE ENTROPY.

→ IF YOU APPLY A TINY AMOUNT OF HEAT TO A SYSTEM, YOU PERTURB ENTROPY BY dS

$$dS = \delta q / T$$

→ BECAUSE WE CAN MEASURE T AND q, WE CAN MEASURE ENTROPY.