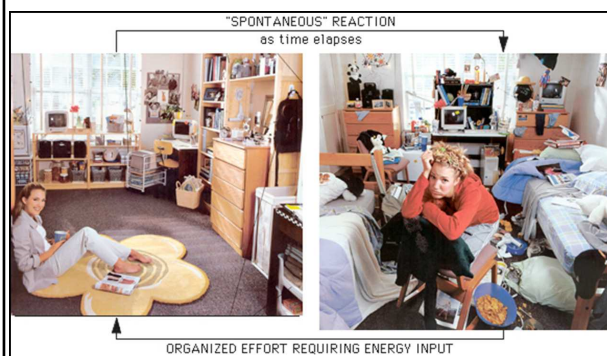


**2.C.3****2<sup>nd</sup> Law of Thermo. and Entropy****General 2<sup>nd</sup> Law**

Certain processes don't take place, even if they are consistent with the 1st law of thermodynamics: just because the algebra works doesn't mean it happens.

Specifically: Heat will not flow spontaneously from a cooler to warmer body.

Also, in a thermal cycle, heat energy cannot be completely transformed into mechanical work.

Forbids perpetual motion machines (Drinking Bird Demo).

**General 2<sup>nd</sup> Law**

Specifies direction in which a process takes place, and applies to all forms of energy.

Whereas the First Law of Thermo. dealt with *quantity* of energy, the Second Law deals with the *quality* of energy.



Can't put Humpty back together!

**Entropy: Symbol = S**

Change in entropy at constant temperature (isothermal process):

$\Delta S = \frac{Q}{T}$	S = Units: J/K
	Q = Heat (J)
	T = Temperature (K)

Why S? It's generally believed that Rudolf Clausius (definer of entropy) chose this to honor the French physicist Nicolas Sadi-Carnot.

**Entropic Perspectives**

$\Delta S$  is positive if a system absorbs heat and negative if it loses heat.

2nd Law stated: "The total entropy of an isolated system can never decrease over time: for every spontaneous process, entropy increases."

During any process, entropy of the universe can only increase or remain constant.

All natural processes move toward a state of greater disorder or disarray.

**Real World Examples:**

$\Delta S$  increases during perspiration: it takes heat energy to vaporize water, and the vaporized water has greater disorder than the liquid water.

Pasta salad: ingredients are chopped up, increasing their disorder. You could pick out the pieces and put them together again, but this would not be a natural process.



Also, your very movements to do so increase the entropy of the universe!

**I. Entropy Math Example**

What is  $\Delta S$  if 15 kg of ice melts at  $0^\circ\text{C}$  (273 K)?

First, find the energy gained by the ice (Unit 2.B.3):

$$\begin{aligned} Q &= L_F \cdot m \\ &= 3.33 \times 10^5 \text{ J/kg} \cdot 15 \text{ kg} \\ &= 5.0 \times 10^6 \text{ J} \end{aligned}$$

Then, compute  $\Delta S$ :

$$\begin{aligned} \Delta S &= Q/T \\ &= 5.0 \times 10^6 \text{ J} / 273 \text{ K} \\ &= 1.8 \times 10^4 \text{ J/K} \end{aligned}$$

**Homework**

Preview 2.C.4

2.C.3 Booklet Problems.

Due: Next Class

**Entropy**

Quantity that indicates natural direction of a process is entropy:

1. Measure of a system to do useful work.
2. Determines the direction of time – points out the forward flow of events.
3. Measure of disorder.

Systems move toward greater disorder – the more order, the lower the entropy.

Entropy of universe is increasing.