Clicker/Poll Question

(Schroeder 3.3): The figure below shows graphs of entropy vs. energy for two objects, A and B. Both graphs are on the same scale. The energies of these two objects initially have the values indicated; the objects are then brought into thermal contact with each other.

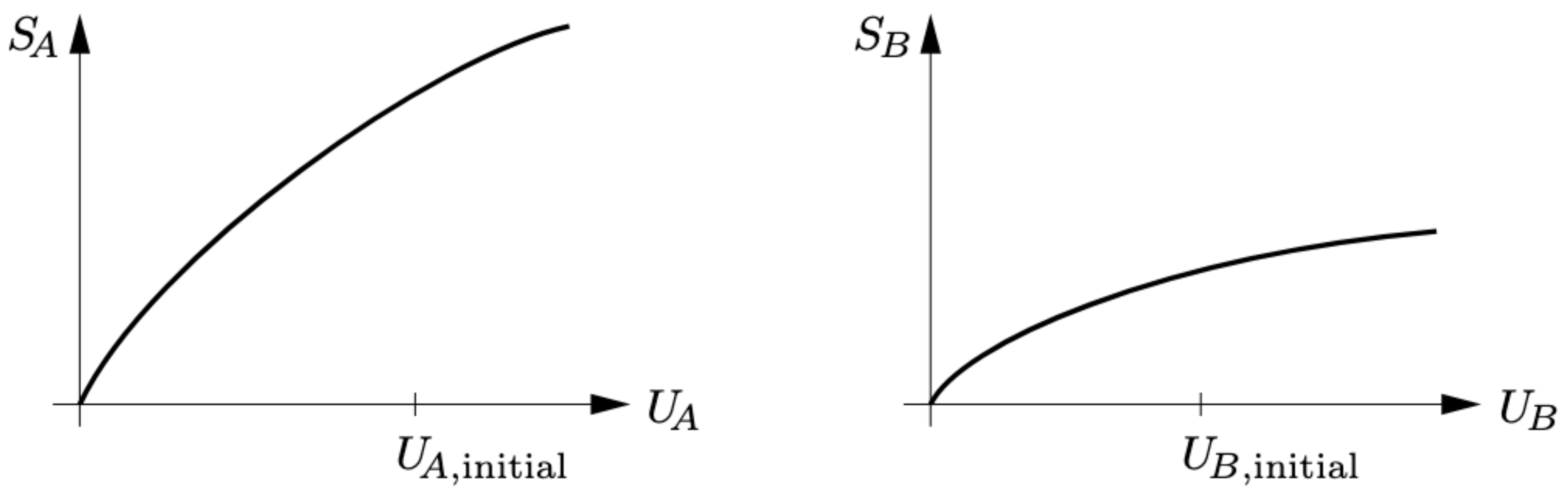

Figure 3.3. Graphs of entropy vs. energy for two objects.

What happens?

A. Energy flows from A to B.

B. Energy flows from B to A.

Clicker/Poll Question

From the multiplicity of an Einstein solid in the q >> N limit, find the relationship between the internal energy U = qe and the temperature, T.

$$\Omega = \left(\frac{eq}{N}\right)^N \implies \Omega(U,N) = \left(\frac{eU}{\epsilon N}\right)^N$$

A. $U = (1/2)NkT$

B. $U = NkT$

C. $U = (3/2)NkT$

D. $U = 2NkT$

E. None of the above

Step 1: find $S(U,N)$

Step 2: $\left(\frac{\partial S}{\partial U}\right)_N = \frac{1}{T}$

Clicker/Poll Question

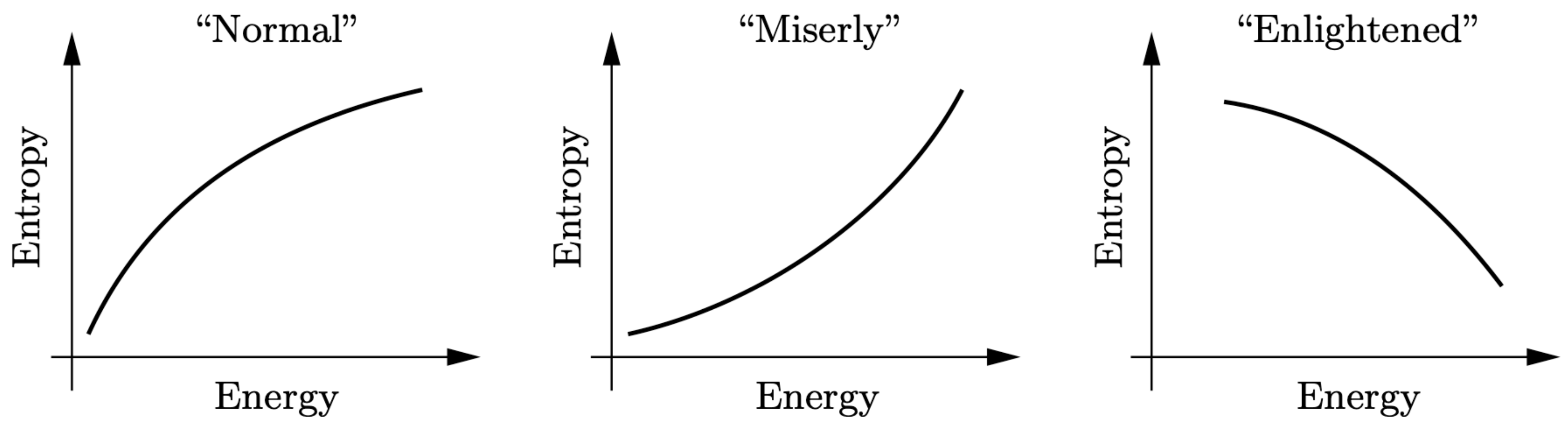

Figure 3.2. Graphs of entropy vs. energy (or happiness vs. money) for a “normal” system that becomes hotter (more generous) as it gains energy; a “miserly” system that becomes colder (less generous) as it gains energy; and an “enlightened” system that doesn't want to gain energy at all. Copyright ©2000, Addison-Wesley.

Recall that a “normal” system has positive heat capacity, and a “miserly” system has negative heat capacity. What is true of “enlightened” systems? (Which have negative temperatures)

A. They have positive heat capacity
B. They have negative heat capacity
C. I’m not sure

Clicker/Poll Question

Assume “spin” and “magnetic moment” are pointing in the same direction (we’ll do this throughout this class, despite the fact that this is only true for positively-charged particles). If a magnetic field is pointing upwards, which is the lower-energy state?

A. A spin pointing upwards
B. A spin pointing downwards
C. They both have the same energy

Clicker/Poll Question

Two two-state paramagnet systems, A and B, each have a million spins. System A initially has 51.00% of the spins as “spin-up” (parallel to the magnetic field), and system B initially has 49.00% of the spins as “spin-up”. Which of the following best describes 1. the direction of energy flow when these systems are put into thermal contact, and 2. the resulting equilibrium temperature?

A. Heat will flow from A to B, and the final temperature will be some positive, finite number.
B. Heat will flow from B to A, and the final temperature will be some positive, finite number.
C. Heat will flow from A to B, and the final temperature will be infinite.
D. Heat will flow from B to A, and the final temperature will be infinite.

Clicker/Poll Question

At a high temperature ($kT \gg \mu B$), 1 “zambooie” of energy increases the temperature of a 2-state paramagnet by exactly 1K. What is true at even higher temperatures?

A. 1 zambooie of energy will increase the temperature by more than 1K.

B. 1 zambooie of energy will increase the temperature by less than 1K.

C. 1 zambooie of energy will increase the temperature by exactly 1K.

Clicker/Poll Question

Which of the following have units of energy?

A. TS (temperature times entropy)
B. PV (pressure times volume)
C. Both of the above
D. None of the above

Clicker/Poll Question

Combining what you know about pressure and temperature, which of the following equations best summarizes the relationship between entropy, energy, volume, temperature, and pressure?

A. $TdS = dU - PdV$

B. $dS = TdU - PdV$

C. $TdS = dU + PdV$

D. $dS = TdU + PdV$

E. None of the above

Clicker/Poll Question

If the chemical potential is negative, what happens when a particle is introduced to a system (at constant internal energy and volume)?

$$\mu \equiv -T\left(\frac{\partial S}{\partial N}\right)_{U,V}$$

A. The entropy increases.
B. The entropy decreases.
C. The entropy remains the same.

Clicker/Poll Question

Chambers A and B are each filled with an ideal gas of the same particle.

- Chamber A has volume V, N particles, and is at temperature T.
- Chamber B has volume 3V, 2N particles, and is at temperature T.

Which chamber has higher chemical potential?

A. Chamber A
B. Chamber B
C. The two have the same chemical potential, and $\mu > 0$
D. The two have the same chemical potential, and $\mu < 0$

Your Turn

Give two expressions for the chemical potential: one as a partial derivative of U, and another as a partial derivative of S.