ANSWERS TO EVEN-NUMBERED CONCEPTUAL QUESTIONS

2. Shaking opens up spaces between the jelly beans. The smaller ones have a chance of falling down into spaces below them. The accumulation of larger ones on top and smaller ones on the bottom implies an increase in order and a decrease in one contribution to the total entropy. However, the second law is not violated and the total entropy of the system increases. The increase in the internal energy of the system comes from the work required to shake the jar of beans (that is, work your muscles must do, with an increase in entropy accompanying the biological process) and also from the small loss of gravitational potential energy as the beans settle together more compactly.

4. Temperature = A measure of molecular motion. Heat = the process through which energy is transferred between objects by means of random collisions of molecules. Internal energy = energy associated with random molecular motions plus chemical energy, strain potential energy, and an object's other energy not associated with center of mass motion or location.

6. A higher steam temperature means that more energy can be extracted from the steam. For a constant temperature heat sink at T_c and steam at T_h, the maximum efficiency of the power plant goes as

$$\frac{T_h - T_c}{T_h} = 1 - \frac{T_c}{T_h}$$

and is maximized for high T_h.

8. Assuming an air temperature of 20°C above the surface of the pond, the difference in temperature between the lower layer of the pond and the atmosphere is

$$\Delta T = T_h - T_c = 100° + 273 - 20° + 273 = 80 \text{ K}$$

and the Carnot efficiency is

$$e_{\max} = e_C = \frac{T_h - T_c}{T_h} = \frac{80 \text{ K}}{373 \text{ K}} \approx 22\%$$

10. Even at essentially constant temperature, energy must be transferred by heat out of the solidifying sugar into the surroundings. This action will increase the entropy of the environment. The water molecules become less ordered as they leave the liquid in the container to mix with the entire atmosphere.

12. A slice of hot pizza cools off. Road friction brings a skidding car to a stop. A cup falls to the floor and shatters. Any process is irreversible if it looks funny or frightening when shown in a videotape running backward. At fairly low speeds, air resistance is small and the flight of a projectile is nearly reversible.