Physics 06-10 Entropy and the 2nd Law of Thermodynamics Name: ________________________

Entropy

- Amount of ____________ not available for ____________
- Related to amount of ____________

$$\Delta S = \frac{Q}{T}$$

- ΔS = change in entropy, Q = heat transfer, T = temperature (K) [If one object is changing temp, then use average T]

2nd Law of Thermodynamics

The total entropy of a system either ____________ or remains ____________ for any process; it never ____________.

- ____________________ processes always result in
  - ____________ of entropy
  - ____________ energy available to do work

$$W_{unavail} = \Delta S \cdot T_0$$

- Where T_0 is the lowest temperature

1200 J of heat flowing spontaneously through a copper rod from a hot reservoir 650 K to a cold reservoir at 350 K. Determine the amount by which this irreversible process changes the entropy of the universe, assuming that no other changes occur.

Find the change in entropy that results when a 2.3-kg block of ice melts slowly (reversibly) at 273 K (0 °C)

Origins of Life

- If the entropy (or disorderliness) increases, how do evolutionists justify evolution (more orderly)?
  - Need for ____________ since they ____________ by assuming God doesn't exist
  - When energy is put into something, it can ____________ entropy for that thing, but total entropy of universe increases
  - They claim the ____________ gave energy to earth which allowed for _______ to ____________________ appear
  - This would mean _________________ making something that ____________ energy to do ____________________ processes (making less entropy)
  - This has never been duplicated in a lab
- Creationists use a similar idea, only we say _________ gave the ____________ and created highly ____________ creation
  - Ever since then, the creation has been ____________ apart

Statistics of Entropy

- Why do spontaneous processes not decrease entropy?
  - A system can have ____________ parts
  - All those parts have ____________ ways they can be
  - Much more ____________ to get ____________ organized combinations
  - Flip 5 coins
    - Macrostates
      - 5 heads or 4 heads, 1 tail or 3 heads, 2 tails or etc.

- Microstates
  - HHHHH
  - HHHHT, HHHTH, HHTHH, HTHHH, THHHH

Entropy

$$S = k \ln W$$

- $k = 1.38 \times 10^{-23} \frac{J}{K}$ Boltzmann's constant, W = number of microstates in system
- Using these statistics, life spontaneously developing is essentially ________________.
- They say that _____________ life exists, it must have _____________
- We say _____________ made it happen

Homework

1. A woman shuts her summer cottage up in September and returns in June. No one has entered the cottage in the meantime. Explain what she is likely to find, in terms of the second law of thermodynamics.
2. Consider a system with a certain energy content, from which we wish to extract as much work as possible. Should the system's entropy be high or low? Is this orderly or disorderly? Structured or uniform? Explain briefly.
3. Does a gas become more orderly when it liquefies? Does its entropy change? If so, does the entropy increase or decrease? Explain your answer.
4. Explain how water's entropy can decrease when it freezes without violating the second law of thermodynamics. Specifically, explain what happens to the entropy of its surroundings.
5. Is a uniform-temperature gas more or less orderly than one with several different temperatures? Which is more structured? In which can heat transfer result in work done without heat transfer from another system?
6. What is the change in entropy in an adiabatic process? Does this imply that adiabatic processes are reversible? Can a process be precisely adiabatic for a macroscopic system?
7. Explain why a building made of bricks has smaller entropy than the same bricks in a disorganized pile. Do this by considering the number of ways that each could be formed (the number of microstates in each macrostate).
8. (a) On a winter day, a certain house loses 5.00×10^8 J of heat to the outside (about 500,000 Btu). What is the total change in entropy due to this heat transfer alone, assuming an average indoor temperature of 21.0 °C and an average outdoor temperature of 5.00 °C? (b) This large change in entropy implies a large amount of energy has become unavailable to do work. Where do we find more energy when such energy is lost to us? (OpenStax 15.47) $\mathbf{9.78 \times 10^4}$ **J/K**
9. On a hot summer day, 4.00×10^6 J of heat transfer into a parked car takes place, increasing its temperature from 35.0 °C to 45.0 °C. What is the increase in entropy of the car due to this heat transfer alone? (OpenStax 15.48) $\mathbf{1.28 \times 10^4}$ **J/K**
10. A hot rock ejected from a volcano's lava fountain cools from 1100 °C to 40.0 °C, and its entropy decreases by 950 J/K. How much heat transfer occurs from the rock? (OpenStax 15.49) $\mathbf{8.01 \times 10^5}$ **J**
11. When 1.60×10^5 J of heat transfer occurs into a meat pie initially at 20.0 °C, its entropy increases by 480 J/K. What is its final temperature? (OpenStax 15.50) **101 °C**
12. The Sun radiates energy at the rate of 3.80×10^{26} W from its 5500 °C surface into dark empty space (a negligible fraction radiates onto Earth and the other planets). The effective temperature of deep space is −270 °C. (a) What is the increase in entropy in one day due to this heat transfer? (b) How much work is made unavailable? (OpenStax 15.51) $\mathbf{1.04 \times 10^{31}}$ **J/K,** $\mathbf{3.28 \times 10^{31}}$ **J**
13. What is the decrease in entropy of 25.0 g of water that condenses on a bathroom mirror at a temperature of 35.0 °C, assuming no change in temperature and given the latent heat of vaporization to be 2450 kJ/kg? (OpenStax 15.53) **−199 J/K**
14. Find the increase in entropy of 1.00 kg of liquid nitrogen that starts at its boiling temperature, boils, and warms to 20.0 °C at constant pressure. (OpenStax 15.54) $\mathbf{3.81 \times 10^3}$ **J/K**
15. Find the change in entropy of the H_2O molecules when (a) three kilograms of ice melts into water at 273 K and (b) three kilograms of water changes into steam at 373 K. (c) On the basis of the answers to parts (a) and (b), discuss which change creates more disorder in the collection of H_2O molecules. (Cutnell 15.71) $\mathbf{3.68 \times 10^3}$ **J/K,** $\mathbf{1.82 \times 10^4}$ **J/K**