Zhejiang University
Department of Physics

General Physics (H)　　　　Problem Set #12

1. In order to take a nice warm bath, you mix 50 liters of hot water at 55°C with 25 liters of cold water at 10°C. How much new entropy have you created by mixing the water?

2. Calculate the change in entropy for a process in which 2 moles of an ideal gas undergoes a free expansion to three times its initial volume.

3. Experimental measurements of the heat capacity of aluminum at low temperatures (below about 50 K) can be fit to the formula

$$C_V = aT + bT^3,$$

   where C_V is the heat capacity of one mole of aluminum, and the constants a and b are approximately $a = 0.00135$ J/K^2 and $b = 2.48 \times 10^{-5}$ J/K^4. From this data, find a formula for the entropy of a mole of aluminum as a function of temperature (assuming $S = 0$ at 0 K). Evaluate your formula at $T = 1$ K and at $T = 10$ K.

4. Derive the efficiency of the Otto cycle

$$e = 1 - \left(\frac{V_2}{V_1}\right)^{\gamma-1},$$

   where V_1/V_2 is the compression ratio and γ is the adiabatic exponent.

5. A bit of computer memory is some physical object that can be in two different states, often interpreted as 0 and 1. A byte is eight bits, a kilobyte is $1024 = 2^{10}$ bytes, a megabyte is 1024 kilobytes, and a gigabyte is 1024 megabytes. (i) Suppose that your computer erases or overwrites one gigabyte of memory, keeping no record of the information that was stored. Explain why this process must create a certain amount of entropy, and calculate how much. (ii) If the entropy is dumped into an environment at room temperature, how much heat must come along with it? Is this amount of heat significant?