Stat Mech (PHYS 370) Guide 5

Fall 2024 v1.5

On Tuesday we'll finish the back of the envelope calculation of climate change. On Thursday we'll return to the behavior of entropy with respect to the other macroscopic parameters and disciver what temperature is.

Soon we have a workshop class devoted to an intro to Mathematica geared to stat mech. Please install Mathematica on your computer this week. Often it takes a couple of days to complete. See **this LITS page** to request a license and begin the process.

Reading:

Chapter 3 sections 3.1, 3.2, 3.4, 3.5 (we'll skip section 3.3 on paramagnetism for now)
Chapter 4 Section 4.1 (Hopefully we will return to heat engines later)

Problems: (Due on Thursday October 3 at the beginning of class)

(1) 3.2 The Zeroth Law

(2) 3.5

(3) 3.7 In 2.42 you may have found that the entropy of a black hole is

$$S_{BH} = k\frac{4\pi G}{\hbar c}M^2$$

where $Mc^2 \equiv U$. In comparing expressions it may be helpful to keep in mind that the reduced Planck constant $\hbar = h/2\pi$.

(4) 3.8 ...continuing the low temperature limit of the Einstein solid. The result you found was

$$U = N\epsilon e^{-\epsilon/kT}$$

(5) (postponed) 3.10 The change in entropy as ice melts

(6) (postponed) 3.13 On life and entropy

(7) (postponed) 3.14 Comment on your results. Where does the linear term dominate? What do you make of the entropy in fundamental units falling below the number of particles?

(8) (postponed) 3.16 An intriguing and perhaps fundamental link between information and entropy. See https://www.nature.com/articles/nature10872.

(9) The computation we did for Earth applies to other planets. Here we'll complete the computation of the equilibrium surface temperature for Mars.
  (a) Find the solar insolation on Mars. Please use the intensity of sunlight at Earth's orbit, 1370 W/m^2, the average radius of Earth's orbit 1.5×10^11 m, and the average radius of Mars' orbit 2.3×10^11 m.
  (b) Estimate the surface equilibrium temperature taking into account the reflectivity of the planet of 0.25 but no other effects. Compare to the measured value of 210 K and comment on your result.

(10) In class I quoted the result that burning 1 g of gasoline (pure 'octane' more precisely) yields 11.5 kcal. We'll check this in this problem. Consider the reaction

$$C_8\ H_{18}\ \text{(liquid)} + \frac{25}{2}\ O_2\ \text{(gas)} \rightarrow 9H_2O\ \text{(liquid)} + 8\ CO_2\ \text{(gas)}$$

all at standard temperature (298K) and pressure (10^5 Pa). The entropy of formation, ΔH, of converting 1 mole of gasoline to its elemental constituents (C and H_2) is -249.7 kJ/mol.

(a) Find ΔH for the process of converting the 9 moles of water and 8 moles of carbon dioxide to their elemental constituents.

(b) Now compute the change in enthalpy ΔH for the above reaction.

(c) What is the change in energy for the above reaction? Please keep in mind that we start with liquid gasoline and end up with liquid water so the number of moles of gas changes. Your result will have the units of kJ/mol

(d) Now convert your result to kJ per gram of gasoline and finally kcal/g. This should agree with the quoted result, does it?