Stat Mech (PHYS 370) Guide 7

Fall 2024 v1.0

Before the Mathematica workshop we lookied into heat engines. On the Tuesday before break we formulated thermodynamical potentials. After break, we'll finish the last bit of section 5.2 before turning to the high powered machinery of statistical mechanics in Chapter 6. Then we are into the heart of the material on stat mech - the Boltzmann weight and the partition function. We will work with these techniques for the remainder of the semester exploring some systems in depth such as a gases of bosons and of fermions.

This is a preliminary guide. Fall break is here. Once I have a better view on where we are in the week after break I may drop a problem or more.

Reading:
Chapter 5 sections 1 and 2
Chapter 6 section 6.1

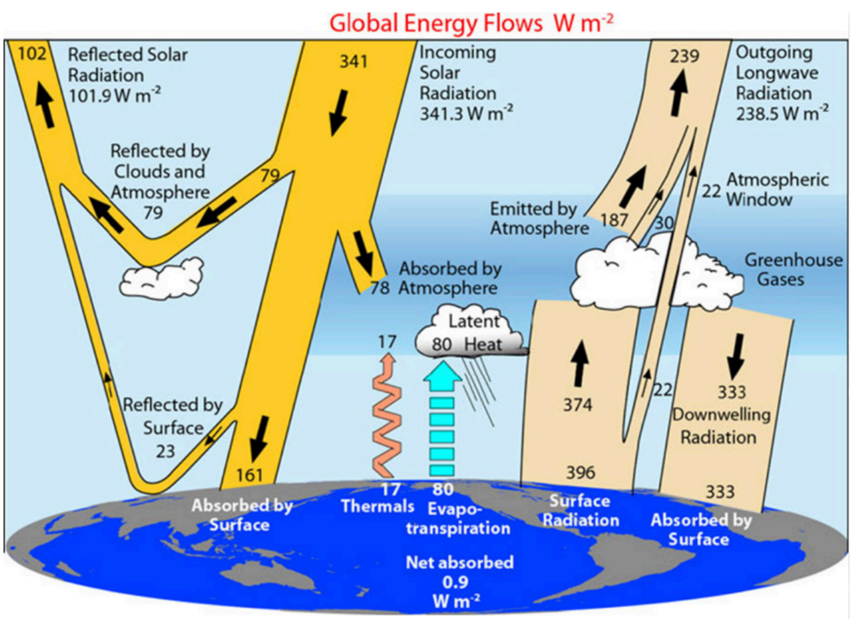
Problems: (Due on Thursday October 24 at the beginning of class)

(1) 3.32 Sudden compression

(2) 3.36 The chemical potential for an Einstein solid

(3) 4.8 One way to cool down on a hot summer's day?

(4) The energy flows are more complex than what we had in out back of the envelope calculation. Have a look at these more-detailed energy flow diagrams in Earth's environment.



(a) Explain how you obtain the radiative forcing of the Sun, 240 W/m^2, from the energy flows in the diagram.

(b) Sum the energy flows in and out of the atmosphere. Is the atmosphere heating up?
(c) Repeat part (b) for the Earth's surface.
(d) Using the graphic and what we discussed in class quantitatively explain the 33 degree temperature difference between Earth with and without an atmosphere.

(5) 4.15 An alternative refrigerator

(6) 5.5 An energy analysis of a methane fuel cell. Assume that the cell produces water vapor. For part (d) you can follow the same method as for the battery calculation in the book.

(7) 5.12 An introduction to Maxwell relations...

(8) 5.14 ...and an example where they are actually useful! This problem is often done as part of the main text since the $C_P - C_V$ relation is significant. You need the result of Problem 1.46(c),

$$\left(\frac{\partial P}{\partial T}\right)_V = -\frac{(\partial V/\partial T)_P}{(\partial V/\partial P)_T}.$$

For part (f) you also need the data in 1.46(e). I found equation (1.48) useful in part (d). For part (e) the quantity to consider is isothermal compressibility, k_T. By looking at what it means you can reason out its sign. In part (f) choose some mass for the water (1 g or 1 kg for instance). For the mercury choose 1 mole so you can use the table on page 405.

(9) 5.20

(10) 5.23 Introducing the grand potential, which we saw at the very end of class on Thursday October 10. In part (d) use the earlier result for $\partial S/\partial N$ of the Sackur-Tetrode relation. Also in this part notice the temperature dependence in the log doesn't matter as much as the leading T dependance.