ASTR 316: Problem Set #1 Due 10am, Tues. Jan 12th

Before completing the problems below, review the Grading Rubric on Canvas to familiarize yourself with the criteria by which these problems will be graded (including the formatting requirements listed under Overall Organization & Clarity).

1) **Hydrogen Lines:** Hydrogen is the most common element in the universe, making light emitted and absorbed by Hydrogen atoms a critical tool in an astrophysicist's toolkit.

Use the Bohr Model to calculate the photon energies (expressed in units of eVs) and wavelengths (expressed in units of microns, where 1 micron = 10^{-6} meters) associated with the following transitions in the Hydrogen atom:

a) Hα (the lowest energy transition in the Balmer Series; n=3 -> 2);
b) Ly α (the lowest energy transition in the Lyman Series);
c) Br γ (the 3rd lowest energy transition in the Brackett Series);
d) the so-called Balmer Jump (the series limit for the Balmer series; n= 2 -> ∞)
What is different about this transition relative to those in parts a, b and c?

Note: calculate all values yourself, either by hand, by python, or by Excel — it is not sufficient to simply state values that are given in the text!

2) **Lyman α lines for highly ionized atoms:** In addition to Hydrogen itself, the Bohr model can actually be used to calculate energy levels for any "Hydrogen-like ion", where all the electrons except one have been removed. For each of the following Hydrogen-like ions, ***identify*** the number of electrons that must be removed to make it a Hydrogen-like ion, ***compute*** the wavelengths associated with the ion's Lyman α transition, and ***state*** whether they fall into the UV (0.01-0.4 microns), soft X-ray (0.01-0.001 microns), hard X-ray (10^{-5} — 10^{-3} microns), or gamma-ray ($\lambda < 10^{-5}$ microns) portion of the spectrum.
a) He II;
b) O VIII;
c) Fe XXVI.

3) **Staying Warm:** The human body has an average temperature of 310 K (98.6°F) Assume the skin is a perfect radiator and absorber, and that you are standing in a room with a constant temperature of 293 K (68°F).
a) What is the peak wavelength λ_{max} of your thermal spectrum? In what part of the electromagnetic spectrum is this found?
b) How much power (in kilowatts kW) do you radiate in the form of blackbody radiation? (Hint: you'll need to estimate a typical body surface area)
c) How much power (in kilowatts kW) do you absorb from the environment, and what is your net energy loss per second from just radiation?
d) How many food Calories does this correspond to in a day? (Note: 1 food Calorie = 4.184 kJ = 1000 "heat" calories)
e) If we didn't eat, how long would it take for our body temperature to drop 10°C, at which point you'd likely be comatose? (Assume we are mostly made of water [which allows you to adopt the specific heat of water for calculating the energy that must be lost to cool 1 degree] and our body does not generate any additional heat)
f) What are the flaws in this model? Use this argument to explain how our clothes keep us warm.