ASTR0 81 - Assignment #4

due Friday before 5 pm

1. Consider a star located at a distance of 50 pc with an effective surface temperature of 10,000 K and a radius of 20 solar radii. By modeling this star as a blackbody, determine the following:
   (a) Luminosity
   (b) Absolute bolometric magnitude
   (c) Apparent bolometric magnitude
   (d) Flux density at the star's surface

2. This week's colloquium was about white dwarfs. We'll learn more about these objects later in the class! The sun will become a white dwarf at the end of its life, and it emits like a blackbody. A typical white has a mass comparable to that of the sun, but a volume comparable to that of the earth. A typical white dwarf has an effective surface temperature of 20,000 K
   (a) What is the luminosity of a typical white dwarf?
   (b) At what wavelength does the specific flux density of a typical white dwarf peak?
   (c) What is the absolute bolometric magnitude of a typical white dwarf?

3. There are 30 magnitudes of visual extinction (A_V) to the Galactic center. If the distance to the Galactic center is 8 kpc and the typical diameter of a dust particle is 1 micron, what is the average number density of dust between the Earth and the center of the Galaxy?

4. Using a photometer, you measure the energy fluxes of a star named Annie and those of the standard star Vega (V = 0 & B = 0 and $M_V = 0$ & $M_B = 0$; *remember Vega is the star that defines the zero point for the magnitude scales*). For each filter, the value of the photometer reading is proportional to the apparent flux. When observing Annie, the photometer reading is 3 in the B band, and 40 in the V band. When observing Vega, the photometer reading is 3,000,000 in B and 4,000,000 in V.
   (a) What are the apparent V and B magnitudes for the star named Annie?
   (b) If Annie has the same absolute magnitude as Vega in both B and V bands, what is the extinction to this star?
   (c) What is the distance to the star Annie?

5. In 2010, planet hunters announced what they called the *first strong case* for a planet observed in the habitable zone of another star, where liquid water can exist on the planet's surface. This planet is unofficially named Zarmina, and its existence actually remains contraversial. Zarmina orbits the star GLIESE581, which has a luminosity of 0.013 solar luminosities and a temperature of 3480 K.

   (a) How far away is the planet from GLIESE581?

   (b) Zarmina has a mass that is three times that of the Earth. If its radius is the radius of the earth and its albedo is 0.4, what is the minimum mass of a molecule that can remain in the atmosphere? How does this compare to the mass of a molecule of water (H_2O)?

   (c) If the albedo was zero, what would be the minimum mass of a molecule that can remain in the atmosphere? How does that compare to your answer in part (b)?

6. Back in the day, the scientist Gustav Kirchhoff observed the spectrum of the sun, and noticed one particular absorption line that precisely matched an emission line of sodium. To prove that this was indeed a sodium line, he observed the sunlight through a sodium gas lamp, expecting that the sodium light would fill in the absorption line in the Sun's spectrum such that no absorption line would be visible in the combined light. Surprisingly, after the sunlight had passed through the glowing sodium gas, the absorption line was even thicker and deeper than before! Please explain this result based off of the principles that are now called Kirchhoff's Laws.

7. Calculate the energies and wavelengths of all possible photons that could be emitted when an electron cascades from the n = 3 to the n = 1 energy level of a hydrogen atom.

8. The Balmer Alpha Hydrogen line is one of the most commonly used lines to classify stars.

   (a) In what quantum level does an electron start and end in order to form this absorption line?

   (b) Derive the wavelength of this absorption line.

   (c) What is the minimum energy of a photon needed to ionize hydrogen with an electron in the n = 4 state?

   (d) A photon with a wavelength of 300 nm strikes an atom of Hydrogen and ionizes an electron in the n = 3 state. What is the velocity of the ejected electron?