Astrophysics

Compulsory Home Exercises. Problem Set 3.

Return by Wednesday, March 25, 2026.
Please, write down **every step in your line of thinking** and state assumptions etc.
A sole answer is not enough.

1. (Expanded problem from lecture 16):

   A B5V star in the LMC – distance 50 kpc – has V=13.5 mag, B-V=-0.07 mag.

   (a) What is its bolometric luminosity, relative to the Sun?
   (b) What is its stellar radius?
   (c) At what wavelength does its radiation peak (assuming Wien's law)?

2. Assume a typical photon mean free path in the Sun of l=0.3 cm.
   Calculate the average time it would take for the photon to escape from the centre of the Sun if this mean free path remained constant for the photon's journey to the surface.

3. For neutral hydrogen gas, at what temperature is the number of atoms in the first excited state only 1% of the number of atoms in the ground state?

4. At what temperature is the number of hydrogen atoms in the first excited state equal to 5% of the number in the ground state?

5. For neutral hydrogen, at what temperature will equal numbers of atoms have electrons in the ground state (n=1) and the first excited state (n=2)? What is the energy required to excite the electron from the ground state to n=2?

6. As temperature approaches ∞, what is the predicted distribution of electrons in each orbital according to the Boltzmann equation? Will this be the distribution that actually occurs? Why or why not?

7. What are the ionization energy of hydrogen, and the first and the second ionization energies of Helium? Give the numbers and explain in words.

8. Consider your results from above as well as your answer to Problem 6. Would you expect a significant number of Hydrogen atoms to be ionized at T=10000 K? At 40000 K? Why or why not?

9. Calculate the fraction of atoms that would be ionized in a stellar atmosphere of pure hydrogen at T=8000K. What about an atmosphere at T=12000K? Assume the electron pressure is constant, P_e=200 dyn/cm^2.