Homework #4

ASTR 1020

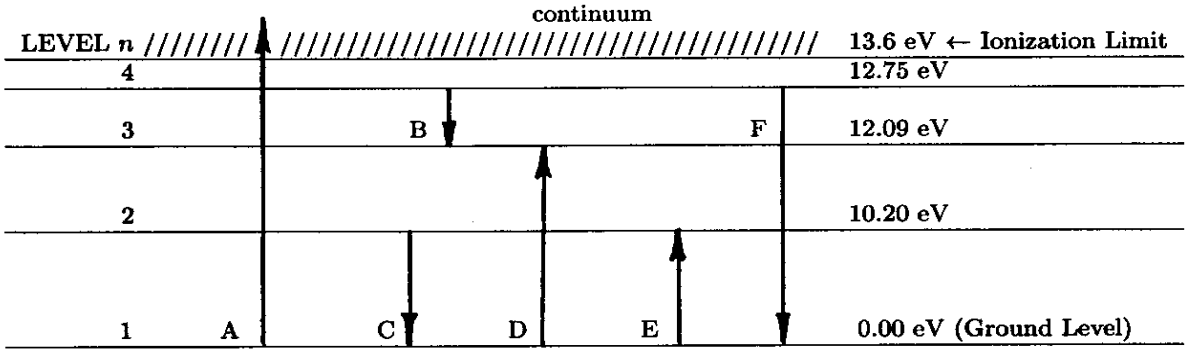
Introductory Astronomy II: Stars & Galaxies ***(John Bally)***

Due Tuesday, 17 Feb 2009

NAME:_____ Student ID: _____

A] Energy Level Diagrams and Spectral Lines

Below is an energy level diagram for hydrogen, with one electron (as shown in class). The capital letters represent individual atoms with electrons undergoing the indicated electron transitions (jumping up or down between orbits). Note : The "electron volt" (1 eV = 1.6 x 10^{-12} erg) is a commonly used unit in discussing energy levels. Visual wavelength photons have en energy of about 2 eV.



1. Which atom(s) have absorbed photons?_____ Which emit photons?_____
2. Which emits the most energetic photon?_____
3. Which emits a photon with energy 0.7 eV? _____
4. Which loses an electron? _____ What is this process called? _____
5. Which transition(s) illustrates(s) excitation processes? _____

The following are some equations and relationships. $E = hf$ $\lambda f = c$

Where: E is photon energy (in ergs), f is photon frequency in Hertz (Hz = 1/sec), λ is photon wavelength in centimeters, h is Planck's constant = 6.626 x 10^{-27} (in c.g.s. units), c is the speed of light = 3 x 10^{10} cm/sec. 1Å = 1 x 10^{-8} cm . The electron volt is related to the erg by 1 eV = 1.6 x 10^{-12} erg. Using the Hydrogen atom energy diagram given above, the equations, and the constants listed, calculate the wavelength in Angstroms (Å) of the following transitions:

6. Transition E? _____ Transition B? _____
7. The Balmer series involves transitions to or from the n=2 level. What is the wavelength of the "leading" transition, from level 2 to level 3 (this is called Hα [alpha])? _____
8. How much energy is needed to ionize an atom that has its electrons in level 2 (in eV)? _____

B] Forces of Nature:

1. List the four forces of nature in order of increasing strength (weakest first, strongest last?). Which forces have infinite range and drop off as an inverse square law? Which forces are "short range" and act like "scotch tape"?

2. Which force is responsible for binding electrons to atomic nuclei?

3. Which force binds protons together in a nucleus?

4. Which force is responsible for the structure of molecules?

5. Which force is responsible for the decay of the neutron into a proton, electron, and neutrino?

6. Which quarks make up a neutron? Which quarks make up a proton?

C] Black body radiation:

1. What is the absolute temperature of the human body? At what wavelength does the intensity of the black body spectrum peak? What is the name of this type of electromagnetic radiation?

2. A black sheet of paper is black because it absorbs all the visible light that falls on it. What happens to the energy in the light? Does the black paper radiate at all?

3. The luminosity of a sphere is given by $L = 4 \pi r^2 \sigma T^4$ where r is the radius of the sphere, T is the absolute temperature, and $\sigma = 5.67 \times 10^{-5}$ (in c.g.s. units) is the so-called Sephan-Boltzman constant. If T is in Kelvin, r is in centimeters, L comes out in ergs per second (erg sec^{-1}). Consider a star with a radius of $r = 7 \times 10^{10}$ cm and a temperature $T = 6{,}000\ K$ (these parameters are similar to the Sun). What is the luminosity of this star?

4. Suppose the above star had a temperature of T = 40,000 K but the same radius. What would be its luminosity? How does this compare to the luminosity of the Sun?

5. Would the star be redder or bluer than the Sun?

D] Hertzprung-Russell (H-R) diagram: Draw an H-R diagram, label the axes in the correct units. Mark the location of the Sun, a blue super-giant star, a red-dwarf, a red super-giant star, and an old white-dwarf.