PHAS1202: PST - Stellar astrophysics -2015

The following constants may be adopted if required:

Planck constant	h	6.63×10^{-34} J s
Speed of light	c	3.0×10^{8} m s^{-1}
Stefan-Boltzmann constant	σ	5.7×10^{-8} W m^{-2} K^{-4}
Mass of the Sun	$M_\odot$	2.0×10^{30} kg
Solar Luminosity	$L_\odot$	3.8×10^{26} W
Solar radius	$R_\odot$	7.0×10^{8} m
1 eV		1.6×10^{-19} J
Proton mass		1.0078 amu
Helium mass		4.0026 amu
1 year	yr	3.16×10^{7} s
Solar effective temperature	$T_{\rm eff}$	$= 5800$ K
Mass of the Sun	$M_\odot$	$= 2.0 \times 10^{30}$ kg
Radius of solar corona	$R_{\rm corona}$	$= 2.0\ R_\odot$
Temperature of the solar corona	$T_{\rm corona}$	$= 2.0 \times 10^{6}$ K
Boltzmann constant	k	$= 1.38 \times 10^{-23}$ J K^{-1}

1. The ionisation potential of the hydrogen atom is 13.6 eV. From this calculate the wavelength (in nm) of light needed to excite an electron from the $n = 3$ to the $n = 4$ orbit of the hydrogen atom. What is the name of the series of hydrogen transitions whose lower level corresponds to $n = 3$, and the name of the transition between levels with $n = 3$ and $n = 4$?

2. The two stars HD36956 and ϵ Indi have surface temperatures of 24100 K and 2800 K, respectively. Determine the wavelengths of peak energy distribution for these stars, and state the corresponding observational waveband.
   If the two stars have the same radii, what is the ratio of the energies emitted?

3. A red star and a blue star have the same size and are at the same distance from Earth. Using appropriate formulae, explain which star looks brighter in the night sky? (Ignore the interstellar gas and dust.)

4. Estimate the total energy output of the Sun's photosphere and corona in watts. Comment on the validity of using the blackbody approximation for the corona.

5. A sunspot has a temperature of 4000 K and is 1800 K cooler than the surrounding photosphere of the Sun (at the same depth in the atmosphere). Calculate the intensity contrast, I_λ(spot)/I_λ(photosphere) at 550 nm and 1.0 μm. (Assume the limit where $e^{(h\,c/\lambda\,k\,T)}$ is much greater than unity.)

6. The spectrum of a star shows an absorption line due to neutral sodium present in a foreground interstellar cloud. If the observed wavelength of this line is 588.965 nm, and its rest wavelength is 588.995 nm, what is the velocity of the interstellar cloud with respect to the observer? Is the cloud moving away or towards us?

   In which spectral band does the absorption line appear? What are the frequency and the energy of the line at rest? (Specify clearly the units of these quantities.)