PHAS0004: Astrophysics PST 1 - Revised Dec 2018

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}
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
Solar effective temperature	$T_{\rm eff}$	$= 5800$ K
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 fact 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 (assuming the blackbody curve is expressed as a function of wavelength), 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. (Ignore cross-section of Sun in the latter case.) 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 $e^{(hc/\lambda kT)}$ is much greater than unity.)

6. (i) At what wavelengths will we observe the following spectral line emitted at 650 nm by a star moving towards us at 200 km/s?

   (ii) A cloud of neutral H emits the 21 cm line while moving away at 150 km/s. At what frequency (in Hz) will we observe this line?

7. (i) Assume the Blackbody radiation formula as a function of wavelength I_λ. Derive the Blackbody radiation formula as a function of intensity I_ν.

   (ii) At what λ does I_λ peak?