PHAS1202 Atoms, Stars & the Universe
Astrophysics PST 2: December 2015

The following may be assumed if required:

Planck constant	h	$= 6.63 \times 10^{-34}$ J s
1 eV		$= 1.6 \times 10^{-19}$ J
Proton mass		= 1.0078 amu
Helium mass		= 4.0026 amu
Mass of the Sun	$M_\odot$	$= 2.0 \times 10^{30}$ kg
Solar Luminosity	$L_\odot$	$= 3.8 \times 10^{26}$ W
Solar radius	$R_\odot$	$= 6.96 \times 10^{8}$ m
1 year	yr	$= 3.16 \times 10^{7}$ s
1 parsec	pc	$= 3.1 \times 10^{16}$ m
Speed of light	c	$= 3.0 \times 10^{8}$ m s^{-1}
Gravitational constant	G	$= 6.67 \times 10^{-11}$ m^3 kg-1 s^{-2}
Hubble constant	H_o	$= 75$ km s^{-1} Mpc^{-1}
Constant in Wien's law	=	3×10^{-3} m.K

1. By first deriving the H to He mass deficit, calculate the main sequence lifetime (in years) of a 5 $M_\odot$ star if it has a luminosity of 600 $L_\odot$ and 10% of its mass is converted from hydrogen to helium.

2. An active galaxy is thought to have a 10^8 solar mass supermassive black hole at its centre. Calculate the Schwarzchild radius (in units of $R_\odot$) of the black hole. Assuming spherical geometry also determine the average density inside the Schwarzchild radius.

3. What are the differences in appearance between a SBc galaxy and a Sa galaxy.

   At what redshift is the Lyman$-\alpha$ line (rest wavelength 121.6 nm) brought into a visible light detector that is sensitive to photons of wavelength greater than 370 nm?

   Quasar 3C 273 has a redshift of 0.16. Calculate its distance in units of Mpc.

4. The Andromeda, has a luminosity (intrinsic brightness) 3 times as bright as the Luminosity of our Milky Way galaxy, and is at a distance = 0.7 Mpc. The flux we observe from the Andromeda galaxy (apparent brightness) is 10,000 times brighter than the flux observed from a distant quasar. This quasar has a luminosity that is 1000 times the luminosity of our Milky Way galaxy. What is the distance to the quasar? [HINT: Use the relation: flux $\propto L/d^2$)

5. Suppose a star orbits its galactic centre at a distance of 8.5 kpc and that the mass of the galaxy contained within that circular orbit is 1.2×10^{11} $M_\odot$. Calculate the star's orbital velocity (in km s^{-1}) and hence its orbital period (in years).

6. For the collapsing gas cloud model of the formation of our Galaxy, briefly explain the observations that halo stars are Population II (i.e. low metal content) and the recently formed disk stars are Population I (higher metal abundance).

7. *Thought of the Day:* How do we know the Milky Way Galaxy has spiral arms?