PHAS1202 Atoms, Stars & the Universe
Astrophysics PST 2: November 2018

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}
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. (a) What are the differences in appearance between a SBc galaxy and a Sa galaxy.

   (b) 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?

   (c) Quasar 3C 273 has a redshift of 0.16. Calculate its distance in units of Mpc, assuming the Hubble Constant is $H_0 = 70$ km/sec/Mpc,

3. 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).

4. (a) What is the age of a universe with density parameter $\Omega_{\rm matter} = 1$ and Cosmological Constant $\Omega_\Lambda = 0$, in which the scale factor $a(t) \propto t^{2/3}$, in terms of the present-epoch Hubble constant H_0?

   (b) If $H_0 = 68$ km/sec/Mpc, what is the age of the universe in model (a)? Compare and discuss it with the age of 13.8 Gyr deduced from the Planck Cosmic Microwave Background experiment.