Physics of Galaxies Exercises Class 2

1. Ionization energy of Hydrogen is 13.6 eV. By equalizing this energy (in Joules!) to the thermal energy, kT, estimate roughly the ionization/recombination temperature of Cosmic Background Radiation (CMB) **[3 marks]**. The correct treatment requires use of Saha equation yielding T=4000K for the recombination temperature. Estimate red-shift, z, when the recombination happened. The red-shift-temperature relation is $T = 2.7\ (1 + z)$ K **[1 mark]**. Use the latter relation to calculate CMB temperature now **[1 mark].**

2. Describe the differences in formation of elliptical versus spiral galaxies by listing the three key stages in their formation **[6 marks].**
Sketch a graph of star-birth-rate in M_{sun}/yr versus 10^9 years for elliptical and spiral galaxies **[4 marks].**

3. Draw a sketch of a thick disk and show by calculation that its ellipticity is given by $e = 1 - \cos\theta - (c/a)\sin\theta$, where a and c are disk radius and half-thickness respectively; and θ is the angle between the disk normal and line of sight to an observer **[6 marks]**. By calculating c/a ratio for the disk, for $\theta = \pi/2$, what is the simple argument against the idea that E7 elliptical galaxies, under Hubble classification, are disks at the inclination **[4 marks]**?

25 marks in total