4.1 An H II region has a density 100 cm^{-3}, a temperature of 9000 K, and a diameter of 13 pc (Strömgren sphere). The chemical abundances, are N(He)/N(H) = 0.1, N(N)/N(H)=2×10^{-4}, N(O)/N(H)=7×10^{-4}.

(a) Assuming the nebula is optically thick in the Lyman continuum and surrounds the ionizing star, what is $Q(H^0)$? Using Table 2.3 in Osterbrock, what can you say about the central ionizing star or stars?

(b) Assuming that helium is singly ionized throughout the nebula, what is the expected line ratio $I(He\ I\ \lambda 5876)/I(H\beta)$ due to radiative recombination?

(c) If oxygen is 70% doubly ionized and 30% singly ionized, what are the expected values of $I(O\ III\ \lambda\lambda 5007, 4959)/I(H\beta)$ and $I(O\ II\ \lambda\lambda 3726, 3729)/I(H\beta)$? What is the intensity ratio $I(N\ II\ \lambda\lambda 6584, 6548)/I(O\ II\ \lambda\lambda 3736, 3729)$ if the ionization fraction is the same for N^+ and O^+? Use a two-level approximation for the collisionally excited lines.

(d) What is the radio frequency at which the nebula becomes optically thin to free-free absorption? If the nebula is observed from a distance of 1 kpc, calculate the received flux πF_ν versus frequency for frequencies in the optically thick and optically thin limits. Give a rough sketch of the spectrum. (Hint: use the intensity at the center of the image for simplicity.)