2) a) Find the populations of the 1[st] and 2[nd] excited states relative to the ground state for atomic H at 300K, assuming M-B statistics are valid.

b) Find the same populations for ηUMa at T = 15,500K.

c) For the populations in b, determine if Balmer or Paschen absorption lines will be stronger.

a) The ratio of populations is

$$\frac{n(E_3)}{n(E_1)} = \frac{g(E_3)Ae^{-\beta E_3}}{g(E_1)Ae^{-\beta E_1}} = \frac{g(E_3)}{g(E_1)} e^{(E_1 - E_3)/kT}$$

For Hydrogen

| | | | |
|---|---|---|---|
| $n=1$: | $g(E_1) = 2$ | $E_1 = -13.6\,eV$ | (1s) |
| $n=2$ | $g(E_2) = 8$ | $E_2 = -3.4\,eV$ | (2s + 2p) |
| $n=3$ | $g(E_3) = 18$ | $E_3 = -1.51\,eV$ | (3s + 3p + 3d) |

Thus

$$\frac{n_3}{n_1} = \frac{18}{2} e^{\overset{-12.1}{(-13.6+1.5)}/(8.62\times10^{-5})(300)} = 9e^{-468} \approx 0!$$

$$\frac{n_2}{n_1} = \frac{8}{2} e^{\overset{-10.2}{(-13.6+3.4)}/(8.62\times10^{-5})(300)} = 4e^{-469} \approx 0!$$

⇒ At room temp., very few H atoms are excited!

b) For ηUMa at T = 15,500K,

$$\frac{n_3}{n_1} = 9e^{(-12.1)/(8.62\times10^{-5})(15500)} = 9e^{-9.06} = 0.001$$

$$\frac{n_2}{n_1} = 4e^{(-10.2)/(8.62\times10^{-5})(15500)} = 4e^{-7.63} = 0.0019$$

c) ⇒ Since $n_2$ is slightly more populated, transitions upward from it will be stronger than from $n_3$

⇒ Balmer stronger than Paschen!