

An astronomer is studying an interesting region of interstellar medium. The interstellar medium is a gas consisting primarily of atomic hydrogen. The energy eigenstates of a hydrogen atom are enumerated by three integers:

$$n \geq 1 \quad (1)$$

$$0 \leq \ell < n \quad (2)$$

$$-\ell \leq m \leq \ell \quad (3)$$

The energy eigenvalues are

$$E_{n\ell m} = -\frac{13.6 \text{ eV}}{n^2} \quad (4)$$

The astronomer measures the fraction of atoms in different energy eigenstates and finds that

$$\frac{N_{1s}}{N_{2p}} = 10^5 \quad (5)$$

where N_{1s} is the number of atoms in the $1s$ state (i.e. $n = 1, \ell = 0, m = 0$) and N_{2p} is the number of atoms in states with $n = 2$ and $\ell = 1$. Solve for the temperature in this region of the interstellar medium.