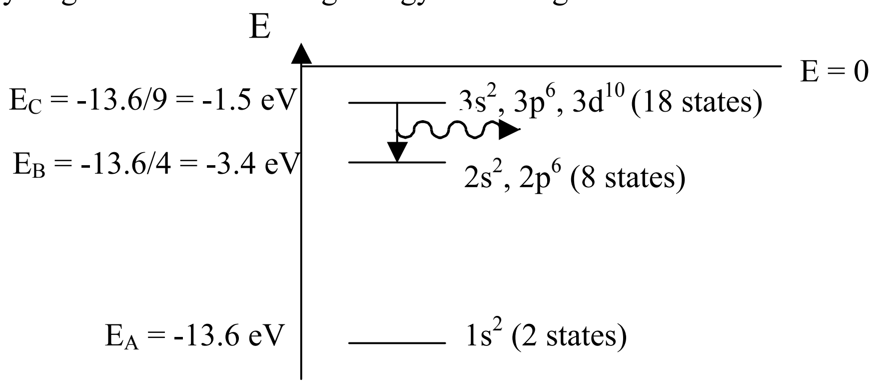
**Physics 213** **Problem 2** **Week 5**

## Boltzmann Distribution in atoms

It's often useful to remotely sense the temperature of objects. Fortunately the Boltzmann distribution of the occupancy of atomic states manifests itself in the spectrum of light emitted from hot objects, so the light can then be used as a thermometer.

Atomic hydrogen has the following energy-level diagram:




The atom emits light when it falls from a higher-energy state to a lower one. The frequency of light depends on the energy of the photons, the same as the difference between the energies of the states. For example, in the transition indicated above, a photon of wavelength 653 nm will be emitted. So the colors of light emitted by atoms falling from states with $E_C$ are different from the light from atoms falling from $E_B$. The ratio of the amounts of the different colors of light then depends on how many atoms are in different excited states. (The ground state can't emit anything.)

1. Calculate the ratio of the number of atoms with $E = E_C$ to the number with $E = E_B$ for $T = 2000$ K. You should see that most of the atoms are in their ground state.

$N_C/N_B = (18/8)\exp(-(E_C-E_B)/kT) = 3.67\times10^{-5}$.

Note that $N_C/N_A = (18/2)\exp(-(E_C-E_A)/kT) = 2.9\times10^{-30}$, tiny!!

2. What is that same ratio at T=2020 K (1% higher)?

$N_C/N_B = (18/8)\exp(-(E_C-E_B)/kT) = 4.10\times10^{-5}$, a 12% increase.

$N_C/N_A = (18/2)\exp(-(E_C-E_A)/kT) = 5.8\times10^{-30}$, still tiny, but twice as big!!