Physics 2700H: Assignment IV

Jeremy Favro (0805980)
Trent University, Peterborough, ON, Canada

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Problem 1. For atomic hydrogen, the allowed energy levels are given by the Bohr equation

$$E_n = -\frac{13.6\,\text{eV}}{n^2}$$

which gives energies of -13.6, -3.4, and $1.5\,\text{eV}$ for the first three energy levels. Rework the example in Section 6.3.2 with atomic hydrogen at $7500\,\text{K}$ using these three energy levels.

(a) Compute the partition function.

(b) Compute the probabilities of the first three levels.

(c) Compare your results with the example in the text.

Solution 1.

Problem 2. Suppose there is a quantized system that can be in one of three energy states, having energies 0, 0.2, and $0.4\,\text{eV}$, respectively. The system is at $5000\,\text{K}$.

(a) Compute the partition function for this system.

(b) Find the mean energy.

(c) Compute the probability that each of the three states will be occupied.

Solution 2.

Problem 3. It is a result of statistical mechanics that the internal energy of an ideal gas is

$$U = U(S,V) = -Nk_B\left(\frac{N}{V}\right)^{2/3}\exp\left(\frac{2S}{3Nk_B}\right)$$

where α is a constant and the other symbols have their usual meanings. Show that the equation of state $PV = nRT$ follows from this equation.

Solution 3. Where is α here?

Problem 4. Water boils at $T = 100\,^\circ\text{C}$ at one atmosphere of pressure. In the process, the entropy increase is $109\,\text{J}\,\text{K}^{-1}$ for each mole of water. Find the molar enthalpy increase.

Solution 4.