Exercises in Statistical Mechanics

Based on course by Doron Cohen, has to be proofed

Department of Physics, Ben-Gurion University, Beer-Sheva 84105, Israel

This exercises pool is intended for a graduate course in "statistical mechanics". Some of the problems are original, while other were assembled from various undocumented sources. In particular some problems originate from exams that were written by B. Horovitz (BGU), S. Fishman (Technion), and D. Cohen (BGU).

===== **[Exercise 6030]**

Thermionic emission of electrons from a metal

A spherical piece of metal ("cathode"), that has radius R and temperature T, is placed inside a vacuum tube. A second metallic piece ("anode") is used to collect the electrons that are emitted from the cathode. The effective temperature of the anode is zero. The cathode has a work function W, while the anode has work function W'. The depth of the potential that holds the electrons inside the cathode, aka the potential floor, is V_0.

 (1) Write an integral expression for the saturation current I_s that would be measured if the bias voltage is very large.

(1a) Show that V_0 does not appear in the final result: the outcome of the calculation is the same for sections that are close to the surface or deep in the metal.

(1b) Calculate the integral using the Boltzmann approximation. Specify the range of temperatures for which the approximation is valid.

 (2) Using the result of the previous item write an estimate for the current if a reverse (stopping) voltage V_{battery} is applied. Explain whether W or W' is relevant.

(2a) Explain the relation to the analysis of the stopping voltage in the photoelectric effect.

 (3) Assume that the cathode is detached and left alone in free space. Calculate the charge $Q(t)$ of the cathode as a function of time assuming that $Q(0) = 0$.

(3a) Explain the limitations of the result that you have obtained.