505 Midterminal Test 1: Oct 4, 2016, in-class.

11:00 am to 12:15 pm. No consultation of persons or book. Only an 8 x 11 cheat sheet allowed.

October 3, 2016

1. State (you do NOT have to calculate) the partition function, the average energy and the specific heat of a 3-dimensional harmonic oscillator of mass m and frequency ω. Do this both quantum mechanically on the one hand and classically on the other and point out the differences...(5)

2. Consider a large number N of non-interacting free particles of mass m in a 1-dimensional box of length L in contact with a heat reservoir at temperature T. Calculate *quantum mechanically* the partition function Z_1 of a single particle assuming that L is extremely large. Recalling that de Broglie introduced the idea of a quantum length h/p where h is the Planck's constant and p the momentum, show that the partition function you have calculated may be looked upon as a ratio of the volume L to a characteristic length that one can associate with the particle at temperature T. What is the value of the momentum p you obtain and what physical significance would you assign to that momentum?...(10)

3. Consider a 2-dimensional solid in which there are wave motions having the dispersion relation $\omega = Aq^r$ between the frequency ω and the wave number q where A and r are constants. Prove or disprove *in full detail* that the specific heat of such a solid at low temperatures goes as T^s where T is the temperature, and obtain the relation between s and r...(10)