Physics 831 Practice Quiz #7 - Monday, Nov. 24

YOUR NAME:_____

1. Consider two identical alpha particles (which are bosons with spin 0). They occupy two single-particle levels with energies, 0 and ϵ.

   (a) What is the probability that the system is at the lowest possible total energy as a function of the temperature T?

   (b) What is the average energy when $T = 0$?

   (c) What is the average energy when $T = \infty$?

   (d) What is the entropy when $T = 0$?

   (e) What is the entropy when $T \to \infty$?

2. Beginning with the fundamental relation,

$$TdS = dE + PdV - \mu dN,$$

   derive the relation,

$$\left.\frac{\partial E}{\partial N}\right|_{P,S} = \mu - P \left.\frac{\partial \mu}{\partial P}\right|_{N,S}$$

3. Consider a Hamiltonian for a particle moving in one dimension,

$$H = \sqrt{m^2 + p^2} - A \ln(x/x_0) + Bx, \quad A > 0, B > 0.$$

   which confines the particle to $0 < x < \infty$. Using the generalized equipartition theorem, or the virial theorem, find the average value of $\langle x \rangle$ as a function of T.

4. Circle the systems that allow Bose Condensation:

   - Massive bosons in 2 dimensions
   - Massive bosons in 3 dimensions
   - Massive bosons in 4 dimensions
   - Massless bosons in 2 dimensions
   - Massless bosons in 3 dimensions
   - Massless bosons in 4 dimensions