HW8, PHYS 3113

P1 (7.14) For a system of particles at room temperature, how large must $\epsilon - \mu$ be before the Fermi-Dirac, Bose-Einstein, and Boltzmann distributions agree within 1%? In this condition ever violated for the gases in our atmosphere? Explain.

P2 (7.20) At the center of the sun, the temperature is approximately 10^7 K and the concentration of electrons is approximately 10^{32} per cubic meter. Would it be (approximately) valid to treat these electrons as a "classical" ideal gas (using Boltzmann statistics), or as a degenerate Fermi gas (with $T \approx 0$), or neither?

P3 (7.26)

(a) Pretending that liquid helium-3 is a noninteracting Fermi gas, calculate the Fermi energy and the Fermi temperature. The molar volume (at low pressures) is 37 cm^3.

(b) Calculate the heat capacity for $T \ll T_F$, and compare to the experimental result $C_V = (2.8 \text{ K}^{-1})NkT$ (in the low-temperature limit). (Don't expect perfect agreement).

P4 (7.61) The heat capacity of liquid helium-4 below 0.6 K is proportional to T^3, with the measured value $C_V/Nk = (T/4.67 \text{ K})^3$. This behavior suggests that the dominant excitations at low temperature are long-wavelength phonons. The only important difference between phonons in a liquid and phonons in a solid is that a liquid cannot transmit transversely polarized waves – sound waves must be longitudinal. The speed of sound in liquid ^{4}He is 238 m/s, and the density is 0.145 g/cm^3. From these numbers, calculate the phonon contribution to the heat capacity of ^{4}He in the low-temperature limit, and compare to the measured value.