Physics 410 - 2002

Thermal Physics

Problem Set 8

The solutions are due on March 20

1. Calculate the partition function of a *classical* harmonic oscillator of mass m and angular frequency ω_0 at temperature τ. Compare the classical result with the limit of the partition function of the quantum oscillator for $\hbar\omega_0 \ll \tau$. (5 pt)

2. Consider an ideal gas of molecules with an electric dipole moment $\mathbf{p}_0$, which can point in an arbitrary direction. The gas is placed into a uniform electric field $\mathbf{E}$. The gas density is n. Neglect the effect of the electric field of one molecule on another, i.e. neglect the interaction between the molecules. Show that the polarization of the gas (the dipole moment per unit volume) is
$$P = np_0 \left[\coth \frac{p_0 E}{\tau} - \frac{\tau}{p_0 E}\right]$$
(7 pt)

3. Chapter 5, p. 145, problem 4 (5 pt)

4. Chapter 5, p. 146, problem 6 (5 pt)

5. Chapter 5, p. 146, problem 8 (5 pt)

6. Chapter 5, p. 147, problem 10 (5 pt)

7. Relate $\langle(\Delta N)^2\rangle$ in the previous problem to the derivative $(\partial^2 p/\partial\mu^2)_{\tau,V}$ (5 pt)

You need to have 30 points (7 extra credit points)

The problems are from Kittel & Kroemer, *Thermal Physics*, 2nd edition, (Freeman, NY 1980).