Physics 12, Spring 2008
Problem Set 7

Date assigned: May 22 **Due on May 29 at 5:00 pm**

Homework sets should be put in the Physics 12 lock box outside 269 Lauritsen.

Reading Assignment: Chapters 8 of Kittel-Kroemer.

Do problems 3, 6, 7, and 9 in Chapter 8.

In addition, do the following problems:

[1] Consider the Fermi-Dirac distribution,

$$f(\epsilon) = \frac{1}{e^{\frac{\epsilon-\mu}{\tau}} + 1}.$$

The density of states is given by $D(\epsilon)d\epsilon$. Consider a physical observable $\psi(\epsilon)$ and its expectation value I given by

$$I = \int_0^\infty \psi(\epsilon)D(\epsilon)f(\epsilon)d\epsilon.$$

We should adjust the chemical potential μ so that the number of particles is N. Suppose the temperature τ is much below the Fermi energy $\epsilon_F = \mu(N, \tau = 0)$. Show

$$\left(\frac{\partial I}{\partial \tau}\right)_\mu = \frac{\pi^2}{3}\tau \frac{d}{d\epsilon}\left(\psi(\epsilon)D(\epsilon)\right)_{\epsilon=\epsilon_F} + O(\tau^3),$$

$$\left(\frac{\partial I}{\partial \mu}\right)_\tau = \psi(\epsilon_F)D(\epsilon_F) + O(\tau^2),$$

$$\left(\frac{\partial I}{\partial \tau}\right)_N = \frac{\pi^2}{3}\tau \frac{d\psi}{d\epsilon}(\epsilon_F)D(\epsilon_F) + O(\tau^3).$$

[2] Suppose there is some material whose internal energy (when expressed as a function of the volume and the temperature) is independent of the volume. Show that:

(a) the heat capacity C_V depends only on the temperature τ,

(b) the volume depends only on the ratio P/τ of the pressure and the temperature, and

(c) the difference $(C_P - C_V)$ depends only on P/τ.