KFUPM
Department of Physics
Phys530

Homework #7

Due with the final exam

Problem 1

Use eqns. (7), (8), and (13) sec. 7.1 to derive the virial coefficients of equation (14). Please show you work in details.

Problem 2

Problem 7.18 from your textbook.

Problem 3

Use eqns. (7) and (8) of sec. 7.1 to show that

$$y \equiv \frac{PV}{NKT_c} = \frac{g_{5/2}(z)}{g_{3/2}(1)}\left(\frac{T}{T_c}\right)^{5/2}$$

And

$$x \equiv \frac{T}{T_c} = \left(\frac{g_{3/2}(1)\left(1-\frac{1}{N}\frac{z}{1-z}\right)}{g_{3/2}(z)}\right)^{2/3}$$

Use these equations without any approximations to plot two graphs of y versus x similar to that in Fig. 7.3 of your textbook. In one graph, you will show that the region where the gas starts to condensate, your graph is nicely fitted to the following function

$$y = \frac{g_{5/2}(1)}{g_{3/2}(1)} x^{5/2}.$$

In the second graph, you will show that for large x, y approaches the ideal gas line.
To plot y versus x, you need to find the values of $g_{3/2}(z)$ and $g_{5/2}(z)$ numerically and then make a table of x and y as a function of z for $N = 10^6$. Choose the range of z carefully to show the Bose condensation region in the first graph clearly and the classical region in the second graph. In your two graphs, do not join your data points.

Problem 4

Na metal has approximately 2.6×10^{22} conduction electrons/cm^3. These conduction electrons behave approximately as a free electron gas.

a- Calculate the Fermi Energy level in eV for this electron gas.
b- Estimate the electronic specific heat of Na at room temperature.

Problem 5

a) Show that eq. 8.1.4 can be written in the following form
$$\frac{4}{3\sqrt{\pi}}\frac{1}{x^{3/2}} = f_{3/2}(e^{y/x})$$
Where $y = \mu/\varepsilon_F$ and $x = T/T_F$. Plot y versus x by solving this equation numerically for the range x = 0 to x = 2. Comment on the behavior of μ for $T \ll T_F$.

b) Plot the occupation number of an ideal Fermi gas as a function of $\varepsilon/\varepsilon_F$ for the following T/T_F = 0.01, 0.1,1 and 10, use μ from part (a) of the problem.