Modern Physics 330: HW # 10

1. Calculate the Fermi energy ϵ_F for N ultra-relativistic electrons.

2. For N non-relativistic electrons in a 2-D box, calculate the average energy, total energy U/N. (Ans: $\epsilon_F/2$) Hint: in this case, the phase space is

$$\frac{L^2}{h^2} d^2p$$

3. *A Simple Model of the Greenhouse Effect* [1]

   In lecture 16 the total energy U per volume V radiated by a black body is proportional to T^4. Multiplying by $c/4$ (4 being a geometric factor) we get the total power radiated per unit area from a perfect black body

$$\frac{P}{A} = \sigma T^4$$

   where σ is the Stephan-Boltzmann constant.

   - Calculate the total power radiated by the sun, the luminosity (lum) of the sun.
   - Calculate the solar constant (SC) which is the energy per unit area at the top of the earth's atmosphere.
   - Calculate the temperature at the top of the earth's atmosphere (TAtm) taking into account that 30% of the incident light is reflected back into space.
   - calculate the wavelength corresponding to the peak energy of the light emitted from the sun and from the atmosphere.
   - In a simple model of the Greenhouse effect, the earth's atmosphere acts as a blanket that is transparent in the visible but opaque in the infrared. Show that in equilibrium this doubles the amount of energy absorbed by the earth, and calculate the temperature of the earth's surface (TE).

   some data:

[1] Taken from Scroeder Thermal Physics

- temperature of sun T=5780 K
- solar radius Rs = 6.96×10^8 m
- earth radius Re = 6.4×10^6 m
- distance to the sun r = 1.5×10^{11} m
- $\sigma = 5.67 \times 10^{-8}$ W/m^2/K^4
- black body peak energy $2.82 \times kT$
- Boltzmann constant k = 8.6×10^{-5} eV/K