Introduction to Solid State Physics 2:10 - 4:10 (1/7/2013)

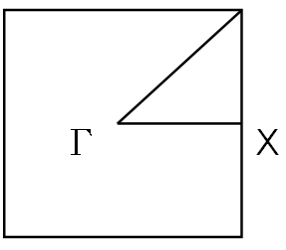
1. (20%) Answer the following questions briefly. Use formulas and figures if that helps your explanation.
(a) What is the *order of magnitude* of Fermi wave vector for alkali metal? What is the order of magnitude of Fermi temperature for alkali metal?
(b) What is the Wiedemann-Franz law?

2. (30%) (a) In 2-dim free electron model, we have a Fermi circle (instead of a Fermi sphere). The radius k_F of the Fermi circle depends on the density of free electrons $n=N/A$ (N is the total number of electrons, A is the area of the sample). Find out the connection between k_F and n.
(b) For a 2-dim electron gas (instead of 3-dim), what would be the temperature dependence of electron specific heat $C_e(T)$ at low T? Briefly explain how you obtain your answer.

3. (20%) (a) A crystal has N_1, N_2, N_3 lattice points along each side of the sample. The primitive vectors of the direct and the reciprocal lattices are $(\vec{a}_1, \vec{a}_2, \vec{a}_3)$ and $(\vec{b}_1, \vec{b}_2, \vec{b}_3)$.

Suppose we impose Periodic Boundary Condition on the crystal. What are the positions of $\boldsymbol{k}$ points in k-space? You can simply write down the answer directly.
(b) In the textbook example explaining the connection Bragg diffraction and energy gap, a lattice potential $V(x)=V\cos(2\pi x/a)$ is used. If the potential is $V(x)= V_1\cos(2\pi x/a) + V_2\cos(4\pi x/a)$, where will be the energy gaps? (show it in a figure)

4. (30%) In the reduced zone scheme, energy bands are plotted in the first Brillouin zone (BZ).
(a) Consider free electrons in an (empty) square lattice with lattice constant a. Plot all of the energy bands below energy $5(\hbar^2/2m)(\pi/a)^2$ along the ΓX direction (see below). Also, write down the energies of the curves at points Γ and X.
(b) If we have a rectangular lattice with lattice constant a and $2a$ (along x and y directions). What would the curves in (a) be changed? Re-plot the figure and write down the energies of the curves at points Γ and X.



First BZ