Solid State Physics – Midterm Exam 2:10 PM - 4:30 PM (11/8)

(10 points for each item)

1. (a) Find and draw the reciprocal lattice of the 2-dim triangular lattice in Fig.1(a).
   (b) Following (a), draw the first Brillouin zone.
   (c) Find out the structure factor $S(\mathrm{G})$ of the honeycomb lattice in Fig.1(b), then draw its reciprocal structure. Different points in the reciprocal structure may have different structure factors. Draw a larger dots if the associated $|S(\mathrm{G})|^2$ is larger. (the atomic form factor is f_a)

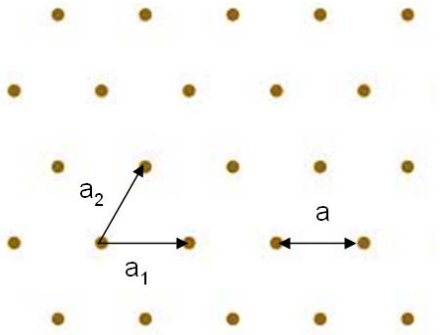

Fig.1(a)

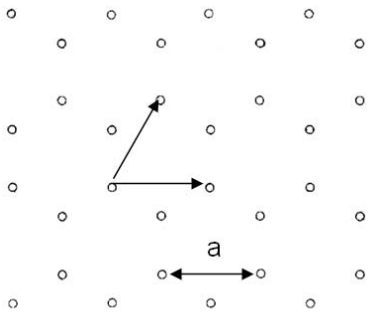

Fig.1(b)

2. (a) Briefly explain *the Ewald construction*. Draw a figure if necessary.
   (b) Prove that, if the incident and the diffracted wave vectors ***k*** and ***k'*** satisfy the Laue condition, then this would lead to the Bragg diffraction condition.

3. (a) Consider a free electron gas in 2 dimension. How does the Fermi wave vector k_F depend on the electron density *n*.
   (b) Find out the density of states $D(\varepsilon)$ for 2-dim electron gas. (electron mass is *m*, sample area is *A*)
   (c) In 3-dim, we know that the electron specific heat C_e is proportional to temperature *T*. In 2-dim, is C_e still proportional to *T*? If it is, explain why. If not, give the correct *T*-dependence. Use a heuristic argument (instead of Sommerfeld expansion).

4. (a) A monatomic crystal with FCC structure has a volume 1 mm^3. The volume of a *primitive* unit cell is 5 A^3. How many *k*-points are there in the first Brillouin zone? How many electrons are required to fill an energy band? (consider spin)

(b) Show that an electron in the Bloch state $\psi_{n\vec{k}}(\vec{r})$ with energy $\varepsilon_n(\vec{k})$ has velocity

$$\vec{v}_n(\vec{k}) = \frac{\partial \varepsilon_n(\vec{k})}{\hbar \partial \vec{k}}.$$