

Quiz 3 | submit at my office by Monday 10:30am. DO IT FULLY YOURSELF.

1. Consider a hexagonal lattice in 2D with lattice vectors  $\vec{a}_1 = a\hat{x}$  and  $\vec{a}_2 = \frac{a}{2}\hat{x} + \frac{a\sqrt{3}}{2}\hat{y}$ . Consider a basis made of atoms at  $(0, 0, 0)$  and  $(\frac{a}{2}, \frac{a}{2\sqrt{3}}, 0)$ .

Draw the crystal structure. (1)

List all the symmetries. (3)

Find an appropriate international notation for the crystallographic point group (2).

Draw the reciprocal lattice vectors and mark the first, second and third Brillouin zones (3).

2. Consider one valence electron per atom. Calculate the area enclosed by the Fermi surface (a closed curve or polygon in this case) if the system is doped such that on average there are 0.25 electron extra per atom. (4)

3. Calculate and schematically plot  $E(\vec{k})$  along  $(1,1,0)$ . Assume nearest neighbor hopping  $t$  and onsite term zero. (4)

Comment how will the band structure change if the onsite term on the two atoms of the basis are  $+m$  and  $-m$ . (3)

4. Consider a square lattice in 2D. Consider two scenarios – (1) nnn hopping is +0.5 times the nn hopping and (2) -0.5 times the nn hopping.

Derive relevant expression and schematically plot the Fermi surface at half filling (implying one electron per site) in the two cases showing sufficient reason.

5. In the absence of nnn hopping in case of square lattice estimate the periodicity of the diamagnetic response in the inverse of magnetic field ( $1/|B|$ ) at half filling and integer filling (2 electron per site). Let the lattice constant be 'a' and nn hopping be 't' if you need those.