Problem Set # 1

(On Solid State Physics for B.Sc. (Physics) Part-III)

Dr. Sunil Kumar Yadav*

Department of Physics, Maharaja College, Arrah, Bihar 802301, India.

(Dated: May 28, 2020)

"Our virtues and our failures are inseparable, like force and matter. When they separate, man is no more."

— Nikola Tesla

---

1. Define primitive unit cell and conventional unit cell.

2. How many atoms are in the primitive unit cell of graphite?

3. Prove that any Bravais lattice has inversion symmetry in a lattice point.

4. Prove that the diamond structure is invariant under an inversion in the midpoint of any nearest neighbor bond.

5. The primitive translation vectors of a hexagonal space lattice are defined as

$$\mathbf{a}_1 = (\sqrt{3}a/2)\hat{\mathbf{x}} + (a/2)\hat{\mathbf{y}}; \quad \mathbf{a}_2 = -(\sqrt{3}a/2)\hat{\mathbf{x}} + (a/2)\hat{\mathbf{y}}; \quad \mathbf{a}_3 = c\hat{\mathbf{z}}.$$

   (i) Show that the volume of the primitive cell is $\sqrt{3}/2a^2c$.

   (ii) Show that the primitive translations of the reciprocal lattice are:

$$\mathbf{b}_1 = \left(\frac{2\pi}{\sqrt{3}}a\right)\hat{\mathbf{x}} + \left(\frac{2\pi}{a}\right)\hat{\mathbf{y}}; \quad \mathbf{b}_2 = -\left(\frac{2\pi}{\sqrt{3}}a\right)\hat{\mathbf{x}} + \left(\frac{2\pi}{a}\right)\hat{\mathbf{y}}; \quad \mathbf{b}_3 = \left(\frac{2\pi}{c}\right)\hat{\mathbf{z}}.$$

   (iii) Describe and sketch the first Brillouin zone of the hexagonal space lattice.

6. Consider a plane hkl in a crystal lattice. (i) Prove that the reciprocal lattice vector $\mathbf{G} = h\mathbf{b}_1 + k\mathbf{b}_2 + l\mathbf{b}_3$ is perpendicular to this plane.

*Electronic address: sunil.phy30@gmail.com

(ii) Prove that the distance between two adjacent parallel planes of the lattice is $d_{hkl} = 2\pi/|\mathbf{G}|$.

(iii) For a simple cubic lattice prove that $d_{hkl} = a/\sqrt{h^2 + k^2 + l^2}$.