Solid State 1 HW2

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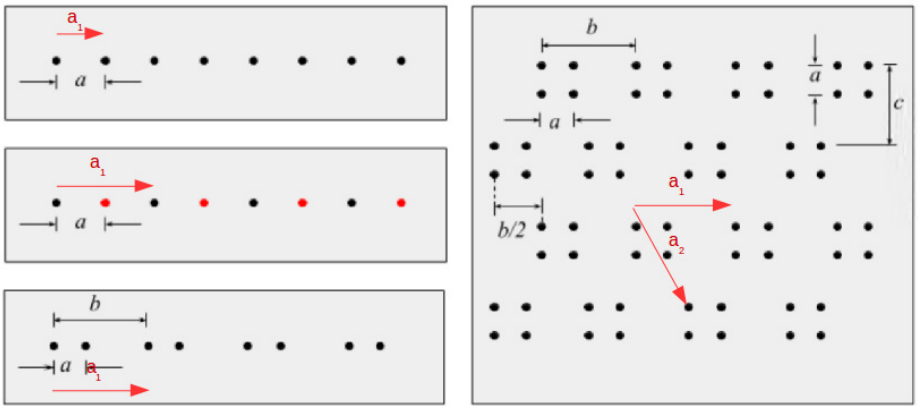
1

Figure 1: Lattice structure



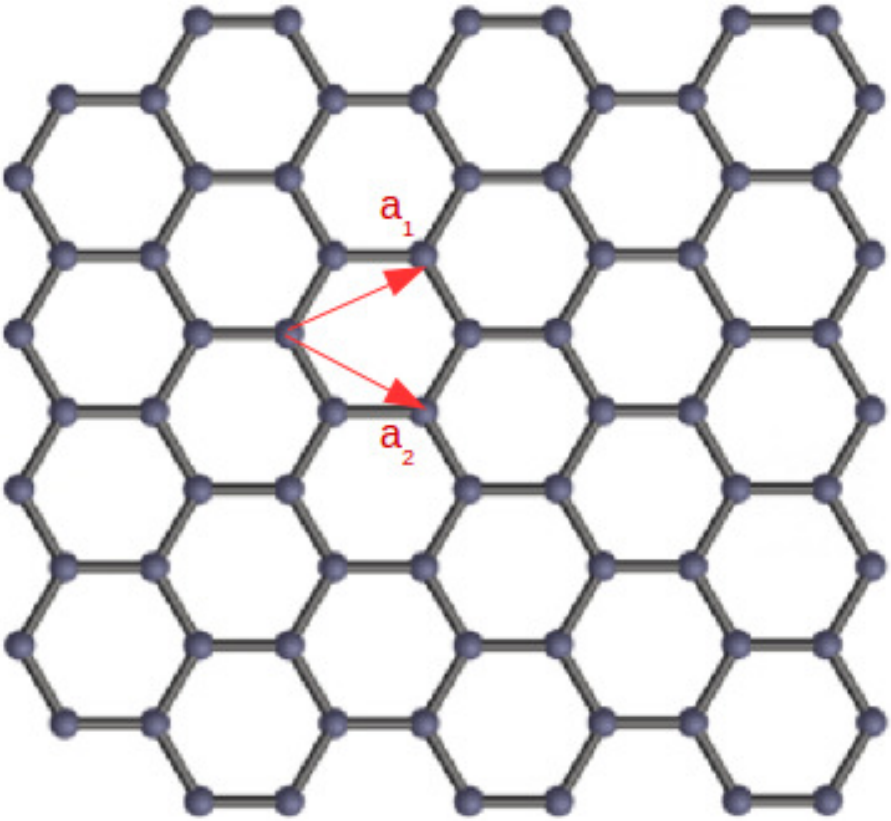
For the first structure, the lattice vector is $\mathbf{a}_1 = a\hat{\mathbf{x}}$ and the basis is a single molecule.

For the second structure, the lattice vector is $\mathbf{a}_1 = 2a\hat{\mathbf{x}}$ and the basis are the two different molecules separated by a.

For the third structure, the lattice vector is $\mathbf{a}_1 = b\hat{\mathbf{x}}$ and the basis is two of the same molecule separated by a.

For the fourth structure, the lattice vectors are $\mathbf{a}_1 = b\hat{\mathbf{x}}, \mathbf{a}_2 = \frac{b}{2}\hat{\mathbf{x}} + c\hat{\mathbf{y}}$ and the basis is a square of four molecules of side a.

Figure 2: Lattice structure



2

For graphene the primitive cell is a single 6-atom ring. One choice of translation vectors that carry one ring into another is $\mathbf{a}_1 = (1 + \cos(60))\hat{\mathbf{x}} + \sin(60)\hat{\mathbf{y}}, \mathbf{a}_2 = (1+\cos(60)\hat{\mathbf{x}}) - \sin(60)\hat{\mathbf{y}}$ where we take the nearest-neighbor distance as 1.

3

In the hcp structure as given the centers of the spheres are separated by length a. Assuming the black spheres in the center have the same radius as the white spheres, each black sphere makes a regular tetrahedron of side length a with three of the white spheres in the bottom layer and the top layer. The height of each tetrahedron is $\frac{\sqrt{6}}{3}a$, so $c = \frac{2\sqrt{6}}{3}a$ and $c/a = \sqrt{8/3}$.

To determine the number of nearest neighbors, and hence the coordina-

tion number, we examine the white sphere in the center of the bottom layer. Its nearest neighbors at distance a include the 6 adjacent white spheres, the three black spheres in the center and the three black spheres in the unit cell below. Therefore the number of nearest neighbors is 12.