H3-2022: Extra Practice Question Set 1

1. The unit cell of a crystal, with a face-centered cubic (fcc) structure, is shown in Figure 1. The lattice constant is a = 5.5 Å and there is one atom at each lattice point.

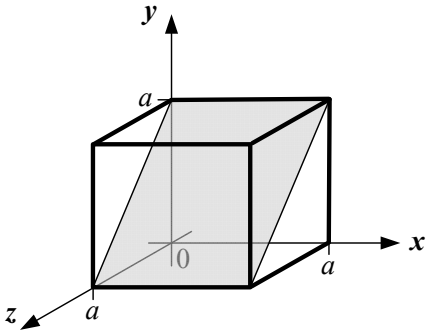

Figure 1

(a) Write down the Miller indices of the shaded plane.

(b) Calculate the surface density of atoms (in units of atoms/cm^2) on the (010) plane.

[Ans: (a) (011), (b) 6.612×10^{14} cm^{-2}]

2. An intrinsic semiconductor with a bandgap energy of 2.1 eV is uniformly illuminated with light. If the wavelength of light is 0.7 μm, will excess electron-hole pairs be produced in the semiconductor? Justify your answer.

3. Figure 3 shows a shaded plane in a body-centered cubic (bcc) crystal structure with a lattice constant of a. There is one atom at each lattice point of the crystal structure.

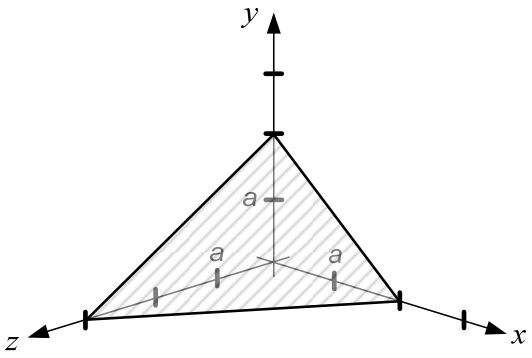

Figure 3

(a) Determine the Miller indices of the shaded plane.

(b) The surface density of atoms on the (111) plane of the crystal is 2.506×10^{14} cm^{-2}. Find the value of a.

(c) Calculate the shortest distance between any two atoms in this crystal structure.

[Ans: (a) (3 3 2), (b) 4.8 Å , (c) 4.157 Å]

4. Figure 4 shows the Si unit cell with a lattice constant of a. The surface density of atoms on the (010) plane is 6.783×10^{14} cm^{-2}.

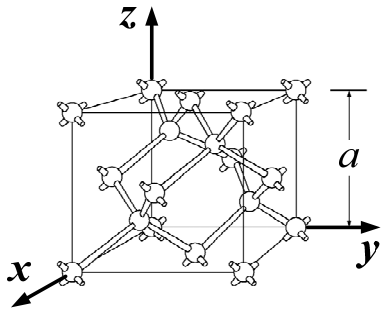

Figure 4

(a) Determine the value of a.

(b) Sketch the (110) plane and indicate clearly the position of all the atoms on the plane.

(c) Hence calculate the surface density of atoms on the (110) plane.

[Ans: (a) 5.43 Å, (c) 9.59×10^{14} cm^{-2}]

5. The position of atoms on the (111) plane of a hypothetical semiconductor is shown in Figure 5. The surface density of atoms on the plane is 1.45×10^{15} cm^{-2}.

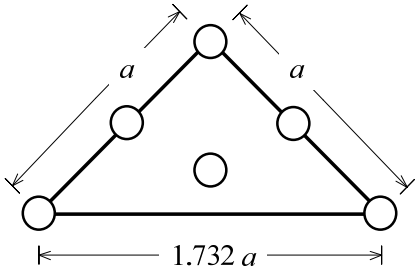

Figure 5

(a) Determine the number of atoms in the plane.

(b) What is the value of a?

[Ans: (a) 2.5, (b) 6.392 Å]

6. Figure 6 shows the conduction band of two semiconductor samples. Which sample has a smaller electron effective mass? Justify your choice.

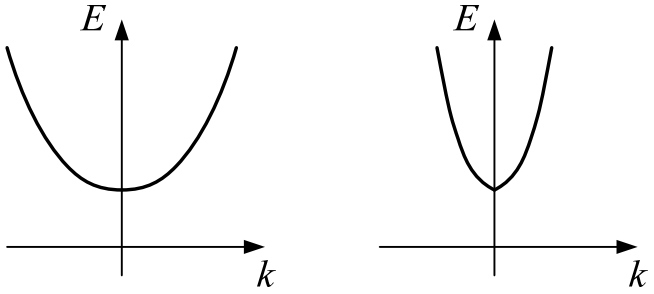

Figure 6