Eðlisfræði þéttefnis I

Dæmablað 9

Skilafrestur 30. Október 2018 kl. 15:00

1. **Kristallsmætti 1D grindar – Crystal potential in 1D lattice** (10)

   Gerum ráð fyrir að kristallsmætti í einvíðri grind samanstandi af rétthyrndum brunnum umhverfis atómin. Gerum ráð fyrir að dýpt brunnanna sé V_0 og að breidd þeirra sé $a/5$.

   (a) Beita skal nánast frjálsa rafeinda líkanið til að reikna stærð fyrstu þriggja orkugeilanna. Berið saman stærð þessara orkugeila.

   (b) Reiknið orkugeilar fyrir tilfellin þegar $V_0 = 6$ eV og $a = 4$ Å.

   Suppose that the crystal potential in a one-dimensional lattice is composed of a series of rectangular wells which surround the atoms. Suppose the depth of each well is V_0 and its width $a/5$.

   (a) Using the near free electron model, calculate the values of the first three energy gaps. Compare the magnitudes of these gaps.

   (b) Evaluate these gaps for the case in which $V_0 = 6$ eV and $a = 4$ Å.

   (Próf Desember 2017)

2. **Empty lattice or free electron model** (15)

   (a) Construct the first, second and third Brillouin zones for a two dimensional square lattice crystal of lattice constant a. In the free electron approximation, what is the

number of electrons per unit cell needed for the third Brillouin zone to start being filled ?

(b) Consider a monovalent simple cubic crystal and calculate the fraction of substitutions with bivalent atoms required for the Fermi surface to touch the boundary of the first Brillouin zone.

(c) In a FCC crystal with conventional lattice constant $a = 0.4$ nm, what is the energy difference between the lowest and next lowest bands at the center of the first Brillouin zone.

(d) Determine if the Fermi surface of a monovalent BCC crystal lies within the first Brillouin zone.

3. **Sound waves** (10)

Would you expect to find sound waves in small maolucules ? If not, how do you explain the propagation of sound waves in gaseous substances ?

4. **Fermi Surface Shapes** (10)

Consider a divalent atom, such as Ca or Sr, that forms an fcc lattice (with a single atom basis). In the absence of a periodic potential, would the Fermi surface touch the Brillouin zone boundary ? What fraction of the states in the first Brillouin zone remain empty ?

5. **Neutron Scattering** (10)

The conventional unit cell dimension for a particular bcc solid is 0.24 nm. Two orders of diffraction are observed. What is the minimum energy of the neutrons ? At what temperature would such neutrons be dominant if the distribution is Maxwell–Boltzmann.