



Arab Academy for Science & Technology & Maritime Transport
(AASTMT – Cairo Branch)
College of Engineering & technology
Electronics & Communication Engineering Department

Course : Solid State Electronics
Course Code : EC210

Sheet #7

TextBook

‘Principles of Electronic Materials and Devices’, Third Edition, S.O. Kasap © McGraw-Hill, 2006

Constants:

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ Fm}^{-1}$$

$$\text{Charge of electron } (q) = 1.6 \times 10^{-19} \text{ C}$$

$$\text{Mass of electron } (m_e) = 9.1 \times 10^{-31} \text{ kg}$$

$$\text{Plank's Constant } (h) = 6.63 \times 10^{-34} \text{ Js}$$

Solve the following problems

- [1] Consider an electron in a hydrogen atom, the attractive force between the electron and the nucleus is given as:

$$F(r) = \frac{Ze^2}{4\pi\epsilon_0 r^2}$$

- a. Derive an expression for the electron potential energy.
- b. Plot the potential energy of interaction between the nucleus (at the origin) and the electron versus the distance r between them.
- c. For two hydrogen atoms with inter-atomic separation given by $r=0.074\text{nm}$, plot the electron potential energy interaction.

- [2] A photon is emitted as a hydrogen atom undergoes a transition from the $n = 6$ state to the $n = 2$ state. Calculate:

- a. The energy
- b. The wavelength
- c. The frequency of the emitted photon.

- [3] The Kronig-Penney model considers the problem of an electron that moves in a superlattice potential with high barriers. The solution of Schrodinger equation for this problem yields to the dispersion relation: $P \frac{\sin(\alpha a)}{\alpha a} + \cos(\alpha a) = \cos(ka)$. Let $P=0$ in this dispersion relation.

- a) Calculate the energy at the bottom of the first band
- b) Obtain an expression for the top of the first energy band.

[4] Use fig.1 to draw the variation of the electron velocity in the first three energy bands.

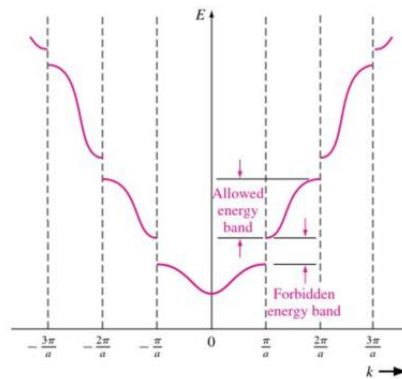


Fig.1

[5] Solution of Schrodinger equation for the Kronig-Penney model yields to the dispersion relation: $P \frac{\sin(\alpha a)}{\alpha a} + \cos(\alpha a) = \cos(ka)$. In this dispersion relation, $\alpha a = 2.6$ rad at the bottom of the first band and $\alpha a = \pi$ rad at the top of the same band, find the bandwidth for $a = 5 \text{ \AA}$.

[6] For silicon, in the $\langle 100 \rangle$ direction, the energy referenced to conduction band edge can be described as: $E = A k^2$. If the measurements show that the effective mass of electrons in the $\langle 100 \rangle$ direction is $0.916m_0$, find the constant A.