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:

$\varepsilon_o = 8.85 \times 10^{-12}\,\mathrm{Fm}^{-1}$

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

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

Plank’s Constant $(\mathrm{h}) = 6.63 \times 10^{-34}\,\mathrm{Js}$

Solve the following problems

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

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

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=0.074nm, 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.

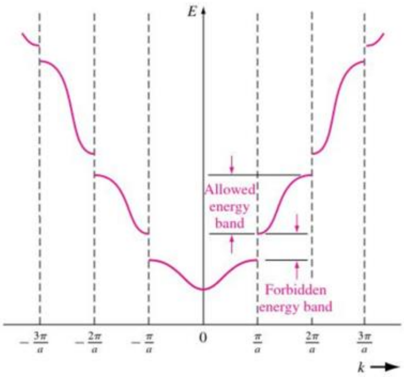

Fig.1

[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, αa = 2.6 rad at the bottom of the first band and αa = π rad at the top of the same band, find the bandwidth for a = 5 Å.

[6] For silicon, in the <100> 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 <100> direction is $0.916m_o$, find the constant A.