PY4118 Physics of Semiconductor Devices - 2017

Assignment #2

Start with the Kronig Penney solution provided with $a = 0.5nm$

$$\cos(ka) = \frac{P\sin(\beta a)}{\beta a} + \cos(\beta a)$$

Question 2.1

[6 marks] Provide a graph showing the allowable E vs. k diagram (optional reduced k) for:

a) [2 marks] free electrons (i.e. P=0)

b) [2 marks] weakly bound electrons with P=5

c) [2 marks] highly confined electrons P=12

Question 2.2

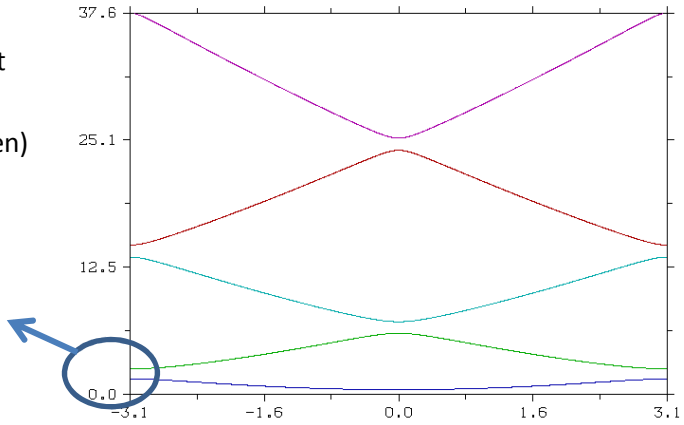
[8 marks] Using the potential from 1b) (i.e. P=5), treat the lowest band (blue) as the valence band (and thus filled with electrons), and the next highest band (green) as the conduction band and therefore not filled.

a) [2 marks] Calculate the highest energy of the valence band (in blue)

b) [2 marks] Calculate the lowest energy of the conduction band (in green)

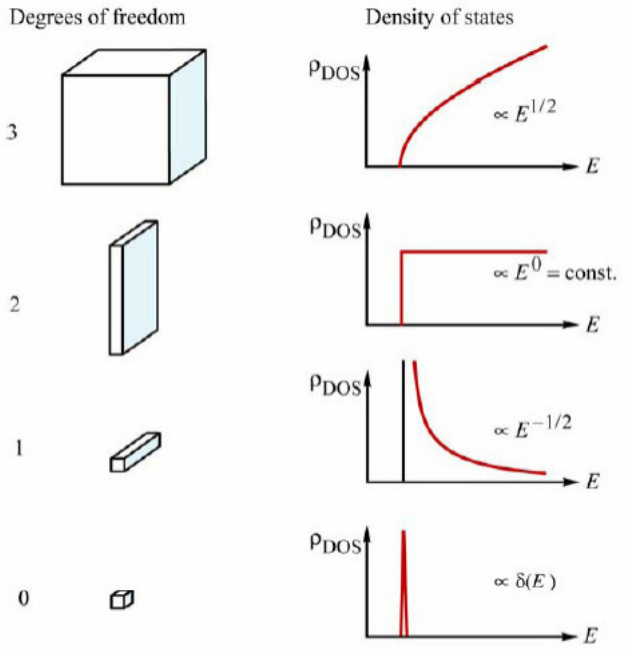
c) [2 marks] What is the bandgap?

d) [2 marks] What are the effective masses (please remember to include the sign as this means something!)?



Question 2.3

[6 marks] Show that the density of states for a Quantum Well and a Quantum Wire can be described by the graphs in the figure.
(i.e. do the calculation and show that the answer matches the figure)



Question 2.4

[3 marks] Using the density of states of the QW, calculate the population densities of the electrons *for the ground state* of the quantum well:

$$n = \int_{E_{c,ground}}^{\infty} \rho_c(E) f(E) dE$$

Hint, use: $u = e^{-(E-E_F)/kT}$

Question 2.5

[2 marks] What does the equation for the electron population from Question 2.4 simplify to, under the condition: $E_F - E_{c,ground} >> kT$

Due: Start of class, Tuesday, October 3, 2017