Exercise-sheet 5

I. The hydrogen atoms

(I.1) The wave function of the lowest energy state (ground state) in a hydrogen atom is given by the Eq. 2.73. We try to find most probable value of the radius for the 1s electron in a hydrogen atom.

(a) Derive an expression of radial probability distribution of finding the electron at a particular distance r from the nucleus.

(b) Show that the most probable value of the radius r in the ground state is equal to the Bohr radius a_0.

(I.2)

For an isolated silicon atom;

(a) Write down the electron configuration ($1s^2$...).

(b) How many valence electron(s) does the atom have?

(c) How many unpaired electrons (electrons that fill half an orbit) does the atom have?

II. Allowed and Forbidden Energy Bands

(II.1) By the Kronig-Penny model, the relation between k, total energy E and potential barrier V_0 can be obtained as follows (equation 3.24 of Neaman page 65);

$$P' \frac{\sin \alpha a}{\alpha a} + \cos \alpha a = \cos ka \tag{1}$$

where

$$P' = \frac{m V_0 b a}{\hbar^2} \tag{2}$$

How E will be expressed, (i) if the potential barrier is negligibly low, i.e., $V_0 = 0$,

(ii) if the potential barrier is infinitively high, i.e., $V_0 \to \infty$, while the width b keep some finite value (so $V_0 b \to \infty$).

For both cases, plot the E as a fuction of k. (You could use Figure 1.)

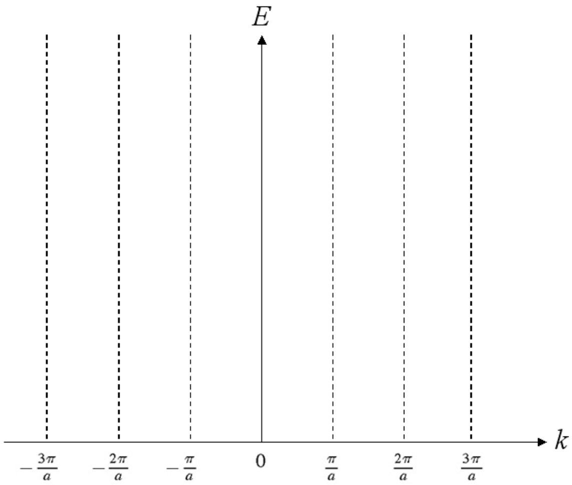

Figure 1: The E-k diagram