1. Explain why "cavity with a hole" (cavity radiation) emits the black-body radiation. (10%)

2. What is the Compton scattering? (The complete answer should include: the process (5%), the results (10%), and the implications (5%)).

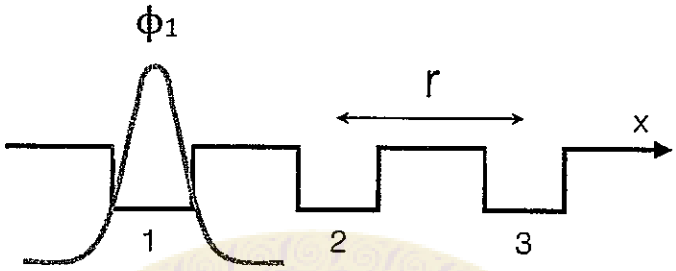

FIG. 1. An 1D system of three identical quantum wells. ϕ_1 is an example of the wavefunction when the electron is at the well 1.

3. Consider an electron in an one-dimensional system of three identical quantum wells mounted on a substrate and separated equally by the distance r, as shown in Fig. 1. The electron, when residing at the well i, can be described by a wavefuction ϕ_i with an energy e_0 independent of r, as depicted in Fig. 1. Since these three wells are identical, we assume that $e_0(<0)$ is the same for each well. However, ϕ_i are not the eigenfunctions, so the electron can "jump" between nearest-neighbor wells with a transfer integral $-\Delta(r) = -\alpha/r$, where $\alpha > 0$. Namely, the electron can transfer between well 1 and well 2, between well 2 and well 3, but not between well 1 and well 3.

   (a) Compute the eigenvalues (15%) in terms of e_0 and $\Delta(r)$ and the corresponding eigenfunctions in terms of ϕ_i (15%).

   (b) Draw all the eigenfunctions. (15%)

   (c) At $t = 0$, the electron is at well 1. Namely, the electron wavefunction $\Psi(0) = \phi_1$. What is the probability $P(t)$ to find the electron at well 3 in the later time t? (5%) Plot $P(t)$. (5%)

   (d) Again, at $t = 0$, the electron wavefunction $\Psi(0) = \phi_1$. At this moment, the energy is measured. Right after the energy is measured, what is the probability to find the electron at well 3 at $t = 0$? (5%)

   (e) The substrate actually feels a force due to the electron "jumping" between wells. Suppose that the electron is in the ground state, calculate the force. (5%) Is it attractive or repulsive? (5%)

試題隨卷繳回