PC2232 Physics for Electrical Engineers: Tutorial 8

Question 1: Nuclear fission

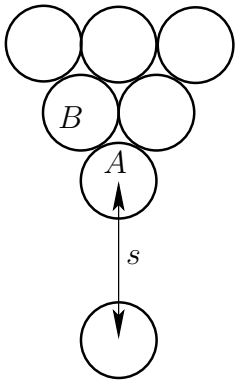
When a free neutron enters a nucleus, it experiences a sudden drop in potential energy, from $U = 0$ outside to around -12 MeV (million electron volts) inside. Suppose a neutron, emitted with energy 4 MeV by a fission event, strikes such a nucleus. What is the probability it will be absorbed, thereby initiating another fission? [*Hint*: You calculated the probability of *reflection* in the previous tutorial. Use $T = 1 - R$ to get the probability of transmission through the surface.]

Question 2: Tunneling

An electron with initial kinetic energy 5.5 eV encounters a square potential barrier with height 10.0 eV. What is the width of the barrier if the electron has a 0.10% probability of tunneling through the barrier? What is the energy of the electron after it tunnels through the barrier?

Question 3:

In the STM, the tunneling current depends exponentially $I = I_0 \mathrm{e}^{-2ks}$ on the distance, s, between the tip atom and the surface atom (center-to-center distance). Let I_A be the tunneling current due to tunneling between the atom (A) and the surface atom. Let I_B be the tunneling current due to tunneling between the atom (B) (one level higher than tip atom) and the surface atom. Calculate the ratio I_B/I_A. (Assume $k = 5 \times 10^9$ m^{-1}, and diameter of the atoms is 0.5nm and $s = 2$ nm.)



Question 4:

5.00×10^5 electrons of energy 2.7 eV are incident upon a potential step of unknown energy U_0. Among these, only 2.00×10^4 are reflected back.

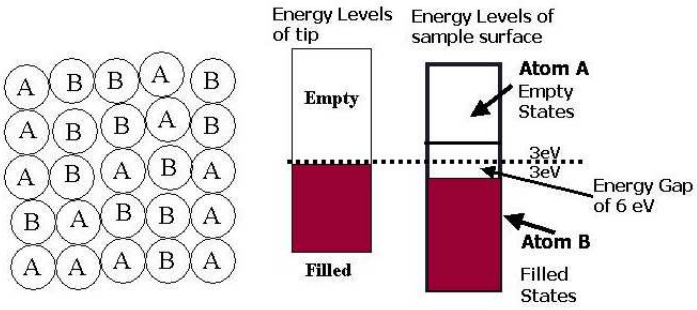
(a) Determine the value of U_0.

(b) For the same potential step, 1.8×10^4 are incident, with only 2.00×10^4 reflected back. Determine the energy of electrons in this case.

For this question, assume that E is always larger than U, and B is always positive.

Question 5:

The figure below shows the arrangements of atoms A and B on the surface of a sample as well as the electron energy levels of the STM tip and sample with no applied voltage bias. If you are interested in locating the positions of atoms A directly using the STM, what can you do?



Question 6:

The STM can be used to image the surface of a sample comprising of (hypothetical) γ^* and γ orbitals as illustrated in the following figure. The energy levels of the STM tip and sample with no applied voltage bias are also shown in the figure. Depending on the conditions of the experiment, the resultant STM image would appear differently. Sketch the STM image of 15×12 Angstrom^2 expected if the experiment is carried out with the STM tip biased at $+1.8$ V with respect to the sample?