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Problem Set #4

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Problem Set #4 Some 1D infinite well stuff

1. The ground state energy of an electron in an atom can be roughly estimated by assuming the electron is trapped in an infinite square well the length of which is about 0.2 nm (a typical atom "size"). Use the infinite square well energy level equation (Sc1, page 3) to estimate the ground state energy of an atomic electron.

2. Though the energy eigenstates of an electron in an atom are infinitely long-lived, perturbations (such as two atoms colliding, for example) can cause transitions between states. When that occurs the energy difference is associated with the emission or absorption of a photon with the required energy. Assuming the model of an atom described in problem 1 is valid, what is the wavelength (in nm) of a photon needed to excite an electron from the ground state to the first excited state?

3. The ground state energy of a proton in an atomic nucleus can be roughly estimated by assuming the proton is trapped in an infinite square well the length of which is about 10–6 nm (a typical nuclear "size"). Use the infinite square well energy level equation (Sc1, page 3) to estimate the ground state energy of a proton in a nucleus. Express your answer in MeV. (Use the approximation that the mass of the proton is roughly 2000 times the mass of the electron.)

4. Redo problem 3, but now assuming that an electron is somehow trapped in the nucleus. "Beta decay" is a nuclear process in which an electron is ejected from the nucleus. The highest observed electron energy in beta decay is about 10 MeV. How does that observation tell us that the ejected electron is not originally in the nucleus, but rather appears because of some kind of transformation process (in particular, when a neutron transforms into a proton plus an electron [technically, plus an electron antineutrino])?