Handout #10

1. (b). Think of a brick in a hole in the ground. It takes energy to get it out of the hole. Energy has to be added to bring an electron from a state with energy $-13.6 \text{ eV}$ to a state with energy $-3.4 \text{ eV}$.

2. (a) The energy of the atom increases as noted above. Hence photon absorption is required.

3. The energy of the photon must be precisely equal to the energy difference, i.e.,

$$\Delta E = E_{\text{final}} - E_{\text{initial}} = (-3.4 \text{ eV}) - (-13.6 \text{ eV}) = -10.2 \text{ eV}.$$

4. The ball starts high up, at rest with zero kinetic energy and some positive (gravitational) potential energy. As it rolls down potential energy is converted to kinetic energy, but throughout the motion (neglecting frictional losses) the sum of kinetic energy and potential remains constant.

5. Neglect gravity in this to focus on the essentials. If a rock is whirled with constant speed in a horizontal orbit on a string, its kinetic energy is not changing (since the speed doesn’t change and, in Newtonian physics, $KE = \frac{1}{2}mv^2$. The kinetic energy is the total energy in this case. If work were being done on the rock, its energy would change. So no work is being done on the rock. But there is a force on the rock due to the string, which is necessary to keep the rock moving in a circular path. BUT the force the string exerts on the rock is perpendicular to the displacement of the rock at any instant! Hence, the string force does not work on the rock, and that is consistent with the KE not changing.

Handout #11

1. Remember (but don’t memorize the numerical value) that in energy units 1 amu is equivalent to 931 MeV of energy. Hence the mass of a helium-4 nucleus in Mev is given as

$$4.00260 \text{ amu} \times \frac{931 \text{ MeV}}{1 \text{ amu}} = 3726.4 \text{ MeV}$$

2. Mass(neutron)+Mass(positron) = $(1.008665 + 5.49 \times 10^{-4}) = 1.0092 \text{ amu}$, which is already greater than the mass of the hydrogen atom. With the mass-energy of a neutrino added the mass of the products will be even greater. So from energy considerations it would violate conservation of energy, and, in fact, this process is not observed. Note that the hypothetical process I gave you is disallowed also because it doesn’t conserve charge. The original hydrogen atom is neutral. We could conserve charge by allowing an additional electron to be produced in the outgoing particles. But that will make the energy imbalance even worse.
3. Supposing the neutron has negligible kinetic energy (OK assumption here, and the information was not provided for that reason) the initial energy of the system is Mass($U^{235}$) + Mass($n$) = $235.04395$ amu + $1.008665$ amu = $236.053$ amu. The mass of the products is $(142.92054 + 89.91959 + 3 \times 1.008665) = 235.87$ amu. This means that the difference $(236.053 - 235.87) = .183$ amu is available for kinetic energy to be divided (not equally in general) among the outgoing “daughter” nuclei and the neutrons.