Practice Problems Solutions Section 4

1. A negative point charge is placed 0.800 m to the left of a negative point charge , which has a mass of 0.0150 kg.

is given an initial velocity of 9.00 m/s directed away from (to the right). Assume is held fixed.

1. What is the direction of the force acting on ?

Since both charges are negative, the force is repulsive. Thus the force on points to the right.

1. Based on your answer to a), what will happen to the electric potential energy of the system as moves to the right? What will happen to the kinetic energy of as it moves to the right?

Since the force points to the right, the potential energy must be decreasing as the charge moves to the right. By energy conservation, the kinetic energy (and thus the speed) will increase.

1. How fast will be moving when it reaches a distance infinitely far away from ?

We must use energy conservation. Initially, the separation distance is m. At the end, the separation distance is infinite, so the final potential energy is zero. The initial speed is m/s and the final speed is unknown. Conservation of energy yields

As expected, the charge is moving faster at the end than at the beginning.

1. A hydrogen atom consists of an electron and a proton. Model the atom as a dipole with separation distance m.
   1. What is the electric potential energy of the hydrogen atom?
   2. What is the minimum work required by an external force to remove the electron from the atom (i.e. to move the electron “infinitely” far away from the proton)?

The minimum work required would be such that the kinetic energy of the electron would not increase (i.e. it would go from rest initially to rest at the end). Using the work-kinetic energy theorem, the work required is thus equal to the change in electric potential energy from the initial configuration to the final configuration. In the initial configuration, the potential energy is as found in part a). In the final configuration, the charges are infinitely far apart, and thus the potential energy is zero. Thus,

* 1. Assume an external force does more work on the electron that your answer to b). What can you say about the motion of the electron when it is very far (infinitely) from the proton?

If the external force does more work than J, then the electron will have to experience an increase in kinetic energy, per the work-energy theorem. Thus, the electron will have some non-zero motion in this case.