PHYSICS—Electrostatic Energy Problems

Name: ________________________ Period: 1 2 3 4 5 6

With energy the idea is that is has to come from somewhere and go somewhere. Basically there is a fixed amount in the universe and the only thing that changes is the form of energy. That is, regardless of the initial form of energy, that energy must go somewhere.

As previously stated, in a conservation system the energy switches only between kinetic and potential. Although kinetic energy is still computed in the same way, electrostatics introduces three new ways of calculating potential energy.

The first looks at the interaction between charges: $\frac{kq_1q_2}{r}$ **Be careful this equation looks a lot like the force equation.**

Another that measures the potential energy of a charge in an electric field: qEr

The third way uses voltage to calculate the potential energy: qV

Of course, the last way means you have to be able to find the voltage before you can determine the potential energy (remember voltage is a rating system for the amount of energy a charge could have at some point in an electric field).

For our purposes, there are two ways we can compute the voltage

The voltage near a charged particle: $\frac{kq}{r}$

The voltage in an electric field: Er

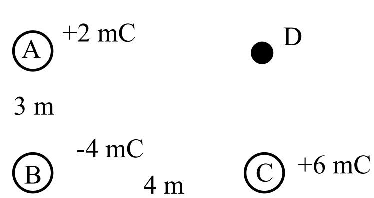
Problems:

1. A 3.0 x 10^{-6}C charge is placed 0.05 meters from a 5.0 x 10^{-7} C charge.

   a. What is the potential energy of the 3.0 x 10^{-6}C charge? (0.27J)
   b. What is the potential energy of the 5.0 x 10^{-7} C charge? (0.27J)
   c. If the 3.0 x 10^{-6}C charge is held in place and the other charge allowed to move, how much potential energy does the moving charge have when it is 0.75 meters away? (0.018J)
   d. How much potential energy was lost? (0.252J)
   e. Where did it go? (Read f. to get a clue)
   f. How much kinetic energy does the charge have? (0.252J)
   g. If it has a mass of 0.004 kg, how fast is it going at that point? (11.2 m/s)

2. A van de Graaf generator is capable of producing a potential difference (voltage) at the surface of the dome of 400,000 V. If the radius of the dome is 0.15 meter, how much charge is on the surface of the dome? (6.67 μC)

3. Find the voltage at point D in the diagram below (find the voltage as though each charge is alone and add them): (1.53 x 10^7V)



4. If you place a proton at point D, how much potential energy does it have there? (2.45 x 10^{-12}J)

5. A proton is released at a point in an electric field where the voltage is 10,000,000 V.

   a. What is its potential energy at that point? (1.6×10^{-12}C)
   b. What is the maximum amount of kinetic energy it could gain? (think)
   c. How fast will the charge be moving when it reaches its maximum kinetic energy? (4.4×10^{7}m/s)

6. Two paralllel plates are 2m by 4m in area, are separated by 0.02 meters, and have +5.3 μC of placed on the surface of the positive plate.

   a. What is the electric field between the plates?* (7.5×10^{4}N/C)
   b. What is the voltage difference between the positive and negative plates? (1.5×10^{3}V)
   c. An electron is placed at the surface of the negative plate, through what potential difference does the electron move in going from the negative to the positive plate ? (-1500 V)
   d. How fast will the electron be traveling when it strikes the plate? (2.3×10^{7}m/s)

7. A lightning bolt has electrons traveling from an electric potential of -1,000,000,000 V to zero. By the time the electrons reach the ground they are only going 60,000 m/s.

   a. How fast would you expect them to be traveling (conservation of energy)? (1.88×10^{10} m/s)
   b. How much energy is lost? (1.61×10^{-10}J)
   c. Where did it go? (it's not potential or kinetic)
   d. If one electron loses that much energy, how much energy would 5C worth of electrons lose? (find the number of electrons in 5C, ultimate ans. 5.0×10^{9}J)
   e. If the specific heat of air is 1000 J/kg°C and 10^{6} kg of air is heated by the lightning, what is the change in temperature of the air? (use $Q = mc\Delta T$, where Q is the heat generated, m is mass, c is the specific heat, and ΔT is the change in temperature). (5°C)

*Useful information:

mass of a proton: 1.67×10^{-27}kg
mass of an electron: 9.1×10^{-31}kg
charge of a proton/electron: +/- 1.6×10^{-19}C
equation for heat: $Q = mc\Delta T$
equation for the electric field between parallel plates:

$$E = \frac{4\pi kq}{A}$$