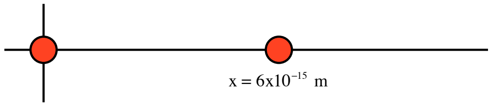
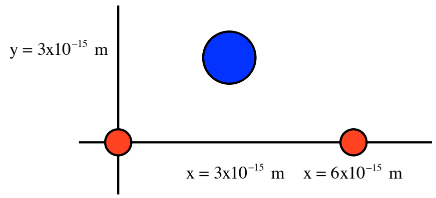
16.19)



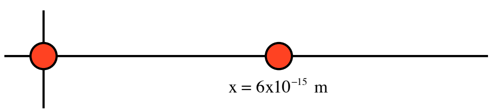
a.) Calculate the electrical potential energy in the system.

b.) Calculate the electrical potential energy in the system with the alpha particle included.



c.) What's the change of electrical potential energy if alpha particle is removed.

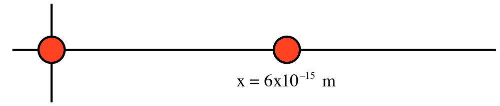
19.)



a.) Calculate the electrical potential energy in the system. We know:

Also, the voltage at infinity is zero. The voltage r units from a field producing point charge is $V = k\frac{q}{r}$. So . . .

19.)



a.) Calculate the electrical potential energy in the system. We know:

$$\Delta V = \frac{\Delta U}{q}$$

$$\Rightarrow (U_2 - U_1) = q(V_2 - V_1)$$

Also, the voltage at infinity is zero. The voltage r units from a field producing point charge is $V = k\frac{q}{r}$. So . . .

$$(U_r - U_\infty) = q(V_r - V_\infty)$$

$$\Rightarrow (U_r - 0) = q\left(k\frac{q}{r} - 0\right)$$

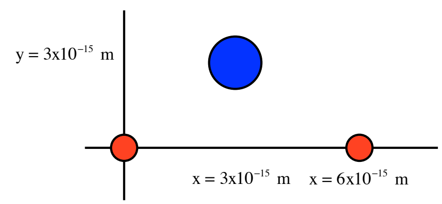
$$\Rightarrow U_r = k\frac{q^2}{r}$$

$$\Rightarrow U_r = (9x10^9)\left(\frac{(1.6x10^{-19})^2}{6x10^{-15}}\right)$$

$$\Rightarrow U_r = 3.84x10^{-14}\ J$$

19.) (con't.)

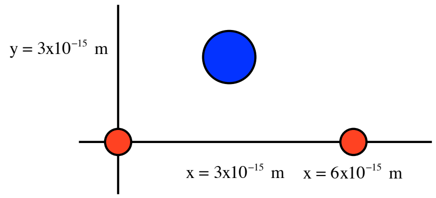
b.) Calculate the electrical potential energy in the system with the alpha particle included.



Added to the energy required to bring the protons together, we have to determine the work required to bring the alpha particle in. As each protons will be the same distance away, all we need to do is double the work done by one, or:

19.) (con't.)

b.) Calculate the electrical potential energy in the system with the alpha particle included.



Added to the energy required to bring the protons together, we have to determine the work required to bring the alpha particle in. As each protons will be the same distance away, all we need to do is double the work done by one, or:

$$W_{total} = W_{bring\ protons\ together} + 2W_{bring\ \alpha\ in\ due\ to\ one\ proton}$$

$$\Rightarrow U_{total} = (U_r - 0)_{p^+} + 2(U_r - 0)_{\alpha}$$

$$= q(V_r - 0)_{p^+} + 2(V_r - 0)_{\alpha}$$

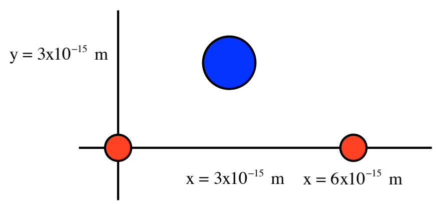
$$\Rightarrow U_{total} = k\frac{{q_{p^+}}^2}{r_{protons}} + 2k\frac{q_{p^+}q_{\alpha}}{r_{p\ to\ \alpha}}$$

$$\Rightarrow U_r = (9x10^9)\left(\frac{(1.6x10^{-19})^2}{6x10^{-15}}\right) + 2(9x10^9)\left(\frac{(1.6x10^{-19})(3.2x10^{-19})}{(3^2+3^2)^{1/2}x10^{-15}}\right)$$

$$\Rightarrow U_r = 2.55x10^{-13}\ J$$

19.) (con't.)

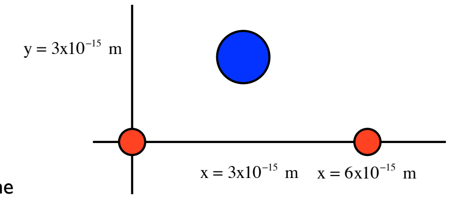
c.) What's the change of electrical potential energy if alpha particle is removed.



With the alpha particle removed, the system energy change is:

19.) (con't.)

c.) What's the change of electrical potential energy if alpha particle is removed.



With the alpha particle removed, the system energy change is:

$$U_{final} = U_{after} - U_{before}$$

$$= (3.84x10^{-14}) - (2.55x10^{-13})$$

$$= (-2.17x10^{-13})\ Joules$$

19.) (con't.)

d.) To determine the speed of the alpha particle at infinity (with the two protons held stationary), we need the work/energy theorem.

e.) Determine the speed at infinity of the two protons if the alpha particle held stationary. (By allowing both protons to move, there is no longer any electric potential energy in the system (a single particle doesn't need any work done to bring it in from infinity). Sooo . . .

19.) (con't.)

d.) To determine the speed of the alpha particle at infinity (with the two protons held stationary), we need the work/energy theorem.

$$\sum KE_1 + \sum U_{\text{in system at time 1}} + \sum W_{ext} = \sum KE_2 + \sum U_{\text{in system at time 2}}$$

$$\Rightarrow 0 + (2.55\text{x}10^{-13}\text{J}) + 0 = \frac{1}{2}\left[4\left(1.67\text{x}10^{-27}\text{kg}\right)\right]v^2 + (3.84\text{x}10^{-14}\text{J})$$

$$\Rightarrow v = 8.08\text{x}10^{6}\text{ m/s}$$

e.) Determine the speed at infinity of the two protons if the alpha particle held stationary. (By allowing both protons to move, there is no longer any electric potential energy in the system (a single particle doesn't need any work done to bring it in from infinity). Sooo . . .

$$\sum KE_1 + \sum U_{\text{in system at time 1}} + \sum W_{ext} = \sum KE_2 + \sum U_{\text{in system at time 2}}$$

$$\Rightarrow 0 + (2.55\text{x}10^{-13}\text{J}) + 0 = \frac{1}{2}\left[2\left(1.67\text{x}10^{-27}\text{kg}\right)\right]v^2 + (0)$$

$$\Rightarrow v = 1.24\text{x}10^{7}\text{ m/s}$$