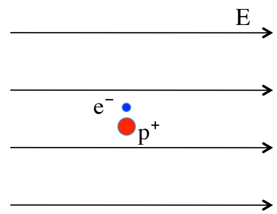
Problem 23.43

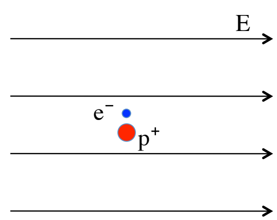
We can approach this problem from two directions, kinematics or impulse. We'll use both.



Kinematics approach: We know from N.S.L. that a=F/m, and we know from the definition of the electric field that F=qE, so we can write:

$$\begin{aligned} v_2 &= \cancel{v_1}^{\,0} + a\Delta t \\ &= \left(\frac{F}{m}\right)\Delta t \\ &= \left(\frac{qE}{m}\right)\Delta t \end{aligned}$$

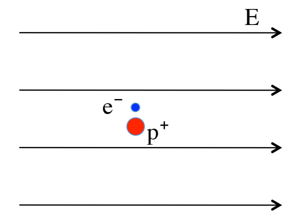
The momentum/impulse approach suggests:



$$\begin{aligned} F\ \ \Delta t &= \Delta p \\ (qE)\Delta t &= \Delta p \\ &= mv_2 - m\cancel{v_1}^{\,0} \\ \Rightarrow v_2 &= \left(\frac{qE}{m}\right)\Delta t \qquad \text{(same relationship)} \end{aligned}$$

For the electron, which will accelerate to the left (i.e., opposite the electric field):

$$\begin{aligned} v_e &= \left(\frac{q_e E}{m_e}\right)\Delta t \\ &= \frac{(1.60\text{x}10^{-19}\ \text{C})(5.20\text{x}10^{2}\ \text{N/C})}{(9.11\text{x}10^{-31}\ \text{kg})}(48.0\text{x}10^{-9}\ \text{sec}) \\ &= 4.38\text{x}10^{6}\ \text{m/s} \end{aligned}$$



For the proton, which will accelerate to the right along the direction of the electric field:

$$\begin{aligned} v_p &= \left(\frac{q_p E}{m_p}\right)\Delta t \\ &= \frac{(1.60\text{x}10^{-19}\ \text{C})(5.20\text{x}10^{2}\ \text{N/C})}{(1.67\text{x}10^{-27}\ \text{kg})}(48.0\text{x}10^{-9}\ \text{sec}) \\ &= 2.39\text{x}10^{3}\ \text{m/s} \end{aligned}$$

You would expect that accelerating the heavier proton in the same force field over the same period of time would effect a smaller final velocity than would be the case with the lighter electron, and that's exactly what we ended up with. Ain't physics wonderful?