Name: Key

Practice – 18.7 Conductors and Electric Fields in Static Equilibrium

1. Calculate the linear velocity and the angular velocity ω of an electron orbiting a proton in the hydrogen atom, given the radius of the orbit is 0.530 x 10^{-10} m. You may assume that the proton is stationary and the centripetal force is supplied by Coulomb attraction. m_e = 9.11 x 10^{-31} kg

$$F_c = \frac{mv^2}{r} = m\omega^2 r$$

$$F_E = \frac{kQ_1Q_2}{r^2}$$

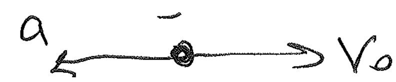
$$\frac{mv^2}{r} = \frac{kQ_1Q_2}{r^2}$$

$$v = \sqrt{\frac{kQ_1Q_2}{mr}} = \sqrt{\frac{(8.99\times10^{9}\frac{Nm^2}{C^2})(1.60\times10^{-19}C)(1.60\times10^{-19}C)}{(9.11\times10^{-31}kg)(0.530\times10^{-10}m)}}$$

$$= \boxed{2.18\times10^{6}\frac{m}{s}}$$

$$\omega = \frac{v}{r} = \frac{2.18\times10^{6}\frac{m}{s}}{0.530\times10^{-10}m} = \boxed{4.12\times10^{16}\frac{rad}{s}}$$

2. An electron has an initial velocity of 5.00×10^6 m/s in a uniform 2.00×10^5 N/C strength electric field. The field accelerates the electron in the direction opposite to its initial velocity.



A. What is the direction of the electric field?

In the direction of the electron's initial velocity.

B. How far does the electron travel before coming to rest?

$$v_f^2 = v_0^2 + 2ax \quad \text{and} \quad F = ma = qE \Rightarrow a = \frac{qE}{m}$$

$$x = \frac{-v_0^2}{2a} = +\frac{mv_0^2}{2qE} = \frac{(9.11\times10^{-31}\,\text{kg})(5.00\times10^{6}\,\frac{\text{m}}{\text{s}})^2}{2(1.60\times10^{-19}\,\text{C})(2.00\times10^{5}\,\frac{\text{N}}{\text{C}})}$$

(If x is positive, a is negative)

$$= \boxed{3.56\times10^{-4}\,\text{m}}$$

0.356 mm

C. How long does it take the electron to come to rest?

$$v_f = v_0 + at \Rightarrow t = -\frac{v_0}{a} = \frac{mv_0}{qE}$$

$$t = \frac{(9.11\times10^{-31}\,\text{kg})(5.00\times10^{6}\,\frac{\text{m}}{\text{s}})}{(1.60\times10^{-19}\,\text{C})(2.00\times10^{5}\,\frac{\text{N}}{\text{C}})} = \boxed{1.42\times10^{-10}\,\text{s}}$$

0.142 ns