Homework Solution "The Magnetic Force"

Problem: An electron moves in a circular orbit (according to the Bohr model of the atom) around a proton of radius 5.3 X 10^{-11}m with a velocity of 2.2 X 10^{6}m/s. What magnetic field is produced at the proton? Remember, the magnetic field is a vector, so be sure to give the magnitude and direction.

Solution:

The magnitude of the magnetic field is given by the relationship:

$$\left|\vec{B}\right| = \frac{\mu_o q v}{4\pi r^2} \qquad \text{where } \mu_o = 1.26\times10^{-6}\,\frac{T\cdot m}{A}$$

Putting in our values gives:

$$\left|\vec{B}\right| = \frac{\left(1.26\times10^{-6}\,\frac{T\cdot m}{A}\right)\left(1.6\times10^{-19}C\right)\left(2.2\times10^{6}\,\frac{m}{s}\right)}{4\pi\left(5.3\times10^{-11}m\right)^2} = \mathbf{12.6T}$$

The direction is given by the cross-product of the velocity of the charge (the electron) and the radius of the circular path it makes around the proton ($\vec{v}\times\vec{r}$). We use the right hand rule to find the direction of the resultant vector.

For example, if the electron is moving in a counter-clock-wise direction (CCW) in the plane of the page, then the velocity is also in a CCW direction in the plane of the page. Using the right hand rule, crossing the velocity into the radius, the resultant vector (the magnetic field direction) is coming out of the page at the center.