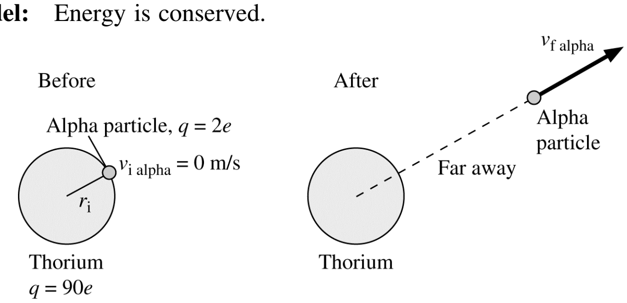
29.55. Model: Energy is conserved.

Visualize:



The alpha particle is initially at rest ($v_{\text{i alpha}} = 0$ m/s) at the surface of the thorium nucleus. The potential energy of the alpha particle is $U_{\text{i alpha}}$. After the decay, the alpha particle is far away from the thorium nucleus, $U_{\text{f alpha}} = 0$ J, and moving with speed $v_{\text{f alpha}}$.

Solve: Initially, the alpha particle has potential energy and no kinetic energy. As the alpha particle is detected in the laboratory, the alpha particle has kinetic energy but no potential energy. Energy is conserved, so $K_{\text{f alpha}} + U_{\text{f alpha}} = K_{\text{i alpha}} + U_{\text{i alpha}}$. This equation is

$$\tfrac{1}{2}mv_{\text{f alpha}}^2 + 0\text{ J} = 0\text{ J} + \frac{1}{4\pi\varepsilon_0}\frac{(2e)(90e)}{r_i}$$

$$\Rightarrow v_{\text{f alpha}} = \sqrt{\frac{1}{4\pi\varepsilon_0}\frac{(360e^2)}{mr_i}} = \sqrt{\frac{(9.0\times10^9\text{ N m}^2/\text{C}^2)360(1.60\times10^{-19}\text{ C})^2}{4(1.67\times10^{-27}\text{ kg})(7.5\times10^{-15}\text{ m})}} = 4.07\times10^7\text{ m/s}$$