SOLUTIONS

Example problem on using Electric Potential

Matt Trawick

Problem: An ionized helium atom (mass $m = 6.7 \times 10^{-27}$ kg, charge $q_0 = +1.6 \times 10^{-19}$ C) is released from rest 20 cm away from a +60 nC point charge. What is the helium ion's speed v when it is 75 cm away from the point charge?

Solution: Your first instinct might be to find the force on the helium ion, and then get the acceleration and velocity from there. But that would be hard, because the force is different everywhere, leading to an acceleration that is not constant. It's much easier to use the idea of electric potential and conservation of energy!

Step 1: Find the electric potential V_i at the place 20 cm from the point charge, and V_f at ~~60~~ 75 cm from the point charge. (Your answers should be in Volts.)

$$V_i = \frac{1}{4\pi\epsilon_0}\frac{Q}{r_i} = \left(8.99\times10^9 \text{ N}\cdot\text{m}^2/\text{C}^2\right)\frac{(60\text{ nC})}{(0.25\text{ m})} = 2697 \text{ Volts}$$

$$V_f = 719 \text{ Volts}$$

Step 2: Use the idea of conservation of energy to write the final kinetic energy of the helium ion K_f in terms of its charge q_0 and the potential difference $V_f - V_i$. What is your numerical answer, in Joules?

$$E_i = E_f$$

$$\cancel{K_i}^{\,0} + U_i = K_f + U_f$$

$$K_f = -(U_f - U_i) = -q_0(V_f - V_i) = -1.6\times10^{-19}\text{C}\,(719\text{V} - 2697\text{V})$$

$$K_f = 3.16\times10^{-16}\text{J}$$

Step 3: So what's the final speed of the helium ion, in meters per second?

$$K_f = \frac{1}{2}mv_f^2$$

$$v = \sqrt{\frac{2K_f}{m}} = 3.07\times10^5 \text{ m/sec}$$

(about 0.1% the speed of light)