Kinetic Energy and Voltage.

When matter moves, it possesses a quantity of energy called Kinetic Energy. This energy can be described by a simple mathematical formula. When matter that carries a charge moves in an electric field, it also carries kinetic energy. By comparing the two mathematical descriptions of kinetic energy, we can relate how the speed of a particle, **V**, changes as its mass, **m**, charge, **q**, or the electrical voltage, **E**, it moves in, is changed. Scientists often measure a charged particle's kinetic energy in terms of its voltage. In this exercise, we will look at the energies of various types of charged particle systems and determine the average speed of the particle. The formula that relates the kinetic energy of a particle to its voltage is given below. The left side is the definition for kinetic energy based on its charge and the voltage, **E**. The right side is the definition of kinetic energy based on the particles mass and speed.

$$qE = \frac{1}{2} m V^2$$

Question 1 – What is the formula for the speed of the particle, **V**, after solving the equation for V, and simplifying?

Question 2 – An electron with a charge **q** = 1.6×10^{-19} Coulombs and a mass **m** = 9.1×10^{-31} kilograms and has an energy **E** = 1000 Volts. What is the speed of the particle in meters per second?

Question 3 - If an oxygen ion has twice the charge of an electron, and 29400 times an electron's mass, what will its speed be for the same amount of energy E = 1,000 Volts?

Question 1 - What is the relationship for **V** after solving and simplifying this equation?
Answer: After a little algebra:

$$qE = \frac{1}{2} m V^2$$ becomes $$V = \sqrt{\frac{2qE}{m}}$$

Question 2 – An electron with a charge **q** = 1.6 x 10^{-19} Coulombs and a mass **m** = 9.1 x 10^{-31} kilograms and has an energy **E** = 1000 Volts. What is the speed of the particle in meters per second?

Answer:

$V^2 = (2 \times 1.6 \times 10^{-19} \times 1000) / (9.1 \times 10^{-31})$

$V^2 = (2 \times 1.6 / 9.1) \times 10^{(-19 + 3 + 31)}$

$V^2 = 3.5 \times 10^{14}$

$V = 1.9 \times 10^7$ meters/sec or 19,000 kilometers/sec.

Question 3 - If an oxygen ion has twice the charge of an electron, and 29400 times an electron's mass, what will its speed for the same amount of energy E = 1,000 Volts?

Answer: Because the mass and charge appear under the square root sign, the oxygen atom will travel at a speed $(2/29400)^{1/2}$ or 0.0082 times slower than the electron. The speed will be V = 0.0082 x 1.9 x 10^7 = 139 kilometers per second. Students can verify this by direct substitution of the new q and m into the equation, and converting to kilometers/sec.