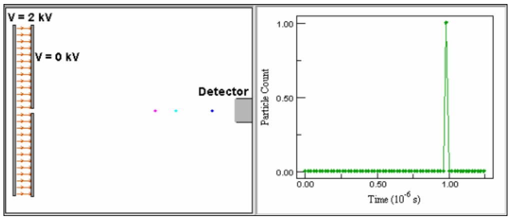
Worksheet for Exploration 25.4: Time-of-Flight Mass Spectrometer



Positively charged particles start in the center of a uniform electric field (created by the charged gray plates; the field is shown, but fringe effects are not). When you push play, four particles leave the parallel plates and head toward the detector. The graph simply plots the signal at the detector: showing a spike every time a particle hits the detector **(position is given in centimeters and time is given in microseconds)**. This is a time-of-flight mass spectrometer and is used to detect what types of charged particles are in an atomic beam. .

a. Given that the electric field is uniform and the voltage at the left plate is 2000 V and at the right plate is 0 V, explain how you know that the voltage in the middle of the plates (where the particles are) is 1000 V.

b. How much potential energy does each charged particle have if its charge is 1.6×10^{-19} C? (Each need one electron to be neutral again.)
   i. Make sure you note where the particles start. This is the PE as the particle starts (where it starts)

   PE_{start}=________

c. After each particle leaves the region with a constant electric field and enters the region without an electric field, what is the value of its potential energy?

   PE_{exit}=________

d. What then is the value of its kinetic energy? (with which each particle leaves the plate region).

e. Since the particles do not have the same speeds, rank the masses of the particles from least massive to most massive. (green, pink, blue, red)

Least Mass (1) ___________

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f. By measuring the time it takes the particle to arrive at the detector and the distance the particles travel through the field-free region, determine the speed of each particle.

v_{red}=__________

v_{pink}=__________

v_{green}=__________

v_{blue}=__________

g. From your calculation of kinetic energy, find the mass of each particle in kg and amu (1 amu = 1.67 x 10^{-27} kg).

m_{red}=_________ _________

m_{pink}=_________ _________

m_{green}=_________ _________

m_{blue}=_________ _________

Looking on a periodic table, what is the atomic mass of aluminum? It should be essentially the same as the value that you calculated for the mass of the smallest particle, as well as the mass difference between each larger particle. Therefore, this animation represents a particle beam where the first particle to hit the detector is a charged aluminum atom and the second particle is two aluminum atoms bound together, and so forth. One way to find out what material is in an unknown substance, then, is to do this type of mass spectrometry. (Illustration 27.3 and Exploration 27.2 demonstrate other types of mass spectrometry.)