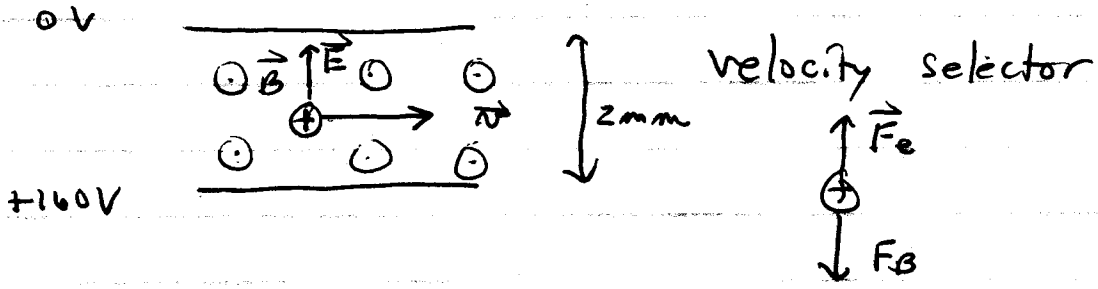
48. Before entering a mass spectrometer, ions pass through a velocity selector consisting of parallel plates separated by 2.0 mm and having a potential difference of 160 V. The magnetic field between the plates is 0.42 T. The magnetic field in the mass spectrometer is 1.2 T. Find (*a*) the speed of the ions entering the mass spectrometer and (*b*) the difference in the diameters of the orbits of singly ionized ^{238}U and ^{235}U. (The mass of a ^{235}U ion is 3.903×10^{-25} kg.)

#48

Mass Spectrometer



Want $F_e = F_B$

$eE = ev B$

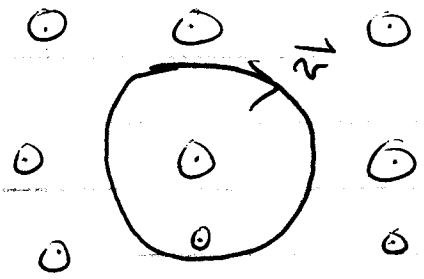
$v = E/B$.

What is E? $E = \frac{\Delta V}{d} = \frac{160\,V}{0.002\,m} = 8.0 \times 10^4\, V/m$

$B = 0.42\,T$ (given)

$v = E/B = 1.905 \times 10^5\, m/s$.

Next: what is radius in spectrometer?



$B = 1.2\,T$

$F = ma$

$evB = m v^2/r$

$r = \frac{mv}{eB}$

$m_{235} = 3.903 \times 10^{-25}\,kg$ (given)

$m_{238} = \frac{238}{235} m_{235}$

$r_{235} = \frac{(3.903 \times 10^{-25}\,kg)(1.905 \times 10^5\,m/s)}{(1.602 \times 10^{-19}\,C)(1.2\,T)} = 0.387\,m$

$r_{238} = \frac{238}{235} r_{235} =$ 0.392 m

$\Delta r = 0.0049\,m = 4.9\,mm$