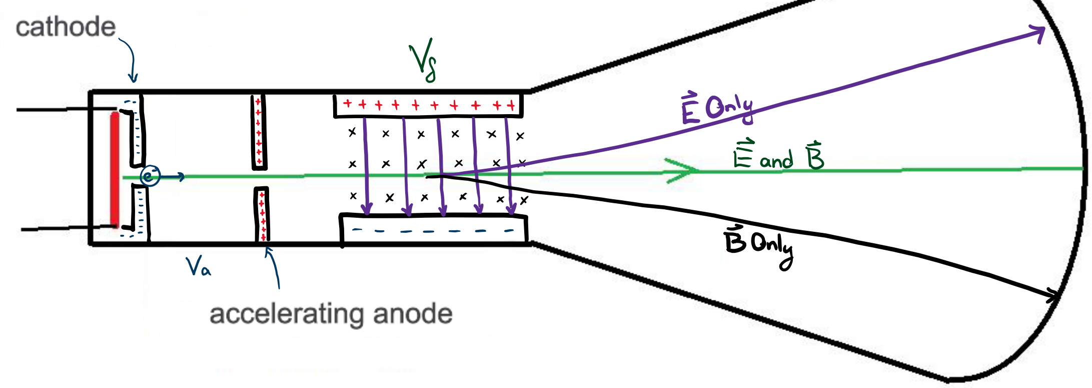
Lesson 7.4- Charges in Fields

Unit 7: Magnetism

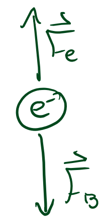
Cathode Ray Tubes (CRT):

Recall the previous unit where we looked at CRT's in terms of electrons being accelerated and deflected through uniform electric fields. Now we will add perpendicular magnetic fields to our model.

Magnetic fields can balance the forces from the electric field to control deflection



FBD:



$$\sum \vec{F}_y = 0$$
$$\vec{F}_e = \vec{F}_B$$
$$\cancel{Q}\vec{E} = \vec{B}\cancel{Q}\vec{v}$$
$$\boxed{\vec{E} = \vec{B}\vec{v} \quad \text{OR} \quad \frac{V}{d} = \vec{B}\vec{v}}$$

Example 1. An electron is accelerated from rest through accelerating plates of 200 V and then passes into a perpendicular magnetic field of 0.25 T between deflection plates 3 cm apart. What is the voltage of the deflection plates if the electron passes straight through?

*Determine the velocity of the e^- after accelerated w/ V_a.

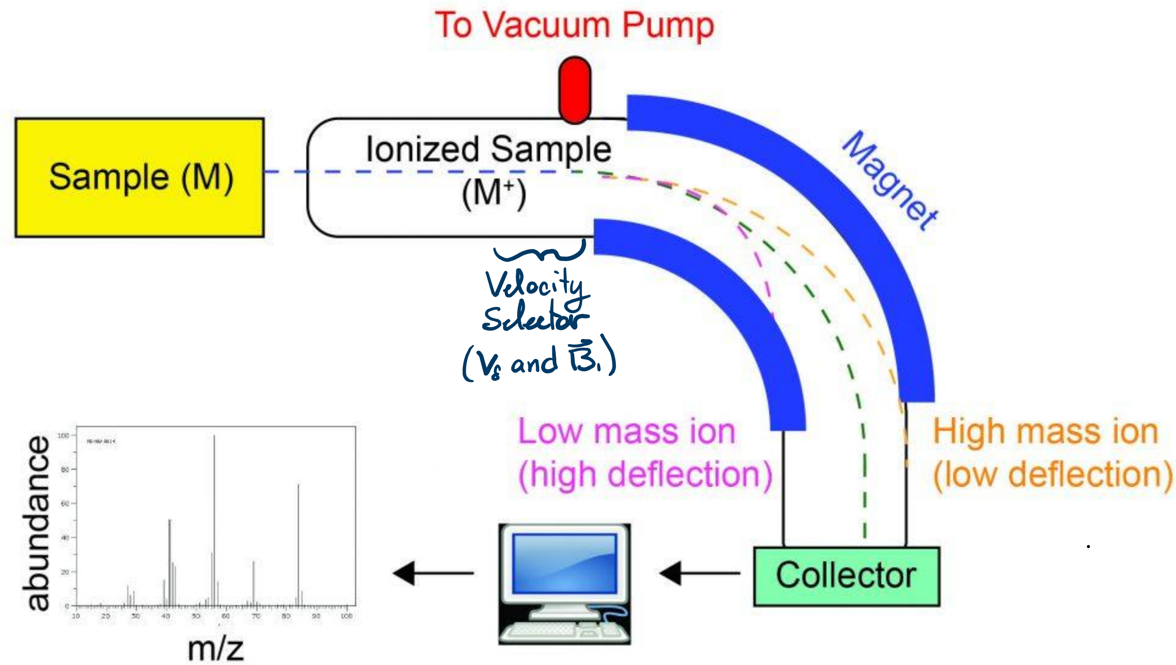
$$E_{po} + \cancel{E_{ko}}^{0} = \cancel{E_p}^{0} + E_k'$$
$$V_aQ = \tfrac{1}{2}m\vec{v}^2$$
$$\vec{v} = \sqrt{\frac{2V_aQ}{m}}$$

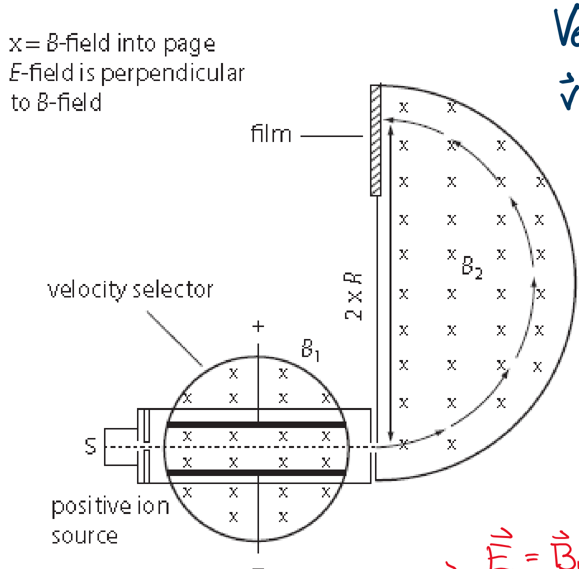
Find V_s

$$F_E = F_B$$
$$\cancel{Q}\vec{E} = \vec{B}\cancel{Q}\vec{v}$$
$$\frac{V_s}{d} = \vec{B}\vec{v}$$
$$V_s = B\vec{v}d$$
$$V_s = \sqrt{\frac{2(200)(1.6\times10^{-19})}{9.11\times10^{-31}}}(0.25)(0.03)$$
$$\boxed{V_s = 6.29\times10^{4}\,V}$$

Mass Spectrometry: Simulation

A tool developed to find the mass to charge ratio of atoms in order to determine the identity of a substance.





Velocity selector insures only ions with the same $\vec{v}$ make enter $\vec{B}_2$

* Allows for precise determination of mass for ID.

*Recall forces that cause circular motion:

$$\vec{F}_{B2} = F_c$$

$$\vec{B}_2 Q \cancel{\vec{v}} = \frac{m\vec{v}^{\cancel{2}}}{r}$$

$$m = \frac{\vec{B}_2 Q r}{\vec{v}}$$

$$\vec{E} = \vec{B}_1 \vec{v}$$

$$\vec{v} = \frac{\vec{E}}{\vec{B}_1}$$

$$m = \frac{\vec{B}_1 \vec{B}_2 Q r}{\vec{E}}$$

Example 2: A proton travelling at 2200 m/s enters a 0.15 T magnetic field perpendicularly. What is the radius of the proton's circular path while travelling through the magnetic field?

$$F_B = F_c$$

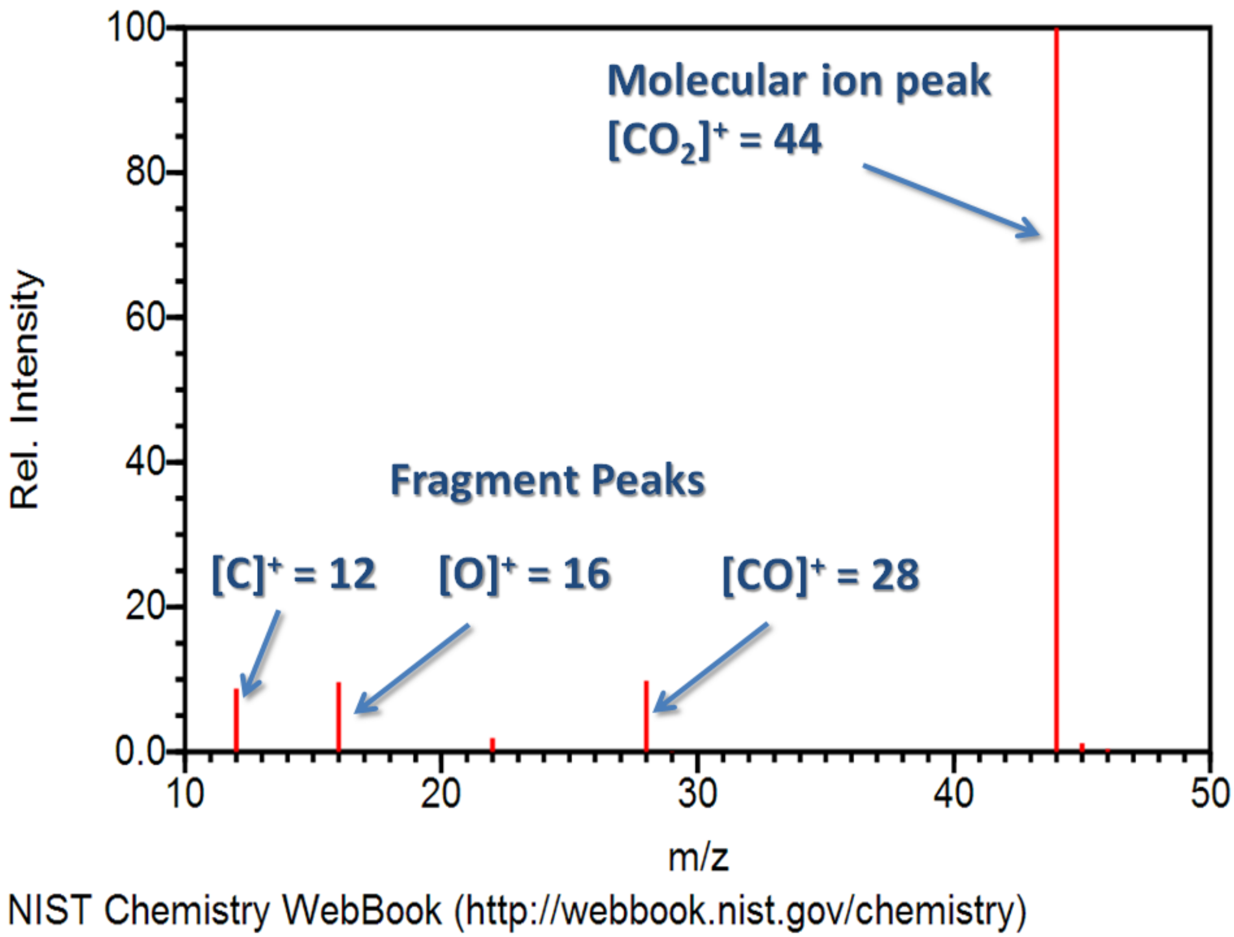
$$\vec{B}Q\cancel{\vec{v}} = \frac{m\vec{v}^{\cancel{2}}}{r}$$

$$r = \frac{m\vec{v}}{\vec{B}Q}$$

$$r = \frac{(1.67\times10^{-27}\,kg)(2200\,m/s)}{(0.15\,T)(1.6\times10^{-19})}$$

$$\boxed{r = 1.5\times10^{-4}\,m}$$

Example MS of a sample of carbon dioxide: Simulation here



Assignment: BC Physics 12 Sandner & Gore Pg. 236 #1-2 | Pg. 238 #1-2 | Pg. 243 # 1-4