4.2: Magnetic Sector

Magnetic Sector. The first mass spectrometer, built by J.J. Thomson in 1897 , used a magnet to measure the *m/z* value of an electron. Magnetic sector instruments have evolved from this same concept. Sector instruments have higher resolution and greater mass range than quadrupole instruments, but they require larger vacuum pumps and often scan more slowly. The typical mass range is to 5000 *m/z*, but this may be extended to 30,000 *m/z*. Magnetic sector instruments are often used in series with an electric sector, described below, for high resolution and tandem mass spectrometry experiments.

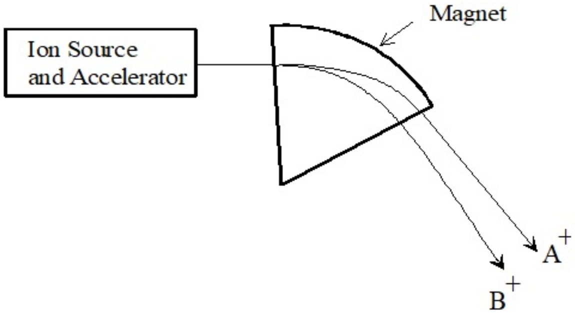

Figure 4.2.1: Magnetic Sector Mass Spectrometer. The low m/z ion $(B^{+})$is separated from the high m/z ion $\left(\mathrm{A}^{+}\right)$.

Magnetic sector instruments (Figure 4.2.1) separate ions in a magnetic field according to the momentum and charge of the ion. Ions are accelerated from the source region into the magnetic sector by a 1 to 10 kV electric field. This acceleration is significantly greater than the 100 V acceleration typical for a quadrupole instrument. Since the ions are charged, as they move through the magnetic sector, the magnetic field bends the ion beam in an arc. This is the same principal that causes electric motors to turn. The radius of this arc (r) depends upon the momentum of the ion μ, the charge of the ion (C) and the magnetic field strength (B) according to Equation 4.2.1.

$$r=\frac{\mu}{C \times B}$$

Ions with greater momentum will follow an arc with a larger radius. This separates ions according to their momentum, so magnetic sectors are often called momentum analyzers. The momentum of the ion is the product of the mass (m) and the velocity (v). The charge of the ion is the product of the charge number of the ion (z) and the charge of an electron (e). Substituting these variables into Equation 4.2.1 yields:

$$r=\frac{m/z \times v}{\mathrm{B} \times \mathrm{e}}$$

The velocity of an ion is determined by the acceleration voltage in the source region (V) and the mass to charge ratio (*m/z*) of the ion. Equation 4.2.2 rearranges to give the *m/z* ion transmitted for a given radius, magnetic field, and acceleration voltage as:

$$m/z=\frac{r^{2}\, \mathrm{B}^{2} \mathrm{e}}{2\, \mathrm{V}}$$

Only one *m/z* value will satisfy Equation 4.2.3 for a given radius, magnetic field, and acceleration voltage. Other *m/z* ions will travel a different radius in the magnetic sector.

Older magnetic sector instruments use a photographic plate to simultaneously detect ions at different radii. Since each *m/z* has a different radius, they strike the photographic plate at a different location. Modern instruments have a set of slits at a fixed radius to transmit a single *m/z* to the detector. The mass spectrum is scanned by changing the magnetic field or the acceleration voltage to transmit different *m/z* ions. Some new instruments use multichannel diode array detectors to simultaneously detect ions over a range of *m/z* values.