

CHAPTER I
INTRODUCTION



1.1 The Basic Theory of the Mass Spectrometer.

The charged particles emerging from the heated tungsten filament in the region G, through a potential difference V , acquires the kinetic energy $\frac{1}{2} mv^2 = eV$. A portion of the beam, selected by the slit S_1 , is then deflected through 180° in a circle of radius R by a uniform perpendicular magnetic field B and passes through slit S_2 and S_3 consecutively. The ions then strike the ion collector. When the ions are passing through the magnetic field, the force equation is $\frac{mv^2}{R} = \frac{Bev}{C}$ so that their masses may be calculated from the relationship

$$m = \frac{eB^2R^2}{2Vc^2} \quad (1.1)$$

The separated ion groups are in turn brought to the ion collector for detection by appropriately varying the accelerating potential. In the actual instrument, B and R are kept fixed, the voltage is varied to bring ions of a particular mass into the collector. With regard to salts of alkali metals, the metallic atoms evaporate in the ionized state. The diagram of the mass spectrometer was shown in Fig. 1.

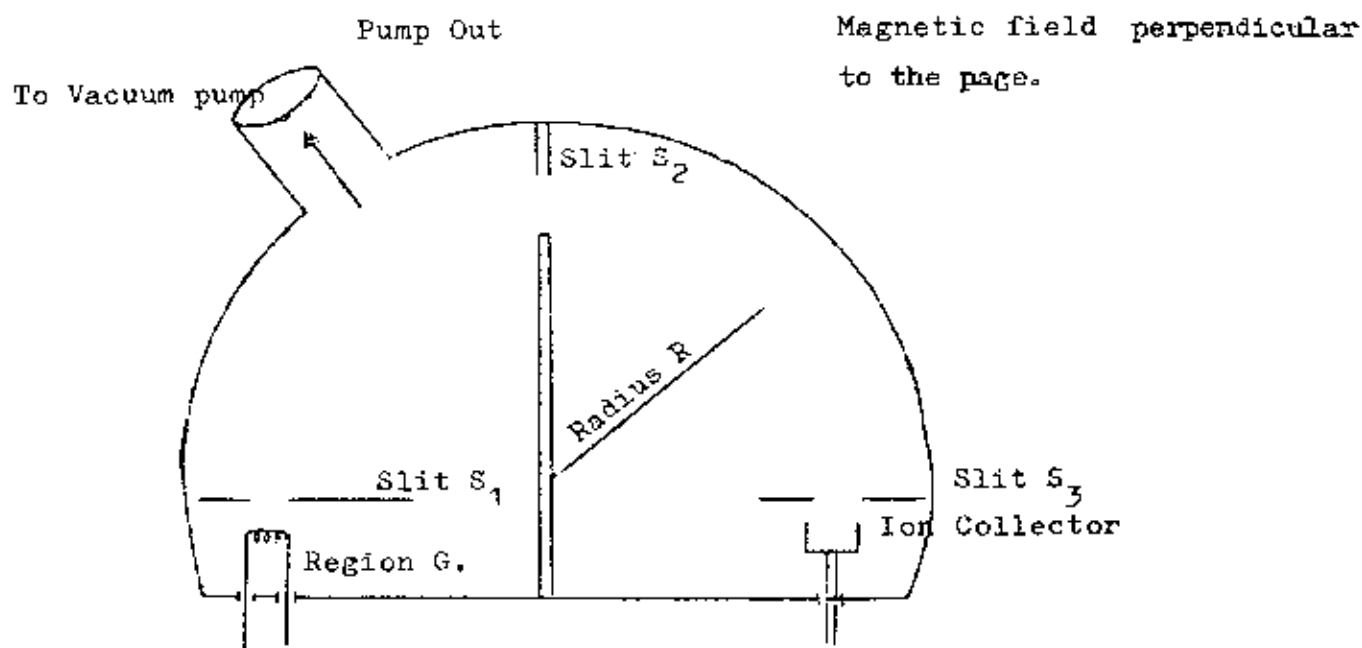


Fig.1 The Diagram of the Mass Spectrometer.

1.2 An Outline of the Investigation in this Thesis.

Dempster, a Canadian at the University of Chicago, was the first spectroscopist who constructed the instrument in 1918. In his experiment, he used salts of alkali metals as the material to be investigated, he only calculated the $\frac{e}{m}$ ratio and showed that positive charged ions deflected into semicircular path when they entered the magnetic field applied perpendicularly to their direction of motion. In 1960, Robert G. Marcle, a physicist at Swarthmore College, constructed the same type of the mass spectrometer used by Dempster, for the undergraduate students to study in the laboratory.

In this thesis, the instrument nearly similar to the one Dempster had constructed, was redesigned. Salts of alkali metals

were used as the salts to be investigated, and the atomic mass of the positive ion was calculated by the formula

$$m = 4.82 \times 10^{-5} \frac{B^2 R^2}{V} \text{ a.m.u.}$$

KCl and Li_2SO_4 were used to determine the atomic masses of K^{39} , K^{41} and Li^6 , Li^7 . From the curve of the ion currents versus the accelerating voltages, the isotopes of K^{39} , K^{41} and Li^6 , Li^7 were shown to be separated. Then the abundance ratios of each isotope in the particular salt were obtained. In addition to these, Na_2SO_4 was used as the salt to evaluate the atomic mass of Na^{23} .

Salts of alkali earth metals, BaCl_2 and CaCO_3 were also used as the salts to be investigated. The isotopes of Ca^{40} , Ca^{44} were separated, but the isotopes of barium could not be separated.

1.3 The Brief Design of the Mass Spectrometer.

As only 10 cm. diameter pole face electromagnets were available in the Physics Laboratory, thus the diameter of the circular path of positive ions was fixed at 8 cm. The body of the instrument including the slits and the ion collector was made of brass. A piece of copper wire using as a filament electrode, was inserted through a capillary glass tube filled with epoxy-resin. An O-ring was placed in the annular groove of the body of the instrument to make it vacuum tight. Epoxy-resin and shellac in alcohol were quite good sealing substances. They produced semipermanent sealing.