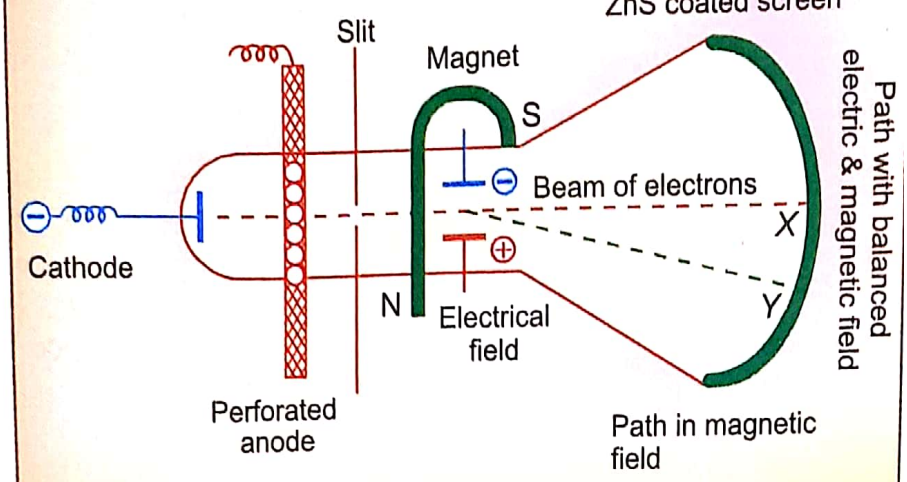

Fig. 7.6: Thomson's experiment for determination of specific charge (e/m) of cathode rays particles

Experiment : (i) Cathode rays generated are passed through perforated anode and a slit. These rays strike on ZnS coated screen where a bright luminous spot 'X' is obtained.

(ii) In second step, magnetic field is applied which interacts with cathode ray particles and consequently spot X is shifted to Y.

(iii) Now electric field is applied and its strength is adjusted such that spot Y is shifted again to X.

Observation and calculations : Let the strength of magnetic field applied in B, charge on cathode ray particle is e and it is moving with speed u, then magnetic field acting upon cathode ray particle (F_m) is

$$F_m = B \cdot e \cdot u \qquad \ldots(i)$$

Suppose the particle moving with speed u travels on a circular arc of radius 'r' (as measured from apparatus) then centripetal force (F_c) is

$$F_c = \frac{mu^2}{r} \qquad \ldots(ii)$$

because the spot is constant at position Y, thus

$$F_m = F_c$$

$$B \cdot e \cdot u = \frac{mu^2}{r}$$

or
$$\frac{e}{m} = \frac{u}{rB} \qquad \ldots(iii)$$

Now, when electric field is applied, the spot again is shifted to position X, because electrostatic force (F_e) acts upon cathode ray particle and its strength is equal to strength of F_m, thus

$$F_e = e \cdot E \qquad \ldots(iv)$$

E = strength of electric field

and
$$F_e = F_m$$

$$e \cdot E = B \cdot e \cdot u \qquad \ldots(v)$$

or
$$u = \frac{E}{B}$$

Putting the value of u in eq. (iii), then

$$\frac{e}{m} = \frac{E}{B^2 r} \qquad \ldots(vi)$$

On the basis of equation (vi), value of e/m was found to be $-1.7 \times 10^{11} \text{C} \cdot \text{kg}^{-1}$.

2. Discovery of Proton: Goldstein's Experiment Positive rays or anode rays or canal rays :

After the discovery of electrons, Goldstein repeated Thomson's experiment taking into consideration the fact that as a whole, matter is electrically neutral. The brief discussion is as follows :

(i) He repeated Thomson's experiment by using perforated cathode and observed a glow behind the perforated cathode also at the time of formation of cathode rays.

(ii) These rays, responsible for glow behind cathode were named as canal rays or anode rays (a misleading term).

(iii) These rays are composed of cations formed after ionisation of gas molecules filled in discharge tube.

$$H + e^- \xrightarrow{\text{High voltage}} H^+ + 2e^-$$

$$He + e^- \xrightarrow{\text{High voltage}} He^+ + 2e^-$$

$$Na_{(v)} + e^- \xrightarrow{\text{High voltage}} Na^+ + 2e^-$$

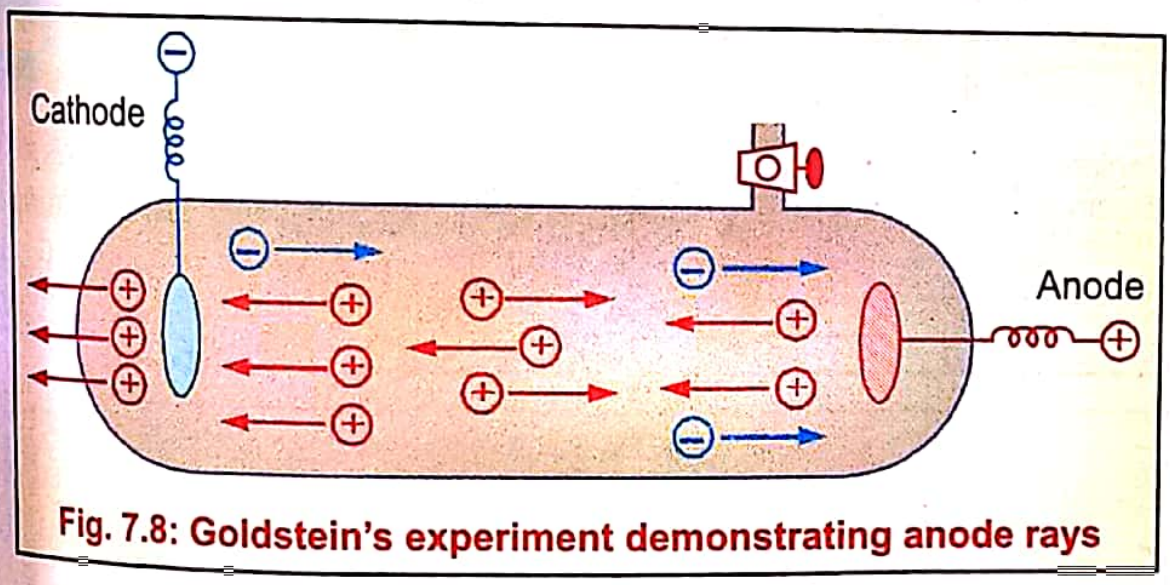

Fig. 7.8: Goldstein's experiment demonstrating anode rays

(iv) The specific charge (e/m) for canal ray particle depends upon the nature of gas. It is maximum when H_2 is used. e/m value of canal rays was determined by Wein.

(v) The positive charge on canal ray particles was supposed to be due to an another fundamental particle named as **proton.** (The name proton is given for canal ray particle if H_2 gas is filled inside the discharge tube.)

(vi) Term **proton** (proteos = fundamental) is now used for another fundamental particle of matter which has $+1.6 \times 10^{-19}$C, or $+4.8 \times 10^{-10}$ esu or +1 unit positive charge and 1.6×10^{-27} kg mass.