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Objective

- Milikan's **oil drop** experiment is used to verify the **quantization of charge.**
- Charge is *quantized*.
- The smallest possible unit of *charge* existing in nature is $1.6 \times 10^{-19} C$.

Working

- The **motion** of the *oil drop* is observed in absence of *electric field*
- The **motion** is observed after the application of **electric field** when the drop gains *terminal velocity.*

Construction

- A **double walled** chamber is taken.

- There are three windows w_1, w_2 and w_3 .
- **Light** is passed through w_1 .
- **Light** is passed for visibility.
- **X-Rays** are passed through w_2 .
- **X-Rays** are passed for ionization of *oil drop* .
- **A travelling microscope** is present in w_3 .
- **Travelling microscope** is used to observer the motion of *oil drop.*
- **Cold Water** is circulated through the **double walled** chamber.
- **Ionization** of oil drop produces heat.
- **Cold Water** maintains steady temperature.
- Two **circular** discs are fitted.
- *Positive* **Potential** is applied at the upper plate.
- **Negative** *Potential* is applied at the lower plate.
- **Atomiser** pushes clock oil to the plates.
- Upper plate has **hole** at the center.

Motion without $\vec{E}$

- The **drop** is considered as **sphere** .
- radius of the drop = r
- density of oil = ρ
- density of medium = σ
- coefficient of velocity = η
- The drop **moves** downward due to it's **weight** W .
- Viscous Force = F_{v_1}
- Upthrust = U
- Volume = V
- Terminal velocity = v_1

$$
\begin{aligned}
W &= F_{v1} + U \\
W - U &= F_{v_1} \\
mg - V\sigma g &= 6\pi\eta r v_1 \\
\rho V g - V\sigma g &= 6\pi\eta r v_1 \\
Vg(\rho - \sigma) &= 6\pi\eta r v_1 \\
\frac{4}{3} r^3 g(\rho - \sigma) &= 6\eta r v_1 \\
r &= \sqrt{\frac{18\eta v_1}{4g(\rho - \sigma)}} \\
r &= \sqrt{\frac{9\eta v_1}{2g(\rho - \sigma)}}
\end{aligned}
$$

- The expression for **radius** of the drop is **expressed** as:

$$
r = \sqrt{\frac{9\eta v_1}{2g(\rho - \sigma)}}
$$

Motion with $\vec{E}$

- The **application** of **electric field** adds an extra **force** .
- The **force** is **electric force**

$$
\begin{aligned}
F &= qE \\
W &= U + F + F_{v_2} \\
W - U &= F + F_{v_2} \\
F_{v_1} - F_{v_2} &= F \\
qE &= 6\pi\eta r v_1 - 6\pi\eta r v_2 \\
qE &= 6\pi\eta(v_1 - v_2) \times r
\end{aligned}
$$

- The magnitude of **charge** if **drop** comes down is expressed as:

$$
q = \frac{6\pi\eta(v_1 - v_2)}{E} \times \sqrt{\frac{9\eta v_1}{2g(\rho - \sigma)}}
$$

- The magnitude of **charge** is **drop** goes up if **electric** field is high.

$$
W + F = U + F_{v_2}
$$

$$q = \frac{6\pi\eta(v_1 + v_2)}{E} \times \sqrt{\frac{9\eta v_1}{2g(\rho - \sigma)}}$$

Specific Charge

- The ratio of charge and mass of particle is called specific charge.
- For electron it is give by:

$$R = \frac{e}{m}$$

JJ Thomson's Experiment

Working Principle

- A beam of electron is accelerated by high electric field.
- The beam is deflected by cross field.

Experimental Setup

- An evacuated glass tube is present.
- There is a presence of flourscent screen at one end.
- There is a presece of cathode at another end.
- An anode plate is placed in fornt of the cathode.
- The anode plate consists of a fine hole.
- Two metallic plates are present.
- The location of the metallic plates is at the middle of the chamber.
- The plates are placed one above the other.
- The purpose of the plates is for the provision of electric field.
- There is a presence of Helmhotz coil.
- Helmhotz coil is present to provide uniform magnetic field.
- There is the application of high potential between the cathode and anode.
- This is done to accelerate the electrons with high velocity.

Theory

- mass = (m)
- charge = (e)
- velocity = (v)
- initial potential difference = (V)
- final potential difference = [V^{'}]
- distance of separation of plates = (d)
- magnetic field intensity = (B)

The expression for specific charge is calculated as:

$$
\begin{aligned}
eV &= \frac{1}{2}mv^2 \\
\frac{e}{m} &= \frac{v^2}{2V} \\
E &= \frac{V'}{d} \\
evB &= eE \\
v &= \frac{E}{B} \\
\frac{e}{m} &= \frac{(\frac{E}{B})^2}{2V} \\
\frac{e}{m} &= \frac{V'^2}{2Vd^2B^2}
\end{aligned}
$$

Value of specific charge

The value of specific charge in thomsons experiment was:

$$\frac{e}{m} = 1.76 \times 10^{11} C/kg$$