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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 observe 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

$$W = F_{v_1} + U$$

$$W - U = F_{v_1}$$

$$mg - V\sigma g = 6\pi\eta r v_1$$

$$\rho V g - V\sigma g = 6\pi\eta r v_1$$

$$Vg(\rho - \sigma) = 6\pi\eta r v_1$$

$$\frac{4}{3}r^3g(\rho - \sigma) = 6\pi\eta r v_1$$

$$r = \sqrt{\frac{18\eta v_1}{4g(\rho - \sigma)}}$$

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

- 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** .

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- The **force** is **electric force**

$$F = qE$$

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

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

$$F_{v_1} - F_{v_2} = F$$

$$qE = 6\pi\eta rv_1 - 6\pi\eta rv_2$$

$$qE = 6\pi\eta(v_1 - v_2) \times r$$

- 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.

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- There is a presence of fluorescent screen at one end.
 - There is a presence of cathode at another end.
 - An anode plate is placed in front 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 Helmholtz coil.
 - Helmholtz 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:

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

Value of specific charge

The value of specific charge in thomsons experiment was:

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