The Millikan Experiment

2 Questions

- Is there a smallest unit of electric charge for which all others are simple multiples?

- If so, what is its magnitude, in Coulombs?

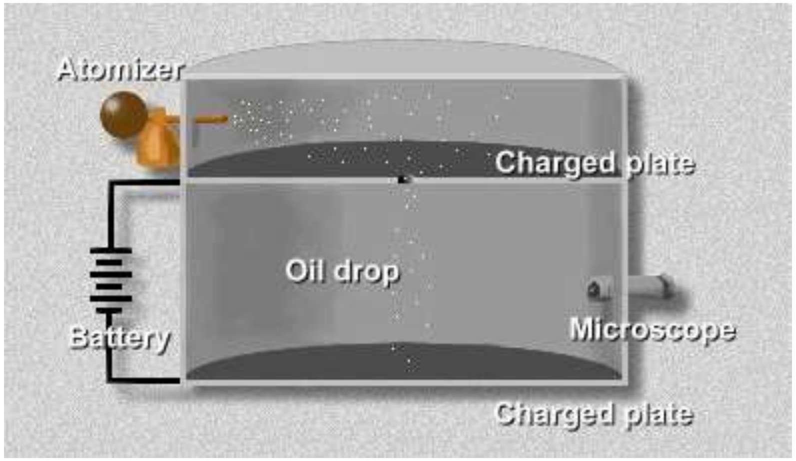
Millikan's Oil Drop Experiment

- Reasoned elementary charge is that of a single electron
- Assumed when tiny oil drops are sprayed in a fine mist from an atomizer they become charged by friction (some have an excess of electrons, some have a deficit)
- If able to measure the charge of 1 drop it would be an integral of the elementary charge.

The Set-up

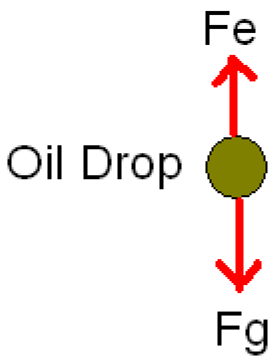
- 2 opposite plates each connected to opposite terminals of a large number of batteries whose potential difference could be varied.

- A mist of oil drops sprayed through a small hole in the upper plate



- Adjusting the potential difference between the plates to "balance" a drop that has same charge as the lower plate

- When balanced, gravitational force downward is equal to the electrical force upward



For a charge of mass m, charge q

$$\overrightarrow{F_e} = q\vec{\varepsilon}$$

When in balance

$$\overrightarrow{F_e} = \overrightarrow{F_g}$$

$$q\vec{\varepsilon} = m\vec{g}$$

But we know that if the electric field between 2 plates is constant

$$\vec{\varepsilon} = \frac{V}{d}$$

- Since

$$q = \frac{mg}{\vec{\varepsilon}}$$

$$q = \frac{mgd}{V}$$

- This leads to the determination of the elementary charge if the mass is known

- The mass of an individual oil drop was determined by measuring the terminal velocity when it falls if the electric force is removed (gravity acts alone)

Observations

- Millikan observed that all the oil drops had a charge of multiples of some smallest value

- Some had the smallest value, none were lower

$$\boxed{e = 1.602 \times 10^{-19}\ C}$$

- An object with an excess (or deficit) of N electrons has a charge

$$Q = Ne$$

Ex. Determine the charge on an electron if it is balanced between two parallel plates that are producing an electric field strength of 5.6 x 10^{-11} N/C.

$F_e = F_g$

$q\varepsilon = mg$

$q = \frac{mg}{\varepsilon}$

$\varepsilon = 5.6 \times 10^{-11}$ N/C

$q = ?$

$m_e = 9.11 \times 10^{-31}$ kg

$g = 9.8$ N/kg

$$q = \frac{(9.11 \times 10^{-31}\ \text{kg})(9.8\ \text{N/kg})}{5.6 \times 10^{-11}\ \text{N/C}}$$

$q = 1.59425 \times 10^{-19}$ C

1.6×10^{-19} C