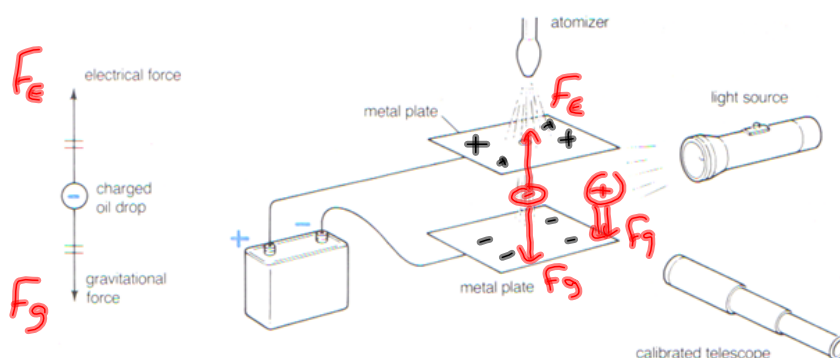


Section 12: A Unit of Charge Defined

- Need to be able to measure an electric charge on an object.
- Electric charge is measured in Coulombs (C), after the French scientist Charles de Coulomb (1736- 1806).

Robert Millikan (1868-1953) performed a series of experiments (over a 7 year period) proving that there does exist a smallest unit of electric charge. This elementary charge is the charge on a single electron.

A simplified diagram of Millikan's experiment can be seen below.



- When tiny oil drops are sprayed from an atomizer, they become charged by friction - some acquiring an excess of a few electrons while others have a deficit.
- Although there was no way of knowing how many extra electrons there were on an oil drop, or how many were missing, Millikan was able to devise a technique for measuring the total amount of charge on each individual drop.

Oil drops were sprayed into the space between two parallel plates. A light was shone on the oil drops, and they were observed through a telescope. A battery was connected to the plates creating a uniform electric field in the space between the plates. As a result, an upward electric force was exerted on those drops whose charge was the same sign as the lower plate's. By adjusting the amount of charge on the plates, it was possible to isolate a single oil drop and balance it so that the downward gravitational force and the upward electric force were equal.

Then using measurements of the "balancing field" and the speed at which the drop fell when the field was removed, Millikan was able to calculate the amount of electric charge on the oil drop in Coulombs.

By repeating this procedure many times, using the same oil drop with different amounts of charge on it and using different oil drops, Millikan was able to compile a long list of values for the amount of charge on an oil drop.

Millikan reasoned that the charge on each oil drop must be a whole number multiple of some smallest charge, the charge on a single electron. Using statistical analysis, Millikan was able to determine that the charge on one electron is $1.602 \times 10^{-19} \text{ C}$. This is called the elementary charge (e) because the charge on an object must be some whole number multiple of " e ".

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

A coulomb of charge can be negative or positive. If an object has an excess of electrons, the charge will be negative. If the object has a deficit of electrons the charge will be positive.

Formula: $q = Ne$

where N – the number of electrons removed or added
 e – the elementary charge
 q – the total charge on an object

Examples

1. What is the charge on an atomic particle that has an excess of 10 electrons?

$$\begin{aligned} q &= Ne \\ q &= 10 (-1.602 \times 10^{-19} \text{ C}) \\ q &= -1.602 \times 10^{-18} \text{ C} \end{aligned}$$

2. When you rubbed a balloon on your hair you transferred 4.2×10^{17} electrons to the balloon. What is the charge on your hair?

$$\begin{aligned} q &= Ne \\ q &= (4.2 \times 10^{17}) (1.602 \times 10^{-19} \text{ C}) \\ q &= 0.0673 \text{ C} \\ q &= 6.7 \times 10^{-2} \text{ C} \end{aligned}$$

3. How many protons are required to create a total charge of 8.0 C?

$$\begin{aligned} N &= \frac{q}{e} = \frac{8.0 \text{ C}}{1.602 \times 10^{-19} \text{ C}} \\ N &= 5.0 \times 10^{19} \end{aligned}$$

Do questions 41-45 on page 582 of your textbook.