"Millikan's Oil Drop Experiment"

Around 1906, Millikan tried to find e, the charge of an electron accurately. The apparatus was made of two chambers. The chamber on top was fitted to an atomizer that sprayed fine clock oil. Millikan used oil instead of water because it reduced evaporation from the surface of the droplets. The oil droplets from the atomizer fell from the first chamber to the second chamber through a small hole connecting the two chambers. The second chamber's top was positively charged and the bottom was negatively charged. In the second chamber, the droplets continued their descent. The oil had a neutral charge and was therefore attracted to the negative plate because of gravity. However, Millikan added an X-ray emitter that ionized the air inside the second chamber. Millikan could not use a vacuum in his apparatus because he needed ionized air. Without the ionization, the droplets could not be charged. The X-rays gave a negative charge to the oil droplets, meaning the droplets either slowed, hung in midair, or rose, depending on the charge because of the magnetic field. They rose when the electromagnetic field was on because the negatively charged droplets were repelled from the bottom plate and attracted to the top.

Millikan could observe this because he installed a microscope in the side of the second chamber to calculate and take notes on different oil drops. Drop number 6 in Millikan's experiment fell 0.01021 m in 11.88 seconds, so the speed of the drop was 0.01021m/11.88s, which is also $8.59 \times 10^{-4} m/s$. The viscosity of the air, taken by Millikan, was 1.825×10^{-5} newton-seconds per meter squared and the density of the oil droplet was found to be $0.9199 \times 10^{3} kg/m^{2}$. From this, Millikan calculated that the radius of the droplet was $2.76 \times 10^{-6} m$, so the mass of the droplet was

$8.10 \times 10^{-14} kg$. We can check this with Newton's second law, F=ma, or $8.10 \times 10^{-14} kg \times 9.8 m/s^2 = 7.9 \times 10^{-13} N$, and Stoke's formula states that the viscous drag is

$$6\pi \times (1.825 \times 10^{-5} \text{ Newton-seconds} / m^2)(8.59 \times 10^{-4} m/s) = 8.10 \times 10^{-13} N$$

The rate at which the drop was rising was $1.26 \times 10^{-4} m/s$, so the drag was $1.2 \times 10^{-13} N$ and the electric field was $3.18 \times 10^5 V$. The sum of the gravity and drag forces was $9.1 \times 10^{-13} N$. This had to be balanced by the electric force, so the unknown charge was $\frac{9.1 \times 10^{-13}}{3.18 \times 10^5} = 29 \times 10^{-19} C$. Millikan, however, used more precise numbers to get 29.87×10^{-19} . He did this with many other droplets. The full list of charges on the droplets was, in 10^{-19} coulombs: 29.87, 39.86, 28.25, 29.91, 34.91, 36.59, 28.28, 34.95, 39.97, 26.65, 41.74, 30.00, and 33.55. These charges are multiples of about 1.665×10^{-19} coulombs, which is understood to be e, the charge of one electron.

Millikan's Oil Drop Apparatus