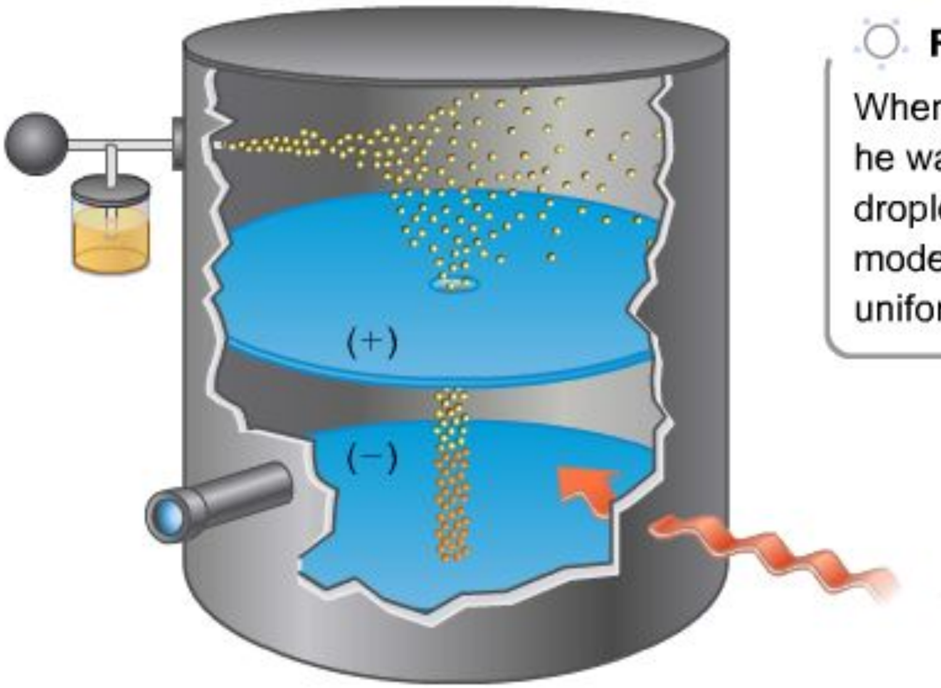
Millikan

Oil Drop Experiment

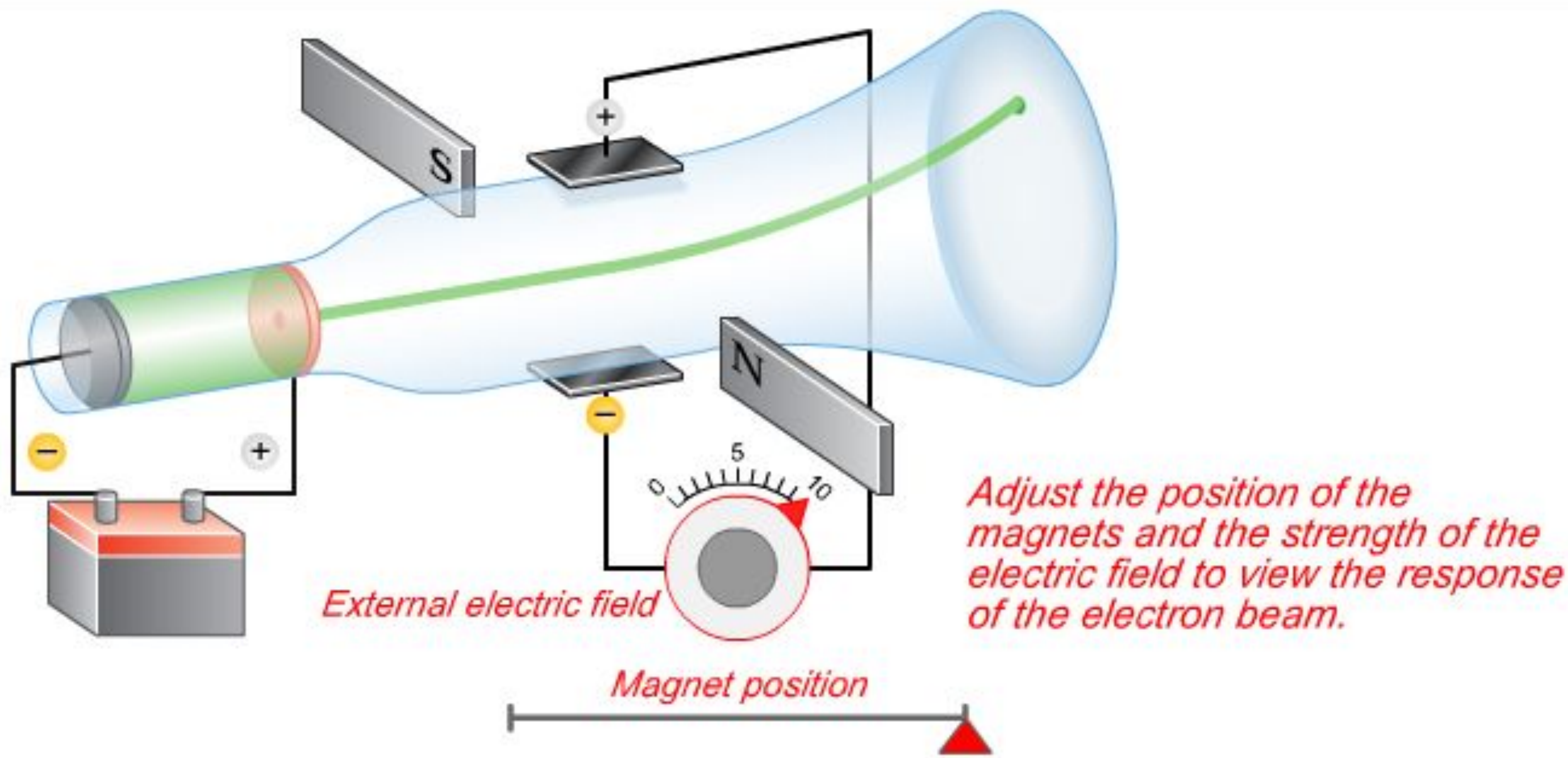
In the first decade of the 20th century, American physicist Robert Millikan performed a series of experiments with the goal of finding the charge of an electron. Using a simple apparatus, he pitted electrical forces on charged oil droplets against gravitational forces. From his experiments, he was able to determine the charge of an electron to within less than one percent error. Later experiments produced a value closer to what is accepted today.



Real-World Connections

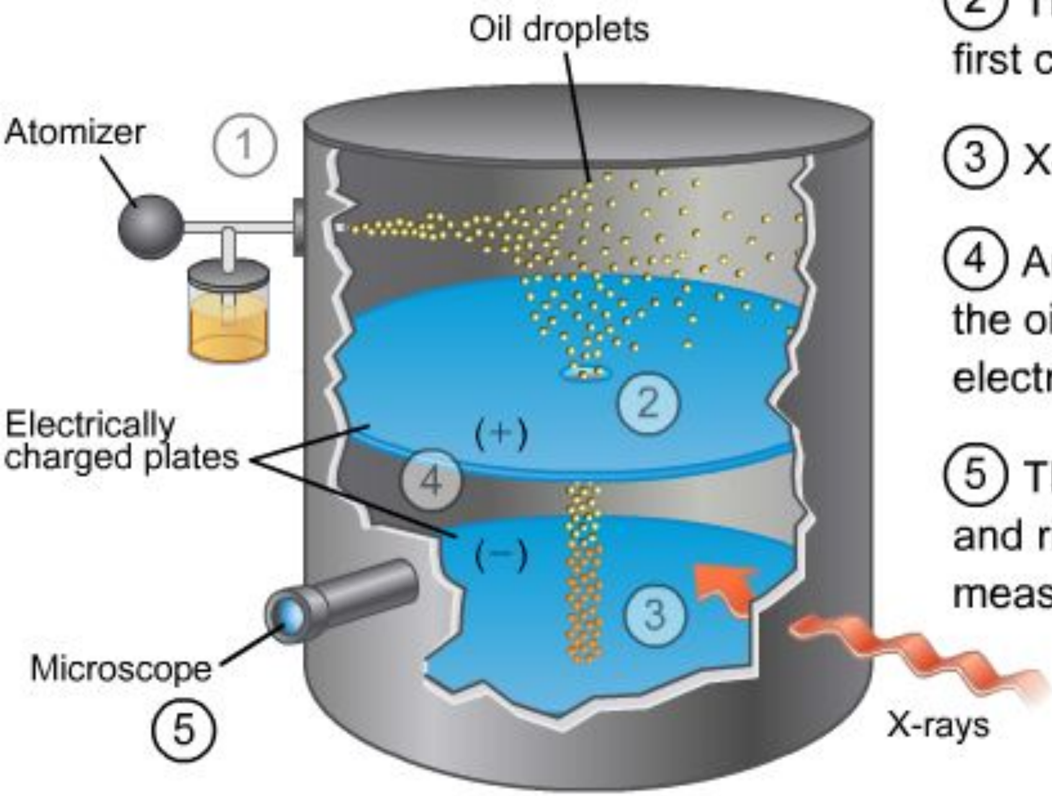
When Millikan originally performed this experiment, he was not able to control the size of the oil droplets. When this experiment is performed in a modern lab, oil droplets are replaced with uniformly-sized spheres of polymer.

Before Millikan, at the end of the 19th century, scientists knew that atoms were not the smallest units of matter, but were composed of smaller particles. J.J. Thomson conducted a series of experiments with cathode-ray tubes, proving the existence of one of these smaller particles, the electron. By adjusting the magnetic and electric fields within the cathode-ray tube, he calculated the mass-to-charge ratio (*m*/*e*) of the electron.



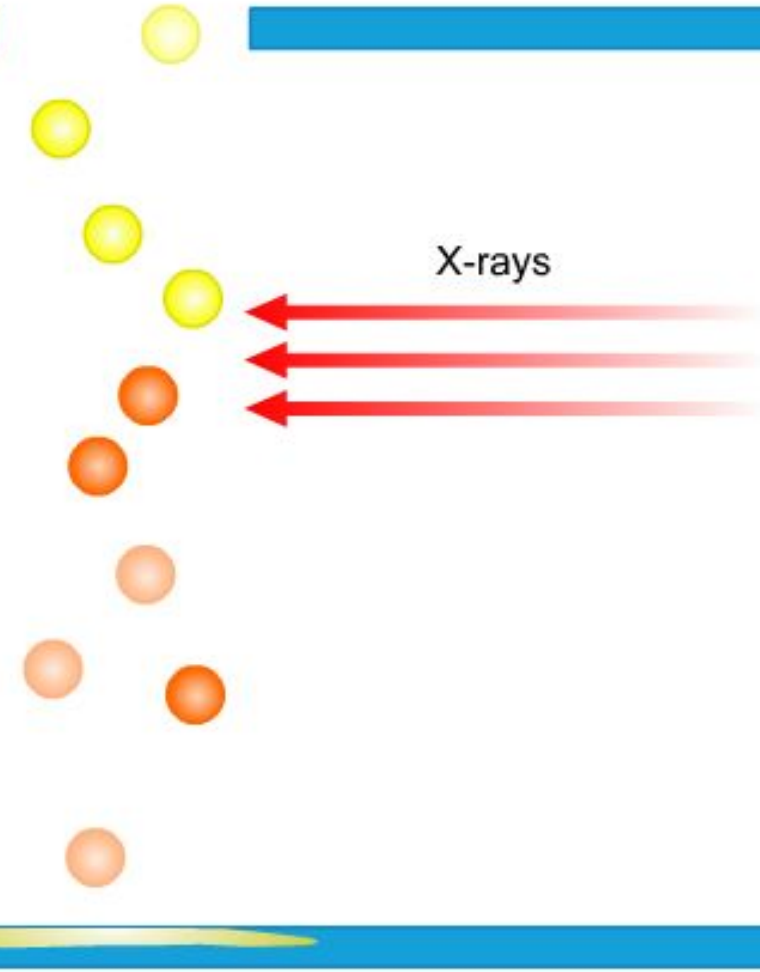
Thomson was unable to provide a value for either *m* or *e*, but if the value of one is determined, the other can be calculated using this ratio.

Millikan set out to find the charge of an electron using this apparatus. It operates as follows.



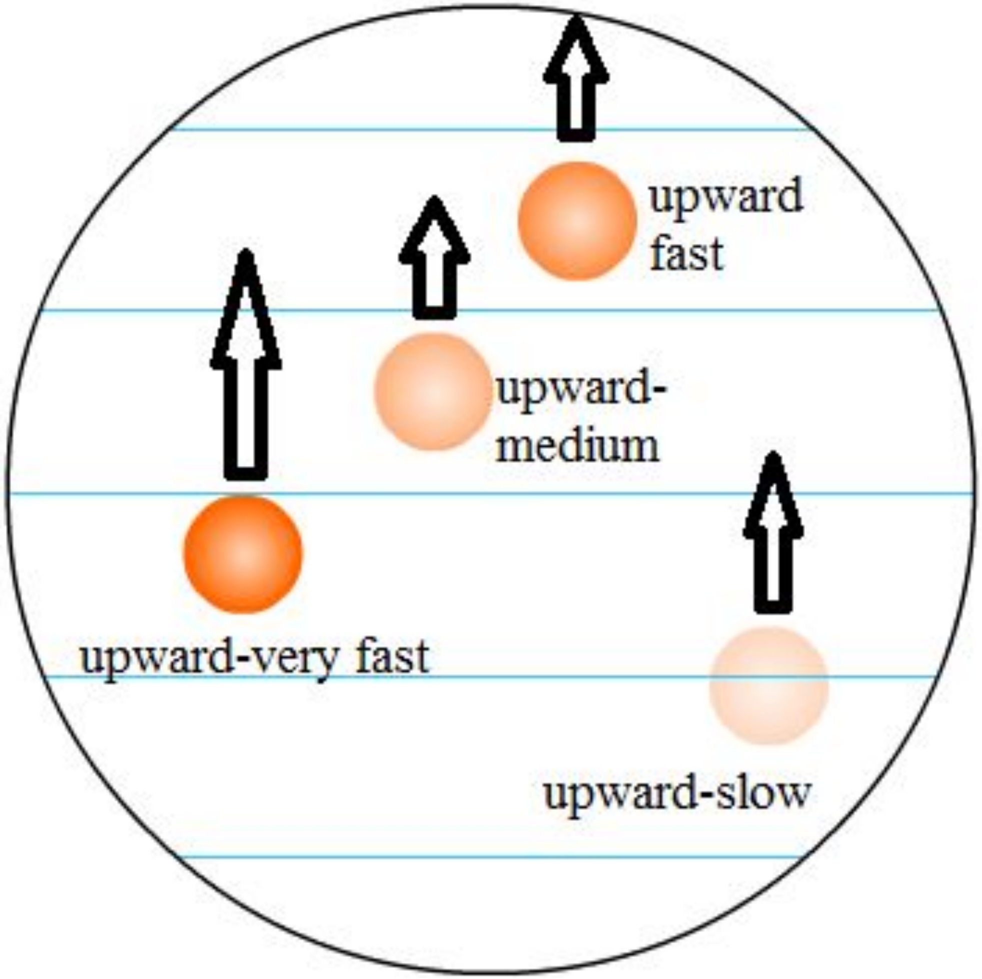
1. An atomizer produces fine oil droplets.
2. The oil droplets fall through a hole in the first chamber as a stream of tiny droplets.
3. X-rays negatively charge the oil droplets.
4. An applied voltage on two plates surrounding the oil droplets creates an electric field. The electric force pulls some droplets upward.
5. The rate at which the oil droplets are falling and rising between the two charged plates is measured through a microscope.

In the lower chamber of Millikan's apparatus, initially oil droplets fall between two uncharged plates.



Droplets that are the same size fall at the same speed. Even after the droplets have a charge on them, they will fall at the same rate as long as they are not in an electric field.

Now we will apply a voltage. In this sample, all droplets are the same size, but have different amounts of charge. The darker orange droplets have more charge than the lighter orange droplets.



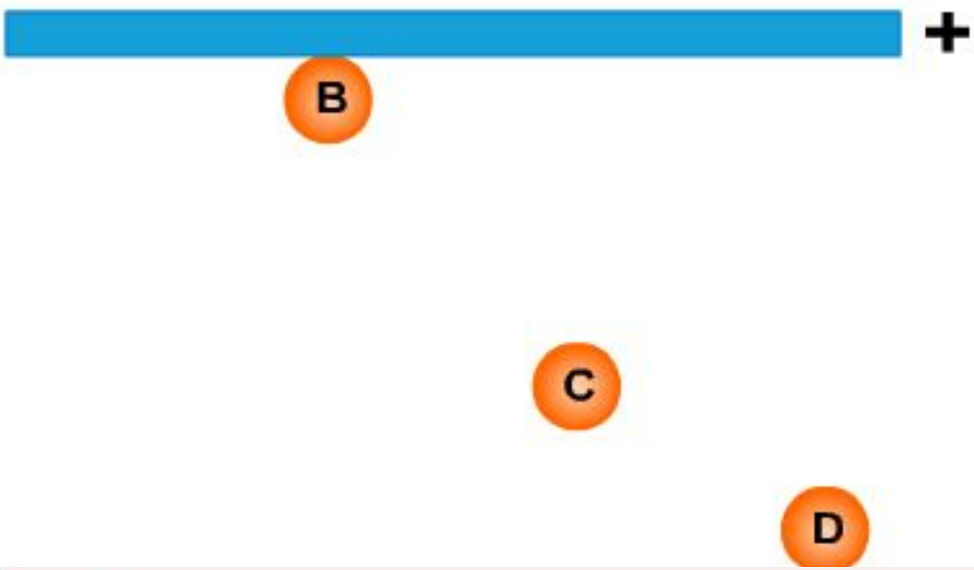
Try it yourself: Use the dial to adjust the voltage on the plates in the chamber to see how an electric field affects the droplets.

When analyzing the differences between velocity measurements for drops with the same mass, a trend emerges.

Drop	Velocity
1	195 μm/s
2	244 μm/s
3	293 μm/s
4	440 μm/s
5	489 μm/s

Question 1:

Rank the droplets below in order from greatest to least amount of electrical charge. Click on the button to turn on the electric field and observe the effect upon the charged droplets. You may view the animation again by clicking on the button to reset the animation.



Turn on electric field

Rank the charges on the droplets by putting the droplet letter in the appropriate box.

Most ☐ ☐ ☐ ☐ Least

Solution

Droplet B has enough charge that the electric force is greater than the force of gravity exerted on each droplet, so it has the most charge. Droplet C has slightly less charge – the electric force is equal to the gravitational force.

Droplets D and A are both moving downward when the electric field is applied. Droplet D is moving slower, so that droplet has more charge on it than Droplet A.

Check Answer