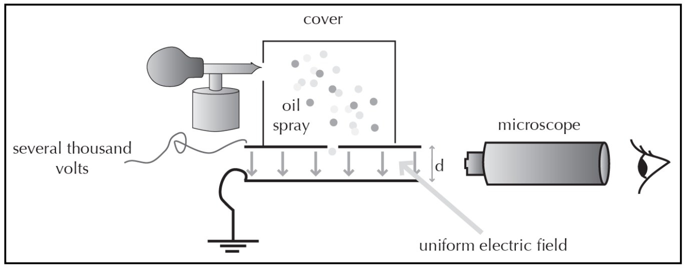
Reading Science

Name: ______________________________ Date: __________

Measuring Elementary Charge



1 Robert Millikan and Harvey Fletcher performed an experiment to measure the elementary charge in 1909. The diagram to the right shows the experimental setup. Fine oil mist is sprayed into a chamber through a nozzle. Friction in the nozzle makes some droplets become charged. The droplets fall through the chamber into the area between the metal plates. The voltage is turned off initially, and all droplets fall due to gravity. Once the voltage is turned on, the electrical force on charged droplets counteracts the gravitational force, and some drops begin to rise. A single droplet is selected by alternately turning on and off the voltage. The uncharged droplets fall to the bottom.

2 When the experiment is performed in air, four forces act on each oil droplet. Both buoyancy and the coulomb, or electrostatic force push the droplet upwards. Gravity and friction push the droplet downwards. The charge on each droplet can be calculated from the voltage that keeps the droplet stationary. Each droplet should have an integer multiple of the elementary charge. The smallest charge measured is the charge of an electron.

3 Several important factors influence the success of the experiment. The amount of oil in each droplet cannot change over time. Otherwise, the gravitational force on the droplet changes over time. This would introduce error into the calculation. Intense lights used in this experiment heat the oil. Many types of oil evaporate when heated. Evaporation would decrease the amount of oil in each droplet over time. Therefore, Millikan and Fletcher selected oil that evaporates very little. Another factor is the orientation of the metal plates in the gravitational field. A small difference from perpendicular introduces an error in the calculated charge.

Reading Science

4 The value Millikan and Fletcher measured for elementary charge is slightly smaller than the currently accepted number. They used an incorrect value for the viscosity of air. This affected their calculation. The number for elementary charge underwent several revisions. Each time the number became a little bigger. Noted physicist, Richard Feynman, remarked on the way physicists arrived at the currently accepted number. Feynman suggested that physicists calculating a value that was significantly larger than Millikan's thought they were wrong. They looked for problems in their experiments to explain their "error." Physicists are subject to bias just as other humans are. Physicists measuring elementary charge trusted the previously published results more than their own calculations. One might call this bias "conformity bias." Conformity bias can be defined as the belief that previously published findings can't be very far off. Conformity bias can be both good and bad. It can lead to more thorough experimentation and analysis. It can also ignore truly novel results.

5 According to theory, all charge has to be a multiple of the elementary charge, the charge of a single electron. More than 100 million additional oil droplets have been measured during the Search for Isolated Fractionally Charged Particles performed at Stanford University. An automated apparatus similar to Millikan and Fletcher's setup was used. No fractionally charged droplet was found. Therefore, while the currently used number for the elementary charge is slightly different from what Millikan and Fletcher measured, the assertion that all charge consists of multiples of the elementary charge is universally accepted.