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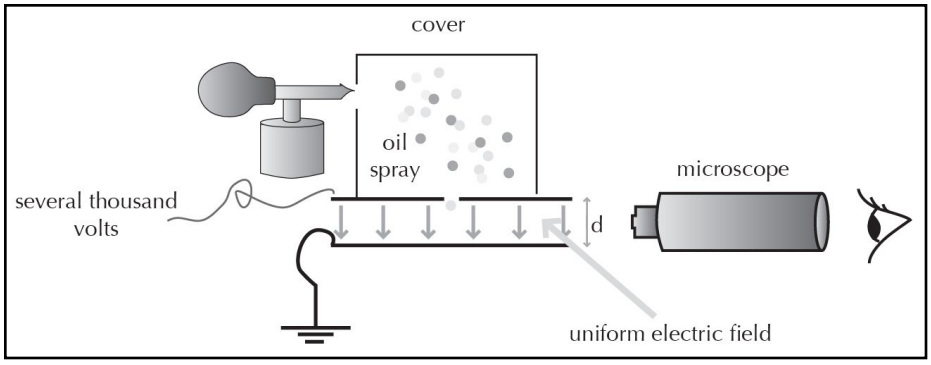
Name: _____ Date: _____

Measuring Elementary Charge



1 In 1909 Robert Millikan and Harvey Fletcher came together to perform an experiment. They wanted to measure the elementary charge, which is the charge of a single electron. The diagram to the right shows the experimental setup. Fine oil mist is sprayed into a 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 two metal plates. At first, the voltage is turned off. All droplets fall due to gravity. Then the voltage is turned on again. The electrical force on charged droplets works against gravity. Some drops will begin to rise. A single droplet is selected by alternately turning on and off the voltage. All 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 electrical 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 still. Each droplet should have an integer multiple of the elementary charge. The smallest charge measured is the charge of an electron.

3 Many things need to be controlled to make the experiment work. The amount of oil in each droplet cannot change over time; otherwise the force of gravity on the droplet would change. This would cause an error in the calculated charge. The lights used in this experiment heat the oil. Many types of oil evaporate when heated, however, and oil evaporating during the experiment would present a problem. It would decrease the amount of oil in each droplet over time. Therefore, Millikan and Fletcher selected oil that evaporates very little. Another factor is how the metal plates are aligned with gravity. A small difference from perpendicular would also cause an error.

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4 Today we do not use the value Millikan and Fletcher measured for elementary charge, as it is slightly smaller than the currently accepted number. They used an incorrect value for the viscosity of air. This affected their calculation. The accepted number for elementary charge has been changed several times. Each time the number became a little bigger. Noted physicist Richard Feynman has discussed this process. Feynman believes that physicists thought they were wrong if their value was much larger than Millikan's. 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 conformity bias. Conformity bias is 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 in-depth analysis, but it can also ignore truly new findings.

5 According to theory, all charge has to be a multiple of the elementary charge. Stanford University has a project called the "Search for Isolated Fractionally Charged Particles." They measured more than 100 million additional oil droplets. An automated experiment similar to Millikan and Fletcher's setup was used. No fractionally charged droplet was found. We are currently using a number for the elementary charge that is slightly different from what Millikan and Fletcher measured. However, it is now universally accepted that all charge consists of multiples of the elementary charge.

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1. Millikan and Fletcher set out to measure–

A the diameter of oil droplets under an electric force.

B the value of the elementary charge.

C the force of gravity on oil.

D the viscosity of air at various temperatures.

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2. If the top metal plate is negatively charged, what is the charge of the droplets that will be attracted to it?

A Negative

B Neutral or no charge

C Positive

D Either negative or positive, depending on the droplet size

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3. If a droplet has three extra electrons, what is its measured charge?

A One-third of an elementary charge

B One elementary charge

C Two elementary charges

D Three elementary charges

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4. In paragraph 3, evaporation of oil from droplets during the experiment is a potential source of–

A excess charges.

B neutral drops.

C error.

D gravity.

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5. Which of the following may be an example of conformity bias?

A Biologists announcing the existence of a new class of mammals.

B Chemists using a novel computer program to design cancer drugs.

C Stanley Prusiner insisting that prions are a new way to transmit infections.

D Physicists dismissing numbers that differ significantly from their previous findings as errors.

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6. The search for fractionally charged particles has–

A measured more than 100 million droplets and found no partially charged droplets.

B reanalyzed Millikan and Fletcher's data and found less than 1% fractionally charged droplets.

C been denounced by leading physicists as not necessary.

D been discontinued due to numerous errors in the experiment.