**Introduction**

The Millikan Oil Drop experiment was performed in 1909 by Robert Millikan and Harvey Fletcher, and published in 1911.1 It entailed spraying charged drops of oil into a chamber with charged electrodes at either end, and measuring the rate at which the drops fell or rose, depending on the electric field generated by the electrodes.

Millikan’s findings showed that all drops exhibited a discrete charge, all multiples of a constant *e*, which he measured to be 1.592 x10-19C, quite close to today’s accepted value of 1.602x10-19C.2 At the time however, it was contentious whether electric charge was discrete or continuous, and this experiment proved conclusively that charge is quantized.

**Background**

Millikan’s experiment sprays charged droplets, measures their terminal velocity, then compares that velocity with new ones found by applying varying electric fields, as shown below in Figure 1. An atomizer sprays drops of oil, and their motion is observed, including calculation of their terminal velocity, as discussed below. Then, an electric field is applied through two charged plates on either ends of the apparatus, and the change in velocities is used to find the charge of the particles.



*Figure 1: The oil drop apparatus.3*

In the Oil drop experiment, first the terminal velocity of a spherical droplet of radius *r* and density *ρ* is dropped and its motion observed. The velocity *v* is measured and the drag, buoyant, and gravitational forces are calculated:

where η is the viscosity of the liquid, *g* is the gravitational constant, and *m* is the mass of the droplet. The net force is set to 0 at terminal velocity vg(acceleration is 0), such that:

.

Rearranging to solve for *r*, the result is

.

When an electric field *E* is applied and there is a charge *q* on the droplet causing the droplet to rise instead of fall, once terminal velocity vu has been reached (), the forces can be written as

or

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Solving for q, the result is:

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**References**

1. Millikan, Robert Andrews. "The Isolation of an Ion, a Precision Measurement of its Charge, and the Correction of Stokes's Law." Physical Review (Series I) 32.4 (1911): 349.
2. "Robert Millikan". APS Physics. Retrieved 26 April 2016.
3. "Millikan Oil-drop Experiment." Encyclopædia Britannica. Encyclopædia Britannica, Inc., n.d. Web. 10 Apr. 2017

**Questions**

1. The lab manual says, "Before you begin your experiment, calculate the time it will take for a 1 μm diameter sphere to fall a distance of 1 mm and how long it will take for such a sphere to reach terminal velocity." Do this calculation keeping in mind the correction to air viscosity mentioned near the end of this lab.
   1. Assuming a temperature T = 298K and pressure P = 1 atm
   2. Viscosity:
   3. 1.8s
   4. 3.6s

Corrected viscosity:

1. Explain how vibrations and convection currents might affect your experiment. How might the lab manual's suggestion help mitigate this?
   1. Brownian motion is going to cause the drops to wiggle and move about due to random kinetic vibrations. This results in our data being less accurate at higher temperatures due to the random movements from thermal excitation. The lab accounts for this with an insulating glass layer around the apparatus.
   2. Convection currents will also impact the experiment as they can cause random motion as well. The lab corrects for this, again, by isolating the apparatus and insulating it to minimize the effects.