Millikan Oil Drop Lab

Robert A. Millikan determined the charge on the electron by suspending tiny droplets of oil in an electric field, and letting them fall at terminal velocity in air. Here you will do the same except in a computer simulation.

Theory:

Suspension of Oil Drops:

When the drop is suspended, the electric force is equal to the force of gravity. So this means that:

$$mg = Eq$$

m - mass
g - 9.80 N/kg
E - Electric Field
q - Charge

But since E is V/d, and m is ρV where ρ is the density of the drop, and V is its volume, substituting $^4/_3\pi r^3$ for volume you get:

Equation 1

$$\rho(^4/_3\pi r^3)g = Vq/d$$

ρ- Density (128 kg/m^3)
r - Drop Radius
g - 9.8 N/kg
V - Potential across plates that create electric field
q - Charge on drop
d - Separation of plates

Which is great, but we know or can measure only V, d, ρ which means we don't know r and q. This is a bad situation with one equation.

Drops at Terminal Velocity:

Stokes Law states that for a small sphere, the viscous force on it as it moves through a fluid is given by

Equation 2:

$$F = 6\pi\eta rv$$

Where η is the viscosity of air (1.81 x 10^{-5} Nsm^{-2}), r is the drop radius, and v is the velocity. At terminal velocity this force equals the weight of the drop so:

Equation 3:

$$mg = \rho(^4/_3\pi r^3)g = 6\pi\eta rv$$

ρ- Density (128 kg/m^3)
r - Drop Radius
g - 9.8 N/kg
η - viscosity of air (1.81 x 10^{-5} Nsm^{-2})
v - terminal drop velocity

You can solve this for r, and then substitute this in for r in Equation 1. This is not pretty.

Procedure:

Drops at Terminal Velocity:
When you get a new drop, you will need to find its radius from their terminal velocity first. Get a charge suspended near the top of the viewing area, disconnect the voltage, and start the timer. Use the distance it falls in the measured time to determine the velocity of the drop. Reconnect the voltage to stop the drop from leaving the viewing area. Be sure to note what magnification you are using.
(77.5 μm/div is the best)

Suspension of Oil Drops:
This part is easy. Get a new drop, or keep working with your old one. Zap the drop with radiation, and adjust the voltage so that it quits moving up or down. Record the voltage. You may have to reverse the polarity to get the drop to suspend. Repeat the process of Zapping the drop, and suspending it for as many times as you can keep the drop in your field of view. If you lose your drop, you have to get a new drop and determine its radius again by letting it go into terminal velocity. Eventually you will find that the voltages for some reason repeat, and you will need to get a new drop.

In General:
I want you to collect 25 unique data points per person. The general procedure is:
1. Get a new drop
2. Determine its terminal velocity. (3 trials??)
3. Zap the drop
4. Suspend the drop/record the voltage
5. Repeat steps 3 and 4 until you either lose the drop, or it repeats the same voltages over and over.
6. If you don't yet have 25 unique data points, go to 1

Take shifts at the computer. Each person in the group needs to collect their own data, but the group as a whole needs only turn in one report for the whole group with all names on it.

What you turn in:
Turn in the following:
Purpose
    •What was the purpose of Millikan's investigation?
Procedure
    •(A diagram of the set up Millikan used. There is one in your book)
Results
    •Your raw data. (radii and suspension voltages)
    •Your known values used for calculation (density, etc)
    •Your calculated Charges. (Please use a spreadsheet)
    •A histogram of your charges sorted by magnitude
    •The general form of any calculation you made (your formulas for radius, velocity, charge)
Conculsion
Your answer to these questions:
    •What did you determine the charge on the electron to be? (What is the size of your steps) - Show how you calculated your electron charge. (Explain with words)
    •What would be your estimation of uncertainty of your results. How did you calculate it? (Explain with words)