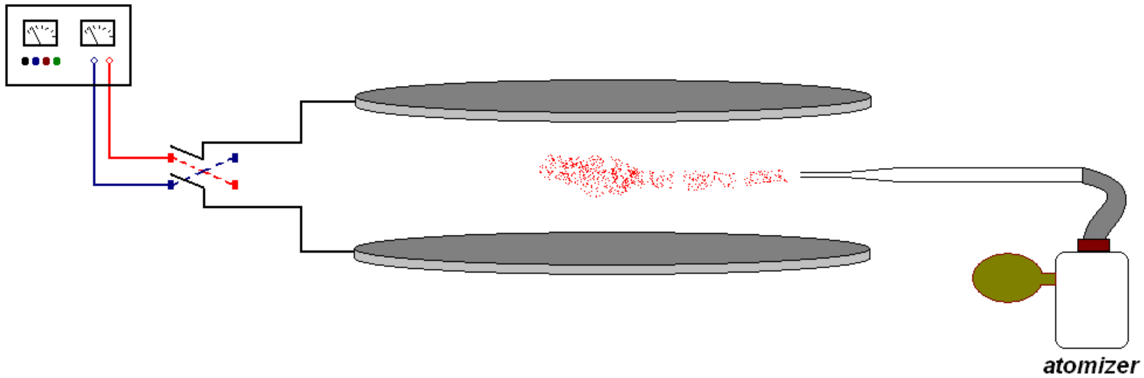
Modern Physics

Millikan Experiment



When the electric force is upward you reach terminal velocity when:

$$qE - mg = bv_{up}$$

When the electric force is downward you reach terminal velocity when:

$$qE + mg = bv_{down}$$

There are two unknowns in these equations: The mass of the droplets and the value of the charge. We are interested mainly in the charge, but we can solve for both variables.
The value of b is given by the Stokes formula and is related to the mass as follows:

$$b = 6\pi\eta_{air} r$$

$$\left.\begin{array}{l} qE - mg = bv_{up} \\ qE + mg = bv_{down} \end{array}\right\} subtracting : 2mg = b(v_{down} - v_{up})$$

But, $m = \frac{4\pi}{3}\rho_{oil} r^3$, so:

$2\left(\frac{4\pi}{3}\rho_{oil} r^3\right)g = 6\pi\eta_{air} r(v_{down} - v_{up})$, which we can use to solve for r:

$$r = \sqrt{\frac{9\eta_{air}(v_{down} - v_{up})}{4\rho_{oil} g}}$$

Now that r is known we can find the mass and charge:

$$\left.\begin{aligned} qE - mg &= bv_{up} \\ qE + mg &= bv_{down} \end{aligned}\right\} adding: 2qE = b(v_{down} + v_{up}) \rightarrow q = \frac{b(v_{down} + v_{up})}{2E}$$

$$m = \frac{3\pi}{2}\sqrt{\frac{\eta^3{}_{air}(v_{down} - v_{up})^3}{\rho_{oil} g^3}}$$

$$q = \frac{9\pi}{2E}\sqrt{\frac{\eta^3{}_{air}(v_{down} - v_{up})^3}{\rho_{oil} g}}$$