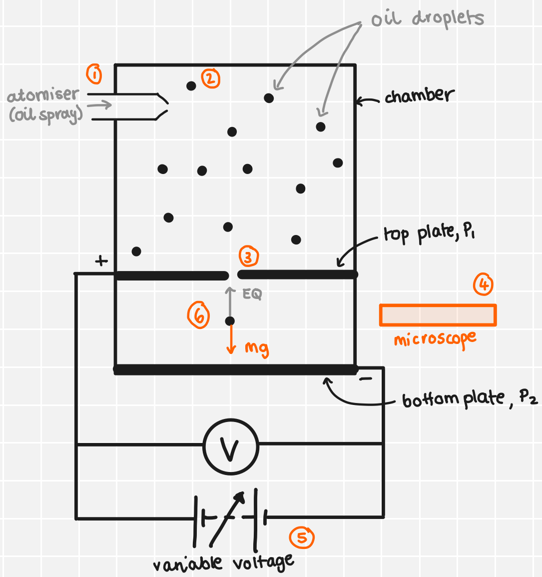
MILLIKAN'S EXPERIMENT

he got a Nobel Prize for it!

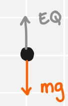
Robert Millikan - 1910-1913 - determined absolute charge, e, of an electron

The Experiment



1. atomiser creates fine droplets in an electrically insulated chamber.
2. oil droplets are negatively charged through friction.
3. some droplet fall through small hole in P_1
4. oil drop is then viewed through a microscope.
5. a potential difference is applied across P_1 and P_2 creating an electric field in the lower chamber creating an upward force (= EQ) on the droplet (assuming droplet has -ve charge)
6. Millikan would then change the p.d. across plates until the droplet was held stationary (forces are balanced) so:

$$EQ = mg$$



since E is between plates:

$$\boxed{\frac{VQ}{d} = mg}$$

from this Q can be determine.

BUT: how do we determine m?

Determining m of the oil droplet

Using our knowledge of density, the mass of a spherical oil droplet can be expressed as:

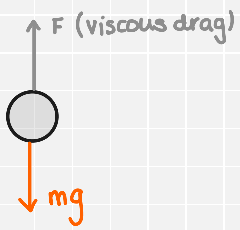
$$\boxed{m = \frac{4}{3}\pi r^3 \rho_{oil}} \quad (A)$$

easily determined

(!) much harder to find r of droplet

Determining r of oil droplet

Millikan did this by observing the motion of the droplet in the absence of the Electric field.



- droplet would accelerate until it reached terminal velocity.
  - ↳ thus forces were balanced (weight = viscous drag)
- viscous force is determined by the following equation:

$$\boxed{F = 6\pi\eta r v}$$

Stokes' Law

viscous force [N]

speed of object [ms^{-1}]

coefficent of viscosity [Nsm^{-2}]

↳ η is higher in more viscous fluids

when forces balance:

$$mg = 6\pi\eta r v$$

sub in (A)

$$\frac{4}{3}\pi r^{\cancel{3}\,2} \rho_{oil}\, g = 6\pi\eta \cancel{r} v$$

thus r can be determined by:

$$\boxed{r = \left(\frac{9\eta v}{2\rho_{oil}\, g}\right)^{\frac{1}{2}}}$$

a graduated scale on microscope allowed this to be measured.

By determining r, m could be calculated and thus Q of the oil droplet could be found!

significance of millikan's experiment

- on repeating this experiment multiple times, Millikan found that the measured values of Q were always multiples of 1.6×10^{-19}C.
  - ↳ charge is QUANTISED
- by setting this common value as 'e': $\boxed{Q = \pm ne}$ $n = 1, 2, 3, \dots$
- since charge could not exist @ values smaller than e, -1.6×10^{-19}C must be the charge on an electron.