•) Blackbody radiation → discrete / quantized

↳ energy is DISCRETE (Planck 1900)

Big Bang
$T = 2.725 \pm 0.001\ K$

•) Electric Charge is DISCRETE

→) Greek Democritus (450 B.C.) – matter is composed of atoms (tiny particles)

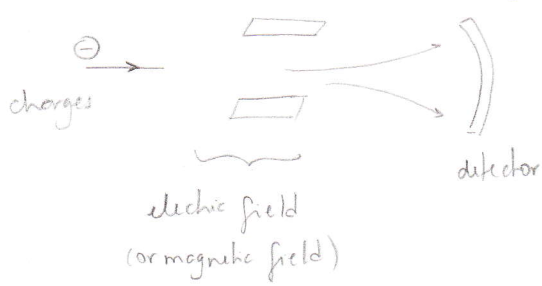
→) Avogadro (1811) – all gases at T : same # of molecules per unit volume (N_A)

↳ development of Kinetic theory (1900) – acceptance of molecular theory of matter

matter is quantized

→) J. J. Thomson's experiment (1897)

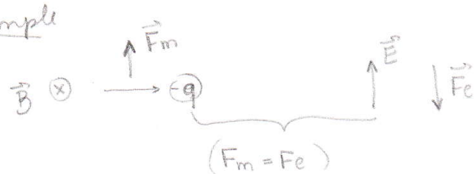
↳ measures q/m



•) Newton's 2nd law

$$\underbrace{qvB}_{\text{magnetic force}} = m \underbrace{\frac{v^2}{R}}_{\text{centripetal acceleration}} \Rightarrow \boxed{\frac{q}{m} = \frac{v}{RB}}$$

Example



•) to determine v adjust ⊥ B and E fields

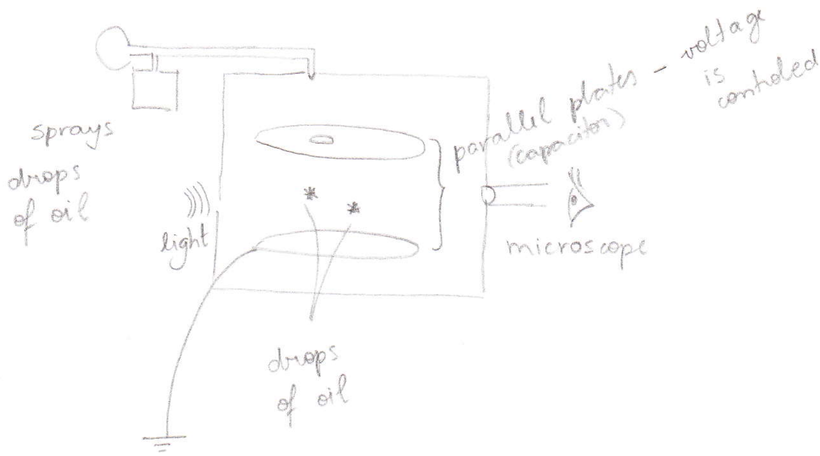
↳ particle undeflected

$$qvB = qE \Rightarrow \boxed{v = \frac{E}{B}}$$

→) Millikan's experiment (1909)

↳ measures e

Millikan's experiment



(oil droplets don't evaporate easily)

we verify that the charge of each droplet is an integer number times the electron charge

(electric charge is quantized)

Assumption: oil-drops = spherical droplets of const m

↳ gravitational force $\boxed{F_g = mg} = \frac{4}{3}\pi r^3 \rho g$

density

radius

1st step (find r)

$\vec{E} = 0$, a const velocity of fall is reached when

$F_g = F_f$ → friction force given by Stoke's law $\boxed{F_f = 6\pi r \eta v}$

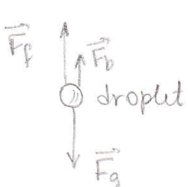
viscosity of air

speed of droplet

correction!

BUT, because of the buoyant force $\boxed{F_b = m_F g = \frac{4}{3}\pi r^3 \rho_{air} g}$

↳ mass of the fluid displaced



$$\boxed{F_g - F_b = F_f}$$

$$\Longrightarrow \frac{4}{3}\pi r^3 g (\rho - \rho_{air}) = 6\pi r \eta v_1$$

$$\boxed{r^2 = \frac{9 \eta v_1}{2 g (\rho - \rho_{air})}}$$

2nd step
(find q)

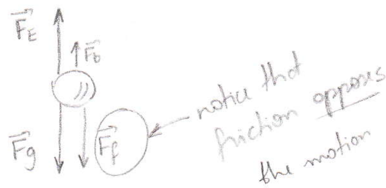
$\vec{E} \neq 0$, drop rises

$$E = \frac{V}{d}$$

we have control of the voltage (V)

d ← distance between plates

$$\boxed{F_E = qE}$$



Drop reaches const velocity when

$$F_E + F_b = F_g + F_f$$

$$qE = \underbrace{\underbrace{(F_g - F_b)}_{6\pi r \eta v_1}}_{\text{from 1st step}} + \underbrace{F_f}_{6\pi r \eta v_2}$$

$$\boxed{q = \frac{6\pi r \eta (v_1 + v_2)}{E}}$$

HW (Tipler: 3.1, 3.2, 3.3, 3.4, 3.8, 3.11)