III. The composition of atoms

knowledge at the end of 19th century:

- Matter consists of atoms

Last doubts disappeared in 1905, when Einstein showed that the random Brownian motion of dissolved dust-particles, seen under the microscope, is due to the collision with atoms in the liquid.

- Avogadro's number $N_A$ as a link between macroscopic world and the world of atoms:
  There are $N_A = 6.022 \times 10^{23}$ (atoms/molecule) per mole.
  Number much improved due to Einstein's work on Brownian motion.

- Molecules are composed of atoms.
  Faraday's law of electrolysis established that

  \[
  \begin{array}{c}
  \text{salt solution} \\
  \text{Cl}^- \quad \text{Na}^+
  \end{array}
  \]

  1 faraday = 96,500 C charge liberates 1 mole of a monovalent substance, but $\frac{1}{2}$ mole of a divalent substance element such as Ca$^{2+}$ in CaCl$_2$.

- The mass of atoms was known from $N_A$ and the weight of 1 mole of various elements.

Do atoms have an internal structure?
III.1 Thomson's Discovery of the Electron

- Deflection of low-pressure gas discharges in electric field \( \frac{V}{d} \)
  - shows that these rays consist of negatively charged particles.

\[ (3.1) \quad \text{Force acting orthogonal to negative charge:} \quad \overrightarrow{F}_y = eE_y = e \frac{V}{d} = \frac{e}{m_e} a_y \]

\[ \text{Acceleration in } y \text{-direction over distance } l = \frac{e}{m_e} \] 
\[ \Rightarrow \quad v_y = a_y \cdot t = \frac{e}{m_e} \cdot \frac{v_y \cdot l}{v_x} \]

- To determine \( v_x \), velocity of negative charge in \( x \)-direction, Thomson uses a magnetic field in \( z \)-direction. According to the Lorentz force \( \overrightarrow{F} = e \overrightarrow{v} \times \overrightarrow{B} \), we have:

\[ (3.3) \quad \overrightarrow{F}_y = e v_x \cdot B_z \]

Thomson chose the \( B \)-field such that deflection angle \( \Theta = 0 \)

\[ (3.4) \quad e v_x B_z = e E_y \quad \Rightarrow \quad v_x = \frac{E_y}{B_z} = \frac{v_y}{B_z \cdot d} \]

- This gives for the deflection angle \( \theta \):

\[ \tan \theta = \frac{v_y}{v_x} \quad (3.2) \quad \frac{v_y}{v_x} \cdot \frac{e}{m_e} \cdot \frac{1}{d} \left( \frac{v_y}{B_z d} \right)^2 \]

allows to determine \( \frac{e}{m_e} \).