The Rutherford-Bohr Model of the Atom

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1 Basic Properties of Atoms

- Around 1900, knowledge about atoms was:
  - Size: Small, 1[Å]/.1[nm]
  - Stable: Forces balance
  - Atoms contain electrons (e^-) and maintain neutral charge
  - Atoms can emit and absorb electromagnetic radiation
- An early atom model: J.J. Thomson (1904):

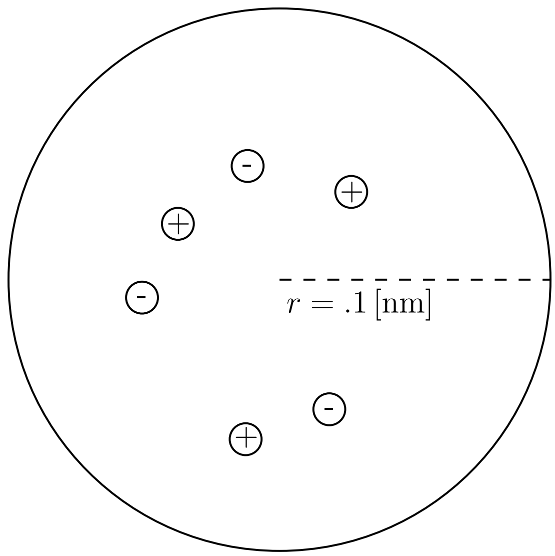

Figure 1: The Jelium Model ("Plum-pudding Model")

- Rutherford discovered two rays, α and β-rays, which he used to experiment with atoms
  - α rays are essentially He^{2+} atoms
    * The positive charge would mean that the atoms should deflect α rays
- The Geiger-Marsden Observation
  - Their observation found:

$$p(\text{backscattering}) \approx 10^{-4}$$

  - This is much larger than expected
  - Rutherford proposed that the charge and mass of atoms are concentrated in a region called the nucleus

- The Bohr Model
  - Proposed by Niels Bohr (1913)
  - Atoms resembled a miniature planetary system

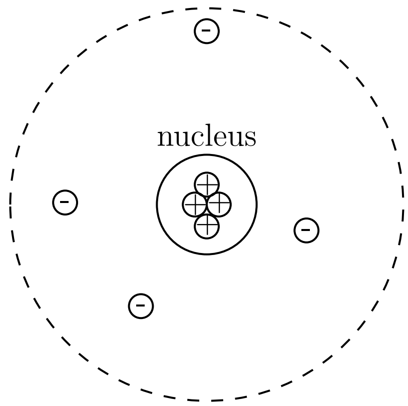

Figure 2: The Bohr Model

  - From this, the Coulomb interaction (force) was determined:

$$\boxed{F = \frac{1}{4\pi\varepsilon_o}\frac{|q_1||q_2|}{r^2}}$$

  - The kinetic energy was determined as:

$$\boxed{K = \frac{1}{8\pi\varepsilon_o}\frac{e^2}{r}}$$

  - If the electron is radiating, it slows down and moves toward nucleus to collapse?
    * Niels Bohr hypothesized that electrons may exist in "stationary states" without radiating electromagnetic energy
  - $L = rp = rmv = n\hbar \rightarrow v = \frac{n\hbar}{mr}$
    * Where L is the angular momentum, r is the radius, n is a quantized number, and m is the mass
  - Substituting this into kinetic energy, we get the permitted radius, r:

$$\boxed{r_n = \frac{4\pi\varepsilon_o\hbar^2}{me^2}n^2}$$

  - Using electron information, we get:

$$\frac{4\pi\varepsilon_o\hbar^2}{me^2} = .0529[\text{nm}]$$

- This value is known as the Bohr radius