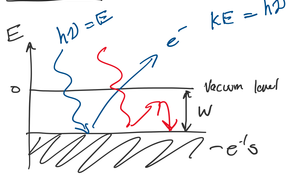
Lecture 3 - Models of the atom

Friday, August 25, 2023 8:51 AM

- Warm-up Quiz
- HW1 due today @ 6PM ; HW2 out
- Today:
  - electrons / atomic spectra
  - Rutherford and planetary model

Einstein 1905



Au − 5.1 eV] UV
Al − 4.1 eV]
Li − 2.9 eV] bluish

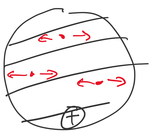
Light is not only a classical wave — particle nature

What about electrons?

Discovered by Thompson in "Cathode Ray" experiments
Established they are charged.

$\frac{e}{m} = -1.76 \times 10^{9}\ C/kg \rightarrow m_e << m_{H^+}$

Suggested "Plum pudding model"



- Large ⊕ sphere w/ const charge density
- embedded ⊖ electrons

Advantages: stable config.
electrons behave as harmonic oscillator

Disadvantage: only predicts 1 frequency

$\omega_p^2 = \frac{n e^-}{\varepsilon_0 m_e} \Rightarrow$ atoms have a more complex spectrum

Atomic Spectra — Atomic spectra have many sharp lines.

J J Balmer, Switzerland 1885 (high school teacher)

H spectrum

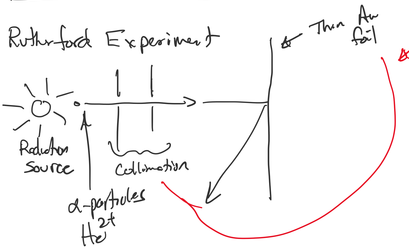
$\lambda_n = \frac{3646\ \text{Å}}{n^2 - 4} \qquad n = 3, 4, 5, \ldots$

Rydberg → similar formula

$\frac{\nu_n}{c} = \frac{1}{\lambda_n} = R_H \left(\frac{1}{4} - \frac{1}{n^2} \right) \qquad n = 3, 4, 5, \ldots$

$R_H = 109{,}500\ cm^{-1}$

Rutherford Experiment



- most α's go through
- some high angle ⇐

Nucleus is very small ~ 10^{-15} m

Compare to density → atomic size 10^{-10} m

Suggested a planetary model

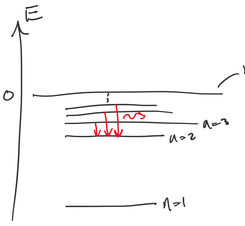
Big Problem: an orbiting charge radiates → gives up energy → spirals in → we don't exist.

radiation is not happening - why?

Rydberg: $\frac{\nu_n}{c} = R_H \left(\frac{1}{4} - \frac{1}{n^2} \right)$

discrete changes in atomic energy

$E = h\nu$



$E_n = \frac{-hcR_H}{n^2} + \text{const}$

Bohr Model (1911) [student of Rutherford]

- Energy levels ⟷ orbits
- Jiers E=hν to spectral lines
- nucleus + orbiting e^- made (Coulomb force)

① e^-'s are in stable circular orbits
→ follows classical orbital mechanics
→ stationary states (don't radiate)

② e^-'s can jump between orbits and emit radiation.
∴ $E_n = \frac{-hcR_H}{n^2}$ integer n