

Fundamental Constants

Planck's constant: $h = 6.62607 \times 10^{-34}$ Js

Reduced planck's constant: $\hbar = 1.05457 \times 10^{-34}$ Js

Speed of light: $c = 2.99792 \times 10^8$ m/s

Mass of electron: $m_e = 9.10938 \times 10^{-31}$ kg

$m_e c^2 = 0.510998$ MeV

Mass of proton: $m_p = 1.67262 \times 10^{-27}$ kg

Charge of proton: $e = 1.60218 \times 10^{-19}$ C

Permittivity of space: $\epsilon_0 = 8.85419 \times 10^{-12}$ C²/(Jm)

$C = \frac{e^2}{4\pi\epsilon_0} = 1.43997 \times 10^{-9}$ Jm

Boltzmann constant: $k_B = 1.38065 \times 10^{-23}$ J/K

Hydrogen Atom

Fine structure constant: $\alpha = \frac{e^2}{4\pi\epsilon_0\hbar c} = 1/137.036$

Bohr radius: $a = \frac{4\pi\epsilon_0\hbar^2}{m_e e^2} = 5.29177 \times 10^{-11}$ m

Bohr energies: $E_n = -\frac{m_e e^4}{2(4\pi\epsilon_0)^2 \hbar^2} \frac{1}{n^2} = \frac{E_1}{n^2}$

Binding energy: $E_1 = -\frac{\hbar^2}{2m_e a^2} = -\frac{\alpha^2 m_e c^2}{2} = -13.6057$ eV

Ground state: $\psi_0 = \frac{1}{\sqrt{\pi a^3}} e^{-r/a}$

Rydberg formula: $\frac{1}{\lambda} = R \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$

Rydberg constant: $R = -\frac{E_1}{2\pi\hbar c} = 1.09737 \times 10^7$ m⁻¹