

2.1: The de Broglie-Bohr Model for the Hydrogen Atom

$\lambda = \frac{h}{mv}$ de Broglie's hypothesis that matter has wave-like properties.

$n\lambda = 2\pi r$ The consequence of de Broglie's hypothesis; an integral number of wavelengths must fit within the circumference of the orbit. This introduces the quantum number which can have values 1, 2, 3...

$mv = \frac{nh}{2\pi r}$ Substitution of the first equation into the second equation reveals that linear momentum is quantized.

$T = \frac{1}{2}mv^2 = \frac{n^2h^2}{8\pi^2m_e r^2}$ If momentum is quantized, so is kinetic energy.

$E = T + V = \frac{n^2h^2}{8\pi^2m_e r^2} - \frac{e^2}{4\pi\epsilon_0 r}$ Which means that total energy is quantized.

Below the ground state energy and orbit radius of the electron in the hydrogen atom is found by plotting the energy as a function of the orbital radius. The ground state is the minimum in the curve.

Fundamental constants: electron charge, electron mass, Planck's constant, vacuum permittivity.

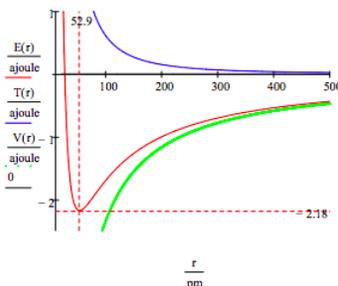
$$e = 1.6021777(10)^{-19} \text{ coul} \quad m_e = 9.10939(10)^{-31} \text{ kg}$$

$$h = 6.62608(10)^{-34} \text{ joule sec} \quad \epsilon_0 = 8.85419(10)^{-12} \frac{\text{coul}^2}{\text{joule m}}$$

Quantum number and conversion factor between meters and picometers and joules and atto joules.

$$n = 1 \quad pm = 10^{-12} m \quad \text{ajoule} = 10^{-18} \text{ joule}$$

$$r = 20pm, 20.5pm, \dots, 500pm \quad T(r) = \frac{n^2h^2}{8\pi^2m_e r^2} \quad V(r) = -\frac{e^2}{4\pi\epsilon_0 r} \quad E(r) = T(r) + V(r)$$



This figure shows that atomic stability involves a balance between potential and kinetic energy. The electron is drawn toward the nucleus by the attractive potential energy interaction ($\sim -1/R$), but is prevented from spiraling into the nucleus by the extremely large kinetic energy ($\sim 1/R^2$) associated with small orbits.

Prepared by Frank Rioux.

This page titled [2.1: The de Broglie-Bohr Model for the Hydrogen Atom](#) is shared under a [CC BY 4.0](#) license and was authored, remixed, and/or curated by [Frank Rioux](#) via [source content](#) that was edited to the style and standards of the LibreTexts platform.