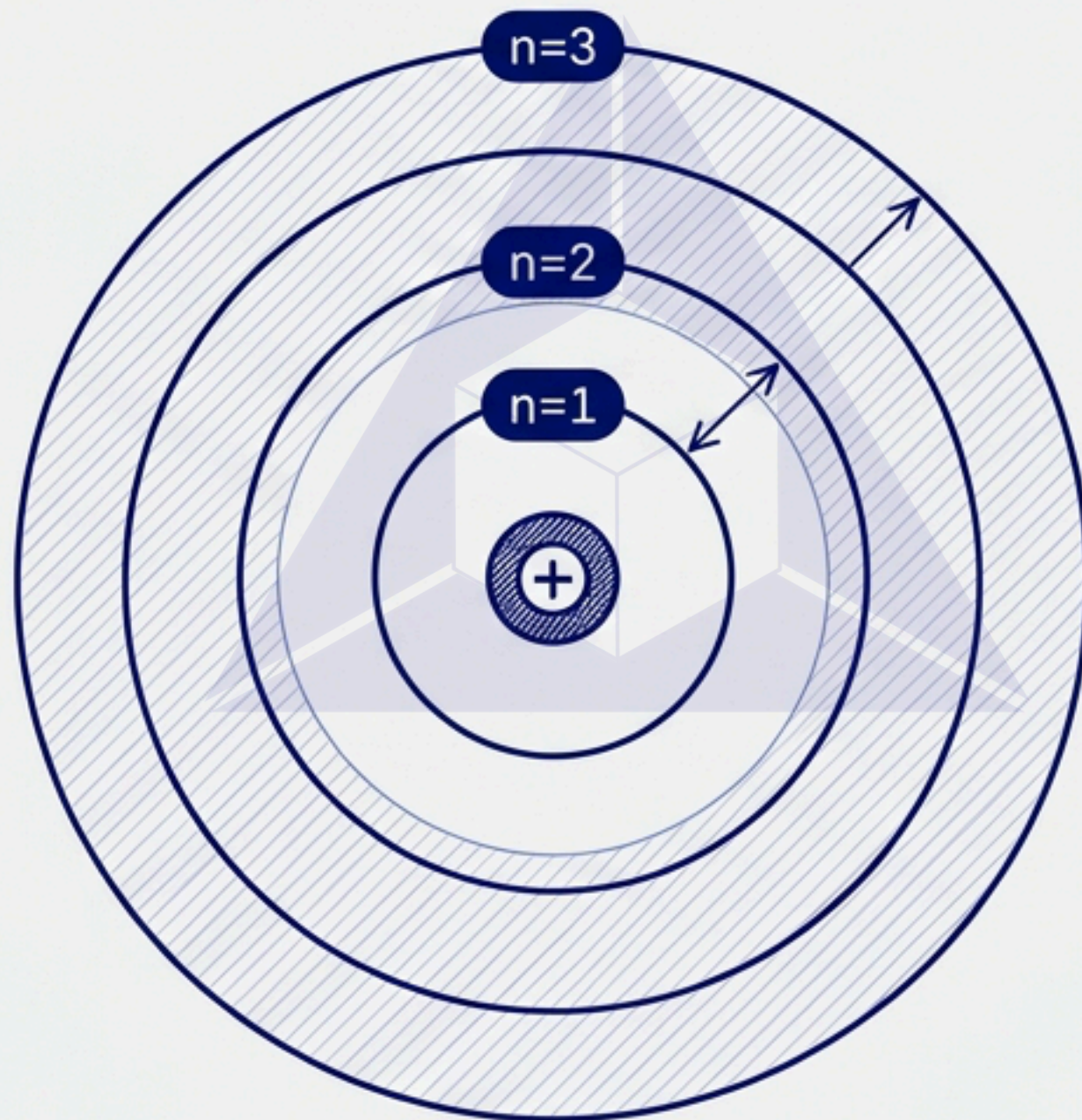


Bohr's Model for the Hydrogen Atom

The Quantum Blueprints Series

Fixed Orbits & Stationary States



The Law

The electron in the hydrogen atom can only move around the nucleus in circular paths of strictly fixed radius and fixed energy.

Terminology Map

Orbits

Stationary States

Allowed Energy States

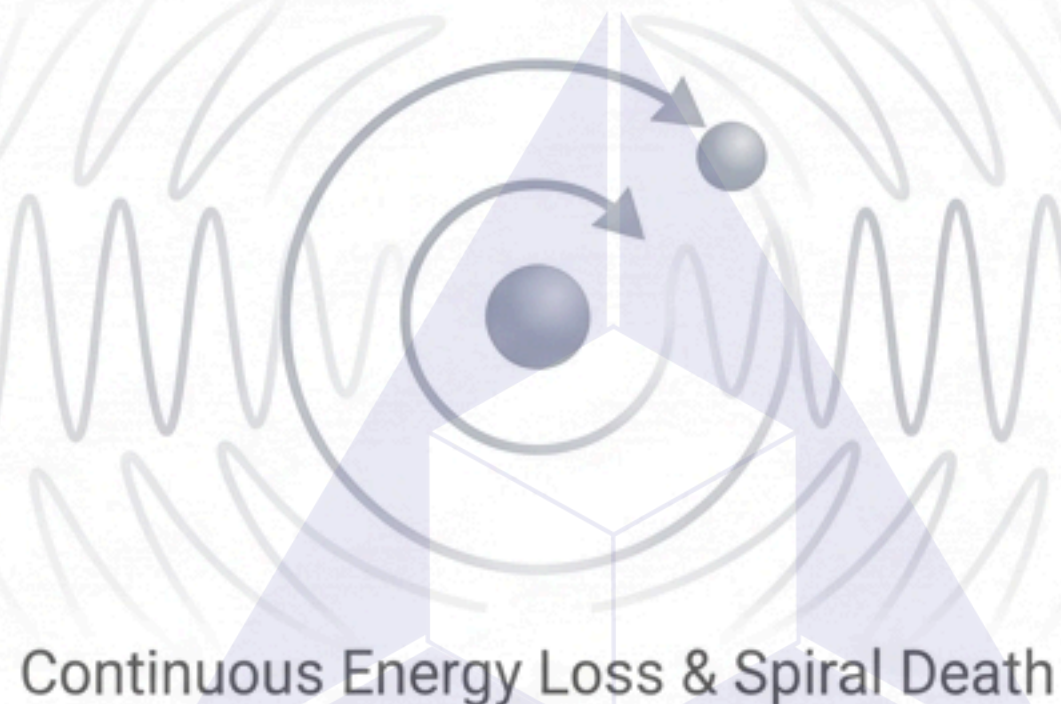
These terms are interchangeable. They represent the only concentric paths concentrically arranged around the nucleus where the electron can legally exist.

Recap Box

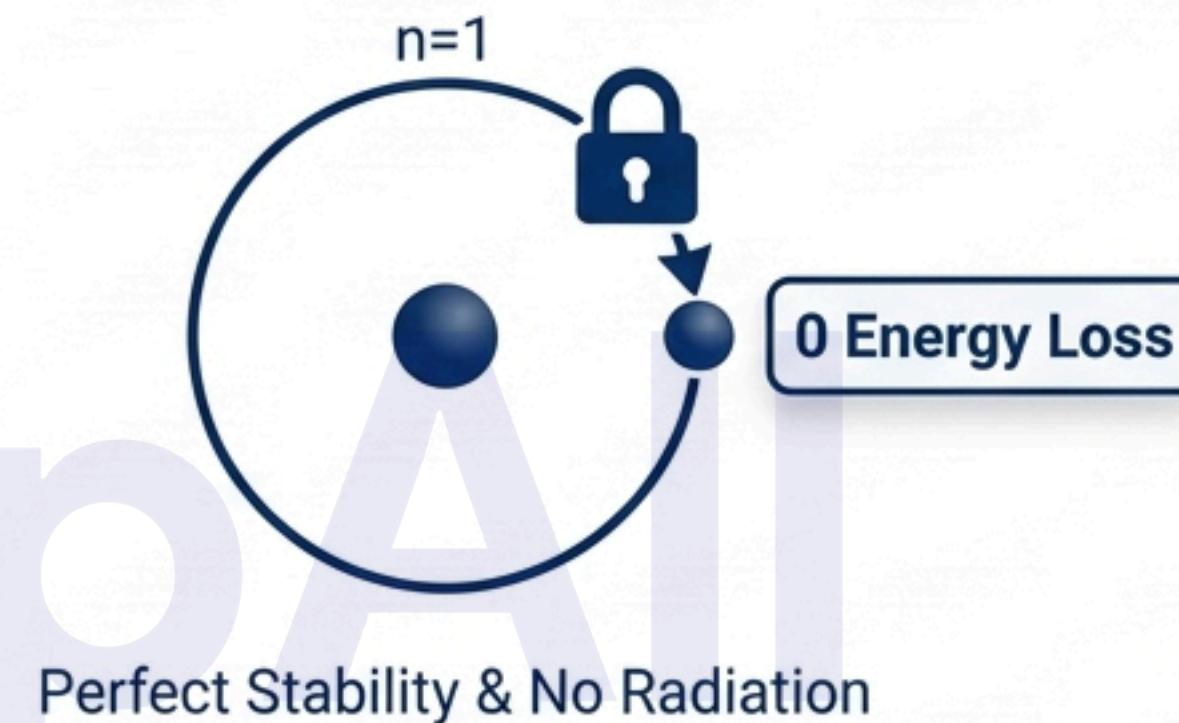
Space is not continuous for an electron; it is strictly zoned into discrete concentric paths.

No Radiation in Stationary States

Classical Expectation



Bohr's Reality



Stationary State:
Energy remains
perfectly constant
over time.

The Core Postulate

The energy of an electron inside an allowed orbit does not change with time. It does not radiate energy while simply orbiting.

The Transition Condition

Energy change is not continuous. An electron only changes energy when it absorbs or emits a very specific, required amount of energy to jump to a different stationary state.

Recap Box: Electrons in stationary states are immune to classical energy loss. Energy only changes during a jump.



You've Learned the Theory. Let's Test Them Now.

$$E=mc^2$$



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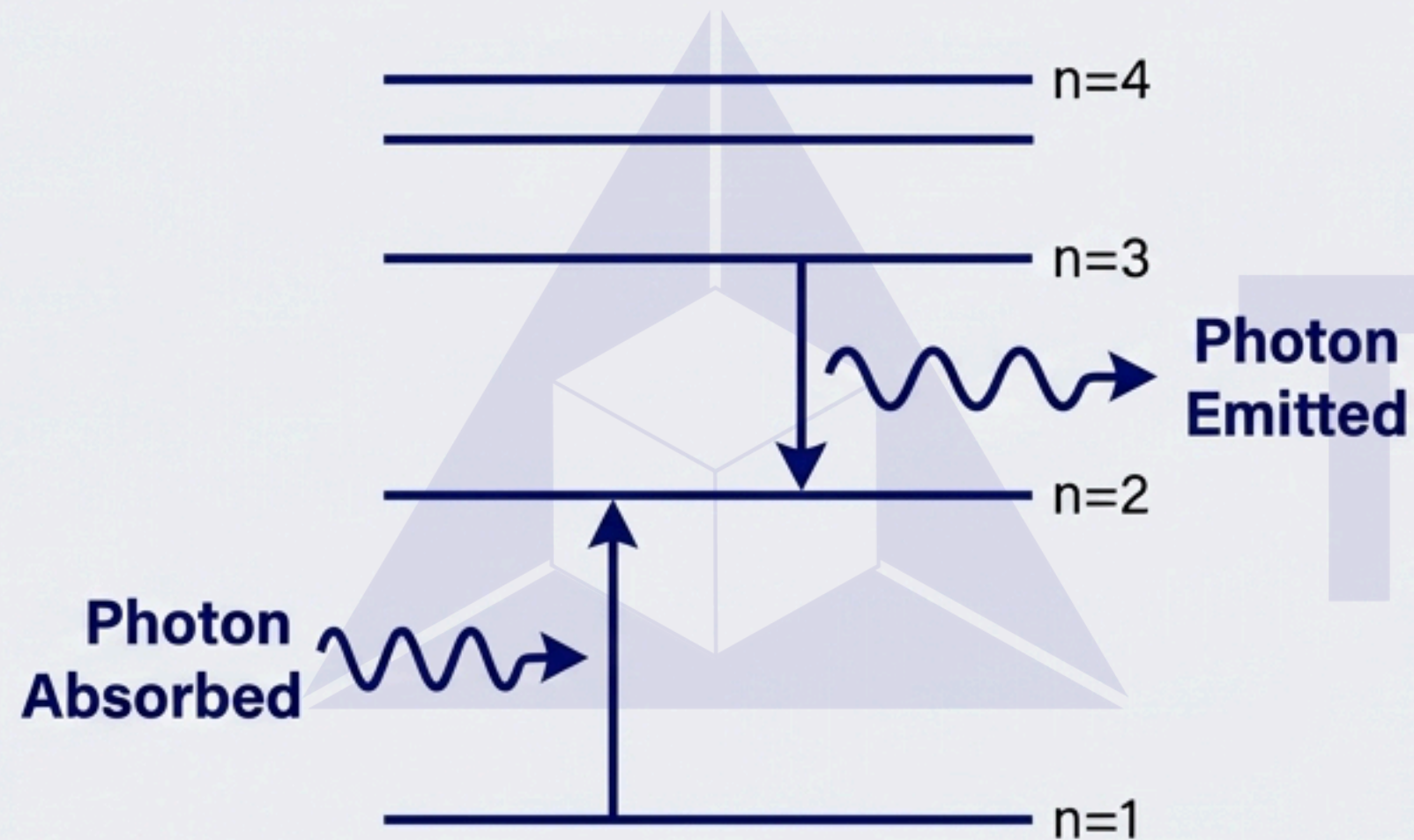
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- » Track Your Performance Smarter



Bohr's Frequency Rule



The frequency of radiation absorbed or emitted during a transition between two stationary states is mathematically absolute.

$$\nu = \frac{\Delta E}{h} = \frac{E_{-2} - E_{-1}}{h}$$

ν = Frequency of radiation

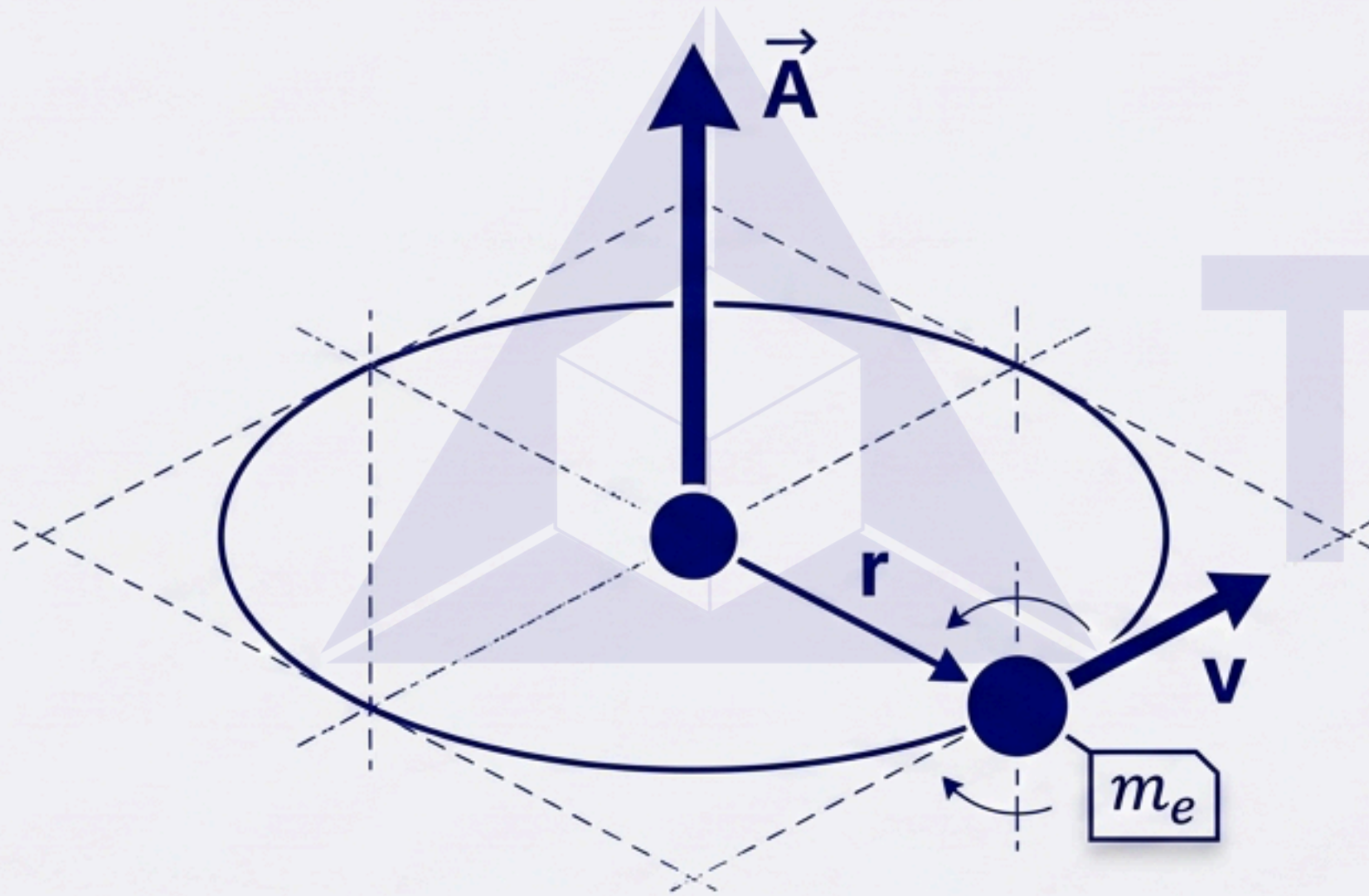
ΔE = Energy difference between states

h = Planck's constant

E_{-1}, E_{-2} = Lower and higher allowed energy states

The energy of the photon exactly matches the energy gap between the two allowed orbits.

Angular Momentum Quantisation



In a given stationary state, the angular momentum of an electron is quantised. It can only exist as an integral multiple of $h / 2\pi$.

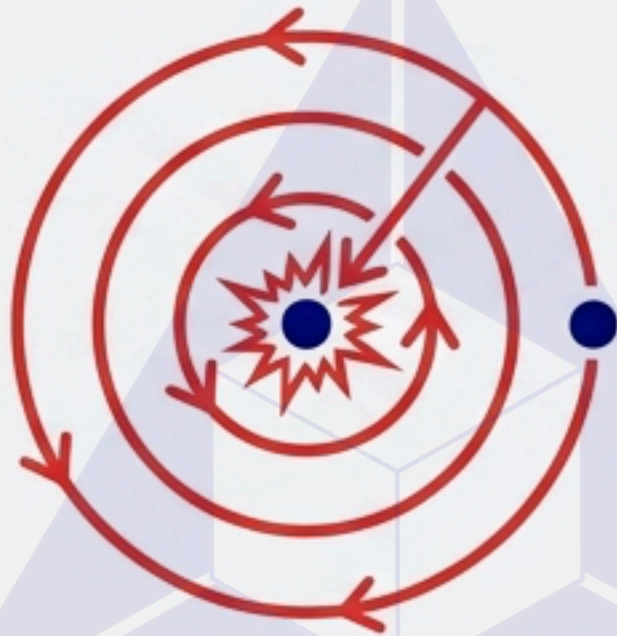
$$m_e v r = n \frac{h}{2\pi} \quad (n = 1, 2, 3 \dots)$$

- Because n must be a whole number, only certain fixed orbits are allowed.
- Maxwell's continuous electromagnetic theory is replaced by discrete quantum steps.

An electron can only orbit where its angular momentum perfectly satisfies this quantum equation.

Why Bohr's Model Solved Hydrogen Stability

Rutherford's Death Spiral



Classical Mechanics & Electromagnetism

Accelerated charged particles must emit radiation. Orbiting electrons constantly change direction (accelerating). They lose energy continuously.

Atom collapses in 10^{-8} seconds (Unstable).

Bohr's Stable Orbits



Quantum Mechanics

Introduces angular momentum quantisation. Electrons are restricted to stationary states where classical emission laws do not apply.

Infinite stability in the ground state.

THE BLUEPRINT SYNTHESIZED

Final Recap: Allowed Orbits & Energies

Where the electron can exist

$$r_n = n^2 a_0$$

- $a_0 = 52.9 \text{ pm}$ (The Bohr radius, $n=1$)
- Radius increases with the square of the principal quantum number (n^2).
- Electron moves further from nucleus as n increases.

The energy of each stationary state

$$E_n = -R_H (1 / n^2)$$

- $R_H = 2.18 \times 10^{-18} \text{ J}$ (Rydberg constant)
- Why Negative? The energy of an electron in the atom is lower (more stable) than a free electron at rest at an infinite distance ($E_\infty = 0$).

Bohr's model proves the structure of hydrogen is entirely governed by the **principal quantum number (n)**.



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