



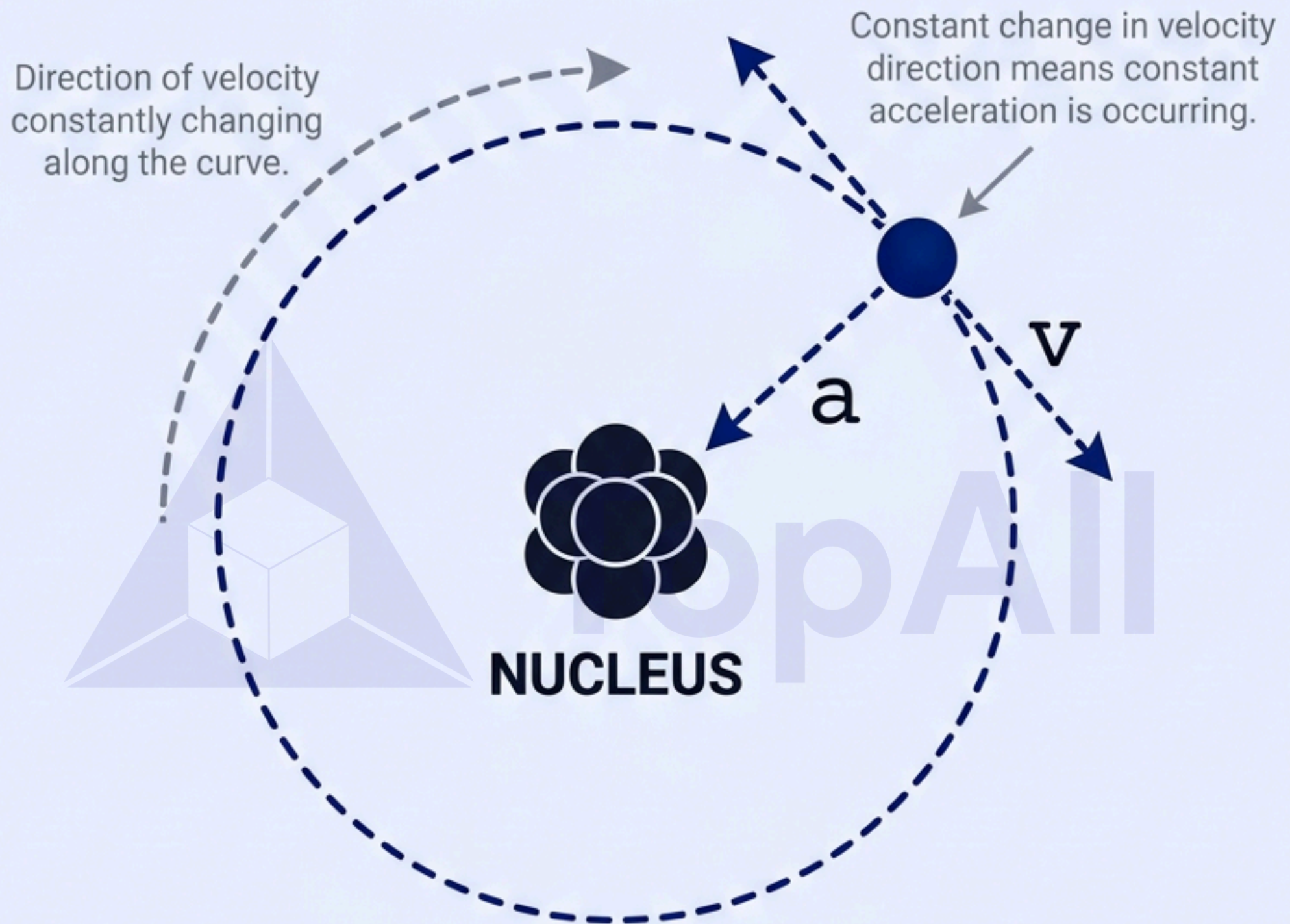
JEE CLASS 11 CHEMISTRY • STRUCTURE OF ATOM

Why Rutherford's Model Failed

The inevitable clash between classical mechanics, electromagnetism, and atomic stability.

The Planetary Assumption

Rutherford proposed that electrons revolve around the dense nucleus in well-defined circular paths, mathematically similar to planets orbiting the sun under gravitational force.



Circular Motion = Constant Acceleration

Even if an electron moves at a constant speed, its direction changes continuously. In classical mechanics, any change in direction means a change in velocity, resulting in acceleration.

$$a = \frac{v^2}{r}$$

UNLIKE PLANETS: Electrons are charged particles. Applying macroscopic planetary mechanics to microscopic charged particles is where the model begins to fracture.

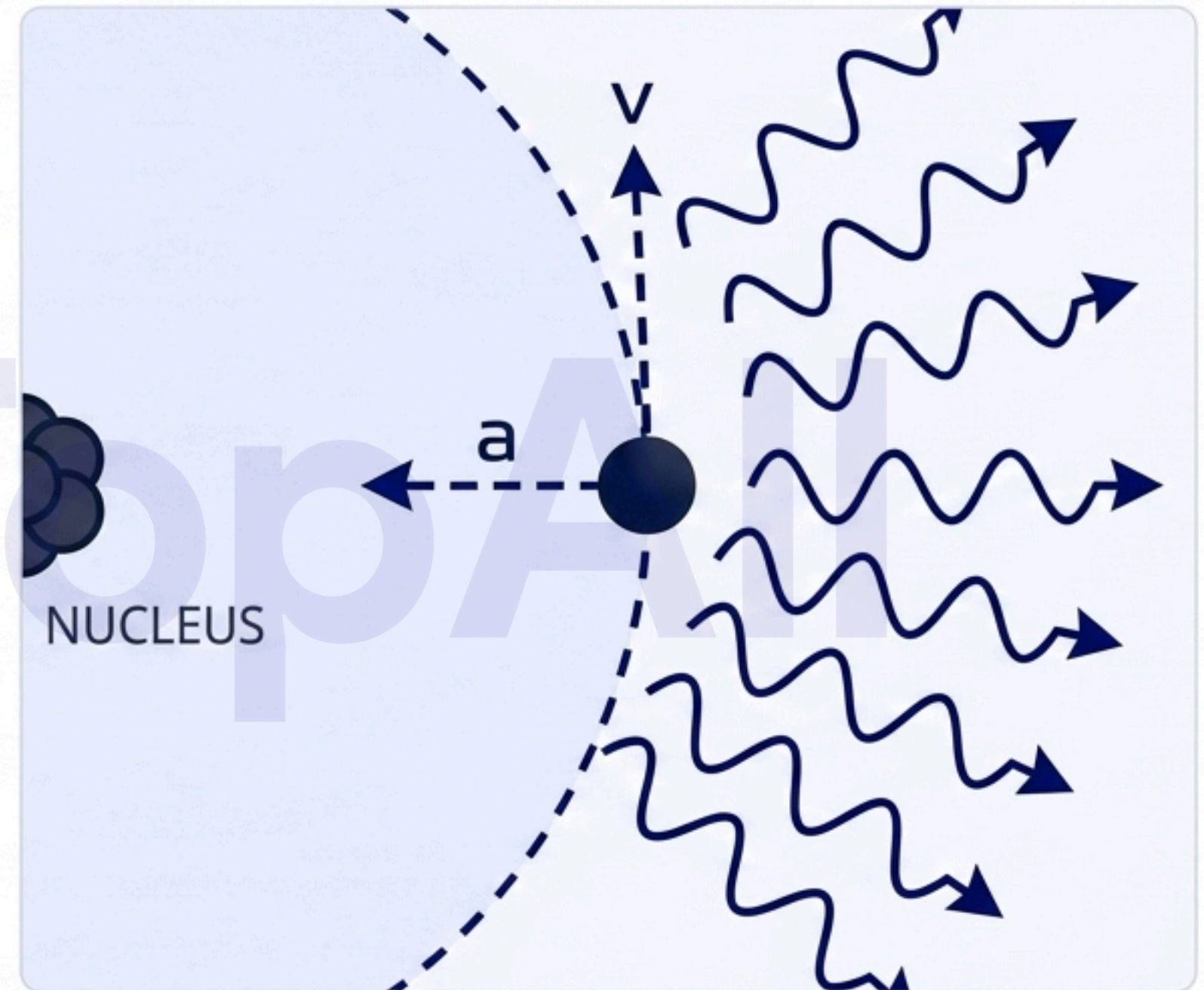
The Electromagnetic Clash

Rutherford built his model on classical mechanics but entirely ignored classical electromagnetism.

Step 1: The electron is a negatively charged particle.

Step 2: The electron is under constant centripetal acceleration.

Step 3: Maxwell's Theory dictates that any accelerated charged particle must continuously emit electromagnetic radiation.



The energy carried by this emitted radiation doesn't appear out of nowhere—it must drain directly from the electron's own kinetic energy.



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$$E=mc^2$$



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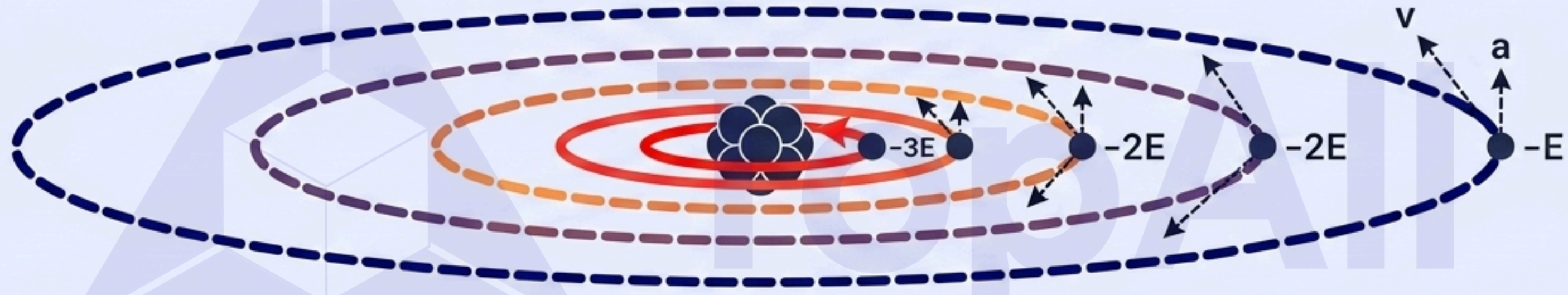
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The Atomic Death Spiral

As the electron continuously emits radiation, it bleeds kinetic energy. To maintain electrostatic balance with less energy, the orbital radius must shrink. The consequence: The orbit continually degrades. The electron spirals inward, inexorably pulled by the positive nucleus.



Red Alert Box

Theoretical Lifespan: 10^{-8} seconds

Calculations prove it would take only this long for an electron to completely spiral into the nucleus.

The Paradox: Matter is incredibly stable. If Rutherford's mechanics were entirely correct, atoms could not exist.

The Incomplete Picture

Beyond the stability paradox, the nuclear model lacked the predictive power to explain how electrons were actually structured.

What Rutherford Solved

- Explained alpha-particle scattering.
- Discovered the dense, positively charged nucleus.
- Proved most of the atom is empty space.

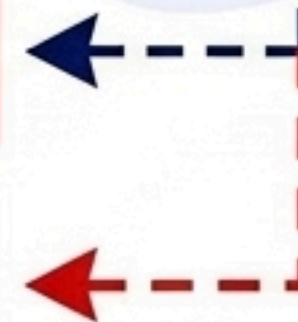
What He Missed

- **Energy Distribution:** Provided zero framework for how electrons are arranged around the nucleus or their respective energies.
- **Line Spectra:** Failed to explain the discrete line spectrum of Hydrogen.

Predicted:
Continuous Spectrum



Observed:
Hydrogen Line Spectrum



Synthesis: Why the Model Evolved

1. Macro vs. Micro

Wrongly applied classical macroscopic mechanics (planetary gravity) to microscopic charged particles.

2. The Stability Paradox

Failed to reconcile circular acceleration with Maxwell's EM theory, mathematically predicting an impossible 10^{-8} s collapse.

3. The Spectra Gap

Provided no framework for electron energy distribution, contradicting the discrete atomic spectra observed in labs.



ENTER THE BOHR MODEL: To fix these exact flaws, Niels Bohr introduced Planck's Quantum Theory. He proposed that angular momentum is quantized, allowing electrons to reside safely in discrete, non-radiating stationary orbits.



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