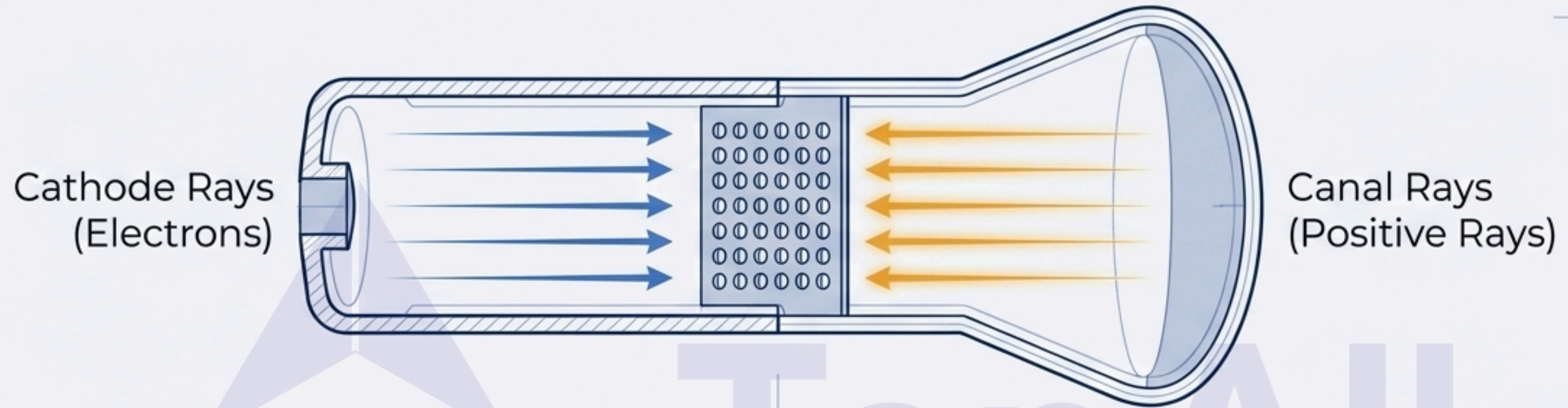


# Protons and Neutrons

Completing the Sub-Atomic Picture

JEE Class 11 • Structure of Atom



# The Discovery of Canal Rays

Electrical discharge in a modified cathode ray tube revealed a new stream of particles moving in the opposite direction of electrons.

- **Nature:** Simply positively charged gaseous ions, not bare sub-atomic particles.
- **Behavior:** Deflect in magnetic and electrical fields in the exact opposite direction to cathode rays.
- **Charge:** Can carry a multiple of the fundamental unit of electrical charge.

# The Gas Dependence Factor

Unlike cathode rays (electrons), which are identical fundamental particles regardless of their source, the nature of canal rays changes depending on the environment.

## Cathode Rays

- $e/m$  ratio is constant.
- Does NOT depend on the nature of the gas.
- Always fundamental electrons.

## Canal Rays

- Charge-to-mass ratio varies.
- Depends heavily on the gas inside the tube.
- Merely ionized gas molecules.

## EXAM TRAP

Do not assume canal rays are a stream of bare protons. If the discharge tube contains Helium gas, the canal rays are  $\text{He}^+$  ions, not protons. Their mass and charge-to-mass ratio fundamentally shift based on the gas used.



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# Isolating the Proton

To find the fundamental positive sub-atomic particle, scientists needed the simplest, lightest possible ion.

## Source: Hydrogen Gas (H<sub>2</sub>)

When hydrogen loses its single electron, what remains is the smallest and lightest positive ion in existence.

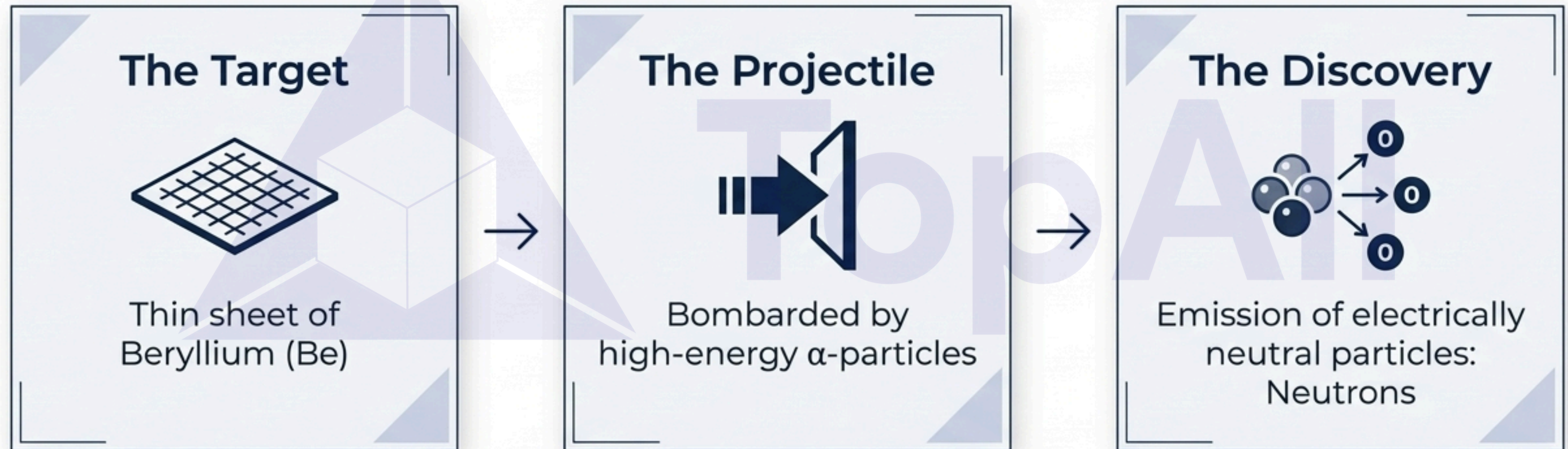


### CONCEPT CAUTION

The proton was officially characterized in 1919. It is essentially a bare hydrogen nucleus (H<sup>+</sup>) and serves as the foundational, indivisible unit of positive charge in all atoms.

# Chadwick & The Neutron (1932)

Atoms were heavier than the sum of their protons and electrons.  
A neutral particle was required to account for the "missing mass."



**Note:** The neutron has a mass slightly greater than that of a proton ( $1.6749 \times 10^{-27}$  kg vs  $1.6726 \times 10^{-27}$  kg), but carries strictly zero electrical charge.

# Fundamental Particles: Comparison Matrix

Absolute and relative values governing atomic structure (Ref: Table 2.1).

| Particle | Symbol | Absolute Charge (C)         | Rel. Charge | Mass (kg)                   | Mass (u) |
|----------|--------|-----------------------------|-------------|-----------------------------|----------|
| Electron | e      | $-1.602176 \times 10^{-19}$ | -1          | $9.109382 \times 10^{-31}$  | 0.00054  |
| Proton   | p      | $+1.602176 \times 10^{-19}$ | +1          | $1.6726216 \times 10^{-27}$ | 1.00727  |
| Neutron  | n      | 0                           | 0           | $1.674927 \times 10^{-27}$  | 1.00867  |

Note: The mass of the neutron is marginally heavier than the proton. The mass of the electron is practically negligible compared to nucleons.

# Key Takeaways: Defining the Nucleus



## THE NUCLEONS

Protons and neutrons reside strictly in the nucleus. Together, they are collectively called nucleons. They contain almost the entirety of the atom's mass in a negligibly small volume.

$$\text{Mass Number (A)} = \text{Protons (Z)} + \text{Neutrons (n)}$$

While an atom's electrons dictate its chemical behavior, the combined protons and neutrons (nucleons) define its physical mass and foundational identity.



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