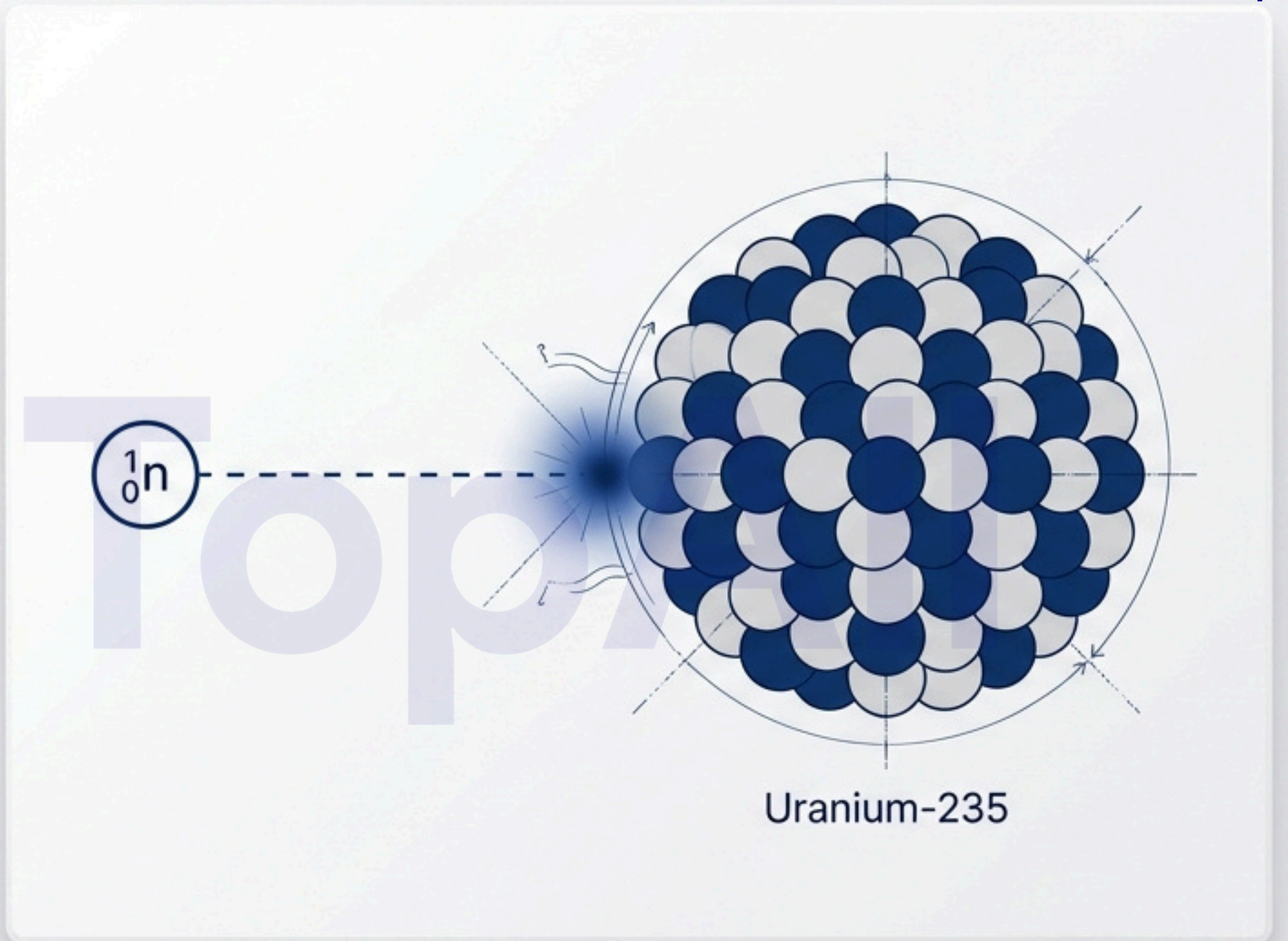


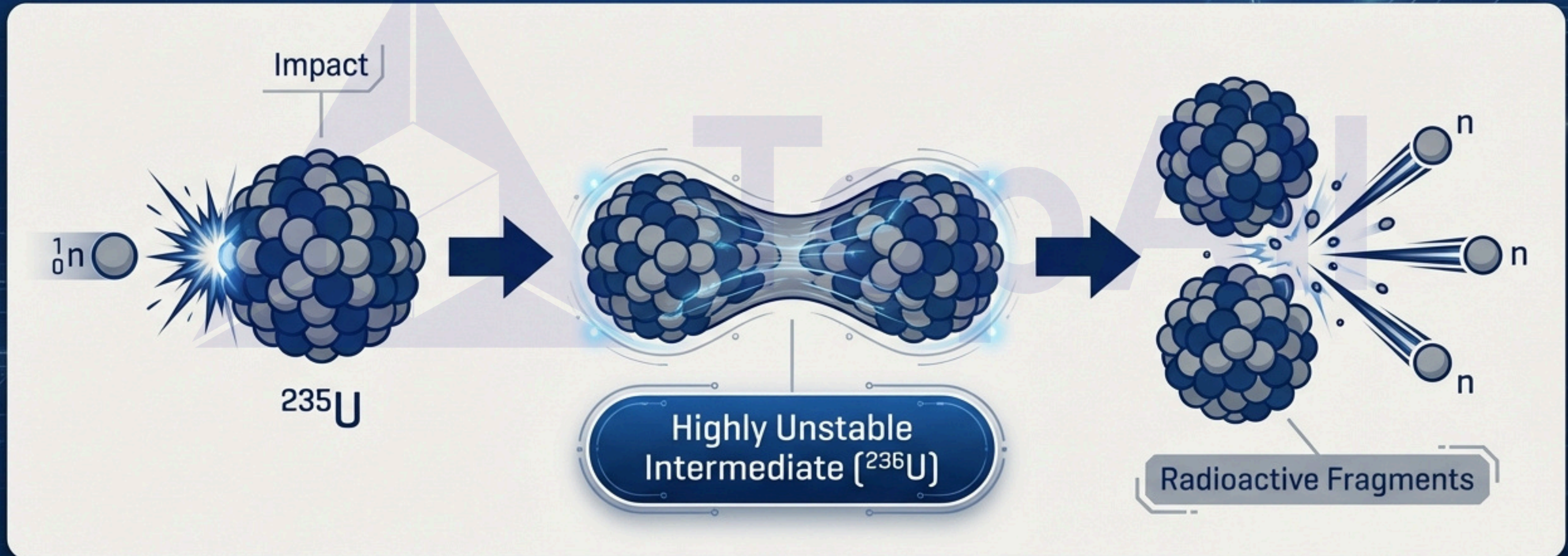
How One Neutron Can Split Uranium

Understanding neutron-induced nuclear fission, intermediate mass fragments, and massive energy release.



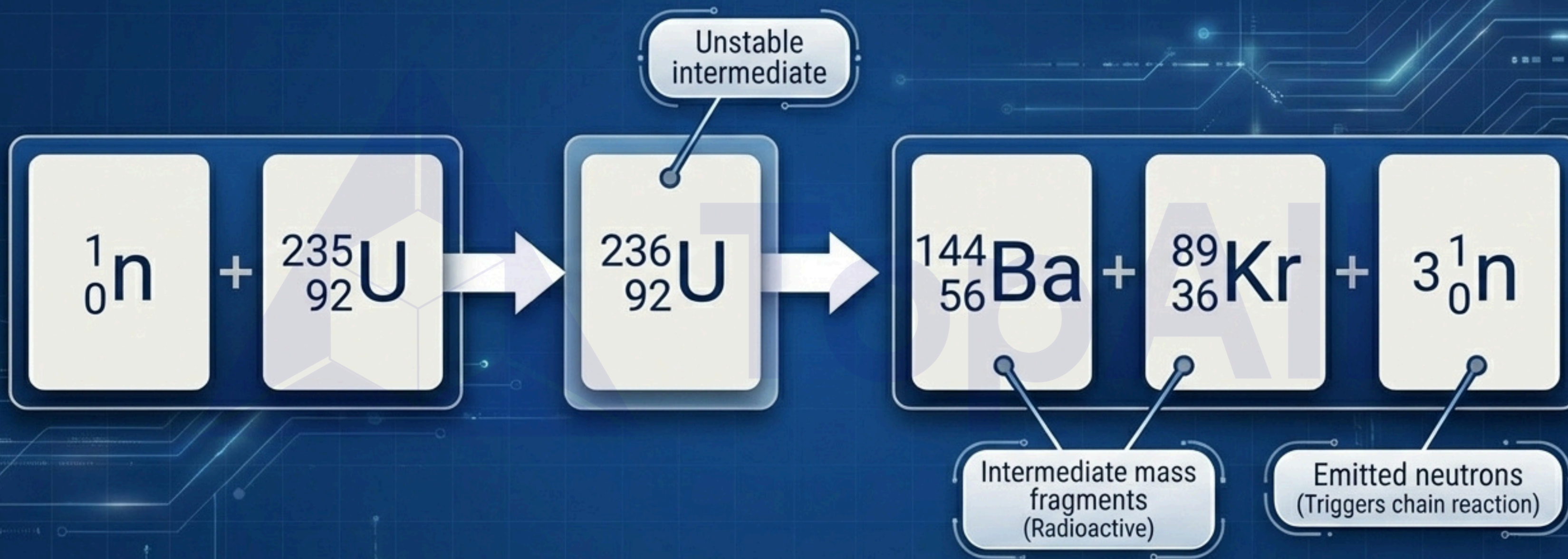
The Anatomy of Nuclear Fission

A neutron-induced nuclear reaction occurs when a heavy nucleus is bombarded by a neutron, causing it to break into intermediate mass fragments.



THE PRIMARY PATHWAY

The Barium-Krypton Reaction



The fragment products are highly radioactive. They emit β particles in succession to eventually achieve stable end products.



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$$E=mc^2$$



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Key Highlights

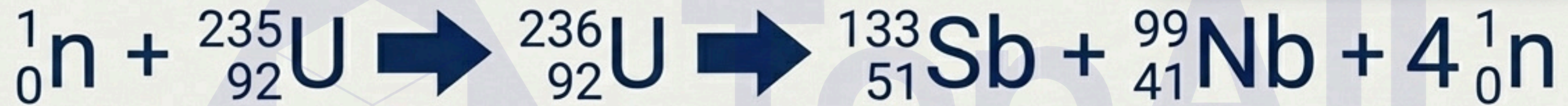
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Fission Yields Alternate Fragments

Fission does not always produce identical products. The uranium nucleus can split into different pairs of intermediate mass fragments, varying the number of emitted neutrons.

Antimony & Niobium Pathway
(Yields 4 neutrons)



Xenon & Strontium Pathway
(Yields 2 neutrons)



The Math Behind the 200 MeV Q-Value

Energy is released because the intermediate fragments are more tightly bound than the original heavy nucleus. This disintegration energy first appears as kinetic energy.

Before Fission

- ⚛ **System:** Heavy Nucleus ($A = 240$)
- ⚛ **Binding Energy (E_{bn}):** ~ 7.6 MeV/nucleon



After Fission

- ⚛ **System:** Two Fragments ($A = 120$ each)
- ⚛ **Binding Energy (E_{bn}):** ~ 8.5 MeV/nucleon

$$\text{Gain per nucleon: } 8.5 - 7.6 = 0.9 \text{ MeV} \longrightarrow \text{Total Energy Gain: } 240 \times 0.9 \text{ MeV} \approx 216 \text{ MeV}$$

Note: The standard Q-value is stated as roughly of the order of 200 MeV per fissioning nucleus.

Controlled vs. Uncontrolled Fission



Nuclear Reactors

Mode: Controlled Fission

Mechanism: Emitted neutrons are carefully regulated (absorbed or slowed) to maintain a steady, sustained reaction rate.

Energy Use: Slower energy transfer. Heat is carefully extracted to produce commercial electricity.



Atom Bombs

Mode: Uncontrolled Fission

Mechanism: Emitted neutrons exponentially trigger more fissions in a rapid, cascading chain reaction.

Energy Use: Instantaneous, massive release of destructive energy.

Key Takeaways & Exam Prep

Key Takeaways

- 1. Fission is neutron-induced:** Heavy nuclei (like U-235) split into intermediate fragments.
- 2. Products are radioactive:** Fragments undergo successive β decays to achieve stability.
- 3. Massive Energy:** Q-value $\approx$ 200 MeV per nucleus, derived from increased binding energy per nucleon ($7.6 \rightarrow 8.5$ MeV).

Exam Traps

-  **Watch the neutrons:** Remember that the number of emitted neutrons varies (2, 3, or 4) depending on the exact fragment pair produced.
-  **Balance the equation:** Ensure mass numbers (A) and atomic numbers (Z) are strictly conserved on both sides of your equations!



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