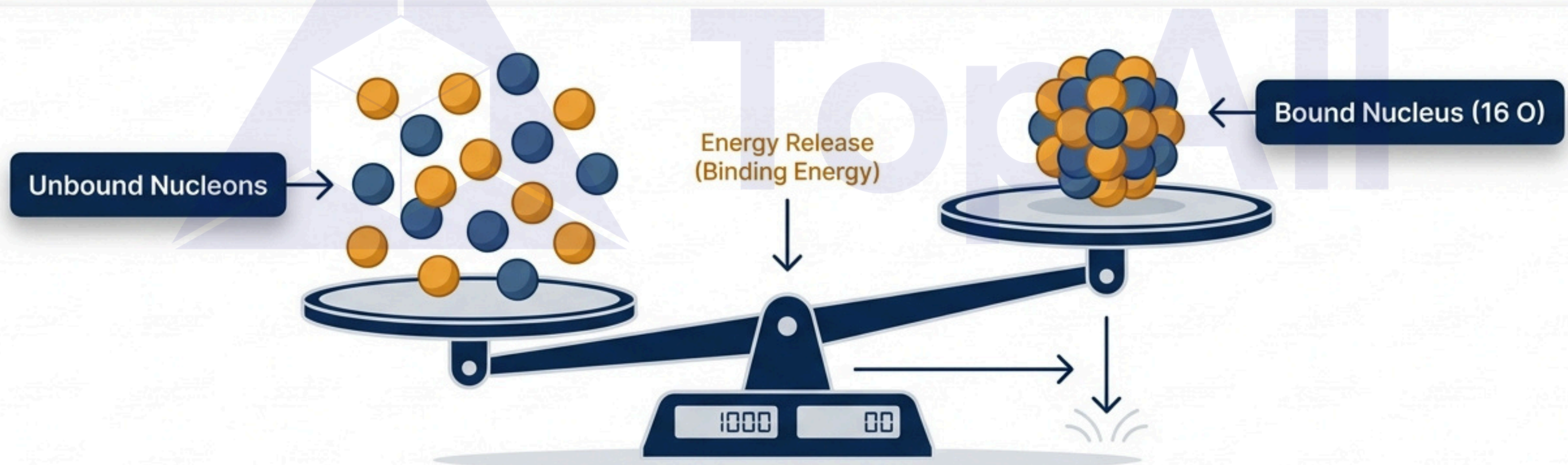


THE MASS PARADOX

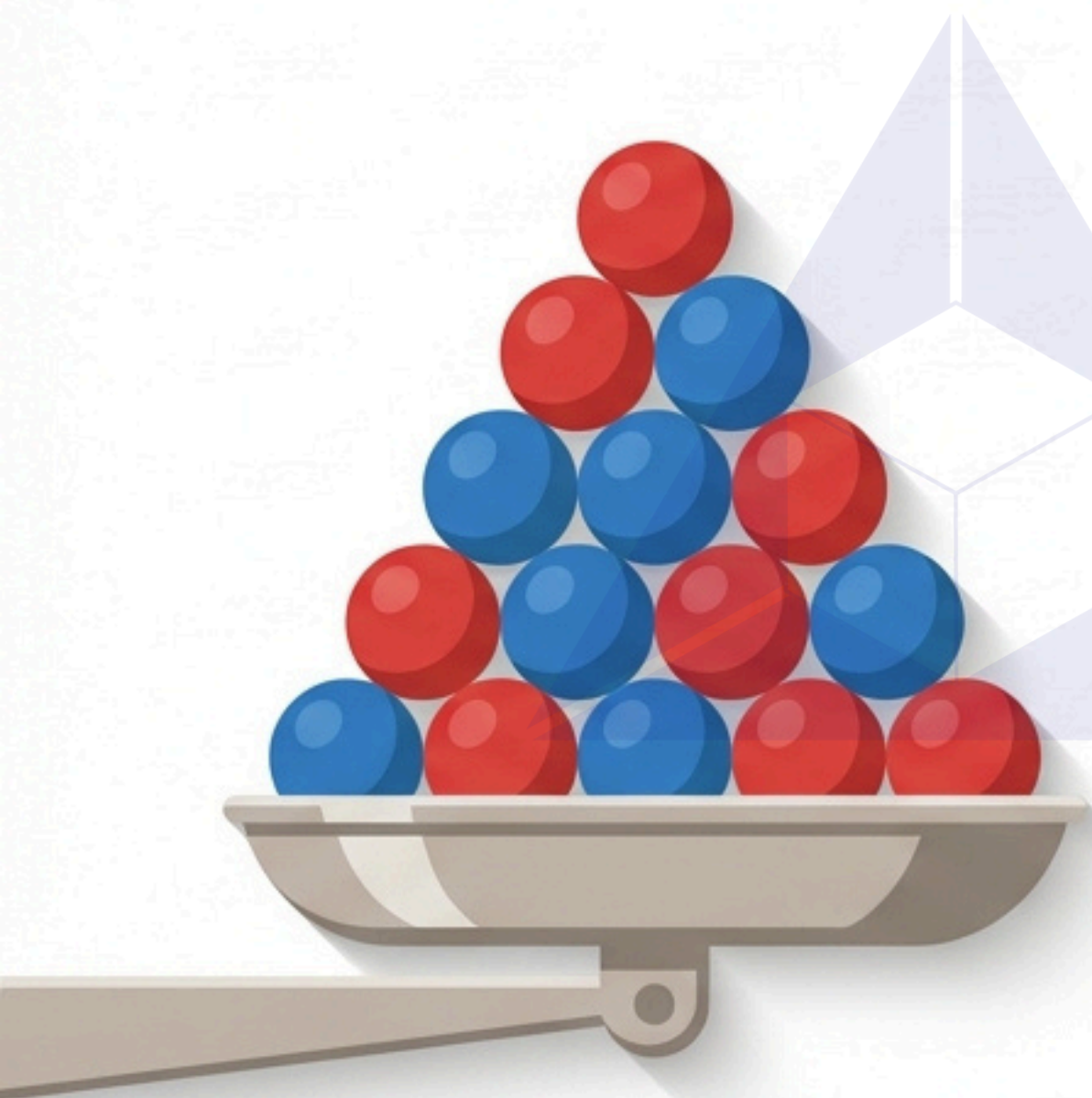
Why the Nucleus Weighs Less Than Its Parts

Understanding Mass Defect & Nuclear Binding Energy.



STEP 01: THE EXPECTED MASS

Calculating the Parts of Oxygen-16



$$8 \text{ protons} \times 1.00727 \text{ u} = 8.05816 \text{ u}$$



$$8 \text{ neutrons} \times 1.00866 \text{ u} = 8.06928 \text{ u}$$

Total Expected Mass

16.12744 u

STEP 02: THE EXPERIMENTAL REALITY

The Missing Mass (ΔM)

Eq. 13.7

$$\Delta M = [Z m_p + (A - Z)m_n] - M$$

Expected Mass

16.12744 u

Experimental Mass

15.99053 u

(Derived from atomic mass 15.99493 u minus 8 electrons)

Mass Defect (ΔM)

$$16.12744 \text{ u} - 15.99053 \text{ u} = 0.13691 \text{ u}$$



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

$$E=mc^2$$



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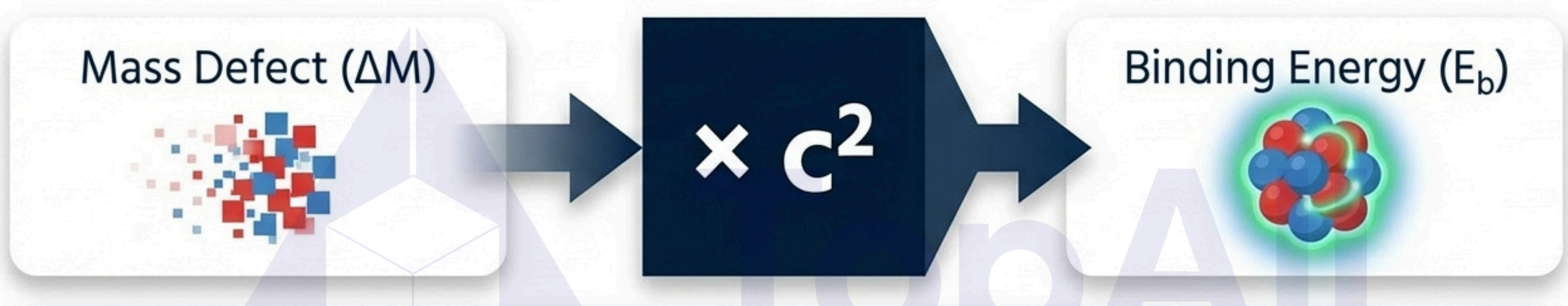
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- » Get Clear Explanations, Not Just Marks
- » Track Your Performance Smarter



STEP 03: MASS BECOMES ENERGY

The Concept of Nuclear Binding Energy (E_b)



$$E_b = \Delta M c^2$$

Eq. 13.8

To break the oxygen nucleus completely apart into its 8 protons and 8 neutrons, this exact amount of extra energy must be supplied.

STEP 04: CALCULATING IN MeV

Finding the Binding Energy of Oxygen-16

Take ΔM for Oxygen-16 $\rightarrow$ **0.13691 u**

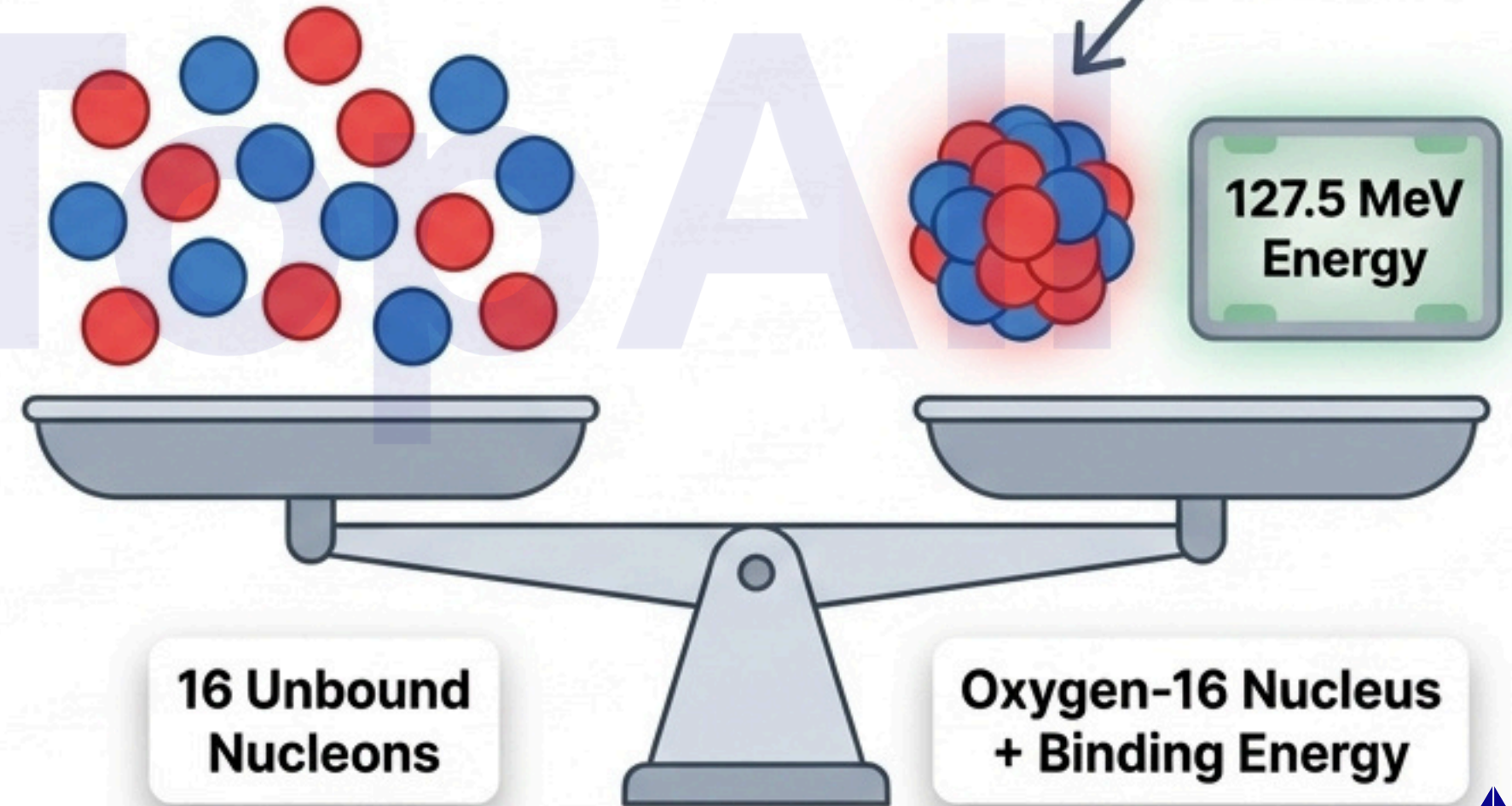
Multiply by equivalent $\rightarrow$ **$\times 931.5 \text{ MeV}/c^2$**

Oxygen-16 Binding Energy (E_b) = 127.5 MeV

To avoid standard SI units, use the mass-energy equivalent:

$$1 \text{ u} = 931.5 \text{ MeV}/c^2$$

Parts = Whole + Energy

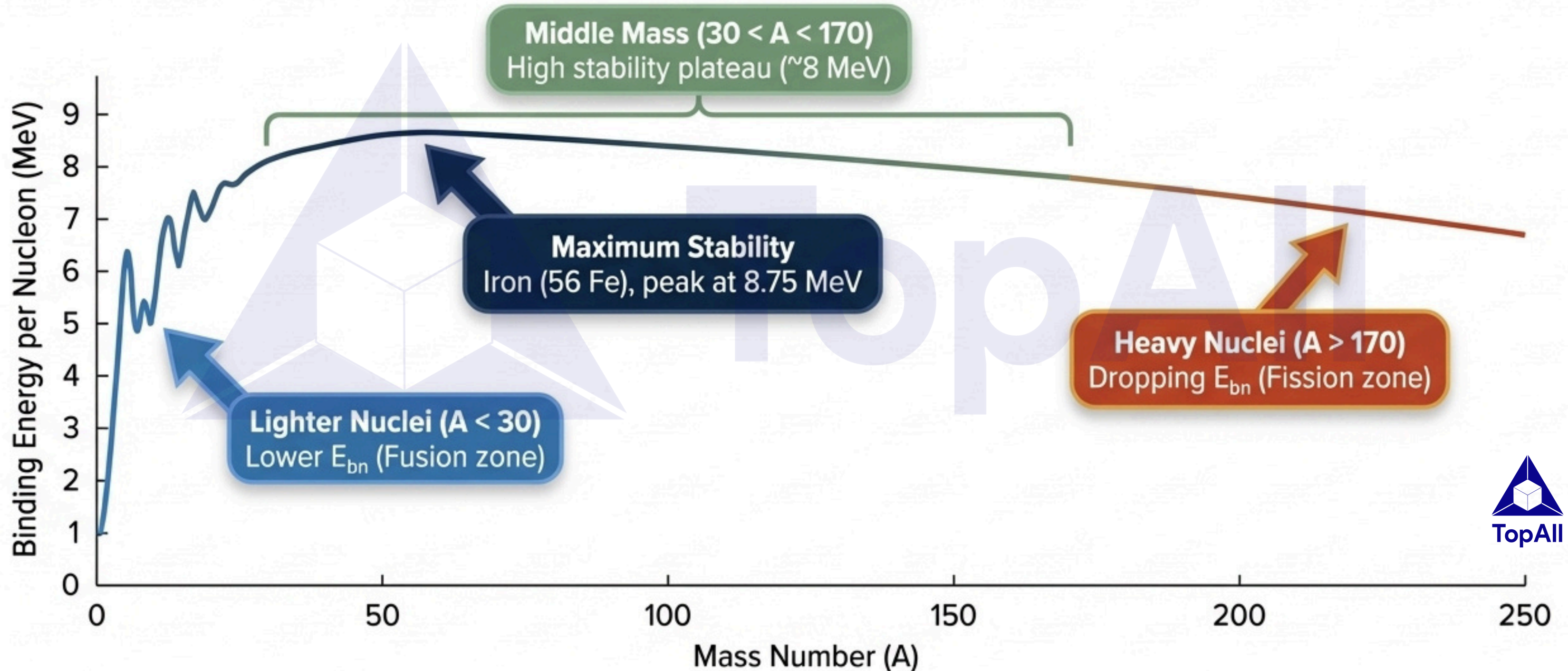


THE RULES OF STABILITY

Binding Energy per Nucleon (E_{bn})

$$\text{Eq. 13.9: } E_{bn} = E_b / A$$

Average energy needed to remove one nucleon



Key Takeaways & Exam Traps



Mass Defect:

$$\Delta M = [Z m_p + (A - Z)m_n] - M$$

Binding Energy:

$$E_b = \Delta M c^2$$

Per Nucleon:

$$E_{bn} = \frac{E_b}{A} \text{ (Maximum stability peaks at Iron-56)}$$



The Electron Trap

Using atomic mass instead of nuclear mass.

Correction: Always subtract the mass of Z electrons ($Z \times m_e$) from the given atomic mass to find the true experimental nuclear mass M .

The Conversion Trap

Wasting time converting to kg and Joules.

Correction: Unless explicitly asked for standard units, multiply ΔM (in u) directly by $931.5 \text{ MeV}/c^2$ to find energy in MeV instantly.



You've Learned the Theory.

Now Let's Test It.

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