

Why Carbon Is 12.011 u

Amber

Wait. If Carbon-12 is exactly 12, why does the periodic table say 12.011?

The Standard: 1 atomic mass unit (u) is defined as exactly $1/12^{\text{th}}$ the mass of a Carbon-12 atom.

Mass of ^{12}C = 12 u (exactly)

6

C

Carbon

12.011

Nature's Variations: Isotopes



^{12}C

6 Protons
6 Neutrons



^{13}C

6 Protons
7 Neutrons



^{14}C

6 Protons
8 Neutrons

Isotopes: Same chemical identity (protons), different physical mass (neutrons).

The Carbon Isotope Data



^{12}C

Relative Abundance: 98.892%

Atomic Mass: 12 u

^{13}C

Relative Abundance: 1.108%

Atomic Mass: 13.00335 u

^{14}C

Relative Abundance: $2 \times 10^{-10} \%$

Atomic Mass: 14.00317 u



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$$E=mc^2$$



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Why Not a Simple Average?

Simple Average

$$\frac{(12 + 13 + 14)}{3} = 13$$

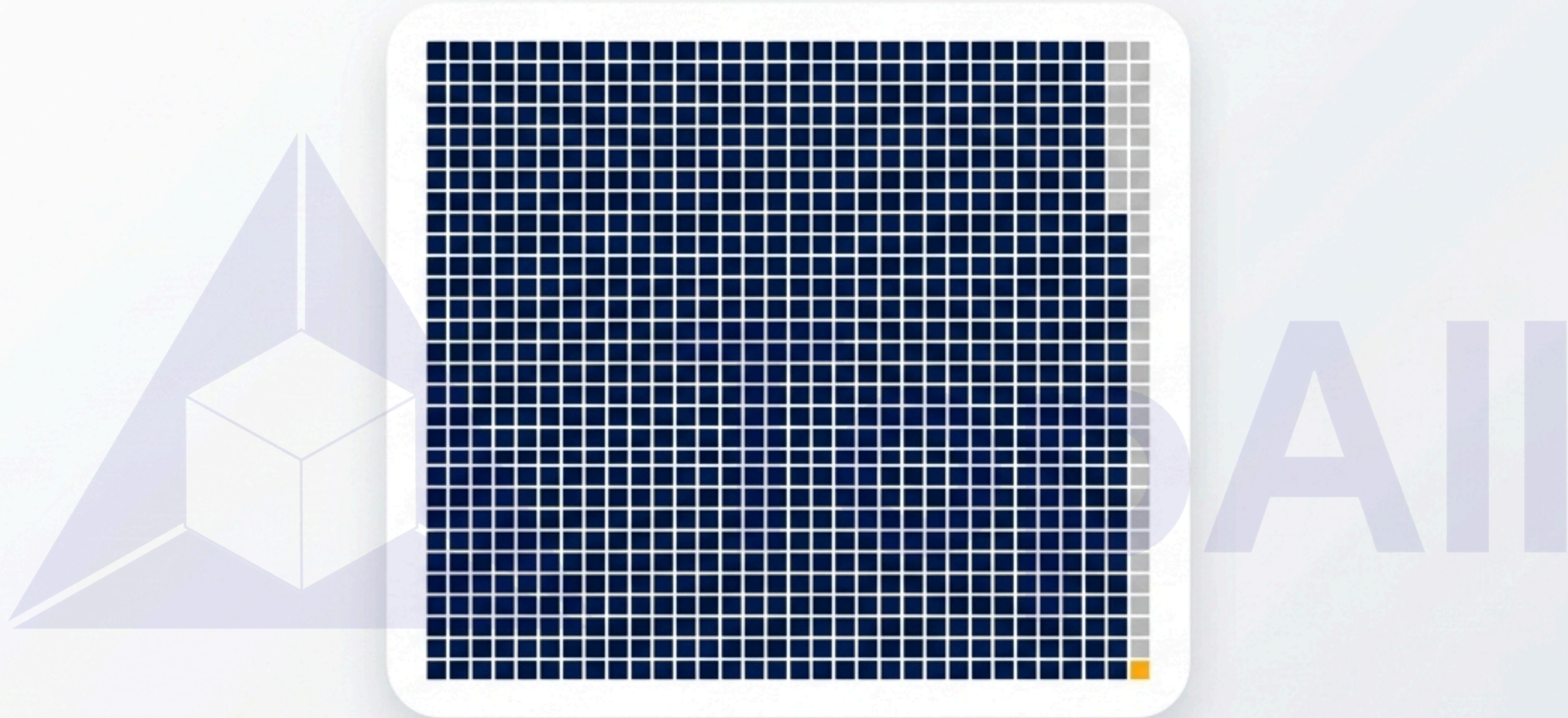
⚠ Incorrect: Assumes all isotopes are mixed equally in nature.

Weighted Average



✓ Correct: Abundance matters. The final mass must account for the exact natural percentage of each isotope.

The Dominance of Carbon-12



Because over 98.8% of all carbon in the universe is Carbon-12, the average atomic mass will inevitably sit just slightly above 12.

Solving the Mystery

$$(\text{Abundance} \times \text{Mass}) + (\text{Abundance} \times \text{Mass}) + (\text{Abundance} \times \text{Mass}) = \text{Average Atomic Mass}$$

$$^{12}\text{C} \ (0.98892 \times 12 \text{ u})$$

$$^{13}\text{C} \ + \ (0.01108 \times 13.00335 \text{ u})$$

$$^{14}\text{C} \ + \ (0.0000000000000002 \times 14.00317 \text{ u})$$



$$= 12.011 \text{ u}$$

The Universal Rule



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Key Takeaway

The atomic masses listed on the periodic table are almost always weighted averages of naturally occurring isotopes, not the mass of a single atom.



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