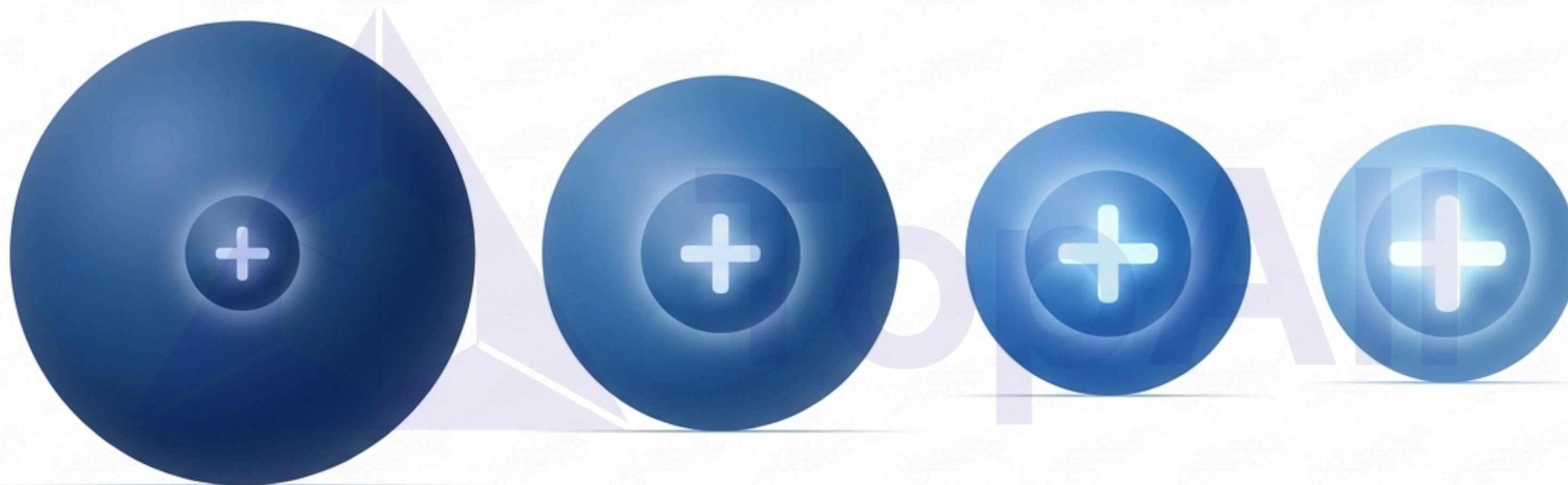


Why Atoms Shrink Across a Period

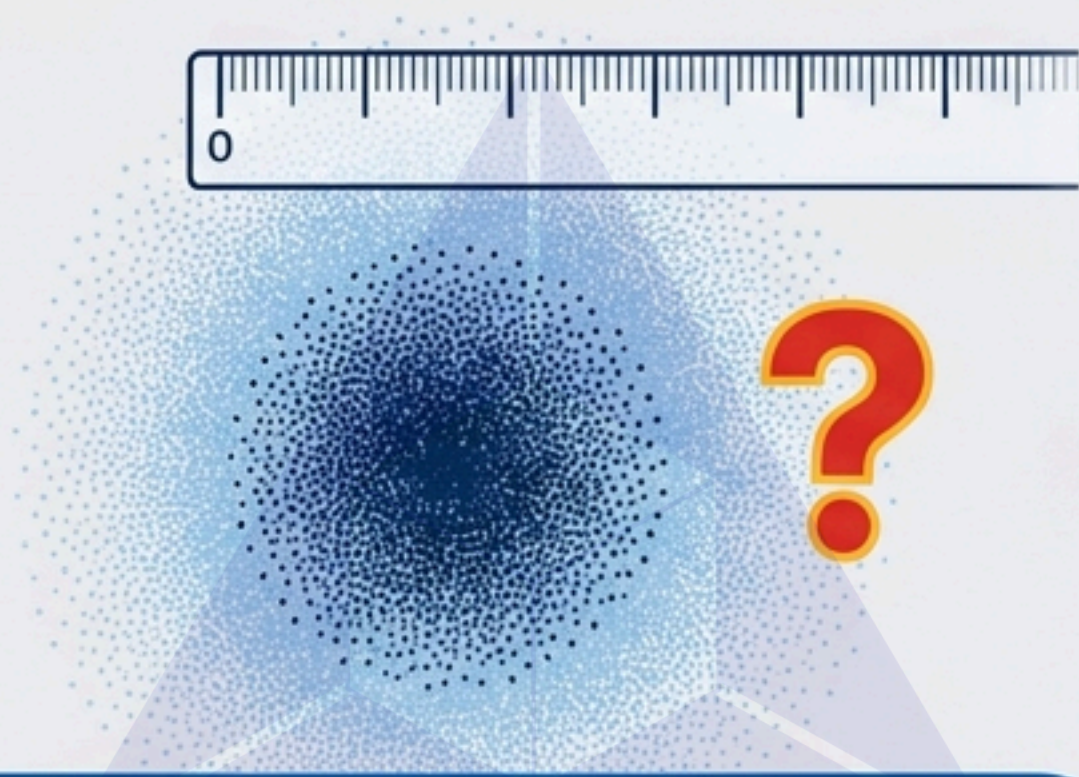


Decoding the paradox of atomic size, effective nuclear charge, and periodic trends.



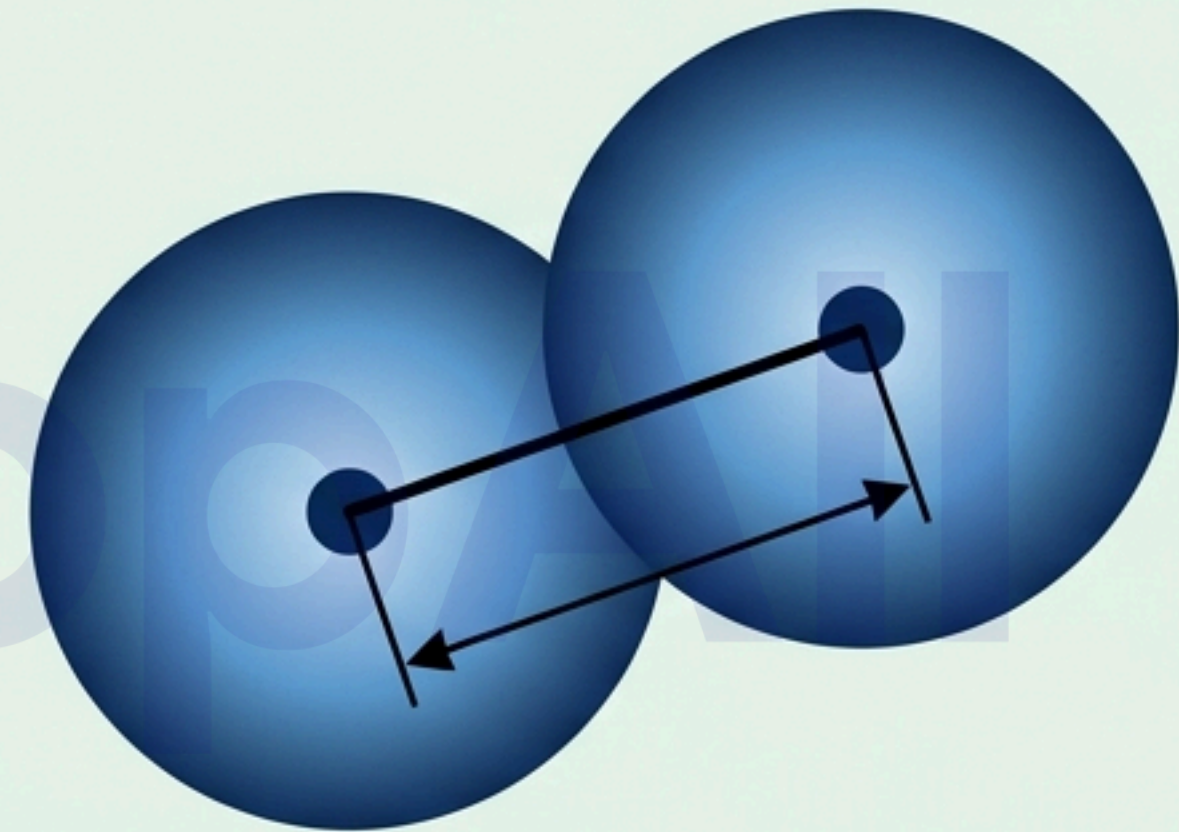
Paradox: Moving left to right on the periodic table adds both mass and electrons, yet the physical footprint of the atom shrinks. To understand why, we first have to figure out how to measure something with no edges.

The Quantum Measurement Problem



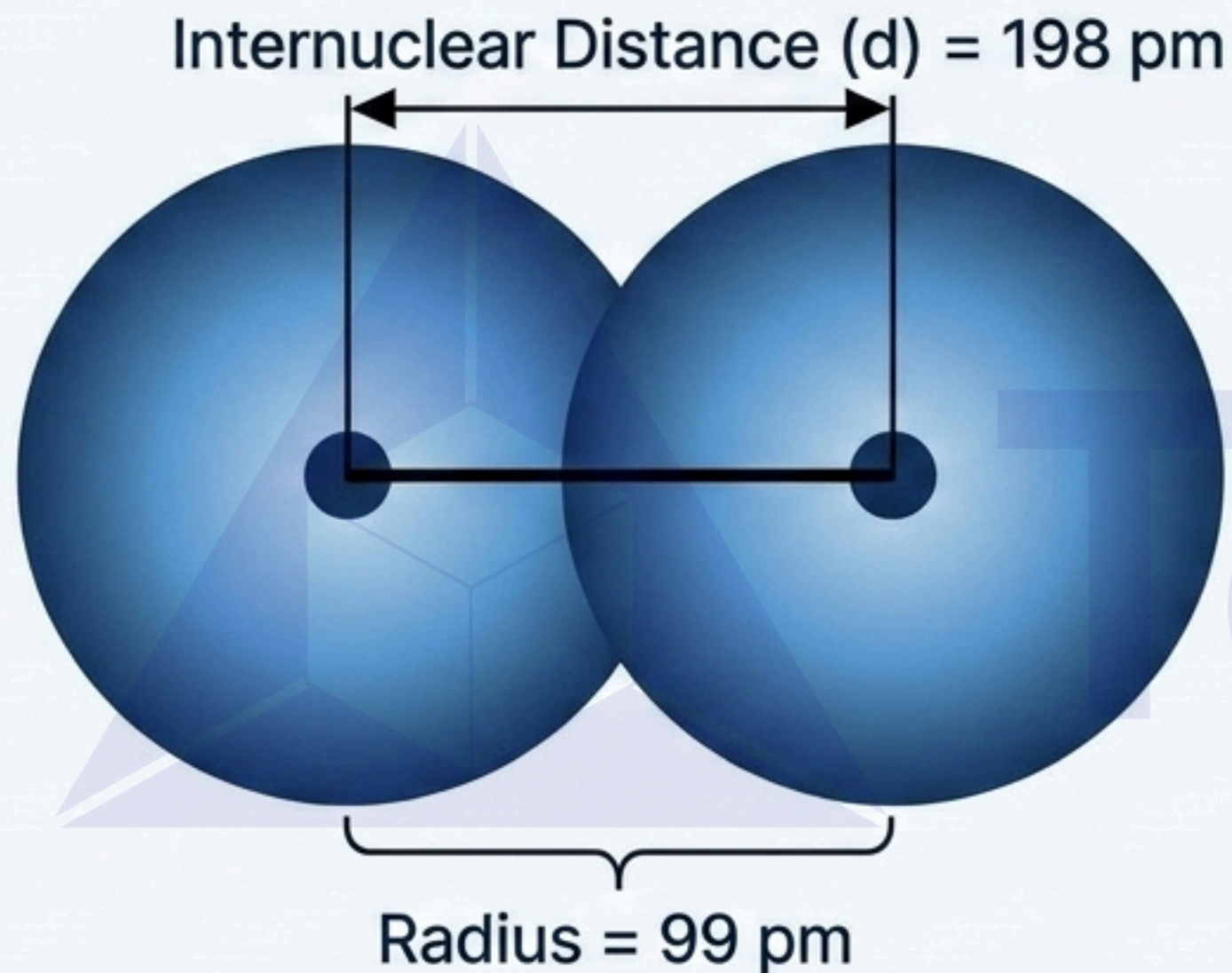
$\sim 1.2 \text{ \AA}$ ($1.2 \times 10^{-10} \text{ m}$) — too small for direct physical boundary measurement.

No sharp boundaries. According to quantum mechanics, the probability of finding an electron never truly drops to zero.



We cannot measure a solitary atom. We must estimate size by measuring the internuclear distance between atoms in a bonded state.

Covalent Radius (Non-Metals)



$$r_{\text{covalent}} = \frac{d}{2}$$

For non-metallic elements connected by a single bond, the atomic radius is exactly half the distance between the nuclei of two identical bonded atoms. Therefore, the radius of Chlorine = 99 pm.



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$$E=mc^2$$



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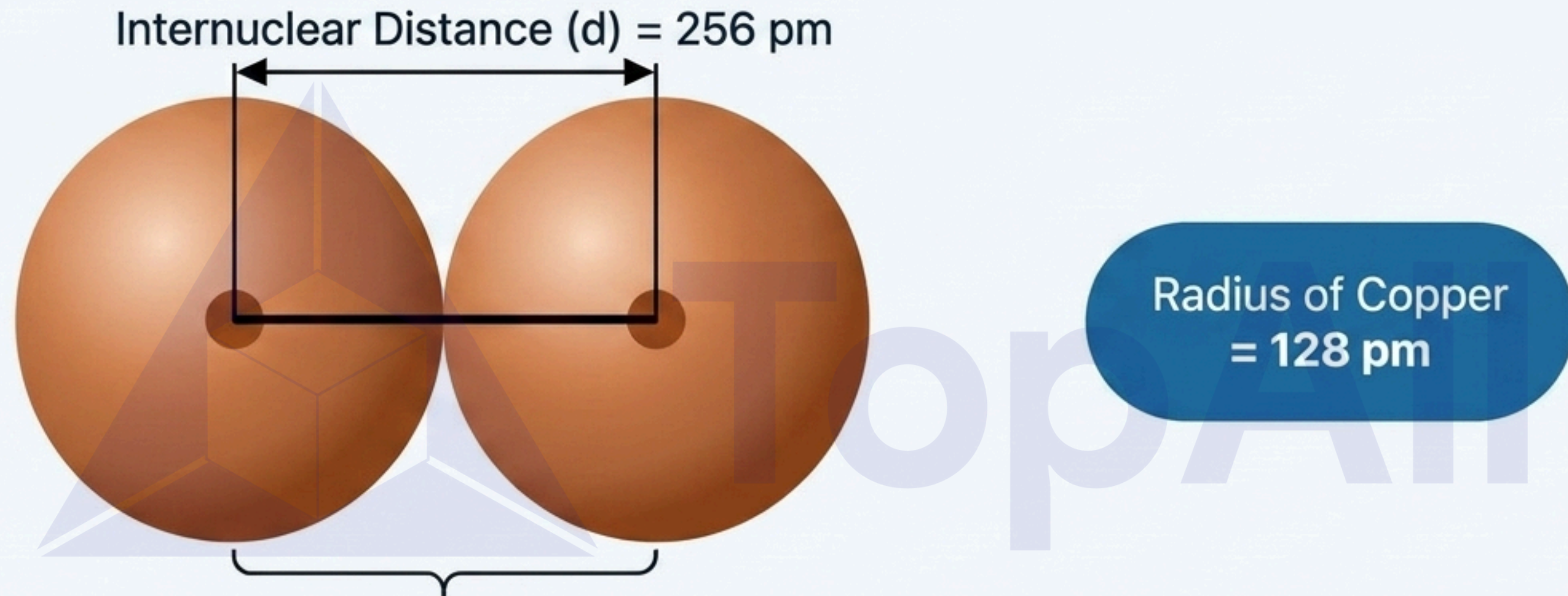
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Metallic Radius (Metals)



The Critical Difference: Covalent radius involves atomic overlap (making it artificially slightly shorter). Metallic radius involves solid cores touching.

Note: For simplicity in periodic trends, both are generally referred to as 'Atomic Radius.'

Across a Period: The Shrinking Trend



Li (152 pm)



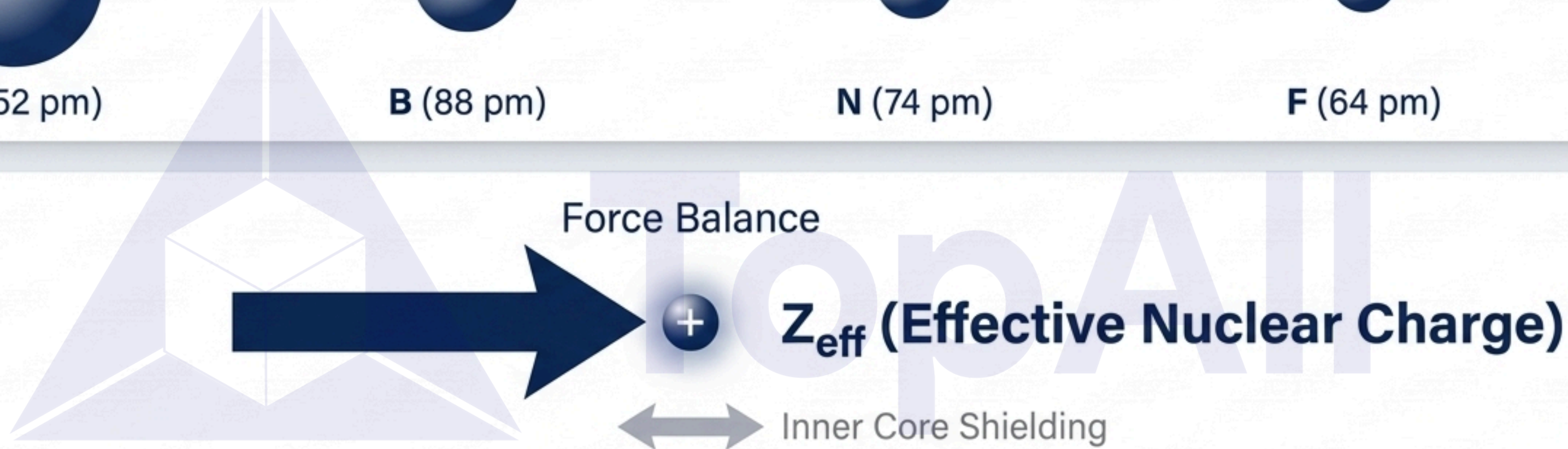
B (88 pm)



N (74 pm)

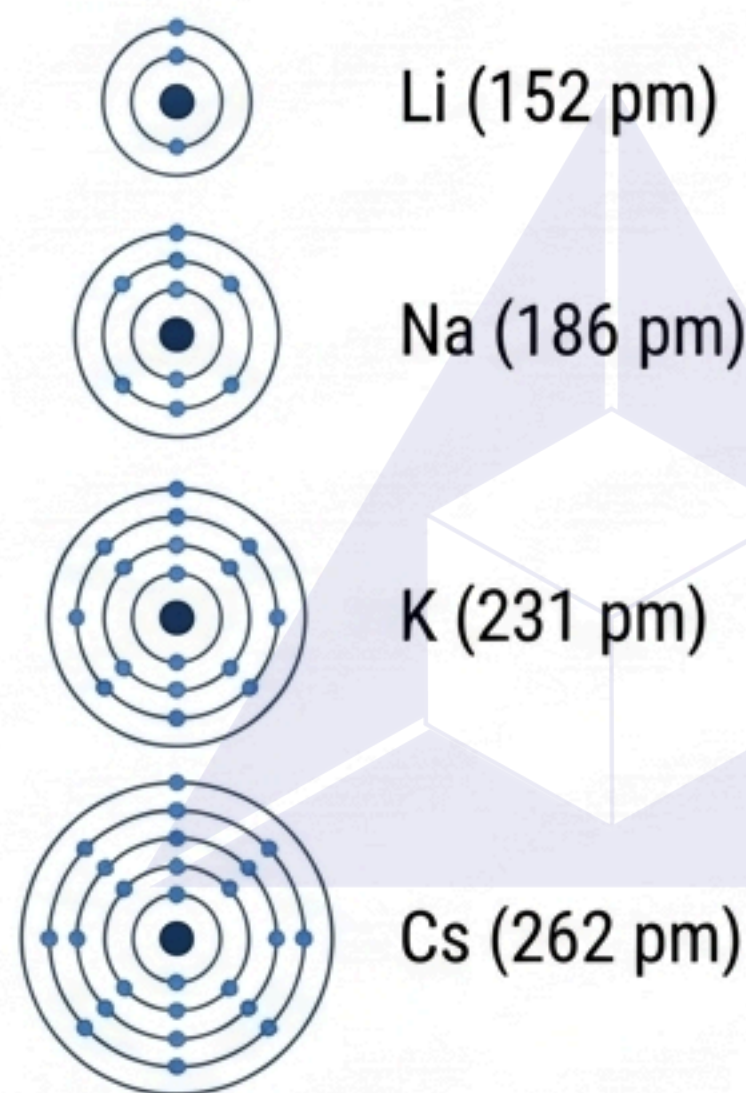


F (64 pm)



As atomic number increases across a period, new electrons are added to the same valence shell. Because the inner shielding core remains constant, the growing positive pull of the nucleus (Z_{eff}) dominates, dragging the electron cloud inward.

Down a Group: The Expansion Trend



Principal Quantum Number (n) Increases.

Mechanic: With every step down a group, an entirely new inner energy level is filled with electrons.

Force Balance: These completely filled inner shells act as a massive shield, blocking the outer valence electrons from the nucleus's pull.

The physical addition of new shells, combined with massive core electron shielding, vastly outpaces the increased nuclear charge. The atom expands.

The Noble Gas Anomaly

EXAM TRAP

Q: Which element in Period 3 has the largest assigned atomic radius?

(A) Sodium (Na) 

(B) Chlorine (Cl) 

(C) Argon (Ar) 



Do not compare apples to oranges! Noble gases (like Ar) do not form covalent bonds. We can only measure their non-bonded van der Waals radius, which includes their electrostatic repulsion space. They appear artificially huge and should NEVER be compared directly with normal covalent radii when tracking periodic trends.



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