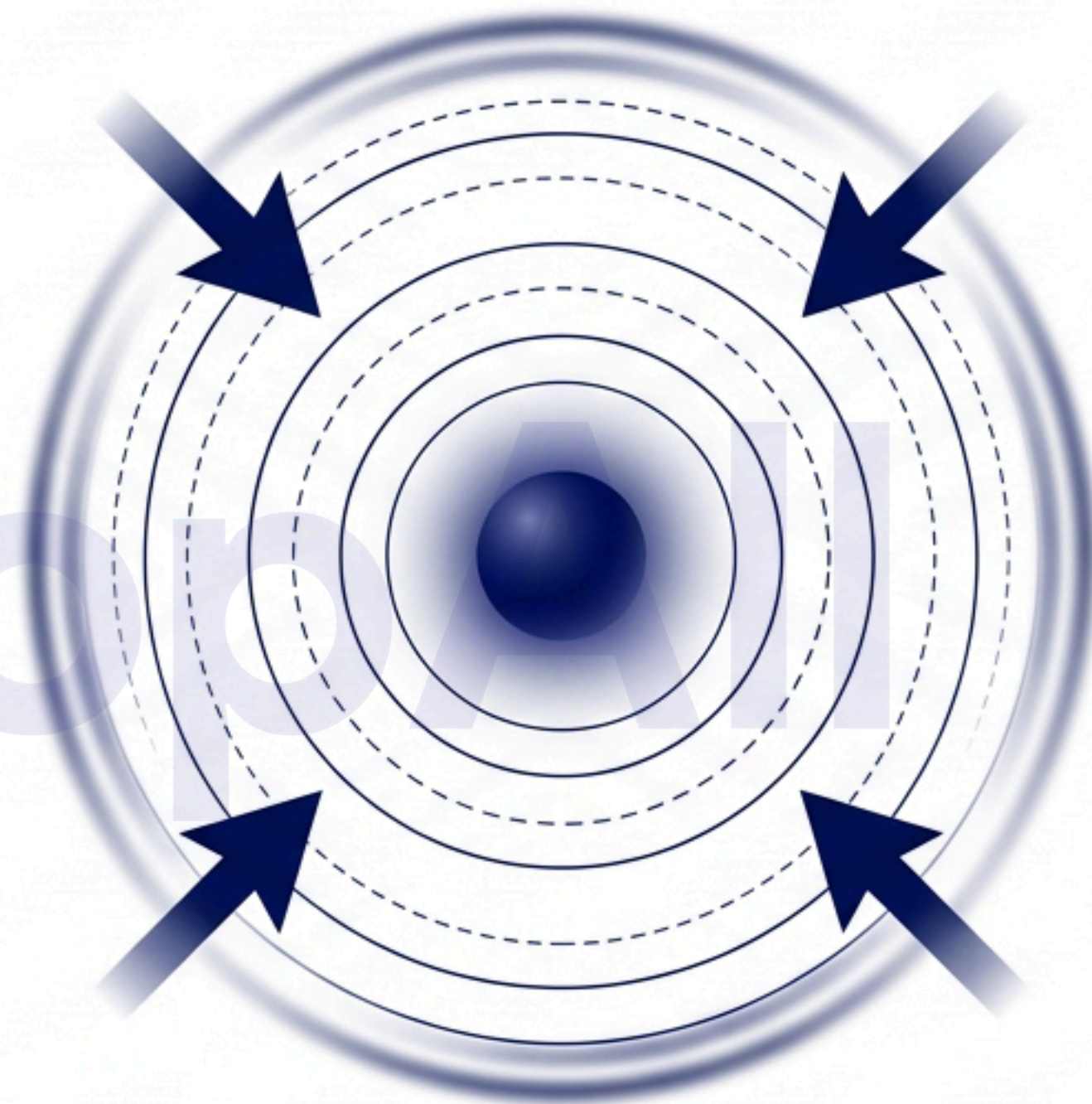


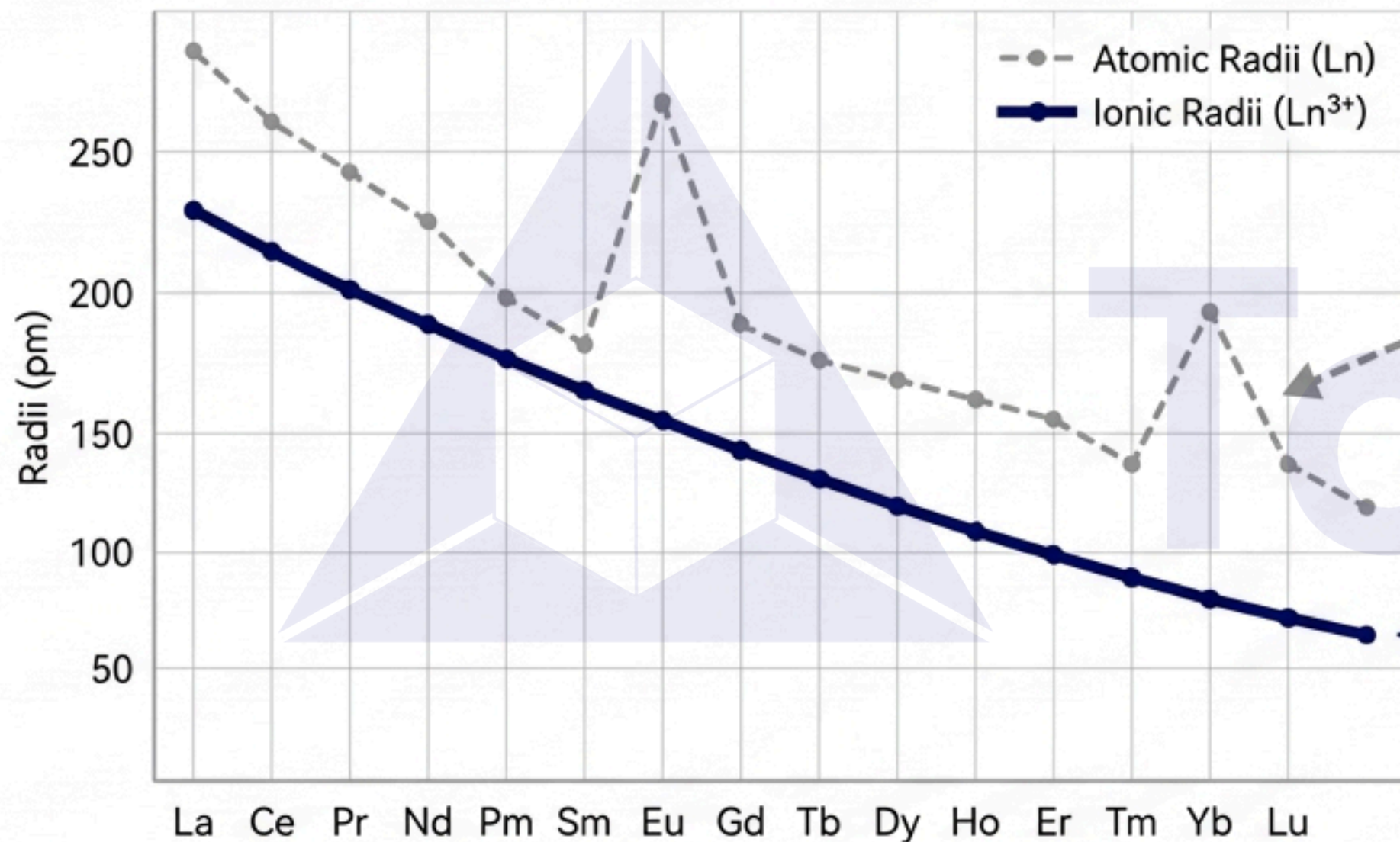
Unit 4: The d- and f-Block Elements

4.5.2 Atomic and Ionic Sizes of Lanthanoids

Mastering the Lanthanoid Contraction, Shielding Effects, and Periodic Consequences for NEET/JEE.



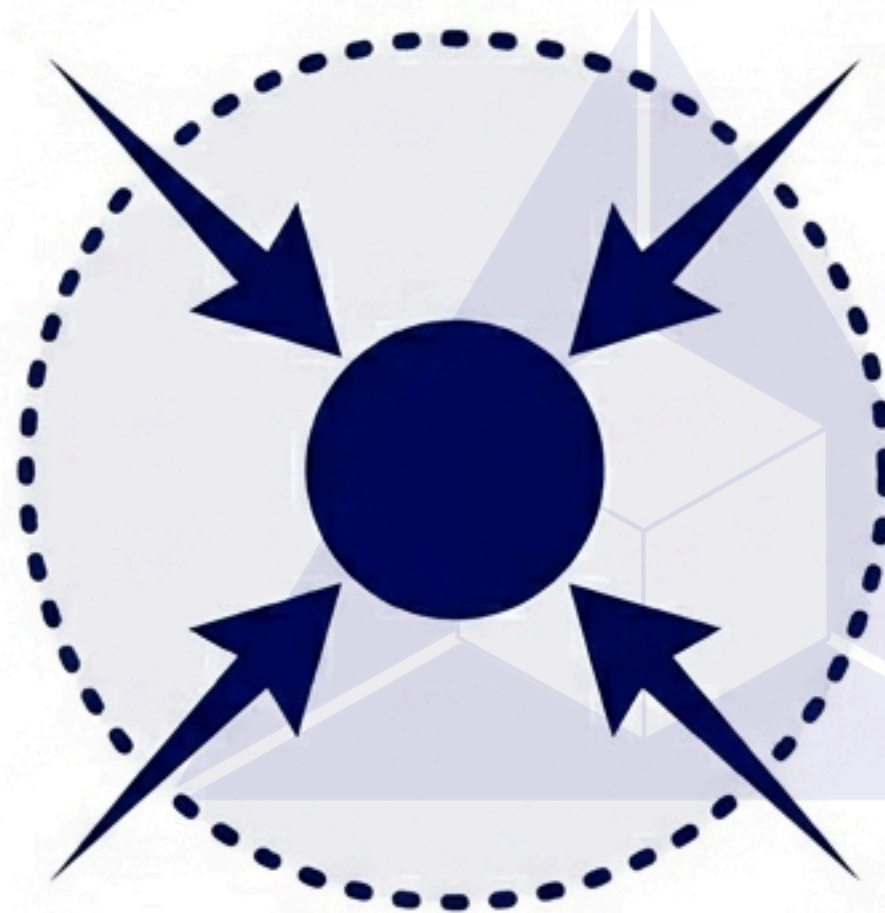
The Phenomenon: Shrinking Across the Series



Atomic Radii (Ln): Decreases overall from Lanthanum (La) to Lutetium (Lu), but exhibits minor irregularities.

Ionic Radii (Ln^{3+}): Shows a highly regular, steady decrease from La^{3+} to Lu^{3+} .

This overall decrease in size is a unique, defining feature of f-block chemistry.



Defining the Core Concept

The Lanthanoid Contraction

“The cumulative, regular decrease in atomic and ionic radii of lanthanoids with increasing atomic number from Lanthanum (La) to Lutetium (Lu).”

Key Fact: The decrease in atomic radii is not quite regular, but it is highly regular in M^{3+} ions.

The Root Cause: Imperfect Shielding



Increasing Nuclear Charge

As atomic number increases along the series, one positive proton is added to the nucleus for each new element.



Poor 4f Shielding

New electrons enter the deeply buried 4f sub-shell. Because of their diffused shape, the shielding of one 4f electron by another is very weak.



High Effective Nuclear Charge (Z_{eff})

The imperfect shielding cannot counter the growing nuclear charge. The nucleus pulls the entire 4f electron cloud inward with progressively greater force.



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

$$E=mc^2$$



Turn theory into marks with **unlimited MCQs, smart analysis, and focused revision.**

Practice Now



At prep.topall.app

Key Highlights

- » Free Study Material, Videos & Infographics
- » Push Your Limits with Level-Based Challenges
- » Climb the Leaderboard Among Fellow Aspirants
- » Practice Unlimited MCQs for NEET & JEE
- » Get Clear Explanations, Not Just Marks
- » Track Your Performance Smarter



Contraction Comparison: d-block vs. f-block

Shielding Power: $s > p > d > f$



d-block Contraction

Shielding of one d electron by another is poor, causing a size decrease across a transition series.



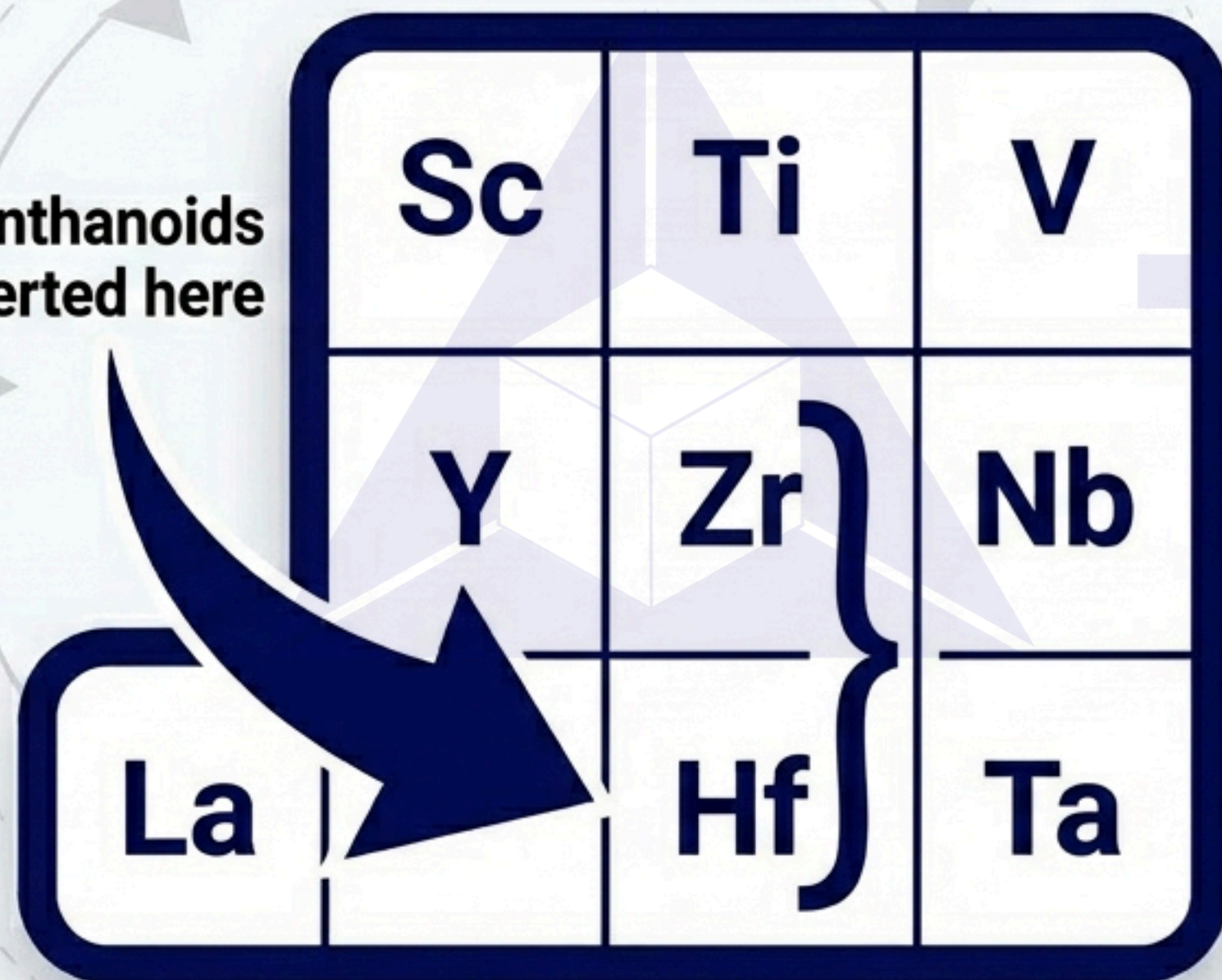
f-block Contraction

Shielding of one 4f electron by another is even less effective than d electrons.

Because 4f shielding is exceptionally weak, the cumulative inward pull across the 14 lanthanoid elements results in a much more profound and noticeable contraction.

The Domino Effect on the Periodic Table

14 Lanthanoids
inserted here



Sc	Ti	V
Y	Zr	Nb
La	Hf	Ta

The lanthanoid contraction has **far-reaching consequences** for the elements that immediately follow them—the 3rd transition series (5d).

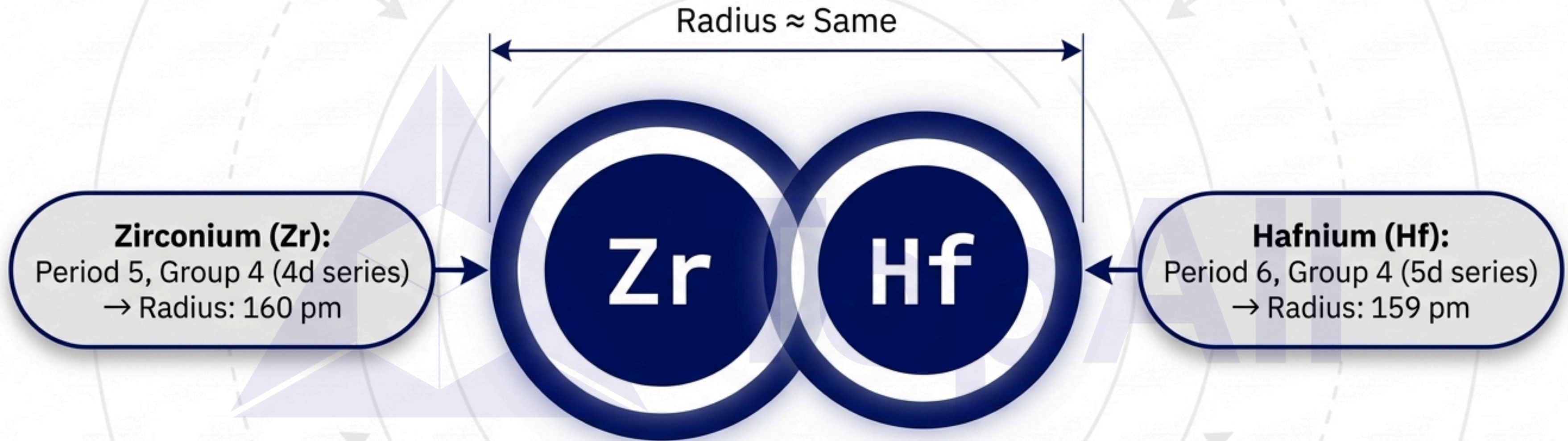
Expected Trend

Down a group, a new shell is added → size should increase.

The Reality

The expected expansion is perfectly canceled out by the Lanthanoid contraction → 2nd series (4d) $\approx$ 3rd series (5d) in size.

The Classic Case: Zirconium & Hafnium



Explanation:

The expected size increase from adding a shell (Period 5 to 6) is completely negated by the inward pull of the preceding 4f electrons.

Result:

They possess almost identical physical and chemical properties, much more so than a typical vertical group relationship.

Industrial Consequence: The Separation Challenge

Because elements like Zirconium and Hafnium are locked into nearly identical radii and chemical behaviors due to the Lanthanoid Contraction...



...they almost always **occur together in nature**. Their profound **similarity** makes them incredibly **difficult to separate** from one another using standard chemical extraction methods.

4.5.2 at a Glance



The Trend

Ln^{3+} ionic sizes decrease smoothly from La $\rightarrow$ Lu.



The Flaw

Extremely poor mutual shielding of diffused 4f electrons.



The Mechanism

Cumulative, unstoppable increase in Effective Nuclear Charge (Z_{eff}).



The Effect

4d and 5d transition series radii become virtually identical (e.g., Zr $\approx$ Hf).



🎯 Target: NEET/JEE Advanced

Why is the Ln^{3+} curve smoother than the atomic Ln curve?

Removing valence electrons to form the 3+ state eliminates outer-shell configuration anomalies, revealing the pure, unhindered nuclear contraction of the 4f core.

Which pair has the same size? Always look for Group 4, 5, or 6 elements immediately following the lanthanoids (Zr/Hf, Nb/Ta, Mo/W). The answer relies entirely on the Lanthanoid Contraction.

Screenshot for Revision



Shielding Power:

$s > p > d > f$



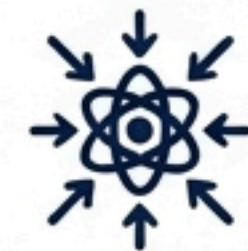
Chemical Twins:

Zr (160 pm) $\approx$ Hf
(159 pm)



Ln³⁺ Radii:

Perfectly regular
decrease



Root Mechanism:

Poor 4f mutual
shielding $\rightarrow$ High Z_{eff}



You've Learned the Theory.

Now Let's Test It.

Reading notes gets you knowledge.

Practicing MCQs gets you marks.

That's exactly what TopAll Pro is built for.

Try TopAll Pro Now

What TopAll Pro Does Differently

-  **Stuck? Snap it. Solve it. — Doubts AI**
Photo → step-by-step solution in seconds, 24/7
-  **Your AI Coach finds your blind spots**
Concept-level weakness detection — not just chapter-level
-  **4.5 Lakh+ questions. Never run out.**
13× more content than any other prep app in India
-  **Build your own test in 60 seconds**
Pick a chapter, set difficulty — AI does the rest instantly.
-  **AI Recommendation that helps you improve**
AI Recommendation Analysis your Tests and tell you where you need to improve.



Practice the moment you finish studying
Jump in while the concept is still fresh in your head

4.5L+
MCQs

1.5L+
Students

AI Powered
In-Depth Analysis