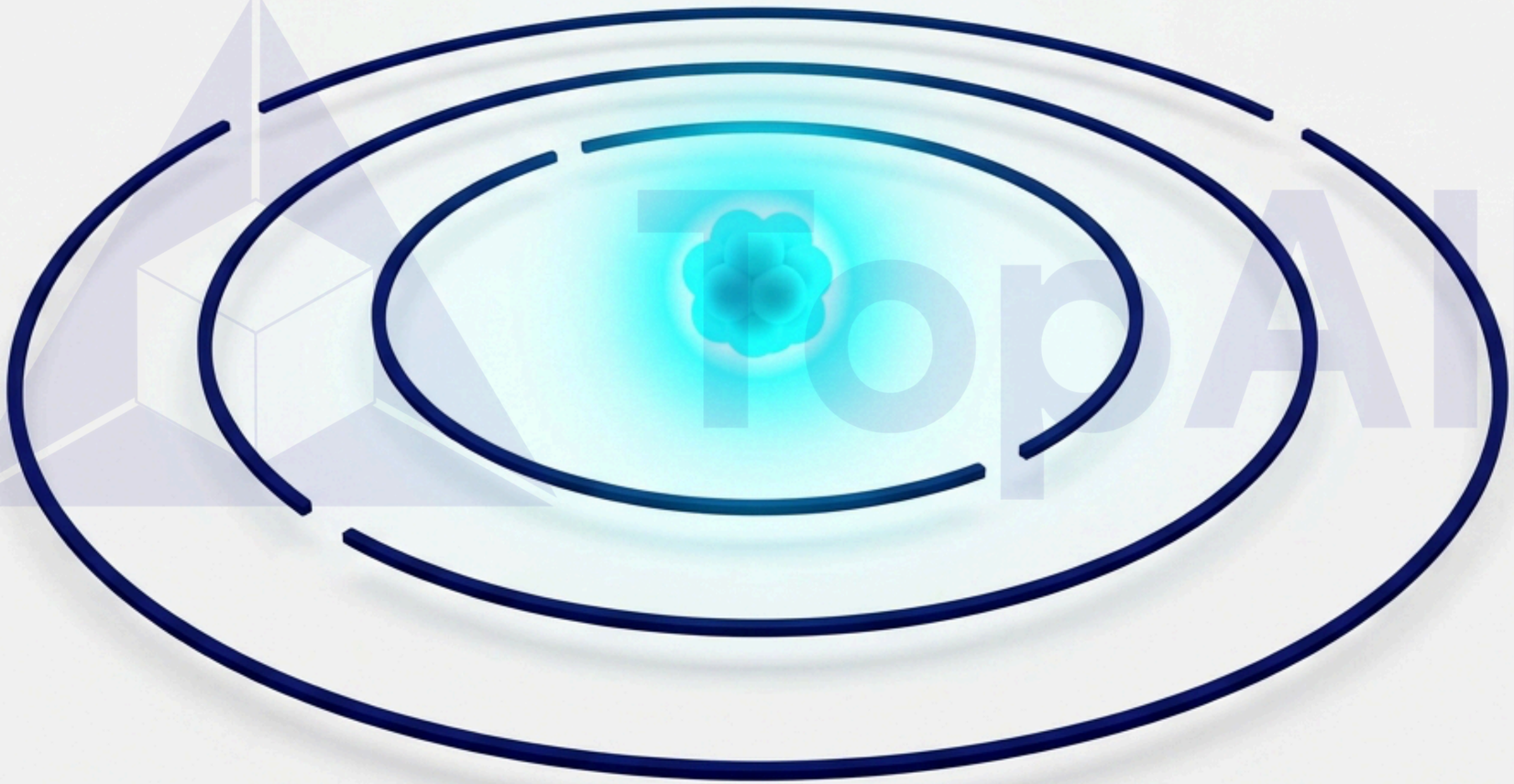
4.6 The Actinoids

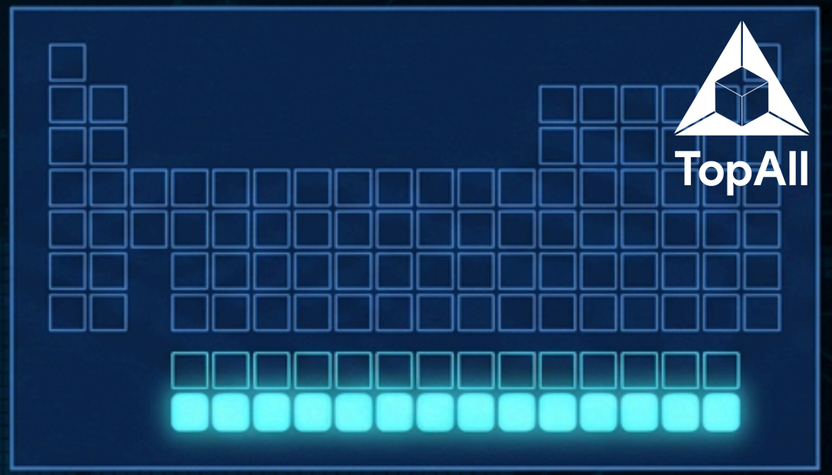
The 5f Inner Transition Series



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The 5f Series: Identity & Location

The actinoids comprise 14 elements following Actinium, characterized by the progressive filling of the 5f subshell.



The series follows Ac, but formal 5f filling often begins at Pa.

Ac (Z=89)

Th (Z=90) Pa (Z=91) U (Z=92) Np (Z=93) Pu (Z=94) Am (Z=95) Cm (Z=96) Bk (Z=97) Cf (Z=98) Es (Z=99) Fm (Z=100) Md (Z=101) No (Z=102) Lr (Z=103)

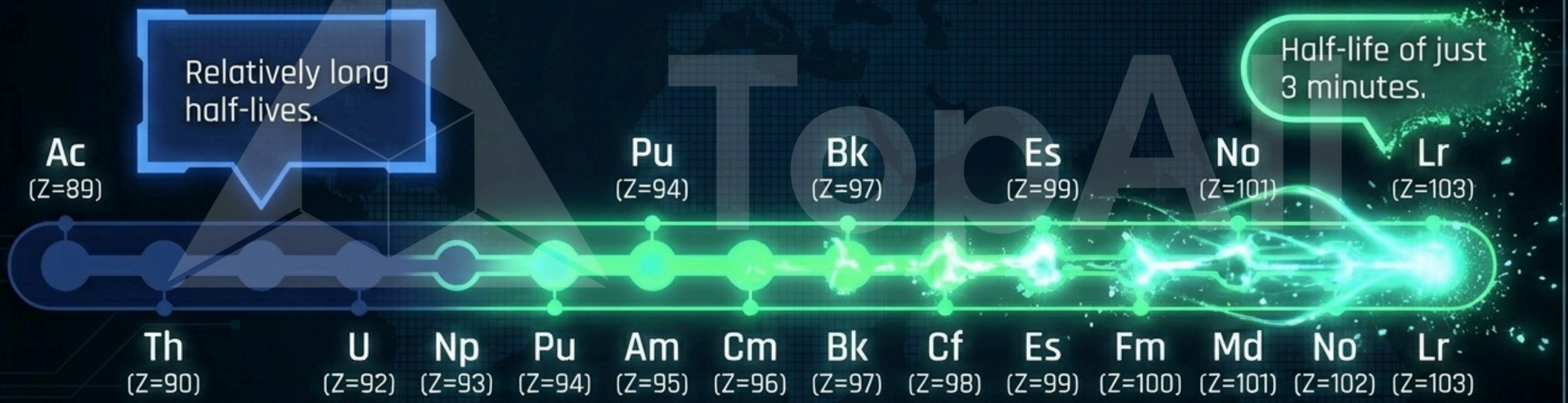
Pu (Z=94) Bk (Z=97) Es (Z=99) No (Z=101) Lr (Z=103)

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The Radioactive Reality

All actinoids are radioactive. Their profound instability dictates how they are studied, limiting late-series elements to nanogram syntheses.

Nanogram Quantities



Decay Gradient

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Electronic Configuration Rules & Anomalies

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All actinoids share a $7s^2$ outer shell, with variable occupancy of 5f and 6d. Irregularities arise from the extreme stability of f^0, f^7, and f^{14} states.

[Rn] $5f^{1-14}$ $6d^{0-1}$ $7s^2$

The f^7 Stability

Americium (Am):

[Rn] $5f^7$ $7s^2$

Curium (Cm):

[Rn] $5f^7$ $6d^1$ $7s^2$

electron shifts to 6d

The Late Fill

Thorium (Th, Z=90)

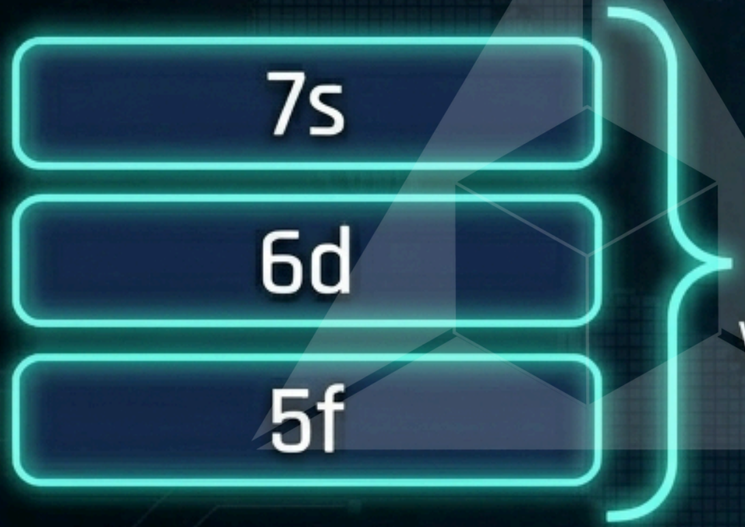
[Rn] $6d^2$ $7s^2$

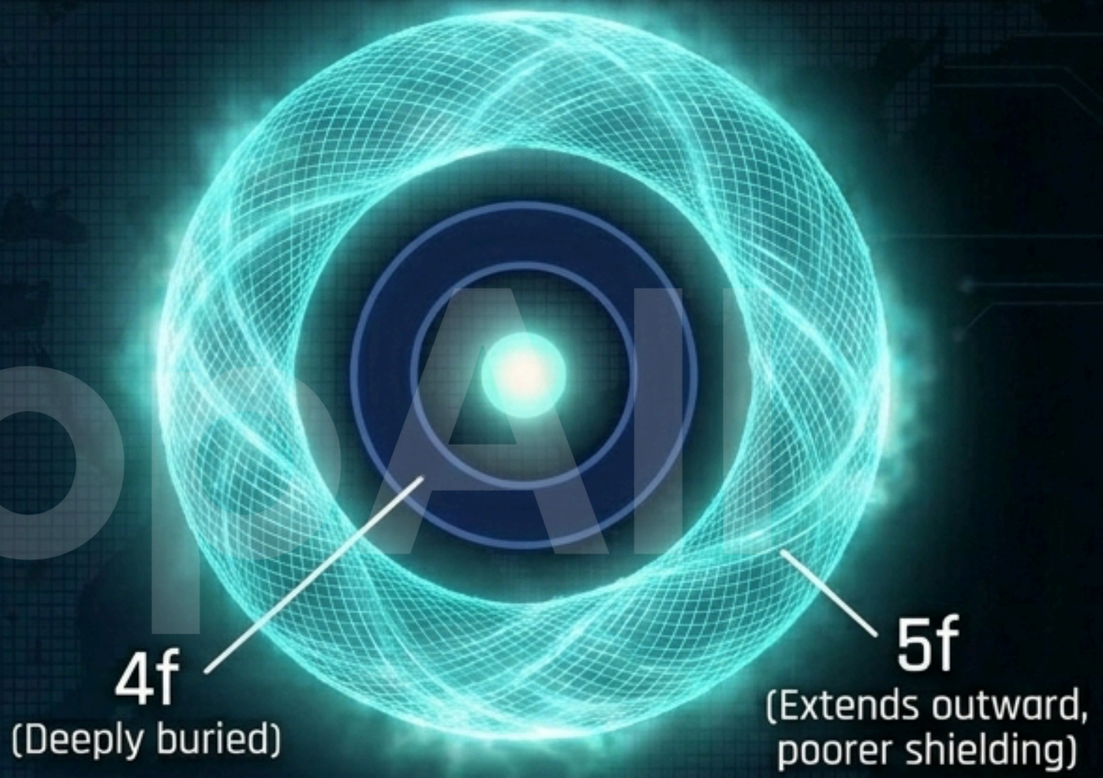
Anomalous start. The 14 electrons formally begin adding to 5f from Pa onwards, completing at Lr.

Orbital Penetration & Comparable Energies

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Unlike deeply buried 4f orbitals, 5f orbitals extend outward. The 5f, 6d, and 7s energy levels are nearly identical, allowing all to participate in bonding.





Exam Insight: Lower Ionization Enthalpy: Early actinoid electrons penetrate less into the inner core, are less firmly held, and are readily available for bonding.





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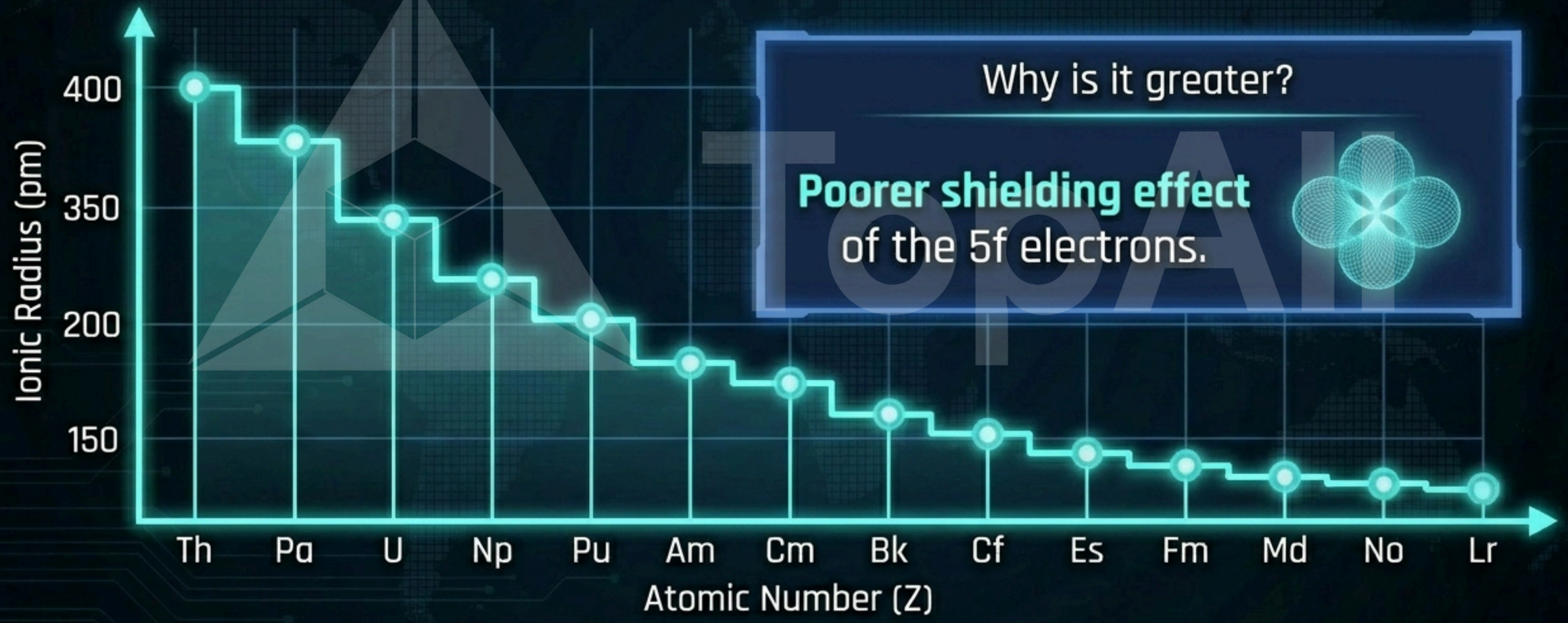
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The Actinoid Contraction

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There is a gradual decrease in atomic and M^{3+} ionic sizes across the series. However, the contraction is more severe from element to element than in the lanthanoids.

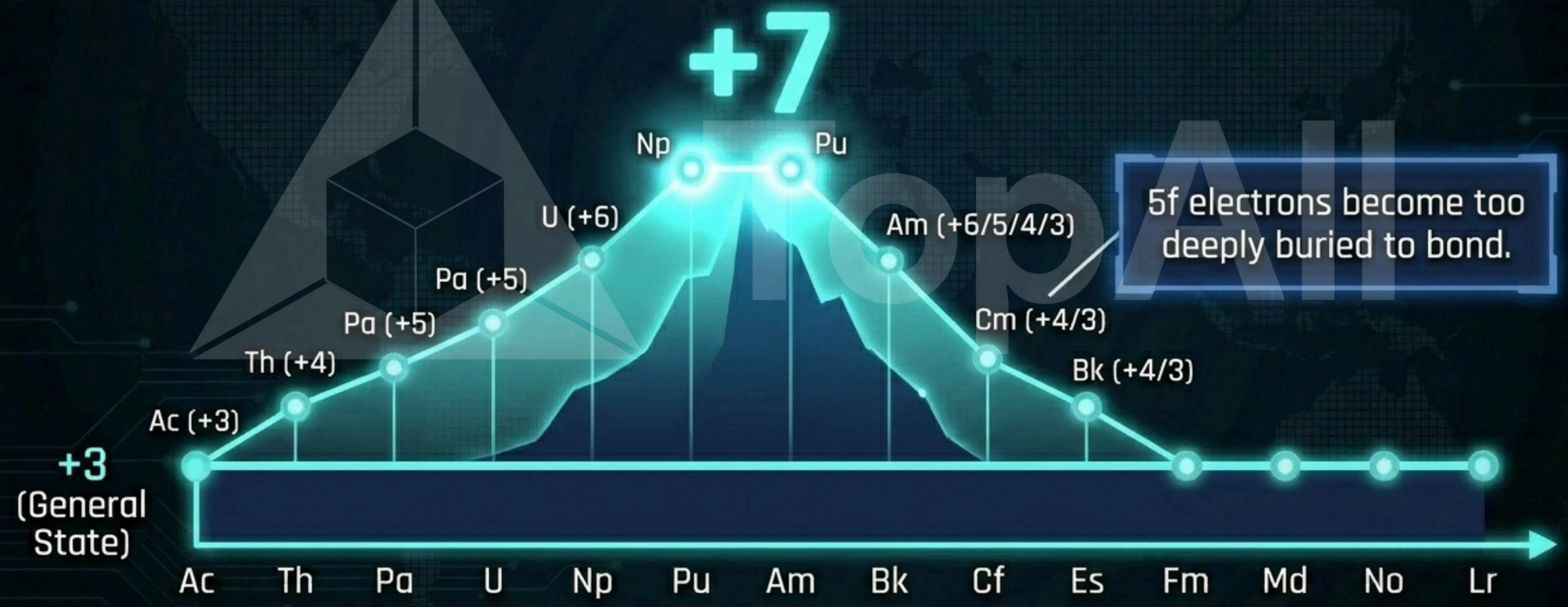


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Oxidation States: The Mountain Curve

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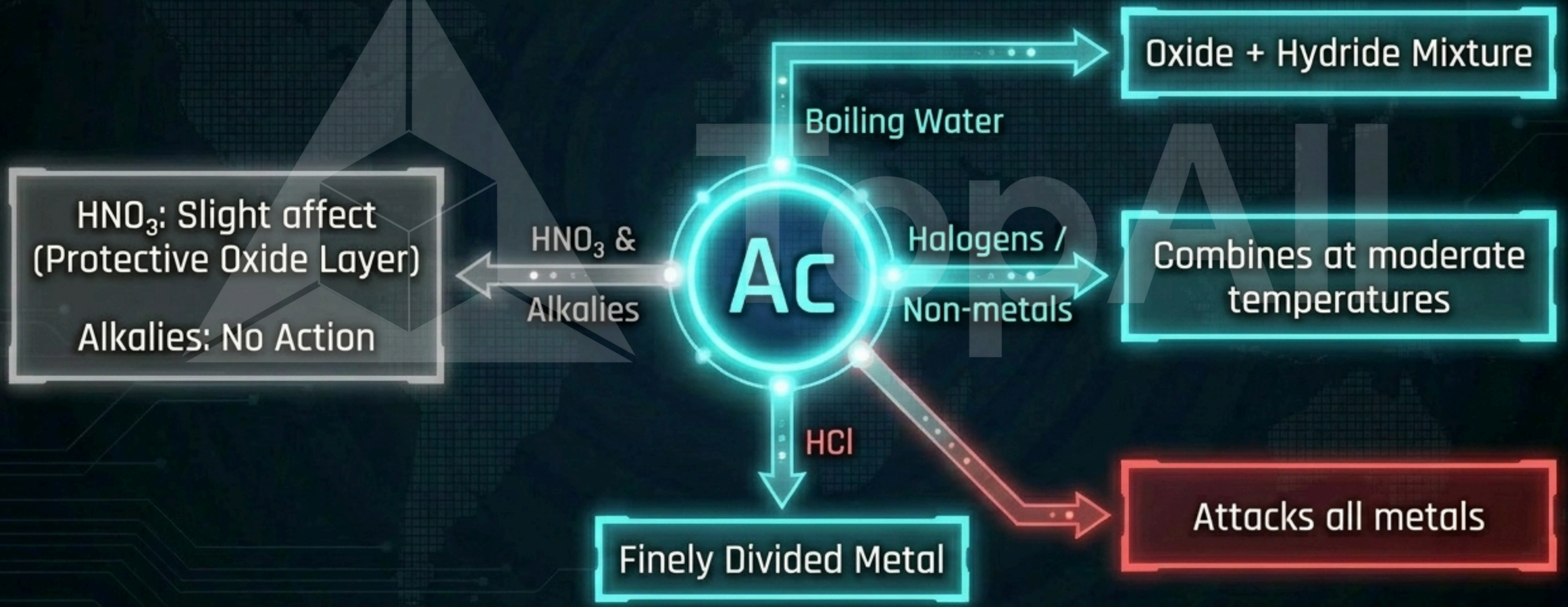
Early actinoids unleash all their valence electrons (5f, 6d, 7s) due to comparable energies, peaking at +7 before stabilizing back to +3 in the late series.



Chemical Reactivity Profile

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Actinoids are highly reactive metals, especially when finely divided, featuring complex magnetic properties and structural variability.



The Ultimate Comparison: 4f vs. 5f

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Actinoids mirror lanthanoids only in the second half of the series. The early actinoids are uniquely complex.

Feature	Lanthanoids (4f)	Actinoids (5f)
Shielding	Imperfect	Poorer shielding (greater contraction)
Oxidation States	+3 (rarely +2, +4)	+3, up to +7 (wide range due to comparable orbital energies)
Bonding	Deeply buried, limited bonding	Extend outward, participate in bonding
Radioactivity	Mostly non-radioactive (except Pm)	All radioactive

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NEET/JEE Exam Traps

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Frequently tested anomalies and high-yield conceptual questions.

⚠ Alert

Why is Actinoid Contraction > Lanthanoid Contraction?

➔ Poorer shielding by 5f electrons compared to 4f.

⚠ Alert

Why do early actinoids have lower Ionization Enthalpy?

➔ 5f electrons penetrate less into the inner core, are less firmly held, and are available for bonding.

⚠ Alert

Which elements show the maximum +7 oxidation state?

➔ Neptunium (Np) and Plutonium (Pu).

⚠ Alert

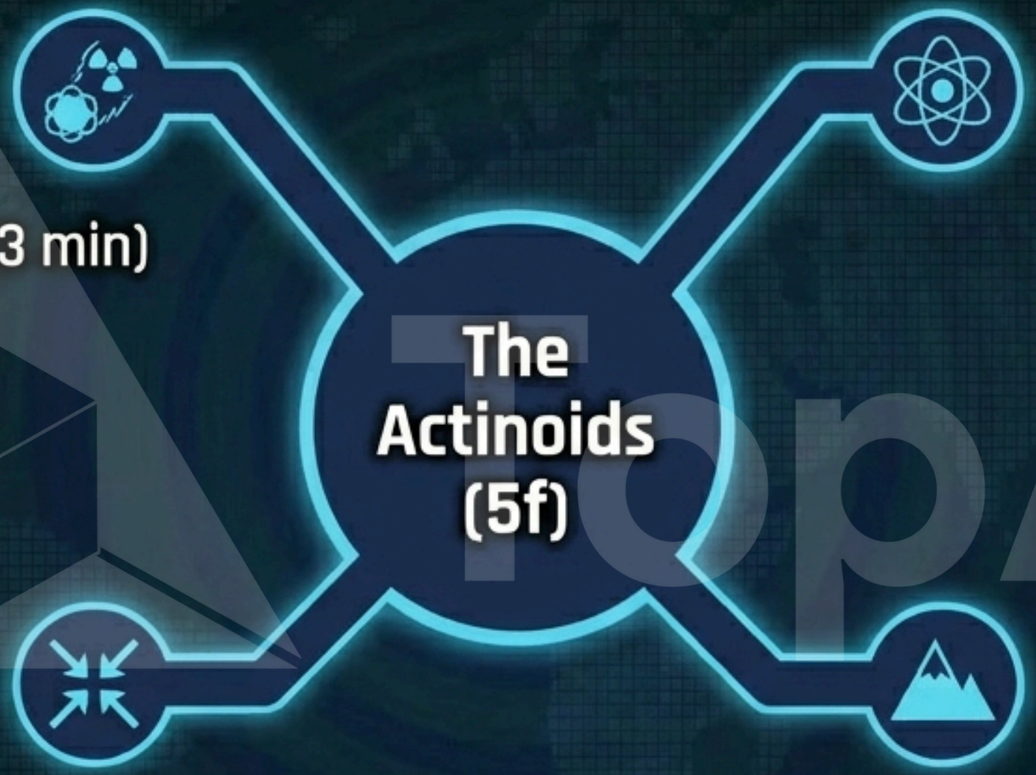
What happens to M^{3+} and M^{4+} ions in aqueous solutions?

➔ They have a high tendency to hydrolyse.

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Quick Revision Summary

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1. Nucleus

- All radioactive
- Th (long half-life) to Lr (3 min)
- Nanogram quantities

2. Electron Cloud

- [Rn] $5f^{1-14}$ $6d^{0-1}$ $7s^2$
- 5f, 6d, 7s have comparable energies

3. Contraction

- Gradual atomic/ionic size decrease
- Worse than 4f due to poorer 5f shielding

4. Chemistry

- General +3 state
- Max +7 (Np, Pu)
- High reactivity

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