▶ Video explanation (YouTube Short)

The Actinoids

Most homes have an actinoid on the ceiling: an ionisation smoke detector holds about one microcurie (≈ 0.3 µg) of americium-241, an element that nature does not make. The actinoids are the f-block row in which the 5f orbitals fill (NCERT 4.6).

1. Members and configuration

Actinoids: the fourteen elements thorium (Z = 90) to lawrencium (Z = 103). General configuration **[Rn] $5f^{1-14}$ $6d^{0-1}$ $7s^2$**.

- Irregularities are related to the stability of f^0, f^7 and f^{14} (e.g. curium: [Rn] $5f^7$ $6d^1$ $7s^2$).

2. Oxidation states

- The 5f, 6d and 7s levels are of comparable energies, so actinoids show a **wider range of oxidation states** than lanthanoids.
- **+3** is the general oxidation state. The first half of the series shows higher states: Th +4, Pa +5, U +6, **Np and Pu +7**; the maximum then falls for the later members.
- Uranyl ion UO_2^{2+}: x + 2(−2) = +2, so U = +6. Uranyl compounds are usually yellow, and uranium glass glows green under UV light.

Element	Th	Pa	U	Np	Pu	Am	Cm → Lr
Highest state	+4	+5	+6	+7	+7	+6	+3 / +4

3. Actinoid contraction

The size of atoms and M^{3+} ions decreases steadily across the series. Because 5f electrons shield poorly, the **actinoid contraction is greater from element to element than the lanthanoid contraction**.

4. Radioactivity

- **All actinoids are radioactive.** The earlier members have long half-lives: thorium-232 ≈ 14 billion years (longer than the age of the universe), uranium-238 ≈ 4.5 billion years (about the age of the Earth).
- Only thorium and uranium occur in nature in substantial amounts (actinium and protactinium as decay products). Elements beyond uranium (transuranium elements) are made in reactors and accelerators; neptunium was the first, made in 1940.
- The later members are short-lived and could be prepared only in nanogram quantities. NCERT gives their half-lives as "a day to 3 minutes for lawrencium"; modern data put the longest-lived lawrencium isotope (Lr-266) at about 11 hours (Lr-260 ≈ 2.7 minutes). Use the NCERT wording in CBSE answers.

5. General characteristics

- Silvery metals with a variety of structures; highly reactive, especially when finely divided.
- Boiling water → a mixture of oxide and hydride; they combine with most non-metals at moderate temperatures.
- Hydrochloric acid attacks all of them; nitric acid affects most only slightly because a protective oxide layer forms; alkalies have no action.
- Magnetic properties are more complex than those of the lanthanoids; ionisation enthalpies of early actinoids are lower than those of early lanthanoids (5f electrons are more effectively shielded).

6. Real world

- Americium-241 in smoke detectors: alpha particles ionise air between two plates; smoke reduces the current and the alarm sounds.
- Plutonium-238 decay heat powers spacecraft such as Voyager 1 and 2 and the Curiosity rover (radioisotope thermoelectric generators).

7. Common mistakes

- ✗ "All actinoids are man-made." ✓ Thorium and uranium are natural.
- ✗ "Actinoids, like lanthanoids, stay mostly at +3." ✓ Early actinoids reach +4 to +7.
- ✗ "Radioactive means short-lived." ✓ Th-232 has a half-life of about 14 billion years.

Practice questions

1. (MCQ) The actinoids are: (a) La to Lu (b) Th to Lr (c) Ac to U (d) Sc to Zn
2. (MCQ) The highest oxidation state of an actinoid is: (a) +3 (b) +4 (c) +6 (d) +7
3. (MCQ) U in UO_2^{2+} is: (a) +2 (b) +4 (c) +6 (d) +3
4. (MCQ) Which occur naturally in large amounts? (a) Pu, Am (b) Th, U (c) Np, Cm (d) Lr, No
5. (Very short) Write the general configuration of the actinoids.
6. (Very short) Name the actinoid used in smoke detectors.
7. (Short) Why do actinoids show more oxidation states than lanthanoids?
8. (Short) Why is the actinoid contraction greater than the lanthanoid contraction?
9. (Short) Describe the action of HCl, HNO_3 and alkalies on actinoid metals.
10. (HOTS) Why could the later actinoids be studied only in nanogram quantities?

Answer key

1. (b).
2. (d) +7.
3. (c) +6.
4. (b) Th, U.
5. [Rn] $5f^{1\text{-}14}$ $6d^{0\text{-}1}$ $7s^2$.
6. Americium (Am-241).
7. 5f, 6d and 7s levels have comparable energies, so more electrons can take part.
8. 5f electrons shield the outer electrons from the nucleus even more poorly than 4f electrons.
9. HCl attacks all of them; HNO_3 affects most only slightly (protective oxide layer); alkalies have no action.
10. They are man-made and very short-lived, so only tiny amounts can be produced and studied.

▶ Watch the video explanation