The f-Block Elements

These elements are also called rare earth metals due to their extremely low natural occurrence. Mostly, these are prepared artificially in laboratory. All the actinoids are radioactive hence, can be used in nuclear power plants or as weapons.

CONCEPT MAP

CLASS XII

Lanthanoids (4f-series)

La	57	[Xe] $5d^1 6s^2$	Gd	64	[Xe] $4f^7 5d^1 6s^2$
Ce	58	[Xe] $4f^1 5d^1 6s^2$	Tb	65	[Xe] $4f^9 6s^2$
Pr	59	[Xe] $4f^3 6s^2$	Dy	66	[Xe] $4f^{10} 6s^2$
Nd	60	[Xe] $4f^4 6s^2$	Ho	67	[Xe] $4f^{11} 6s^2$
Pm	61	[Xe] $4f^5 6s^2$	Er	68	[Xe] $4f^{12} 6s^2$
Sm	62	[Xe] $4f^6 6s^2$	Tm	69	[Xe] $4f^{13} 6s^2$
Eu	63	[Xe] $4f^7 6s^2$	Yb	70	[Xe] $4f^{14} 6s^2$
			Lu	71	[Xe] $4f^{14} 5d^1 6s^2$

Oxidation States

+3, *e.g.*, Gd^{3+}, Lu^{3+} and +2 and +4. *e.g.*, Eu^{2+}, Ce^{4+} Lanthanoids show limited number of oxidation states because the energy gap between 4*f*- and 5*d*-subshells is large .

Lanthanoid Contraction

The steady decrease in the atomic/ionic radii of lanthanoids with increasing atomic no. is called *lanthanoid contraction*.

Cause of Lanthanoid Contraction

As the atomic number increases in lanthanoid series, the new electron goes to fill 4*f*-orbitals. The nuclear charge, however, increases by one at each step. Thus, there is a gradual increase in the effective nuclear charge experienced by the outer electrons. Consequently, the attraction of the nucleus for the electrons in the outermost shell increases which results in gradual decrease in size of lanthanoids with increase in atomic number.

Consequences of Lanthanoid Contraction

- Similarity in properties of second and third transition series elements.
- Due to lanthanoid contraction, the differences in physical properties enable the separation of individual lanthanoid elements by ion exchange method.
- Due to lanthanoid contraction the basic strength decreases from $La(OH)_3$ to $Lu(OH)_3$.

Magnetic Properties

All the lanthanoid ions except La^{3+}, Lu^{3+}, Ce^{4+} and Yb^{2+} are paramagnetic. Magnetic moment $(\mu) = \sqrt{4S(S+1) + L(L+1)}$

Uses

- Used for the production of alloys *e.g.*, Mischmetal, which contains lanthanoid metals (≈95%) and iron (≈5%).
- La_2O_3 is used in Crooke's lenses.

Actinoids (5f-series)

Ac	89	[Rn] $6d^1 7s^2$	Cm	96	[Rn] $5f^7 6d^1 7s^2$
Th	90	[Rn] $6d^2 7s^2$	Bk	97	[Rn] $5f^9 7s^2$
Pa	91	[Rn] $5f^2 6d^1 7s^2$	Cf	98	[Rn] $5f^{10} 7s^2$
U	92	[Rn] $5f^3 6d^1 7s^2$	Es	99	[Rn] $5f^{11} 7s^2$
Np	93	[Rn] $5f^4 6d^1 7s^2$	Fm	100	[Rn] $5f^{12} 7s^2$
Pu	94	[Rn] $5f^6 7s^2$	Md	101	[Rn] $5f^{13} 7s^2$
Am	95	[Rn] $5f^7 7s^2$	No	102	[Rn] $5f^{14} 7s^2$
			Lr	103	[Rn] $5f^{14} 6d^1 7s^2$

Oxidation States

- General oxidation state is +3.
- Besides +3 state, other possible oxidation states are +2, +4, +5, +6 and +7.
- Actinoids show a large number of oxidation states because of very small energy gap between 5*f*, 6*d* and 7*s* subshells.

Actinoid Contraction

The steady decrease in ionic radii with increase in atomic number is referred to as *actinoid contraction*. The contraction is greater from element to element in actinoid series as compared to lanthanoid contraction. This is due to poor shielding of 5*f*-electrons.

Colour of the Ions

The actinoid cations are generally coloured due to *f-f* transition, *e.g.*, U^{3+} $(5f^3)$: Red, Np^{3+} $(5f^4)$: Purple, Pu^{3+} $(5f^5)$: Violet, Am^{3+} $(5f^6)$: Pink, U^{4+} $(5f^2)$: Pink.

Magnetic Properties

The actinoid elements or ions are paramagnetic due to the presence of unpaired electrons. However, the magnetic properties of actinoids are higher than lanthanoids.

Uses

- Thorium is used in atomic reactors as fuel rods and in the treatment of cancer.
- Uranium is used as nuclear fuel. Its salts are used in glass industry (for imparting green colour), textile industry and also in medicines.
- Plutonium is used as fuel for atomic reactors as well as in atomic bombs.