(yellow) (orange)

INNER TRANSITION ELEMENTS

The elements in which the filling of atomic orbitals by electrons take place in f subshells, two levels inside the outer subshell, are known as inner transition elements. Thus these elements form a series within the transition series. They are also known as f- block elements since the differentiating electron enters the f -subshell.

CLASSIFICATION OF F-BLOCK ELEMENTS

They have been classified into two series.

- **4f-series (first inner transition series)** - The differentiating electron enters in 4 f orbitals. The elements belonging to this series are also known as **Lanthanides or Lanthanones**.
- **5f -series (second inner transition series)** -The differentiating electron enters in 5 f orbitals. The elements belonging to this series are also known as **Actinides or Actinones**.

For the sake of symmetry of the periodic table they have been placed outside the periodic table.

LANTHANIDES

The fifteen elements from lanthanum (At. no. 57) to lutetium (At. no. 71) are known as lanthanides or rare earths (because they were obtained as earths (oxides) from relatively rare minerals).

PROPERTIES

ELECTRONIC CONFIGURATION

The general electronic configuration of these elements is $[Xe]4f^{0-14}5d^{0-1}6s^2$

The lanthanum electronic configuration $[Xe]4f^0 5d^1 6s^2$ and lutetium electronic configuration $[Xe]4f^{14}5d^1 6s^2$, have no partially filled 4 f orbital in their ground state, are considered as lanthanides due to their properties close to these elements.

OXIDATION STATE

The common oxidation state of lanthanides is +3 but some elements also exhibit +2 and +4 oxidation states in which they leave behind stable ions eg.

$Eu^{2+}[Xe]4f^7$, Yb^{2+} $[Xe]4f^{14}$

$Ce^{4+}[Xe]4f^0$, Tb $[Xe]4f^7$

An aqueous solution of is a good oxidising agent. The Eu^{2+} and Yb^{2+} can exist in aqueous solution and are good reducing agents. But there are exceptions also e.g.

Sm^{2+} $[Xe]4f^6$ Tm^{2+} $[Xe]4f^{13}$

Pr^{4+} $[Xe]4f^1$ Nb $[Xe]4f^2$

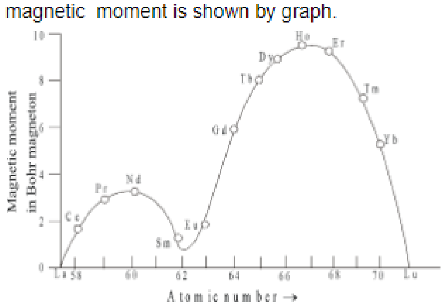
MAGNETIC PROPERTIES

Magnetic properties have spin and orbit contributions (Contrast "spin only"of transition metals). Hence magnetic momentums are given by the formula.

$$\mu = \sqrt{4S(S+1)+L(L+1)}$$

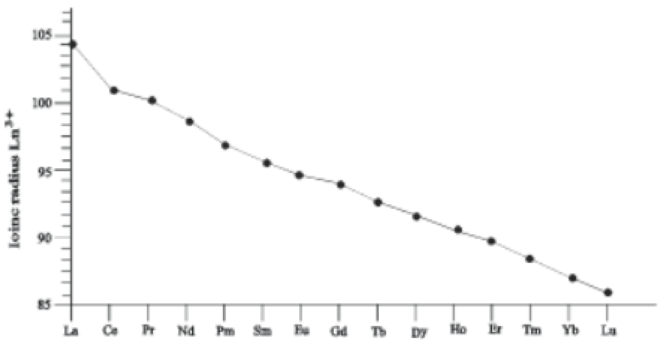
where L = Orbital quantum number, S = Spin quantum number

All lanthanide ions with the exception of La^{3+}, Lu^{3+} and Ce^{4+} are paramagnetic in nature. The trend in magnetic moment is shown by graph.



LANTHANIDE CONTRACTION

There is a steady decrease in the radii as the atomic number of the lanthanide elements increases. For every additional proton added in nucleus the corresponding electron goes to subshell. The shape of f -orbitals is very much diffused and they have poor shielding effect. The effective nuclear charge increases which causes the contraction in the size of electron charge cloud. This contraction in size is quite regular and known as Lanthanide contraction.



Consequences of lanthanide contraction

- Covalent character of cations increase.
- Electronegativity - The electronegativity of trivalent ions increase slightly.
- Basicity - There is decrease in basic strength of oxides and hydroxides.
- E^{0} value - There is small increase in standard electrode potential values.

COLOUR

The species containing unpaired electrons are coloured and so is the case with lanthanide ions. The f-f transitions are possible due to absorption of light from the visible region.

MELTING AND BOILING POINT

Lanthanides have high melting and boiling points but there is no regular trend.

DENSITY

Lanthanides have densities varying from. But there is no definite trend for these values.

ELECTRONEGATIVITY

Electronegativity values of lanthanides are almost same as that of s-block elements. Lanthanides form ionic compounds.

IONISATION ENERGIES
The ionisation energy values of lanthanides are not very high due to their large size and are comparable with those of alkaline earth metals.

COMPLEX COMPOUND
Due to having large ionic size they have little tendency to form complexes.

REACTIVITY
Due to their low values of ionisation energies the lanthanides are very reactive.

ALLOYS
They form alloy especially with iron e.g. MISCH METAL rare earths

ACTINIDES

The fifteen elements from actinium (At. no. 89) to lawrencium (At. no. 103) are known as actinides and constitute the 5f. Series. From neptunium to onwards the elements are man made (artificially prepared) and also known as transuranium elements.

PROPERTIES

ELECTRONIC CONFIGURATION
The differentiating electron enters the 5f atomic orbital. Their general electronic configuration is
$[Rn]5f^{0-14}6d^{0-2}7s^2$

Since there is not much difference between 5f and 6d, it is difficult to predict whether the electron has entered 5f or 6d.

OXIDATION STATE
The common oxidation state is +3 but other oxidation states are also exhibited by actinides the maximum being +7.

MAGNETIC PROPERTIES
The magnetic moments of actinide ions are smaller than theoretical values.
It is hard to interpret due to large spin orbit coupling.

ACTINIDE CONTRACTION

It is similar to lanthanide contraction due to poor shielding of electrons.

MELTING AND BOILING POINTS

They have high values for melting and boiling points but there is no regular trend.

DENSITY

The value of density vary from 7.0 gcm^{-3} to 19.84 gcm^{-3}. Again there is no regular trend.

REDUCING CHARACTER

They are strong reducing agents as they have high values approximately 2.0 volts.

REACTIVITY

Actinides are very reactive in nature and combine with oxygen and halogens like lanthanides.

COLOURED IONS

Actinide ions are coloured due to the presence of unpaired electrons and transitions.

COMPLEX FORMATION

They have higher tendency to form complex compounds.