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Topic Name: transition elements and the module name, lanthanides electronic configuration and oxidation state.

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outline of this modules are lanthanides electronic configurations and their oxidation states

learning outcomes students will be able to write the electronic configuration of lanthanides, know the different oxidation states shown by the lanthanides.

Lanthanides the term lanthanide was introduced by Victor Goldsmith in 1925.

very first element that is the lanthanum and at atomic number 57 and the next 14 elements starting at atomic number 58 till 71 follows the lanthanum are called lanthanides.

Here you all can see a very first element that is the lanthanum and denoted by the La at atomic number 57.

The elements in which the additional electron enters that is n-2f orbitals are termed as inner transition elements.

These elements are also called as F block elements because extra electron enters 4f orbital which belongs (n-2)th shell.

The valence shell electronic configuration of the lanthanides are represented by $\mathbf{(n-2)f^{1-14}\ (n-1)d^{0-1}\ ns^{2}}$

1-14 electrons can be fillled in F-orbitals, in d 0-1 electrons can be filled in the orbital and S^2

meaning 2 numbers of electron can be filled.

Element lanthanum itself has been studied in D block elements and not in F block elements, because there are no electrons in F orbital.

The F orbital actually starts filling at cerium at atomic number 58 and it completely filled at atomic number 71.

And hence these elements from Cerium should have been actually studied in F Block.

Lanthanum is the element that proceeds lanthanide series at atomic number 57, which shows the electronic configuration $1s^2$ $2s^2$ $2p^6$ $3s^2$ $3p^6$ $3d^{10}$ $4s^2$ $4p^6$ $4d^{10}$ $5s^2$ $5p^6$ $5d^1$ $6s^2$ which can also be written as [Xe] $5d^1$ $6s^2$ where Xe is the core element of lanthanide series. At Atomic number 58 the energy level of 4F orbital falls below that of the 5d level and hence electrons enters in an inner 4F orbital.

As there are seven f-orbitals, there can be a 14 electrons which can occupy this seven orbital and hence these lanthanide elements are termed as F block elements.

You all can see the table which consist of Atomic number along with the elements, their symbols and the electronic configuration at atomic number 57, a very first element called lanthanum which is denoted by the symbol La, shows the electronic configuration as [Xe] $4f^0$ $5d^1 6s^2$

A very next element that is cerium denoted by symbol Ce, shows electronic configuration as [Xe] $4f^2$ $5d^0$ $6s^2$ at this atomic number 4F level shell becomes more stable as compared to 5d level and hence the reason next electron enters in 4F orbital and not in 5d orbital.

Next atomic number 59 element Praseodymium shows symbol Pr electronic configuration [Xe] $4f^3$ $5d^0$ $6s^2$ next element Neodymium Nd [Xe] $4f^4$ $5d^0$ $6s^2$ next element promethium Pm [Xe] $4f^5$ $5d^0$ $6s^2$

next element samarium denoted by Sm [Xe] $4f^6$ $5d^0$ $6s^2$, next element Europium Eu [Xe] $4f^7$ $5d^0$ $6s^2$

next element Gadolinium, Gd [Xe] $4f^7$ $5d^1$ $6s^2$ .Now at the element gadolinium, it's actual electronic configuration has to be [Xe] $4f^8$ $5d^0$ $6s^2$, but it shows [Xe] $4f^7$ $5d^1$ $6s^2$ and it is because of an extra stability of the electronic configuration.

Next element that is terbium denoted by symbol Tb shows electronic configuration as [Xe] $4f^9$ $5d^0$ $6s^2$ next element at atomic number 66 shows Dy, [Xe] $4f^{10}$ $5d^0$ $6s^2$, next element holmium Ho, it shows electronic configuration [Xe] $4f^{11}$ $5d^0$ $6s^2$, next element europium denoted by symbol Er shows electronic configuration [Xe] $4f^{12}$ $5d^0$ $6s^2$, next element thulium, Tm [Xe] $4f^{13}$ $5d^0$ $6s^2$, next element ytterbium Yb [Xe] $4f^{14}$ $5d^0$ $6s^2$ and the last element that is lutetium denoted by Lu shows electronic configuration [Xe] $4f^{14}$ $5d^1$ $6s^2$

The oxidation states

Lanthanum exhibits only the +3 oxidation state and which is the most stable oxidation states of all the lanthanide elements. Only +3 states exhibited by lanthanum, gadolinium and lutetium, which is due to extra stability of empty, then completely half filled and completely full fulfilled F orbitals.

Lanthanum in +3 oxidation state shows the electronic configuration as [Xe] $4f^0$ $5d^0 6s^0$
and hence it is due to the extra stability of the completely empty F orbital.

Then the next element that is gadolinium, oxidation in +3 state shows the electronic configuration [Xe] $4f^7$ $5d^0$ $6s^0$ this F orbital got 7 electrons hence it is completely half filled and it is due to extra stability.

Next element that is lutetium, in +3 oxidation state shows [Xe] $4f^{14}$ $5d^0$ $6s^0$, where all seven orbitals are completely filled and it is also due to extra stability.

In addition to the usual +3 oxidation state, few of the lanthanide exhibits +2 and +4 oxidation state.
And the +2 and +4 oxidation state, shows the stable electronic configuration as $4f^0$,$4f^7$ and $4f^{14}$ configuration.

For example, in case of cerium +4, it shows electronic configuration as [Xe] $4f^0$ $5d^0$ $6s^0$ which shows all F orbitals are completely empty.
Then the next element that is terbium +4 oxidation state shows electronic configuration as [Xe] $4f^7$ $5d^0$ $6s^0$ which shows half filled F orbital and it is also due to more stable electronic configuration.
The next element that is europium in +2 oxidation state show [Xe] $4f^7$ $5d^0$ $6s^0$ again it is half filled.
Then next element that is ytterbium +2 shows electronic configuration [Xe] $4f^{14}$ $5d^0$ $6s^0$ it show completely filled for F orbitals.

It is not possible to explain certain oxidation states like for example in case of samarium which shows +2 oxidation state having an configuration as F^6, Tm^{+2} having f^{13}, Pr^{+4}having f^1, Nd^{+4} having f^2 configuration on the basis of extra stability.

On the basis of highly complicated thermodynamic and kinetic consideration, it is possible to learn about this certain oxidation States and not on the basis of extra stability.

Here is the table containing symbols of all the lanthanides and the electronic configuration in its most stable +3 oxidation state and possible oxidation states shown by the lanthanide elements.
lanthanum in +3 oxidation state got f^O as the electronic configuration and it shows +3 oxidation state.

Then next element that is cerium as f^1 is the electronic configuration in its most stable oxidation state.
And other possible oxidation states are +3 and +4.

Similarly for presodymium f^2 which shows possible oxidation state +3 and + 4. Then for Nd F^3 +2 , +3, +4, these are the possible oxidation states.

Then for Pm F^4 +3 is the possible oxidation state, then samarium F^5 +2 and +3, then similarly for Eu F^6 +2 and +3, then for Gd F^7 is the electronic configuration and +3 oxidation state, next tb F^8 +3 and +4, next Dy F^9 +3 &+4. Then holmium shows +3 as the possible oxidation state, then Er +3, tm +2 and +3, Yb +2 and +3 and last element that shows only the +3 as the possible oxidation state is the Lu.

These are the some of the references.

Thank You