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UNIT-II

B.Sc. II
UNIT-II

A] Inner Transition Elements

Introduction

The elements in which last electrons enters in $(n-2)f$ sub orbitals are called f-block elements or inner transition elements or rare earth elements.

- These elements are placed at the bottom of main body of periodic table. These elements are present in 3rd group of 6th and 7th periods.
- These elements are classified into two series namely Lanthanides and Actinides.

- The Lanthanides series contain 14 elements from $_{58}\text{Ce}$ to $_{71}\text{Lu}$.

- The Actinides series contain 14 elements from $_{90}\text{Th}$ to $_{103}\text{Lr}$.

The general E.C. is $(n-2)f^{1-14}(n-1)d^{0-1}ns^2$

Comparative study of Lanthanides elements

Def- The elements in which last electrons enters in $4f$ sub orbitals are called Lanthanides or $4f$ series elements.

- It contain 14 elements from $_{58}\text{Ce}$ to $_{71}\text{Lu}$
- These elements are present in 3rd group of 6th period.
- These elements are called as Lanthanides because they come immediately after Lanthanum.
- It contain only one radioactive element that is Promethium (PM) which is short lived.
- The alloy of Lanthanide is misch metal [La, Ce and C.S. Ca Al] which is used to make bullets and shells.

La Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu
 लैर से कार नही प्रेम गगनो मुही निगरी नुदे ती हे एब नुदे गारुणर गुणो

① Electronic configuration

The general electronic configuration of Lanthanides is $4f^{1 \text{ to } 14} 5d^{0 \text{ or } 1} 6s^2$

In the lanthanide series, Lanthanum is first element which is actually d-block element present in the lanthanide series but their properties are similar to that of lanthanides.

In Lanthanides, last electrons enter in 4f orbitals. But filling of electrons in 4f orbitals is not regular because of the energy gap between 4f and 5d orbitals is very small. Therefore two electronic configurations are suggested that is expected (or probable) and observed (or actual).

| S.No. | Element | Symbol | At.No. | Expected E.C. | Observed E.C. |
|-------|--------------|-----------------|--------|--------------------------|--------------------------|
| 1 | Lanthanum | लैर La | 57 | $[Xe] 4f^0 5d^1 6s^2$ | $[Xe] 4f^0 5d^1 6s^2$ |
| 2 | Cerium | सिप्रिमा Ce | 58 | $[Xe] 4f^1 5d^1 6s^2$ | $[Xe] 4f^1 5d^1 6s^2$ |
| 3 | Praseodymium | प्रसाय Pr | 59 | $[Xe] 4f^2 5d^1 6s^2$ | $[Xe] 4f^3 5d^0 6s^2$ |
| 4 | Neodymium | न्युडुम Nd | 60 | $[Xe] 4f^3 5d^1 6s^2$ | $[Xe] 4f^4 5d^0 6s^2$ |
| 5 | Promethium | प्रमिथियम Pm | 61 | $[Xe] 4f^4 5d^1 6s^2$ | $[Xe] 4f^5 5d^0 6s^2$ |
| 6 | Samarium | समीरि Sm | 62 | $[Xe] 4f^5 5d^1 6s^2$ | $[Xe] 4f^6 5d^0 6s^2$ |
| 7 | Europium | इयुरोप Eu | 63 | $[Xe] 4f^6 5d^1 6s^2$ | $[Xe] 4f^7 5d^0 6s^2$ |
| 8 | Gadolinium | गडोलीनियम Gd | 64 | $[Xe] 4f^7 5d^1 6s^2$ | $[Xe] 4f^7 5d^1 6s^2$ |
| 9 | Terbium | तर्बियम Tb | 65 | $[Xe] 4f^8 5d^1 6s^2$ | $[Xe] 4f^9 5d^0 6s^2$ |
| 10 | Dysprosium | डिप्रोसियम Dy | 66 | $[Xe] 4f^9 5d^1 6s^2$ | $[Xe] 4f^{10} 5d^0 6s^2$ |
| 11 | Holmium | होल्मियम Ho | 67 | $[Xe] 4f^{10} 5d^1 6s^2$ | $[Xe] 4f^{11} 5d^0 6s^2$ |
| 12 | Erbium | इरबियम Er | 68 | $[Xe] 4f^{11} 5d^1 6s^2$ | $[Xe] 4f^{12} 5d^0 6s^2$ |
| 13 | Thulium | थुलियम Tm | 69 | $[Xe] 4f^{12} 5d^1 6s^2$ | $[Xe] 4f^{13} 5d^0 6s^2$ |
| 14 | Ytterbium | युट्टेर्बियम Yb | 70 | $[Xe] 4f^{13} 5d^1 6s^2$ | $[Xe] 4f^{14} 5d^0 6s^2$ |
| 15 | Lutetium | लुटेशियम Lu | 71 | $[Xe] 4f^{14} 5d^1 6s^2$ | $[Xe] 4f^{14} 5d^1 6s^2$ |

The E.C. of Cerium (Ce) is $[Xe] 4f^1 5d^1 6s^2$. After Cerium, the electron is not present in 5d sub-orbital except Gd & Lu. In Gd & Lu, the electron present in 5d orbital and attain stable half filled and completely filled electronic configuration.

② Atomic Size:

As we go left to right in lanthanides, atomic and ionic radii decrease. The decrease in at. size

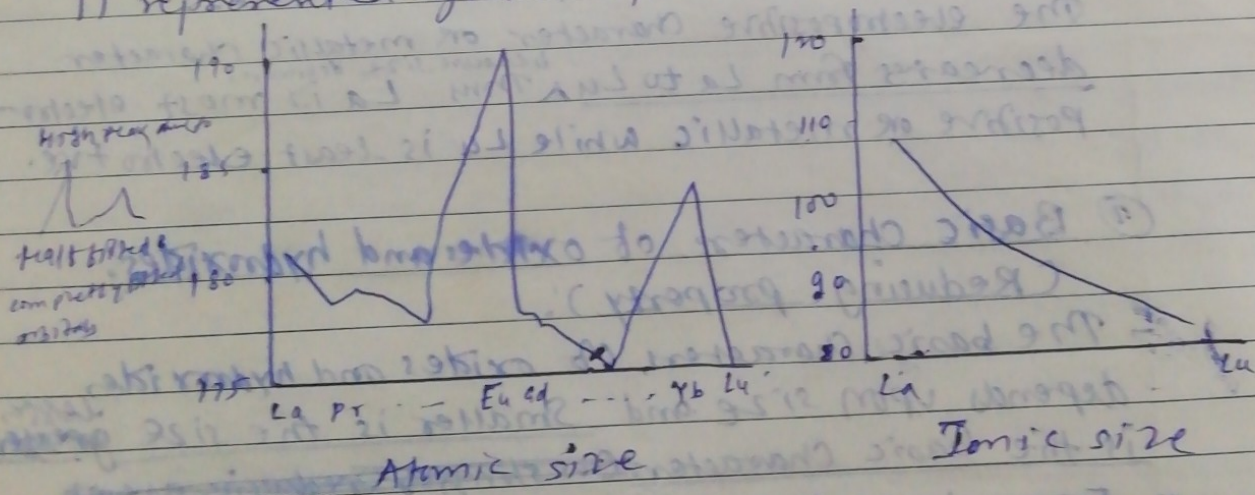
Diff.
 At. radius 15 pm
 Ionic radius 21 pm
 and ionic size is small. [At. radius decreases from 188 pm to 173 pm and ionic radius decrease from 106 pm to 85 pm]

This regular decrease in atomic and ionic size is called as lanthanide contraction.

The lanthanide contraction is due to poor shielding effect of f-orbitals ~~due to this~~. This can be explained

As we go left to right in Lanthanides, At. no. increases, ~~and~~ nuclear charge increases, and electrons are necessarily added to 4f orbital but f-orbitals has improper and distorted shape therefore poor shielding effect. Therefore electrons are pulled inward therefore size decreases.

The decrease in atomic and ionic size can be represented graphically as



Cause of lanthanide contraction OR

Reasons for lanthanide contraction

The steady decrease in atomic and ionic size is called as lanthanide contraction.

The reasons for lanthanide contraction are

- ① As we go from La to Lu , Atomic no. increases from 57 to 71, nuclear charge increases progressively by one unit

At the same time, electrons are added to the 4f-orbitals. The 4f orbitals have distorted and improper shape therefore 4f orbitals have poor shielding effect therefore last orbital electrons (6s orbital electrons) are pulled inward therefore size decreases. (contraction in size).

Effect or Consequence of Lanthanide contraction

The lanthanide contraction affect the properties of lanthanides as well as post lanthanides (The element coming after lanthanides).

Effect on lanthanides:

① Electropositive or metallic Character:

The tendency of atom to loose electron and forms the ion is called electropositive character.

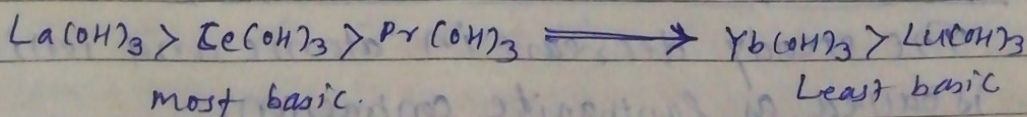
The electropositive character or metallic character decreases from La to Lu ^{because size decreases}. Thus La is most electropositive or metallic while Lu is least electropositive.

② Basic character of oxides and hydroxides:

(Reducing property):

- The basic character of oxides and hydroxides depends upon size and smaller is the size ^{less} ~~greater~~ is the basic character. ~~But stronger reducing agent~~

- From La to Lu atomic and ionic size decreases therefore basic character ^{oxide & hydroxide} ~~decreases~~ from La to Lu.



③ Ionic character:

Ionic size decreases from La to Lu. Thus Lanthanum compd. are most ionic while Lutetium compd. are least ionic.

④ Decomposition temperature of oxy salts:

As ionic character decreases from La to Lu, then the decomposition temp. of oxy salts like nitrate, carbonate decreases from La to Lu.
Thus $La(NO_3)_3$ has higher decomposition temp.

⑤ Electronegativity of lanthanide ion:

There is slight increase in electronegativity of the trivalent ion from La to Lu.

⑥ Complex formation:

Formation of complex depends upon ~~ionic~~ ionic size. Smaller is the ^{ionic} size, greater is the tendency to form complexes.

As we go La to Lu ionic size decreases. Therefore tendency to form complexes increases from La to Lu.

⑦ Separation of Lanthanides:

As lanthanides have ~~same~~ almost same size, therefore their chemical properties also same therefore they can not be separated by ordinary method. However, due to steady decrease in ionic size, lanthanides can be separated by special methods like ion exchange, solvent extraction & chromatography.

** Effect on post lanthanides:

① As we go top to bottom, atomic size increases

② But due to lanthanide contraction, the elements present in 2nd and 3rd series have same size.

③ Due to same size of zirconium (Zr) - Hafnium (Hf), Niobium (Nb) - Tantalum (Ta), Molybdenum (Mo) - ~~W~~

Zr-Hf
Nb-Ta tungsten (W), Technetium (Tc) - rhenium (Re)

Mo-W Ruthenium (Ru) - osmium (Os).

Tc-Re - These pair of elements have same size therefore they have same properties.

Ru-Os - these pair of ~~elements~~ elements are called as

Chemical twin.

| Element | Atomic radius (pm) | Ionic radius (pm) |
|---------|--------------------|-------------------|
| Zr | 145 | 79 |
| Hf | 144 | 78 |
| Nb | 134 | 69 |
| Ta | 134 | 68 |
| Mo | 129 | 62 |
| W | 130 | 62 |
| Tc | 127 | |
| Re | 128 | |
| Ru | 125 | |
| Os | 126 | |

(3) Oxidation state:

- Lanthanides shows variable oxidation state because energy gap between 4f and 5d orbital is very small.
- They shows +3 common o.s. but some elements shows +2 and +4 o.s.

(a) +3 oxidation state: [common o.s.]

The general expected E.C. of Lanthanide is $4f^{1-14} 5d^1 6s^2$.
 Suppose if one electron from 5d orbital and two electrons from 6s orbital are removed then it shows +3 o.s.
 If orbitals are completely vacant, half filled and completely filled shows extra stability and it is observed in La, Eu, Gd, Yb and Lu.

- (a) La shows only +3 o.s.
- (b) Gd — " — "
- (c) Lu — " — "

(b) +2 and +4 oxidation state

Along with +3 o.s. lanthanides also shows +2 & +4 o.s. that can be explain on the basis of completely vacant, half filled & completely filled orbital.

eg (1) Ce shows +2 o.s. by the loss of two electrons from 6s orbital and +4 o.s. by the loss of one electron each from 4f and 5d and two electrons from 6s orbital.

② Eu and Yb shows +2 o.s. can be explain
Tb \rightarrow $4f^9 5d^0 6s^2$ on the basis of half filled $[4f^7 5d^0 6s^2]$ and completely filled $[4f^{14} 5d^0 6s^2]$ electronic configuration respectively.

③ Tb shows +4 o.s. on the basis of half filled $[4f^7 5d^0 6s^2]$ E.C.

④ Magnetic properties:

Magnetic properties of in the substance depends upon no. of unpaired electron.

Def:- The substance which does not contain unpaired electrons and ^{have} zero ~~net~~ magnetic moment is called as diamagnetic substance.

Def:- The substance which contain unpaired electrons and ^{have} resultant magnetic moment is called as paramagnetic substance.

The magnetic properties of the substance depends upon moving electron. The moving electron is considered as micro-magnet. The electron has spin and orbital motion. therefore it can contribute to magnetic properties in two ways. Therefore total or effective magnetic moment sum of ~~net~~ magnetic moment due to spin motion and orbital motion of unpaired electron

$\mu_{\text{effective}} = \mu_{\text{spin}} + \mu_{\text{orbital}}$

When the substance is placed in magnetic field and there are no unpaired electrons and pairing of all electrons nullifies their individual contribution. Such substance is called as diamagnetic substance.

and property is called as diamagnetism.

eg La^{3+} , Yb^{2+} , Lu^{3+} are diamagnetic when unpaired electrons are present ~~and~~ then ~~and~~ such

substance is called paramagnetic substance and property is called paramagnetism.

eg All of the other lanthanides tripositive ions are paramagnetic

The magnetic moment is calculated by the formula:

$$\mu = \sqrt{n(n+2)} \text{ B.M.}$$

where n is no. of unpaired electrons.

eg La^{3+} and Lu^{3+} no unpaired electrons

$$n=0$$

$$\mu = \sqrt{n(n+2)}$$

$$\mu = 0$$

eg Gd^{3+} has 7 unpaired electrons

$$n=7$$

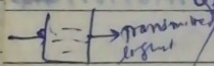
$$\mu = \sqrt{7(7+2)}$$

$$\mu = \sqrt{63}$$

$$\mu = 7.9 \text{ B.M.}$$

⑤ Colour of salts:

Many trivalent lanthanide ions are coloured in solid and aqueous solⁿ. The colour of lanthanide ions depends upon no. of unpaired electrons in f-orbitals.



When visible light is fall on the solⁿ of lanthanide ion, then electrons are transferred from ground state to excited state. Suppose if all light is absorbed then solution become black. Suppose if all light is transmitted then solution is white or colourless, suppose if some amount of light is absorbed and some amount of light is transmitted then solution becomes a colour. It is observed that the element with nf electrons have same colour with that of $(n-14)f$ electrons.

The ~~lanthanide~~ ion with $4f^0$, $4f^14$ configuration are colourless eg La^{3+} , Lu^{3+} . Some exceptional ions Ce^{3+} , Gd^{3+} , Yb^{3+} are colourless. The other ions are colour due to $f-f$ transition.

① chelating Ligands: Ligands containing more than two donor atoms and forms ring structure is called as chelating ligands

② Coordination Number: Total no. of coordinate bonds present in the coordination compounds [complex] is called coordination number

③ Complex formation: The complex is formed when ~~metal~~ ligands donate electron pairs to metal ion and form coordinate bonds.

For the formation of stable complex, the metal ion should possess three properties

- ① It should have high positive charge to attract the ligand.
- ② It should have small size for larger force of attraction.
- ③ It should have vacant orbitals to accommodate the electron pair donated by ligands. These orbitals undergoes hybridization and then accept electron pairs.

But these requirements are not fulfilled by lanthanides because

- ① They show only +3 o.s. and thus have low +ve charge
- ② They have empty f-orbitals but f-orbitals have distorted shape and not suitable for necessary hybridization before complex formation.

Due to these reasons, lanthanides do not form complexes readily.

But among lanthanides, only Ce^{4+} forms many complexes because higher +ve charge density than others.

In general, the tendency to form ~~anhydrous~~ anhydrous Ln^{3+} ion increases from La^{3+} to Lu^{3+} but that of hydrated Ln^{3+} decreases in same order because size of anhydrous Ln^{3+} (aqueous Ln^{3+}) decreases and corresponding hydrated increases with increase in atomic number.

However, if ligands are strong like chelating ligands or ligands having fluoride or oxygen donor atoms are strong enough to form complexes with lanthanide ions. with coordination no. 6 or 8.

eg of chelating ligands are EDTA, oxalate, citrates, tartrate and acetylacetone etc forms complexes with lanthanides

Ln^{3+}
lanthanide ions
exists as

~~11/11~~

1800889999

9834827296

(7) Occurrence of Lanthanides:

originally lanthanides are called as rare earth elements ~~because~~ The word earths means oxides. Therefore they were found in the form of oxides.

Except promethium (Pm), all lanthanides occurs in nature in good concentration. Promethium is radioactive element.

It has been found that, lanthanides with even atomic numbers exist more abundantly than those with odd atomic numbers.

Cerium (Ce) is probably most abundant among them.

Ores of Lanthanides:

Lanthanides exist in the form of ores. Depending upon concentration of lanthanide elements, they are classified into two types.

(a) Cerium earths:

They contain higher concentration of lower lanthanides having atomic no. 58 to 63. They are also called as light earths.

(b) Yttrium earths:

They contain higher concentration of higher lanthanides having atomic no. 64 to 71. They are also called as heavy earths.

| category | ores | Composition | Location |
|----------------|---|---|---|
| | ① monazite sand phosphate mineral (Ce)PO ₄ | 50-70% Ce-earths 1-4% Y-earths 5-10% ThO ₂ , 1-2% SiO ₂ | occurs in the sand beaches of Travancore (India), Brazil, South Africa, USA |
| | Cerium earth ② Bastnaesite carbonate mineral (Ce)FCO ₃ | 65-70% Ce-earths < 1% Y-earths | Sweden, California, New Mexico |
| | ③ Cerite silicate mineral (Ce) ₃ M ^{II} H ₃ Si ₃ O ₁₁ (M → Ca, Fe) | 50-70% Ce-earths 7-6% Y-earths Traces of Th, U, Zr | Sweden, Caucasus |
| Yttrium Earths | ① Euxenite oxide mineral (Y)(Nb, Ta)TiO ₆ · xH ₂ O | 13-35% Y-earths 2-8% Ce earths 20-30% TiO ₂ | Australia, USA |
| | | 25-35% (Nb, Ta) ₂ O ₆ | |

- Dow X-50 is sulphonated polystyrene resin containing
- SO_3H functional group.
- Resin is cross linked ^{organic} polymer

(11)

| | | |
|--------------------|--------------------------------------|--------|
| ② Xenotime | 54-65% - Y-earths | Norway |
| Phosphate minerals | 0.1% - Ce-earths | Brazil |
| (Y)PO ₄ | 3% - ThO ₂ | |
| | 3.5% - U ₃ O ₈ | |
| | 2-3% - ZrO ₂ | |

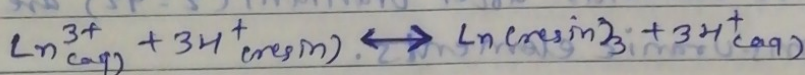
⑧ Isolation of lanthanides by ion-exchange method:

The properties of lanthanide ions depends upon size & charge. All lanthanides are typically trivalent and almost same size and have same chemical properties therefore they are difficult to separate from one another.

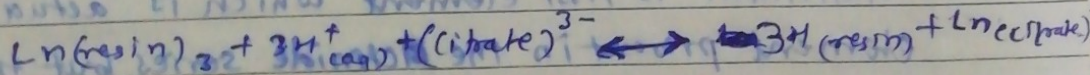
However, ion exchange, solvent extraction are the recent methods used for separation and purification of lanthanides.

The ion exchange method is most important, rapid, effective and convenient method for separation and purification of lanthanides (Ln^{3+})

In this method, a solution of lanthanide ions is passed through column of synthetic ion exchange resin like Dow X-50. The Ln^{3+} ions are absorbed into resin and replace H^+ from the resin.



The H^+ ions produced are washed through the column. Then the metal ions are eluted (given out) in a selective manner. The eluting agent is a complexing agent (ie. buffer solⁿ of citric acid / ammonium citrate having pH 4-7)



The Ln^{3+} ions are removed in the form of citrate complex

Now, due to lanthanide contraction, the size goes on decreasing therefore La^{3+} has largest size while Lu^{3+} ion has smallest size.

But size hydrated ions of lanthanides follow reverse order therefore hydrated La^{3+} ion has smallest size while Lu^{3+} ion has largest size. Therefore force of attraction of La^{3+} ion

with resin is maximum while that of Lu^{3+} ion is minimum.

As the binding force is minimum for Lu^{3+} ion therefore it comes out first while La^{3+} comes out in the end.

In ions are eluted out one by one from Lu^{3+} to La^{3+} .

In order to achieve complete separation, the solution has to be recycled through the column several times and gives 99.9% pure lanthanide metals.

Actinides or 5f-series Elements

The elements in which last electronic enters in 5f sub-orbitals are called as actinides or 5f-series elements.

It contains 14 elements from $_{88}\text{Ra}$ to $_{102}\text{No}$.

These elements are present in 3rd group of 7th period.

These elements are called as actinides because

they come immediately after actinium.

- Almost all the actinides are radioactive.

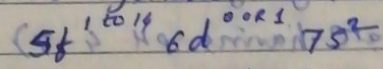
- They are synthetic elements.

- They show variable oxidation states like d-block elements.

- The elements after uranium ($Z=92$) are called trans-uranic elements.

Electronic Configuration

The general electronic of actinides is



Actinium is first element which is actually of block element present in the actinide series but their properties are similar to that of actinides.

In actinides, the last electronic enters in 5f orbitals.

but filling of electrons in 5f orbitals is not regular because energy gap between 5f and 6d orbitals is

very small. Therefore two electronic configurations are

suggested. That is expected (or) probable and observed (or) actual.

| S.No | Elements | symbol | At. no | Expected E.C. | observed E.C. |
|------|--------------|--------|--------|--------------------------|--------------------------|
| 1 | Actinium | Ac | 89 | $[Rn] 5f^0 6d^1 7s^2$ | $[Rn] 5f^0 6d^1 7s^2$ |
| 2 | Thorium | Th | 90 | $[Rn] 5f^0 6d^1 7s^2$ | $[Rn] 5f^0 6d^2 7s^2$ |
| 3 | Protactinium | Pa | 91 | $[Rn] 5f^2 6d^1 7s^2$ | $[Rn] 5f^2 6d^1 7s^2$ |
| 4 | Uranium | U | 92 | $[Rn] 5f^3 6d^1 7s^2$ | $[Rn] 5f^3 6d^1 7s^2$ |
| 5 | Neptunium | Np | 93 | $[Rn] 5f^4 6d^1 7s^2$ | $[Rn] 5f^4 6d^1 7s^2$ |
| 6 | Plutonium | Pu | 94 | $[Rn] 5f^5 6d^1 7s^2$ | $[Rn] 5f^6 6d^0 7s^2$ |
| 7 | Americium | Am | 95 | $[Rn] 5f^6 6d^1 7s^2$ | $[Rn] 5f^7 6d^0 7s^2$ |
| 8 | Curium | Cm | 96 | $[Rn] 5f^7 6d^1 7s^2$ | $[Rn] 5f^7 6d^1 7s^2$ |
| 9 | Berkelium | Bk | 97 | $[Rn] 5f^8 6d^1 7s^2$ | $[Rn] 5f^9 6d^0 7s^2$ |
| 10 | Californium | Cf | 98 | $[Rn] 5f^9 6d^1 7s^2$ | $[Rn] 5f^{10} 6d^0 7s^2$ |
| 11 | Einsteinium | Es | 99 | $[Rn] 5f^{10} 6d^1 7s^2$ | $[Rn] 5f^{11} 6d^0 7s^2$ |
| 12 | Fermium | Fm | 100 | $[Rn] 5f^{11} 6d^1 7s^2$ | $[Rn] 5f^{12} 6d^0 7s^2$ |
| 13 | Mendelevium | Md | 101 | $[Rn] 5f^{12} 6d^1 7s^2$ | $[Rn] 5f^{13} 6d^0 7s^2$ |
| 14 | Nobelium | No | 102 | $[Rn] 5f^{13} 6d^1 7s^2$ | $[Rn] 5f^{14} 6d^0 7s^2$ |
| 15 | Lawrencium | Lr | 103 | $[Rn] 5f^{14} 6d^1 7s^2$ | $[Rn] 5f^{14} 6d^1 7s^2$ |

- It is expected that 5f suborbitals are filled but energy ^{gap between} 5f and 6d orbitals ^{is} close. (or small) therefore electron can enter either in 5f or 6d suborbitals. Hence E.C. of first four actinides Th, Pa, U and Np are doubtful. In case of Th, electron goes to 6d in state of 5f while Pa, U & Np contain only one e⁻ in 6d.

- From Pu onwards, the energy of 5f is lower than 6d therefore electron fill regularly in 5f subshell.

- In case of Curium and Lawrencium, 6d orbital gets one electron due to extra stability of 5f⁷ & 5f¹⁴ configuration.

② Oxidation state:

Actinides shows variable o.s. because energy gap between 5f and 6d orbitals is very small.

| S. No. | Element | Symbol | At. No. | Oxidation state |
|--------|--------------|--------|---------|-----------------|
| 1 | Actinium | Ac | 89 | +3 |
| 2 | Thorium | Th | 90 | +2 +3 +4 |
| 3 | Protactinium | Pa | 91 | +3 +4 +5 |
| 4 | Uranium | U | 92 | +3 +4 +5 +6 |
| 5 | Neptunium | Np | 93 | +3 +4 +5 +6 +7 |
| 6 | Plutonium | Pu | 94 | +3 +4 +5 +6 +7 |
| 7 | Americium | Am | 95 | +2 +3 +4 +5 +6 |
| 8 | Curium | Cm | 96 | +3 +4 |
| 9 | Berkelium | Bk | 97 | +3 +4 |
| 10 | Californium | Cf | 98 | +2 +3 |
| 11 | Einsteinium | Es | 99 | +2 +3 |
| 12 | Fermium | Fm | 100 | +2 +3 |
| 13 | Mendelevium | Md | 101 | +2 +3 |
| 14 | Nobelium | No | 102 | +2 +3 |
| 15 | Lawrencium | Lr | 103 | +3 |

① +2 Oxidation state:

- Ⓐ It is unusual o.s.
- Ⓑ It is common for heaviest elements
- Ⓒ No^{2+} and Md^{2+} are more stable.

② +3 Oxidation state:

- Ⓐ It is most common o.s.
- Ⓑ It is shown by all elements because they are present in group 3rd.

③ +4 O.S.

- Ⓐ It is the principal oxidation ^{state} of Thorium.
- Ⓑ It is very important & stable o.s. for Pa, U, Pu.
- Ⓒ eg MCl_4 known for Th, Pa, U & NP.

④ +5 O.S.

- Ⓐ It is the principal o.s. of Pa, U, Pu & Am
- Ⓑ or fluoride PaF_5 , NpF_5 , UF_5

⑤ +6 O.S.

- ① It is important O.S. for U, Np, Pu, Am elements
- ② ex. AnF_6 ($An = U, Np, Pu$); UCl_6, UO_2F_2 etc

⑥ +7 O.S.

- ① It is stable oxoanions of Np & Pu ~~ex. AnO_4^{3-}~~

Comparison of lanthanides and actinides

A Similarities

- ① In both lanthanides and actinides last electron enters in f-suborbital
- ② Both series elements are electrop⁺ve or metallic in nature quite
- ③ Both series elements are reactive.
- ④ Both series shows contraction in atomic & ionic radii.
- ⑤ Both series shows +3 common O.S.
- ⑥ The salt of both series elements shows paramagnetic
- ⑦ They show typical colour.
- ⑧ Salt of both series like nitrates, sulphates and perchlorate are water soluble.

B Differences

| S.N. | Lanthanides | Actinides |
|------|--|---|
| 1 | The last electron is added to 4f sub level. | The last electron is added to 5f sub level. |
| 2 | They show +3 common O.S. and +2 & +4 for some elements | They show +3 common O.S. and +2 to +7 for some elements |
| 3 | All lanthanides occurs naturally except promethium (Radioactive) | only first four actinides (Ac, Th, Pa & U) occurs in nature. After uranium all other elements are synthetic |
| 4 | Their magnetic moment value is higher | Their mag moment is lower |
| 5 | Their spectral bands are sharp but less intense | Their spectral bands are broad and more intense. |
| 6 | They do not form the oxo ions | They can form oxo ions. |

Applications of Lanthanides

- ① The misch-metal [50% Ce, 40% La, 7% Fe & 3% other metal] is added to steel to improve its strength and working ability. It also used for making ignition devices like bullets and lighter flints.
- ② Crook's lenses: La_2O_3 is used in Crook's lenses, which is used for protection from UV light.
- ③ Ceramic application: The mixture of CeO_2 (47%), La_2O_3 + Nd_2O_3 + Pr_2O_3 (51%) + SiO_2, CaO, Fe_2O_3 is called a polirite. It is used as abrasive for polishing glasses.
- ④ Gas mantles: The mixture of CeO_2 (1/3) & ThO_2 (2/3) are used to increase the brightness of mantles.
- ⑤ Cerium salts are used to increase hemoglobin content in blood and for treatment of vomiting.
- ⑥ Lanthanide compounds are used as good catalyst for hydrogenation, dehydrogenation, refining of crude oil and oxidation of various organic compounds.
- ⑦ Nd_2O_3 is used in liquid lasers.

Applications of Actinides

(A) Thorium

- ① In the preparation of fuel rods in atomic reactors.
- ② " " magnesium flash light.
- ③ many thorium salts are used for cancer treatment.
- ④ ThO_2 ~~has~~ is used in gas mantles, refractory material and additive in tungsten filament.

(B) Uranium

- ① U^{235} is used as nuclear fuel. It gives large amount energy used for production of electricity and preparation of atom bomb.
- ② It is used in the manufacture of lamp filament, gas ~~mantle~~ mantles and iron alloy.
- ③ Uranium compds are used in textile industry, glass industry and ceramic industry.
- ④ It is used in medicine to treat gout, diabetes