□ **Chemical Properties :**

(i) **Action of heat :** $2KMnO_4 \xrightarrow[\Delta]{200°C} K_2MnO_4 + MnO_2 + O_2$

(ii) **Action of conc. H_2SO_4 :**

(a) **A small quantity of $KMnO_4$ is added to conc. H_2SO_4 :**

$KMnO_4 + 3H_2SO_4 \longrightarrow K^+ + MnO_3^+ + 3HSO_4^- + H_3O^+$ (green solution)

(b) **With larger amounts of $KMnO_4$:** $2KMnO_4 + H_2SO_4 \longrightarrow Mn_2O_7$ (explosive oil) $+ K_2SO_4 + H_2O$

(iii) **Action of H_2 :** Solid $KMnO_4$ burns on heating in a current of H_2 to form MnO.

$2KMnO_4 + 5H_2 \longrightarrow 2KOH + 2MnO + 4H_2O$.

(iv) **Oxidizing action :**

(a) **In acidic solution :** $MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 3H_2O$ ($E^0 = 1.51$ V)

(b) **In alkaline soluton :** $MnO_4^- + 2H_2O + 3e^- \longrightarrow MnO_2 + 4OH^-$ ($E^0 = 1.23$ V)

(c) **In neutral or weakly acidic solution :** $MnO_4^- + 4H^+ + 3e^- \longrightarrow MnO_2 + 2H_2O$.

In acid solution, it oxidizes Fe^{2+} to Fe^{3+} salt, iodides to I_2, H_2O_2 to O_2, SO_2 to H_2SO_4, $C_2O_4^{2-}$ to CO_2, nitrite to nitrate, hydrogen halides to halogens, sulphites to sulphates etc.

- **Some examples :**

(i) $2MnO_4^- + 16H^+ + 5C_2O_4^{2-} \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$.

(ii) $2MnO_4^- + 16H^+ + 10I^- \longrightarrow 2Mn^{2+} + I_2 + 8H_2O$.

(iii) $2MnO_4^- + 6H^+ + 5H_2O_2 \longrightarrow 2Mn^{2+} + 5O_2 + 8H_2O$.

(iv) $MnO_4^- + SO_2 + 2H_2O \longrightarrow Mn^{2+} + 2H_2SO_4$.

(v) $MnO_4^- + 5Fe^{2+} + 8H^+ \longrightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$.

(vi) $2MnO_4^- + 6H^+ + 5NO_2^- \longrightarrow 2Mn^{2+} + 5NO_3^- + 3H_2O$.

In alkaline soluton, it oxidizes iodide to iodate and formate to carbonate etc.

$2MnO_4^- + H_2O + I^- \longrightarrow 2MnO_2 + 2OH^- + IO_3^-$.

$2KMnO_4 + 3HCOOK = 2MnO_2 + KHCO_3 + 2K_2CO_3 + H_2O$.

In neutral or **weakly acidic solution,** it oxidizes Mn^{2+} to MnO_2, $H_2O_2 + O_2$ and thiosulphate to sulphate.

$2MnO_4^- + 3Mn^{2+} + 2H_2O = 5MnO_2 + 4H^+$.

$2MnO_4^- + 3H_2O_2 \longrightarrow 2MnO_2 + 2OH^- + 2H_2O + 3O_2$.

$8MnO_4^- + 3S_2O_3^{2-} + H_2O = 8MnO_2 + 6SO_4^{2-} + 2OH^-$.

▶ **Uses :** It is used —

(i) as a disinfectant;

(ii) as an oxidizing agent in the laboratory and industry;

(iii) as Baeyer's reagent (alkaline $KMnO_4$) for detecting unsaturation in organic compounds;

(iv) as a secondary standard in volumetric analysis;

(v) for qualitative detection of halides, oxalates, tartarates etc.

POINTS TO REMEMBER :

(a) Permanganate solutions are intrinsically unstable in acidic solution and decomposes slowly and also catalyzed by sunlight. Thus, $KMnO_4$ solutions should be stored in dark bottles and they must be standarized frequently.

(b) The permanaganate ion has an intense purple colour. Mn(+VIII) has d^0 configuration, so the colour arises from charge transfer and not from d-d spectra.

into four main blocks. These are s, p, d and f-block elements (fig. 3.3). The classification is based on the type of orbital into which the last electron enters.

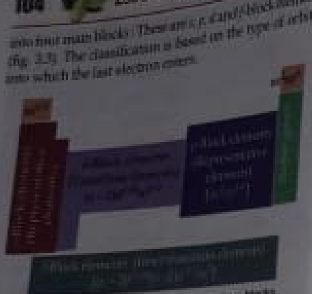


Fig. 3.3 Division of periodic table into various blocks

3.14.1 s-block elements

The elements in which the last electron enters the s-orbital of their outermost shell are called **s-block elements**. These elements have ns^1 or ns^2 configuration in the ground state. s-orbital can accommodate only two electrons. So, there are only two groups which contain s-block elements. Elements of group 1 and group 2, i.e., hydrogen, alkali metals and alkaline earth metals and inert gas helium of group 18 are s-block elements.

General characteristics of s-block elements

1. All the s-block elements are soft metals (exceptions are hydrogen and helium which are gases) with low m.p. and b.p.
2. All these metals have very low ionisation potentials. So these metals are highly reactive. The reactivity of these metals increases on moving down the group.
3. They are strongly electropositive metals. The electropositivity in the metallic character increases on moving down the group.
4. Since they are highly electropositive, they readily lose electrons and hence, they are strong reducing agents.
5. All these metals are good conductors of heat and electricity.
6. They show oxidation states of +1 (in case of alkali metals) or +2 (in case of alkaline earth metals).
7. The compounds of s-block elements are predominantly ionic. Exceptions are lithium and beryllium which form covalent compounds.
8. All the s-block metals produce characteristic colours to the flame except Be and Mg.
9. All the compounds of s-block elements are colourless, exceptions are chromate, dichromate and permanganates.
10. The hydroxides of these metals are strong bases.

3.14.2 p-block elements

The elements in which the last electron enters the p-orbital of the outermost shell are called **p-block elements**. Thus the general electronic configuration of the outermost shell of p-block elements is $ns^2 np^{1-6}$.

Since p-orbital can accommodate six electrons, there are six groups in the periodic table which contain p-block elements. Thus the elements of group 13, 14, 15, 16, 17, and 18 (except helium) are called p-block elements.

General characteristics of p-block elements :

1. Most of these elements are non-metals, some are metalloids and a few heavy elements are there which are metals. The non-metallic character increases on moving from left to right across a period and the metallic character increases on moving down the group.
2. They can form ionic as well as covalent compounds.
3. They show variable oxidation states.
4. The ionisation potentials of these elements are much higher than those of s-block elements. It increases on moving from left to right along a period and it decreases down a group.
5. Most of the elements of p-block are electronegative. The electronegativity increases on moving left to right across a period and it decreases on moving down a group.
6. On moving left to right across a period, the oxidising power increases and reducing power decreases. On moving down a group, the oxidising power decreases and reducing power increases.
7. Most of the elements of p-block are bad conductors of heat and electricity (except the metals and graphite).
8. Most of them form acidic oxides. Only some of them (e.g. Al) form amphoteric oxides.

3.14.3 d-block elements

The elements in which the last electron goes to $(n-1)d$ orbital (i.e., the d-orbital of penultimate shell) are called **d-block elements**. Since d-orbital can accommodate a maximum of ten electrons, there are ten groups in the periodic table which contain d-block elements. These groups are 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 respectively. These elements have 1 or 2 electrons in the s-orbital of the outermost shell. Thus the electronic configuration of these elements is $(n-1)d^1ns^2$ to $(n-1)d^{10}ns^2$. On the left hand side of the d-block elements, there are electropositive elements of groups 1 and 2 and on the right hand side, there are electronegative elements of groups 13 and 14. Thus, transition elements form a bridge between highly electropositive and highly electronegative elements. So, d-block elements are called **transition elements**.

[Transition elements are said to have incompletely filled d-orbital. So, Zn, Cd and Hg can not be defined as transition elements as they have completely filled d-orbital. They do not exhibit most of the characteristic properties of transition elements. So, all the transition elements are d-block elements but all the d-block elements are not transition elements.]

The d-block elements can be divided into three distinct series –

1. The first transition series : Here, the last electron enters into 3d orbital. These elements belong to period 4. 3d transition series starts from Sc (Z = 21) and ends at Zn (Z = 30).

2. The second transition series : Here, the last electron enters the 4d orbital. These elements belong to period 5. 4d transition series starts from Y (Z = 39) and ends with Cd (Z = 48).

3. The third transition series : Here, the last electron enters the 5d orbital. These elements belong to period 6. 5d transition starts from La (Z = 57) and ends at Hg (Z = 80).

General properties of transition elements :

1. Metallic character : All the transition elements are metals. All of them (except Hg) are hard, malleable and ductile. All of them possess high tensile strength.

Their metallic character is due to

- Their relatively lower ionisation energies.
- Presence of a few valence electrons and empty valence orbitals.
- These are good conductors of heat and electricity.

2. Colour : Transition metals form coloured compounds.

3. Variable valency : The transition elements show variable oxidation states.

4. Catalytic property : All the transition metals and their compounds are used as catalysts.

5. Magnetic property : Because of the presence of one or more unpaired electrons, most of the transition metals are paramagnetic.

6. Complex compounds : All the transition metals form complex compounds.

7. They form ionic as well as covalent compounds.

3.14.4 f-block elements

The elements in which the last electron enters into $(n-2)f$ subshell are known as **f-block elements**. The f-orbitals of (n – 2) subshell is gradually filled up whereas ns orbital remains completely filled and the d-orbital of (n – 1) shell invariably contains zero or 1 electron. This f-orbital can accommodate fourteen electrons. Their electronic configuration is $(n-2)f^{1-14}(n-1)d^{10}ns^2$. The f-block elements can be divided into two series –

1. 4f series : In the 6th period, there are fourteen elements where 4f orbital is gradually filled up. This series starts from Ce (Z = 58; $4f^{1}5d^{1}6s^{2}$) and ends with Lu (Z = 71; $4f^{14}5d^{1}6s^{2}$). These are called **lanthanides**.

2. 5f series : In the 7th period, again there are fourteen elements where 5f orbital is gradually filled up. This series starts from Th (Z = 90; $5f^{0}6d^{2}7s^{2}$) and ends at Lr (Z = 103, $5f^{14}5d^{1}6s^{2}$). These are called **actinides**. All these actinides are radioactive. The first three members of the actinide family, i.e., Th (Z = 90), Pa (Z = 91) and U (Z = 92) are found in nature, but all others are man-made elements.

The lanthanides and actinides are also called **inner transition elements** or **rare earth elements**.

General properties of f-block elements

1. All the lanthanides and actinides are heavy metals. They are all good conductors of heat and electricity.
2. They have high densities. The density increases with increase in atomic weight.
3. They have very high melting and boiling points.
4. They have low ionisation potential values. So they are strong reducing agents as they readily lose electrons.
5. Most of the lanthanide ions are coloured.
6. They form complex compounds, most of which are coloured.
7. They are paramagnetic due to the presence of unpaired electrons.
8. They form mostly ionic compounds.

3.14.5 Advantages of Long form of Periodic Table

1. The position of some elements which are misfit on the basis of atomic mass is now justified on the basis of atomic numbers. For example, argon (atomic mass 39.9) preceeds potassium (atomic mass 39.1) because argon has atomic numbers 18 and potassium has 19.
2. The gradual change in properties along the periods and groups can be interpreted by considering the electronic configuration i.e., atomic members. This long form of the periodic table actually stands on **Aufbau principle**.
3. The A and B sub-group elements are placed separately.
4. The trids were placed in Gr. VIII of Mendeleev's periodic table, but there was no justification for this. In modern periodic table, they are separately grouped. They have the general electronic configurations $(n-1)d^6ns^2$, $(n-1)d^7ns^2$ and $(n-1)d^8ns^2$ and they are placed in three consecutive groups.
5. The fourteen lanthanides are forced to be placed in a single room. In terms of electronic configurations of the (n – 2) f (i.e., 4f) sub-level, the fourteen lanthanides have got fourteen rooms characterised by $4f^1, 4f^2, 4f^{14}$.

The protecting power of zinc is based on the fact that zinc $\left(E^{\circ}_{Zn^{2+}/Zn} = -0.76V\right)$ is **more electropositive than iron** $\left(E^{\circ}_{Fe^{2+}/Fe} = -0.44V\right)$ and forms ions more readily than iron. Thus, in presence of zinc iron is not oxidized instead zinc is oxidized to Zn^{2+} and it protects iron from rusting.

Preparation, properties and uses of $K_2Cr_2O_7$ and $KMnO_4$:

- **Potassium dichromate ($K_2Cr_2O_7$) :**

(a) Preparation of sodium chromate :

$$\underset{\text{(chromite)}}{4FeCr_2O_4} + 16NaOH + \underset{\text{(air)}}{7O_2} \xrightarrow[\text{quick-lime}]{\text{fusion}} 8Na_2CrO_4 + 2Fe_2O_3 + 8H_2O$$

Quick-lime keeps the mass porous and facilitates oxidation. The fused mass is extracted with water and filtered.

(b) Conversion of sodium chromate to sodium dichromate :

$$\underset{\text{(filtrate)}}{2Na_2CrO_4} + H_2SO_4\,(\text{dil.}) \longrightarrow Na_2Cr_2O_7 + Na_2SO_4 + H_2O$$

Sodium sulphate being less soluble is separated as $Na_2SO_4 \cdot 10H_2O$ by fractional crystallization.

(c) Conversion of sodium dichromate into potassium dichromate :

$$Na_2Cr_2O_7 + \underset{\text{(calculated amount)}}{2KCl} \xrightarrow{\Delta} \underset{\text{(orange-red crystals)}}{K_2Cr_2O_7} + 2NaCl$$

Potassium dichromate being less soluble is separated by fractional crystallization.

- **Properties :**
  - **Physical Properties :** Potassium dichromate is an orange-red coloured crystalline solid, melts at 396°C. It is moderately soluble in cold water, but freely soluble in hot water.
  - **Chemical Properties :**

1. Action of heat : $4K_2Cr_2O_7 \xrightarrow[\text{(strongly heated)}]{\text{white heat}} 4K_2CrO_4 + 2Cr_2O_3 + 3O_2\uparrow$

2. Action of alkali : $\underset{\text{(orange-red)}}{K_2Cr_2O_7} + \underset{\text{(solution)}}{2KOH} \longrightarrow \underset{\text{(yellow)}}{2K_2CrO_4} + H_2O$

3. Action of acids : $K_2Cr_2O_7 + 14HCl\,(\text{conc.}) \xrightarrow[\text{heating}]{\text{strong}} 2KCl + 2CrCl_3 + 3Cl_2\uparrow + 3O_2$

In cold : $K_2Cr_2O_7 + \underset{\text{(conc.)}}{2H_2SO_4} \longrightarrow 2KHSO_4 + \underset{\text{(red crystals)}}{2CrO_3} + H_2O$

In hot : $2K_2Cr_2O_7 + \underset{\text{(conc.)}}{8H_2SO_4} \xrightarrow{\Delta} K_2SO_4 + \underset{\text{(green)}}{2Cr_2(SO_4)_3} + 8H_2O + 3O_2$

4. Oxidizing properties : In neutral or acidic solution, it acts as a powerful oxidizing agent.

Ionic equation : $Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$

$\therefore$ Equivalent wt. of $K_2Cr_2O_7 = \dfrac{\text{molecular mass of } K_2Cr_2O_7}{6}$

It oxidizes iodides to iodine, ferrous to ferric salts, SO_2 to H_2SO_4, oxalate to CO_2, C_2H_5OH to CH_3CHO, arsenious acid to arsenic acid etc.

(a) $Cr_2O_7^{2-} + 14H^+ + 6I^- \longrightarrow 2Cr^{3+} + 7H_2O + 3I_2$;

(b) $Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \longrightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$;

(c) $Cr_2O_7^{2-} + 3SO_2 + 2H^+ \longrightarrow 2Cr^{3+} + H_2O + 3SO_4^{2-}$;

(d) $Cr_2O_7^{2-} + 14H^+ + 3C_2O_4^{2-} \longrightarrow 2Cr^{3+} + 6CO_2 + 7H_2O$;

(e) $Cr_2O_7^{2-} + 8H^+ + 3H_2S \longrightarrow 2Cr^{3+} + 3S\downarrow + 7H_2O$;

(f) $C_2H_5OH + [O] \xrightarrow{K_2Cr_2O_7} CH_3CHO + H_2O$.

5. Reaction with H_2O_2 :

$K_2Cr_2O_7 + H_2SO_4 + 4H_2O_2 \longrightarrow 2CrO_5\,(\text{deep blue solution}) + K_2SO_4 + 5H_2O$

The blue colour fades away gradually due to decomposition of chromic diperoxide (CrO_5) to Cr^{3+} ions.

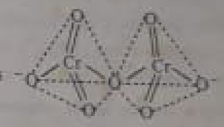
6. Formation of volatile chromyl chloride :

$K_2Cr_2O_7 + 4NaCl + (\text{conc.})\,6H_2SO_4 \xrightarrow{\Delta} 2KHSO_4 + 4NaHSO_4 + 2CrO_2Cl_2\downarrow\,(\text{orange-red vapours})$

- **Uses :** It is used —

(i) as an oxidizing agent;
(ii) for detecting Cl^- ions by chromyl chloride test;
(iii) in volumetric estimation of reducing agents;
(iv) for the preparation of chrome alum;
(v) in photography for hardening of gelatin;
(vi) in chrome tanning (in leather industry), in calico printing and dying.

- **Structure :** Structure of dichromate ion containing two tetrahedra as



- **Potassium permanganate ($KMnO_4$) :**
  - **Preparation :**

1. From pyrolusite (MnO_2) :

$$\underset{\text{(pyrolusite)}}{MnO_2} \xrightarrow[\text{of } O_2 \text{ or } KNO_3]{\text{fuse with KOH in presence}} \underset{\substack{\text{[potassium}\\ \text{manganate]}\\ \text{(green)}}}{K_2MnO_4} \xrightarrow[\text{in alkaline solution}]{\text{electrolytic oxidation}} \underset{\substack{\text{[potassium}\\ \text{permanganate]}\\ \text{(purple)}}}{2KMnO_4}$$

2. It is also prepared by treating a solution of Mn^{2+} ions with very strong oxidizing agents, such as PbO_2 or sodium bismuthate, ($NaBiO_3$).

- **Properties :**

Physical properties :

Potassium permanganate forms deep purple rhombic prisms with a green iridescence. It is isomorphous with potassium perchlorate. It is moderately soluble in water, giving a deep purple solution.

into four main blocks: These are s, p, d and f-block elements (fig. 3.3). The classification is based on the type of orbital into which the last electron enters.

Fig. 3.3 Division of periodic table into various blocks

3.14.1 s-block elements

The elements in which the last electron enters the s-orbital of their outermost shell are called **s-block elements**. These elements have ns^1 or ns^2 configuration in the ground state. s-orbital can accommodate only two electrons. So, there are only two groups which contain s-block elements. Elements of group 1 and group 2 i.e., hydrogen, alkali metals and alkaline earth metals and inert gas helium of group 18 are s-block elements.

General characteristics of s-block elements

1. All the s-block elements are soft metals (exceptions are hydrogen and helium which are gases) with low m.p. and b.p.
2. All these metals have very low ionisation potentials. So these metals are highly reactive. The reactivity of these metals increases on moving down the group.
3. They are strongly electropositive metals. The electropositivity in the metallic character increases on moving down the group.
4. Since they are highly electropositive, they readily lose electrons and hence, they are strong reducing agents.
5. All these metals are good conductors of heat and electricity.
6. They show oxidation states of +1 (in case of alkali metals) or +2 (in case of alkaline earth metals).
7. The compounds of s-block elements are predominantly ionic. Exceptions are lithium and beryllium which form covalent compounds.
8. All the s-block metals produce characteristic colours to the flame, except Be and Mg.
9. All the compounds of s-block elements are colourless, exceptions are chromate, dichromate and permanganates.
10. The hydroxides of these metals are strong bases.

3.14.2 p-block elements

The elements in which the last electron enters the p-orbital of the outermost shell are called **p-block elements**. Thus the general electronic configuration of the outermost shell of p-block elements is $ns^2 np^{1-6}$.

Since p-orbital can accommodate six electrons, there are six groups in the periodic table which contain p-block elements. Thus the elements of group 13, 14, 15, 16, 17 and 18 (except helium) are called p-block elements.

General characteristics of p-block elements

1. Most of these elements are non-metals, some are metalloids and a few heavy elements are there which are metals. The non-metallic character increases on moving from left to right across a period and the metallic character increases on moving down the group.
2. They can form ionic as well as covalent compounds.
3. They show variable oxidation states.
4. The ionisation potentials of these elements are much higher than those of s-block elements. It increases on moving from left to right along a period and it decreases down a group.
5. Most of the elements of p-block are electronegative. The electronegativity increases on moving left to right across a period and it decreases on moving down a group.
6. On moving left to right across a period, the oxidising power increases and reducing power decreases. On moving down a group, the oxidising power decreases and reducing power increases.
7. Most of the elements of p-block are bad conductors of heat and electricity (except the metals and graphite).
8. Most of them form acidic oxides. Only some of them (e.g., Al) form amphoteric oxides.

3.14.3 d-block elements

The elements in which the last electron goes to (n-1)d orbital (i.e., the d-orbital of penultimate shell) are called **d-block elements**. Since d-orbital can accommodate a maximum of ten electrons, there are ten groups in the periodic table which contain d-block elements. These groups are 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 respectively. These elements have 1 or 2 electrons in the s-orbital of the outermost shell. Thus the electronic configuration of these elements is $(n-1)d^1ns^2$ to $(n-1)d^{10}ns^2$. On the left hand side of the d-block elements, there are electropositive elements of groups 1 and 2 and on the right hand side, there are electronegative elements of groups 13 and 14. Thus, transition elements form a bridge between highly electropositive and highly electronegative elements. So, d-block elements are called **transition elements**.

[Transition elements are said to have incompletely filled d-orbital. So, Zn, Cd and Hg can not be defined as transition elements as they have completely filled d-orbital. They do not exhibit most of the characteristic properties of transition elements. So, all the transition elements are d-block elements but all the d-block elements are not transition elements.]

The d-block elements can be divided into three distinct series –

1. **The first transition series :** Here, the last electron enters into 3d orbital. These elements belong to period 4. 3d transition series starts from Sc (Z = 21) and ends at Zn (Z = 30).
2. **The second transition series :** Here, the last electron enters the 4d orbital. These elements belong to period 5. 4d transition series starts from Y (Z = 39) and ends with Cd (Z = 48).
3. **The third transition series :** Here, the last electron enters the 5d orbital. These elements belong to period 6. 5d transition starts from La (Z = 57) and ends at Hg (Z = 80).

General properties of transition elements :

1. **Metallic character :** All the transition elements are metals. All of them (except Hg) are hard, malleable and ductile. All of them possess high tensile strength. Their metallic character is due to
   - Their relatively lower ionisation energies.
   - Presence of a few valence electrons and empty valence orbitals.
   - These are good conductors of heat and electricity.
2. **Colour :** Transition metals form coloured compounds.
3. **Variable valency :** The transition elements show variable oxidation states.
4. **Catalytic property :** All the transition metals and their compounds are used as catalysts.
5. **Magnetic property :** Because of the presence of one or more unpaired electrons, most of the transition metals are paramagnetic.
6. **Complex compounds :** All the transition metals form complex compounds.
7. They form ionic as well as covalent compounds.

3.14.4 f-block elements

The elements in which the last electron enters into (n-2)f subshell are known as **f-block elements**. The f-orbitals of (n – 2) subshell is gradually filled up whereas ns orbital remains completely filled and the d-orbital of (n – 1) shell invariably contains zero or 1 electron. This f-orbital can accommodate fourteen electrons. Their electronic configuration is $(n-2)f^{1-14}(n-1)d^{0-1}ns^2$. The f-block elements can be divided into two series –

1. **4f series :** In the 6th period, there are fourteen elements where 4f orbital is gradually filled up. This series starts from Ce (Z = 58, $4f^15d^16s^2$) and ends with Lu (Z = 71, $4f^{14}5d^16s^2$). These are called **lanthanides**.
2. **5f series :** In the 7th period, again there are fourteen elements where 5f orbital is gradually filled up. This series starts from Th (Z = 90, $5f^06d^27s^2$) and ends at Lr (Z = 103, $5f^{14}5d^16s^2$). These are called **actinides**. All these actinides are radioactive. The first three members of the actinide family, i.e., Th (Z = 90), Pa (Z = 91) and U (Z = 92) are found in nature, but all others are man-made elements.

The lanthanides and actinides are also called **inner transition elements** or **rare earth elements**.

General properties of f-block elements

1. All the lanthanides and actinides are heavy metals. They are all good conductors of heat and electricity.
2. They have high densities. The density increases with increase in atomic weight.
3. They have very high melting and boiling points.
4. They have low ionisation potential values. So they are strong reducing agents as they readily lose electrons.
5. Most of the lanthanide ions are coloured.
6. They form complex compounds, most of which are coloured.
7. They are paramagnetic due to the presence of unpaired electrons.
8. They form mostly ionic compounds.

3.14.5 Advantages of Long form of Periodic Table

1. The position of some elements which are misfit on the basis of atomic mass is now justified on the basis of atomic numbers. For example, argon (atomic mass 39.9) preceeds potassium (atomic mass 39.1) because argon has atomic numbers 18 and potassium has 19.
2. The gradual change in properties along the periods and groups can be interperted by considering the electronic configuration i.e., atomic members. This long form of the periodic table actually stands on **Aufbau principle**.
3. The A and B sub-group elements are placed separately.
4. The trids were placed in Gr. VIII of Mendeleev's periodic table, but there was no justification for this. In modern periodic table, they are separately grouped. They have the general electronic configurations $(n-1)d^6ns^2$, $(n-1)d^7ns^2$ and $(n-1)d^8ns^2$ and they are placed in three consecutive groups.
5. The fourteen lanthanides are forced to be placed in a single room. In terms of electronic configurations of the (n – 2) f (i.e., 4f) sub-level, the fourteen lanthanides have got fourteen rooms characterised by $4f^1$, $4f^2$, $4f^{14}$.