

8. THE d & f BLOCK ELEMENTS

**HAIZEL G. ROY
H.S.S.T. (HG) CHEMISTRY
GOVT. H.S.S. KALAMASSERY
ERNAKULAM**

THE TRANSITION ELEMENTS (d-BLOCK)

- The elements belonging to groups 3-12 are known as d block elements or transition elements.
- Transition elements are placed in between s block and p block.
- In transition elements, a transition from metallic to non-metallic character takes place.
- They have incompletely filled d-orbitals in its ground state or in any one of its oxidation states.



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- **Zinc, cadmium and mercury are not regarded as transition metals.**
 - **It is due to the completely filled d^{10} configuration in their ground state as well as in their common oxidation states.**

TRANSITION ELEMENTS (d-BLOCK)

21 Sc Scandium 44.956	22 Ti Titanium 47.88	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.933	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.39
39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.411
	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.967	80 Hg Mercury 200.59
	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [269]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]

ELECTRONIC CONFIGURATION OF d-BLOCK ELEMENTS

- **The general outer electronic configuration of d-block elements is $(n-1)d^{1-10} ns^{1-2}$.**
- **The $(n-1)$ stands for the inner d orbitals which may have 1 to 10 electrons.**
- **The outermost ns orbitals may have one or two electrons.**
- **The d block elements consist of four rows of elements.**
- **These rows are called first, second, third and fourth transition series.**
- **They involve the filling of 3d, 4d, 5d and 6d orbitals respectively.**

ELECTRONIC CONFIGURATION OF d-BLOCK ELEMENTS

- **3d series Sc (21) to Zn (30)**
- **4d series Y (39) to Cd (48)**
- **5d series La (57) and Hf (72) to Hg (80)**
- **6d series Ac (89) and elements 104 to 112**



TRANSITION SERIES

FIRST TRANSITION SERIES (3d series)

- **Scandium, Titanium, Vanadium, Chromium, Manganese, Iron, Cobalt, Nickel, Copper and Zinc.**

SECOND TRANSITION SERIES (4d series)

- **Yttrium, Zirconium, Niobium, Molybdenum, Technetium, Ruthenium, Rhodium, Palladium, Silver, Cadmium**

TRANSITION SERIES

THIRD TRANSITION SERIES (5d series)

- Lanthanum, Hafnium, Tantalum, Tungsten, Rhenium, Osmium, Iridium, Platinum, Gold, Mercury

FOURTH TRANSITION SERIES (6d series)

- Actinium, Rutherfordium, Dubnium, Seaborgium, Bohrium, Hassium, Meitnerium, Darmstadtium, Roentgenium, Copernicium.

3d series		4d series		5d series		6d series	
E	E.C	E	E.C	E	E.C	E	E.C
²¹ Sc	[Ar]3d ¹ 4S ²	³⁹ Y	[Kr]4d ¹ 5S ²	⁵⁷ La	[Xe]5d ¹ 6S ²	⁸⁹ Ac	[Rn]5f ⁰ 6d ¹ 7S ²
²² Ti	[Ar]3d ² 4S ²	⁴⁰ Zr	[Kr]4d ² 5S ²	⁷² Hf	[Xe]5d ² 6S ²	¹⁰⁴ Rf	[Rn]5f ¹⁴ 6d ¹ 7S ²
²³ V	[Ar]3d ³ 4S ²	⁴¹ Nb	[Kr]4d ⁴ 5S ¹	⁷³ Ta	[Xe]5d ³ 6S ²	¹⁰⁵ Db	[Rn]5f ¹⁴ 6d ² 7S ²
²⁴ Cr	[Ar]3d ⁵ 4S ¹	⁴² Mo	[Kr]4d ⁵ 5S ¹	⁷⁴ W	[Xe]5d ⁴ 6S ²	¹⁰⁶ Sg	[Rn]5f ¹⁴ 6d ³ 7S ²
²⁵ Mn	[Ar]3d ⁵ 4S ²	⁴³ Tc	[Kr]4d ⁵ 5S ²	⁷⁵ Re	[Xe]5d ⁵ 6S ²	¹⁰⁷ Bh	[Rn]5f ¹⁴ 6d ⁴ 7S ²
²⁶ Fe	[Ar]3d ⁶ 4S ²	⁴⁴ Ru	[Kr]4d ⁷ 5S ¹	⁷⁶ Os	[Xe]5d ⁶ 6S ²	¹⁰⁸ Hs	[Rn]5f ¹⁴ 6d ⁵ 7S ²
²⁷ Co	[Ar]3d ⁷ 4S ²	⁴⁵ Rh	[Kr]4d ⁸ 5S ¹	⁷⁷ Ir	[Xe]5d ⁷ 6S ²	¹⁰⁹ Mt	[Rn]5f ¹⁴ 6d ⁶ 7S ²
²⁸ Ni	[Ar]3d ⁸ 4S ²	⁴⁶ Pd	[Kr]4d ¹⁰ 5S ⁰	⁷⁸ Pt	[Xe]5d ⁹ 6S ¹	¹¹⁰ DS	[Rn]5f ¹⁴ 6d ⁷ 7S ²
²⁹ Cu	[Ar]3d ¹⁰ 4S ¹	⁴⁷ Ag	[Kr]4d ¹⁰ 5S ¹	⁷⁹ Au	[Xe]5d ¹⁰ 6S ¹	¹¹¹ Rg	[Rn]5f ¹⁴ 6d ¹⁰ 7S ¹
³⁰ Zn	[Ar]3d ¹⁰ 4S ²	⁴⁸ Cd	[Kr]4d ¹⁰ 5S ²	⁸⁰ Hg	[Xe]5d ¹⁰ 6S ²	¹¹² Cn	[Rn]5f ¹⁴ 6d ¹⁰ 7S ²

GENERAL PROPERTIES OF TRANSITION ELEMENTS

1. METALLIC CHARACTER

- **All the transition elements are metals.**
- **This is due to their low ionisation energy and also due to the incompletely filled d orbitals.**
- **They are good conductors of heat and electricity, since the valence electrons are highly mobile.**
- **They have high tensile strength, ductility, malleability, lustre and relatively high densities.**

2. MELTING AND BOILING POINTS

- **The melting and boiling points of transition metals are high.**
- **This is due to the strong metallic bonds between the atoms of these elements.**
- **Greater the number of unpaired electrons, stronger the bonding and consequently melting points are high.**

3. OXIDATION STATES

- **Most of the transition elements show variable oxidation states.**
- **This is due to the participation of penultimate $(n-1)$ d electrons as well as ultimate 'ns' electrons in chemical combination.**
- **The highest oxidation states are found in compounds of fluorine and oxygen.**
- **This is due to the high electronegativity values and small size of F and O.**
- **The highest oxidation state shown by any transition metal is eight.**

PROMINENT FEATURES OF OXIDATION STATES

- For the elements of the first transition series (except Sc), the most common oxidation state is +2.
- In each transition series, the oxidation state reaches a maximum value near the centre of the series and then decreases as we move towards the right of the series.
- Within a group, the highest oxidation state increases with increase in atomic number.
- In lower oxidation states, +2 and +3, the transition metal form ionic bonds.
- But in higher oxidation states, the bonds formed are essentially covalent.



4. CATALYTIC PROPERTIES

- Many transition metals and their compounds are good catalysts.
- Finely divided Iron (Spongy Iron) is used as a catalyst in the manufacture of ammonia by Haber process.
- V_2O_5 or Pt is used in contact process for the manufacture of H_2SO_4 .

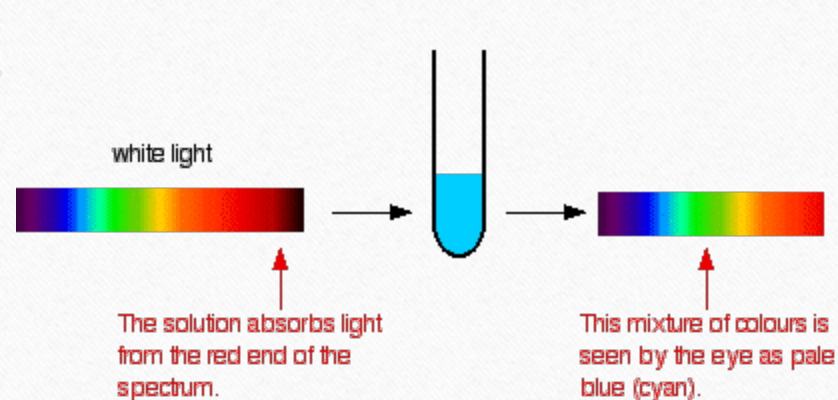
REASON FOR THE CATALYTIC PROPERTY

- **The catalytic activity of transition metal is due to the following reasons.**
- **(i) Variable valencies enable transition metals to form unstable intermediate compounds readily.**
- **(ii) Catalysts provides a new path with lower activation energy for the reaction.**
- **(iii) Transition metals can provide a large surface area for the reactants to be adsorbed.**

5. FORMATION OF COLOURED IONS

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- **Most of the transition metal compounds are coloured both in the solid state and in aqueous solution.**
 - **The unpaired d electrons of transition metal ions can undergo d–d transition.**
 - **An electron from a lower energy d orbital is excited to a higher energy d- orbital.**
 - **The energy of excitation corresponds to the frequency of light absorbed.**
 - **This frequency generally lies in the visible region.**

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- The colour observed corresponds to the complementary colour of the light absorbed.
 - Eg: Hydrated cupric compounds absorb red light and the transmitted colour is greenish blue.



E	Valence E.C.	E.C Box diagram	Metal ion	Valence EC of ion	E.C Box diagram	Colour
$_{21}\text{Sc}$	$3d^1 4s^2$		Sc^{3+}	$3d^0 4s^0$		Colourless
$_{22}\text{Ti}$	$3d^2 4s^2$		Ti^{4+}	$3d^0 4s^0$		Colourless
$_{22}\text{Ti}$	$3d^2 4s^2$		Ti^{3+}	$3d^1 4s^0$		Purple
$_{23}\text{V}$	$3d^3 4s^2$		V^{4+}	$3d^1 4s^0$		Blue
$_{23}\text{V}$	$3d^3 4s^2$		V^{3+}	$3d^2 4s^0$		Green
$_{24}\text{Cr}$	$3d^5 4s^2$		Cr^{3+}	$3d^3 4s^0$		Violet
$_{25}\text{Mn}$	$3d^5 4s^2$		Mn^{3+}	$3d^4 4s^0$		Violet
$_{25}\text{Mn}$	$3d^5 4s^2$		Mn^{2+}	$3d^5 4s^0$		Pink
$_{26}\text{Fe}$	$3d^6 4s^2$		Fe^{3+}	$3d^5 4s^0$		Yellow
$_{26}\text{Fe}$	$3d^6 4s^2$		Fe^{2+}	$3d^6 4s^0$		Green
$_{27}\text{Co}$	$3d^7 4s^2$		Co^{2+}	$3d^7 4s^0$		pink
$_{28}\text{Ni}$	$3d^8 4s^2$		Ni^{2+}	$3d^8 4s^0$		green
$_{29}\text{Cu}$	$3d^{10} 4s^2$		Cu^{2+}	$3d^9 4s^0$		blue
$_{30}\text{Zn}$	$3d^{10} 4s^2$		Zn^{2+}	$3d^{10} 4s^0$		Colourless

6. COMPLEX FORMATION

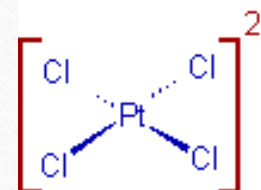
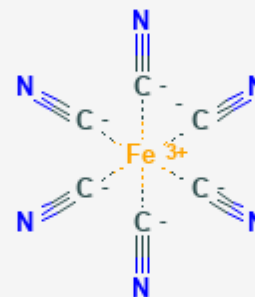
Transition metal forms a large number of complexes.

- **It is due to**
- **their small size**
- **high effective nuclear charge**
- **availability of vacant d orbitals of suitable energy for bonding with molecules or ions containing pairs of electrons.**



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- In complexes, the transition metal ions bind to a number of anions or neutral molecules by coordinate bonds.

- Eg: $[\text{Fe}(\text{CN})_6]^{3-}$, $[\text{Cu}(\text{NH}_3)]^{4+}$, $[\text{PtCl}_4]^{2-}$, $[\text{Ag}(\text{NH}_3)_2]^+$



7. MAGNETIC PROPERTIES

- Many transition metals and their compounds exhibit magnetic properties.
- Paramagnetism, diamagnetism and ferromagnetism are found in transition metal compounds.
- The substances which are weakly attracted by a magnetic field are called paramagnetic substances.



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- **Paramagnetism is caused by the presence of unpaired electrons.**
 - **Transition metals contain unpaired electrons, and are paramagnetic.**
 - **The paramagnetism is expressed in terms of magnetic moment.**
 - **Magnetic Moment, $\mu = \sqrt{n(n+2)}$ Where n is the number of unpaired electrons.**

Ion	EC	No of unpaired electron	Magnetic moment	
			observed	calculated $\mu = \sqrt{n(n+2)}$
Sc ³⁺	3d ⁰	0	0	0
Ti ³⁺	3d ¹	1	1.75	1.73
V ³⁺	3d ²	2	2.76	2.83
Cr ³⁺	3d ³	3	3.80	3.87
Mn ²⁺	3d ⁵	5	5.96	5.92
Fe ²⁺	3d ⁶	4	5.3-5.5	4.90
Co ²⁺	3d ⁷	3	4.4-5.2	3.87
Ni ²⁺	3d ⁸	2	2.9-3.4	2.84
Cu ²⁺	3d ⁹	1	1.8-2.2	1.73
Zn ²⁺	3d ¹⁰	0	0	0

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- The substances which are weakly repelled by a magnetic field are called **diamagnetic substances**.
 - Diamagnetism is due to the presence of pairs of electrons with opposite spin.
 - **Ferromagnetism** is a special type of paramagnetism in which permanent magnetic moment is acquired by substances.
 - They can retain magnetism even after they are removed from the applied magnetic field.



8. INTERSTITIAL COMPOUNDS

- **When small atoms like H, C or N are trapped inside the crystal lattices of metals, Interstitial compounds are formed.**
- **They are prepared by heating together the transition metal and the non-metal.**
- **The non-metallic atoms occupy the voids between the larger metal atoms in the metallic lattice and also form bonds with them.**
- **The interstitial compounds are non-stoichiometric compounds.**

9. ALLOY FORMATION

- **The transition metals have almost similar atomic sizes.**
- **Metals can mutually substitute their positions in the crystal lattice, giving solid solutions called alloys.**
- **Transition metals are miscible with each other in the molten state.**
- **On cooling, transition metal alloys are formed.**
- **The alloys so formed are harder and more resistant to corrosion than the parent metals.**

SOME IMPORTANT COMPOUNDS OF TRANSITION ELEMENTS

1. POTASSIUM DICHROMATE

- Potassium dichromate is a very important chemical used in leather industry.
- It is used as an oxidant for the preparation of many azo compounds.



PREPARATION

- Potassium Dichromate is prepared from chromite ore (FeCr_2O_4).

a) Conversion of chromite ore to sodium chromate

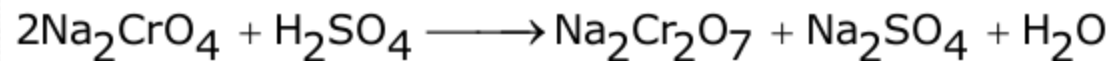
- The chromite ore is fused with Na_2CO_3 or K_2CO_3 in presence of air.



b) Conversion of sodium chromate to sodium dichromate



- **The yellow solution of sodium chromate is filtered and acidified with dilute H_2SO_4 .**



c) Conversion of sodium dichromate to potassium dichromate

- A hot concentrated solution of dichromate is treated with KCl.
- NaCl being less soluble, precipitates out from the hot solution.
- It is removed by filtration.
- On cooling the mother liquor, orange crystals of $\text{K}_2\text{Cr}_2\text{O}_7$ separate out..

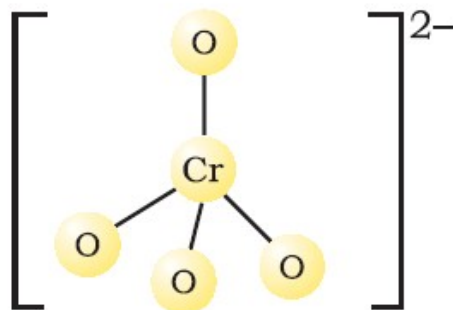
COLOUR OF CHROMATE ION AND DICHROMATE ION IN ACIDIC AND BASIC MEDIUM

- The chromates and dichromates are inter convertible in aqueous solution depending upon the pH of the solution.
- In acid medium, potassium dichromate is orange in colour
- In basic medium it is yellow in colour.

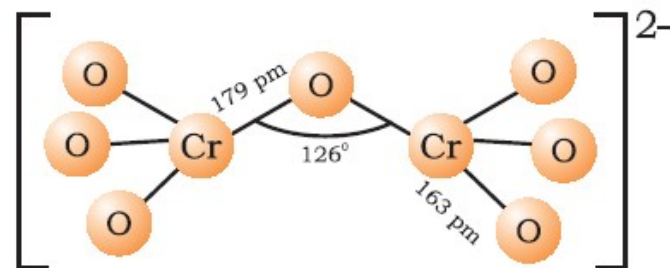


STRUCTURE OF CHROMATE ION AND DICHROMATE ION

- The chromate ion is tetrahedral.
- The dichromate ion consists of two tetrahedron sharing an oxygen atom at the common corner.



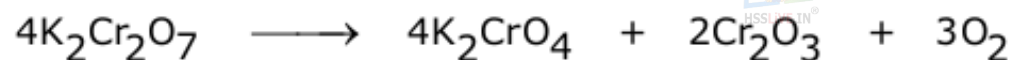
Chromate ion



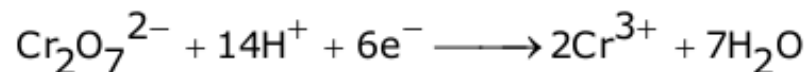
Dichromate ion

REACTIONS OF POTASSIUM DICHROMATE

1. On heating, $\text{K}_2\text{Cr}_2\text{O}_7$ decomposes to give potassium chromate, chromic oxide and oxygen.

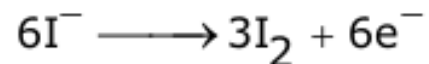


2. It act as a powerful oxidising agent in acidic medium.

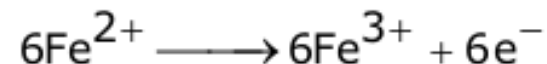


TYPICAL OXIDATION REACTIONS OF ACIDIFIED POTASSIUM DICHROMATE

a) It oxidises Iodide to Iodine.



b) It oxidises ferrous salts to ferric salts.



c) It oxidises Hydrogen sulphide to Sulphur. $3\text{H}_2\text{S} \longrightarrow 6\text{H}^+ + 3\text{S} + 6\text{e}^-$

d) It oxidises tin(II) to tin(IV). $3\text{Sn}^{2+} \longrightarrow 3\text{Sn}^{4+} + 6\text{e}^-$

USES OF POTASSIUM DICHROMATE

- $\text{K}_2\text{Cr}_2\text{O}_7$ is used as a powerful oxidising agent.
- It is used as a laboratory reagent in volumetric analysis.
- It is used in leather industry.
- It is used as an oxidant for the preparation of many azo compounds.

2. POTASSIUM PERMANGANATE

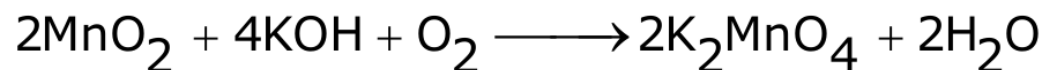
- Potassium permanganate is a purple coloured crystalline solid.
- It is used as a disinfectant.
- It is used to treat a variety of skin conditions including fungal infections.



PREPARATION

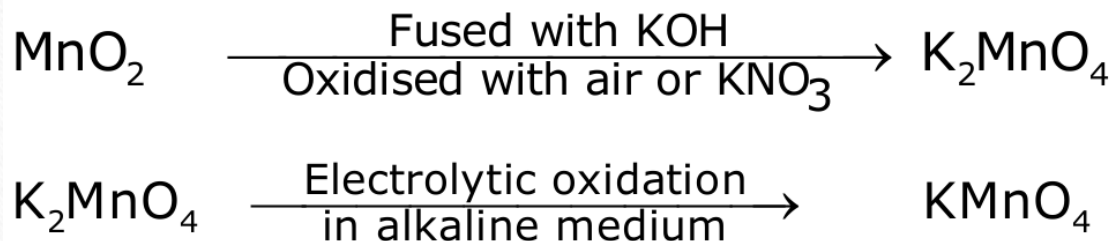
A) From Pyrolusite Ore

- Potassium permanganate is prepared from Pyrolusite ore (MnO_2).
- Pyrolusite is fused with KOH and an oxidising agent like KNO_3 .
- This produces the dark green coloured potassium manganate, K_2MnO_4 .
- It disproportionates in a neutral or acidic solutions to give permanganate.



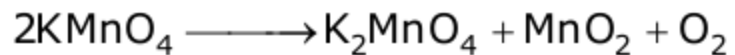
COMMERCIAL PREPARATION

- Commercially KMnO_4 is prepared by the alkaline oxidative fusion of MnO_2 followed by the electrolytic oxidation of manganate (VI).



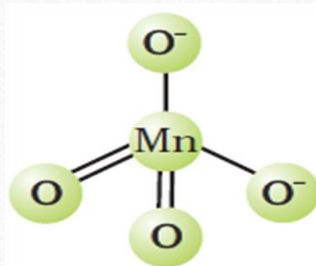
PROPERTIES

- **KMnO_4 is a purple coloured crystalline solid.**
- **It is fairly soluble in water.**
- **It is a very powerful oxidising agent in acidic, alkaline and neutral media.**
- **On heating, KMnO_4 decomposes at 513K.**

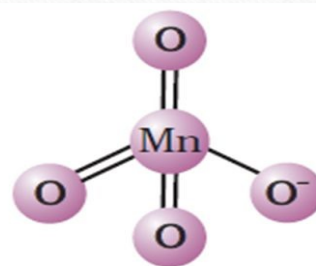


STRUCTURES OF MANGANATE AND PERMANGANATE IONS

- The manganate and permanganate ions are tetrahedral.
- Manganate ion is paramagnetic with one unpaired electron
- Permanganate ion is diamagnetic.



Tetrahedral
manganate
(green) ion



Tetrahedral
permanganate
(purple) ion

IMPORTANT OXIDATION REACTIONS OF ACIDIFIED KMnO_4

1. IN ACID SOLUTIONS

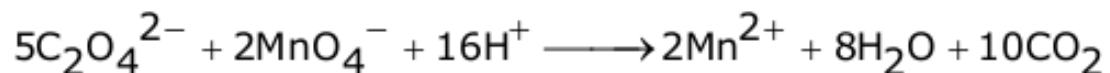
a) Iodine is liberated from potassium iodide.



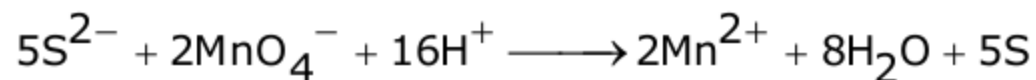
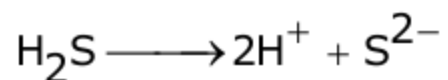
b) Fe^{2+} ion (green) is converted to Fe^{3+} (yellow)



c) Oxalate ion or Oxalic acid is oxidized at 333K.



d) H_2S is oxidised, sulphur being precipitated.



e) Sulphurous acid or sulphite is oxidised to a sulphate or sulphuric acid.

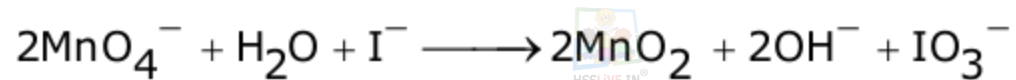


f) Nitrite ion is oxidised to nitrate.



2. IN NEUTRAL OR FAINTLY ALKALINE SOLUTIONS

a) Oxidation of Iodide to Iodate.

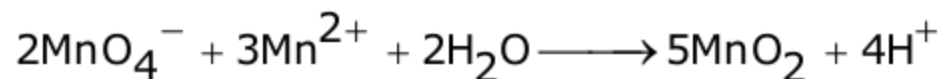


b) Thiosulphate is oxidized almost quantitatively to sulphate.



c) Manganous salt is oxidized to MnO_2 .

The presence of Zinc Sulphate or ZnO catalysis the oxidation.



USES OF POTASSIUM PERMANGANATE

- KMnO_4 is used as a powerful oxidising agent.
- It is used as a laboratory reagent in volumetric analysis.
- It is used for bleaching wool, cotton, silk and other textile fibres.
- It is used for the decolourisation of oils.

THE INNER TRANSITION ELEMENTS (f-BLOCK)

F-BLOCK BLOCK ELEMENTS

- The elements in which the last electron enters the f orbitals of their atoms are called f-block elements.
- In these elements, the last electron is added to the f-orbital of the antipenultimate shell. i.e., $(n-2)f$.
- These elements are also called inner transition elements.
- They consist of two series of elements namely lanthanides and actinides.

4f →	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
5f →	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

LANTHANIDES

57 La lanthanum 138.905 $4f^0 5d^1 6s^2$	58 Ce Cerium 140.116 $4f^2 5d^0 6s^2$	59 Pr Praseodymium 140.908 $4f^3 5d^0 6s^2$	60 Nd Neodymium 144.243 $4f^4 5d^0 6s^2$	61 Pm Promethium 144.913 $4f^5 5d^0 6s^2$	62 Sm Samarium 150.360 $4f^6 5d^0 6s^2$	63 Eu Europium 151.964 $4f^7 5d^0 6s^2$	64 Gd Gadolinium 157.250 $4f^7 5d^1 6s^2$
65 Tb Terbium 158.925 $4f^9 5d^0 6s^2$	66 Dy Dysprosium 162.500 $4f^{10} 5d^0 6s^2$	67 Ho Holmium 164.930 $4f^{11} 5d^0 6s^2$	68 Er Erbium 167.259 $4f^{12} 5d^0 6s^2$	69 Tm Thulium 168.934 $4f^{13} 5d^0 6s^2$	70 Yb Ytterbium 173.055 $4f^{14} 5d^0 6s^2$	71 Lu Lutetium 174.967 $4f^{14} 5d^1 6s^2$	

ACTINIDES

89 Ac Actinium 227.028 $5f^0 6d^1 7s^2$	90 Th Thorium 232.038 $5f^0 6d^1 7s^2$	91 Pa Protactinium 231.036 $5f^2 6d^1 7s^2$	92 U Uranium 238.029 $5f^3 6d^1 7s^2$	93 Np Neptunium 237.048 $5f^4 6d^1 7s^2$	94 Pu Plutonium 244.064 $5f^6 6d^0 7s^2$	95 Am Americium 243.061 $5f^7 6d^0 7s^2$	96 Cm Curium 247.070 $5f^7 6d^1 7s^2$
97 Bk Berkelium 247.070 $5f^8 6d^1 7s^2$	98 Cf Californium 251.080 $5f^{10} 6d^0 7s^2$	99 Es Einsteinium 254 $5f^{11} 6d^0 7s^2$	100 Fr Fermium 257.095 $5f^{12} 6d^0 7s^2$	101 Md Mendelevium 258.100 $5f^{13} 6d^0 7s^2$	102 No Nobelium 259.101 $5f^{14} 6d^0 7s^2$	103 Lw Lawrencium 262 $5f^{14} 6d^1 7s^2$	

ELECTRONIC CONFIGURATION

- The general electronic configuration is $(n-2)f^{1-14} (n-1)d^{0-1} ns^2$.
- Inner 4f and 5f orbitals are progressively filled.
- The extra stability of half-filled orbitals is seen in the elements Europium ($4f^7 6s^2$) and Gadolinium ($4f^7 5d^1 6s^2$).
- Ytterbium ($4f^{14} 6s^2$) and Lutetium ($4f^{14} 5d^1 6s^2$) show the stability of completely filled f orbitals.
- Lanthanum, Gadolinium and Lutetium have a single electron in 5d orbitals.
- The other lanthanides do not have electrons in the 5d orbitals.

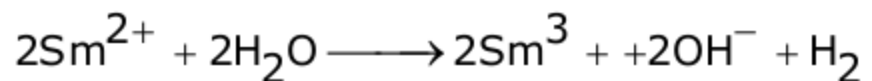
OXIDATION STATES

- The most common and the most stable oxidation state of the lanthanides is +3.
- Cerium and Terbium also exhibit +4 oxidation states.
- An aqueous solution of Ce^{4+} is a good oxidising agent.



OXIDATION STATES

- Some of the elements exhibit +2 oxidation states also.
- Aqueous solutions of Sm^{2+} , Eu^{2+} and Yb^{2+} are good reducing agents.



- The actinides exhibit several oxidation states.
- +3 oxidation state is most common in actinides.
- Actinoids exhibit higher oxidation states from +4 to +7.
- This is because 5f, 6d, and 7s subshells have nearly equal energies.

Atomic No.	Element	Symbol	Oxidation states	Electronic Configuration	
				Lanthanoid (Ln)	Lanthanoid ion (Ln ³⁺)
57	Lanthanum	La	+3	[Xe] 5d ¹ 6S ²	[Xe] 4f ⁰
58	Cerium	Ce	+3, +4	[Xe] 4f ² 6S ²	[Xe] 4f ¹
59	Praseodymium	Pr	+3, +4	[Xe] 4f ³ 6S ²	[Xe] 4f ²
60	Neodymium	Nd	+2, +3, +4	[Xe] 4f ⁴ 6S ²	[Xe] 4f ³
61	Promethium	Pm	+3	[Xe] 4f ⁵ 6S ²	[Xe] 4f ⁴
62	Samarium	Sm	+2, +3	[Xe] 4f ⁶ 6S ²	[Xe] 4f ⁵
63	Europium	Eu	+2, +3	[Xe] 4f ⁷ 6S ²	[Xe] 4f ⁶
64	Gadolinium	Gd	+3	[Xe] 4f ⁷ 5d ¹ 6S ²	[Xe] 4f ⁷
65	Terbium	Tb	+3, +4	[Xe] 4f ⁹ 6S ²	[Xe] 4f ⁸
66	Dysprosium	Dy	+3, +4	[Xe] 4f ¹⁰ 6S ²	[Xe] 4f ⁹
67	Holmium	Ho	+3	[Xe] 4f ¹¹ 6S ²	[Xe] 4f ¹⁰
68	Erbium	Er	+3	[Xe] 4f ¹² 6S ²	[Xe] 4f ¹¹
69	Thulium	Tm	+2, +3	[Xe] 4f ¹³ 6S ²	[Xe] 4f ¹²
70	Ytterbium	Yb	+2, +3	[Xe] 4f ¹⁴ 6S ²	[Xe] 4f ¹³
71	Lutetium	Lu	+3	[Xe] 4f ¹⁴ 5d ¹ 6S ²	[Xe] 4f ¹⁴

Atomic No.	Element	Symbol	Oxidation States	Electronic Configuration	
				Actinoid	Actinoid ion (M^{3+} ion)
89	Actinium	Ac	+3	$[Rn] 6d^1 7s^2$	$[Rn] 5f^0$
90	Thorium	Th	+3, +4	$[Rn] 6d^2 7s^2$	$[Rn] 5f^1$
91	Protactinium	Pa	+3, +4, +5	$[Rn] 5f^2 6d^1 7s^2$	$[Rn] 5f^2$
92	Uranium	U	+3, +4, +5, +6	$[Rn] 5f^3 6d^1 7s^2$	$[Rn] 5f^3$
93	Neptunium	Np	+3, +4, +5, +6, +7	$[Rn] 5f^4 6d^1 7s^2$	$[Rn] 5f^4$
94	Plutonium	Pu	+3, +4, +5, +6, +7	$[Rn] 5f^6 7s^2$	$[Rn] 5f^5$
95	Americium	Am	+3, +4, +5, +6	$[Rn] 5f^7 7s^2$	$[Rn] 5f^6$
96	Curium	Cm	+3, +4	$[Rn] 5f^7 6d^1 7s^2$	$[Rn] 5f^7$
97	Berkelium	Bk	+3, +4	$[Rn] 5f^8 6d^1 7s^2$	$[Rn] 5f^8$
98	Californium	Cf	+2, +3	$[Rn] 5f^{10} 7s^2$	$[Rn] 5f^9$
99	Einsteinium	Es	+2, +3	$[Rn] 5f^{11} 7s^2$	$[Rn] 5f^{10}$
100	Fermium	Fm	+2, +3	$[Rn] 5f^{12} 7s^2$	$[Rn] 5f^{11}$
101	Mendelivium	Md	+2, +3	$[Rn] 5f^{13} 7s^2$	$[Rn] 5f^{12}$
102	Nobelium	No	+2, +3	$[Rn] 5f^{14} 7s^2$	$[Rn] 5f^{13}$
103	Lawrencium	Lr	+3	$[Rn] 5f^{14} 6d^1 7s^2$	$[Rn] 5f^{14}$

COLOUR OF LANTHANIDES

- Many trivalent lanthanoid ions are coloured both in the solid state and in aqueous solutions.
- Colour of these ions is due to the presence of 'f' electrons.
- Neither La^{3+} nor Lu^{3+} ion shows any colour.

MAGNETIC PROPERTIES OF LANTHANIDES

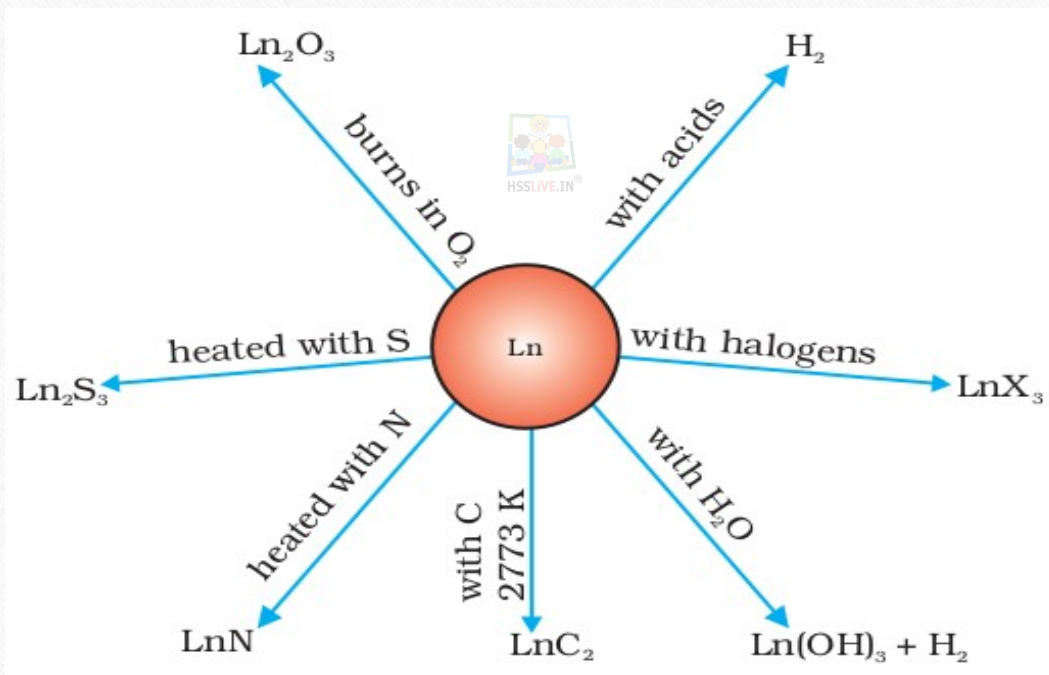
- The lanthanoid ions other than the f^0 type (La^{3+} and Ce^{4+}) and the f^{14} type (Yb^{2+} and Lu^{3+}) are all paramagnetic.
- The paramagnetism rises to maximum in neodymium.



PHYSICAL PROPERTIES

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- **The lanthanides and actinides have high density and high melting points.**
 - **A well-known alloy of lanthanides and actinides is 'Misch Metal'.**
 - **It consists of a rare earth element (94-95%), Iron (upto 5%) and traces of sulphur, carbon, calcium and aluminium.**
 - **It is pyrophoric (ignites spontaneously in air) and used in cigarette & gas lighters, tracer bullets, shells etc.**
 - **3% misch metal is added to magnesium for making jet engine parts with an increased strength.**

CHEMICAL PROPERTIES



LANTHANIDE CONTRACTION

- **In the lanthanide series, with the increase in atomic number, there is a regular decrease in the size of the atoms and ions from lanthanum to lutetium.**
- **The contraction of atomic and ionic size along the period of lanthanide elements from Lanthanum to Lutetium is known as lanthanide contraction.**

CAUSE OF LANTHANIDE CONTRACTION

- **Along the lanthanide series, the nuclear charge increases by one unit at each successive element.**
- **The new electron is added to the 4f orbitals.**
- **The shape of the f orbitals is much diffused.**
- **So the electrons in them cannot effectively shield the nuclear charge from the valence electrons.**
- **This ineffective shielding is unable to counter balance the effect of increased nuclear charge.**
- **Hence the net result is a contraction in size, though the decrease is very small.**

CONSEQUENCES OF LANTHANIDE CONTRACTION

- **Difficulty in the separation of lanthanides.**
- **Similarity in size of elements belonging to the second and third transition series.**
- **Eg: Zr (160 pm) and Hf (159 pm) have almost the same size.**
- **Due to this Zr and Hf have almost same chemical properties and hence their separation is difficult.**

ACTINIDE CONTRACTION

- **There is a gradual decrease in the size of atom or M^{3+} ions across the actinide series.**
- **This is called Actinide contraction.**
- **This results from the poor shielding by 5f electrons.**

GENERAL CHARACTERISTICS OF LANTHANIDES

- **All the lanthanides are silvery white soft metals and tarnish rapidly in air.**
- **The hardness increases with increasing atomic number.**
- **They are good conductors of heat and electricity.**
- **Many trivalent lanthanide ions are coloured both in solid state and in aqueous solutions.**
- **Colour of these ions may be due to the presence of f electrons.**
- **The lanthanide ions other than f^0 type and f^{14} type are all paramagnetic.**

APPLICATIONS OF d-BLOCK ELEMENTS

- **Iron and steels are the most important construction materials.**
- **TiO is used in pigment industry.**
- **MnO₂ is used in dry cells.**
- **Zn, Ni and Cd are used in battery industry.**
- **The elements of group II are used as coinage metals.**
- **Many of the d block elements are used as catalysts.**



APPLICATIONS OF f-BLOCK ELEMENTS

USES OF LANTHANIDES

-
- **Lanthanide oxides are used for polishing glass.**
 - **Cerium salts are used in dyeing cotton. They are also used as catalysts.**
 - **Lanthanide compounds are used as catalysts for hydrogenation, oxidation, petroleum cracking etc.**
 - **Misch metal is used in Mg-based alloy to produce bullets and shell.**
 - **Mixed oxides of lanthanoids are employed as catalysts in petroleum cracking.**
 - **Some individual Ln oxides are used as phosphors in television screens and similar fluorescing surfaces.**

USES OF ACTINIDES

- **Thorium oxide is used for making incandescent mantles.**
- **Thorium salts are used in medicines in the treatment of cancer.**
- **Uranium is used in the production of nuclear energy by the process of nuclear fission.**
- **Uranium salts are used in textile industry, ceramic industry as well as in medicines.**
- **Plutonium is used as a fuel in atomic reactors.**



Thank
you

