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12th Class Chemistry
d and f block elements

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The d- and f- Block elements

- **d- Block elements :-** Those elements in which last electron enters in d- orbital are called d- Block elements. These are also known as transition elements.

- **Transition element :-** A transition element is defined as the one which has incompletely filled d-orbitals in its ground state or in any of oxidation states.

  Note :- Zn, Cd, Hg of group 12 have full filled d- orbital [d^{10}] configuration and are not regarded as transition elements.

- **Series of transition metals :-**
  There are mainly three series of the transition. metals, i.e., 3d-Series [Sc to Zn]., 4d-Series [Y to Cd] and 5d- Series [La to Hg, omitting Ce to Lu].

The fourth series 6d which begins with Ac is still incomplete.

The two series of inner transition series 4f and 5f, which involve filling of f- orbitals are known as lanthanoids and actinoids respectively.

- **General Configuration :-**
  General electronic configuration of transition metals is $(n-1)\,d^{1-10}\,ns^{1-2}$.

Some Exceptions observed in electronic Configuration

=> Cr and Cu have five and ten electrons in 3d - orbitals rather than four and nine. because fully-filled and half-filled orbitals have lower energy and thus have extra Stability.

Cr : $3d^5 4s^1$

Cu : $3d^{10} 4s^1$

=> Zinc (Zn), Cadmium (Cd), mercury (Hg) are represented by a general formula $(n-1)d^{10} ns^2$. These are not regarded as transition metals due to completely filled d- orbitals.

3d - Series.

Atomic Number	Element	Symbol	Electronic Configuration	Oxidation State.
21	Scandium	Sc	$[Ar]\,3d^1\,4s^2$	+3
22	Titanium	Ti	$[Ar]\,3d^2\,4s^2$	+2, +3, +4
23	Vanadium	V	$[Ar]\,3d^3\,4s^2$	+2, +3, +4, +5.
24	chromium	Cr	$[Ar]\,3d^5\,4s^1$	+1, +2, +3, +4, +5, +6
25	Manganese	Mn	$[Ar]\,3d^5\,4s^2$	+2, +3, +4, +5, +6, +7
26	Iron	Fe	$[Ar]\,3d^6\,4s^2$	+2, +3, +4, +5, +6
27	Cobalt	Co	$[Ar]\,3d^7\,4s^2$	+2, +3, +4
28	Nickel	Ni	$[Ar]\,3d^8\,4s^2$	+2, +3, +4.
29	Copper	Cu	$[Ar]\,3d^{10}\,4s^1$	+1, +2
30	Zinc	Zn	$[Ar]\,3d^{10}\,4s^2$	+2

Properties of d-Block elements :-

1> Metallic character

=> All the transition elements exhibit metallic properties.
=> They are very much hard and have low volatility. (except Zn, Cd and Hg).
=> They have melting and boiling point due to strong metallic bonding.
=> Greater the number of valence electrons, stronger is the resultant bonding.
=> They have high enthalpy of atomisation.

2> Atomic radii :-

=> From Sc to Cr, atomic radii decreases because effective nuclear charge increases.
=> The atomic sizes ~~of~~ Fe, Co and Ni are almost same because pairing of electrons in d- orbitals causes repulsion.
=> The Atomic Size of Zinc is greater than copper due to Screening effect.

3> Density of the transition metals

from Sc to Cu increases due to high atomic mass and small atomic volume.

4> Ionisation enthalpy

Generally increases with increase in nuclear charge along each Series.
→ Sc has the lowest while Zn has the highest first ionization enthalpy.
→ Cu has the highest while Sc has the lowest second ionization enthalpy. [But Zn has highest 3rd Ionization enthalpy]

→ 3d Series

5> OXIDATION State :-

=> Transition metals show variable oxidation state due to participation of (n-1)d as well as ns electrons in bond formation.

=> The maximum oxidation states are shown by Mn, i.e. from +2 to +7 (in first series).

=> Sc shows only +3 oxidation state.

=> High oxidation state is shown by their fluorides and oxides because fluorine and oxygen are strong oxidising agents.

6> Electrode Potential :-

=> [A Potential difference developing between the electrode and the electrolyte is known as electrode potential].

=> The electrode potentials of first row of transition elements generally show an increase with increasing atomic numbers.

=> Electrode potential M^{2+}/M of a metal is dependent upon three parameters viz. enthalpy of atomisation, enthalpy of ionisation and enthalpy of hydration of M^{2+}.

=> Cu^{2+} is more stable than Cu^{+} due to lower reduction potential which is due to higher hydration energy.

=> Cu^{+} compounds are unstable in aqueous solution and undergo disproportionation.

$$2\,Cu^{+} \longrightarrow Cu^{2+} + Cu.$$

7> **Magnetic properties :-**

=> Most of the transition metals are paramagnetic due to the presence of unpaired electrons.

=> As paramagnetic character ∝ number of unpaired electron

=> The species having all paired electrons are diamagnetic in nature.

=> The magnetic field measured by magnetic moment.

=> The magnetic is determined by the formula,

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

where, n is the number of unpaired electrons.

and BM is Bohr magneton (unit of magnetic moment).

8> **Catalytic behaviour :-**

=> Most of the transition metals and their compounds are used as catalyst.

Because (i) They show variable oxidation state.

(ii) They have ability to form complexes.

Example :- V_2O_5 in contact process.

9) Tendency to form Complexes :-

=> Transition elements form complexes.

It is due to
(i) Small Size
(ii) high nuclear charge.
(iii) Higher charge on cation.
(iv) Presence of vacant d- orbital.

Example :- $[Fe(CN)_6]^{3-}$, $[Cu(NH_3)_4]^{2+}$ etc.

10) Formation of Coloured ions :-

=> Transition elements form Coloured ions due to the presence of unpaired electrons in d- orbitals as they can undergo d-d transition by absorbing colour from visible region and radiating Complementary Colour.

11) Formation of Interstitial compounds :-

=> Transition metals form interstitial compounds with elements such as [H, B, C, N etc].

=> These Small size atoms of non- metallic elements get trapped in vacant spaces of the lattices of the transition metal

The general characteristics of Interstitial compounds:-

(i) They have high melting point
(ii) They retain metallic Conductivity.
(iii) They are very hard.
(iv) They are chemically inert.

12> **Alloy formation :-**

=> They also form alloy due to Similar Size.
=> Alloys are formed by the atoms with metallic radii differ for about 15 percent from each other.
=> Becaus of Similar radii and other characteristics of transition metals, alloys are easily formed by these metals.

13> Transition elements have lower value of Reduction potential. due to irregular variation in ionisation energy, hydration energy etc.

14> Transition metal oxides in lowest oxidation state are basic, in intermediate oxidation state are amphoteric and in highest oxidation state are Acidic.

15> Transition metal halides in lower oxidation state are ionic and in higher oxidation state are covalent.
Mostly fluorides are ionic and chlorides and Bromides are covalent.