Topic-Electronic configuration and general properties of d – block elements.

Introduction – As you have studied earlier about d- block elements in your previous class,I would like to further discuss few more interesting facts about d – block elements

Objectives-

1.Know the electronic configuration of d- block elements.

2.Understand the general characteristics of d- block elements and group trends in them.

Theory –

Electronic configurations of d block elements

The 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 one to ten electrons and the outermost ns orbital may have one or two electrons.

General Properties of the Transition Elements (d-Block) Physical Properties

- **Metallic properties:** All theelements show metallic properties such as high tensile strength, ductility, malleability, high thermal and electrical conductivity and metallic lustre except Zn, Cd and Hg.

The trend in melting points of transition metals belonging to 3d, 4d and 5d series is shown by the following graph

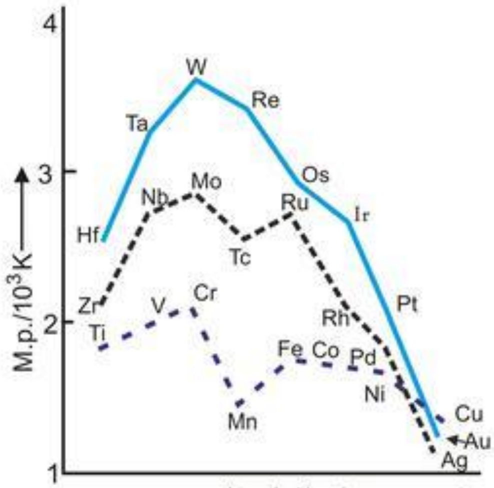

Fig. Trends in melting points of transition elements

The high melting points of these metals are attributed to the involvement of greater number of electrons from (n-1)d in addition to the ns electrons in the interatomic metallic bonding.

- In general, greater the number of valence electrons, stronger is the resultant bonding.
- Also, the metals of the second and third series have greater enthalpies of atomisation than the elements belonging to the first series.
- **Atomic and ionic sizes:** The atomic radii of the elements of 3d-series decreases as the atomic number increases.
    - The atomic radii increase from 3d to 4d. The atomic radii of the 4d and 5d transition series are very close due to lanthanoid contraction.
- **Ionisation enthalpy:** There is a slight and irregular variation in ionization energies of transition metals due to irregular variation of atomic size. The ionization enthalpy of 5d

transition series is higher than 3d and 4d transition series because of lanthanoid contraction.

- **Oxidation state:** Transition metals show variable oxidation states due to the tendency of (n-1)d as well as ns electrons to take part in bond formation.
    - Here, the common oxidation states of the first row transition elements are provided below:

(Sc)	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	(Zn)
								+1	
	+2	+2	+2	+2	+2	+2	+2	+2	+2
+3	+3	+3	+3	+3	+3	+3	+3	+3	
	+4	+4	+4	+4	+4	+4	+4		
		+5	+5	+5	+5	+5			
			+6	+6	+6				
				+7					

- **Magnetic Properties:** Most of transition metals are paramagnetic in nature due to the presence of unpaired electrons. It increases from Sc to Mn due to the increased number of unpaired electrons and then starts decreasing as the number of unpaired electrons decreases.
- **Formation of Coloured Ions:** They form coloured ions due to the presence of incompletely filled d-orbitals. They can undergo d-d transition by absorbing colour from visible region and radiating complementary colour.
    - A few coloured solutions of d-block elements are given:

Configuration	Example	Colour
$3d^0$	Sc^{3+}	colourless
$3d^0$	Ti^{4+}	colourless
$3d^1$	Ti^{3+}	purple
$3d^1$	V^{4+}	blue
$3d^2$	V^{3+}	green
$3d^3$	V^{2+}	violet
$3d^3$	Cr^{3+}	violet
$3d^4$	Mn^{3+}	violet
$3d^4$	Cr^{2+}	blue
$3d^5$	Mn^{2+}	pink
$3d^5$	Fe^{3+}	yellow
$3d^6$	Fe^{2+}	green
$3d^6 3d^7$	$Co^{3+} Co^{2+}$	bluepink
$3d^8$	Ni^{2+}	green
$3d^9$	Cu^{2+}	blue
$3d^{10}$	Zn^{2+}	colourless

- **Formation of complex compounds:** The transition metals form a large number of complex compounds. This is due to the comparatively smaller sizes of the metal ions, their high ionic charges and the availability of d orbitals for bond formation. For example: $[Fe(CN)6]3-$.
- **Catalytic properties:** Most of transition metals are used as catalyst because of (i) presence of incomplete or empty d-orbitals, (ii) large surface area, (iii) variable oxidation state, (iv) ability to form complexes, e.g., Fe, Ni, V2O3, Pt, Mo, Co are used as catalyst.
- **Formation of Interstitial Compounds:** Transition metals have voids or interstitials in which C, H, N, B etc. can fit in, resulting in the formation of interstitial compounds. They are non-stoichiometric, i.e., their composition is not fixed, e.g., steel. They are harder and less malleable and ductile.
- **Alloy formation:** Alloy is a homogeneous mixture of two or more metals. Due to the comparable size of transition metals,

one metal can displace other metal in the crystal lattice and this results in the alloy formation.

- The alloys so formed are hard and have high melting points.

	Alloy	Composition (%)
1.	Stainless	Fe = 73, Cr = 18, NI = 8, C (traces)
2.	Coinage alloy or Coinage silver	Ag = 92.5, Cu = 7.5
3.	Dental alloy	Ag = 33, Hg = 52, Sn = 12.5, Cu = 2, Zn = 0.5
4.	Brass	Cu = 80, Zn = 20
5.	Bronze	Cu = 80, Zn = 20
6.	Gun metal	Cu = 87, Sn = 10, Zn = 3
7.	Bell metal	Cu = 80, Sn =20
8.	German silver	Cu = 60, Zn = 20, NI = 20
9.	Duralumin	Al = 95, Cu = 4, Mg and Mn : 1%
10.	Misch metal	Ce(25%) + lanthanide metals + 5% Fe + traces of S, C, Si, Ca, Al

Questions-

Q1 .Why does copper not replace hydrogen from acids?

Answer:

Copper does not replace hydrogen from acids because Cu has a positive E° value, i.e., it is less reactive than hydrogen, which has an electrode potential of 0.0 V. So, Cu cannot replace hydrogen from acids.

Q2**.** Why is the first ionisation enthalpy of Cr is lower than that of Zn?

Answer:

Ionisation enthalpy of Cr is less than that of Zn because Cr has a stable configuration. In the case of zinc, the electron comes out from wholly filled 4s orbital. So, the removal of an electron from zinc requires more energy as compared to Cr.

Q3.Transition elements show high melting points. Why?

Answer:

The high melting points of transition metals are due to the involvement of a greater number of electrons of (n-1)d in addition to the ns electrons in the interatomic metallic bonding.

Q4. Although fluorine is more electronegative than oxygen, but the ability of oxygen to

stabilise higher oxidation states exceeds that of fluorine. Why?

Answer:

Oxygen can form multiple bonds with metals, while fluorine can’t form multiple bonds. Hence, oxygen has more ability to stabilise a higher oxidation state rather than fluorine.

ACTIVITY

QUIZ QUESTIONS

1.The pair that has similar atomic radii is

[A] Mn and Re

[B] Ti and Hf

[C] Sc and Ni

[D] Mo and W

2.The number of unpaired electrons in gaseous species of Mn^{3+}, Cr^{3+} and V^{3+} respectively are:

[A] 4, 4 and 2

[B] 3, 3 and 2

[C] 4, 3 and 2

[D] 3, 3 and 3

3.Gun metal is an alloy of:

[A] Cu and Al

[B] Cu and Sn

[C] Cu, Zn and Sn

[D] Cu, Zn and Ni

4.Zinc and mercury do not show variable valency like d-block elements because

[A] they are soft

[B] their d-shells are complete

[C] they have only two electrons in the outermost subshell

[D] their d-shells are incomplete