B.Sc. (Honours) Part-II

Paper-IIIA

Topic: Introductory of Transition Metal

UG

Subject-Chemistry

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Introductory Transition Elements

The d-block elements have been defined as "the elements whose atoms receive the last electron in the d-subshell belonging to the penultimate or $(n-1)^{th}$ shell". The d-block elements are also called the transition elements or metals. This is because they exhibit gradual transitional behaviour between highly reactive s-block. (electropositive) and p-block (electronegative) elements, i.e. their properties have been found to be intermediate between those of the s-block and p-block elements. Thus these elements are located in the middle of the periodic table and are the members of the Groups 3 to 12 (IIIB to VIII to II B) in the modern periodic table. According to IUPAC definiton, "a transition element is an element which has an incomplete d-subshell in either neutral atom or in ions in chemically significant (or common) oxidation state". According to this definition zinc (Zn), cadmium (Cd) and mercury (Hg) are excluded from the list of transition elements as they neither have partly filled d-subshell in their atoms or ions nor they show the usual properties of transition elements to an appreciable extent. Still in order to rationalize the classification of elements, they are studied along with other d-block elements.

There are four series of elements which constitute the *d*-block elements. Each series comprises ten elements as given below:

1. Elements of the First Transition series or 3d-Transition series: The elements from scandium (Sc, Z = 21) to Zinc (Zn, Z = 30) form the 3d-series.

2. Elements of the Second Transition series or 4d-Transition series: This series consists of the elements from yttrium (Y, Z = 39) to cadmium (Cd, Z = 48).

3. Elements of the Third Transition series or 5d-Transition series: The elements lanthanum (La, Z= 57) and hafnium (Hf, Z= 72) to mercury (Hg, Z = 80) constitute the 5d-Transition series.

4. Elements of the Fourth Transition series or 6d-Transition series: The elements actinium (Ac, Z = 89) and rutherfordium (Rf, Z = 104) to copernicum (Cn, Z = 112) are the members of this series. All these elements are radio-active and do not occur in nature. These have been artificially made in the laboratory.

Electronic Configuration and Variable Oxidation States:

The d-block elements have a valence shell electronic configuration of (n-l)$d^{l-l0}ns^{0-2}$ where (n-l) stands for inner shell whose d-orbitals may have one to ten electrons and the s-orbitals of the outermost shell (n) may have no electron or one or two electrons. The filling of d-orbitals takes place after the s-orbital of next higher shell has already filled as has been discussed in Aufbau principle in Unit l (BCH-l0l). This is because ns orbitals have lower energy than (n-l)d orbitals. But during ionization of the elements (oxidation), the electrons are first lost from ns level followed by the expulsion from (n-l)d subshell (deviation from the expected behaviour) because (n- l)d subshell becomes of the lower energy than ns subshell once the filling of electrons commences in (n-l)d subshell.

Most of the d-block elements show several oxidation states (variable) in their compounds due to the availability of d-electrons in the valence shell which comprises of the two subshells, *viz.*, (n-l)d and ns whose orbitals are quite close together in energy and hence the electrons can be used from both the subshells for bonding and under different conditions different number of electrons can be used by them. The variability in the oxidation states increases towards the middle of the series from both ends, i.e. left ⟶ middle ← right. It has been observed that the d-block elements can form ionic bonds in their lower oxidation states and the ionic character of the bond decreases as well as the covalent character increases with increasing oxidation state. As a result, with decreasing ionic character the acidic character of the oxides and chlorides increases.