

**B.Sc. Semester-IV
Core Course-VIII (CC-VIII)
Inorganic Chemistry-III**



II. Transition Elements

1. Transition Elements - Electronic Configurations



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Transition Elements:

12 Lectures

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third transition series.

Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy)

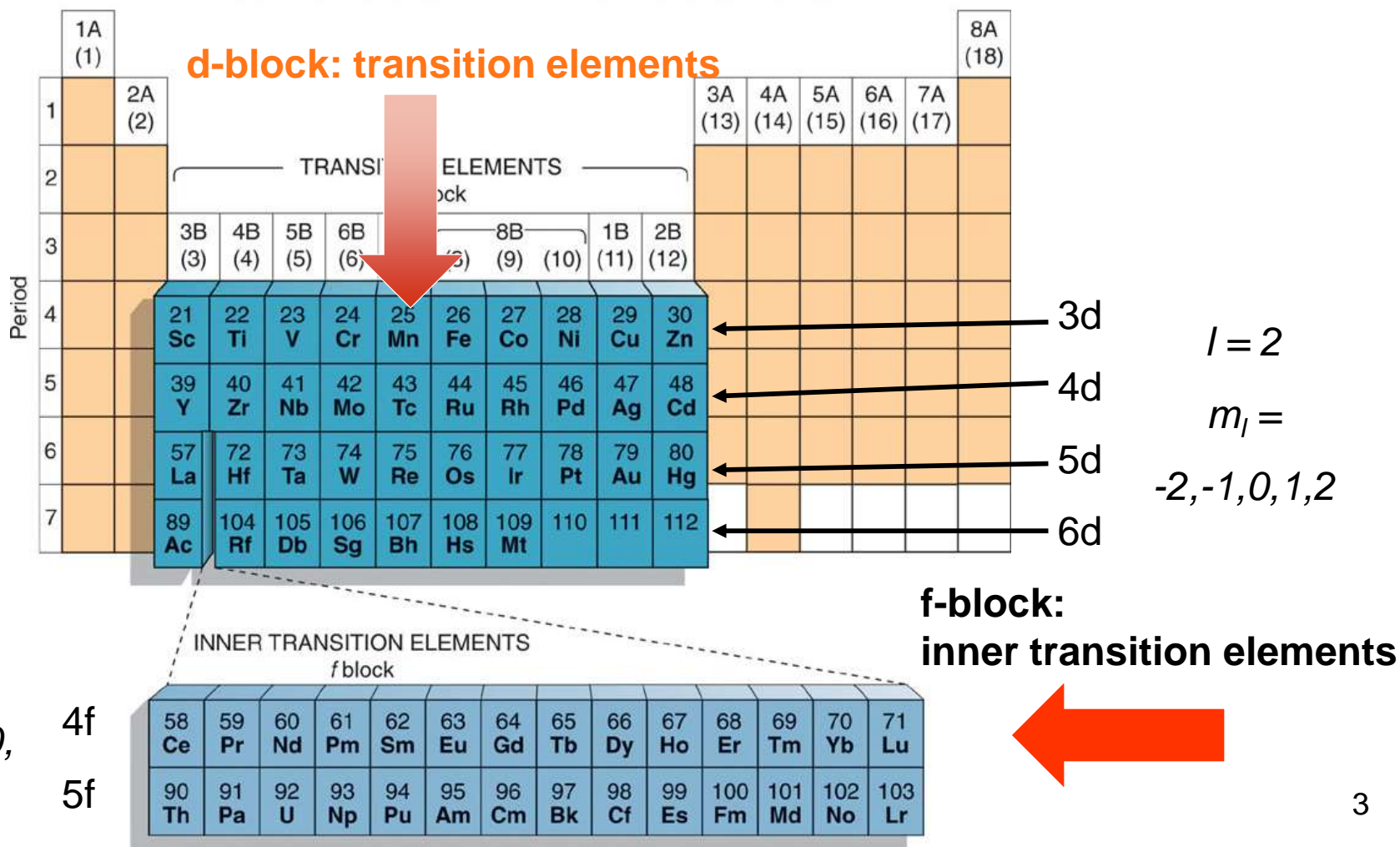
Coverage:

1. Transition Elements-Electronic Configurations

What is a transition element?

“an element with valance d- or f-electrons”

ie. a d-block or f-block metal



Transition Elements

- Show great similarities within a given period as well as within a given vertical group.

Forming Ionic Compounds

- Transition elements generally exhibit more than one oxidation state.
- Cations are often *complex ions* – species where the transition metal ion is surrounded by a certain number of ligands (Lewis bases).

d-block transition elements

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd
La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg
Ac†	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub

f-block transition elements

*Lanthanides	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
†Actinides	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

Electronic Configurations

- **Example**
 - **V: [Ar]4s²3d³**
 - **Fe: [Ar]4s²3d⁶**
- **Exceptions: Cr and Cu**
 - **Cr: [Ar]4s¹3d⁵**
 - **Cu: [Ar]4s¹3d¹⁰**
- **First-row transition metal *ions* do not have 4s electrons.**
 - **Energy of the 3d orbitals is less than that of the 4s orbital.**



Concept Check:

Qu. What is the expected electron configuration of Sc⁺?

Explain.

Ans. [Ar]3d²

3d-Transition Elements

- **Scandium – chemistry strongly resembles lanthanides**
- **Titanium – excellent structural material (light weight)**
- **Vanadium – mostly in alloys with other metals**
- **Chromium – important industrial material**
- **Manganese – production of hard steel**
- **Iron – most abundant heavy metal**
- **Cobalt – alloys with other metals**
- **Nickel – plating more active metals; alloys**
- **Copper – plumbing and electrical applications**
- **Zinc – galvanizing steel**

Electronic configurations of the first series of the *d*-block elements

Element	Atomic number	Electronic configuration
Scandium	21	[Ar] 3d ¹ 4s ²
Titanium	22	[Ar] 3d ² 4s ²
Vanadium	23	[Ar] 3d ³ 4s ²
Chromium	24	[Ar] 3d ⁵ 4s ¹
Manganese	25	[Ar] 3d ⁵ 4s ²
Iron	26	[Ar] 3d ⁶ 4s ²
Cobalt	27	[Ar] 3d ⁷ 4s ²
Nickel	28	[Ar] 3d ⁸ 4s ²
Copper	29	[Ar] 3d ¹⁰ 4s ¹
Zinc	30	[Ar] 3d ¹⁰ 4s ²

The 3dⁿ electron configurations of M(II) and M(III) cations of the atoms of transition elements

Element	Neutral atom	M ²⁺ Ion	M ³⁺ Ion
Sc	[Ar]4s ² 3d ¹	[Ar]3d ¹	[Ar]
Ti	[Ar]4s ² 3d ²	[Ar]3d ²	[Ar]3d ¹
V	[Ar]4s ² 3d ³	[Ar]3d ³	[Ar]3d ²
Cr	[Ar]4s ¹ 3d ⁵	[Ar]3d ⁴	[Ar]3d ³
Mn	[Ar]4s ² 3d ⁵	[Ar]3d ⁵	[Ar]3d ⁴
Fe	[Ar]4s ² 3d ⁶	[Ar]3d ⁶	[Ar]3d ⁵
Co	[Ar]4s ² 3d ⁷	[Ar]3d ⁷	[Ar]3d ⁶
Ni	[Ar]4s ² 3d ⁸	[Ar]3d ⁸	[Ar]3d ⁷
Cu	[Ar]4s ¹ 3d ¹⁰	[Ar]3d ⁹	[Ar]3d ⁸
Zn	[Ar]4s ² 3d ¹⁰	[Ar]3d ¹⁰	[Ar]3d ⁹

d-Block Elements as Metals

Physical properties of *d*-Block elements :

- good conductors of heat and electricity
- hard and strong
- malleable and ductile
- lustrous
- high melting points and boiling points

• Exceptions : Mercury

- low melting point
- liquid at room temperature and pressure
- extremely useful as construction materials
- ∴ strong and unreactive
- used for construction and making machinery nowadays (Fe)
- abundant
- easy to extract } → Cheap

d-Block Elements as Metals

- Iron
 - corrodes easily
 - often combined with other elements to form steel
 - ∴ harder and more resistant to corrosion

Transition Metals

- Transition metals are found in nature
 - Rocks and minerals contain transition metals
 - The color of many gemstones is due to the presence of transition metal ions
 - Rubies are red due to Cr
 - Sapphires are blue due to presence of Fe and Ti
 - Many biomolecules contain transition metals that are involved in the functions of these biomolecules
 - Vitamin B12 contains Co
 - Hemoglobin, myoglobin, and cytochrome C contain Fe

Transition Metals

- Transition metals and their compounds have many useful applications
 - Fe is used to make steel and stainless steel
 - Ti is used to make lightweight alloys
 - Transition metal compounds are used as pigments
 - TiO_2 = white
 - PbCrO_4 = yellow
 - $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$ (prussian blue) = blue
 - Transition metal compounds are used in many industrial processes

Transition Metals

- General Properties
 - Have typical metallic properties
 - Not as reactive as Grp. IA, IIA metals
 - Have high MP's, high BP's, high density, and are hard and strong
 - Have 1 or 2 s electrons in valence shell
 - Differ in d electrons in n-1 energy level
 - Exhibit multiple oxidation states

Thank You



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