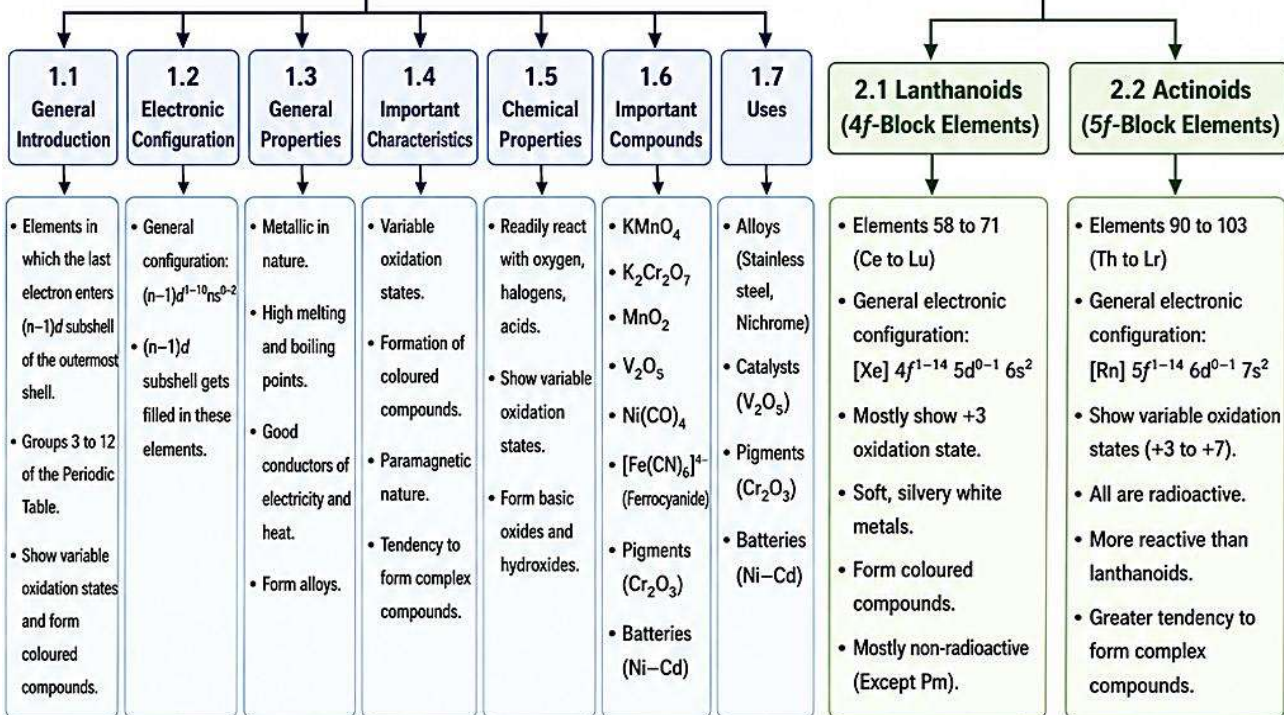


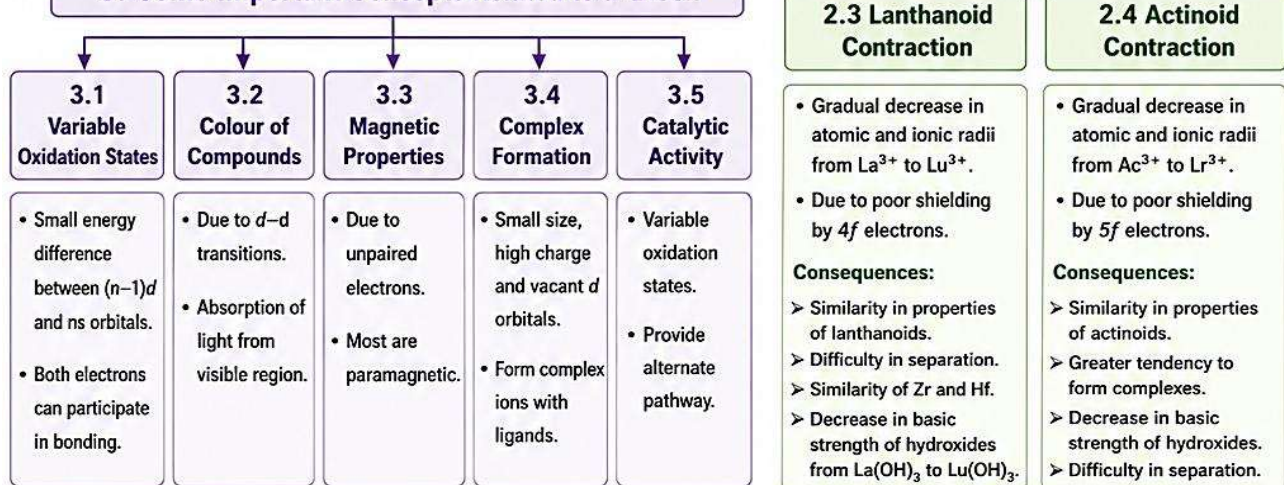
Unit-4 *d* AND *f* BLOCK ELEMENTS

1. *d*-BLOCK ELEMENTS (Transition Elements)

2. *f*-BLOCK ELEMENTS (Inner Transition Elements)



3. Some Important Concepts Related to *d*-Block



4. Importance of *d* and *f* Block Elements

- Used in various industries, medicines, catalysts, alloys, pigments, batteries and electronic devices.
- Essential for biological processes (e.g., Fe in haemoglobin, Co in Vitamin B_{12}).
- Actinoids are important in nuclear energy.
- f*-Block elements show unique properties due to lanthanoid and actinoid contraction.

QUESTIONS AND ANSWERS

Section A (1 MARK)

- Manganate ion is paramagnetic due to the presence of :
(A) one unpaired electron (B) two unpaired electrons
(C) three unpaired electrons (D) fully paired electrons
- Iron forms Fe^{2+} and Fe^{3+} ions. Which of the following is true regarding their electronic configuration?
a) $\text{Fe}^{2+} : [\text{Ar}] 3d^6$, $\text{Fe}^{3+} : [\text{Ar}] 3d^5$ b) $\text{Fe}^{2+} : [\text{Ar}] 3d^7$, $\text{Fe}^{3+} : [\text{Ar}] 3d^6$
c) $\text{Fe}^{2+} : [\text{Ar}] 3d^5$, $\text{Fe}^{3+} : [\text{Ar}] 3d^4$ d) $\text{Fe}^{2+} : [\text{Ar}] 3d^4$, $\text{Fe}^{3+} : [\text{Ar}] 3d^3$
- Which of the following is the correct order of magnetic moment (spin-only) for the ions?
a) $\text{Ti}^{3+} < \text{V}^{3+} < \text{Cr}^{3+} < \text{Mn}^{2+}$ b) $\text{Mn}^{2+} < \text{Cr}^{3+} < \text{V}^{3+} < \text{Ti}^{3+}$
c) $\text{Cr}^{3+} < \text{Ti}^{3+} < \text{Mn}^{2+} < \text{V}^{3+}$ d) $\text{Ti}^{3+} < \text{Cr}^{3+} < \text{Mn}^{2+} < \text{V}^{3+}$
- The electronic configuration of a transition metal ion is $[\text{Ar}]3d^5$. The ion could be:
a) Mn^{2+} b) Fe^{2+} c) Cr^{3+} d) Co^{2+}
- To which of the following series the transition element from $Z = 39$ to $Z = 48$ belong:
(a) 3d series (b) 4d series (c) 5d series (d) 6d series
- Why is Zn^{2+} ion colourless?
a) It has a fully filled d-orbital b) It has unpaired electrons
c) It absorbs all visible light d) It has empty d-orbitals
- The separation of lanthanides is difficult due to:
a) High reactivity of lanthanides
b) Similar chemical and physical properties
c) Different oxidation states of lanthanides
d) Low melting and boiling points of lanthanides
- The stability of which ion is due to its half-filled d-orbital configuration?
a) Fe^{2+} b) Mn^{2+} c) Cu^{2+} d) Zn^{2+}
- Chromium forms most stable compound in the following oxidation state:
(a) Cr (I) (b) Cr(II) (c) Cr (III) (d) Cr (IV)
- Not more than one oxidation state is shown by:
(a) Mn (b) Cr (c) Fe (d) Sc

Ques	1	2	3	4	5	6	7	8	9	10
Ans	A	A	A	A	B	A	B	B	C	D

Section B (Assertion-Reason questions)

ASSERTION & REASON QUESTIONS

These questions contains, Assertion and Reason

- (a) Assertion is True, Reason is True; Reason is a correct explanation for Assertion
(b) Assertion is True, Reason is True; but Reason is NOT a correct explanation for Assertion
(c) Assertion is True, Reason is False. (d) Assertion is False, Reason is True.

1. **Assertion:** 1st ionisation potential of mercury is greater than cadmium.

Reason: Hg has stable electronic configuration ($5d^{10} 6s^2$).

2. **Assertion (A):** Transition metals form alloys easily.

Reason (R): Transition elements have partially filled d subshell.

3. **Assertion (A):** Lanthanides show a gradual decrease in atomic and ionic radii across the series.

Reason (R): This is due to the poor shielding effect of 4f electrons.

4. **Assertion:** Change in colour of acidic solution of potassium dichromate by breath is used to test drunk drivers.

Reason: Change in colour is due to the complexation of alcohol with $K_2Cr_2O_7$.

5. **Assertion:** K_2CrO_4 has yellow colour due to charge transfer.

Reason: CrO_4^{2-} ion is tetrahedral in shape.

Ques	1	2	3	4	5
Ans	B	B	A	C	B

Section- C (2 Marks questions)

1. Why are Sm^{2+} , Eu^{2+} , and Yb^{2+} ions in solutions good reducing agents but an aqueous solution of Ce^{4+} is a good oxidizing agent?

(Hint: The most stable oxidation state of lanthanoids is +3. Hence +2 oxidation state tend to change +3 state by loss of electron whereas those in +4 oxidation state tend to change to +3 oxidation state by gain of electron.)

2. E° of Cu is + 0.34V while that of Zn is – 0.76V. Explain.

(Hint: High ionisation enthalpy to transform $Cu(s)$ to $Cu^{2+}(aq)$ is not balanced by its hydration enthalpy. However, in case of Zn after removal of electrons from 4s-orbital, stable $3d^{10}$ configuration is acquired.)

3. On what ground can you say that scandium ($Z = 21$) is a transition element, but zinc ($Z = 30$) is not?

(Hint. Scandium ($Z = 21$), atom has incompletely filled d-orbitals ($3d^1$) in its ground state,

On the other hand, zinc ($Z = 30$) atom has completely filled d-orbitals ($3d^{10}$) in its ground state as well as most common oxidation state of +2.)

4. Which element of first transition series is a strong oxidising agent in +3 oxidation state and why?

(Hint: Mn, because change of Mn^{3+} to Mn^{2+} give stable half filled (d^5) electronic Configuration).

5. Most of the transition metal ions exhibit characteristic colours in aqueous solutions. Explain

(Hint: d-d transition/presence of unpaired electrons)

Section - D (3 Marks questions)

1. Give reasons for the following features of transition metal chemistry.

(a) There is a general increase in density from titanium ($Z = 22$) to copper ($Z = 29$)

(b) Transition metals are well known to form complex compounds

(c) The second and third members in each group of the transition elements have very similar atomic radii

(Hint: (a) Atomic volume decreases but at the same time, atomic mass increases.

(b) Small size and high charge on cation and presence of vacant d-orbitals.

(c) Due to lanthanoid contraction.)

2. Demonstrate your understanding of the lanthanoid contraction by explaining it, analyzing the causes behind it, and evaluating its impact on the chemical properties of elements that follow the lanthanoids in the periodic table.

(Hint: Steady decrease is the size of lanthanoids with increase in atomic number across the period is known as Lanthanoid contraction. It is because the electrons of 4f orbitals offer imperfect/poor shielding effect in the same sub-shell.

Consequences: 1) Due to this 5d series elements have nearly same radii as that of 4d series.

2) Basic Strength decreases from $La(OH)_3$ to $Lu(OH)_3$.

3) Lanthanoid contraction makes separation of lanthanoids possible.)

3. Assign reasons for the following:

- (i) The enthalpies of atomisation of transition elements are high.
- (ii) The transition metals and many of their compounds act as good catalysts.
- (iii) Scandium ($Z=21$) does not exhibit variable oxidation states and yet it is regarded as a transition element.

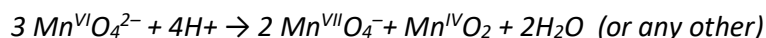
(Hint: (i) strong metallic bonds due to large number of unpaired electrons.

(ii) Because of their variable oxidation states suitable larger surface area.

(iii) Partially filled d orbitals in the ground state ($3d^1 4s^2$) of scandium .)

4. Explain why Cu^+ ion is not stable in aqueous solutions? Give another example of a disproportionation reaction in aqueous solution.

Hint: Cu^+ ion undergoes disproportionation.



5. Compare the chemistry of the actinoids with that of lanthanoids with reference to:

- (i) Electronic configuration
- (ii) Oxidation states and
- (iii) Chemical reactivity.

Ans. (i) For lanthanoids is $[\text{Xe}]^{54} 4f^{0-14} 5d^{0-1} 6s^2$ and that for actinoids is $[\text{Rn}]^{86} 5f^{1-14} 6d^{0-1} 7s^2$.

(ii) The principal oxidation state of lanthanoids is (+3). However, some also exhibit oxidation states of +2 and +4. Actinoids exhibit a greater range of oxidation states. Again, (+3) is the principal oxidation state for actinoids.

(iii) In the lanthanoid series, the earlier members of the series are more reactive. They have reactivity that is comparable to Ca. Actinoids, on the other hand, are highly reactive metals, especially when they are finely divided.)

Section - D (Case Based questions)

1. Read the passage given below and answer the following questions:

The lanthanoids, also known as rare earth elements, are a series of elements in the f-block of the periodic table, from atomic number 58 (Cerium) to 71 (Lutetium). These elements are characterized by the filling of 4f orbitals. Lanthanoids exhibit similar chemical properties due to their similar electronic configurations and are known for their high melting points and ability to form colored compounds. The lanthanoid contraction, caused by the poor shielding effect of 4f electrons, results in a gradual decrease in atomic and ionic radii across the series. These elements are widely used in industries, such as in the production of alloys, catalysts, and phosphors for electronic displays.

- (i) Why do lanthanoids show similar chemical properties? (1 Mark)
- (ii) How does the poor shielding of the 4f electrons effect Lanthanoids? (1 Mark)
- (iii) Explain how lanthanoid contraction affects the atomic radii of the third transition series compared to the second transition series. (2 Marks)

(Hint: (i) Their similar outer electronic configurations and lanthanoid contraction results in minimal differences in the size of the lanthanoid ions.

(i) Lanthanoid contraction.

(ii) Similar atomic radii of both transition series.)

2. Read the passage given below and answer the following questions:

The d-block elements exhibit unique magnetic properties due to the presence of unpaired electrons in their d-orbitals. For instance, iron (Fe , $[\text{Ar}] 3d^6 4s^2$) can form compounds like FeSO_4 , where Fe^{2+} has a $3d^6$ configuration. The magnetic behavior of such compounds depends on whether the electrons are paired or unpaired. Paramagnetic substances are attracted to magnetic fields due to

unpaired electrons, while diamagnetic substances, with all electrons paired, are weakly repelled. The magnetic moment is calculated using the formula $\sqrt{n(n+2)}$ BM, where n is the number of unpaired electrons.

- (i) Write the electronic configuration of Fe^{2+} ion? (1 Mark)
- (ii) What is meant by paramagnetic behaviour? (1 Mark)
- (iii) Calculate the spin-only magnetic moment of Fe^{2+} ion and explain whether it is paramagnetic or diamagnetic. (2 Marks)

(Hint: (i) The electronic configuration of Fe^{2+} ion is $[\text{Ar}] 3d^6$.

(ii) Paramagnetic behaviour refers to the property of a substance to be attracted to an external magnetic field due to the presence of unpaired electrons in its orbitals.

(iii) For Fe^{2+} ($[\text{Ar}] 3d^6$), use $n=4$ in the formula, $\mu = \sqrt{n(n+2)}$ BM)

Section - E (5 Marks questions)

1.(a) When a chromite ore (A) is fused with sodium carbonate in free excess of air and the product is dissolved in water, a yellow solution of compound (B) is obtained. After treatment of this yellow solution with sulphuric acid, compound (C) can be crystallised from the solution. When compound (C) is treated with KCl, orange crystals of compound (D) crystallise out. Identify A to D and also explain the reactions.

(b) Describe the oxidising action of potassium dichromate and write the ionic equations for its reaction with: (i) Iodide and (ii) H_2S

Hint: (a) $\text{A} = \text{FeCr}_2\text{O}_4$, $\text{B} = \text{Na}_2\text{CrO}_4$, $\text{C} = \text{Na}_2\text{Cr}_2\text{O}_7 \cdot 2\text{H}_2\text{O}$, $\text{D} = \text{K}_2\text{Cr}_2\text{O}_7$



2. When an oxide of manganese (A) is fused with KOH in the presence of an oxidising agent and dissolved in water, it gives a dark green solution of compound (B). Compound (B) disproportionates in neutral or acidic solution to give purple compound (C). An alkaline solution of compound (C) oxidises potassium iodide solution to a compound (D) and compound (A) is also formed. Identify compounds A to D and also explain the reactions involved.

(Hint: $\text{A} = \text{MnO}_2$ (B) K_2MnO_4 (C) KMnO_4 (D) KIO_3)