

d and f - Block

Q1. What are d-Block elements?

Ans. These are those elements in which the last electron enter the d-subshell.

Q2. Why are d-block elements called transition elements?

Ans. Because in this block the elements lie between s and p block i.e., between group 12 and group 13.

Q3. Give the general electronic configuration of d-block elements.

Ans. $(n-1)d^{1-10} ns^{1-2}$

Q4. Name the 3 series of transition elements.

Ans. (i) 3d series

First transition series. Has 10 elements from scandium (Sc) to Zinc (Zn)

(ii) 4d series

Second transition series. Has 10 elements from Yttrium (Y) to cadmium (Cd)

(iii) 5d series

Third transition series. Has 10 elements from Lanthanum (La) to mercury (Hg)

Q5. Which is the most commonly known feature/characteristic of d-block elements.

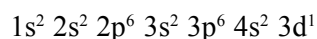
Ans. It is the presence of unpaired electrons in the d-orbitals ; i.e., incompletely set of d-orbitals.

Q6. Why Zn, Hg and Cd often not regarded as transition elements.

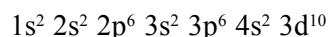
Ans. Being the end members of their respective transition series, their configuration is generally given by $(n-1)d^{10} ns^2$ i.e., these elements have completely filled d-orbitals and hence do not fulfill the general characteristic of d-block elements which the presence of incompletely filled d-orbital. Hence are not regarded as transition elements.

Q7. On what grounds you can say that Scandium ($Z = 21$) is a transition elements but Zn is not?

Ans. Electronic configuration of Sc ($Z = 21$)



Electronic configuration of Zn ($t = 30$)



We can say this on the basis of filling of d orbitals. Sc fulfills the general condition of d-block due to presence of incompletely filled d-orbitals (Presence of unpaired electrons) whereas zinc does not as it has completely filled of orbital.

Q8. Why does Ionic size or atomic size decrease in any transition series ?

Ans. As we move left in the transition series the nuclear charge increase by one unit and the additional e^- goes into the inner d-orbital and since d e^- s are poor shielded so they high effective nuclear charge and attracted towards the nucleus due to which decrease in atomic and ionic radius is observed.

Q9. Why do transition metals show variable oxidation states?

Ans. This is because the outer ns electrons also participate with the inner $(n-1)d$ electrons in bond as their energies are same. And also due to presence of incompletely filled d-orbitals so diff no. of electrons can be lost by atoms.

Q10. Why are most of the transition elements paramagnetic? How is their magnetic moment calculated?

Ans. This is due to the presence of unpaired electrons and each e^- has a magnetic moment associated with spin and rotation around the axis

$$\text{Magnetic moment } (\mu) = \sqrt{n(n+2)} \text{ B.M.}$$

n = no. of unpaired e^- in d-orbital.

Q11. Calculate the magnetic moment of the compound with $Z = 25$.

Ans. $Z = 25 \rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^5$

$$n = 5$$

$$= \sqrt{n(n+2)} \text{ B.M.} = \sqrt{5(5+2)} = \sqrt{35} = \sqrt{5.92} \text{ B.M.}$$

Q12. Why do transition metals form complex compounds?

Ans. (i) Due to high Charge / size ratio (Due to small size)

(ii) Availability of vacant d-orbitals for bond formation.

Q13. What is Lanthanoid Contraction? Give its cause and consequence. Show with the help of graph.

Ans. The steady decrease in atomic and ionic sizes of Lanthanoid elements with increasing atomic number is called Lanthanoid contractions.

Causes :-

As one moves from one element to another in the Lanthanoid series, the nuclear charge increases by one unit the additional e^- goes into the inner 4f orbital and since 4f electrons are poorly shielded for high effective nuclear charge and are attracted towards the nucleus due to which decrease in atomic and ionic size is observed.

Consequences :-

(i) Due to lanthanoid contraction the increase in radius from second to third transition series almost vanishes (Zr to Hf and Nb to Ta) have similar radii.

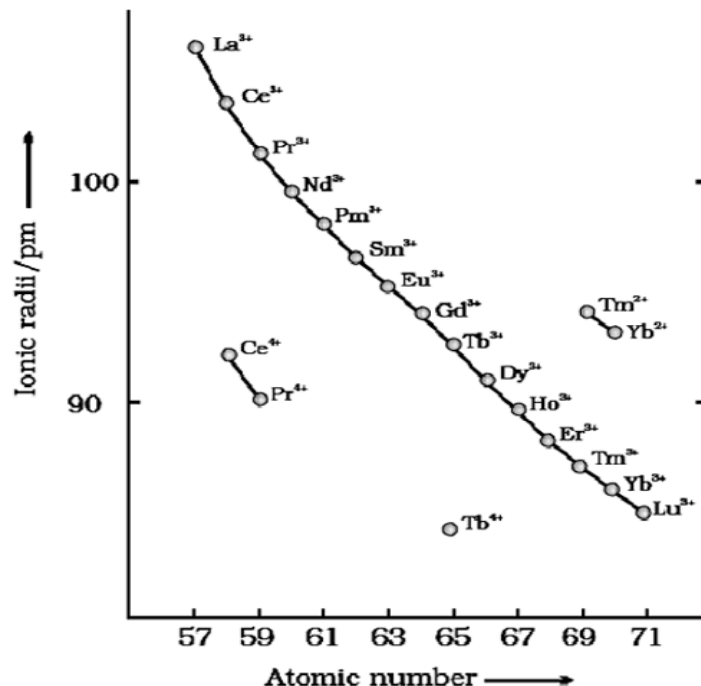
(ii) Due to very small change in radii of the lanthanoids, their chemical properties are quite similar. Hence from a mixture their separation is very difficult.

(iii) Due to decrease in ionic radius (due to lanthanoid contraction) the size of ion decreases and hence the covalent character of the bond between Ln^{3+} (lanthanoid ion) and OH^- ion increases from La^{3+} to Lu^{3+} . Therefore basic strength of hydroxides decreases with increase in atomic no.

$\text{La}(\text{OH})_3$ - Most Basic

$\text{Lu}(\text{OH})_3$ - Least Basic

[La = Lanthanum, Lu = Lutetium]

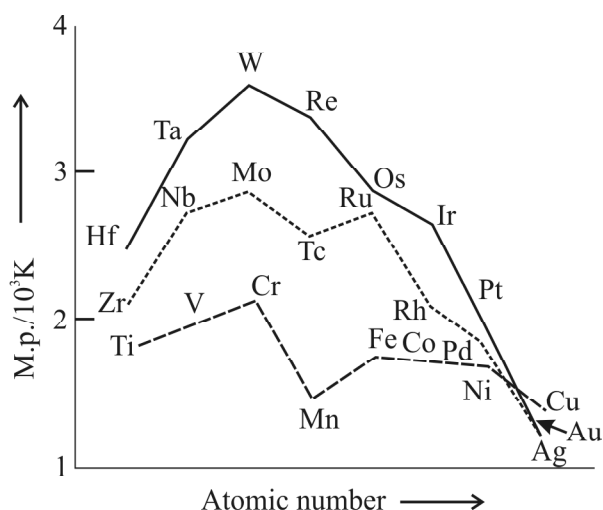


Q14. Why Cr^{2+} is reducing and Mn^{3+} is oxidizing when both have the same d^4 configuration?

Ans. Cr^{2+} is reducing as its configuration changes from d^4 to d^3 i.e., half filled t_{2g} , on the other hand, when we change from Mn^{3+} to Mn^{2+} , it results in extra stable half filled d^5 configuration due to which Mn^{3+} is oxidizing.

Q15. Why is that melting point increase from 3d to 4d to 5d series? Show the graph for m.pt v/s atomic no. for the 3 series.

Ans. This is because metal-metal bonding becomes more frequent from 3d to 4d to 5d series due to availability of more no. of valence electrons.



Q16. What happens to density from Ti to Cu? Why?

Ans. The density increases from Titanium to copper because when we move from Ti to Cu, the atomic mass increases but the metallic radius decreases [$\because e^-$ enters the d-orbital hence poor shielding effect]

$$\text{And also density} = \frac{\text{Atomic Mass}}{\text{Atomic Vol.}}$$

Q17. Why do transition metals have high enthalpies of atomisation?

Ans. Because of strong inter atomic interactions which are a result of large number valence electrons involved in metal bonding.

Q18. Name a transition element liquid at room temperature.

Ans. Mercury (Hg)

Q19. Why does ionisation enthalpy increase from left to right?

Ans. Because of increase in nuclear charge due to which inner d-orbitals are filled up (poor shielding effect).

Q20. Why do transition metals form coloured ions?

Ans. Due to presence of unpaired electrons in d-orbital

eq:- Ti^{3+} forms purple coloured ion

Cu^{2+} forms blue coloured ions

Ti^{4+} , Sc^{3+} , Zn^{2+} are colourless due to absence of unpaired electrons.

Q21. Why are transition metals and their compounds used as catalysts?

Ans. (i) Ability to form complexes

(ii) Ability to form multiple oxidation states.

eq. Iron (III) catalyst is used in reaction with Iodide and per sulphate ions.



Q22. What are interstitial compounds ? Why do transition metals form interstitial compounds?

Ans. Compounds which are formed when small non-metal atoms like H, N, C, Br are trapped inside the **voids**/ interstitial sites of the crystal lattice of the metals are called interstitial compounds.

Transition metals form interstitial compounds because crystal lattice of these metals have empty spaces called **voids** where small non-metal atoms like H, N, C, Br can get trapped.

Characteristics of Interstitial compounds / transition metals

- (i) These metals are non-stoichiometric.
- (ii) High M. P. and are pure metals.
- (iii) Hard, conducting and chemically inert.
- (iv) Neither typically covalent nor ionic.

Q23. Why transition metals form alloys?

Ans. Because transition elements metals have got almost similar radii hence atoms of one element can easily get distributed among the atoms of other elements and form alloy. eg. ferrous alloys.

Q24. Explain why E° value for $\text{Mn}^{3+} / \text{Mn}^{2+}$ couple is larger than that of $\text{Cr}^{3+} / \text{Cr}^{2+}$ or $\text{Fe}^{3+} / \text{Fe}^{2+}$?

Ans. This is because when we move from Mn^{2+} to Mn^{3+} the electronic configuration changes from $3d^5$ to $3d^4$, hence the stable **condition** is **changed** due to which the 3rd ionisation enthalpy is very very high and hence E° value is also high (+ve).

Q25. Explain the irregular behaviour

| E° | V | Cr | Mn | Fe |
|-----------------------|----------|-----------|-----------|-----------|
| Mn ²⁺ / Mn | − 1.18 | 0.91 | − 1.18 | − 0.44 |

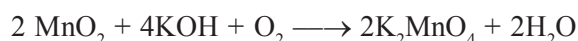
Ans. The irregular behaviour can be explained from the irregular variation in ionisation energies ($IE_1 + IE_2$) and also the sublimation energy which are very low for manganese and vanadium.

Q26. Actinoids contraction is larger than lanthanoid contraction? Why?

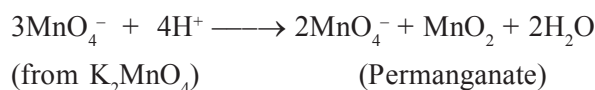
Ans. This is because the shielding effect of $5f$ electron is poorer than that of $4f$ electrons.

Q27. Give the methods of preparation of potassium permanganate (KMnO_4).

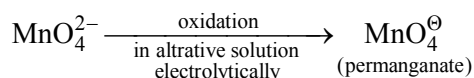
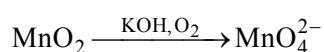
Ans. (i) By fusion of MnO_2 (pyrolusite ore) with an alkali metal hydroxide in pressure of O_2



The dark green K_2MnO_4 (potassium manganate) produced undergoes disproportionation reaction in acid medium.

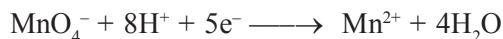


(ii) **Commercial Preparation :-** KMnO_4 is prepared by alkalin oxidative fusion of MnO_2 followed by the electrolytic oxidation of manganate ion (MnO_4^{2-})

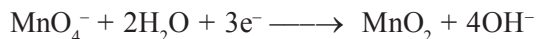


Q28. Write the equations to show oxidising action of KMnO_4 in acidic and basic medium.

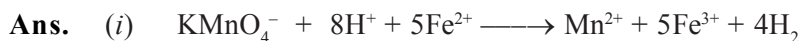
Ans. In Acidic Medium:-



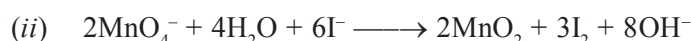
In Basic Medium:-



Q29. Give two reactions to show oxidising action of KMnO_4 in acid medium.



Q30. Give two reactions to oxidising action of KMnO_4 in basic medium.



Q31. Give the properties and uses of KMnO_4 .

Ans. (i) Strong oxidising agent in acidic and basic medium.

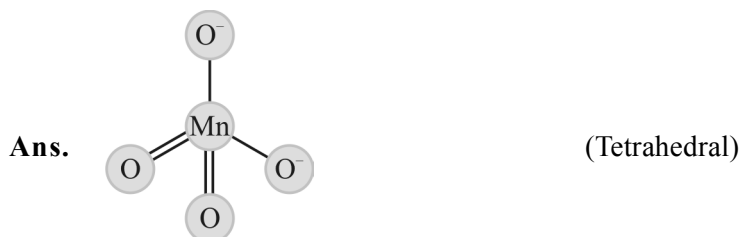
(ii) It is purple solid.

Uses:-

(i) Used for decolorisation of oils.

(ii) Used as oxidant in lab.

Q32. Draw the structure of MnO_4^- .



Q33. Why do transition metals have high melting and boiling points?

Ans. Due to strong inter atomic bonding which involves outer ns electrons with (n – 1) d inner elements in bonding. (because greater the number of valence electrons, greater is the bonding).

Q34. How is potassium dichromate prepared?

Ans. $\text{K}_2\text{Cr}_2\text{O}_7$ is prepared from chromite ore ($\text{Fe}_2\text{Cr}_2\text{O}_4$).

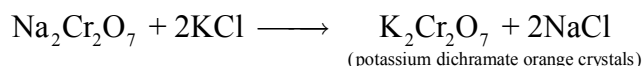
(i) Fusion of chromite ore with Na_2CO_3 Na_2 in air



(ii) Acidification of sodium chromate formed.



(iii) Treatment of sodium dichromate with KCl.



Q35. Give the chemical equation to show oxidising action of $\text{K}_2\text{Cr}_2\text{O}_7$ in acidic medium.

Ans. $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^- \longrightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$
(chromic ion)

Q36. Give three reactions to show oxidising action of $\text{K}_2\text{Cr}_2\text{O}_7$ in acidic medium.

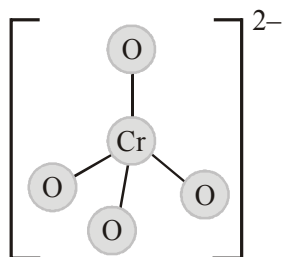
Ans. (i) $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{Fe}^{2+} \longrightarrow 2\text{Cr}^{3+} + 6\text{Fe}^{3+} + 7\text{H}_2\text{O}$
(ii) $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{I}^- \longrightarrow 2\text{Cr}^{3+} + 3\text{I}_2 + 7\text{H}_2\text{O}$
(iii) $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 3\text{Sn}^{2+} \longrightarrow 2\text{Cr}^{3+} + 3\text{Sn}^{4+} + 7\text{H}_2\text{O}$

Q37. Explain how chromate and dichromate ions interconvertible? Or explain the effect of pH on chromate and dichromate ions.

Ans. $2\text{CrO}_4^{2-} + 2\text{H}^+ \longrightarrow \text{Cr}_2\text{O}_7^{2-} + \text{H}_2\text{O}$
 $\text{Cr}_2\text{O}_7^{2-} + 2\text{OH}^- \longrightarrow 2\text{CrO}_4^{2-} + \text{H}_2\text{O}$

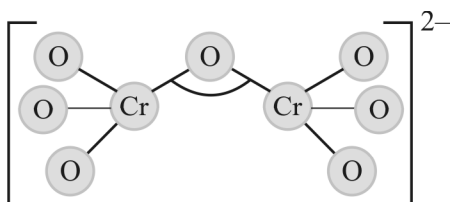
Q39. Draw the structures of chromate and Dichromate ions.

Ans. Chromate ion $\longrightarrow \text{CrO}_4^{2-}$



(Tetrahedral)

Dichromate ion $\longrightarrow \text{Cr}_2\text{O}_7^{2-}$



(Two Tetrahedral units sharing one O)

Q40. What is the highest oxidation state of Cr.

Ans. +6 in CrO_4^{2-}

Q41. What is the highest oxidation states of Mn.

Ans. +7 in KMnO_4

Q42. What are inner transition elements?

Ans. These are those elements which have partly filled f-orbitals in their neutral atom or ion.

Q43. What are Lanthanoids?

Ans. Elements from La (Lanthanum) to Lu (lutetium) are called Lanthanoids. These are characterised by the filling of 4f-orbitals in their atoms.

Q44. Give the general electronic configuration of lanthanoid.

Ans. $[\text{Xe}] 4f^{0-14} 5d^{0-1} 6s^2$

Q45. What is the most common oxidation state of lanthanoids?

Ans. +3, however some elements exhibit +2 and +4 also.

Q46. What are actinoids?

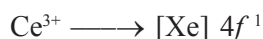
Ans. The elements from Ac (actinium) to Lr (Lawrencium) are called actinoids. These are characterised by filling of 5f orbitals.

Q47. What is the general electronic config of actinoids?

Ans. $[\text{Rn}] 5f^{0-14} 6d^{0-2} 7s^2$

Q48. Why among lanthanoids, Ce (III) can be easily oxidised to Ce (IV)?

Ans. Electronic config.



In Ce^{3+} , one electron is present in the 4f orbital. This electron can be lost to form Ce^{4+} which has a stable configuration of noble gas reaction. Therefore Ce (III) can be easily oxidised to Ce (IV).

Q49. Compare the chemistry Lanthanoids and actinoids on the basis of electron config, oxidation state, atomic, ionic sizes and chemical reactivity.

| Ans. | <i>Lanthanoids</i> | <i>Actinoids</i> |
|-------------|---|---------------------------------------|
| (i) | $[\text{Xe}] 4f^{0-14} 5d^{0-1} 6s^2$ | $[\text{Rn}] 5f^{0-14} 6s^{0-2} 7s^2$ |
| (ii) | Oxidation state +3 is principle, +2 and +4 3 general also exhibited | +4, +5, +6, +7 also exhibited |
| (iii) | Irregular decrease in size across the series | Gradual decrease in size. |
| (iv) | Less reactive than actinoids (5f orbital are placed further away from the nucleus than 4f orbital) | More reactive than Lanthanoids |