**UNIT 7**

**THE *d-* AND *f-*BLOCK ELEMENTS**

# Introduction

**The *d*- and *f* -Block Elements | 111**

*d*-block elements are present from fourth period onwards. There are mainly three series of the transition metals – 3*d* series (Sc to Zn), 4*d* series (Y to Cd) and 5*d* series (La to Hg, omitting Ce to Lu).

*d-*block elements are known as transition elements because their position in the periodic table is between the s-block and p-block elements. Electronic configuration of the *d*-block elements is (*n* – 1)*d*1-10*nsº* –2 but Cu+, Zn, Cd, Hg etc. [(*n* – 1)*d*10] are *d*-block elements, but not transition metals because these have completely filled *d*-orbitals.

# Transition Metals of *d*-block Elements

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **3rd group** *ns*2 | **4th group** *d*1 *ns*2*d*2 | **5th group** *ns*2*d*3 | **6th group** *ns*2*d*5 | **7th group** *ns*2*d*5 | **8th group** *ns*2*d*6 | **9th group** *ns*2*d*7 | **10th group** *ns*2*d*8 | **11th group** *ns*2*d*10 | **12th group** *ns*2*d*10 |
| (*n* – 1) | (*n* – 1) | (*n* – 1) | (*n* – 1) | (*n* – 1) | (*n* – 1) | (*n* – 1) | (*n* – 1) | (*n* – 1) | (*n* – 1) |
| 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 |

1. **General Properties of the Transition Elements**

## Atomic and Ionic Radii

In transition metals, left to right net nuclear charge increases due to poor shielding effect. Due to this, the atomic and ionic radii for transition elements for a given series show a decreasing trend for first five elements and then becomes almost constant for next five elements of the series.

## Enthalpies of Atomisation

Transition elements exhibit higher enthalpies of atomization because of large number of unpaired electrons in their atoms. They have stronger interatomic interaction and hence, stronger bond.

## Ionisation Enthalpies

* + - In a series from left to right, ionization enthalpy increases due to increase in nuclear charge.
* The irregular trend in the first ionization enthalpy of the 3*d* metals, though of little chemical significance, can be accounted for by considering that the removal of one electron alters the relative energies of 4*s* and 3*d* orbitals.

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## Oxidation States

* + - Transition metals shows variable oxidation state due to two incomplete

outermost shells. Only stable oxidation states of the first row transition metals are

Sc(+ 3), Ti(+ 4), V(+ 5), Cr(+ 3, + 6), Mn(+ 2, + 7), Fe(+ 2, + 3), Co(+ 2, +

3), Ni(+ 2), Cu)+ 2), Zn(+ 2)

* The transition elements in their lower oxidation states (+ 2 and + 3) usually

forms ionic compounds. In higher oxidation state compounds are normally covalent.

* Only Os and Ru show + 8 oxidation states in their compounds.
* Ni and Fe in Ni(CO)4 and Fe(CO)5 show zero oxidation state.

## Trends in the Standard Electrode Potentials

* Transformation of the solid metal atoms to M2+ ions in solution and their standard electrode potentials.
* If sum of the first and second ionization enthalpies is greater than hydration enthalpy standard potential (Eº 2+ ) will be positive and reactivity will be lower and vice-versa.

M /M

## Trends in Stability of Higher Oxidation States

The higher oxidation numbers are achieved in TiX4, VF5 and CrF6. The + 7 state for Mn is not represented in simple halides but MnO3F is known and beyond Mn no metal has a trihalide except FeX3 and CoF3 and increasing order of oxidizing power in the series VO + < Cr O 2 < MnO .

2 2 7 4

## Magnetic Properties

* When a magnetic field is applied to substances, mainly two types of magnetic behavior are observed : diamagnetism and paramagnetism. Paramagnetism due to presence of unpaired electrons, each such electron having a magnetic moment associated with its spin angular momentum.
* The magnetic moment is determined by the number of unpaired electrons.

Magnetic moment =

*n**n*  2

where, *n* = number of unpaired electrons.

If all electrons are paired, substance will be diamagnetic and magnetic moment will be zero.

## Formation of Coloured Ions

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* The *d*-orbitals are non-degenerated in presence of ligands. When an electron from a lower energy *d*-orbital is excited to a higher energy *d*-orbital, the energy of required wavelength is absorbed and rest light is transmitted out. Therefore, the colour observed corresponds to the complementary colour of the light absorbed.
* In V2O5, V is in + 5 oxidation state. It is coloured due to defects in crystal

lattice.

## Formation of Complex Compounds

* Transition metals have small size high nuclear charge which facilitates the

acceptance of lone pair of electron from ligands.

* They have vacant *d*-orbitals of appropriate energy in order to accommodate the lone pair of electrons.

## Catalytic Properties

* Transition metals have two outermost shells incomplete and ability to adopt

multiple oxidation states and to form complexes, therefore used as a catalyst.

* Transition metals also provide larger surface area for the reactant to be

adsorbed.

## Formation of Interstitial Compounds

* Small size of non-metals (H, C, N) fit into the voids of crystalline solid of

transition metals and form interstitial compounds.

* The principal physical and chemical characteristics of these compounds are

as follows :

1. They have high melting points, higher than those of pure metals.
2. They are very hard, some borides approach diamond in hardness.
3. They retain metallic conductivity.
4. They are chemically inert.

## Alloy Formation

Alloy is the homogeneous mixture of two or more metals. Transition metals have approximate same size therefore, in molten form they can fit to each other crystalline structure and form homogeneous mixture and form the alloy.

*E.g.,* Brass (copper-zinc) and bronze (copper-tin) etc.

# Some Important Compounds of Transition Elements

**Potassium Dichromate (K2Cr2O7)**

* 1. **Ore**

Ferrochrome or chromate (FeO.Cr2O3) or (FeCr2O4)

* 1. **Preparation**

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2

4

4FeO.Cr2O3

+ 8Na2CO3

+ 7O2

 8Na CrO (yellow)

+ 2Fe2O3

+ 8CO2

2Na CrO + 2H+  Na Cr O + 2Na+ + H O

2 4 2 2 7 2

(orange)

Na Cr O + 2KCl  K Cr O + 2NaCl

2 2 7 2 2 7

Sodium dichromate is more soluble than potassium dichromate.

* Chromates and dichromates are interconvertible in aqueous solution

depending upon pH of the solutions.

* 1. **Properties**

Sodium and potassium dichromates are strong oxidizing agents, thus, acidified

K2Cr2O7 will oxidise iodides to iodine, sulphides to sulphur, tin (II) to tin (IV) and iron

(II) salts to iron (III).

Cr O 2 + 14H+ + 6I  2Cr3+ + 7H O + 3I Cr O 2 + 3H S + 8H+  2Cr3+ + 3S + 7H O

2 7 2 2

2 7 2 2

Cr O 2 + 14H+ + 3Sn2+  3Sn4+ + 2Cr3+ + 7H O

2 7 2

* 1. **Uses**
1. K2Cr2O7 is used as oxidizing agent in volumetric analysis.
2. It is used in mordant dyes, leather industry, photography (for hardening of

film).

1. It is used in chromyl chloride test.
2. It is used in cleaning glassware.

**Potassium Permanganate (KMnO4)**

1. **Ore**

Pyrolusite (MnO2)

1. **Preparation**

2

4

2MnO2

+ 4KOH + O2

 2K MnO (green)

+ 2H2O

3MnO42 + 4H+  2MnO4 + MnO2 + 2H2O

1. **Commercial preparation**

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MnO

* Fusedwith KOH oxidised  MnO 2

2 with air or KNO3

4

Manganate ion

MnO 2 Electrolytic oxidation 

MnO 

4 (alkaline medium)

1. **Properties**

4

Permanganate ion (purple)

KMnO4 acts as strong oxidizing agent.

* 1. In presence of dilute H2SO4, KMnO4 is reduced to manganous salt. MnO4 + 8H+ + 5*e*  Mn2+ + 4H2O

Acidic KMnO4 solution oxidizes oxalates to CO2, iron (II) and iron (III), nitrites to nitrates and iodides to iodine. The half reactions of reductants are

C2O42  CO2 + 2*e*

Fe2+  Fe3+ + *e* NO2  NO3 + 2*e* 2I  I2 + 2*e*

To acidify KMnO4, only H2SO4 is used and not HCl or HNO3 because HCl reacts with KMnO4 and produce Cl2 while HNO3, itself acts as oxidizing agent.

* 1. In alkaline medium, KMnO4 is reduced to insoluble MnO2. MnO4 + 3*e* + 2H2O  MnO2 + 4OH

Alkaline or neutral KMnO4 solution oxidizes I to IO3, S2O32 to SO42,

Mn2+ to MnO2 etc.

1. **Uses**
	1. In laboratory preparation of Cl2.
	2. KMnO4 is used as an oxidizing agent, disinfectant.
	3. In making Baeyer’s reagent.

# The Inner Transition Elements (*f*-Block)

The *f*-block consists of the two series, lanthanoids and actinoids. Lanthanoids are known as rare earth metals and actinoids are known as radioactive elements (Th to Lr).

**Lanthanoids**

**General characteristics**

* General configuration [Xe] 4*f*1-14, 5*d*0-1, 6*s*2.
* Atomic and ionic size from left to right, decreases due to increase in nuclear

charge. This is known as lanthanoid contraction.

* All the lanthanoids are silvery white soft metals and tarnish rapidly in air.

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* Many trivalent lanthanoid ions are coloured both in the solid state and in

aqueous solutions. Neither La3+ nor Lu3+ ion shows any colour but the rest do so.

* The lanthanoid ions other than the *f* 0 type (La3+ and Ce4+) and the *f*14 type (Yb2+ and Lu3+) are all paramagnetic. The paramagnetism arises to maximum in neodymium.
* Oxidation states  Ce4+; (Some elements) is favoured by its noble gas configuration, but it is a strong oxidant reverting to the common + 3 state. The Eºvalue for Ce4+/Ce3+ is + 1.74 V, the reaction rate is very slow and hence, Ce(IV) is a good

analytical reagent. Pr, Nd, Tb and Dy also exhibit + 4 state but only in oxides. Eu2+ is formed by losing the two s-electrons and its *f*7 configuration accounts for the formation of this ion. However, Eu2+ is a strong reducing agent changing to the common + 3 state. Similarly, Yb2+ which has *f*14 configuration is a reductant, Tb4+ has half-filled *f*-orbitals and is an oxidant.

* Lanthanoid are very reactive metals like alkaline earth metals.
* Misch metals, contain lanthanoids about 90-95% (Ce 40-5%, Lanthanum and neodymium 44%) iron 4.5%, calcium, carbon and silicon, used in cigarette and gas lighters, toys, tank and tracer bullets.

**Actinoids**

* Genral configuration [Rn] 5*f*1-14, 6*d*0-2, 7*s*2.
* Actinoids exhibit a range of oxidation states due to comparable energies of 5*f*, 6*d* and 7*s* orbitals. The genral oxidation state of actinoids is + 3.
* All the actinoids are strong reducing agents and very reactive.
* Actinoids also react with oxygen, halogen, hydrogen and sulphur, etc. like

lanthanoids.

* Actinoids are radioactive in nature and therefore, it is difficult to study their

chemical nature.

**MULTIPLE CHOICE TYPE QUESTIONS**

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### One of the characteristics of transition metals to form the complex ion is:

* 1. Having unpaired electron in *d*-subshell
	2. Having paired electrons in *d*-subshells
	3. Providing empty *d*-orbitals
	4. Having small charge/size ratio

### The correct electronic configuration of copper atom is:

(a) 3*d*104*s*1 (b) 3d104s2

(c) 3*d*94*s*2 (d) 3d54*s*24*p*4

### The equivalent wight of K2Cr2O7 in acid medium is equal to

* 1. molecule weight (b) 1/2 molecular weight

(c) 1/6 molecular weight (d) 1/5 molecular weight

### Manganese exhibits maximum oxidation state in:

* 1. K2MnO4 (b) KMnO4

(c) MnO2 (d) Mn3O4

### The equivalent weight of KMnO4 (formula weight M) when it is used as an oxidant in neural medium is

* 1. M (b) M/2

(c) M/3 (d) M/5

### Number of moles of K2Cr2O7 reduced by one mole of Sn2+ ions is

(a) 1/3 (b) 3

(c) 1/6 (d) 6

### CrO3 dissolves in aqueous NaOH to give:

* 1. CrO42– (b) Cr(OH)3

(c) Cr2O72– (d) Cr(OH)2

### The electronic configuration of gadolinium (At. No 64) is:

(a) [Xe] 4*f* 8 5*d*0 6*s*2 (b) [Xe] 4*f* 7 5*d*2 6*s*2

(c) [Xe] 4*f* 3 5*d*5 6*s*2 (d) [Xe] 4*f* 6 5*d*2 6s2

### Electronic configuration of a transition element in + 3 oxidation state is [Al]

**3*d*5. What is is atomic number?**

(a) 25 (b) 26

(c) 27 (d) 24

### On addition of small amount of KMnO4 to concentrated H2SO4, a green oily compound is obtained which is highly explosive in nature. Identify the compound from the following.

* 1. Mn2O7 (b) MnO2

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(c) MnSO4 (d) Mn2O3

### Which of the following oxidation state is common for all lanthanoids?

(a) + 2 (b) + 3

(c) + 4 (d) + 5

### When KMnO4 solution is added to oxalic acid solution, the decolourisation is slow in the beginning but becomes instantaneous after some time because:

* 1. CO2 is formed as the products (b) Reaction is exothermic

(c) MnO – catalysis the reaction (d) Mn2+ acts as autocatalyst

4

### KMnO4 acts as an oxidising agent in acidic medium. The number of moles of KMnO4 that will be needed to react with one mole of sulphide ions in acidic solution is:

* 1. 2 5

(c) 4 5

(b) 3 5

(d) 1 5

### Which of the following is amphotric oxide?

Mn2O7, CrO3, Cr2O3, CrO, V2O5, V2O4.

* 1. V2O5, Cr2O3 (b) Mn2O7, CrO3

(c) CrO, V2O5 (d) V2O5, V2O4

### The magnetic moment is associated with its spin angular momentum. Spin only magnetic moment value of Cr3+ ion is ...........

(a) 2.87 B.M (b) 3.87 B.M

(c) 3.47 B.M (d) 3.57 B.M

### Generally transition elements and their salts are coloured due to the product of unpaired electrons in metal ions. Which of the following compounds are coloured?

* 1. KMnO4 (b) Ce(SO4)2

(c) TiCl4 (d) Cu2Cl2

### Transition elements show magnetic moment due to spin and orbital motion of electrons. Which of the following metallic ions have almost same spin only magnetic moment?

* 1. CO2+ (b) Cr2+

(c) Mn2+ (d) Cr3+

### Which of the following actionoids show oxidation states upto + 7?

* 1. Am (b) Pu

(c) U (d) Np

### Which of the following ions show higher spin only magnetic moment value?

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* 1. Ti3+ (b) Mn2+

(c) Fe2+ (d) Co3+

### Which of the following will not act as oxidising agents?

* 1. CrO3 (b) MnO3
1. WO3
2. CrO2–

### Match the components/elements given in column I with uses given in column II.

4

**Column 1 Column 2**

1. Lanthanoid oxide (1) Production of iron alloy
2. Lanthanoid (2) Television screen
3. Misch metal (3) Petroleum cracking
4. Magnesium based alloy (4) Lanthanoid metal + iron
5. Mixed oxides of lanthanoids (5) bullets

are employed (6) In X-ray screen

(a) A–4, B–3, C–1, D–2 (b) A–3, B–4, C–1, D–2

(c) A–4, B–1, C–2, D–3 (d) A–2, B–1, C–3, D–4

### Match the solutions given in Column 1 and the colours given in column II.

**Column 1 Column 2**

1. FeSO4.7H2O (a) green
2. NiCl2.4H2O (b) light pink
3. MnCl2.4H2O (c) Blue
4. COCl2.6H2O (d) Pale green
5. Cu2Cl2 (e) pink

(f) colourless

**Assertion and Reason Type**

***Note :*** *In the following questions a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choice.*

1. Both assertion and reason are True, and reason is the correct explanation of the assertion.
2. Both assertion and reason are True, but reason is not the correct explanation of the assertion.
3. Assertion is not True, but reason is True.
4. Both assertion and reason are False.
5. **Assertion:** Cu2+ iodide is not known.

**Reason:** Cu2+ oxidises I– to iodine.

1. **Assertion:** Separation of Zr and Hf is difficult.

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Reason : Because Zr and Hf lie in the same graph of the periodic table.

### The magnetic moment of a transition metal ion is found to be 4.90 BM. The number of unpaired electrons present in the ion is

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 3 | 4 | 5 | 6 | 5.5 | 2 |

**ANSWERS**

**1.** (d) **2.** (b) **3.** (c) **4.** (a) **5.** (d) **6.** (c) **7.** (a) **8.** (b) **9.** (b) **10.** (a)

**11.** (b) **12.** (d) **13.** (a) **14.** (a) **15.** (b) **16.** (a, b) **17.** (a, d)

**18.** (b, d) **19.** (b, c) **20.** (b, c)

**21.** (i)—(b), (ii)—(a), (iii)—(d), (iv)—(e), (v)—(c)

**22.** (i)—(d), (ii)—(a), (iii)—(b), (iv)—(e), (v)—(f) **23.** (a) **24.** (b) **25.** 4

**VERY SHORT ANSWER TYPE QUESTIONS (1 Mark)**

**Q. 1. Explain CuSO4.5H2O is blue while CuSO4 is colourless ?**

**Ans.** Because water molecules act as ligands and results in crystal field splitting of

*d*-orbitals of Cu2+ ion.

### Q. 2. Which element among 3*d* series exhibit highest oxidation state ? Ans. Mn

**Q. 3. In 3*d* series (Sc to Zn), the enthalpy of atomization of Zn is low. Why ? Ans.** Due to absence of unpaired electrons.

### Q. 4. Which element among 3*d* series exhibit only one oxidation state ? Ans. SC

**Q. 5. Why is the 3rd ionization energy of Mn (Z = 25) is unexpectedly high ? Ans.** Due to half-filled electronic configuration.

### Q. 6. Define alloy.

**Ans.** Alloys are homogeneous solid solutions of two or more metals.

**Q. 7. Transition metals show zero oxidation state with ligands like CO. Explain. Ans.** Co form synergic bonding with metal ion.

**Q. 8. Why can’t HCl acid be used to acidify KMnO4 solution ? Ans.** Because KMnO4 oxidize HCl into Cl2.

### Q. 9. Name one ore of Mn and Cr.

**Ans.** Mn : MnO2

Cr : FeCr2O4

### Q. 10. Why Mn2+ compounds are more stable than Fe2+ compounds towards oxidation to their + 3 state ?

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**Ans.** Mn+2 has half-filled electronic configuration.

**Q. 11. Why do transition metal (elements) show variable oxidation states ? Ans.** Due to presence of vacant *d*-orbitals.

**Q. 12. Write any uses of pyrophoric alloy. Ans.** Making bullets, shells and ligher flints.

### Q. 13. Which is more basic – La(OH)3 or Lu(OH)3 ? Why ?

**Ans.** La(OH)3, due to lanthanide contraction, lower size, more covalent character, least basic.

### Q. 14. Find out number of Cr – O – Cr bond/bonds in Cr O 2 ion. Ans. 1

**2 7**

**Q. 15. What is effect of increasing pH on K2Cr2O7 solution ?**

**Ans.** It changes into K2CrO4 solution/orange colour change into yellow colour.

**Q. 16. Why is Ce4+ in aqueous solution a good oxidizing agent ? Ans.** Because Ce4+ is most stable in Ce+3 state in aqueous solution.

**Q. 17. Why do Zr and Hf exhibit similar properties ? Ans.** Due to lanthanide contraction.

### Q. 18. What is lanthanoid contraction ?

**Ans.** The regular slow decrease in the atomic or ionic radii of lanthanoids with increasing atomic number.

**Q. 19. Why is Cu (Z = 29) considered a transition metal ? Ans.** Due to its partially filled *d-*orbital in Cu2+ state.

### Q. 20. Arrange the given in increasing order of acidic character : CrO3, CrO, Cr2O3.

**Ans.** CrO < Cr2O3 < CrO3

**Q. 21. Why KMnO or MnO**  **ion is coloured ? Ans.** Due to charge transfer complex formation.

**4 4**

# SHORT ANSWER-I TYPE QUESTIONS (2 Marks)

### Q. 1. Chromium is typical hard metal while mercury is a liquid. Explain why ?

**Ans.** Cr has five unpaired *d*-electrons. Hence metallic bonds are strong. In Hg, there is absence of unpaired electrons and size is larger.

**Q. 2. Why KMnO4 is used in cleaning surgical instruments in hospitals ? Ans.** This is because KMnO4 has a germicidal action.

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### Q. 3. Most of the transition metals do not displace hydrogen from dilute acids, why ?

**Ans.** Due to their –ve reduction potential.

### Q. 4. Explain why Cu+ is not stable in aqueous solution ?

**Ans.** Due to less –ve hydH of Cu+/it cannot compensate 2nd ionization potential of Cu.

### Q. 5. Why is the highest oxidation state of a metal exhibited in its oxide or

**fluoride only ?**

**Ans.** Oxygen and fluoride have small size and high electronegativity. They can

oxidise the metal.

**Q. 6. Write electronic configuration of Cu+2 and Co+2. Ans.** Cu+2 = [Ar] 3*d*9 4*s*0

Co+2 = [Ar] 3*d*7

### Q. 7. Balance the following equations :

**(a) MnO4** **+ Fe2+ + H+** 

**(b) Cr2O72** **+ Sn2+ + H+** 

**Ans.** (a) MnO4 + Fe2+ + H+  Mn+2 + Fe+3

(b) Cr2O72 + Sn2+ + H+  Cr+3 + Sn+4

### Q. 8. Briefly explain why electronic configuration of lanthanoids are not known

**with certainty ?**

**Ans.** 4*f*/5*d* subshells are very close in energy. +ve electrons can jump from 4*f* to 5*d* or vice-versa.

### Q. 9. Why Zn, Cd, Hg are soft and have low melting point ?

**Ans.** Due to weak interatomic attraction/absence of unpaired electrons.

### Q. 10. What is the effect of pH on the solution of K2Cr2O4 solution ?

**Ans.** K2Cr2O4 solution changes into K2Cr2O7/yellow colour changes into orange colour.

### Q. 11. Which of the following is/are transition element and why ? Zn, Cd, Ag, Fe, Ni

**Ans.** Fe, Ni, Ag

### Q. 12. What are interstitial compounds ? Give example.

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**Ans.** When small atoms like C, H, B and N occupy interstitial site in their lattice.

Example, TiC, Fe3H,

**Q. 13. Why are Zn, Cd, Hg volatile metals ? Explain. Ans.** Due to weak interatomic attraction/low boiling point.

### Q. 14. Why is first ionization energy of 5*d* elements higher than those of 3*d* and 4*d* elements ?

**Q. 15. Explain ‘Misch metal’ and write its use.**

**Ans.** It is an alloy of 95% lanthanoid and 5% iron and traces of S, C, Ca and Al. Used in lighter flint, bullet tips etc.

### Q. 16. The following two reactions of HNO3 with Zn are given :

1. **Zn + conc. HNO**  **Zn(NO ) + X + H O**

**3 3 2 2**

### Zn + dil. HNO  Zn(NO ) + Y + H O Identify X and Y.

**3 3 2 2**

**Ans.** X = NO2

Y = N2O

### Q. 17. Complete the equations :

1. **KMnO4**
2. **3K MnO**



**on s****tand****ing**

**2 4 for long time acidic medium**

**Ans.** (a) 2KMnO4  K2MnO4 + MnO2 + O2

(b) 3K2MnO4  MnO4 + MnO2 + 2H2O

### Q. 18. Out of Fe and Cu, which one would exhibit higher melting point ?

**Ans.** Fe, due to large number of unpaired *d-*electrons/more interatomic attraction.

### Q. 19. Sc, the first member of first transition series does not exhibit variable

**oxidation state. Why ?**

**Ans.** Due to noble gas electronic configuration in + 3 oxidation state no other

oxidation state is stable.

# SHORT ANSWER-II TYPE QUESTIONS (3 Marks)

### Q. 1. (a) Deduce the number of 3*d* electrons in the following ions :

**Cu2+, Sc+3**

### Why do transition metals form alloy ?

1. **Why Zn+2 salts are white ?**

**Ans.** (a) Cu+2 : 9 electrons

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Sc+3 : 0 electron

1. Transition metals have similar atomic radii.
2. Absence of unpaired electron.

### Q. 2. Complete and balance the following equations :

1. **MnO 2** **+ H+** 

**4**

1. **KMnO4** **h****eat**
2. **MnO**  **+ FeC O H**

**4 2 4** 

**Ans.** (a) 3MnO 2 + 4H+  2MnO  + MnO + 2H O

4 4 2 2

1. 2KMnO4 *h**eat* K2MnO4 + MnO2 + O2
2. MnO  + FeC O + H+  Mn+2 + Fe+3 + CO

4 2 4 2

### Q. 3. Describe the oxidizing action of K2Cr2O7 with the following. Write ionic equations for its reaction (acidic medium) with :

1. **I** **(b) Iron(II) (c) H S Ans.** (a) It liberates I form I.

**2**

2

Cr O 2 + 14H+ + 6I  2Cr+3 + 7H O + 3I

2 7 2 2

1. It oxidizes Fe+2 to Fe+3.

Cr O 2 + 6Fe+2 + 14H+  2Cr+3 + 7H O + 6Fe+3

2 7 2

(b) It oxidizes H2S to sulphur.

Cr O 2 + 3H S + 8H+  2Cr+3 + 7H O + 3S

2 7 2 2

### Q. 4. Write any four differences between lanthanoids and actinoids.

|  |  |  |  |
| --- | --- | --- | --- |
| **Ans.** | (a) | **Lanthanoids**They are generally | **Actinoids**They are radioactive. |
|  |  | non-radioactive. |  |
|  | (b) | Most of their ions are colourless. | Coloured ions. |
|  | (c) | Show + 3, + 4 and + 2 oxidation state. | Beside + 3, show higher oxidation state. |

(d) Less tendency of complex formation. Higher tendency.

### Q. 5. (a) Why is separation of lanthanoid elements difficult ?

1. **Transition metal exhibit higher enthalpies of atomization. Explain why ?**

### Why have the transition metal high enthalpy of hydration ?

**Ans.** (a) Due to lanthanide contraction, the size of these elements is nearly same.

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1. Transition metal contain large number of unpaired electrons, and they have strong interatomic attractions.
2. Due to their small size and large nuclear charge.

### Q. 6. (a) Use Hund’s rule to derive the electronic configuration of Ce+3 ions and calculate its magnitude moment.

**(b) Is lanthanum a *f*-block element ? Ans.** (a) Ce = [Xe] 4*f*1 5*d*1 6*s*2

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Ce+3 = 4*f*1 one unpaired electron

  1.73 BM

*n*(*n*  2)

(b) No, it is a *d*-block element.

### Q. 7. Account for the following :

1. **Silver chloride dissolves in excess of NH3.**

### Cuprous chloride is diamagnetic while cupric chloride is paramagnetic.

1. **In CrO42** **ion, all the Cr – O bond length are equal. Ans.** (a) AgCl forms a soluble complex with NH3.

AgCl + 2NH3  [Ag(NH3)2]Cl

1. Cu+ : 3*d*10 4*s*0 – All electrons are paired.

Cu+2 : 3*d*9 – Here, one unpaired electron is present.

1. Due to resonance.

### Q. 8. The Eº values in respect of electrodes of Cr, Mn and iron are : Cr+3/Cr+2 =  0.4 V

**Mn+3/Mn+2 = + 1.5 V Fe+3/Fe+2 = + 0.8 V**

### Compare the feasibilities of further oxidation of these ions.

**Ans.** Cr+3 is more stable than Cr2+. Mn+2 is more stable than Mn+3. Fe3+ is more stable than Fe2+.

Order of feasibility of + 2 oxidation state is : Mn+2 > Fe+2 > Cr+2

**Q. 9. Write any three properties of interstitial compounds. Ans.** (a) They are chemically inert.

1. They retain metallic conductivity.
2. They have high melting point than their pure metals.

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1. These are harder and more corrosion resistant.

### Q. 10. Account for the following :

1. **All Scandium salts are white.**

### The Ist ionization energy of the 5*d* series are higher than 3*d* and 4*d* transition elements in respective groups.

1. **Ce+3 can be easily oxidized to Ce+4.**

**Ans.** (a) Sc has only + 3 oxidation state, there is no unpaired electron.

1. Due to lanthanide contraction, effective nuclear charge increase.
2. Due to gain noble gas electron configuration.

### Q. 11. A green chromium compound (A) on fusion with alkali gives a yellow compound (B) which on acidification gives a orange coloured compound (C). Identify A, B, C. Write equations for reactions.

**Ans.** A : FeCr2O4 B : Na2CrO4 C. Na2Cr2O7 4FeCr O + 8Na CO + 7O  8Na CrO + 2Fe O + 8CO

2 4 2 3 2 2 4 2 3 2

(A) (B)

Na CrO + H SO  Na Cr O + Na SO + H O

2 4 2 4 2 2 7 2 4 2

(C)

### Q. 12. When an oxide of Mn (A) is fused with KOH in the presence of an oxidizing agent and dissolved in water, it gives a dark solution of compound (B). Compound (B) disproportionate in neutral or acidic solution to give purple compound (C). Identify A, B, C.

**Ans.** A : MnO2 B : K2MnO4 C : KMnO4

# LONG ANSWER TYPE QUESTIONS (5 Marks)

### Q. 1. A violet compound of manganes (A) decomposes on heating to liberate oxygen and compounds (B) and (C) of manganese are formed. Compound

1. **reacts with KOH in the presence of KNO3 to give compound (B). On heating compound (C) with conc. H2SO4 and NaCl, Cl2 gas is liberated and compound (D) of manganese is formed. Identify A, B, C, D alongwith**

### reactions involved.

**Ans.** A : KMnO4 B : K2MnO4 C : MnO2 D : MnCl2



KMnO4  K MnO + MnO + O

2 4 2 2

* 1. (B)

MnO2 + KOH + KNO3  K2MnO4

(C) (B)

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MnO + NaCl + conc. H SO  MnCl

2 2 4 2

(C) (D)

### Q. 2. (a) What is meant by disproportionation of an oxidation state ? Give one example.

1. **Draw the structures of Cr O 2****, CrO** **2, MnO** **.**

**2 7 4 4**

### What is the effect of lanthoids contraction beyond lanthanoid ?

**Ans.** (a) When any atom or ion undergo oxidation and reduction simultaneously it is called disproportionation.

2Cu+  Cu+2 + Cu

(b)

(c) Size of respective 4*d* and 5*d* series elements becomes comparable from fourth group onwards (*e.g.,* Zr and Hf).



*Source: EDUDEL*