Std. XII **8**

Transition and Inner Transition Elements

Points to Remember

8.1 Introduction

- **d-block elements :** The elements in which last electron the entering the d-orbital of the penultimate shell.
- **Transition elements:** d-blocks elements are called transition elements because their properties are between those of s and p-block elements and they have partly or incompletely filled (n – 1) d-orbitals in the atomic and ionic states.
- **Zn, Cd, Hg and Cn:** In the (n – 1)d subshell of these elements, they are completely filled in atomic and ionic states. As per the definition of transition elements these elements are excluded but due to similar chemical behaviour, they are included in the transition series.
- There are **four** series of transition elements, namely 3d, 4d, 5d, and 6d series in the long form of the periodic table.

8.2 Position in Periodic Table

- In the long form of the periodic table, d-block elements are placed between s and p block elements.
- These elements belong to the groups 3 to 12 and periods 4 to 7 those constitute – 3d, 4d, 5d and 6d series.

8.3 Electronic Configuration

- General electronic configuration = $(n-1)d^{1-10}\,ns^{1-2}$

Transition series	Period	Elements	General electronic configuration
1^{st} = 3d	4^{th}	Sc(21) to Zn (30)	$[Ar]\,3d^{1-10}\,4s^{1-2}$
2^{nd} = 4d	5^{th}	Y(39) to Cd(48)	$[Kr]\,4d^{1-10}\,5s^{0-2}$
3^{rd} = 5d	6^{th}	La(57), Hf(72) to Hg(80)	$[Xe]\,5d^{1-10}\,6s^{2}$
4^{th} = 6d	7^{th}	Ac(89), Rf(104) to Cn(112)	$[Rn]\,6d^{1-10}\,7s^{1-2}$

- Copper and chromium show exceptions in the electronic configuration.
  Completely filled subshell s^2, p^6, d^{10}, f^{14} and half filled subshells s^1, p^3, d^5, f^7 have extra stability.

No.	Chromium	No.	Copper
(i)	e^- configuration $= 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^4\,4s^2$ (expected)	(i)	e^- configuration $= 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^9\,4s^2$ (expected)
(ii)	4s is completely filled but 3d subshell neither completely nor half filled.	(ii)	4s is completely filled but 3d subshell neither completely nor half filled.
(iii)	Due to inter electronic repulsion forces, one 4s e^- transfer to 3d subshell and acquire observe e^- configuration.	(iii)	3d and 4s subshell have extra stability due to completely filled 3d and half filled 4s orbital and give special stability.
(iv)	3d and 4s subshell have extra stability due to half filled orbital and give special stability to atom.	(iv)	3d and 4s subshell have extra stability due to completely filled 3d and half filled 4s orbital and give special stability.
(v)	e^- configuration $= 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^5\,4s^1$ (observed)	(v)	e^- configuration $= 1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^{10}\,4s^1$ (observed)

- Symmetrical distribution of electrons in these subshell which allows the maximum exchanged electron and gives stability.

8.4 Oxidation States of First Transition Series

- Transition element show variable oxidation states from + 1 to +7.

Table Electronic configuration of various ions of 3d elements

Elements	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
Atomic no. :	21	22	23	24	25	26	27	28	29	30
Species	**Valence shell Electronic Configuration**									
M	$3d^1 4s^1$	$3d^2 4s^2$	$3d^3 4s^2$	$3d^5 4s^1$	$3d^5 4s^2$	$3d^6 4s^2$	$3d^7 4s^2$	$3d^8 4s^2$	$3d^{10} 4s^1$	$3d^{10} 4s^2$
M^{+}	$3d^1 4s^1$	$3d^2 4s^1$	$3d^3 4s^1$	$3d^5$	$3d^5 4s^1$	$3d^6 4s^1$	$3d^7 4s^1$	$3d^8 4s^1$	$3d^{10} 4s^0$	$3d^{10} 4s^1$
M^{2+}	$3d^1$	$3d^2$	$3d^3$	$3d^4$	$3d^5$	$3d^6$	$3d^7$	$3d^8$	$3d^9$	$3d^{10}$
M^{3+}	[Ar]	$3d^1$	$3d^2$	$3d^3$	$3d^4$	$3d^5$	$3d^6$	$3d^7$	–	–

Common oxidation state +2. Ionic bonds are formed in +2 and +3.

8.5 Physical Properties of First Transition Series

(1) All transition elements are metals and they are hard, lustrous, malleable, ductile and form alloys with other metals.

(2) They are good conductors of heat and electricity.

(3) They have high melting and boiling point.

8.6. Trends in Atomic Properties of the First Transition series

- Atomic and ionic radii
- Ionisation enthalpy
- Metallic characters
- Magnetic Properties
- Colour
- Catalytic Properties
- Interstitial Compounds formation
- Alloy formation

- **Atomic and Ionic Radii:**

(1) From Sc to Cr = Atomic radii decreases then constant upto Cu and then increases.

(2) Beginning increase in At No. $\longrightarrow$ increases nuclear charge = At size decreases.

(3) Middle of series = Number of d electron increases
= increase nuclear charge and screening effect.
= that balance each atom lead to constancy

(4) End of series $\longrightarrow$ electron pairing takes place $\longrightarrow$ Repulsive interaction between added e^- than attractive force due to nuclear charge $\longrightarrow$ Atomic radii increases slightly.

(5) For the same oxidation state with an increase in nuclear charge, the ionic radii gradually decreases.

(6) At higher oxidation states, the effective nuclear charge increases, so the ionic radii decreases.

- **Ionisation Enthalpy (IE):**

(1) The ionization enthalpies of transition metals are higher and they lie between s and p block elements.

(2) In transition series first ionization enthalpy increases (but no regular) with increase in atomic number. In transition element the added electron enters, in the (n – 1)d subshell, which shields the valence electrons from the nucleus, hence the increase in ionization enthalpy is slow and not a regular.

(3) In the third transition series, the first ionsiation enthalpies of elements are higher than the elements of first and second transition series. In third transition series atoms have filled 4f orbitals. The shielding effect of 4f orbitals is very poor (due to shape of 4f orbitals) hence nuclear attraction is more for valence electrons, thus their ionization enthalpies are higher.

- **Metallic Characters:**

(1) Due to low ionization enthalpy and vacant d orbitals, transition metals favour metallic bond.

(2) They have HCP (*hexagonal close packed*), CCP (*cubic close packed*), or BCC (*body centred cubic*).

(3) These metals are hard. Due to presence of unpaired electrons, it forms covalent bonds.
Number unpaired electrons increases = hardness increases.

(4) MP and BP, values are high due to the metallic and covalent bond.
MP, BP values are high at middle of period due to the large number of unpaired electrons.
Beyond d^5 as electrons start pairing, the MP, BP decreases.

- **Magnetic Properties:**

(1) **Paramagnetic:** Most of the transition metal ions and their compounds are paramagnetic (attracted by the magnetic field) due to presence of unpaired electrons.

As the number of unpaired electrons increases from 1 to 5, the paramagnetic character increases.

(2) **Diamagnetic:** Those transition elements have paired electrons are diamagnetic i.e. they are repelled by the magnetic field.

(3) **Ferromagnetic:** The metals like Fe, Co, Ni are highly paramagnetic and used as permanent magnet.

(4) **Alnico:** Permanent magnet [Al (12%), Ni(20%), Co(50%) Fe(10%).

(5) **Magnetic character;** expressed in term of magnetic moment arises from spin of electrons.

(6) Magnetic moment (Bohr magneton (B.M.))

$1 \text{ BM} = \frac{eh}{4\pi mc}$ (h = planks constant, e = electronic charge, c = velocity of light, m = mass of electron)

(7) Effective magnetic moment = $\mu_{eff} = \sqrt{n(n+2)}$ BM (n = number of unpaired electrons, BM = bohr magneton)

- **Colour:**

(1) The colour of a substance depends upon absorption of visible light of a particular wavelength.

(2) In general colour of the transition ion can be related to

  (i) Presence of unpaired d electron.

  (ii) d-d-transition

  (iii) Nature of ligands linked to the metal ion.

  (iv) Geometry of complex formed by the metal ion.

  (v) Charge transfer.

- **Catalytic Properties:**

(1) Transition elements on account of their variable oxidation states, are able to form unstable intermediates.

(2) These elements also provide a large surface area for reactants to be absorbed and bring them closer allowing reactions to occur.

(3) They are used as catalyst e.g. Fe, Co, Pt, Cr, Mn etc.

(4) Examples

No.	Catalyst	Catalyst for the process
(1)	MnO_2	Decomposition of $KClO_3$ to O_2
(2)	Nickel	Hydrogenation of oil to fats
(3)	V_2O_5	Manufacture of H_2SO_4 by Contact process
(4)	Fe (III)	Reaction between iodide and persulphate ions $2I^- + S_2O_8^{2-} \longrightarrow I_2 + 2SO_4^{2-}$
(5)	Titanium chloride (Zeiglar Natta catalyst)	High density polymer $nCH_2 = CH_2 \longrightarrow \left[+ CH_2 - CH_2 + \right]_n$
(6)	Fe with Mo	Manufacture of Ammonia
(7)	Co-Th alloy	Fischer Tropsch process for the synthesis of gasoline.

- **Formation of Interstitial Compounds**

(1) Transition metals have defects in their crystal lattice.

(2) Transition metal form a number of interstitial compounds with element such as H, C, N, B etc.

(3) They are non-stoichiometric neither ionic nor covalent.

(4) Examples : TiC, TiH, Mn H, Fe H, VH, ZrH etc.

$3Fe_2O_3 \rightarrow 2Fe_3O_4 + CO_2$

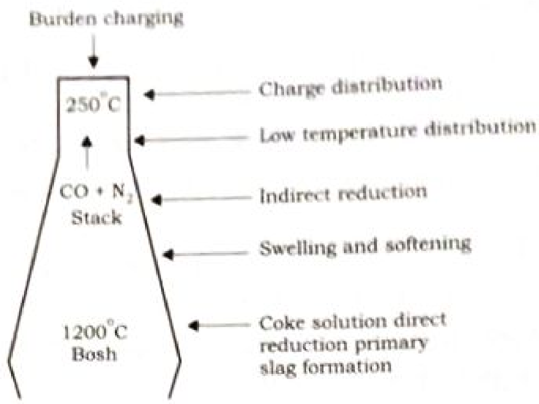
$Fe_3O_4 + CO \rightarrow 3FeO + CO_2$

$FeO + C \rightarrow Fe + CO$

$MnO + C \rightarrow Mn + CO$

$P_2O_5 + 5C \rightarrow P_2 + 5CO$

$SiO_2 + 2C \rightarrow Si + 2CO$



- **Alloy formation:**

(1) Transition metals form a number of alloys.

(2) Alloys are hard and have a high M.P.

(3) Stainless steel = alloy of Fe with Cr, V, W, Mn etc.

(4) **Alloy:** Due to similar atomic size one metal can easily replace the other metal in its lattice to form a solid solution known as an alloy.

(5) The molten state solution of two or more transition metals on cooling form alloy.
e.g. Brass (Cu – Zn) Bronze (Cu – Sn)

8.7. Compounds of Mn and Cr ($KMnO_4$ and $K_2Cr_2O_7$)

- **Preparation of Potassium Permanganate ($KMnO_4$):**

Ore used for preparation of $KMnO_4$ is pyrolusite ore (MnO_2)

Step – I : Pyrolusite ore → Potassium manganate (K_2MnO_4)

Step – II : Potassium manganate → Potassium per mangnate ($KMnO_4$)

(1) MnO_2 to K_2MnO_4 $\quad 3MnO_2 + 6KOH + KClO_3 \longrightarrow 3K_2MnO_4 + KCl + 3H_2O$

(2) K_2MnO_4 to $KMnO_4$

(a) By oxidation:

In neutral or acidic medium the green potassium magnate disproportionates to $KMnO_4$ and MnO_2

$$3K_2MnO_4 + 4CO_2 + 2H_2O \longrightarrow 2KMnO_4 + MnO_2 + 4KHCO_3$$

(b) Electrolytic oxidation:

The oxygen evolved at the anode converts magnate to permanganate

At anode, $\underset{\text{(Green)}}{MnO_4^{2-}} \longrightarrow \underset{\text{(Purple)}}{MnO_4^-} + e^-$

At cathode, $2H^+ + 2e^- \longrightarrow H_2$

$$2K_2MnO_4 + H_2O + [O] \longrightarrow \underset{\text{(Purple black)}}{2KMnO_4} + 2KOH$$

Overall reaction: $2K_2MnO_4 + H_2O + [O] \longrightarrow 2KMnO_4 + 2KOH$

- **Chemical Properties of $KMnO_4$:**

(1) Physical Properties:

Deep purple, crystalline solid, moderately soluble in water, MP – 523 K

(2) Action of Heat:

$$2KMnO_4 \xrightarrow{\Delta} K_2MnO_4 + MnO_2 + O_2$$

$$2K_2MnO_4 \xrightarrow[\text{hot}]{\text{Red}} 2K_2MnO_3 + O_2\uparrow$$

(3) Action of H_2SO_4:

$$2KMnO_4 + 2H_2SO_4 \xrightarrow[\text{conc. } H_2SO_4]{\text{Cold}} Mn_2O_7 + 2KHSO_4 + H_2O$$

$$2Mn_2O_7 \longrightarrow 4MnO_2 + 3O_2$$

$$4KMnO_4 + \underset{\text{conc.}}{6H_2SO_4} \xrightarrow{\text{Warm}} 2K_2SO_4 + 2MnSO_4 + 6H_2O + 5O_2$$

- **Preparation of Potassium dichromate ($K_2Cr_2O_7$):**

Step I: Concentration of ore : In hydraulic classifier, powdered chromate ore is concentrated by washing with current of water.

Step II: Roasting conversion of chromite ore into sodium. chromate:

$$2FeO \cdot Cr_2O_3 + 8Na_2CO_3 + 7O_2 \longrightarrow 2Fe_2O_3 + 8Na_2CrO_4 + 8CO_2$$

(Chromate ore)

Step III: Conversion of sodium chromate into sodium dichroniate:

$$2Na_2CrO_4 + H_2SO_4 \longrightarrow Na_2Cr_2O_7 + Na_2SO_4 + H_2O$$

Step IV: Conversion of sodium dichromate into potassium dichromate:

$$Na_2Cr_2O_7 + 2KCl \longrightarrow K_2Cr_2O_7 + 2NaCl$$

- **Chemical properties of Potassium Dichromate:**

(i) It is strong oxidising agent.

(ii) When H_2S gas is passed through acidified $K_2Cr_2O_7$, the orange colour changes to green indicating reduction of $K_2Cr_2O_7$ to chromic sulphate and oxidation of $S^{2\ominus}$ to sulphure.

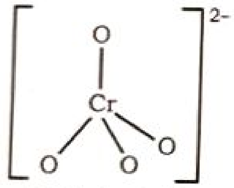
$$K_2Cr_2O_7 + H_2S + 4H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O + 3S\downarrow$$

(iii) Acidified $K_2Cr_2O_7$ when reacts with KI, solution turns brown due to liberation of free iodine (oxidation of $I^{\ominus}$ ion).

$$K_2Cr_2O_7 + 6KI + 7H_2SO_4 \longrightarrow 4K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O + 3I_2$$

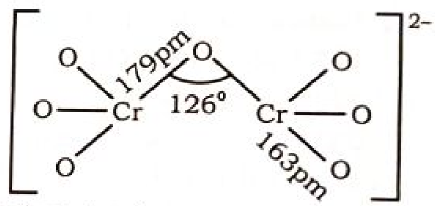
- **Structure of chromate ion and Dichromate ion:**

(1) Chromate ion $[CrO_4]^{2-}$:



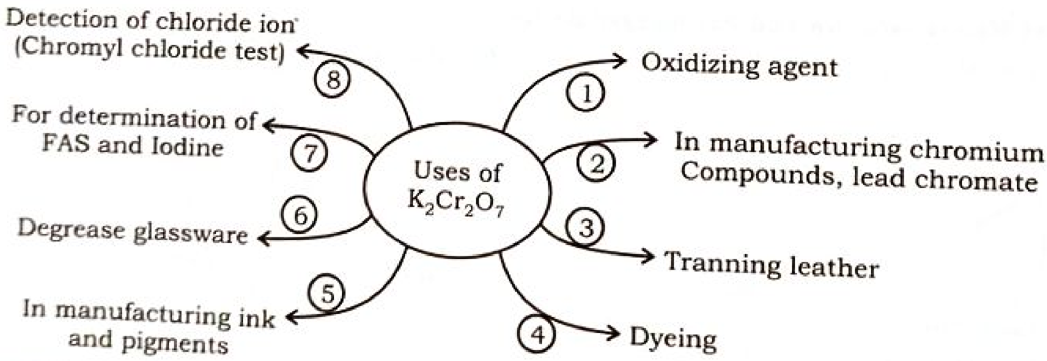
Tertrahedral

(2) Dichromate ion $(Cr_2O_7)^{2-}$:



Two tertrahedral sharing one corner with Cr—O—Cr

- **Uses of $K_2Cr_2O_7$:**



8.8 Common Properties of d-Block Elements

(i) They exhibit variable valencies and form coloured salts and complexes.

(ii) They are good reducing agents.

(iii) All d-block elements are electropositive metals.

(iv) They form insoluble oxides and hydroxides.

(v) Molybdenum, zinc, iron, cobalt and nickel are biologically improtant metals.

(vi) Catalyse biological reactions.

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$4FeO \cdot Cr_2O_3 + 8Na_2CO_3 + 7O_2 \longrightarrow 2Fe_2O_3 + 8Na_2CrO_4 + 8CO_2$

Chromite ore

Step III: Conversion of sodium chromate into sodium dichromate

$2Na_2CrO_4 + H_2SO_4 \longrightarrow Na_2Cr_2O_7 + Na_2SO_4 + H_2O$

Step IV: Conversion of sodium dichromate into potassium dichromate

$Na_2Cr_2O_7 + 2KCl \longrightarrow K_2Cr_2O_7 + 2NaCl$

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$K_2Cr_2O_7 + 3H_2S + 4H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O + 3S$

(iii) Acidified $K_2Cr_2O_7$ when reacts with KI solution, turns brown due to liberation of free iodine (oxidation of I^- ion).

$K_2Cr_2O_7 + 6KI + 7H_2SO_4 \longrightarrow 4K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O + 3I_2$

- **Structure of chromate ion and Dichromate ion**

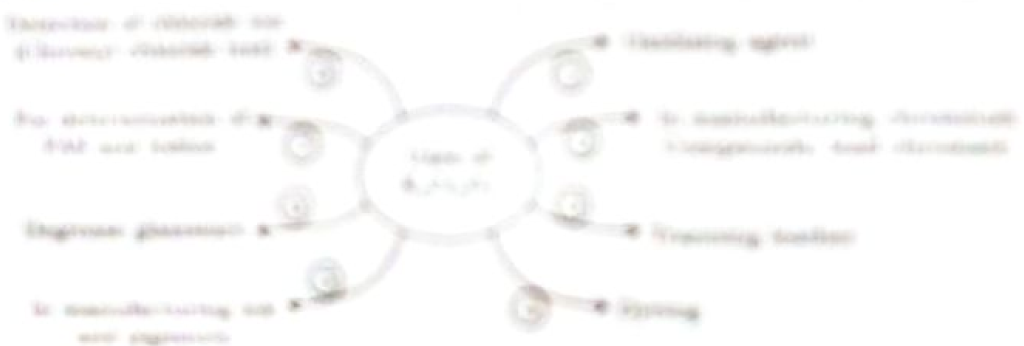
(1) Chromate ion $[CrO_4]^{2-}$:

Tetrahedral

(2) Dichromate ion $[Cr_2O_7]^{2-}$:

Two tetrahedra sharing one corner with Cr–O–Cr

- **Uses of $K_2Cr_2O_7$**



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(iv) They form insoluble oxides and hydroxides.

(v) Molybdenum, zinc, iron, cobalt and nickel are biologically important metals.

(vi) Catalyse biological reactions.

8.9 Extraction of Metals

Minerals	Ores
These are naturally occuring chemical substances in the earth's crust obtainable by mining.	The minerals from which a metal can be economically and conveniently extracted is known as ore
e.g. Bauxite ($Al_2O_3.2H_2O$) and clay ($Al_2O_3.2SiO_2.2H_2O$) are the minerals of Al	Bauxite is an ore of Al because Al can be economically extracted from it.

- **Metallurgy:**

Commerical extraction of a metal in a pure state from its ore is called metallurgy.

Metallurgy
↓

Pyrometallurgy	Hydrometallurgy	Electro-metallurgy
(Ore is reduced to metal at high temperature	(Extraction of metals from aqueous solutions of their salts	(Metal is extracted by electrolytic reduction of molten (fused) metallic compound)

Gangue: The mud sand and other unwanted impurities present in the ore is called gangue.

- **Extraction of Iron from Haematite ore using blast furnace:**

Iron [Fe] is extracted from haematite ore [Fe_2O_3] by its reduction using coke and limestone.

Steps:

(1) Concentration: In hydraulic classifier by using a powerful current of water.

(2) Roasting: The sulphur and arsenic impurities present in the concentrated ore get converted into their oxides and escape out.

$$4FeO + O_2 \longrightarrow 2Fe_2O_3$$

(3) Reduction (smelting): This step is carried out in a blast furnace.

There are 3 temperature zones in the blast furnace:

(a) Zone of cumbustion: (around 2000 K) - (5-10 m from bottom) combustion of coke with O_2 in the air.

(b) Zone of reduction: (around 900 K) (22-25 m near the top) - Reduction of Fe_2O_3 to metallic iron.

(c) Zone of slag formation: (around 1200 K) - (20 m unit) - Formation of slag by reaction of gangue with limestone.

- Table Summary of reactions taking place in blast furnace at different temperature zones:

Temp K	Changes taking place	Reaction
500	loss of moisture from ore	
900	Reduction of ore by CO	$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$
1200	Decomposition of lime	$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$
1500	Reduction of ore by C	$Fe_2O_3 + 3C \longrightarrow 2Fe + 3CO$
2000	Slag formation	$CaO + SiO_2 \longrightarrow CaSiO_3$ $12CaO + 2Al_2O_3 \longrightarrow 4Ca_3AlO_3 + 3O_2$

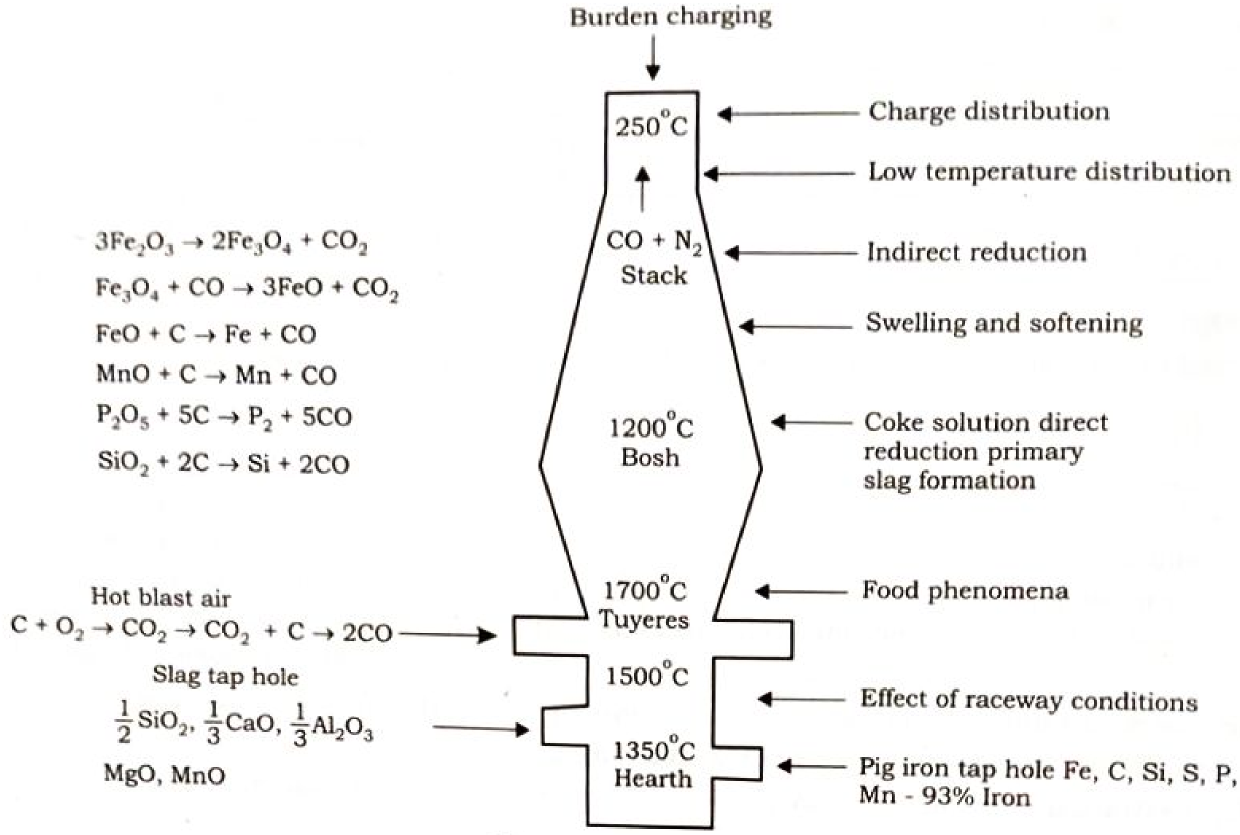

Fig. Blast furnace

- **Difference between cast iron, wrought iron and steel:**

	Cast iron	Wrought iron	Steel
1.	Hard and brittle	Very soft texture	Not very hard and not very soft
2.	Carbon present 4%	Carbon present 0.2%	Carbon present 0.2 - 2%
3.	Used for manufacturing pipes, automotive parts, pots, pans, utensils.	Used for manufacturing pipes, bars for stay belts, engine bolts and rivetts	Used in making tools, ships, automobiles, weapons and building infrastructures.

8.10 Inner Transition (f-block) Elements: (Lanthanoids and Actinoids)

- **f-block** = The elements in which last electron enter into (n – 2)f orbital (prepenultimate shell).
- **f-block element** = In all 28 ⇒ At no. 58 – 71 and 91 to 103
- **Inner transition elements** = Since f-orbital lies much inside the d-orbital in comparision to the transition metals the f-block elements are called inner transition elements.
- 4f block elements = Lanthanoid series
- 5f block elements = Actinoid series
- Lanthanoids belong to Gr.3 of the periodic table and are placed in 6th period.
- Lanthanoids interrupt the 3rd transition series of d-block element in the sixth period.
- Exact position is in between La (57) to Hf (72).
- Lanthanoid elements from Ce to Lu have similar physical and chemical properties.
- Only for sake of convenience, these elements are shown at the bottom of the periodic table as lanthanoids (to maintain symmetry).

8.11 Properties of f-block elements

(1) These elements are soft with moderate densities.
(2) They have high m.p. and b.p.
(3) They are very reactive in the metallic state.
(4) Common oxidation state is the +2 and +3.
(5) Lanthanoids have lower heat of atomization than d-block elements.

(6) Lanthanoids form nitrides (LnN) and Halide (LnX_3) type.
(7) At high temperature they form carbides (LnC_2).
(8) Many of the lantuanoids are coloured in +3 oxidation state.

8.12 Properties of Lanthanoids

(1) Soft silvery white coloured metals with moderate densities of $\sim 7\ gcm^{-3}$
(2) All are non-radioactive, except promethium (Pm).
(3) They all are good conductor of heat and electricity.
(4) They show Lanthanoid contraction.
(5) They show binding with water.
(6) Coordination numbers are generally more than 6.
(7) They are strongly paramagnetic.

- **Electronic Configuration:**

(1) General electronic configuration $_{54}[Xe]4f^{0-14}5d^{0-2}6s^2$.
(2) As atomic number increases from La to Lu, after lanthanum electrons enter into 4f subshell not in 5d.
(3) Elements Gd and Lu posses single electron in 5d subshell while in others 5d orbital is empty.
(4) Observed electronic configuration involves moving of single electron from 5d to 4f subshell.
(5) f^7, f^{14} electronic configuration achieve extra stability due to half and completely filled f orbitals e.g. Gd($4f^7$) Lu($4f^{14}$)

- **Oxidation States:**

(1) +2 oxidation state = Europium = Eu^{2+} = $[Xe]4f^7$ half filled
Yetterbium = Yb^{+2} = $[Xe]4f^{14}$ completely filled
Samarium = Sm^{2+} = $[Xe]4f^6$
Thulium = Tm^{+2} = $[Xe]4f^{13}$ } Thermodynamic factor
Neodymium = Nd^{2+} = $[Xe]4f^4$]
(2) +3 oxidation state = This is the common oxidation state of all lanthanoids.
(3) +4 oxidation state = Cerium = Ce^{+4} = $[Xe]4f^0$
Terbium = Tb^{+4} = $[Xe]4f^7$
Praseodymium = Pr^{+4} = $[Xe]4f^1$
Neodymium = Nd^{+4} = $[Xe]4f^2$
Dysprosium = Dy^{+4} = $[Xe]4f^8$
(4) Good reducing agent = Sm^{2+}, Eu^{2+}, Yb^{+2}
(5) Good oxidizing agent = Ce^{4+}, Tb^{4+}

- **Colour and spectra:**

The colour of the lanthanoid ion is due to f-f transition.

- **Chemical Reactivity of Lanthanoids:**

$Ln^{3+}_{(aq)} + 3e^- \longrightarrow Ln_{(s)}$

(1) Carbides $\quad Ln + C \xrightarrow{2500^\circ C}$ Lanthanoid carbide (Ln_3C, LnC_2, Ln_2C_3)
(2) Hydride $\quad 2Ln + 3H_2 \longrightarrow 2LnH_3$
(3) Oxides $\quad 4Ln + 3O_2 \longrightarrow 2Ln_2O_3$
$Ln_2O_3 + 3H_2O \longrightarrow 2Ln(OH)_3$
$Ln_2O_3 + 3CO_2 \longrightarrow Ln_2(CO_3)_3$
(4) Reaction with Nitrogen $\quad 2Ln + N_2 \xrightarrow{\Delta} 2LnN$
(5) Reaction with Mineral acid $\quad 2Ln + 6HCl \longrightarrow 2LnCl_3 + 3H_2$
(6) Reaction with H_2O $\quad Ln + 3H_2O \longrightarrow Ln(OH)_3 + H_2$
(7) Reaction with S $\quad 2Ln + 3S \longrightarrow Ln_2S_3$

- **Atomic and ionic radii (Lanthanoid Contraction):**

(1) The gradual decrease in atomic and ionic size of lanthanoids with anincrease in atomic number is called lanthanoid contraction.

(2) **Causes of Lanthanoid contraction:**

- As the atomic number increases, electrons are added one by one in 4f inner shell.
- The extent of shielding created by electron of 4f is weaker than d subshell due to diffused shape of subshell.
- Due to this nuclear charge increases and screening effect decreases and so atomic and ionic radii get contracted slightly.

- **Effect of Lanthanoid Contraction:**

(a) Decrease in basicity:

- According to Fajan Rule, larger the size of cation, greater is the tendency of such hydroxides to dissociate and stronger will be base.
- Due to lanthanoid contraction, size of tripositive ion regularly decreases with increase in atomic number i.e. from La^{3+} to Lu^{3+}.
- Basic character from La^{3+} to Lu^{3+} decreases.

(b) Ionic radii of post lanthanoids:

- In the third transition series, the element which follow the lanthanoids are called as post lanthanoids.
- There is normal increase in size from Sc to Y to La.
- This trend disappears after lanthanoids and pairs of elements Zr – Hf (gr 4) Nb-Ta (gr. 5), Mo-W (gr.6) and Tc-Re (gr.7) have almost identical size.
- **Chemical Twins:** A pair of elements having similar properties due to similar atomic radii and almost same size are called chemical twin elements.

8.13 Applications of Lanthanoids

The Lanthanoid compounds are used in

→ Inside colour television and computer monitor.
→ Luminescent materials.
→ Optical fibre communication systems.
→ Hybrid cars, super conductors and permanent magnets.

8.14 Actinoids

- The series of elements from Thorium (90) to Lawrencium (103) in which 5f orbitals are progressively filled are called Actinoids.
- They are named actinoids because their properties are similar to actinium which is a prototype of this series.
- **Transuranic elements:** These are man made elements having atomic number higher than Uranium (92).
- They belong to 3 gr and 7th period of the periodic table.
- They are placed at the bottom of the periodic table for convenience.
- **Electronic Configuration:**

(1) General electronic configuration $[Rn]5f^{0-14}\,6d^{0-2},\,7s^2$
(2) Electronic configuration is not definite.
(3) Thorium does not contain 5f electrons.
(4) 3rd member protactinium possesses two e^- in 5f and one e^- in 6d.

- **Oxidation state of actionids:**

(1) Common oxidation state +3 (atomic number increases stability of +3 oxidation state increases)
(2) +2 oxidation state = Am, Th
(3) +4 oxidation state Th to Bk
(4) +5 oxidation state = Th to Am
(5) +6 oxidation state U to Am
(6) +7 oxidation state = Np to Pu

8.15 Properties of Actinoids

No.	Properties	Lanthanoids	Actinoids
(1)	Last electron	in 4f subshell	in 5f subshell
(2)	Period of Periodic Table	Part of 3rd transition and 1st inner transition series	Part of 4th transition and second inner transition series.
(4)	Occurrence	All are natural except Promethium	Most of synthetically prepared
(5)	Binding energy	High	Low
(6)	Radioactivity	Non radioactive except Promethium	All are radioactive.
(7)	Oxidation states	With +3, they show +2 and +4	With +3, they show +2, +4, +5, +7
(8)	Complex formation	Less tendency	More tendency
(9)	Colour	Fairly coloured	Deeply coloured
(10)	Oxocations	Do not form	Forms like UO_2^{2+} , PuO_2^{2+} , UO^+
(11)	Basicity	Less	More
(12)	Contraction	Less	greater

8.16 Applications of Actinoids

(1) ThO_2 with 1% CeO_2 is used in indoor and outdoor lighting.

(2) Uranium is used in nuclear reactor.

MULTIPLE CHOICE QUESTIONS

TEXTUAL ZONE

8.1 Introduction

(1) The wrong statement for transition elements is ....

(a) They belong to d-block of periodic table
(b) They exhibit properties between those of s and p block elements
(c) They belong to groups 1 – 12
(d) They have an incomplete d-subshell

(2) The 3d series is from

(a) Ac to Cn **(b)** La – Hg
(c) Sc to Zn **(d)** Y – Cd

8.2 Position in Periodic Table

(3) The position of transition elements in the periodic table is ....

(a) Periods 4–7 and groups 2–12
(b) Periods 1–7 and groups 3–12
(c) Periods 4–7 and groups 3–12
(d) Periods 3–7 and groups 3–12

(4) The noble gas element preceding scandium (Z = 21) is ....

(a) He **(b)** Ne **(c)** Kr **(d)** Ar

(5) The correct sequence of 3d series in the following is ....

(a) Sc Ti Cr Fe **(b)** Sc Cr Ti Fe
(c) Sc Fe Cr Ti **(d)** Sc Cr Fe Ti

(6) Which of the following cannot be regarded as transition element?

(a) Zinc **(b)** Iron
(c) Titanium **(d)** Cobalt

(7) The element that can be considered a transition element is ....

(a) Zinc **(b)** Cadmum
(c) Iron **(d)** Mercury

(8) The fourth element in the 3d series is ....

(a) Titanium **(b)** Vanadium
(c) Chromium **(d)** Monganese

8.3 Position in Periodic Table

(9) Electronic configuration of scandium is ....

(a) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^1\ 4s^2$
(b) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^7\ 4s^2$
(c) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ 4s^0$
(d) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5\ 3d^2\ 4s^2$

(10) The general electronic configuration of transition elements is ....

(a) $nd^{1-10}ns^{1-2}$ **(b)** $(n-1)d^{1-10}ns^{1-2}$
(c) $(n-2)d^{1-10}ns^{1-2}$ **(d)** $nd^{1-9}ns^2$

(11) Match the following:

(1) Sc – Zn	(i) $[Kr]4d^{1-10}\ 5s^{0-2}$
(2) Y – cd	(ii) $[Xe]5d^{1-10}\ 6s^2$
(3) La – Hg	(iii) $[Rn]6d^{1-10}\ 7s^2$

(4) Ac – Cn (iv) $[Ar]3d^{1-10}4s^2$

(a) (1) – (i), (2) – (ii), (3) – (iii), (4) – (iv)
(b) (1) – (ii), (2) – (iii), (3) – (iv), (4) – (i)
(c) (1) – (iv), (2) – (i), (3) – (ii), (4) – (iii)
(d) (1) – (iii), (2) – (ii), (3) – (i), (4) – (iv)

(12) The electronic configuration of chromium that assigns is ....
(a) $[Ar]3d^4\ 4s^2$ **(b)** $[Ar]3d^5\ 4s^1$
(c) $[Ar]3d^3\ 4s^3$ **(d)** $[Ar]3d^2\ 4s^4$

(13) The electronic configuration of copper in the + 1 oxidation state is ....
(a) $[Ar]3d^{10}\ 4s^1$ **(b)** $[Ar]3d^9\ 4s^2$
(c) $[Ar]3d^{10}\ 4s^0$ **(d)** $[Ar]3d^8\ 4s^3$

(14) $[Ar]3d^54s^1$ is the condensed electronic configuration of ....
(a) Copper **(b)** Chromium
(c) Cobalt **(d)** Titanium

(15) Outer electronic configuration of Cu^{+2} can be represented as ....
(a) $3d^94s^1$ **(b)** $3d^94s^0$
(c) $4d^95s^1$ **(d)** $4d^{10}5s^0$

8.4 Oxidation States of First Transition Series

(16) Copper is transition element, in the following oxidation state ....
(a) Zero **(b)** + 1 **(c)** + 2 **(d)** – 1

(17) Highest oxidation state shown by the element of 1st (first) transition series is ....
(a) Vanadium **(b)** Chromium
(c) Manganese **(d)** Iron

8.5 Physical Properties of First Transition Series

(18) Among the following, the INCORRECT statement for 3d series is ....
(a) They are hard, lustrous, malleable and ductile
(b) They form alloys with other metals
(c) They are good conductor of heat and electricity
(d) They possess low melting and boiling points

8.6 Trends in Atomic Properties of First Transition Series

(19) Atomic radii of First transition series ....
(a) Decreases gradually
(b) Increases gradually
(c) First increases and then decreases
(d) Remains same from left to right

(20) Ferromagnetic transition metal in 3d series is
(a) Sc **(b)** Ti **(c)** V **(d)** Fe

(21) The spin-only formula for magnetic moment is ....
(a) $\mu = \sqrt{n(n+1)}$ BM **(b)** $\mu = \sqrt{n(n+2)}$ BM
(c) $\mu = \sqrt{n(2n+2)}$ BM **(d)** $\mu = \sqrt{\frac{n+2}{c}}$ BM

(22) Magnetic moment of 1.73 BM indicates number of unpaired electron ....
(a) One **(b)** Two **(c)** Three **(d)** Four

(23) The paragmagnetic species is ....
(a) Cu^{+1} **(b)** Zn^{+2} **(c)** Sc^{+3} **(d)** Fe^{+3}

(24) The spin-only magnetic moment for V^{3+} is ......
(a) 1.73 BM **(b)** 2.83 BM
(c) 3.87 BM **(d)** 4.90 BM

(25) If the magnetic moment is 4.90 BM the value of 'n' is ....
(a) 1 **(b)** 2 **(c)** 3 **(d)** 4

(26) The spin only magnetic moment of divalent cation having atomic number 26 is ....
(a) 2.84 BM **(b)** 3.87 BM
(c) 4.90 BM **(d)** 5.92 BM

(27) The colour of transition metal ion depends upon ....
(a) Presence of unpaired d-electrons
(b) d-d transition
(c) Ligand and geometry of complex
(d) All the above

(28) The colour of Ti^{+4} ion in the Compound is ......
(a) Blue **(b)** Red
(c) Orange **(d)** Colourless

(29) Amongst the following, the INCORRECT example of a catalyst of transition metal is ....
(a) MnO_2 acts as a catalyst for decomposition of $kClO_3$
(b) CO - Th alloy is used in Fischer-Tropsch process in the synthesis of gasoline
(c) In manufacture of ammonia by Haber's process catalyst used is chromium
(d) Finely divided 'Ni' used for hydrogenation of alkene or oil to fats

(30) The INCORRECT property of interstitial compounds is ....
(a) Their melting points are higher than pure metals
(b) Their densities are less than pure metals
(c) The metallic carbides are chemically reactive and very soft
(d) They are hard and good conductor of heat and electricity

(31) Bronze is an alloy of ....
(a) Copper and tin
(b) Copper and nickel
(c) Nickel and Chromium
(d) Copper and Zinc

(32) Alloy used for making statues, medals and trophies is ....
(a) Nichrome (b) Titanium
(c) Cupra-nickel (d) Bronze

(33) Alloy used for ultra high speed flight, fire proof bulkheads and exhaust shrouds is ....
(a) Brass (b) Bronze
(c) Nichrome (d) Titanium alloy

(34) Ferrous alloy is ....
(a) Stainless steel (b) Brass
(c) Bronze (d) Nichome

(35) Non ferrous alloy is ....
(a) Nickel steel (b) Chromium steel
(c) Stainless steel (d) Brass

(36) Nichrome is an alloy of ....
(a) Nickel and Copper
(b) Nickel and chromium
(c) Nickel and cobalt
(d) Nickel and zinc

8.7 Compounds of Mn and Cr ($KMnO_4$ and $K_2Cr_2O_7$)

(37) When a finely divided MnO_2 is heated with KOH and oxidising agent $KClO_3$, product formed is ....
(a) $KMnO_4$ (b) K_2MnO_4
(c) $MnSO_4$ (d) K_3MnO_4

(38) In the preparation of $KMnO_4$ from MnO_2, first step involved conversion of MnO_2 to K_2MnO_4, oxidation state changes from ....
(a) + 2 to + 7 (b) + 4 to + 7
(c) + 4 to + 6 (d) + 3 to + 6

(39) The reaction,
$$3K_2MnO_4 + 4CO_2 + 2H_2O \longrightarrow 2KMnO_4 + MnO_2 + 4KHCO_3$$ is
(a) Combustion reaction
(b) Disproportionation reaction
(c) Decomposition reaction
(d) Displacement reaction

(40) The equivalent weight of potassium permanganate for acidic solution is ....
(a) 158 (b) 79
(c) 52.16 (d) 31.6

(41) $KMnO_4$ in alkaline or netural medium convert thiosulphate ($S_2O_3^{-2}$) to ....
(a) Sulphur (b) Sulphur dioxide
(c) Sulphate (d) Oleum

(42) The reaction,
$$2MnO_4^- + 3Mn^{+2} + 2H_2O \longrightarrow 5MnO_2 + 4H^+$$
The oxidation state changes from ....
(a) +6 and +2 to +4 (b) +7 and +2 to +4
(c) +4 and +2 to +3 (d) +2 and +4 to +7

(43) Chromite ore is ....
(a) $ZnO.Cr_2O_3$ (b) $FeO.Cr_2O_3$
(c) $SnO.Cr_2O_3$ (d) $NiO.Cr_2O_3$

(44) Acidified $K_2Cr_2O_7$ oxidises KI to ....
(a) Iodine (b) Iodate
(c) Per-iodate (d) Iodide

(45) When H_2S gas is passed through acidified solution of $K_2Cr_2O_7$, orange colour changes to green due to formation of ....
(a) $CrCl_3$ (b) $Cr_2(SO_4)_3$
(c) CrO_3 (d) Cr_2S_3

(46) Industrially potassium dichromate can be manufacture by ....
(a) Haematite ore (b) Zinc blende
(c) Chromite ore (d) Chalcocite ore

(47) Amongst the following, the INCORRECT chemical equation for the manufacture of $K_2Cr_2O_7$ is ....
(1) $4(FeO.Cr_2O_3) + 8Na_2CO_3 + 7O_2 \longrightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$
(2) $2Na_2CrO_4 + H_2SO_4 \longrightarrow Na_2Cr_2O_7 + 2NaCl + Na_2Cr_2O_7H_2O$
(3) $Na_2Cr_2O_7 + 2KCl \longrightarrow K_2Cr_2O_7 + 2NaCl$
(4) $Na_2Cr_2O_7 + 2KOH \longrightarrow K_2Cr_2O_7 + 2NaOH$
(a) 1 (b) 2 (c) 3 (d) 4

8.8 Common Properties of d and f black Elements

(48) The highest oxidation state shown by transition element is ....
(a) Iron (b) Cobalt
(c) Osmium (d) Manganese

(49) The INCORRECT physical properties of d-block elements is ....
(a) They are hard and high density
(b) They are good electrical and thermal conductors
(c) They have low melting and boiling points
(d) The have high tensile strength and malleability

(50) The correct properties of f-block elements in the following is ....

(a) They are all electronegative non metals
(b) They are good oxidising agent
(c) They catalyse biological reactions
(d) They do not show variable oxidation states

8.9 Extraction of Metals

(51) Important Ore of Iron is ....

(a) Magnetite **(b)** Limonite
(c) Siderite **(d)** Haematite

(52) Calamine is ....

(a) ZnO **(b)** ZnS
(c) $ZnCO_3$ **(d)** $ZnSO_4$

(53) Chalcocite is ore of ....

(a) Iron **(b)** Copper
(c) Zinc **(d)** Cobalt

(54) The sand, mud and other unwanted impurities which remain mixed with the ore deposits are called ....

(a) Flux **(b)** Gangue
(c) Minerals **(d)** Metallurgy

(55) The steps involved during extraction of iron from haematite ore is in the order ....

(a) Concentration, Refining, Reduction, Roasting
(b) Reduction, Roasting, Refining, Concentration
(c) Concentration, Roasting, Reduction, Refining
(d) Roasting, Reduction, Concentration, Refining

(56) Flux used during extraction of Iron from haematite ore is

(a) $CaSO_4$ **(b)** $CaCO_3$
(c) $CaCl_2$ **(d)** $Ca(NO_3)_2$

(57) The reaction takes place of 900K during extraction of Iron from haematite in blast furnace is..........

(a) $CaCO_3 \longrightarrow CaO + CO_2$
(b) $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$
(c) $Fe_2O_3 + 3C \longrightarrow 2Fe + 3CO$
(d) $CaO + SiO_2 \longrightarrow CaSiO_3$

(58) The percentage of carbon in Wrought iron is ....

(a) Less than 0.2% **(b)** Between 0.2 to 2%
(c) 4% carbon **(d)** 8 to 10% carbon

(59) Among the following, the INCORRECT statement for extraction of Iron from haematite is ....

(a) Blast furnace is comprised of Hearth, Bash and Stack
(b) Three temperature zone such as Combustion, Reduction, Slag formation
(c) Lime stone acts as a flux
(d) Ore is concentrated by Leaching

8.10 Inner Transition (f-block) Element

(60) Inner Transition elements are those elements in which electrons are added to

(a) nf orbital **(b)** (n – 1) f-orbital
(c) (n – 2) f-orbital **(d)** (n – 3) f-orbital

(61) Lanthanoids begin with atomic number ....

(a) 38 to 48 **(b)** 57 to 71
(c) 89 to 103 **(d)** 104 to 112

(62) Actinoids begin with atomic number ....

(a) 72 to 84 **(b)** 104 – 116
(c) 57 to 71 **(d)** 89 to 103

(63) Lanthanoids belong to ....

(a) 3^{rd} period 6^{th} group
(b) 3^{rd} group and 6^{th} period
(c) 4^{th} period 7^{th} group
(d) 3^{rd} group and 7^{th} period

(64) Actinoids belong to ....

(a) Group 3 and 6^{th} period
(b) Group 3 and 7^{th} period
(c) Group 6 and 3^{rd} period
(d) Group 6 and 7^{th} period

(65) Electronic configuration of Gadolinium is ......

(a) $[Xe]4f^8\ 5d^0\ 6s^2$ **(b)** $[Xe]4f^8\ 5d^1\ 6s^1$
(c) $[Xe]4f^7\ 5d^1\ 6s^2$ **(d)** $[Xe]4f^6\ 5d^2\ 6s^2$

(66) Besides +3, cerium and Terbium show oxidation state of ....

(a) + 1 **(b)** + 2 **(c)** + 3 **(d)** + 4

(67) Europium and Ytterbium show oxidation states of ....

(a) +2, +3 **(b)** +2, +4
(c) +3, +3 **(d)** +3, +4

(68) Radioactive element in 4f series is ....

(a) Cerium **(b)** Gadolinium
(c) Promethium **(d)** Holmium

(69) Among the following, the strongest base is ....

(a) $Ce(OH)_3$ **(b)** $Lu(OH)_3$
(c) $La(OH)_3$ **(d)** $Tb(OH)_3$

(70) Weakest base in the following is ....

(a) $Lu(OH)_3$ **(b)** $La(OH)_3$
(c) $Nd(OH)_3$ **(d)** $Eu(OH)_3$

(71) The INCORRECT properties of Lanthanoids is

(a) The atomic and ionic radii decreases from La to Lu

(b) Lanthanoids are strongly paramagnetic

(c) Gadolinium becomes ferromagnetic above curie point (16°C)

(d) Magnetic and optical properties are largely independent of environment

(72) The correct statement regarding Lanthanoid is ....

(a) They react with water to give $M(OH)_2$

(b) They react with nitrogen and halogen to give LnN and LnX_3

(c) They react with Carbon at low temp. to form LnC_3

(d) In +3 oxidation state, many of the lanthanoids are colourless

(73) The electronic configuration of lanthanoids is ....

(a) $[Xe]4f^{0-14}\,5d^0\,6s^2$ **(b)** $[Xe]4f^{0-14}5d^{0-2}6s^2$

(c) $[Rn]4f^{0-14}5d^{0-2}6s^2$ **(d)** $[Rn]5f^{0-14}6d^{0-2}7s^2$

(74) f^7 configuration is exhibited by following ion ....

(a) Ce^{+4} **(b)** Tb^{+4} **(c)** Yb^{+2} **(d)** Pr^{3+}

(75) The series of the elements, starting from cerium and ending to lutetium, is called

(a) radioactive series **(b)** actinide series

(c) lanthanide series **(d)** electromotive series

(76) Observed electronic configuration of Europium is (Eu atomic no. = 63)

(a) [Xe] $4f^6\,5d^1\,6s^2$ **(b)** [Xe] $4f^7\,5d^1\,6s^2$

(c) [Xel $4f^7\,5d^\circ\,6s^2$ **(d)** [Xe] $4f^6\,5d^\circ\,6s^2$

(77) Which one of the element have observed electronic configuration $[Xe]4f^{13}\,5d^0\,6s^2$

(a) Eu **(b)** Tm **(c)** Er **(d)** Yb

(78) Select the element which does not have any 4f electrons.

(a) La **(b)** Lu **(c)** Yb **(d)** Ce

(79) The outer electronic configuration, [Xe] $6s^2$ $4f^4$ $5d^0$ is for

(a) $_{66}Dy$ **(b)** $_{60}Nd$ **(c)** $_{60}Ho$ **(d)** Nd

(80) The observed electronic configuration,

[Xe] $6s^2\,4f^{10}\,5d^\circ$ is of

(a) $_{58}Ce$ **(b)** $_{66}Dy$ **(c)** $_{61}Sm$ **(d)** $_{59}Pr$

(81) In the observed electronic configuration of Holmium, the number of 4f-electrons is

(a) 9 **(b)** 11 **(c)** 8 **(d)** 7

(82) [Xe] $4f^7\,5d^1\,6s^2$ is electronic configuration of

(a) Europium **(b)** Gadolinium

(c) Terbium **(d)** Dysprosium

(83) The most common oxidation state of all the lanthanoids is

(a) +3 **(b)** +2 **(c)** +4 **(d)** +5

(84) Stability of ion Gd^{3+} is due to

(a) completely filled f-subshell

(b) half filled f-subshell

(c) no electrons in f-subshell

(d) Sd electronic distribution

(85) The oxidation state at which Cerium attain $4f^0$ configuration of

(a) +3 **(b)** +5 **(c)** +2 **(d)** +4

(86) In the +4 oxidation state, Terbium attains configuration of

(a) $4f^0$ **(b)** $4f^{14}$ **(c)** $4f^7$ **(d)** $4f^1$

(87) In the +2 oxidation state, the configuration shown by Europium is

(a) $4f^7$ **(b)** $4f^0$ **(c)** $4f^{14}$ **(d)** $4f^6$

(88) Which one of the following is good oxidising agent ?

(a) Sm^{2+} **(b)** Cu^{2+} **(c)** Ce^{4+} **(d)** Yb^{2+}

(89) The most stable oxidation state of Yb is

(a) +1 **(b)** +2 **(c)** +3 **(d)** +4

(90) When lanthanoids are heated around 2500°C with carbon it forms

(a) Ln_3C **(b)** LnC_2

(c) Ln_2C_3 **(d)** all of these

(91) Lanthanoid on reaction with mineral acid forms salt. The gas evolved in the reaction is

(a) O_2 **(b)** Cl_2 **(c)** N_2 **(d)** H_2

(92) The hydroxides of lanthanoids are

(a) basic **(b)** acidic

(c) neutral **(d)** amphoteric

(93) Misch metal is

(a) Lanthanoid metal and traces of S, C, Ca and Al

(b) Lanthanoid metal and Actinium metal

(c) Lanthanoid metal and N_2

(d) None of these

(94) The lanthanide contraction is responsible to acquire

(a) Zr and Nb, the similar oxidation states.

(b) Zr and Zn, the same oxidation states

(c) Zr and Y, the same radii

(d) Zr and Hf, the same radii

(95) The element with smallest atomic radii among following is

(a) La **(b)** Eu **(c)** Tb **(d)** Yb

(96) Uranium belongs to

(a) Lanthanioids **(b)** Actinioids

(c) Lanthanides and actinides both
(d) Neither lanthanide nor actinides

(97) All the elements belonging to the following series are radio-active:
(a) lanthanide series (b) halogens
(c) noble gases (d) actinide series

(98) Common oxidation state of Actinoids is
(a) +3 (b) +4
(c) +2 (d) +5

(99) Select the correct observed electronic configuration of Np. (Np-atomic no. = 93)
(a) $[Rn]5f^5\ 6d^{10}\ 7s^2$ (b) $[Rn]5f^6\ 6d^2\ 7s^2$
(c) $[Rn]5f^4\ 6d^1\ 7s^2$ (d) $[Rn]5f^7\ 6d^5\ 7s^2$

(100) Which one of the following is incorrect for lanthanoids ?
(a) They cannot form oxocation.
(b) Only promethium is radioactive.
(c) They show greater tendency to for complexes.
(d) Some of the ions of lanthanoids are fairl coloured.

(101) Select incorrect statement for Actinoids.
(a) All the members of the series ar radioactive.
(b) Contraction is relatively less.
(c) They are deeply coloured.
(d) Actinoids form oxocations.

(102) Except Pm, all the lanthanide series elements are
(a) radio-active (b) non-radioactive
(c) water soluble (d) non-metals

COMPLEX ZONE

(1) The colour of Fe^{2+} ion is
(a) Pale green (b) Pink
(c) Violet (d) Purple

(2) Match the following:

(A) Cu^{1+}	(p) $[Ar]3d^7$
(B) Co^{2+}	(q) $[Ar]3d^3$
(C) Cr^{3+}	(r) $[Ar]3d^5$
(D) Mn^{2+}	(a) $[Ar]3d^{10}$

(a) (A)-(s), (B)-(q), (C)-(p), (D)-(r)
(b) (A)-(q), (B)-(p), (C)-(s), (D)-(r)
(c) (A)-(s), (B)-(p), (C)-(q), (D)-(r)
(d) (A)-(r), (B)-(p), (C)-(q), (D)-(s)

(3) Which of the following is not regarded as transition elements
(a) Sc (b) S (c) Ni (d) Ti

(4) Select the correct spin only formula
(a) $S = \sqrt{\mu + 2}$ BM (b) $\mu = \sqrt{n(n+2)}$ BM
(c) $\mu = \sqrt{(n+2)}$ BM (d) $\mu = \sqrt[3]{(n+2)}$ BM

(5) Match the following:

	Catalyst		Reaction
(A)	Co-Th alloy	(p)	Fischer Tropsch process
(B)	MnO_2	(q)	Decomposition of $KClO_3$
(C)	V_2O_5	(r)	For the manufacture of H_2SO_4
(D)	Ni	(s)	hydrogenation reaction

(a) (A)-(s), (B)-(p), (C)-(r), (D)-(s)
(b) (A)-(r), (B)-(s), (C)-(p), (D)-(q)
(c) (A)-(p), (B)-(q), (C)-(r), (D)-(s)
(d) (A)-(p), (B)-(r), (C)-(s), (D)-(q)

(6) Electronic configuration of Mn^{2+} is
(a) $[Ar]3d^8$ (b) $(Ar]3d^7$
(c) $[Ar]3d^3$ (d) $[Ar]3d^5$

(7) What is the magnetic moment of a divalent ion in aqueous solution whose atomic number is 25 ?
(a) 3.84 BM (b) 5.92 BM
(c) 4.90 BM (d) 1.73 BM

(8) The calculated value of magnetic moment of Ti^{3+} ion is
(a) 1.73 BM (b) 3.84 BM
(c) 4.90 SM (d) 5.92 SM

(9) Fourth transition element of first transition series
(a) Mn (b) Cr (c) Co (d) V

(10) Select the correct number of unpaired electrons if magnetic moment is 2.84.
(a) 3.5 (b) 4.0 (c) 2 (d) 0.0

(11) Select the divalent metal ion which has maximum paramagnetic character among the first transition series
(a) Fe^{2+} (b) Cr^{2+} (c) Mo^{2+} (d) Mn^{2+}

(12) Which one of the following ion is coloured?
(a) Ni^{2+} (b) Sc^{3+} (c) Ti^{+4} (d) Cu^{+}

(13) Select the correct equivalent weight of $KMnO_4$ in alkaline medium (molecular wt. 158)
(a) 52.67 (b) 62.57 (c) 26.58 (d) 67.52

(14) What will be the oxidation state of Cr in $K_2Cr_2O_7$?
(a) +4 (b) +7 (c) +6 (d) +5

(15) Select the correct order of acidic character
(a) $Mn_2O_7 < MnO_3 < MnO_2 < Mn_2O_3$

(b) $Mn_2O_7 > MnO_2 > Mn_2P_3 > MnO_3$
(c) $Mn_2O_7 > MnO_3 > Mn_2O_3 > MnO_2$
(d) $Mn_2O_7 > MnO_3 > MnO_2 > Mn_2O_3$

(16) Complete the given reaction
$MnO_4^- + 5Fe^{2+} + 8H^+ \longrightarrow$
(a) $Mn^{3+} + 5Fe^{2+} + 4H_2O$
(b) $Mn^{2+} + 5Fe^{2+} + 4H_2O$
(c) $Mn^{2+} + 5Fe^{3+} + 4H_2O$
(d) $Mn^{3+} + 5Fe^{3+} + 4H_2O$

(17) Oxidation of $S_2O_3^{2-}$ by MnO_4^- in neutral medium produces
(a) Mn_2O (b) MnO_3
(c) MnO_2 (d) Mn_2O_3

(18) Which one of the following shows only +3 oxidation state?
(a) La (b) Gd
(c) Lu (d) all of these

(19) Match the following
(A) La^{3+} (p) Green
(B) Pr^{3+} (q) Pink
(C) Nd^{3+} (r) Colourless
(D) Sm^{3+} (s) yellow
(a) (A-(r), (B)-(p), (C)-(q), (D)-(s)
(b) (A-(s), (B)-(p), (C)-(q), (D)-(r)
(c) (A-(p), (B)-(q), (C)-(r), (D)-(s)
(d) (A-(r), (B)-(s), (C)-(p), (D)-(q)

(20) Match the following:

(A)	Cerium-magnesium alloys	(p)	Flash light powder
(B)	Cerium salt	(q)	In dying cotton
(C)	Neodynamium and praseody-mium oxides	(r)	For making coloured glasses
(D)	3% misch metal to magnesium	(s)	In making jet engine parts

(a) (A-(s), (B)-(p), (C)-(q), (P)-(s)
(b) (A-(r), (B)-(p), (C)-(q), (D)-(s)
(c) (A-(p), (B)-(q), (C)-(r), (D)-(s)
(d) (A-(p), (B)-(s), (C)-(r), (D)-(q)

(21) Which one of the elements from the lanthanoid series is well known to exhibit +4 oxidation state?
(a) Nd (b) Ce (c) Sm (d) Tm

(22) Number of unpaired electrons are present in Gd (Z = 64) is
(a) 8 (b) 7 (c) 6 (d) 5

(23) Select the ion that has all of its electrons paired?
(a) Ni^{2+} (b) Cu^+ (c) Mn^{2+} (d) Cr^{2+}

(24) Europium (II) more stable than - cerium (II) because
(a) in Eu^{2+}, 4f subshell is half filled
(b) in Ce^{-2}, 5d subshell is half filled.
(c) in Eu^{2+}, 5d subshell is half filled
(d) in Ce^{2+}, 4f subshell is half filled

(25) One of the d-block metals is
(a) Al (b) Na (c) Mg (d) Ag

(26) Cu and Au are known as,
(a) soft metals
(b) transition metals
(c) alkali metals
(d) alkaline earth metals

(27) A change, between the most electropositive elements and the least electropositive elements is exhibited (shown) by
(a) s-block elements (b) p-block elements
(c) d-block elements (d) f-block elements

(28) The element containing the maximum number of unpaired electrons from 3d series among following is
(a) Fe (b) Mn (c) Cu (d) Zn

(29) Only in the following oxidation state, Zn is not regarded as a transition element.
(a) +1 (b) −1 (c) +2 (d) 0

(30) The producer gas is
(a) $CO + H_2$ (b) $CO_2 + N_2$
(c) $CO_2 + H_2O$ (d) $CO + N_2$

(31) The most abundant transition element in nature is
(a) Fe (b) Zn (c) Cr (d) Os

(32) In the first transition series, the following element is not present:
(a) Fe (b) Ti (c) Ag (d) Cr

(33) In Ni^{+2} ion, the number of unpaired electron is
(a) 0 (b) 1 (c) 2 (d) 3

(34) A set of transition elements is
(a) Hg, Pb, Ca (b) Sn, Bi, Ca
(c) Zr, Au, Ni (d) Pt, Cd, Sr

(35) In the galvanization of iron, the metal used is
(a) Al (b) Sn (c) Cd (d) Zn

(36) The following statement is not a true one for transition elements :
(a) Transition metals form interstitial compounds.
(b) The 3d and 4d-elements have lower energies than 5d-elements.
(c) Transition metals have low melting and boiling points.

(d) The atomic and ionic radii of Zr and Hf are almost same.

(37) The following electrons of transition elements exhibit maximum oxidation states:

(a) nd-electrons
(b) ns-electrons
(c) (n - 1) d-electrons
(d) ns + (n - 1) d-electrons

(38) In Mn^{2+} ion, the number of unpaired electrons are

(a) 2 **(b)** 3 **(c)** 4 **(d)** 5

(39) The first and third transition series begin with the elements respectively

(a) Sc and La **(b)** Zn and Cd
(c) Cu and Au **(d)** Hg and Ag

(40) The incorrect statement is that,

(a) the transition metal cations are coloured.
(b) cuprous ion is not a transition metal ion.
(c) transition metals and many of their compounds are paramagnetic in nature.
(d) the transition metals never exhibit variable oxidation states.

(41) The correct statement is that, the

(a) compounds containing Zn^{2+} is colourless, but the compounds containing Ni^{2+} and Cr^{3+} are coloured.
(b) compounds of Ni^{2+} are coloured and that of Zn^{2+} and Cr^{3+} are colourless.
(c) compounds containing all the 3 ions are coloured.
(d) compound containing all the 3 ions are colourless.

(42) The following statement is false (about transition elements):

(a) All transition elements are metals.
(b) Their compounds containing ions are coloured.
(c) They exhibit variable oxidation states (differing by 2 units).
(d) They form co-ordination compounds.

(43) The following is not regarded as the transition element:

(a) Zn **(b)** Co **(c)** Mn **(d)** Sc

(44) The following chemical species is paramagnetic in nature:

(a) Zn^{2+} **(b)** Cu^{+} **(c)** Cu^{2+} **(d)** Mg

(45) The following ion is paramagnetic in character:

(a) $[Ni(CN)_4]^{2-}$ **(b)** $[Fe(CN)_6]^{4-}$
(c) $[CoF_6]^{3-}$ **(d)** $[Ni(CO)_4]^{2-}$

(46) In OsO_4 oxidation state of Os is

(a) +4 **(b)** +2 **(c)** +8 **(d)** +6

(47) A transition metal has its configuration, [Ar] $3d^6\ 4s^2$. Its atomic number is

(a) 25 **(b)** 26 **(c)** 28 **(d)** 29

(48) [Xe] $4f^0 5d^1 6s^2$ is the electronic configuration of

(a) La **(b)** Ac **(c)** Ce **(d)** Th

(49) In $[Ni(CN)_4]^n$, n is equal to

(a) + 2 **(b)** –2 **(c)** + 4 **(d)** –4

(50) In first row, the maximum stable oxidation state is shown by

(a) Ni **(b)** Co **(c)** Mn **(d)** Fe^{2+}

(51) The ion, $[Ti(H_2O)]^{+3}$ imparts purple colour, because of

(a) a charge of 3+
(b) six water molecules
(c) unpaired d-electrons
(d) 2-electrons in the last orbital

(52) The cupric ion is coloured, but cuprous ion does not impart any colour because,

(a) cuprous ion has partly filled d-orbital.
(b) both the ions possess unpaired electrons in their d-orbitals.
(c) both the ions have half filled p and d-orbitals.
(d) cuprous ion has completely filled d-orbital and cupric ion has partly filled d-orbitals.

(53) The number of unpaired electrons in promethium

(a) 4 **(b)** 5 **(c)** 6 **(d)** 3

(54) Lanthanoids on reaction with water forms

(a) hydride **(b)** oxide
(c) hydroxide **(d)** peroxide

(55) The metals of d-block elements, with completely filled d-orbitals are

(a) Zn, Cd and Pt **(b)** Zn, Cr and Hg
(c) Zn, Cd and Hg **(d)** Zn, Cd and Fe

(56) The transition elements in their commonly occurring oxidation states have

(a) partially filled d-orbitals
(b) completely filled d-orbitals
(c) partially filled f-orbitals
(d) none of these options are correct

(57) The d^5-electronic configuration is exhibited by

(a) Mn^{3+} **(b)** Ni^{3+} **(c)** Cr^{2+} **(d)** Fe^{3+}

(58) The colour of cations of transition metals is caused due to absorption of some light of a particular wavelength. This helps in transition of electrons of

(a) p-p transition **(b)** d-p transition
(c) d-s transition **(d)** d-d transition

(59) Elements placed in the same group show the similar chemical properties because, they possess the same

(a) number of valence shells
(b) atomic number
(c) number of valence electrons
(d) number of electrons

(60) The following chemical species is diamagnetic in nature:

(a) Cu **(b)** Cu^+ **(c)** Cu^{2+} **(d)** Cu^{3+}

(61) Among the following, the strongest base is

(a) $La(OH)_3$ **(b)** $Sc(OH)_3$
(c) $Lu(OH)_3$ **(d)** $Yb(OH)_3$

(62) Which one of the following elements, belongs to the actinide series?

(a) Lu **(b)** Cu **(c)** Tm **(d)** U

(63) Hf and Zr the two elements, show

(a) similar chemical behaviour
(b) dis-similar chemical behaviour
(c) increase in atomic and ionic radii
(d) decrease in atomic and ionic radii

(64) The decrease in atomic size is found to be less in case of

(a) transition elements
(b) inner transition elements
(c) d-block elements
(d) p-block 1ements

(65) The following ion does not the have unpaired electrons:

(a) Lu^{3+} (Lu = 71) **(b)** Er^{3+} (Er = 68)
(c) Tm^{3+} (Tm= 69) **(d)** Gd^{3+} (Gd = 64)

(66) In Eu^{2+} ion, the number of unpaired electrons is

(a) 4 **(b)** 5 **(c)** 6 **(d)** 7

(67) In Tb^{3+} ion, the number of 4f-electrons is

(a) 5 **(b)** 6 **(c)** 7 **(d)** 8

(68) The electronic configuration of gadolinium (Z = 64) can be written as,

(a) [Xe] $4f^7 5d^2 6s^1$ **(b)** [Xe] $4f^6 5d^2 6s^2$
(c) [Xe] $4f^8 5d^1 6s^2$ **(d)** [Xe] $4f^7 5d^1 6s^2$

(69) In Tb(65) and Tb^{4+} ion, the number of 4f-electrons are respectively,

(a) 5, 7 **(b)** 7, 5 **(c)** 9, 7 **(d)** 5, 5

(70) The 4f-subshell has already been completely filled in

(a) Tm **(b)** Lu **(c)** Nd **(d)** Gd

(71) The most stable oxidation state of Ce(58)is

(a) 1+ **(b)** 2+ **(c)** 4+ **(d)** 3+

(72) The incorrect statement is

(a) Elements belonging to lanthanide series are radioactive
(b) Lanthanide and actinide elements show contraction in atomic size with increase in atomic numbers.
(c) In both the series (actinides and lanthanides) +3 is found to be the common oxidation state
(d) f-orbitals are progressively filled in actinides as well as lanthanides

(73) The shielding effect of the electrons in case of lanthanoids, decreases in the following order:

(a) $s < p < d < f$ **(b)** $s < p > d > f$
(c) $s > p > d > f$ **(d)** $f > d > s > p$

(74) The most stable oxidation states of Th(90), Pa(91), U(92) and Np(93) respectively are

(a) +3, +4, +5, +6 **(b)** +4, +5, +6, +7
(c) +2, +3, +4, +5 **(d)** 0, +3, +4, +5

(75) Effective magnetic moment of Sc3+ is

(a) 5.92 **(b)** 0 **(c)** 2.73 **(d)** 1.69

(76) Transuranic series begins with

(a) Th **(b)** Pu **(c)** Np **(d)** Bk

(77) Gun metal is an alloy of

(a) Ag **(b)** Cu **(c)** Ge **(d)** Nb

(78) Ruby copper is

(a) $CuOCl_2$ **(b)** $Cu_3O_2Cl_2$
(c) Cu_2Cl_2 **(d)** $CuCl_2$

(79) Blue Vitriol is

(a) $CuCl_2 . 7H_2O$ **(b)** $CuSO_4 . 5H_2O$
(c) $CuSO_4 + CuCl_2$ **(d)** $CuSO_4 . H_2O$

(80) Select the catalyst for synthesis of garoline by fisher Tropasch process.

(a) V_2O_5 **(b)** Pt/Pd
(c) Pyrolusite **(d)** Co-Th alloy

(81) +2 oxidation state of iron is known as

(a) ferric **(b)** ferrate
(c) ferrous **(d)** ferro

(82) In acidic solution one mole of sulphite ion react with x moles of $KMnO_4$ and X is

(a) $\frac{2}{5}$ **(b)** $\frac{2}{4}$ **(c)** $\frac{3}{2}$ **(d)** $\frac{4}{3}$

(83) The most strongly oxidizing state of manganese is

(a) +4 **(b)** +3 **(c)** +7 **(d)** +5

(84) Sc to Zn belongs period to .....

(a) 4^{th} **(b)** 3^{rd} **(c)** 5^{th} **(d)** 6^{th}

(85) The reason for the stability of Gd^{3+} ion is

(a) 4f subshell is completely filled

(b) 4f subshell is half filled

(c) possesses general electronic configuration of noble gases

(d) 4f subshell is empty

(86) If $[Xe]4f^7\ 5d^1\ 6s^2$ is the electronic configuration of element A, then A will be

(a) Nd **(b)** Sm **(c)** Gd **(d)** Dy

(87) Select the correct compound for the preparation of $KMnO_4$.

(a) Chromite **(b)** Malachite

(c) Limonite **(d)** pyrolusite

(88) Which of the following statement about the intestinal compound is incorrect?

(a) They are chemically reactive

(b) They are much harder than the pure metal

(c) They have higher melting points than pure metal

(d) They retain metallic conductivity

(89) A magnetic moment of 1.73 BM will be shown by one among the following

(a) $[Ni(CN)_4]^{2-}$ **(b)** $TiCl_4$

(c) $[Cu(NH_3)_4]^{2+}$ **(d)** $[CoCl_6]^{4-}$

(90) Colour of Ni^{2+} is

(a) Red **(b)** colourless

(c) Green **(d)** yellow

(91) Alnico is the alloy of

(a) Al, Ni, Co **(b)** Fe, Al, Zn, Co

(c) Zn, Co, Al, Ni **(d)** Fe, Co, Ni, Al

ANSWERS

TEXTUAL ZONE

1.	(c)	2.	(c)	3.	(c)	4.	(d)	5.	(a)	6.	(a)	7.	(c)	8.	(c)	9.	(a)	10.	(b)
11.	(c)	12.	(b)	13.	(c)	14.	(b)	15.	(b)	16.	(c)	17.	(c)	18.	(d)	19.	(a)	20.	(d)
21.	(b)	22.	(a)	23.	(d)	24.	(b)	25.	(d)	26.	(c)	27.	(d)	28.	(d)	29.	(c)	30.	(c)
31.	(a)	32.	(d)	33.	(d)	34.	(a)	35.	(b)	36.	(b)	37.	(b)	38.	(c)	39.	(b)	40.	(d)
41.	(c)	42.	(b)	43.	(b)	44.	(a)	45.	(b)	46.	(c)	47.	(d)	48.	(c)	49.	(c)	50.	(c)
51.	(d)	52.	(c)	53.	(d)	54.	(b)	55.	(c)	56.	(b)	57.	(b)	58.	(a)	59.	(d)	60.	(c)
61.	(b)	62.	(d)	63.	(b)	64.	(b)	65.	(c)	66.	(d)	67.	(a)	68.	(c)	69.	(c)	70.	(a)
71.	(c)	72.	(b)	73.	(b)	74.	(b)	75.	(c)	76.	(c)	77.	(b)	78.	(a)	79.	(b)	80.	(b)
81.	(b)	82.	(b)	83.	(a)	84.	(b)	85.	(d)	86.	(c)	87.	(a)	88.	(c)	89.	(b)	90.	(d)
91.	(d)	92.	(a)	93.	(a)	94.	(d)	95.	(d)	96.	(b)	97.	(d)	98.	(a)	99.	(c)	100.	(c)
101.	(b)	102.	(b)																

COMPLEX ZONE

1.	(a)	2.	(c)	3.	(b)	4.	(b)	5.	(c)	6.	(d)	7.	(b)	8.	(a)	9.	(b)	10.	(c)
11.	(d)	12.	(a)	13.	(a)	14.	(c)	15.	(d)	16.	(b)	17.	(c)	18.	(d)	19.	(a)	20.	(c)
21.	(b)	22.	(a)	23.	(b)	24.	(a)	25.	(d)	26.	(b)	27.	(c)	28.	(b)	29.	(c)	30.	(d)
31.	(a)	32.	(c)	33.	(c)	34.	(c)	35.	(d)	36.	(c)	37.	(d)	38.	(d)	39.	(a)	40.	(b)
41.	(a)	42.	(c)	43.	(a)	44.	(c)	45.	(c)	46.	(c)	47.	(b)	48.	(c)	49.	(b)	50.	(c)
51.	(c)	52.	(d)	53.	(b)	54.	(c)	55.	(c)	56.	(a)	57.	(d)	58.	(d)	59.	(c)	60.	(b)
61.	(a)	62.	(d)	63.	(a)	64.	(b)	65.	(a)	66.	(d)	67.	(d)	68.	(d)	69.	(c)	70.	(b)
71.	(c)	72.	(a)	73.	(c)	74.	(b)	75.	(b)	76.	(c)	77.	(b)	78.	(d)	79.	(b)	80.	(d)
81.	(a)	82.	(a)	83.	(a)	84.	(b)	85.	(c)	86.	(d)	87.	(a)	88.	(c)	89.	(c)	90.	(c)
91.	(a)																		

HINTS & SOLUTIONS (Selected)

TEXTUAL ZONE

(1) (c) Transition elements are found in group number 3-12 in modern periodic table i.e. d-block.

(2) (c) The elements of 3d transition series in correct sequence are given as :

Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn

(6) (a) A transition element is one whose atom or ion contains incompletely filled d-orbitals. In case of zinc neither the atom nor the ion has incompletely filled d-orbitals.

Zn - 30 : $3d^{10}, 5s^2$

(17) (c) Transition elements show variable oxidation state in which the highest oxidation state is exhibited by Mn. The element Mn exihibits its highest oxidation state in the oxoanions of a metal.Mn shows +7 highest oxidation state.

(18) (d) Transition elements have a high melting point because of the presence of metallic properties. They also have large ionisation enthalpies that increase their melting and boiling points.

(19) (a) Atomic radii of the first transition series decrease from Sc to Cr, then remains almost constant till Ni and then increases from Cu to Zn.

(22) (a) We have the formula for magnetic moment as,

$$\mu = \sqrt{n(n+2)}$$

where, n = Number of unpaired electrons

$$\begin{aligned}
\therefore \quad 1.73 &= \sqrt{n(n+2)} \\
\therefore \quad n(n+2) &= (1.73)^2 \\
n^2 + 2n &= 3 \\
n^2 + 2n - 3 &= 0 \\
n^2 + 3n - n - 3 &= 0 \\
n(n+3) - (n+3) &= 0 \\
\therefore \quad (n-1)(n+3) &= 0
\end{aligned}$$

i.e. $n = 1$ or $n = -3$

But $n \neq -3 \quad \therefore n = 1$

(24) (b) The electronic configuration of V is $[Ar]3d^34s^2$.

E.C. of $[V]^{3+}$ = $[Ar]3d^24s^0$

$\therefore n = 2$

The magnetic momentum can be calculated by using the following formulae,

$$\begin{aligned}
\mu &= \sqrt{n(n+2)} \\
&= \sqrt{2(2+2)} \\
&= \sqrt{2 \times 4} = \sqrt{8} \approx 2.83 \text{ BM}
\end{aligned}$$

(29) (c) Finely divided iron is used as catalyst in the manufacture of ammonia by Haber's process.

(30) (c) The interstitial compounds are chemically inert as the impurity ions are present in the interstitial sites. The chemical reactivity of such compounds is similar to that of the parent compound.

(37) (b) $MnO_2 + KClO_3 + 6KOH \longrightarrow \underset{\text{(green)}}{3K_2MnO_4} + KCl + 3H_2O$

(38) (c) Oxidation state of Mn in (MnO_2) is +4 and Oxidation state of Mn in (K_2MnO_4) is +6.

(40) (d) In acidic medium, the following change occurs:

$$MnO_4 \longrightarrow Mn^{2+}$$

The change in oxidation state = +7 − (+2) = +5

Therefore, equivalent weight

$$= \frac{\text{Molecular weight of } KMnO_4}{5}$$

$$= \frac{158}{5} = 31.6$$

(44) (a) $K_2Cr_2O_7 + 7H_2SO_4 + 6KI \longrightarrow 4K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O + 3I_2$

(45) (b) When hydrogen sulphide (H_2S) gas is passed into solution of $K_2Cr_2O_7$, H_2S is oxidised to a pale yellow solid (precipitate) of sulphur. Orange coloured solution becomes green due to formation of chromic sulphate (green coloured). In the reaction, H_2S is oxidised to S and $K_2Cr_2O_7$ is reduced to $Cr_2(SO_4)_3$

$$\underset{\text{(Orange)}}{K_2Cr_2O_7} + 4H_2SO_4 + 3H_2S \longrightarrow K_2SO_4 + \underset{\text{(Green)}}{Cr_2(SO_4)_3} + 7H_2O + \underset{\text{(Pale yellow)}}{3S}$$

(56) (b) Limestone $(CaCO_3)$ decomposes to give CaO and CO_2. The resultant lime (CaO) acts as flux, combines with silica (present as impurity - gangue) to form calcium silicate (fusible slag):

$$CaCO_3 \longrightarrow CaO + CO_2$$

$$CaO + SiO_2 \longrightarrow CaSiO_3 \text{ (slag)}$$

(57) (b) Wrought iron is a form of commercial iron containing less than 0.10% of carbon, less than 0.25% of impurities total of sulfur, phosphorus, silicon and manganese, and less than 2% slag by weight.

(69) (c) Due to the lanthanoid contraction, the size of the tripositive lanthanoid ion (M^{3+}) regularly decreases with increase in atomic number, i.e., from La^{3+} to Lu^{3+}. It results in decrease of basic character from La^{3+} to Lu^{3+}. The ionic character of the M–OH bond decreases and the covalent character of the M–OH bond gradually increases.

Therefore, the basic strength of the corresponding hydroxides decreases from $La(OH)_3$ to $Lu(OH)_3$. Therefore, $La(OH)_3$ is the strongest base.

(71) (c) Above its Curie temperature, gadolinium is paramagnetic.

(85) (d) The electronic configuration of Ce is $[Xe]4f^25d^06s^2$. Ce loses 4 electrons to form Ce^{4+}.

The electronic configuration of Ce^{4+} is $[Xe]4f^0$

Thus, Ce^{4+} attains electronic configuration of nearest noble gas Xe. Octet is completed in Ce^{4+}.

(89) (b) According to Hund's rule $4f^{14}$ configuration is more stable. Hence Yb shows +2 stable oxidation state.

(93) (a) Misch metal is an alloy which consists of a lanthanoid metal (~ 95%) and iron (~ 5%) and traces of S, C, Ca and Al. It is used in Mg-based alloy to produce bullets, shell and lighter flint.

(94) (d) Lanthanide Contraction is the result of poor shielding effect of the 4f electrons. Due to this, the atomic radii of Zr and Hf are nearly the same.

(101) (b) From element to element, the actinoid contraction is greater than the lanthanoid contraction due to poor shielding by 5f-electrons in actinoids than that by 4f-electrons in the lanthanoids.

(102) (b) The promethium is the only self-made radioactive lanthanide. Except the promethium, all other lanthanides are non-radioactive. However, on the other hand, the actinides are highly radioactive.

COMPLEX ZONE

(7) (b) 5.92 BM

$$\mu = \sqrt{n(n+2)}\ \text{BM}$$
$$= \sqrt{5(5+2)} = 5.92\ \text{BM}$$

(10) (c) 2,

$$\mu = \sqrt{n(n+2)} = 2.84$$
$$\therefore n = 2$$

(11) (d) Mn^{2+} has maximum number of unpaired electrons.

(12) (a) Ni^{2+} has incompletely filled d-orbitals.

(13) (a) $\frac{158}{3} = 52.67$ in alkaline medium, the equivalent weight of $KMnO_4$ is

$$\text{Eq. wt of } KMnO_4 = \frac{\text{Mol. wt}}{3} = 52.67$$

(17) (c) $8MnO_4^- + 3S_2O_3^{2-} + H_2O \longrightarrow 8MnO_2 + 6SO_4^{2-} + 2OH^-$

(25) (d) Ag(47) is the transition element of 4d-series.

(27) (c) d-block elements show properties between s and p block elements.

(28) (b) The electronic configuration of Mn [Ar] $3d^5\ 4s^2$ contain 5 unpaired electrons in 3d subshell.

(29) (c) Zn has its oxidation state +2.

(30) (d) Producer gas is mixture of CO and N_2.

(31) (a) Iron is the most abundant transition metal and copper is the second most abundant transition metal in the world.

(32) (c) Ag(47) is present in the second (4d) transition series.

(33) (c) $Ni^{2+} \longrightarrow [Ar]3d^8\ 4s^2$

(36) (c) Transition metals have high boiling and melting point.

(37) (d) In transition metals, (n – 1)d and ns electrons are of nearly same energy.

(38) (d) $Mn^{2+} \longrightarrow [Ar]3d^5\ 4s^2$

(40) (b) Copper salts in + 1 oxidation state are called cuprous salts.

(41) (a) Zn^{2+} is colourless but Ni^{2+} and Cr^{3+} are green and violet in colour respectively.

(42) (c) metals show variable oxidation states even in difference of 1 also.

(43) (a) Since, in Zn, the d-orbitals are completely filled.

(44) (c) $Cu^{2+} \longrightarrow 3d^{10}\ 4s^1$ $\therefore$ (paramagnetic in nature).

(45) (c) Cobalt possess unpaired electrons.

(46) (c) In OsO_4 oxidation state of O = –2 and Os = + 8

(47) (b) Fe(26) $\longrightarrow$ [Ar] $3d^6\ 4s^2$

(49) (b) Ni is +2, CN is –1. Thus, $[Ni(CN)_4]^x$ is making $[Ni(CN_4]^{-2}$ ion.

(50) (c) Mn show maximum oxidation state of +7.

(51) (c) Transition metal ion (Ti) imparts colour, due to unpaired d-electrons.

(52) (d) Cu^+ (colourless) is a cuprous ion and Cu^{2+} (blue) is a cupric ion.

(53) (b) The observed electronic configuration of promethium is [Xe] $4f^5\ 5d^0\ 6s^2$. It contain 5 unpaired electrons.

(54) (c) $Ln + H_2O \longrightarrow Ln(OH)_3 + H_2$

(55) (c) $Zn \longrightarrow [Ar]3d^{10}\ 4s^2$; $Cd \longrightarrow [Kr]\ 4d^{10}\ 5s^2$; $Hg \longrightarrow [Xe]4f^{14}\ 5d^{10}\ 4s^2$.

(56) (a) Transition elements, mostly have partially filled d-orbitals.

(57) (d) $Fe \longrightarrow [Ar]3d^6\ 4s^2$

$Fe^{3+} \longrightarrow [Ar]^3\ d^5$

(59) (c) In the same group, the number of valence electrons are the same.

(60) (b) The electronic configuration of Cu is, 2, 8, 18. It has paired electrons.

(61) (a) Basicity decreases from La to Lu

$\therefore$ La $(OH)_3$ > $Lu(OH)_3$

(62) (d) Uranium is an actinoids and others are Lanthanoids.

(64) (b) The decrease in atomic size is found to be less in case of inner Iransition elements due to lanthanide contraction.

(65) (a) $Lu^{3+} \longrightarrow [Xe]\ 4f^{14}, 5d^0, 6s^0$

$Er^{3+} \longrightarrow [Xe]\ 4f^{11}, 5d^0, 6s^0$

$Tm^{3+} \longrightarrow [Xe]\ 4f^{12}, 5d^0, 6s^0$

$Gd^{3+} \longrightarrow [Xe]\ 4f^7, 5d^0, 6s^0$

$Tb^{3+} \longrightarrow [Xe]\ 4f^8, 5d^0, 6s^0$

(66) (d) $Eu^{2+} \longrightarrow [Xe]\ 4f^7\ 6s^0$

(68) (d) Gadolinium (Gd – 64) $\longrightarrow$ [Xe] $4f^7\ 5d^1\ 6s^2$

(69) (c) Tb(65) $\longrightarrow 4f^9\ 5d^0\ 6s^2$

$Tb^{4+} \longrightarrow 4f^7\ 5d^0\ 6s^0$

(71) (c) The most stable oxidation state of Ce is +4.

(72) (a) Elements belonging to actinide series are radioactive.

(73) (c) As we increase the orbitals (s, p, d and f), the shielding effect (attraction of electrons to the nucleus) decreases.

(78) (d) $CuCl_2$ is known as ruby copper.

(79) (b) Blue vitriol is $CuSO_4{\cdot}5H_2O$

(80) (d) Co-Th alley is used in Fischer Tropasch process.

(82) (a) $2MnO_4^- + 5SO_3^{2-} + 6H^+ \longrightarrow 2Mn^{2+} + 5SO_4^{2-} + 3H_2O$

So, according to reaction, number of moles of $KMnO_4$ that will be needed to react with one mole of sulphite ion in acidic solution is $\frac{2}{5}$