18

d- and *f*-Block Elements

TOPIC 1
Characteristics of *d*-Block Elements

01 The calculated spin only magnetic moment of Cr^{2+} ion is **[NEET (Sep.) 2020]**

(a) 4.90 BM (b) 5.92 BM
(c) 2.84 BM (d) 3.87 BM

Ans. *(a)*

Electronic configuration of Cr^{2+} ion is

$Cr^{2+}_{(22e^-)}$: $[Ar]3d^4$ or $[Ar]$ | 1 | 1 | 1 | 1 | | (under $3d^4$)

It has four ($n = 4$) unpaired electrons.

$\therefore$ Spin only magnetic moment

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

$= \sqrt{4(4+2)}$ BM $= 4.90$ BM

02 Identify the incorrect statement. **[NEET (Oct.) 2020]**

(a) The transition metals and their compounds are known for their catalytic activity due to their ability to adopt multiple oxidation states and to form complexes.
(b) Interstitial compounds are those that are formed when small atoms like H, C or N are trapped inside the crystal lattices of metals.
(c) The oxidation states of chromium in CrO_4^{2-} and $Cr_2O_7^{2-}$ are not the same.
(d) $Cr^{2+}(d^4)$ is a stronger reducing agent than $Fe^{2+}(d^6)$ in water.

Ans. *(c)*

Statements in options (a), (b) and (d) are correct.

Statement in option (c) is incorrect, because oxidation states of Cr in CrO_4^{2-} (chromate) and $Cr_2O_7^{2-}$ (dichromate) are same and it is +6.

i.e., $\overset{x}{Cr}O_4^{2-} \Rightarrow x + 4(-2) = 2 \Rightarrow x = +6$

$\overset{y}{Cr_2}O_7^{2-} \Rightarrow 2y + 7(-2) = -2 \Rightarrow y = +6$

03 Match the followings aspects with the respective metal.

	Aspects		Metal
A.	The metal which reveals a maximum number of oxidation states	I.	Scandium
B.	The metal although placed in 3*d* block is considered not as a transition element.	II.	Copper
C.	The metal which does not exhibit variable oxidation states	III.	Manganese
D.	The metal which in +1 oxidation state in aqueous solution undergoes disproportionation	IV.	Zinc

Select the correct option. **[NEET (Oct.) 2020]**

	A	B	C	D		A	B	C	D
(a)	I	IV	II	III	(b)	III	IV	I	II
(c)	III	I	IV	II	(d)	II	IV	I	III

Ans. *(b)*

(A) Mn shown six oxidation states in its compounds, *viz*, + 2, + 3, + 4, + 5, + 6 and + 7 $\Rightarrow$(III)

(B) Zn is a pseudo transition element like Cd and Hg of group12 (d^{10}-configuration) $\Rightarrow$(IV)

(C) Sc does not exhibit variable oxidation states. Only + 3 state is shown by to Sc in its compounds $\Rightarrow$(I)

(D) Cu^+ disproportionaton in aqueous solution as,

$2Cu^+ \longrightarrow Cu^0 + Cu^{2+} \Rightarrow$(II)

04 Match the catalyst with the process

	Catalyst		Process
1.	V_2O_5	i.	The oxidation of ethyne to ethanal
2.	$TiCl_4 + Al(CH_3)_3$	ii.	Polymerisation of alkynes
3.	$PdCl_2$	iii.	Oxidation of SO_2 in the manufacture of H_2SO_4
4.	Nickel complexes	iv.	Polymerisation of ethylene

Which of the following is the correct option? **[NEET (Odisha) 2019]**

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

Ans. *(a)*

(1) V_2O_5 –(iii) Oxidation of SO_2 in the manufacture of H_2SO_4 by contact process.
(2) $TiCl_4 + Al(CH_3)_3$ – (*Ziegler-Natta* catalyst) – (iv) Polymerisation of ethylene.
(3) $PdCl_2$ –(i) Oxidation of ethyne to ethanal.
(4) Nickel complexes–(ii) Polymerisation of alkynes.

Thus, the correct match is

(1)$\rightarrow$(iii), (2)$\rightarrow$(iv), (3)$\rightarrow$(i), (4)$\rightarrow$(ii)

05 When neutral or faintly alkaline $KMnO_4$ is treated with potassium iodide, iodide ion is converted into '*X*'. '*X*' is **[NEET (Odisha) 2019]**

(a) I_2 (b) IO_4^-
(c) IO_3^- (d) IO^-

Ans. *(c)*

When neutral or faintly alkaline $KMnO_4$ is treated with potassium iodide, $KMnO_4$ is converted into MnO_2 while iodide (I^-) ion is converted inot IO_3^- (iodate). The reaction takes place as follows:

$$KMnO_4 + I^- + \bar{O}H \longrightarrow \underset{}{MnO_2} + \underset{X}{IO_3^-} + H_2O$$

06 Match the metal ions given in Column I with the spin magnetic moments of the ions given in Column II and assign the correct code : **[NEET 2018]**

	Column I		Column II
1.	Co^{3+}	i.	$\sqrt{8}$ BM
2.	Cr^{3+}	ii.	$\sqrt{35}$ BM
3.	Fe^{3+}	iii.	$\sqrt{3}$ BM
4.	Ni^{2+}	iv.	$\sqrt{24}$ BM
		v.	$\sqrt{15}$ BM

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

Ans. *(c)*

Key Concept *Spin magnetic moment can be calculated as*

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

where, μ = *magnetic moment*

BM = *Bohr Magneton (unit of* μ)

n = *number of unpaired electrons in d-orbital.*

The electronic configuration of Co^{3+} is $[Ar]3d^6$.

Here, $n = 4$

$$\mu = \sqrt{4(4+2)} = \sqrt{24}\,\text{BM}$$

The electronic configuration of Cr^{3+} is $[Ar]3d^3$.

Here, $n = 3$

$$\mu = \sqrt{3(3+2)} = \sqrt{15}\,\text{BM}$$

The electronic configuration of Fe^{3+} is $[Ar]3d^5$.

Here, $n = 5$

$$\mu = \sqrt{5(5+2)} = \sqrt{35}\ \text{BM}$$

The electronic configuration of Ni^{2+} is $[Ar]3d^8$.

Here, $n = 2$

$$\mu = \sqrt{2(2+2)} = \sqrt{8}\,\text{BM}$$

So, the correct option is (c).

07 Which one of the following ions exhibits *d-d* transition and paramagnetism as well? **[NEET 2018]**

(a) MnO_4^- (b) $Cr_2O_7^{2-}$ (c) CrO_4^{2-} (d) MnO_4^{2-}

Ans. *(d)*

Key Concept *In d-d transition, an electron in a d-orbital of the metal is excited by a photon to another d-orbital of higher energy.*

Paramagnetism The complex compound which contains unpaired electrons shows paramagnetism while which contains paired electrons shows diamagnetism.

The complex which contains unpaired electrons exhibit d-d transition and paramagnetism.

(i) In MnO_4^-,

The electronic configuration of Mn^{7+} is $[Ar]3d^0$.

Number of unpaired electrons = 0

Therefore, it will be diamagnetic and will not show *d-d* transition.

(ii) In $Cr_2O_7^{2-}$,

The electronic configuration of Cr^{6+} is $[Ar]3d^0$.

Number of unpaired electrons = 0

So, it will be diamagnetic and will not show *d-d* transition.

(iii) In CrO_4^{2-},

The electronic configuration of Cr^{6+} is $[Ar]3d^0$.

Number of unpaired electrons = 0

Therefore, it is also diamagnetic and will not show *d-d* transition.

(iv) In MnO_4^{2-}, The electronic configuration of Mn^{6+} is $[Ar]3d^1$.

Number of unpaired electrons = 1

Since, it contains one unpaired electron so it will exhibit both *d-d* transition and paramagnetism.

08 Magnetic moment 2.84 BM is given by (At. no.
Ni = 28, Ti = 22, Cr = 24, Co = 27)
[CBSE AIPMT 2015, 2014]

(a) Ni^{2+} (b) Ti^{3+}
(c) Cr^{3+} (d) Co^{2+}

Ans. *(a)*

Magnetic moment, $\mu = \sqrt{n(n+2)}$ BM

where,

n = number of unpaired electrons

$$\mu = 2.84 \text{ (given)}$$

$$\therefore \quad 2.84 = \sqrt{n(n+2)}\ \text{B.M}$$

$$(2.84)^2 = n(n+2)$$

$$8 = n^2 + 2n$$

$$n^2 + 2n - 8 = 0$$

$$n^2 + 4n - 2n - 8 = 0$$

$$n(n+4) - 2(n+4) = 0$$

$$n = 2$$

$Ni^{2+} = [Ar]3d^8 4s^0$ (two unpaired electrons)

$Ti^{3+} = [Ar]3d^1 4s^0$ (one unpaired electrons)

$Cr^{3+} = [Ar]3d^3$, (three unpaired electrons)

$Co^{2+} = [Ar], 3d^7, 4s^0$ (three unpaired electrons)

So, only Ni^{2+} has 2 unpaired electrons.

09 Which of the following does not give oxygen on heating? **[NEET 2013]**

(a) $KClO_3$ (b) $Zn(ClO_3)_2$
(c) $K_2Cr_2O_7$ (d) $(NH_4)_2Cr_2O_7$

Ans. *(d)*

Oxygen rich compounds like chlorate, perchlorate, $K_2Cr_2O_7$, etc. when heated gives oxygen but ammonium dichromate gives nitrogen gas when heated.

$$2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2\uparrow$$

$$2Zn(ClO_3)_2 \xrightarrow{\Delta} ZnCl_2 + 3O_2$$

$$\underset{\text{Potassium dichromate}}{4K_2Cr_2O_7} \xrightarrow{\Delta} \underset{\text{Potassium chromate}}{4K_2CrO_4} + \underset{\text{Chromic oxide}}{2Cr_2O_3} + 3O_2\uparrow$$

$$(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} N_2\uparrow + Cr_2O_3 + 4H_2O$$

10 Which of the following statements about the interstitial compounds is incorrect? **[NEET 2013]**

(a) They retain metallic conductivity
(b) They are chemically reactive
(c) They are much harder than the pure metal
(d) They have higher melting points than the pure metals

Ans. *(b)*

Interstitial compounds are obtained when small atoms like H, B, C, N, etc., fit into the interstitial space of lattice metals. These retain metallic conductivity. These resemble the parent metal in chemical properties (reactivity) but differ in physical properties like hardness, melting point, etc.

11 The *d*-electron configurations of Cr^{2+}, Mn^{2+} Fe^{2+} and Co^{2+} are d^4, d^5, d^6 and d^7 respectively.

Which one of the following will exhibit minimum paramagnetic behaviour? **[CBSE AIPMT 2011]**

(At. no.
Cr = 24, Mn = 25, Fe = 26, Co = 27)

(a) $[Fe(H_2O)_6]^{2+}$ (b) $[Co(H_2O)_6]^{2+}$
(c) $[Cr(H_2O)_6]^{2+}$ (d) $[Mn(H_2O)_6]^{2+}$

Ans. *(b)*

$Cr^{2+}: d^4$ | ↑ | ↑ | ↑ | ↑ | | (4 unpaired electrons)

$Mn^{2+}: d^5$ | ↑ | ↑ | ↑ | ↑ | ↑ | (5 unpaired electrons)

$Fe^{2+}: d^6$ | ↿⇂ | ↑ | ↑ | ↑ | ↑ | (4 unpaired electrons)

$Co^{2+}: d^7$ | ↿⇂ | ↿⇂ | ↑ | ↑ | ↑ | (3 unpaired electrons)

$\therefore [Co(H_2O)_6]^{2+}$ has minimum number of unpaired electrons and thus, shows minimum paramagnetic behaviour.

Higher the unpaired e^-.

Higher the magnetic moment

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

n = Number of unpaired e^-

12 For the four successive transition elements (Cr, Mn, Fe and Co), the stability of +2 oxidation state will be there in which of the following order ? **[CBSE AIPMT 2011]**

(At. no. Cr = 24, Mn = 25, Fe = 26, Co = 27)

(a) Fe > Mn > Co > Cr
(b) Co > Mn > Fe > Cr
(c) Cr > Mn > Co > Fe
(d) Mn > Fe > Cr > Co

Ans. ***(d)***

This can be understood on the basis of $E°$ values for M^{2+}/M.

$E°/V$	Cr	Mn	Fe	Co
M^{2+}/M	– 0.90	–1.18	–0.44	–0.28

$E°$ value for Mn is more negative than expected from general trend due to extra stability of half-filled electronic configuration of Mn^{2+} ion.

Thus, the correct order should be

Mn > Cr > Fe > Co

An examination of $E°$ values for redox couple M^3/M^{2+} shows that Cr^{2+} is strong reducing agent ($E°_{M^{3+}/M^{2+}} = 0.41$ V) and liberates H_2 from dilute acids.

$2Cr^{2+}(aq) + 2H^+(aq) \rightarrow 2Cr^{3+}(aq) + H_2\uparrow(g)$

$\therefore$ The correct order is Mn > Fe > Cr > Co.

13 Which one of the following ions has electronic configuration $[Ar]3d^6$?

(At. no. Mn = 25, Fe = 26, Co = 27, Ni = 28)

[CBSE AIPMT 2010]

(a) Ni^{3+} (b) Mn^{3+} (c) Fe^{3+} (d) Co^{3+}

Ans. ***(d)***

$Ni^{3+}(28) = [Ar]3d^7$

$Mn^{3+}(25) = [Ar]3d^4$

$Fe^{3+}(26) = [Ar]3d^5$

$Co^{3+}(27) = [Ar]3d^6$

Hence, Co^{3+} has $3d^6$ electronic configuration correct answer is (d).

14 Which of the following pairs has the same size? **[CBSE AIPMT 2010]**

(a) Fe^{2+}, Ni^{2+} (b) Zr^{4+}, Ti^{4+}
(c) Zr^{4+}, Hf^{4+} (d) Zn^{2+}, Hf^{4+}

Ans. ***(c)***

In general, the atomic and ionic radii increases on moving down a group but the elements of second transition series (Zr, Nb, Mo) have almost same radii as the elements of third transition series (Hf, Ta, W, etc). This is because of lanthanoid contraction, i.e. imperfect shielding of one $4f$ e^- by another.

15 Which one of the following ions is the most stable in aqueous solution? **[CBSE AIPMT 2007]**

(At. no. Ti = 22, V = 23, Cr = 24, Mn = 25)

(a) Cr^{3+} (b) V^{3+} (c) Ti^{3+} (d) Mn^{3+}

Ans. ***(d)***

Stability of transition metal ions is directly proportional to the unpaired electrons. The exactly half-filled and completely filled d-orbitals are extra stable.

$Cr^{3+}(21) = 3d^3, 4s^0$ (3 unpaired electrons)

$V^{3+}(20) = 3d^2, 4s^0$ (2 unpaired electrons)

$Ti^{3+}(19) = 3d^1, 4s^0$ (1 unpaired electron)

$Mn^{3+}(22) = 3d^4, 4s^0$ (4 unpaired electrons)

So, Mn^{3+} ion is most stable in aqueous solution.

16 The d electron configurations of Cr^{2+}, Mn^{2+}, Fe^{2+} and Ni^{2+} are $3d^4$, $3d^5$, $3d^6$ and $3d^8$ respectively. Which one of the following aqua complexes will exhibit the minimum paramagnetic behaviour?

(At. no. of Cr = 24, Mn = **25**, Fe = 26, Ni = 28) **[CBSE AIPMT 2007]**

(a) $[Fe(H_2O)_6]^{2+}$ (b) $[Ni(H_2O)_6]^{2+}$
(c) $[Cr(H_2O)_6]^{2+}$ (d) $[Mn(H_2O)_6]^{2+}$

Ans. ***(b)***

As the number of unpaired electron increases, the magnetic moment increases and hence, the paramagnetic behaviour increases.

So, $Cr^{2+}(22) = 3d^4$ (4 unpaired electrons)

$Mn^{2+}(23) = 3d^5$ (5 unpaired electrons)

$Fe^{2+}(24) = 3d^6$ (4 unpaired electrons)

$Ni^{2+}(26) = 3d^8$ (2 unpaired electrons)

So, $[Ni(H_2O)_6]^{2+}$ exhibit minimum paramagnetic behaviour.

17 In which of the following pairs are both the ions coloured in aqueous solution?

(At. no. Sc = 21, Ti = 22, Ni = 28, Cu = 29, Co = 27) **[CBSE AIPMT 2006]**

(a) Ni^{2+}, Ti^{3+} (b) Sc^{3+}, Ti^{3+}
(c) Sc^{3+}, Co^{2+} (d) Ni^{2+}, Cu^+

Ans. ***(a)***

$_{28}Ni = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^8, 4s^2$

$Ni^{2+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^8$

$3d^8$ | ⇅ | ⇅ | ⇅ | 1 | 1 |

(2 unpaired electrons)

$_{22}Ti = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^2, 4s^2$

$Ti^{3+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^1$

(1 unpaired electron)

$_{21}Sc = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^1, 4s^2$

$Sc^{3+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6$

(no unpaired electron)

$_{29}Cu = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^1$

$Cu^+ = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}$

(no unpaired electron)

Hence, in the above ions, Ni^{2+} and Ti^{3+} are coloured in aqueous solution due to the presence of unpaired electrons in d subshell.

18 The aqueous solution containing which one of the following ions will be colourless ?

(At. no. Sc = 21, Fe = 26, Ti = 22, Mn = 25) **[CBSE AIPMT 2005]**

(a) Sc^{3+} (b) Fe^{2+}
(c) Ti^{3+} (d) Mn^{2+}

Ans. ***(a)***

$_{21}Sc = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^1, 4s^2$

So, $Sc^{3+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6$

(It is colourless due to the absence of unpaired electrons in d sub-shell)

$_{26}Fe = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^6, 4s^2$

$Fe^{2+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^6$

d

| ⇅ | 1 | 1 | 1 | 1 |

(It is coloured due to the presence of four unpaired electrons in d sub-shell)

$_{22}Ti = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^2, 4s^2$

$Ti^{3+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^1$

d

| 1 | | | | |

(It is coloured due to the presence of an unpaired electron in d sub-shell)

$_{25}Mn = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^5, 4s^2$

$Mn^{2+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^5$

d

| 1 | 1 | 1 | 1 | 1 |

(It is coloured due to the presence of five unpaired electrons in d sub-shell).

19 Four successive members of the first row transition elements are listed below with their atomic numbers. Which one of them is expected to have the highest third ionisation enthalpy? **[CBSE AIPMT 2005]**

(a) Vanadium ($Z = 23$)
(b) Chromium ($Z = 24$)
(c) Iron ($Z = 26$)
(d) Manganese ($Z = 25$)

Ans. ***(d)***

$_{23}V = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^3, 4s^2$

Third electron which is removed to give third ionisation potential, belongs to $3d^3$ subshell.

$_{24}Cr = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^5, 4s^1$

Third electron which is removed to give third ionisation potential, belongs to $3d^5$ subshell.

$_{26}Fe = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^6, 4s^2$

Third electron which is removed to give third ionisation potential, belongs to $3d^6$ subshell.

$_{25}Mn = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^5, 4s^2$

Third electron which is removed to give third ionisation potential, belongs to $3d^5$ subshell.

In all elements shell and subshells are same. Required amount of energy (enthalpy) is based upon the stability of *d*- subshell.

The $3d^5$-subshell has highest stability in all because it is half-filled subshell. So, Mn shows highest third ionisation potential.

20 Among the following series of transition metal ions, the one in which all metal ions have $3d^2$ electronic configuration is (At. no. Ti = 22, V = 23, Cr = 24, Mn = 25) **[CBSE AIPMT 2004]**

(a) Ti^{3+}, V^{2+}, Cr^{3+}, Mn^{4+}
(b) Ti^{+}, V^{4+}, Cr^{6+}, Mn^{7+}
(c) Ti^{4+}, V^{3+}, Cr^{2+}, Mn^{3+}
(d) Ti^{2+}, V^{3+}, Cr^{4+}, Mn^{5+}

Ans. ***(d)***

$Ti^{2+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^2, 4s^0$
$V^{3+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6, 3d^2, 4s^0$
$Cr^{4+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^2, 4s^0$
$Mn^{5+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^2, 4s^0$

21 Which one of the following characteristics of the transition metals is associated with their catalytic activity? **[CBSE AIPMT 2003]**

(a) Colour of hydrated ions
(b) Variable oxidation states
(c) High enthalpy of atomisation
(d) Paramagnetic behaviour

Ans. ***(b)***

The catalytic activity of transitional metals is due to their variable oxidation states.

22 The basic character of the transition metal monoxides follows the order **[CBSE AIPMT 2003]**

(At. no. Ti = 22, V = 23, Cr = 24, Fe = 26)
(a) TiO > FeO > VO > CrO
(b) TiO > VO > CrO > FeO
(c) VO > CrO > TiO > FeO
(d) CrO > VO > FeO > TiO

Ans. ***(b)***

The order of basic character of the transition metal monoxide is TiO > VO > CrO> FeO because basic character of oxides decreases with increase in atomic number. Hence, oxides of transitional metals in low oxidation state, i.e. +2 and +3 are generally basic except Cr_2O_3.

23 In the following transition metals, the maximum number of oxidation states are exhibited by **[CBSE AIPMT 2002, 2000]**

(a) chromium ($Z = 24$)
(b) manganese ($Z = 25$)
(c) iron ($Z = 26$)
(d) titanium ($Z = 22$)

Ans. ***(b)***

Manganese shows maximum number of oxidation states because it has 5 unpaired electrons in 3*d* and also contains 2 electrons in 4*s* sub-shell.

$+2 \; +3 \; +4 + 5 + 6 + 7$

Other given metals show the following oxidation states

$Cr = +2 + 3 + 4 + 5 + 6$
$Fe = +2 + 3$; $Ti = +2 + 3 + 4$

24 Which one of the following forms a colourless solution in aqueous medium? (At. no. Sc = 21, Ti = 22, V = 23, Cr = 24) **[CBSE AIPMT 2000]**

(a) V^{2+} (b) Cr^{3+} (c) Ti^{3+} (d) Sc^{3+}

Ans. ***(d)***

The electronic configuration of Sc is

$1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^1, 4s^2$

and configuration of Sc^{3+} is

$1s^2, 2s^2 2p^6, 3s^2 3p^6$

So, Sc^{3+} is colourless due to absence of electrons in *d*-orbital.

25 Bell-metal is an alloy of **[CBSE AIPMT 1999]**

(a) Cu + Pb (b) Cu + Sn
(c) Cu + Zn (d) Cu + Ni

Ans. ***(b)***

Bell-metal is an alloy of copper and tin.

Cu = 80% and Sn = 20%.

It is used for making bells, utensils, etc.

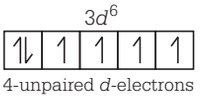
26 Which of the following has more unpaired *d*-electrons? **[CBSE AIPMT 1999]**

(a) Zn^+ (b) Fe^{2+}
(c) N^{3+} (d) Cu^+

Ans. ***(b)***

Zn^+ (at. no. = 30) $= 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}, 4s^1$
(no unpaired *d*-electrons)

Fe^{2+} (at .no. = 26) $= 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^6$



N^{3+} (at. no. = 7) $= 1s^2, 2s^2 2p^0$
(no unpaired *d*-electrons)

Cu^+ (at. no. = 29) $= 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}$
(no unpaired *d*-electrons)

So, maximum number of unpaired electrons are present in Fe^{2+}.

27 Which one of the following ionic species will impart colour to an aqueous solution? **[CBSE AIPMT 1998]**

(a) Ti^{4+} (b) Cu^+ (c) Zn^{2+} (d) Cr^{3+}

Ans. ***(d)***

$Cr^{3+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^3$ (coloured)
(Cr^{3+} contains 3 unpaired e^-, so it gives colour)

$Zn^{2+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}$
(colourless)

$Cu^+ = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}$
(colourless)

$Ti^{4+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6$ (colourless)

(Colour is produced due to presence of unpaired electrons.)

28 Which of the following elements is responsible for oxidation of water to O_2 in biological processes? **[CBSE AIPMT 1997]**

(a) Fe (b) Cu (c) Mn (d) Mo

Ans. *(c)*

Manganese is responsible for oxidation of water to O_2 in biological processes.

29 Which of the following does not represent the correct order of the properties indicated? **[CBSE AIPMT 1997]**

(a) $Ni^{2+} > Cr^{2+} > Fe^{2+} > Mn^{2+}$ (size)

(b) Sc > Ti > Cr > Mn (size)

(c) $Mn^{2+} > Ni^{2+} > Co^{2+} > Fe^{2+}$ (unpaired electron)

(d) $Fe^{2+} > Co^{2+} > Ni^{2+} > Cu^{2+}$ (unpaired electron)

Ans. *(a)*

In a period on moving from left to right ionic radii decreases. So, the order of cationic radii is

$$Cr^{2+} > Mn^{2+} > Fe^{2+} > Ni^{2+}$$

In Sc > Ti > Cr > Mn (correct order of atomic radii)

In

Mn^{2+}	>	Ni^{2+}	<	Co^{2+}	<	Fe^{2+}
↓		↓		↓		↓
Five unpaired electrons		Two unpaired electrons		Three unpaired electrons		Four unpaired electrons

In

Fe^{2+}	>	Co^{2+}	>	Ni^{2+}	>	Cu^{2+}
↓		↓		↓		↓
4		3		2		1

Number of unpaired electrons

30 The common oxidation states of Ti are **[CBSE AIPMT 1994]**

(a) +2, +3 (b) +3, +4

(c) 3, −4 (d) +2, +3, +4

Ans. *(b)*

The most common oxidation state of titanium are +3 and +4.

31 When $CuSO_4$ is electrolysed using platinum electrodes? **[CBSE AIPMT 1993]**

(a) Copper is liberated at cathode, sulphur at anode

(b) Copper is liberated at cathode, oxygen at anode

(c) Sulphur is liberated at cathode, oxygen at anode

(d) Oxygen is liberated at cathode, copper at anode

Ans. *(b)*

During electrolysis, copper is deposited at the cathode while oxygen is liberated at anode. The following reactions occur at the electrodes

At anode

$$2H_2O \longrightarrow 4H^+ + O_2 + 4e^- \quad \text{(Oxidation)}$$

At cathode

$$Cu^{2+} + 2e^- \longrightarrow Cu(s) \quad \text{(Reduction)}$$

32 The transition elements have a general electronic configuration. **[CBSE AIPMT 1991]**

(a) $ns^2np^6nd^{1-10}$

(b) $(n-1)\,d^{1-10}, ns^{0-2}, np^{0-6}$

(c) $(n-1)\,d^{1-10}, ns^{1-2}$

(d) $nd^{1-10}ns^2$

Ans. *(c)*

In the transition elements, the *d*-orbitals are successively filled. The general electronic configuration of *d*-block is

$$(n-1)d^{1-10}\,ns^{1-2}$$

Where $(n-1)$ stands for inner shell and *d*-orbitals may have one to ten electrons and the *s*-orbital of the outermost shell (*n*) may have one or two electrons.

33 Which of the following metals corrodes readily in moist air? **[CBSE AIPMT 1988]**

(a) Gold (b) Silver

(c) Nickel (d) Iron

Ans. *(d)*

Iron corrodes readily in moist air because iron is more reactive than Ni, Au and Ag. In other words the reduction potential of iron is very less, so its oxidation takes place readily.

TOPIC 2
Important Compounds of *d*-Block Elements

34 Which of the following reactions is the metal displacement reaction ? Choose the right option. **[NEET 2021]**

(a) $2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2$

(b) $Cr_2O_3 + 2Al \xrightarrow{\Delta} Al_2O_3 + 2Cr$

(c) $Fe + 2HCl \longrightarrow FeCl_2 + H_2\uparrow$

(d) $2Pb(NO_3)_2 \longrightarrow 2PbO + 4NO_2 + O_2\uparrow$

Ans. *(b)*

(a) $2KClO_3 \xrightarrow{\Delta} 2KCl + 3O_2$; (Decomposition reaction)

(b) $Cr_2O_3 + 2Al \xrightarrow{\Delta} Al_2O_3 + 2Cr$; (Metal displacement reaction)

(c) $Fe + 2HCl \xrightarrow{\Delta} FeCl_2 + H_2$; (Displacement reaction)

(d) $2Pb(NO_3)_2 \longrightarrow 2PbO + 4NO_2 + O_2$; (Decomposition reaction)

Metal displacement reaction is a displacement reaction in which a more reactive metal displaces/replaces the less reactive metal. In option (c), hydrogen is a non-metal. So, it is displacement reaction but not a metal displacement reaction.

35 The manganate and permanganate ions are tetrahedral, due to **[NEET (National) 2019]**

(a) there is no π-bonding

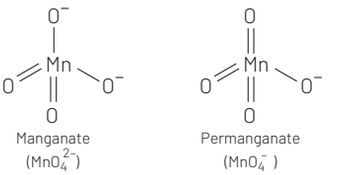
(b) the π-bonding involves overlap of *p* -orbitals of oxygen with *p* -orbitals of manganese

(c) the π-bonding involves overlap of *d*-orbitals of oxygen with *d*-orbitals of manganese

(d) the π-bonding involves overlap of *p*-orbitals of oxygen with *d*-orbitals of manganese

Ans. *(d)*

The structures of manganate and permanganate ions are as follows :



Manganate (MnO_4^{2-}) Permanganate (MnO_4^-)

The manganate and permanganate ions are tetrahedral and contain π-bonds of $d\pi$ - $p\pi$-type, oxygen does not have any *d*-orbital.

Hence, the π-bonding takes place by overlap of *p*-orbital of oxygen and *d*-orbitals of manganese.

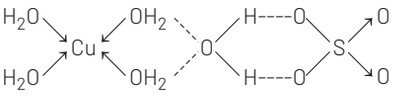
36 The number of hydrogen bonded water molecule(s) associated with $CuSO_4 \cdot 5H_2O$ is **[NEET (Odisha) 2019]**

(a) 3 (b) 1

(c) 2 (d) 5

Ans. *(b)*

Cu^{2+} ion has 17 electrons in its outermost orbital. $4H_2O$ molecules donate 4 pairs of electrons for coordinate covalent sharing. The one H_2O molecule is attached to the sulphate ion by hydrogen bonding, the oxygen being oriented to the hydrated cupirc ion.



Thus, the number of hydrogen bonded water molecule associated with $CuSO_4 \cdot 5H_2O$ is 1.

37 Name the gas that can readily decolourise acidified $KMnO_4$ solution. **[NEET 2017]**

(a) CO_2 (b) SO_2 (c) NO_2 (d) P_2O_5

Ans. *(b)*

SO_2 gas can readily oxidise acidified $KMnO_4$ solution because $KMnO_4$ is an oxidising agent and SO_2 act as reducing agent.

$$2MnO_4^- + 5SO_2 + 2H_2O \longrightarrow 2Mn^{2+} + 5SO_4^{2-} + 4H^+$$

While other options such as NO_2 (strong oxidising agent), CO_2 (neither oxidising agent nor reducing agent) cannot decolourise acidified $KMnO_4$ Solution.

38 $HgCl_2$ and I_2 both when dissolved in water containing I^- ions the pair of species formed is **[NEET 2017]**

(a) HgI_2, I_3^- (b) HgI_2, I^-
(c) HgI_4^{2-}, I_3^- (d) Hg_2I_2, I^-

Ans. *(c)*

$HgCl_2$ and I_2 both when dissolved in water containing I^- ions, the pair of species formed is HgI_4^{2-} and I_3^-.

In aqueous solution, I_2 reacts with I^- and maintains the following equilibrium.

$$I_2 + I^- \rightleftharpoons I_3^-$$

Hg^{2+} gives ppt. of HgI_2 on reaction with I^-.

But HgI_2 is soluble in excess of I^-

$$Hg^{2+} + 2I^- \longrightarrow \underset{\text{Red ppt.}}{HgI_2 \downarrow} + 2Cl^-$$

$$HgI_2 + 2I^- \rightleftharpoons [HgI_4]^{2-}$$

39 When copper is heated with conc. HNO_3 it produces **[NEET 2016, Phase I]**

(a) $Cu(NO_3)_2$ and NO
(b) $Cu(NO_3)_2$, NO and NO_2
(c) $Cu(NO_3)_2$ and N_2O
(d) $Cu(NO_3)_2$ and NO_2

Ans. *(d)*

Nitric acid acts as an oxidising agent while reacting with copper. When dil. HNO_3 reacts, reaction proceeds as:

$$3Cu + 8HNO_3(dil.) \longrightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$$

and when conc. HNO_3 is used, reaction proceeds as

$$Cu + 4HNO_3(conc.) \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$$

40 Which one of the following statements is correct when SO_2 is passed through acidified $K_2Cr_2O_7$ solution? **[NEET 2016, Phase I]**

(a) The solution is decolourised
(b) SO_2 is reduced
(c) Green $Cr_2(SO_4)_3$ is formed
(d) The solution turns blue

Ans. *(c)*

When SO_2 is passed through acidified $K_2Cr_2O_7$ solution, green chromium sulphate is formed. In this reaction, oxidation state of Cr changes from +6 to +3.

$$\underset{\text{OS of Cr = +6}}{K_2Cr_2O_7} + H_2SO_4 + 3SO_2 \longrightarrow K_2SO_4 + \underset{\substack{\text{OS of Cr = +3}\\ \text{Green}}}{Cr_2(SO_4)_3} + H_2O$$

The appearance of green colour is due to the reduction of chromium metal.

41 Assuming complete ionisation, same moles of which of the following compounds will require the least amount of acidified $KMnO_4$ for complete oxidation? **[CBSE AIPMT 2015]**

(a) $FeSO_4$ (b) $FeSO_3$
(c) FeC_2O_4 (d) $Fe(NO_2)_2$

Ans. *(a)*

$FeSO_4$ will require the least amount of acidified $KMnO_4$ for complete oxidation.

42 Which of the following processes does not involve oxidation of iron? **[CBSE AIPMT 2015]**

(a) Rusting of iron sheets
(b) Decolourisation of blue $CuSO_4$ solution by iron
(c) Formation of $Fe(CO)_5$ from Fe
(d) Liberation of H_2 from steam by iron a high temperature

Ans. *(c)*

(a) $\overset{0}{Fe} + \underbrace{H_2O + O_2}_{\text{from air}} \longrightarrow \overset{III}{Fe_2O_3 \cdot x H_2O}]$

(b) $\overset{0}{Fe} + CuSO_4 \longrightarrow \overset{II}{FeSO_4} + Cu$

(c) $\overset{0}{Fe} + 5CO \longrightarrow \overset{0}{Fe}(CO)_5$

(d) $\overset{0}{Fe} + \underset{\text{Steam}}{H_2O} \longrightarrow \overset{III}{Fe_2O_3} + H_2$

$\therefore$ Formation of $Fe(CO)_5$ from Fe does not involve oxidation of iron because there is no change in oxidation state.

43 The pair of compounds that can exist together is **[CBSE AIPMT 2014]**

(a) $FeCl_3$, $SnCl_2$ (b) $HgCl_2$, $SnCl_2$
(c) $FeCl_2$, $SnCl_2$ (d) $FeCl_3$, KI

Ans. *(c)*

The compounds with lower oxidation number and which cannot reduced by one another can exist together. Thus, $FeCl_2$ and $SnCl_2$ can exist together as Fe^{2+} cannot be reduced by Sn^{2+}.

44 The reaction of aqueous $KMnO_4$ with H_2O_2 in acidic conditions gives **[CBSE AIPMT 2014]**

(a) Mn^{4+} and O_2 (b) Mn^{2+} and O_2
(c) Mn^{2+} and O_3 (d) Mn^{4+} and MnO_2

Ans. *(b)*

The reaction of aqueous $KMnO_4$ with H_2O_2 in acidic medium is

$$3H_2SO_4 + 2KMnO_4 + 5H_2O_2 \longrightarrow 5O_2 + 2MnSO_4 + 8H_2O + K_2SO_4$$

In the above reaction, $KMnO_4$ oxidises H_2O_2 to O_2 and itself i.e. $[MnO_4^-]$ gets reduced to Mn^{2+} ion as $MnSO_4$. Hence, aqueous solution of $KMnO_4$ with H_2O_2 yields Mn^{2+} and O_2 in acidic conditions.

45 Identify the alloy containing a non-metal as a constituent in it. **[CBSE AIPMT 2012]**

(a) Invar (b) Steel
(c) Bell-metal (d) Bronze

Ans. *(b)*

Alloy	Constituents
Invar	Fe + Ni
Steel	Fe + C
Bell-metal	Cu (80%) + Sn(20%)e
Bronze	Cu(75.90%) + Sn(10.25)%

Among these alloys, only steel contains carbon which is a non-metal.

46 Acidified $K_2Cr_2O_7$ solution turns green when Na_2SO_3 is added to it. This is due to the formation of **[CBSE AIPMT 2011]**

(a) CrO_4^{2-} (b) $Cr_2(SO_3)_3$
(c) $CrSO_4$ (d) $Cr_2(SO_4)_3$

Ans. *(d)*

$K_2Cr_2O_7$ is oxidising reagent.

$$K_2Cr_2O_7 + 3Na_2SO_3 + 4H_2SO_4 \longrightarrow 3Na_2SO_4 + K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O$$

47 Copper sulphate dissolves in excess of KCN to give **[CBSE AIPMT 2006]**

(a) CuCN (b) $[Cu(CN)_4]^{3-}$

(c) $[Cu(CN)_4]^{2-}$ (d) $Cu(CN)_2$

Ans. *(b)*

Copper sulphate when react with KCN first give precipitate of cupric cyanide which reduce into Cu_2CN_2 and dissolve in excess of KCN to give soluble $K_3[Cu(CN)_4]$ complex salt

$$[CuSO_4 + 2KCN \rightarrow \underset{\text{Cupric cyanide}}{Cu(CN)_2} + K_2SO_4] \times 2$$

$$2Cu(CN)_2 \longrightarrow Cu_2(CN)_2 + \underset{\text{Cyanogen}}{NC\text{-}\overset{\ominus}{C}N}$$

$$Cu_2(CN)_2 + 6KCN \longrightarrow \underset{\text{Soluble complex salt}}{2K_3[Cu(CN)_4]}$$

$$2CuSO_4 + 10KCN \rightarrow 2K_3[Cu(CN)_4] + 2K_2SO_4 + (CN)_2$$

48 $CuSO_4$ when reacts with KCN forms CuCN which is insoluble in water. It is soluble in excess of KCN due to the formation of the complex **[CBSE AIPMT 2002]**

(a) $K_2[Cu(CN)_4]$ (b) $K_3[Cu(CN)_4]$

(c) $Cu(CN)_2$ (d) $Cu[KCu(CN)_4]$

Ans. *(b)*

$CuSO_4$ reacts with KCN to give a white precipitate of cuprous cyanide and cyanogen gas. The cuprous cyanide dissolves in excess of KCN forming $K_3[Cu(CN)_4]$.

$$CuSO_4 + 2KCN \rightarrow K_2SO_4 + \underset{\text{Unstable}}{Cu(CN)_2}$$

$$2Cu(CN)_2 \rightarrow 2CuCN + \underset{\text{Insoluble cyanogen}}{CN\text{—}CN}$$

$$CuCN + 3KCN \rightarrow \underset{\text{Soluble}}{K_3[Cu(CN)_4]}$$

49 In the silver plating of copper, $K[Ag(CN)_2]$ is used instead of $AgNO_3$. The reason is **[CBSE AIPMT 2002]**

(a) a thin layer of Ag is formed on Cu

(b) more voltage is required

(c) Ag^+ ions are completely removed from solution

(d) less availability of Ag^+ ions, as Cu cannot displace Ag from $[Ag(CN)_2]^-$ ion

Ans. *(d)*

In the silver plating of copper, $K[Ag(CN)_2]$ is used instead of $AgNO_3$. The reason is less availability of Ag^+ ions, as Cu cannot displace Ag from $[Ag(CN)_2]^-$ ion.

50 In which of the following compounds, transition metal has zero oxidation state? **[CBSE AIPMT 1999]**

(a) $Fe(CO)_5$ (b) $NH_2 \cdot NH_2$

(c) $NOClO_4$ (d) CrO_5

Ans. *(a)*

Oxidation state of Fe in $Fe(CO)_5$ is zero because CO is a neutral ligand and it shows zero oxidation state.

51 When a substance *A* reacts with water it produces a combustible gas *B* and a solution of substance *C* in water. When another substance *D* reacts with this solution of *C*, it also produces the same gas *B* on warming but *D* can also produce gas *B* on reaction with dilute sulphuric acid at room temperature. *A* imparts a deep golden yellow colour to a smokeless flame of Bunsen burner. *A*, *B*, *C* and *D*, respectively are **[CBSE AIPMT 1998]**

(a) Na, H_2, NaOH, Zn

(b) K, H_2, KOH, Al

(c) CaH_2, $Ca(OH)_2$, Sn

(d) CaC_2, C_2H_2, $Ca(OH)_2$, Fe

Ans. *(a)*

Only Na gives golden colour to bunsen flame. So, *A* is Na

$$\underset{A}{2Na} + 2H_2O \longrightarrow \underset{C}{2NaOH} + \underset{B}{H_2}\uparrow$$

$$\underset{D}{Zn} + \underset{C}{2NaOH} \longrightarrow Na_2ZnO_2 + \underset{B}{H_2}\uparrow$$

$$\underset{D}{Zn} + \text{dil. } H_2SO_4 \longrightarrow ZnSO_4 + \underset{B}{H_2}\uparrow$$

Na, produces golden yellow colour with smokeless flame of Bunsen burner

52 $K_2Cr_2O_7$ on heating with aqueous NaOH gives **[CBSE AIPMT 1997]**

(a) CrO_4^{2-} (b) $Cr(OH)_3$

(c) $Cr_2O_7^{2-}$ (d) $Cr(OH)_2$

Ans. *(a)*

$$K_2Cr_2O_7 + 2NaOH \longrightarrow K_2CrO_4 + Na_2CrO_4 + H_2O$$

Hence, CrO_4^{2-} ion is obtained.

53 Cuprous compounds such as CuCl, CuCN and CuSCN are the only salts stable in H_2O due to **[CBSE AIPMT 1996]**

(a) high hydration energy of Cu^+ ions

(b) their inherent tendency not to disproportionate

(c) diamagnetic nature

(d) insolubility in water

Ans. *(a)*

Cuprous compound contains Cu^+ ion which has small size, so the hydration is maximum and hence, the system has lower energy which result in stability of the compounds.

54 Stainless steel contains iron and **[CBSE AIPMT 1995]**

(a) Cr + Ni (b) Cr + Zn

(c) Zn + Pb (d) Fe + Cr + Ni

Ans. *(a)*

Stainless steel is resistant to rusting. It contains 73% iron, 18% chromium and 8% nickel. Stainless steel is used in utensils, cycle, cutlery and automobile parts.

55 By pasing H_2S gas in acidified $KMnO_4$ solution, we get **[CBSE AIPMT 1995]**

(a) S (b) K_2S

(c) MnO_2 (d) K_2SO_3

Ans. *(a)*

$$2KMnO_4 + 5H_2S + 3H_2SO_4 \longrightarrow K_2SO_4 + 5S + 2MnSO_4 + 8H_2O$$

56 When $(NH_4)_2Cr_2O_7$ is heated, the gas evolved is **[CBSE AIPMT 1994]**

(a) N_2 (b) NO_2

(c) O_2 (d) N_2O

Ans. *(a)*

When ammonium dichromate is heated, it form nitrogen gas, Cr_2O_3 and water.

$$(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} Cr_2O_3 + 4H_2O + N_2$$

57 The most durable metal plating on iron to protect against corrosion is **[CBSE AIPMT 1994]**

(a) nickel plating (b) tin plating

(c) copper plating (d) zinc plating

Ans. *(d)*

Zinc is commonly used for covering iron surfaces. The process of covering iron with zinc is called **galvanisation**. If some scratches occur on the protective zinc film on coated iron, even then iron will not be rusted. This is due to the fact that because of scratches, both zinc and iron get exposed to oxidation but zinc undergoes oxidation in preference to iron, because the reduction potential of zinc is less than the reduction potential of iron. So, zinc coating is the best and durable method for protection of iron.

58 Nitriding is the process of surface hardening of steel by treating it in an atmosphere of **[CBSE AIPMT 1989]**

(a) NH_3 (b) N_2
(c) O_3 (d) H_2S

Ans. *(a)*

Nitriding is the process of heating of steel in the presence of ammonia. In this process the layer of iron nitride is formed which prevent the rusting of iron.

59 Photographic plates and films have an essential ingredient of **[CBSE AIPMT 1989]**

(a) silver nitrate
(b) silver bromide
(c) sodium chloride
(d) oleic acid

Ans. *(b)*

The photographic plate of film consists of a glass plate or thin strip of celluloid which is coated with the thin layer of an emulsion of silver bromide dispersed in gelatin.

TOPIC 3
Inner Transition Elements

60 The incorrect statement among the following is **[NEET 2021]**

(a) actinoid contraction is greater for element to element than lanthanoid contraction.
(b) most of the trivalent lanthanoid ions are colourless in the solid state.
(c) lanthanoids are good conductors of heat and electricity.
(d) actinoids are highly reactive metals, especially when finely divided.

Ans. *(b)*

The shielding effect of 5*f*-orbitals in actinoids is poor than the shielding effect of 4*f*-orbitals. So, the effective nuclear charge on valence electrons is more in actinoids. Hence, actinoid contraction is greater than lanthanoid contraction.

∴ Statement (a) is correct.

Trivalent lanthanoid ions are coloured in the solid state due to presence of *f*-electrons.

∴ Statement (b) is incorrect.

Lanthanoids are inner transition metals. So, they are good conductors of heat and electricity.

∴ Statement (c) is correct.

The surface area increases when actinoids are finely divided which results in exposure of more reactant molecules to react. Hence, rate increases and so, actinoids are highly reactive metals when finely divided.

∴ Statement (d) is correct.

61 Zr ($Z = 40$) and Hf ($Z = 72$) have similar atomic and ionic radii because of **[NEET 2021]**

(a) belonging to same group
(b) diagonal relationship
(c) lanthanoid contraction
(d) having similar chemical properties

Ans. *(c)*

$Zr(Z = 40) \rightarrow 1s^2, 2s^2\ 2p^6 3s^2 3p^6\ 3d^{10}, 4s^2 4p^6 4d^2, 5s^2$

$Hf(Z = 72) \rightarrow 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10},\ 4s^2 4p^6 4d^{10}, 5s^2 5p^6 4f^{14} 5d^2, 6s^2$

Hf is a post lanthanoid element. Due to presence of 4*f*-orbitals which have poor shielding effect, the effective nuclear charge on valence shell electrons is more which result in the decrease of the size of Hf. This effect is known as lanthanoid contraction.

62 The reason for greater range of oxidation states in actinoids is attributed to **[NEET 2017]**

(a) the radioactive nature of actinoids
(b) actinoid contraction
(c) 5*f*, 6*d* and 7*s* levels having comparable energies
(d) 4*f* and 5*d* levels being close in energies

Ans. *(c)*

The reason for greater range of oxidation states in actinoid is attributed to the 5*f*, 6*d* and 7*s* levels having comparable energies.

The 5*f*-orbitals extend into space beyond the 7*s* and 6*p*-orbitals and participate in bonding. This is in direct contrast to the lanthanides where the 4*f*-orbitals are buried deep inside the atom, totally shielded by outer orbitals and thus unable to take part in bonding.

63 The electronic configurations of Eu (Atomic no. 63), Gd (Atomic no. 64) and Tb (Atomic no. 65) are **[NEET 2016, Phase I]**

(a) $[Xe]4f^6 5d^1 6s^2$, $[Xe]4f^7 5d^1 6s^2$ and $[Xe]4f^9 6s^2$
(b) $[Xe]4f^6 5d^1 6s^2$, $[Xe]4f^7 5d^1 6s^2$ and $[Xe]4f^8 5d^1 6s^2$
(c) $[Xe]4f^7 6s^2$, $[Xe]4f^7 5d^1 6s^2$ and $[Xe]4f^9 6s^2$
(d) $[Xe]4f^7 6s^2$, $[Xe]4f^8 6s^2$ and $[Xe]4f^8 5d^1 6s^2$

Ans. *(c)*

Electronic configuration of $_{63}Eu = [Xe]_{54}\ 4f^7 6s^2$

Electronic configuration of $_{64}Gd = [Xe]_{54}\ 4f^7 5d^1 6s^2$

Electronic configuration of $_{65}Tb = [Xe]_{54}\ 4f^9 6s^2$

64 Which one of the following statements related to lanthanons is incorrect? **[NEET 2016, Phase II]**

(a) Europium shows +2 oxidation state
(b) The basicity decreases as the ionic radius decreases from Pr to Lu
(c) All the lanthanons are much more reactive than aluminium
(d) Ce (+4) solutuion are widely used as oxidising agent in volumetric analysis

Ans. *(c)*

$Eu(63) = 4f^7 \cdot 5d^0, 6s^2, Eu^{2+} = 4f^7$

In lanthanoids series, ionic radius decreases and covalent character increases, thus basicity decreases. Lanthanons are less reactive than aluminium due to high ionisation potential. The reason for this high ionisation potential is lanthanoid contraction. Ce^{4+} is a good oxidising agent, it is easily converted to Ce^{3+}

65 Gadolinium belongs to 4*f* series. It's atomic number is 64. Which of the following is the correct electronic configuration of gadolinium? **[CBSE AIPMT 2015]**

(a) $[Xe]4f^8 6d^2$ (b) $[Xe]4f^9 5s^1$
(c) $[Xe]4f^7 5d^1 6s^2$ (d) $[Xe]4f^6 5d^2 6s^2$

Ans. *(c)*

$_{64}Gd = [Xe]4f^7\ 5d^1 6s^2$

66 Because of lanthanoid contraction, which of the following pairs of elements have nearly same atomic radii? (Numbers in the parenthesis are atomic numbers). **[CBSE AIPMT 2015]**

(a) Ti (22) and Zr (40)
(b) Zr (40) and Nb (41)
(c) Zr (40) and Hf (72)
(d) Zr (40) and Ta (73)

Ans. *(c)*

Because of the lanthanoid contraction Zr (atomic radii 160 pm) and Hf (atomic radii 158 pm) have nearly same atomic radii.

Lanthanoids include the elements from lanthanum La ($Z = 57$) to lutetium Lu ($Z = 71$). zirconium Zr (40) belong to the second transition series (4*d*) and Hf (72) belongs to third transition series (5*d*). Lanthanoid contraction is associated with the intervention of the 4*f* orbitals which are filled before the 5*d*-series of elements starts. The filling of 4*f* orbitals before 5*d*-orbitals results in regular decrease in atomic radii which compensates the expected increase in atomic size with increasing atomic number. As a result of this lanthanoid contraction, the elements of second and third transition series have almost similar atomic radii.

67 Reason of lanthanoid contraction is **[CBSE AIPMT 2014]**

(a) negligible screening effect of *f*-orbitals
(b) increasing nuclear charge
(c) decreasing nuclear charge
(d) decreasing screening effect

Ans. *(a)*

Lanthanoid contraction is the regular decrease in atomic and ionic radii of lanthanides. This is due to the imperfect shielding [or poor screening effect] of *f*-orbitals due to their diffused shape which unable to counterbalance the effect to the increased nuclear charge. Hence, the net result is a contraction in size of lanthanoids.

68 Which of the following lanthanoid ions is diamagnetic?
(At. no. Ce = 58, Sm = 62, Eu = 63, Yb = 70) **[NEET 2013]**

(a) Ce^{2+} (b) Sm^{2+} (c) Eu^{2+} (d) Yb^{2+}

Ans. *(d)*

Lanthanoid ion with no unpaired electron is diamagnetic in nature.

$Ce_{58} = [Xe]4f^2\ 5d^0 6s^2$
$Ce^{2+} = [Xe]4f^2$
(two unpaired electrons)

$Sm_{62} = [Xe]4f^6 5d^0 6s^2$
$Sm^{2+} = [Xe]4f^6$
(six unpaired electrons)

$Eu_{63} = [Xe]4f^7 5d^0 6s^2$
$Eu^{2+} = [Xe]4f^7$
(seven unpaired electrons)

$Yb_{70} = [Xe]4f^{14} 5d^0 6s^2$
$Yb^{2+} = [Xe]4f^{14}$
(no unpaired electrons)

Because of the absence of unpaired electrons, Yb^{2+} is diamagnetic.

69 Which of the following ions will exhibit colour in aqueous solutions? **[CBSE AIPMT 2010]**

(a) La^{3+} ($Z = 57$) (b) Ti^{3+} ($Z = 22$)
(c) Lu^{3+} ($Z = 71$) (d) Sc^{3+} ($Z = 21$)

Ans. *(b)*

Key Idea *Colour is obtained as a consequence of d-d (or f-f) transition, and for d-d (or f-f) transition, presence of unpaired electrons is the necessary condition.*

Electronic configuration of

$La^{3+}(Z = 57) = [Xe]4f^0 5d^0 6s^0$
(no unpaired electron)

$Ti^{3+}(Z = 22) = [Ar]3d^1 4s^0$
(one unpaired electron)

$Lu^{3+}(Z = 71) = [Xe]4f^{14} 5d^0 6s^0$
(no unpaired electron)

$Sc^{3+}(Z = 21) = [Ar]3d^0 4s^0$
(no unpaired electron)

70 Identify the incorrect statement among the following. **[CBSE AIPMT 2007]**

(a) There is a decrease in the radii of the atoms or ions as one proceeds from La or Lu
(b) Lanthanide contraction is the accumulation of successive shrinkages
(c) As a result of lanthanide contraction, the properties of 4*d* series of the transition elements have no similarities with the 5*d* series of elements
(d) Shielding power of 4*f* electrons is quite weak

Ans. *(c)*

The regular decrease in the radii of lanthanide ions from La^{3+} to Lu^{3+} is known as lanthanides contraction.

It is due to the greater effect of the increased nuclear charge than that of screening effect (shielding effect).

As a result of lanthanide contraction, the atomic radii of element of 4*d* and 5*d* come closer, so the properties of 4*d* and 5*d*-transition element shows the similarities.

71 More number of oxidation states are exhibited by the actinides than by the lanthanides. The main reason for this is **[CBSE AIPMT 2006, 2005]**

(a) more energy difference between 5*f* and 6*d*-orbitals than that between 4*f* and 5*d*-orbitals
(b) lesser energy difference between 5*f* and 6*d*-orbitals than that between 4*f* and 5*d*-orbitals
(c) greater metallic character of the lanthanides than that of the corresponding actinides
(d) more active nature of the actinides

Ans. *(b)*

More number of oxidation states are exhibited by the actinides than by the corresponding lanthanides due to lesser energy difference between 5*f* and 6*d* orbitals than that between 4*f* and 5*d*-orbitals.

72 Lanthanides are **[CBSE AIPMT 2004]**

(a) 14 elements in the sixth period (At. no. = 90 to 103) that are filling 4*f* sub-level
(b) 14 elements in the seventh period (At. no. = 90 to 103) that are filling 5*f* sub-level
(c) 14 elements in the sixth period (At. no. = 58 to 71) that are filling 4*f* sub-level
(d) 14 elements in the seventh period (At. no. = 58 to 71) that are filling 4*f* sub-level

Ans. *(c)*

Lanthanides are the 14 elements of IIIB group and sixth period (at. no. = 58 to 71) that are filling 4*f* sub-shell of antipenultimate shell from 1 to 14. Actually, they are placed below the periodic table in horizontal row as lanthanide series.

73 The correct order of ionic radii of Y^{3+}, La^{3+}, Eu^{3+} and Lu^{3+} is **[CBSE AIPMT 2003]**

(At. no. Y = 39, La = 57, Eu = 63, Lu = 71)

(a) $Lu^{3+} < Eu^{3+} < La^{3+} < Y^{3+}$
(b) $La^{3+} < Eu^{3+} < Lu^{3+} < Y^{3+}$
(c) $Y^{3+} < La^{3+} < Eu^{3+} < Lu^{3+}$
(d) $Y^{3+} < Lu^{3+} < Eu^{3+} < La^{3+}$

Ans. *(d)*

The correct order of ionic radii of Y^{3+}, La^{3+}, Eu^{3+} and Lu^{3+}, is $Y^{3+} < Lu^{3+} < Eu^{3+} < La^{3+}$ because Eu and Lu are the members of lanthanide series (so they show lanthanide contraction) and La is the representative element of all elements of such series and Y^{3+} ion has lower radii as comparison to La^{3+} because it lies immediately above it in the periodic table.

74 General electronic configuration of lanthanides are

[CBSE AIPMT 2002]

(a) $(n-2)\, f^{1-14}\, (n-1)\, s^2 p^6 d^{0-1} ns^2$

(b) $(n-2)\, f^{10-14}\, (n-1) d^{0-1} ns^2$

(c) $(n-2)\, f^{0-14}\, (n-1)\, d^{10} ns^2$

(d) $(n-2)\, d^{0-1}\, (n-1)\, f^{1-14}\, ns^2$

Ans. ***(a)***

In lanthanides (at. no. of elements 57 to 71) the electronic configuration of outermost shells are $(n-2) f^{1-14}\, (n-1) s^2 p^6 d^{0 \text{ to } 1} ns^2$.

75 Which of the following statements is not correct?

[CBSE AIPMT 2001]

(a) $La(OH)_3$ is less basic than $Li(OH)_3$

(b) In lanthanide series, ionic radius of Ln^{3+} ion decreases

(c) La is actually an element of transition series rather lanthanide

(d) Atomic radius of Zr and Hf are same because of lanthanide contraction

Ans. ***(a)***

La^{3+} ions larger than Li^{3+}. So, it easily gives OH^- ion $La(OH)_3$ is more basic than $Li(OH)_3$. In lanthanides the basic character of hydroxides decreases as the ionic radius decreases.

76 Which one of the following elements shows maximum number of different oxidation states in its compounds?

[CBSE AIPMT 1998]

(a) Eu (b) La (c) Gd (d) Am

Ans. ***(d)***

Oxidation states shown by elements are as follows:

La = + 3

Eu and Gd = + 2 and + 3

Am = + 2 + 3 + 4 + 5

and + 6

Am shows maximum number of different oxidation state due to its larger size and low ionisation energy.

77 The lanthanide contraction is responsible for the fact that

[CBSE AIPMT 1997]

(a) Zr and Yt have about the same radius

(b) Zr and Nb have similar oxidation state

(c) Zr and Hf have about the same radius

(d) Zr and Zn have the same oxidation state

Ans. ***(c)***

The elements of second and third transition series resembles more in properties than the elements of first and second transition series. It is due to lanthanide contraction. So, due to lanthanide contraction Zr and Hf have the same radius and also known as twins.

78 Among the lanthanides, the one obtained by synthetic method is

[CBSE AIPMT 1994]

(a) Lu (b) Pm

(c) Pr (d) Gd

Ans. ***(b)***

Promethium (Pm) is the element which is prepared only by synthetic methods. It is not present in nature. It is the only synthetic radioactive lanthanoid.

79 Actinides **[CBSE AIPMT 1994]**

(a) are all synthetic elements

(b) include element 104

(c) have any short lived isotopes

(d) have variable valency

Ans. ***(d)***

All actinides show different oxidation states such as +2 +3 +4 +5 and +7. However, +3 oxidation state is most common among all the actinides. The wide range of oxidation states of actinides is attributed to the fact that the 5*f*, 6*d* and 7*s* energy levels are of comparable energies. Therefore, all these three sub-shells can participate.