CHAPTER
8

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

8.2 Electronic Configurations of the *d*-Block Elements

1. Sc ($Z = 21$) is a transition element but Zn ($Z = 30$) is not because

(a) both Sc^{3+} and Zn^{2+} ions are colourless and form white compounds
(b) in case of Sc, $3d$ orbitals are partially filled but in Zn these are filled
(c) last electron is assumed to be added to $4s$ level in case of Zn
(d) both Sc and Zn do not exhibit variable oxidation states *(Karnataka NEET 2013)*

2. Which of the following ions has electronic configuration $[Ar]3d^6$?
(a) Ni^{3+} (b) Mn^{3+} (c) Fe^{3+} (d) Co^{3+}
(At. nos. Mn = 25, Fe = 26, Co = 27, Ni = 28) *(2010)*

3. Among the following series of transition metal ions, the one where all metal ions have $3d^2$ electronic configuration is
[At. nos. Ti = 22, V = 23, Cr = 24, Mn = 25]
(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+} *(2004)*

4. Which of the following configuration is correct for iron?
(a) $1s^22s^22p^63s^23p^64s^23d^7$ (b) $1s^22s^22p^63s^23p^64s^23d^5$
(c) $1s^22s^22p^63s^23p^63d^5$ (d) $1s^22s^22p^63s^23p^64s^23d^6$
(1999)

5. Which of the following has more unpaired *d*-electrons?
(a) N^{3+} (b) Fe^{2+} (c) Zn^{+} (d) Cu^{+}
(1999)

6. The electronic configuration of transition elements is exhibited by
(a) ns^1 (b) ns^2np^5
(c) $ns^2\,(n-1)d^{1-10}$ (d) $ns^2\,(n-1)d^{10}$ *(1996)*

7. The electronic configurations of four elements are given below. Which element does not belong to the same family as others?
(a) $[Xe]4f^{14}5d^{10}6s^2$ (b) $[Kr]4d^{10}5s^2$
(c) $[Ne]3s^23p^5$ (d) $[Ar]3d^{10}4s^2$ *(1989)*

8.3 General Properties of the Transition Elements (*d*-Block)

8. Identify the incorrect statement.
(a) Cr^{2+} (d^4) is a stronger reducing agent than Fe^{2+} (d^6) in water.
(b) 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.
(c) Interstitial compounds are those that are formed when small atoms like H, C or N are trapped inside the crystal lattices of metals.
(d) The oxidation states of chromium in CrO_4^{2-} and $Cr_2O_7^{2-}$ are not the same. *(NEET 2020)*

9. The calculated spin only magnetic moment of Cr^{2+} ion is
(a) 3.87 BM (b) 4.90 BM
(c) 5.92 BM (d) 2.84 BM
(NEET 2020)

10. 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 :

Column-I	**Column-II**
A. Co^{3+}	(i) $\sqrt{8}$ B.M.
B. Cr^{3+}	(ii) $\sqrt{35}$ B.M.
C. Fe^{3+}	(iii) $\sqrt{3}$ B.M.
D. Ni^{2+}	(iv) $\sqrt{24}$ B.M.
	(v) $\sqrt{15}$ B.M.

	A	B	C	D
(a)	(iv)	(v)	(ii)	(i)
(b)	(i)	(ii)	(iii)	(iv)
(c)	(iv)	(i)	(ii)	(iii)
(d)	(iii)	(v)	(i)	(ii)

(NEET 2018)

11. Magnetic moment 2.84 B.M. is given by
(At. nos. Ni = 28, Ti = 22, Cr = 24, Co = 27)
(a) Cr^{2+} (b) Co^{2+} (c) Ni^{2+} (d) Ti^{3+}
(2015, Cancelled)

12. Which of the following processes does not involve oxidation of iron?
(a) Formation of $Fe(CO)_5$ from Fe.
(b) Liberation of H_2 from steam by iron at high temperature.
(c) Rusting of iron sheets.
(d) Decolourisation of blue $CuSO_4$ solution by iron. *(2015, Cancelled)*

13. Which of the following statements about the interstitial compounds is incorrect?
(a) They are much harder than the pure metal.
(b) They have higher melting points than the pure metal.
(c) They retain metallic conductivity.
(d) They are chemically reactive. *(NEET 2013)*

14. Identify the alloy containing a non-metal as a constituent in it.
(a) Invar (b) Steel
(c) Bell metal (d) Bronze *(2012)*

15. The catalytic activity of transition metals and their compounds is ascribed mainly to
(a) their magnetic behaviour
(b) their unfilled *d*-orbitals
(c) their ability to adopt variable oxidation states
(d) their chemical reactivity. *(Mains 2012)*

16. Which one of the following does not correctly represent the correct order of the property indicated against it?
(a) Ti < V < Cr < Mn; increasing number of oxidation states
(b) $Ti^{3+} < V^{3+} < Cr^{3+} < Mn^{3+}$: increasing magnetic moment
(c) Ti < V < Cr < Mn : increasing melting points
(d) Ti < V < Mn < Cr : increasing 2nd ionization enthalpy *(Mains 2012)*

17. Four successive members of the first series of the transition metals are listed below. For which one of them the standard potential ($E^\circ_{M^{2+}/M}$) value has a positive sign?
(a) Co ($Z = 27$) (b) Ni ($Z = 28$)
(c) Cu ($Z = 29$) (d) Fe ($Z = 26$)
(Mains 2012)

18. 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?
(a) Mn > Fe > Cr > Co (b) Fe > Mn > Co > Cr
(c) Co > Mn > Fe > Cr (d) Cr > Mn > Co > Fe
(At. nos. Cr = 24, Mn = 25, Fe = 26, Co = 27) *(2011)*

19. Which of the following ions will exhibit colour in aqueous solutions?
(a) La^{3+} ($Z = 57$) (b) Ti^{3+} ($Z = 22$)
(c) Lu^{3+} ($Z = 71$) (d) Sc^{3+} ($Z = 21$) *(2010)*

20. Which of the following pairs has the same size?
(a) Fe^{2+}, Ni^{2+} (b) Zr^{4+}, Ti^{4+}
(c) Zr^{4+}, Hf^{4+} (d) Zn^{2+}, Hf^{4+} *(2010)*

21. Which one of the elements with the following outer orbital configurations may exhibit the largest number of oxidation states?
(a) $3d^5 4s^1$ (b) $3d^5 4s^2$
(c) $3d^2 4s^2$ (d) $3d^3 4s^2$ *(2009)*

22. The correct order of decreasing second ionisation enthalpy of Ti(22), V(23), Cr(24) and Mn(25) is
(a) Mn > Cr > Ti > V (b) Ti > V > Cr > Mn
(c) Cr > Mn > V > Ti (d) V > Mn > Cr > Ti
(2008)

23. 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)
(a) Ni^{2+}, Cu^{+} (b) Ni^{2+}, Ti^{3+}
(c) Sc^{3+}, Ti^{3+} (d) Sc^{3+}, Co^{2+} *(2006)*

24. 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?
(a) Vanadium ($Z = 23$)
(b) Chromium ($Z = 24$)
(c) Manganese ($Z = 25$)
(d) Iron ($Z = 26$) *(2005)*

25. The aqueous solution containing which one of the following ions will be colourless?
(Atomic number : Sc = 21, Fe = 26, Ti = 22, Mn = 25)
(a) Sc^{3+} (b) Fe^{2+}
(c) Ti^{3+} (d) Mn^{2+} *(2005)*

26. Which one of the following characteristics of the transition metals is associated with their catalytic activity?
(a) High enthalpy of atomization
(b) Paramagnetic behaviour
(c) Colour of hydrated ions
(d) Variable oxidation states *(2003)*

27. The basic character of the transition metal monoxides follows the order
(Atomic no's. Ti = 22, V = 23, Cr = 24, Fe = 26)
(a) VO > CrO > TiO > FeO
(b) CrO > VO > FeO > TiO
(c) TiO > FeO > VO > CrO
(d) TiO > VO > CrO > FeO *(2003)*

28. Which of the following shows maximum number of oxidation states?
(a) Cr (b) Fe
(c) Mn (d) V *(2002, 2000, 1994)*

29. Which ion is colourless?
(a) Cr^{4+} (b) Sc^{3+}
(c) Ti^{3+} (d) V^{3+} *(2000)*

30. Bell metal is an alloy of
(a) Cu + Zn (b) Cu + Sn
(c) Cu + Pb (d) Cu + Ni *(1999)*

31. In which of the following compounds transition metal has zero oxidation state?
(a) $NOClO_4$ (b) NH_2NH_2
(c) CrO_5 (d) $[Fe(CO)_5]$ *(1999)*

32. Which one of the following ionic species will impart colour to an aqueous solution?
(a) Zn^{2+} (b) Cu^+
(c) Ti^{4+} (d) Cr^{3+} *(1998)*

33. A transition element *X* has a configuration $[Ar]3d^4$ in its +3 oxidation state. Its atomic number is
(a) 22 (b) 19
(c) 25 (d) 26 *(1996)*

34. Amongst TiF_6^{2-}, CoF_6^{3-}, Cu_2Cl_2 and $NiCl_4^{2-}$, which are the colourless species? (Atomic number of Ti = 22, Co = 27, Cu = 29, Ni = 28)
(a) CoF_6^{3-} and $NiCl_4^{2-}$ (b) TiF_6^{2-} and Cu_2Cl_2
(c) Cu_2Cl_2 and $NiCl_4^{2-}$ (d) TiF_6^{2-} and CoF_6^{3-}
(1995)

35. The mercury is the only metal which is liquid at 0°C. This is due to its
(a) high vapour pressure
(b) weak metallic bond
(c) high ionization energy
(d) both (b) and (c). *(1995)*

8.4 Some Important Compounds of Transition Elements

36. The manganate and permanganate ions are tetrahedral, due to
(a) the π-bonding involves overlap of d-orbitals of oxygen with d-orbitals of manganese
(b) the π-bonding involves overlap of p-orbitals of oxygen with d-orbitals of manganese
(c) there is no π-bonding
(d) the π-bonding involves overlap of p-orbitals of oxygen with p-orbitals of manganese.
(NEET 2019)

37. When neutral or faintly alkaline $KMnO_4$ is treated with potassium iodide, iodide ion is converted into '*X*'. '*X*' is
(a) I_2 (b) IO_4^- (c) IO_3^- (d) IO^-
(Odisha NEET 2019)

38. Which one of the following ions exhibits *d-d* transition and paramagnetism as well?
(a) CrO_4^{2-} (b) $Cr_2O_7^{2-}$
(c) MnO_4^- (d) MnO_4^{2-} *(NEET 2018)*

39. Name the gas that can readily decolourise acidified $KMnO_4$ solution.
(a) SO_2 (b) NO_2
(c) P_2O_5 (d) CO_2 *(NEET 2017)*

40. Which one of the following statements is correct when SO_2 is passed through acidified $K_2Cr_2O_7$ solution?
(a) SO_2 is reduced.
(b) Green $Cr_2(SO_4)_3$ is formed.
(c) The solution turns blue.
(d) The solution is decolourised. *(NEET-I 2016)*

41. Assuming complete ionisation, same moles of which of the following compounds will require the least amount of acidified $KMnO_4$ for complete oxidation?
(a) $FeSO_3$ (b) FeC_2O_4
(c) $Fe(NO_2)_2$ (d) $FeSO_4$ *(2015)*

42. The reaction of aqueous $KMnO_4$ with H_2O_2 in acidic conditions gives
(a) Mn^{4+} and O_2 (b) Mn^{2+} and O_2
(c) Mn^{2+} and O_3 (d) Mn^{4+} and MnO_2.
(2014)

43. Which of the statements is not true?
(a) On passing H_2S through acidified $K_2Cr_2O_7$ solution, a milky colour is observed.
(b) $Na_2Cr_2O_7$ is preferred over $K_2Cr_2O_7$ in volumetric analysis.
(c) $K_2Cr_2O_7$ solution in acidic medium is orange.
(d) $K_2Cr_2O_7$ solution becomes yellow on increasing the pH beyond 7. *(2012)*

44. Acidified $K_2Cr_2O_7$ solution turns green when Na_2SO_3 is added to it. This is due to the formation of
(a) $Cr_2(SO_4)_3$ (b) CrO_4^{2-}
(c) $Cr_2(SO_3)_3$ (d) $CrSO_4$ *(2011)*

45. The number of moles of $KMnO_4$ reduced by one mole of KI in alkaline medium is
(a) one (b) two
(c) five (d) one fifth. *(2005)*

46. $K_2Cr_2O_7$ on heating with aqueous NaOH gives

(a) $Cr_2O_7^{2-}$ (b) $Cr(OH)_2$

(c) CrO_4^{2-} (d) $Cr(OH)_3$ *(1997)*

47. $KMnO_4$ reacts with oxalic acid according to the equation

$$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

Here 20 mL of 0.1 M $KMnO_4$ is equivalent to

(a) 50 mL of 0.5 M $C_2H_2O_4$

(b) 20 mL of 0.1 M $C_2H_2O_4$

(c) 20 mL of 0.5 M $C_2H_2O_4$

(d) 50 mL of 0.1 M $C_2H_2O_4$ *(1996)*

48. The oxidation state of Cr in $K_2Cr_2O_7$ is

(a) +5 (b) +3

(c) +6 (d) +7 *(1988)*

8.5 The Lanthanoids

49. Which one of the following statements related to lanthanons is incorrect?

(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) solutions are widely used as oxidizing agent in volumetric analysis. *(NEET-II 2016)*

50. The electronic configurations of Eu (Atomic No. 63), Gd (Atomic No. 64) and Tb (Atomic No. 65) are

(a) $[Xe]4f^65d^16s^2$, $[Xe]4f^75d^16s^2$ and $[Xe]4f^85d^16s^2$

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

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

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

(NEET-I 2016)

51. Gadolinium belongs to 4*f* series. Its atomic number is 64. Which of the following is the correct electronic configuration of gadolinium?

(a) $[Xe]\ 4f^9 5s^1$ (b) $[Xe]\ 4f^75d^16s^2$

(c) $[Xe]\,4f^65d^26s^2$ (d) $[Xe]\ 4f^86d^2$

(2015, 1997)

52. Because of lanthanoid contraction, which of the following pairs of elements have nearly same atomic radii? (Numbers in the parenthesis are atomic numbers)

(a) Zr(40) and Hf(72) (b) Zr(40) and Ta(73)

(c) Ti(22) and Zr(40) (d) Zr(40) and Nb(41)

(2015, Cancelled)

53. Reason of lanthanoid contraction is

(a) negligible screening effect of '*f*'-orbitals

(b) increasing nuclear charge

(c) decreasing nuclear charge

(d) decreasing screening effect. *(2014)*

54. Which of the following lanthanoid ions is diamagnetic?

(At. nos. Ce = 58, Sm = 62, Eu = 63, Yb = 70)

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

(NEET 2013)

55. Which of the following oxidation states is the most common among the lanthanoids?

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

(Mains 2010)

56. Identify the incorrect statement among the following :

(a) Lanthanoid contraction is the accumulation of successive shrinkages.

(b) As a result of lanthanoid contraction, the properties of 4*d* series of the transition elements have no similarities with the 5*d* series of elements.

(c) Shielding power of 4*f* electrons is quite weak.

(d) There is a decrease in the radii of the atoms or ions as one proceeds from La to Lu. *(2007)*

57. Lanthanoids are

(a) 14 elements in the sixth period (atomic no. 90 to 103) that are filling 4*f* sublevel

(b) 14 elements in the seventh period (atomic number = 90 to 103) that are filling 5*f* sublevel

(c) 14 elements in the sixth period (atomic number = 58 to 71) that are filling the 4*f* sublevel

(d) 14 elements in the seventh period (atomic number = 58 to 71) that are filling 4*f* sublevel.

(2004)

58. The correct order of ionic radii of Y^{3+}, La^{3+}, Eu^{3+} and Lu^{3+} is (At. nos. Y = 39, La = 57, Eu = 63, Lu = 71)

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

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

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

(d) $La^{3+} < Eu^{3+} < Lu^{3+} < Y^{3+}$ *(2003)*

59. General electronic configuration of lanthanides is

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

(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) $(n-2)\,d^{0-1}\,(n-1)\,f^{1-14}\,ns^2$ *(2002)*

60. Which of the following statement is not correct?

(a) $La(OH)_3$ is less basic than $Lu(OH)_3$.

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

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

(d) Atomic radius of Zn and Hf are same because of lanthanide contraction. *(2001)*

61. The lanthanide contraction is responsible for the fact that

(a) Zr and Hf have about the same radius

(b) Zr and Zn have the same oxidation state

(c) Zr and Y have about the same radius

(d) Zr and Nb have similar oxidation state. *(1997)*

62. Which of the following statements concerning lanthanide elements is false?

(a) All lanthanides are highly dense metals.

(b) More characteristic oxidation state of lanthanide elements is +3.

(c) Lanthanides are separated from one another by ion exchange method.

(d) Ionic radii of trivalent lanthanides steadily increases with increase in the atomic number.

(1994)

8.6 The Actinoids

63. The reason for greater range of oxidation states in actinoids is attributed to

(a) actinoid contraction

(b) 5*f*, 6*d* and 7*s* levels having comparable energies

(c) 4*f* and 5*d* levels being close in energies

(d) the radioactive nature of actinoids.

(NEET 2017)

64. Which of the following exhibits only +3 oxidation state?

(a) U (b) Th

(c) Ac (d) Pa *(Mains 2012)*

65. More number of oxidation states are exhibited by the actinoids than by the lanthanoids. The main reason for this is

(a) more active nature of the actinoids

(b) more energy difference between 5*f* and 6*d* orbitals than that between 4*f* and 5*d* orbitals

(c) lesser energy difference between 5*f* and 6*d* orbitals than that between 4*f* and 5*d* orbitals

(d) greater metallic character of the lanthanoids than that of the corresponding actinoids.

(2006, 2005)

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

(a) Gd (b) La

(c) Eu (d) Am *(1998)*

8.7 Some Applications of *d*- and *f*-Block Elements

67. Match the catalyst with the process :

Catalyst	**Process**
(i) V_2O_5	(p) The oxidation of ethyne to ethanal
(ii) $TiCl_4 + Al(CH_3)_3$	(q) Polymerisation of alkynes
(iii) $PdCl_2$	(r) Oxidation of SO_2 in the manufacture of H_2SO_4
(iv) Nickel complexes	(s) Polymerisation of ethylene

Which of the following is the correct option?

(a) (i)-(r), (ii)-(s), (iii)-(p), (iv)-(q)

(b) (i)-(p), (ii)-(q), (iii)-(r), (iv)-(s)

(c) (i)-(p), (ii)-(r), (iii)-(q), (iv)-(s)

(d) (i)-(r), (ii)-(p), (iii)-(s), (iv)-(q)

(Odisha NEET 2019)

68. $HgCl_2$ and I_2 both when dissolved in water containing I ions, the pair of species formed is

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

(c) Hg_2I_2, I^- (d) HgI_2, I_3^-

(NEET 2017)

69. Which of the following elements is responsible for oxidation of water to O_2 in biological processes?

(a) Cu (b) Mo

(c) Fe (d) Mn *(1997)*

70. When calomel reacts with NH_4OH, we get

(a) Hg_2O (b) HgO

(c) $HgNH_2Cl$ (d) NH_2–Hg–Hg–Cl

(1996)

71. Photographic films and plates have an essential ingredient of

(a) silver nitrate (b) silver bromide

(c) sodium chloride (d) oleic acid. *(1989)*

ANSWER KEY

1.	(b)	**2.**	(d)	**3.**	(d)	**4.**	(d)	**5.**	(b)	**6.**	(c)	**7.**	(c)	**8.**	(d)	**9.**	(b)	**10.**	(a)
11.	(c)	**12.**	(a)	**13.**	(d)	**14.**	(b)	**15.**	(c)	**16.**	(c)	**17.**	(c)	**18.**	(a)	**19.**	(b)	**20.**	(c)
21.	(b)	**22.**	(c)	**23.**	(b)	**24.**	(c)	**25.**	(a)	**26.**	(d)	**27.**	(d)	**28.**	(c)	**29.**	(b)	**30.**	(b)
31.	(d)	**32.**	(d)	**33.**	(c)	**34.**	(b)	**35.**	(d)	**36.**	(b)	**37.**	(c)	**38.**	(d)	**39.**	(a)	**40.**	(b)
41.	(d)	**42.**	(b)	**43.**	(b)	**44.**	(a)	**45.**	(b)	**46.**	(c)	**47.**	(d)	**48.**	(c)	**49.**	(c)	**50.**	(b)
51.	(b)	**52.**	(a)	**53.**	(a)	**54.**	(b)	**55.**	(d)	**56.**	(b)	**57.**	(c)	**58.**	(b)	**59.**	(a)	**60.**	(a)
61.	(a)	**62.**	(d)	**63.**	(b)	**64.**	(c)	**65.**	(c)	**66.**	(d)	**67.**	(a)	**68.**	(b)	**69.**	(c)	**70.**	(c)
71.	(b)																		

Hints & Explanations

1. (b) : Sc ($Z = 21$) has incompletely filled $3d$-orbitals in its ground state ($3d^1$), it is considered as a transition element but Zn ($Z = 30$) has completely filled d-orbitals ($3d^{10}$) in its ground state and its common oxidation state (+2), thus, it is not considered as a transition element.

2. (d) : The electronic configuration of the given ions is :

Ni^{3+} : $[Ar]3d^7 4s^0$, Mn^{3+} : $[Ar]3d^4 4s^0$

Fe^{3+} : $[Ar]3d^5 4s^0$, Co^{3+} : $[Ar]3d^6 4s^0$

Thus, Co^{3+} is the ion with the desired configuration.

3. (d) : $_{22}Ti = 3d^2 4s^2$; $Ti^{2+} = 3d^2$

$_{23}V = 3d^3 4s^2$; $V^{3+} = 3d^2$

$_{24}Cr = 3d^4 4s^2$; $Cr^{4+} = 3d^2$

$_{25}Mn = 3d^5 4s^2$; $Mn^{5+} = 3d^2$

4. (d) **5. (b)**

6. (c) : General electronic configuration of transition elements is $ns^2 (n-1)d^{1-10}$.

7. (c) : $[Ne]3s^2 3p^5$ is the electronic configuration of a p-block element whereas other configurations are those of d-block elements.

8. (d) : The oxidation states of Cr in CrO_4^{2-} and $Cr_2O_7^{2-}$ is same *i.e.*, +6.

9. (b) : Cr : $3d^5 4s^1$, Cr^{2+} : $3d^4$ has four unpaired electrons.

$$\mu = \sqrt{n(n+2)} = \sqrt{4(4+2)} = \sqrt{24} \approx 4.90 \text{ B.M.}$$

10. (a) : Co^{3+} : $[Ar]3d^6$, unpaired $e^-(n) = 4$

Spin magnetic moment (μ) = $\sqrt{4(4+2)} = \sqrt{24}$ B.M.

Cr^{3+} : $[Ar]3d^3$, unpaired $e^-(n) = 3$

Spin magnetic moment (μ) = $\sqrt{3(3+2)} = \sqrt{15}$ B.M.

Fe^{3+} : $[Ar]3d^5$, unpaired $e^-(n) = 5$

Spin magnetic moment (μ) = $\sqrt{5(5+2)} = \sqrt{35}$ B.M.

Ni^{2+} : $[Ar]3d^8$, unpaired $e^-(n) = 2$

Spin magnetic moment (μ) = $\sqrt{2(2+2)} = \sqrt{8}$ B.M.

11. (c) : Magnetic moment (μ) = $\sqrt{n(n+2)}$

2.84 B.M. corresponds to 2 unpaired electrons.

$Cr^{2+} - 3d^4$, 4 unpaired electrons

$Co^{2+} - 3d^7$, 3 unpaired electrons

$Ni^{2+} - 3d^8$, 2 unpaired electrons

$Ti^{3+} - 3d^1$, 1 unpaired electron

12. (a) : Oxidation number of Fe in $Fe(CO)_5$ is zero.

13. (d) : Interstitial compounds are generally chemically inert.

14. (b) : Invar ⇒ Ni(metal) + Fe(metal)

Steel ⇒ C(non-metal) + Fe(metal)

Bell ⇒ Cu(metal) + Sn(metal) + Fe(metal)

Bronze ⇒ Cu(metal) + Sn(metal)

15. (c)

16. (c) : Element : Ti < V < Cr < Mn

No. of oxidation states : +3 +4 +5 +6

Hence, given order is correct.

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

For Ti^{3+} $n = 1, \mu = \sqrt{1(1+2)} = \sqrt{3}$ B.M.

For V^{3+} $n = 2, \mu = \sqrt{2(2+2)} = \sqrt{8}$ B.M.

For Cr^{3+} $n = 3, \mu = \sqrt{3(3+2)} = \sqrt{15}$ B.M.

For Mn^{3+} $n = 4, \mu = \sqrt{4(4+2)} = \sqrt{24}$ B.M.

Thus, magnetic moment order : $Ti^{3+} < V^{3+} < Cr^{3+} < Mn^{3+}$

Melting point order : Mn < Ti < Cr < V

1245°C 1668°C 1875°C 1900°C

2^{nd} ionisation enthalpy order

Ti < V < Mn < Cr

(in kJ/mol) : 1309 1414 1509 1592

17. (c) :

Element	Co	Ni	Cu	Fe
$E^\circ_{M^{2+}/M}$ (V)	− 0.28	−0.25	+0.34	−0.44

18. (a) : Spin correlation and exchange energy gives an electronic configuration a special stability which is greatest for half-filled electronic configurations.

Mn^{2+} (d^5) gets stabilisation due to half-filled configuration.

In Fe^{2+} (d^6) the placing of one extra electron in a subshell destabilises. Placing of 2 electrons in Co^{2+} (d^7) destabilises it more. Cr^{2+} (d^4) has one vacant subshell. Fe^{2+} gets more stabilisation compared to Cr^{2+} through exchange energy.

So, the order is as follows : Mn > Fe > Cr > Co.

19. (b) : Ions which have unpaired electrons exhibit colour in aqueous solution. Ti^{3+} has an outer electronic configuration of $4s^0 3d^1$, *i.e.*, 1 unpaired electron. Thus, its solution will be coloured. Others are colourless due to empty or completely filled outermost orbitals.

20. (c) : Hf^{4+} and Zr^{4+} belong to group IVB. But, Hf^{4+} has same size as Zr^{4+} due to the addition of 14 lanthanide elements before it in which electrons are added into the f-subshell which poorly shield the outer electrons and contraction in size occurs.

21. (b) : Greater the number of valence electrons, more will be the number of oxidation states exhibited by the element.

$3d^5 4s^1$, can show a maximum of 6 oxidation states.

$3d^5 4s^2$, can show a maximum of 7 oxidation states.
$3d^2 4s^2$ can show a maximum of 4 oxidation states.
$3d^3 4s^2$ can show a maximum of 5 oxidation states.

22. (c) : Electronic configuration of the given elements are

Mn : $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^5\,4s^2$
Cr : $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^5\,4s^1$
Ti : $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^2\,4s^2$
V : $1s^2\,2s^2\,2p^6\,3s^2\,3p^6\,3d^3\,4s^2$

In general, ionization potential (both 1st and 2nd) increases from left to right across the period due to increase in effective nuclear charge. On this basis, the second IP values should exhibit the trend :

Mn > Cr > V > Ti

But the actual observed order is : Cr > Mn > V > Ti
Practically, only chromium is exceptional and rest others show the normal trend. This exceptional behaviour of chromium is due to the stable configuration ($3d^5$) that it achieves after the loss of first electron.

23. (b) : Sc : [Ar] $3d^1\,4s^2$, Sc^{3+} : [Ar] Colourless
Ti : [Ar]$3d^2\,4s^2$, Ti^{3+} : [Ar]$3d^1$ Coloured
Ni : [Ar]$3d^8\,4s^2$, Ni^{2+} : [Ar]$3d^8$ Coloured
Cu : [Ar]$3d^{10}\,4s^1$, Cu^+ : [Ar]$3d^{10}$ Colourless
Co : [Ar]$3d^7\,4s^2$, Co^{2+} : [Ar]$3d^7$ Coloured

Ti^{3+}, Ni^{2+} and Co^{2+} are coloured due to presence of unpaired electrons.

24. (c) : V^{2+} (23) : [Ar]$3d^3\,4s^0$
Cr^{2+} (24) : [Ar]$3d^4\,4s^0$
Mn^{2+} (25) : [Ar]$3d^5\,4s^0$
Fe^{2+} (26) : [Ar]$3d^5\,4s^1$

$\Rightarrow I.E_3\,(Mn) > I.E_3\,(Cr) > I.E_3\,(Fe) > I.E_3\,(V)$
3260 2990 2962 2833

25. (a) : If the transition metal ion has unpaired electron then it shows colour.

Sc^{3+} : [Ar]$3d^0\,4s^0$
Fe^{2+} : [Ar]$3d^5\,4s^1$
Ti^{3+} : [Ar]$3d^1\,4s^0$
Mn^{2+} : [Ar]$3d^5\,4s^0$

Sc^{3+} does not contain unpaired electron, hence it will not undergo $d - d$ transition and do not show colour.

26. (d) : The transition elements, on account of their variable valency, are able to form unstable intermediate compounds very readily.

27. (d) : The order of basicity of transition metal monoxides is, TiO > VO > CrO > FeO.

28. (c) : Each of the element in group III B to VII B can show the maximum oxidation state equal to its group number. Mn is in group seven shows a maximum oxidation state of +7 in $KMnO_4$.

29. (b) : $_{21}Sc$: [Ar] $3d^1 4s^2$
In Sc^{3+} there is no unpaired '*d*' electrons, therefore it is colourless in its solution.

30. (b) : Bell metal ⇒ Cu = 80%, Sn = 20%
It is used for making bells, utensils, etc.

31. (d) : In iron carbonyl, the oxidation number of 'Fe' is zero.

$[Fe(CO)_5] : x + 5 \times 0 = 0 \Rightarrow x = 0$

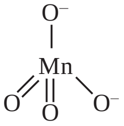
32. (d) : Cr^{3+}(24) : $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^3$
As Cr^{3+} ion has three unpaired electrons in its valence shell, so it imparts colour to an aqueous solution.

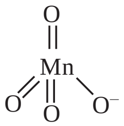
33. (c) : The metal atom will have three more electrons. Therefore, the atomic number of the metal = 18 + 4 + 3
= 25

34. (b) : In TiF_6^{2-} titanium is in +4 oxidation state. In Cu_2Cl_2, the copper is in +1 state. Thus, in both cases, transition from one *d*-orbital to other is not possible.
Ti : [Ar] $3d^2 4s^2 \rightarrow Ti^{4+}$: [Ar]$3d^0 4s^0$
Cu : [Ar] $3d^{10} 4s^1 \rightarrow Cu^+$: [Ar]$3d^{10} 4s^0$

35. (d) : Very high ionisation energy of Hg makes it difficult for electrons to participate in metallic bonding.

36. (b) :


Tetrahedral
Manganate ion (green)


Tetrahedral
Permanganate ion (purple)

In manganate and permanganate ions, π-bonding takes place by overlap of *p* -orbitals of oxygen with *d*-orbitals of manganese.

37. (c) : In neutral or faintly alkaline solutions :
$$2MnO_4^- + H_2O + I^- \longrightarrow 2MnO_2 + 2OH^- + IO_3^-$$

38. (d) :

In CrO_4^{2-}, Cr^{+6} ($n = 0$) diamagnetic
In $Cr_2O_7^{2-}$, Cr^{+6} ($n = 0$) diamagnetic
In MnO_4^-, Mn^{+7} ($n = 0$) diamagnetic
In MnO_4^{2-}, Mn^{+6}($n = 1$) paramagnetic

In MnO_4^{2-}, one unpaired electron (n) is present in *d*-orbital so, *d*-*d* transition is possible.

39. (a) : SO_2 readily decolourises pink violet colour of acidified $KMnO_4$ solution.

$$\underset{\text{(Pink violet)}}{2KMnO_4} + 5SO_2 + 2H_2O \longrightarrow K_2SO_4 + \underset{\text{(Colourless)}}{2MnSO_4} + 2H_2SO_4$$

40. (b) : $K_2Cr_2O_7 + H_2SO_4 + 3SO_2 \longrightarrow K_2SO_4 + \underset{\text{(Green)}}{Cr_2(SO_4)_3} + H_2O$

41. (d) : $KMnO_4$ (Mn^{7+}) changes to Mn^{2+} *i.e.*, number of electrons involved per mole of $KMnO_4$ is 5.

(a) For $FeSO_3$,

$Fe^{2+} \longrightarrow Fe^{3+}$ (No. of e^-s involved = 1)

$SO_3^{2-} \longrightarrow SO_4^{2-}$ (No. of e^-s involved = 2)

Total number of e^-s involved = 1 + 2 = 3

(b) For FeC_2O_4,

$Fe^{2+} \longrightarrow Fe^{3+}$ (No. of e^-s involved = 1)

$C_2O_4^{2-} \longrightarrow 2CO_2$ (No. of e^-s involved = 2)

Total number of e^-s involved = 1 + 2 = 3

(c) For $Fe(NO_2)_2$,

$Fe^{2+} \longrightarrow Fe^{3+}$ (No. of e^-s involved = 1)

$2NO_2^- \longrightarrow 2NO_3^-$ (No. of e^-s involved = 4)

Total number of e^-s involved = 1 + 4 = 5

(d) For $FeSO_4$,

$Fe^{2+} \longrightarrow Fe^{3+}$ (No. of e^-s involved = 1)

Total number of e^-s involved = 1

As $FeSO_4$ requires least number of electrons thus, it will require least amount of $KMnO_4$.

42. (b) : Hydrogen peroxide is oxidised to H_2O and O_2.

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

or, $2MnO_4^- + 5H_2O_2 + 6H^+ \longrightarrow 2Mn^{2+} + 8H_2O + 5O_2$

43. (b) : Potassium dichromate is preferred over sodium dichromate in volumetric analysis, primarily because the latter is hygroscopic nature and therefore, accurate weighing is not possible in normal atmosphere.

44. (a) : $K_2Cr_2O_7 + 4H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O]$

$[Na_2SO_3 + [O] \longrightarrow Na_2SO_4] \times 3$

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

or $Cr_2O_7^{2-} + 3SO_3^{2-} + 8H^+ \longrightarrow 3SO_4^{2-} + 2Cr^{3+} + 4H_2O$

45. (b) : In alkaline medium :

$2KMnO_4 + H_2O \rightarrow 2KOH + 2MnO_2 + 3[O]$

$KI + 3[O] \rightarrow KIO_3$

$2KMnO_4 + KI + H_2O \rightarrow 2KOH + 2MnO_2 + KIO_3$

46. (c) : $K_2Cr_2O_7 + 2NaOH \rightarrow K_2CrO_4 + Na_2CrO_4 + H_2O$

or $Cr_2O_7^{2-} + 2OH^- \rightarrow 2CrO_4^{2-} + H_2O$

47. (d) : $2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$

$\therefore$ 2 moles of $MnO_4^- \equiv$ 5 moles of $C_2O_4^{2-}$

20 mL of 0.1 M $KMnO_4$ = 2 mmol of $KMnO_4$

Also, 50 mL of 0.1 M $C_2H_2O_4 \equiv$ 5 mmol of $C_2O_4^{2-}$

Therefore, these are equivalent.

48. (c) : Let, oxidation state of Cr in $K_2Cr_2O_7$ is x. Then,

$2 + 2x - 14 = 0$

$\Rightarrow 2x = 12 \quad \therefore \quad x = +6$

49. (c) : The first few members of the lanthanoid series are quite reactive, almost like calcium. However, with increasing atomic number, their behaviour becomes similar to that of aluminium.

50. (b) **51. (b)**

52. (a) : Zr and Hf have nearly same radii due to lanthanoid contraction.

53. (a) : Due to poor shielding effect of 4*f*-orbitals, nucleus will exert a strong attraction and size of atom or ion goes on decreasing as move in the series with increase in atomic number.

54. (b) : Sm^{2+} (Z = 62) : $[Xe]4f^6$

Eu^{2+} (Z = 63) : $[Xe]4f^7$

Yb^{2+} (Z = 70) : $[Xe]4f^{14}$

Ce^{2+} (Z = 58) : $[Xe]4f^2$

Only Yb^{2+} is diamagnetic.

55. (d) : The common stable oxidation state of all the lanthanoids is +3. The oxidation state of +2 and +4 are also exhibited by some of the elements. These oxidation states are only stable in those cases where stable $4f^0$, $4f^7$ or $4f^{14}$ configurations are achieved.

56. (b) : In each vertical column of transition elements, the elements of second and third transition series resemble each other more closely than the elements of first and second transition series on account of lanthanide contraction. Hence, the properties of elements of 4*d* series of the transition elements resemble with the properties of the elements of 5*d* series of the transition elements.

57. (c) : As sixth period can accommodate only 18 elements in the table, 14 members of 4*f* series (atomic number 58 to 71) are separately accommodated in a horizontal row below the periodic table. These are called as lanthanides.

58. (b) : On going from La^{3+} to Lu^{3+}, the ionic radius shrinks from 1.15 Å to 0.93 Å (lanthanide contraction). The radius of La^{3+} is also larger than that of Y^{3+} ion which lies immediately above it in periodic table.

59. (a) : The general electronic structure of lanthanides is, $(n-2)f^{1-14}(n-1)s^2p^6d^{0-1}ns^2$.

60. (a) : $La(OH)_3$ is more basic than $Lu(OH)_3$. In lanthanides, the basic character of hydroxides decreases as the ionic radius decreases.

61. (a) : Due to lanthanide contraction, the elements of second and third transition series *i.e.*, Zr and Hf resemble more with each other than the elements of first and second transition series.

62. (d) : Ionic radii of trivalent lanthanides decreases with increase in atomic number.

63. (b) : Actinoids have a greater range of oxidation states due to comparable energies of 5*f*, 6*d* and 7*s* orbitals. Hence, all their electrons can take part in bond formation.

64. (c) : U exhibits + 3, + 4, + 5, + 6

Th exhibits + 3, + 4 ; Ac exhibits + 3 only

Pa exhibits + 3, + 4, +5

65. (c) : The 5*f*-orbitals extend into space beyond the 6*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 in the atom, totally shielded by outer orbitals and thus, unable to take part in bonding.

66. (d) : 'La' forms compounds in which its oxidation no. is +3.

'Eu' and 'Gd' exhibit +2 as well as +3 oxidation states and not higher than that, due to stable (f^7) configuration. whereas 'Am' exhibits the oxidation states +3, +4, +5, +6, etc. due to extremely large size and low ionisation energy.

67. (a)

68. (b) : $HgCl_{2(aq)} + 4I^-_{(aq)} \longrightarrow HgI_4^{2-}{}_{(aq)} + 2Cl^-_{(aq)}$

$I_{2(s)} + I^-_{(aq)} \underline{\qquad} I^-_{3\,(aq)}$

69. (c)

70. (c) : When calomel reacts with NH_4OH, it turns black due to the formation of a mixture of mercury and ammonium basic mercury (II) chloride.

$\underset{\text{(Calomel)}}{Hg_2Cl_2} + 2\,NH_4OH \rightarrow NH_4Cl + 2H_2O + Hg + HgNH_2Cl$

71. (b) : AgBr is highly photosensitive and is used as an ingredient for photographic films and plates.