CHAPTER
22

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

FACT/DEFINITION TYPE QUESTIONS

1. The transition elements have a general electronic configuration

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

2. Correct electronic configuration of Cr (Z = 24) is

(a) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7\ 4s^1$

(b) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$

(c) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^7\ 4s^2$

(d) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^2$

3. Which of the following configuration is correct for iron ?

(a) $1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^4$

(b) $1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^6 4s^2$

(c) $1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^2$

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

4. Which one 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)

5. Which of the following element does not belong to first transition series?

(a) Fe (b) V

(c) Ag (d) Cu

6. $(n-1)d^{10}ns^2$ is the general electronic configuration of

(a) Fe, Co, Ni (b) Cu, Ag, Au

(c) Zn, Cd, Hg (d) Se, Y, La

7. The last electron in d-block elements goes to

(a) (n-1) d (b) nd

(c) np (d) (n-1) s

8. The elements which exhibit both vertical and horizontal similarites are

(a) inert gas elements (b) representative elements

(c) rare elements (d) transition elements

9. An atom has electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3 4s^2$ in which group would it be placed?

(a) Fifth (b) Fifteenth

(c) Second (d) Third

10. In 3d-series atomic number (Z) varies from

(a) $Z = 21 - 30$ (b) $Z = 22 - 30$

(c) $Z = 20 - 30$ (d) $Z = 31 - 40$

11. The valence shell of transition elements consists of

(a) nd orbitals (b) (n-1) d orbitals

(c) ns np nd orbitals (d) (n-1) d ns orbitals

12. Number of unpaired electrons in Ni^{2+}(*Z*=28) is

(a) 4 (b) 2

(c) 6 (d) 8

13. Which of the following element is not a member of transition elements ?

(a) Zn (b) Pt

(c) Ce (d) Mo

14. The number of unpaired electrons in gaseous species of Mn^{3+}, Cr^{3+} and V^{3+} respectively are.

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

(c) 4, 3 and 2 (d) 3, 3 and 3

15. The first element in the 3d-transition series is

(a) Sc (b) Ti

(c) V (d) Ca

16. Which of the following has more unpaired d-electrons?

(a) Zn^+ (b) Fe^{2+}

(c) Ni^+ (d) Cu^+

17. The number of unpaired electrons in a nickel atom in ground state are (At. No. of Ni = 28)

(a) 2 (b) 5

(c) 3 (d) 7

18. Which one of the following is an example of non-typical transition elements ?

(a) Li, K, Na (b) Be, Al, Pb

(c) Zn, Cd, Hg (d) Ba, Ga, Sr.

19. Which of the following has the maximum number of unpaired electrons?
(a) Ti^{2+} (b) Fe^{2+}
(c) Cr^{+} (d) Cu^{+}

20. The outer electronic configuration of Ag is $4d^{10}\,5s^{1}$, it belongs to
(a) 5^{th} period, group 4 (b) 4^{th} period, group 5
(c) 5^{th} period, group 11 (d) 6^{th} period, group 9

21. Manganese belongs to
(a) 1^{st} transition series (b) 2^{nd} transition series
(c) 3^{rd} transition series (d) 4^{th} transition series

22. The no. of unpaired electrons in Mn^{7+} ions (At. no. of Mn = 25) is
(a) 0 (b) 1
(c) 2 (d) 3

23. Which one of the following species is paramagnetic?
(a) N_2 (b) Co
(c) Cu^{+} (d) Zn

24. Which of the following species is/are paramagnetic?
Fe^{2+}, Zn^{0}, Hg^{2+}, Ti^{4+}
(a) Fe^{2+} only (b) Zn^{0} and Ti^{4+}
(c) Fe^{2+} and Hg^{2+} (d) Zn^{0} and Hg^{2+}

25. In first transition series, the melting point of Mn is low because
(a) due to d^{10} configuration, metallic bonds are strong
(b) due to d^{7} configuration, metallic bonds are weak
(c) due to d^{5} configuration, metallic bonds are weak
(d) None of these

26. The transition metals have a less tendency to form ions due to
(a) high ionisation energy
(b) low heat of hydration of ions
(c) high heat of sublimation
(d) All of these

27. The common oxidation states of Ti are
(a) +2 and +3 (b) +3 and +4
(c) –3 and –4 (d) +2, +3 and +4

28. Maximum oxidation state is shown by
(a) Os (b) Mn
(c) Co (d) Cr

29. 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) $3d^{3}4s^{2}$

30. 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+}

31. 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

32. Iron exhibits +2 and + 3 oxidation states. Which of the following statements about iron is incorrect ?
(a) Ferrous oxide is more basic in nature than the ferric oxide.
(b) Ferrous compounds are relatively more ionic than the corresponding ferric compounds.
(c) Ferrous compounds are less volatile than the corresponding ferric compounds.
(d) Ferrous compounds are more easily hydrolysed than the corresponding ferric compounds.

33. 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 ionization enthalpy?
(a) Vanadium (Z = 23) (b) Chromium (Z = 24)
(c) Manganese (Z = 25) (d) Iron (Z = 26)

34. Of the following outer electronic configurations of atoms, the highest oxidation state is achieved by which one of them ?
(a) $(n-1)d^{3}\,ns^{2}$ (b) $(n-1)d^{5}\,ns^{1}$
(c) $(n-1)d^{8}\,ns^{2}$ (d) $(n-1)d^{5}\,ns^{2}$

35. For *d* block elements the first ionization potential is of the order
(a) Zn > Fe > Cu > Cr (b) Sc = Ti < V = Cr
(c) Zn < Cu < Ni < Co (d) V > Cr > Mn > Fe

36. Which of the following does not represent the correct order of the properties indicated ?
(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)

37. Zinc and mercury do not show variable valency like *d*-block elements because
(a) they are soft
(b) their *d*-shells are complete
(c) they have only two electrons in the outermost subshell
(d) their *d*-shells are incomplete

38. Which of the following transition element shows the highest oxidation state ?
(a) Mn (b) Fe
(c) V (d) Cr

39. Which of the following elements does not show variable oxidation states?
(a) Copper (b) Iron
(c) Zinc (d) Titanium

40. Which one of the following transition elements does not exhibit variable oxidation state?
(a) Ni (b) Cu
(c) Fe (d) Sc

41. Electronic configuration of a transition element X in +3 oxidation state is $[Ar]3d^{5}$. What is its atomic number ?
(a) 25 (b) 26
(c) 27 (d) 24

42. Metallic radii of some transition elements are given below. Which of these elements will have highest density ?

Element	Fe	Co	Ni	Cu
Metallic radii/pm	126	125	125	128

(a) Fe (b) Ni
(c) Co (d) Cu

43. Transition metals mostly are
(a) diamagnetic
(b) paramagnetic
(c) neither diamagnetic nor paramagnetic
(d) both diamagnetic and paramagnetic

44. Transition metals usually exhibit highest oxidation states in their
(a) chlorides (b) fluorides
(c) bromides (d) iodides

45. Which of the following statements is incorrect?
(a) Zn,Cd and Hg due to presence of completely filled *d*-orbitals $[(n-1)d^{10}ns^2]$ are not studied along with other transition metals.
(b) Zn, Cd and Hg have low m.p and are comparitively softer than other transition metals.
(c) Metallic bond made by elements with d^5 configuration is stronger as compared to metalic bond made by elements with d^3 configuration.
(d) Metals of 5*d* series forms strong metallic bonds as compared with metals of 3*d* series.

46. Which of the following is incorrect?
(a) Mn shows oxidation state of +7 in MnF_7
(b) Fe and Co shows +3 oxidation state in FeX_3 and CoF_3.
(c) V shows oxidation state of + 5 in VF_5.
(d) Cu does not shows +2 oxidation state with I^-.

47. Which of the following is not correct about transition metals?
(a) Their melting and boiling points are high
(b) Their compounds are generally coloured
(c) They can form ionic or covalent compounds
(d) They do not exhibit variable valency

48. Transition elements
(a) have low melting point
(b) exhibit variable oxidation states
(c) do not form coloured ions
(d) show inert pair effect

49. Which one of the following ions is the most stable in aqueous solution?
(a) V^{3+} (b) Ti^{3+}
(c) Mn^{3+} (d) Cr^{3+}
(At.No. Ti = 22, V = 23, Cr = 24, Mn = 25)

50. 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

51. What is wrong about transition metals?
(a) Diamagnetic
(b) Paramagnetic
(c) Form complexes
(d) Shows variable oxidation state

52. Which of the following ions has the maximum magnetic moment?
(a) Mn^{+2} (b) Fe^{+2}
(c) Ti^{3+} (d) Cr^{+2}.

53. Four successive members of the first row transition elements are listed below with atomic numbers. Which one of them is expected to have the highest $E^\circ_{M^{3+}/M^{2+}}$ value ?
(a) Cr(Z = 24) (b) Mn(Z = 25)
(c) Fe(Z = 26) (d) Co(Z = 27)

54. Which one of the following ions exhibit highest magnetic moment?
(a) Cu^{2+} (b) Ti^{3+}
(c) Ni^{2+} (d) Mn^{2+}

55. A compound of a metal ion $M^{x+}(Z = 24)$ has a spin only magnetic moment of $\sqrt{15}$ Bohr Magnetons. The number of unpaired electrons in the compound are
(a) 2 (b) 4
(c) 5 (d) 3

56. Titanium shows magnetic moment of 1.73 B.M. in its compound. What is the oxidation number of Ti in the compound?
(a) +1 (b) +4
(c) +3 (d) +2

57. Which of the following ions having following electronic structure would have maximum magnetic moment?
(a) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$
(b) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$
(c) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7$
(d) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^9$

58. If n is the number of unpaired electrons, the magnetic moment (in BM) of transition metal/ion is given by
(a) $\sqrt{n(n+2)}$ (b) $\sqrt{2n(n+1)}$
(c) $\sqrt{n(n-2)}$ (d) $\sqrt{2n(n-1)}$

59. Which one of the following ions has the maximum magnetic moment?
(a) Sc^{3+} (b) Ti^{3+}
(c) Cr^{3+} (d) Fe^{3+}

60. The magnetic nature of elements depend on the presence of unpaired electrons. Identify the configuration of transition element, which shows highest magnetic moment.
(a) $3d^7$ (b) $3d^5$
(c) $3d^8$ (d) $3d^2$

61. Transition elements show magnetic moment due to spin and orbital motion of electrons. Which of the following metallic ions have almost same spin only magnetic moment?
(i) Co^{2+} (ii) Cr^{2+}
(iii) Mn^{2+} (iv) Cr^{3+}
(a) (i) and (iii) (b) (i) and (iv)
(c) (ii) and (iii) (d) (ii) and (iv)

62. 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+}

63. Transition elements form coloured ions due to
(a) *d-d* transition (b) fully filled *d*-orbitals
(c) smaller atomic radii (d) availability of *s*-electrons

64. The catalytic activity of transition metals and their compounds is mainly due to
(a) their magnetic behaviour
(b) their unfilled *d*-orbitals
(c) their ability to adopt variable oxidation state
(d) their chemical reactivity

65. Which of the following is colourless in water?
(a) Ti^{3+} (b) V^{3+}
(c) Cu^{3+} (d) Sc^{3+}

66. Which group contains coloured ions out of
(i) Cu^{2+} (ii) Ti^{4+}
(iii) Co^{2+} (iv) Fe^{2+}
(a) (i), (ii), (iii), (iv) (b) (i), (iii), (iv)
(c) (ii), (iii) (d) (i), (ii)

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

68. Formation of interstitial compound makes the transition metal
(a) more soft (b) more ductile
(c) more metallic (d) more hard

69. If a non metal is added to the interstital sites of a metal, then the metal becomes
(a) softer (b) less tensile
(c) less malleable (d) more ductile

70. Gun metal is an alloy of
(a) Cu and Al (b) Cu and Sn
(c) Cu, Zn and Sn (d) Cu, Zn and Ni

71. Brass is an alloy of
(a) Zn and Sn (b) Zn and Cu
(c) Cu, Zn and Sn (d) Cu and Sn

72. Which one of the following is coinage metal ?
(a) Zn (b) Cu
(c) Sn (d) Pb.

73. Bronze is an alloy of
(a) Pb + Sn + Zn (b) Cu + Sn
(c) Pb + Zn (d) Cu + Zn

74. An alloy of transition metal containing a non transition metal as a constituent is
(a) invar (b) bronze
(c) chrome steel (d) stainless steel

75. Choose the correct increasing order of the oxidation state of the central metal atom in the following oxoanions.

$VO_2^+, VO^{2+}, TiO^{2+}, CrO_4^{2-}$

(a) $VO^{2+} \simeq VO_2^+ < TiO^{2+} < CrO_4^{2-}$

(b) $VO^{2+} \simeq TiO^{2+} < VO_2^+ < CrO_4^{2-}$

(c) $CrO_4^{2-} < TiO^{2+} < VO_2^+ < VO^{2+}$

(d) $TiO^{2+} < VO^{2+} \simeq VO_2^+ < CrO_4^{2-}$

76. Which of the following ion(s) is/are oxidising in nature?

(i) $V^{2+}\left(E^\circ_{M^{2+}/M} = -1.18\right)$

(ii) $Mn^{3+}\left(E^\circ_{M^{3+}/M^{2+}} = +1.57\right)$

(iii) $Cr^{2+}\left(E^\circ_{M^{2+}/M} = -0.91\right)$

(a) (i) and (iii) (b) only (ii)
(c) (ii) and (iii) (d) only (iii)

77. Which of the following transition metal ion is colourless in aqueous solution?
(a) Ti^{4+} (b) Zn^{2+}
(c) V^{4+} (d) Both (a) and (b)

78. Transition metals show catalytic activity
(a) Due to their ability to form complexes.
(b) Due to their ability to show multiple oxidation state.
(c) Due to availabiltiy of *d* orbitals for bond formation.
(d) Both (a) and (b).

79. Which of the following transition metal on catalysis the reaction between iodide and persulphate ion?
(a) Fe^{2+} (b) Fe^{3+}
(c) Ni^{2+} (d) Both (a) and (c)

80. Which of the following reactions are disproportionation reactions ?

(i) $Cu^+ \longrightarrow Cu^{2+} + Cu$

(ii) $3MnO_4^- + 4H^+ \longrightarrow 2MnO_4^- + MnO_2 + 2H_2O$

(iii) $2KMnO_4 \longrightarrow K_2MnO_4 + MnO_2 + O_2$

(iv) $2MnO_4^- + 3Mn^{2+} + 2H_2O \longrightarrow 5MnO_2 + 4H^+$

(a) (i) and (ii) (b) (i), (ii) and (iii)
(c) (ii), (iii) and (iv) (d) (i) and (iv)

81. In the form of dichromate, Cr (VI) is a strong oxidising agent in acidic medium but Mo (VI) in MoO_3 and W (VI) in WO_3 are not because _____ .
(i) Cr (VI) is more stable than Mo(VI) and W (VI).
(ii) Mo (VI) and W(VI) are more stable than Cr(VI).
(iii) Higher oxidation states of heavier members of group-6 of transition series are more stable.
(iv) Lower oxidation states of heavier members of group-6 of transition series are more stable.
(a) (i) and (ii) (b) (ii) and (iii)
(c) (i) and (iv) (d) (ii) and (iv)

82. $K_2Cr_2O_7$ on heating with aqueous NaOH gives
(a) CrO_4^{2-} (b) $Cr(OH)_3$
(c) $Cr_2O_7^{2-}$ (d) $Cr(OH)_2$

83. CrO_3 dissolves in aqueous NaOH to give
(a) $Cr_2O_7^{2-}$ (b) CrO_4^{2-}
(c) $Cr(OH)_3$ (d) $Cr(OH)_2$

84. The oxidation state of chromium in the final product formed by the reaction between KI and acidified potassium dichromate solution is
(a) +3 (b) +2
(c) +6 (d) +4

85. The bonds present in the structure of dichromate ion are
(a) four equivalent Cr – O bonds only
(b) six equivalent Cr – O bonds and one O – O bond
(c) six equivalent Cr – O bonds and one Cr – Cr bond
(d) six equivalent Cr – O bonds and one Cr – O – Cr bond

86. Potassium dichromate when heated with concentrated sulphuric acid and a soluble chloride, gives brown-red vapours of
(a) CrO_3 (b) $CrCl_3$
(c) CrO_2Cl_2 (d) Cr_2O_3

87. The acidic, basic or amphoteric nature of Mn_2O_7, V_2O_5 and CrO are respectively
(a) acidic, acidic and basic
(b) basic, amphoteric and acidic
(c) acidic, amphoteric and basic
(d) acidic, basic and amphoteric

88. Which of the following oxides of Cr is amphoteric
(a) CrO_2 (b) Cr_2O_3
(c) CrO_5 (d) CrO_3

89. Which of the following is amphoteric oxide ?
$Mn_2O_7, CrO_3, Cr_2O_3, CrO, V_2O_5, V_2O_4$
(a) V_2O_5, Cr_2O_3 (b) Mn_2O_7, CrO_3
(c) CrO, V_2O_5 (d) V_2O_5, V_2O_4

90. When acidified $K_2Cr_2O_7$ solution is added to Sn^{2+} salts then Sn^{2+} changes to
(a) Sn (b) Sn^{3+}
(c) Sn^{4+} (d) Sn^{+}

91. In neutral or faintly alkaline medium, thiosulphate is quantitatively oxidized by $KMnO_4$ to
(a) SO_3^{2-} (b) SO_4^{2-}
(c) SO_2 (d) SO_5^{2-}

92. $KMnO_4$ can be prepared from K_2MnO_4 as per the reaction:

$$3MnO_4^{2-} + 2H_2O \rightleftharpoons 2MnO_4^{2-} + MnO_2 + 4OH^-$$

The reaction can go to completion by removing OH^- ions by adding.
(a) KOH (b) CO_2
(c) SO_2 (d) HCl

93. In the laboratory, manganese (II) salt is oxidised to permanganate ion in aqueous solution by
(a) hydrogen peroxide (b) conc. nitric acid
(c) peroxy disulphate (d) dichromate

94. The starting material for the manufacture of $KMnO_4$ is
(a) pyrolusite (b) manganite
(c) magnatite (d) haematite

95. An explosion take place when conc. H_2SO_4 is added to $KMnO_4$. Which of the following is formed?
(a) Mn_2O_7 (b) MnO_2
(c) $MnSO_4$ (d) M_2O_3

96. If $KMnO_4$ is reduced by oxalic acid in an acidic medium then oxidation number of Mn changes from
(a) 4 to 2 (b) 6 to 4
(c) +7 to +2 (d) 7 to 4

97. $KMnO_4$ acts as an oxidising agent in alkaline medium. When alkaline $KMnO_4$ is treated with KI, iodide ion is oxidised to _____ .
(a) I_2 (b) IO^-
(c) IO_3^- (d) IO_4^-

98. On the basis of data given below,

$E^{\ominus}_{Sc^{3+}/Sc^{2+}} = -0.37$, $E^{\ominus}_{Mn^{3+}/Mn^{2+}} = +1.57$

$E^{\ominus}_{Cr^{2+}/Cr} = -0.90$, $E^{\ominus}_{Cu^{2+}/Cu} = 0.34$

Which of the following statements is incorrect?
(a) Sc^{3+} has good stability due of $[Ar]3d^04s^0$ configuration.
(b) Mn^{3+} is more stable than Mn^{2+}.
(c) Cr^{2+} is reducing in nature.
(d) Copper does not give H_2 on reaction with dil. H_2SO_4.

99. Which of the following is most acidic?
(a) Mn_2O_7 (b) V_2O_5
(c) Fe_2O_3 (d) Cr_2O_3

100. Which of the following is the use of potassium permanganate?
(a) Bleaching of wool, cotton and silk fibers.
(b) decolourisation of oils.
(c) In analytical chemistry.
(d) All of these.

101. Which of the following is not correctly matched?

Compound of transition metal	**Use**
(a) TiO	Pigment industry
(b) MnO_2	Dry battery cell
(c) V_2O_5	Manufacture of H_2SO_4
(d) $PdCl_2$	Manufacture of polyethylene

102. A series1 metal ion , M(II) aqueous solution react with the KI to form iodine and a precipitate is formed, this M(II) can be:

(a) Zn^{2+} (b) Mn^{2+}
(c) Cu^{2+} (d) Ni^{2+}

103. Total number of inner transition elements in the periodic table is

(a) 10 (b) 14
(c) 28 (d) 30

104. 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)

105. The lanthanoide contraction is responsible for the fact that

(a) Zr and Y 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

(Atomic numbers : Zr = 40, Y = 39, Nb = 41, Hf = 72, Zn = 30)

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

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

107. 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 no. = 90 to 103) that are filling 5*f* sublevel
(c) 14 elements in the sixth period (atomic no. = 58 to 71) that are filling 4*f* sublevel
(d) 14 elements in the seventh period (atomic no. = 58 to 71) that are filling 4*f* sublevel

108. Which of the following factors may be regarded as the main cause of lanthanoide contraction?

(a) Greater shielding of 5*d* electrons by 4*f* electrons
(b) Poorer shielding of 5*d* electrons by 4*f* electrons
(c) Effective shielding of one of 4*f* electrons by another in the subshell
(d) Poor shielding of one of 4*f* electron by another in the subshell

109. Lanthanoid which has the smallest size in +3 state is

(a) Tb (b) Er
(c) Ce (d) Lu

110. Lanthanum is grouped with *f*-block elements because

(a) it has partially filled *f*-orbitals
(b) it is just before Ce in the periodic table
(c) it has both partially filled *f* and *d*-orbitals
(d) properties of lanthanum are very similar to the elements of *f*-block

111. A reduction in atomic size with increase in atomic number is a characteristic of elements of

(a) high atomic masses (b) *d*-block
(c) *f*-block (d) radioactive series

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

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

113. Identify the incorrect statement among the following:

(a) 4*f* and 5*f* orbitals are equally shielded.
(b) *d*-Block elements show irregular and erratic chemical properties among themselves.
(c) La and Lu have partially filled *d*-orbitals and no other partially filled orbitals.
(d) The chemistry of various lanthanoids is very similar.

114. In context of the lanthanoids, which of the following statements is not correct?

(a) There is a gradual decrease in the radii of the members with increasing atomic number in the series.
(b) All the members exhibit +3 oxidation state.
(c) Because of similar properties the separation of lanthanoids is not easy.
(d) Availability of 4*f* electrons results in the formation of compounds in +4 state for all the members of the series.

115. The outer electronic configuration of Gd (Atomic No. : 64) is

(a) $4f^3\ 5d^5\ 6s^2$ (b) $4f^8\ 5d^0\ 6s^2$
(c) $4f^4\ 5d^4\ 6s^2$ (d) $4f^7\ 5d^1\ 6s^2$

116. The correct order of ionic radii of Y^{3+}, La^{3+}, Eu^{3+} and Lu^{3+} is

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

(Atomic nos. Y = 39, La = 57, Eu = 63, Lu = 71)

117. Which of the following lanthanoid ions is diamagnetic ? (At nos. Ce = 58, Sm = 62, Eu = 63, Yb = 70)

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

118. Lanthanide contraction can be observed in

(a) At (b) Gd
(c) Ac (d) Lw

119. The approximate percentage of iron in mischmetal is

(a) 10 (b) 20
(c) 50 (d) 5

120. The most common lanthanide is

(a) lanthanum (b) cerium
(c) samarium (d) plutonium

121. Non-lanthanide atom is
(a) La (b) Lu
(c) Pr (d) Pm

122. In which of the following lanthanides oxidation state +2 is most stable?
(a) Ce (b) Eu
(c) Tb (d) Dy

123. Actinoides
(a) are all synthetic elements
(b) include element 104
(c) have any short lived isotopes
(d) have variable valency

124. Which of the following exhibit only + 3 oxidation state ?
(a) U (b) Th
(c) Ac (d) Pa

125. Larger number of oxidation states are exhibited by the actinoids than those by the lanthanoids, the main reason being
(a) 4*f* orbitals more diffused than the 5*f* orbitals
(b) lesser energy difference between 5*f* and 6*d* than between 4*f* and 5*d* orbitals
(c) more energy difference between 5f and 6d than between 4f and 5d orbitals
(d) more reactive nature of the actionids than the lanthanoids

126. The maximum oxidation state exhibited by actinide ions is
(a) +5 (b) +4
(c) +7 (d) +8

127. There are 14 elements in actinoid series. Which of the following elements does not belong to this series ?
(a) U (b) Np
(c) Tm (d) Fm

128. Which of the following actinoids show oxiation states upto +7 ?
(i) Am (ii) Pu
(iii) U (iv) Np
(a) (i) and (ii) (b) (ii) and (iv)
(c) (iii) and (iv) (d) (i) and (iii)

129. Which of the following lanthanoid element is steel hard in nature?
(a) Eu (b) Pm
(c) Sm (d) Ce

130. What is the percentage of lanthanoid metal in mischmetall?
(a) 90% (b) 20%
(c) 5% (d) 95%

131. Which of the following is the use of mischmetall ?
(a) In bullets
(b) In lighter flint
(c) As catalyst in petroleum cracking
(d) Both (a) and (b)

132. Which of the following actinoid element has $5f^7\ 6d^1\ 7s^2$ configuration?
(a) Bk (b) Cm
(c) Pa (d) No

133. The increasing order of the shielding of electrons by the orbitals *ns,np,nd,nf* is
(a) *ns,np,nd,nf* (b) *np,ns,nd,nf*
(c) *nd,nf,np,ns* (d) *nf,nd.np,ns*

134. Which of the following in its oxidation state shows the paramagnetism ?
(a) Tb(IV) (b) Lu(III)
(c) Ce(IV) (d) La(III)

STATEMENT TYPE QUESTIONS

135. Mark the correct statement(s).
(i) Manganese exhibits +7 oxidation state
(ii) Zinc forms coloured ions
(iii) $[CoF_6]^{3-}$ is diamagnetic
(iv) Sc forms +4 oxidation state
(v) Zn exhibits only +2 oxidation state
(a) (i) and (ii) (b) (i) and (v)
(c) (ii) and (iv) (d) (iii) and (iv)

136. Which of the following statements are correct ?
(i) The maximum oxidation state of Mn with the oxygen is +VII while with fluorine is +IV.
(ii) Fluorine is more oxidizing in nature than oxygen.
(iii) Fluorine exhibit an oxidation state of –1.
(iv) Seven fluorine cannot be accommodated around Mn.
(a) (i), (ii) and (iii)
(b) (ii), (iii) and (iv)
(c) (i) and (iv)
(d) (i), (ii), (iii) and (iv)

137. Which of the following statements are correct ?
(i) Chromium has the highest melting point among the series 1 metals.
(ii) Number of unpaired electrons is greater in Cr than other elements of series 1.
(iii) In any row the melting point of transition metal increases as the atomic number increases.
(a) (i) and (iii) (b) (i) and (ii)
(c) (ii) and (iii) (d) (i), (ii) and (iii)

138. Read the following statements?
(i) Aqueous solutions formed by all ions of Ti are colourless.
(ii) Aqueous solution of ferrous ions is green in colour.
(iii) Small size and presence of vacant *d*-orbitals make transition metal ions suitable for formation of complex compounds.
(iv) Catalytic action of transition metals involves the increase of reactant concentration at catalyst surface and weakening of the bonds in the reacting molecules.
Which of the following is the correct code for above statements?
(a) FTTT (b) TFFT
(c) TFTT (d) FFTT

139. Which of the following statements are correct?
(i) Interstitial compounds contain non-metal atoms trapped inside the metal crystal whereas alloys are homogeneous blend of metals.
(ii) Steel and bronze are alloys of transition and non-transition metals.
(iii) Some boride containing interstitial compounds are very hard comparable to that of diamond.
(iv) Interstitial compounds are chemically more reactive than parent metal.
(a) (i) and (iii) (b) (ii) and (iv)
(c) (ii) and (iii) (d) (i), (ii) and (iii)

140. Which of the following statements are correct?
(i) As a result of lanthanoid contraction members of 4*d* and 5*d* series exhibit similar radii.
(ii) IE_2 is high for Cr and Cu whereas IE_3 is very high for Zn.
(iii) Heavier members of *d*-block elements like *p*-block elements favours lower oxidation states.
(iv) In any transition series maximum number of oxidation states is shown by middle elements or elements near middle elements.
(a) (i) and (ii) (b) (i), (ii) and (iv)
(c) (i), (ii) and (iii) (d) (ii) and (iv)

141. Consider the following statements
(i) $La(OH)_3$ is the least basic among hydroxides of lanthanides.
(ii) Zr^{4+} and Hf^{4+} posses almost the same ionic radii.
(iii) Ce^{4+} can as an oxidizing agent.
Which of the above is/are true ?
(a) (i) and (iii) (b) (ii) and (iii)
(c) (ii) only (d) (i) and (ii)

142. Read the following statements.
(i) Chemistry of actinoids is complex in comparsion to chemistry of lanthanoids.
(ii) Ce^{4+} is very good reducing agent.
(iii) Eu^{2+} is a strong reducing agent.
(iv) Out of all lanthanides Ce,Pr,Nd,Dy and Ho shows +4 oxidation state.
Which of the following is the correct code for the statements above?
(a) TTFF (b) TFTF
(c) FTFT (d) FTTF

143. Read the following statements?
(i) Only Pu show maximum oxidation state of +7 in actinoids.
(ii) M^{4+} ion of Th is the only diamagnetic M^{4+} ion of actinoid series.
(iii) Electrons present in the 5f orbitals of actinides can participate in bonding to a firm greater extent as compared to electrons present in 4f orbitals of lanthanides.
(iv) Magnetic properties of actinoids are more complex than lanthanoids
Which of the following is the correct code for the statements above?
(a) FTTT (b) TFTT
(c) TFFT (d) FFTT

144. Which of the following statement(s) regarding Hf and Zr is/are correct ?
(i) Hf has greater density than Zr.
(ii) Lanthanoid contraction is responsible for such radii.
(a) Both (i) and (ii) are correct.
(b) Both (i) and (ii) are incorrect
(c) Statement (i) is correct only
(d) Statement (ii) is correct only.

MATCHING TYPE QUESTIONS

145. Match the columns

Column-I	Column -II
(A) Metal of the 3*d*-series which does not form MO type oxide.	(p) Manganese
(B) Metal of the 3*d*-series which forms most covalent oxide.	(q) Vanadium
(C) Metal of the 3*d*-series which forms the amphoteric oxide.	(r) Scandium

(a) A – (p), B – (r), C – (q)
(b) A – (r), B – (p), C – (q)
(c) A – (r), B – (q), C – (p)
(d) A – (q), B – (p), C – (r)

146. Match the columns

Column-I (Ion)	Column-II ($M_{calculated}$)
(A) Ti^{2+}	(p) 2.84
(B) Zn^{2+}	(q) 5.92
(C) Mn^{2+}	(r) 0
(D) Sc^{3+}	(s) 4.90

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

147. Match the columns

Column-I	Column-II
(A) Compound formed when yellow CrO_4^{2-} is acidified.	(p) acidified MnO_4^-
(B) reagent oxidises Fe^{2+} to Fe^{3+}	(q) $Cr_2O_7^{2-}$
(C) Compound produced when MnO_2 is fused with KNO_3	(r) K_2MnO_4
(D) Compound having dark purple crystals isostructural with $KClO_4$	(s) $KMnO_4$

(a) A – (q),B – (p), C – (r), D – (s)
(a) A – (p),B – (q), C – (r), D – (s)
(a) A – (q),B – (r), C – (p), D – (s)
(a) A – (q),B – (p), C – (s), D – (r)

148. Match the columns

Column-I	Column-II
(A) Lanthanide hard as steel.	(p) Lu
(B) Lanthanide with maximum paramagnetic character in Ln^{4+} state.	(q) Tb
(C) Lanthanide with maximum value of E° for reaction $Ln^{3+}(aq)+3e^- \rightarrow Ln(s)$.	(r) Sm
(D) Lanthanide whose Ln^{3+} ion is diamagnetic in nature	(s) Eu

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

ASSERTION-REASON TYPE QUESTIONS

Directions : Each of these questions contain two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.

(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

149. Assertion : Cuprous ion (Cu^+) has unpaired electrons while cupric ion (Cu^{++}) does not.
Reason : Cuprous ion (Cu^+) is colourless whereas cupric ion (Cu^{++}) is blue in the aqueous solution

150. Assertion : Transition metals show variable valency.
Reason : Transition metals have a large energy difference between the ns^2 and $(n-1)d$ electrons.

151. Assertion : Transition metals are good catalysts.
Reason : V_2O_5 or Pt is used in the preparation of H_2SO_4 by contact process.

152. Assertion : Magnetic moment values of actinides are lesser than the theoretically predicted values.
Reason : Actinide elements are strongly paramagnetic.

CRITICAL THINKING TYPE QUESTIONS

153. 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) $Ti^{2+}, V^{3+}, Cr^{4+}, Mn^{5+}$

154. The electronic configuration of Cu(II) is $3d^9$ whereas that of Cu(I) is $3d^{10}$. Which of the following is correct ?
(a) Cu (II) is more stable
(b) Cu (II) is less stable
(c) Cu (I) and (II) are equally stable
(d) Stability of Cu (I) and Cu (II) depends on nature of copper salts

155. Highest oxidation state of manganese in fluoride is +4 (MnF_4) but highest oxidation state in oxides is +7 (Mn_2O_7) because _____.
(a) fluorine is more electronegative than oxygen.
(b) fluorine does not possess *d*-orbitals.
(c) fluorine stabilises lower oxidation state.
(d) in covalent compounds fluorine can form single bond only while oxygen forms double bond.

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

157. The standard redox potentials for the reactions $Mn^{2+} + 2e^- \rightarrow Mn$ and $Mn^{3+} + e^- \rightarrow Mn^{2+}$ are –1.18 V and 1.51 V respectively. What is the redox potential for the reaction $Mn^{3+} + 3e^- \rightarrow Mn$?
(a) 0.33 V (b) 1.69 V
(c) –0.28 V (d) –0.85 V

158. Which one of the following transition metal ions shows magnetic moment of 5.92 BM?
(a) Mn^{2+} (b) Ti^{3+}
(c) Cr^{3+} (d) Cu^{2+}

159. In the following salts the lowest value of magnetic moment is observed in
(a) $MnSO_4.4H_2O$ (b) $CuSO_4.5H_2O$
(c) $FeSO_4.6H_2O$ (d) $ZnSO_4.7H_2O$

160. In which of the following pairs both the ions are coloured in aqueous solutions ?
(a) Sc^{3+}, Ti^{3+} (b) Sc^{3+}, Co^{2+}
(c) Ni^{2+}, Cu^{+} (d) Ni^{2+}, Ti^{3+}
(At. no. : Sc = 21, Ti = 22, Ni = 28, Cu = 29, Co = 27)

161. For the ions Zn^{2+}, Ni^{2+} and Cr^{3+} which among the following statements is correct?
(atomic number of Zn = 30, Ni = 28 and Cr = 24)
(a) All these are colourless
(b) All these are coloured
(c) Only Ni^{2+} is coloured and Zn^{2+} and Cr^{3+} are colourless
(d) Only Zn^{2+} is colourless and Ni^{2+} and Cr^{3+} are coloured

162. Cuprous ion is colourless while cupric ion is coloured because
(a) both have half filled p-and d-orbitals
(b) cuprous ion has incomplete d-orbital and cupric ion has a complete d-orbital
(c) both have unpaired electrons in the d-orbitals
(d) cuprous ion has complete d-orbital and cupric ion has an imcomplete d-orbital.

163. The colour of the following ions V^{2+}, V^{3+}, V^{4+}, Fe^{2+}, Fe^{3+} are respectively
(a) green, violet, blue, green, yellow
(b) yellow, green, violet, green, blue
(c) violet, green, yellow, green, blue
(d) yellow, green, blue, green, violet

164. Which of the following arrangements does not represent the correct order of the property stated against it ?
(a) $V^{2+} < Cr^{2+} < Mn^{2+} < Fe^{2+}$: Paramagnetic behaviour
(b) $Ni^{2+} < Co^{2+} < Fe^{2+} < Mn^{2+}$: Ionic size
(c) $Co^{3+} < Fe^{3+} < Cr^{3+} < Sc^{3+}$: Stability in aqueous solution
(d) Sc < Ti < Cr < Mn : Number of oxidation states

165. 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) $CrSO_4$

166. 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.

167. Which one of the following is an amphoteric oxide ?
(i) Mn_2O_7 (ii) CrO
(iii) V_2O_4 (iv) Cr_2O_3
(a) (i) and (ii) (b) (ii), (iii) and (iv)
(c) (iii) and (iv) (d) (ii) and (iv)

168. Among the oxides, Mn_2O_7 (I), V_2O_3 (II), V_2O_5 (III), CrO (IV) and Cr_2O_3 (V) the basic oxides are
(a) I and II (b) II and III
(c) III and IV (d) II and IV

169. When a small amount of $KMnO_4$ is added to concentrated H_2SO_4, a green oily compound is obtained which is highly explosive in nature. Compound may be
(a) $MnSO_4$ (b) Mn_2O_7
(c) MnO_2 (d) Mn_2O_3

170. Identify the product and its colour when MnO_2 is fused with solid KOH in the presence of O_2.
(a) $KMnO_4$, purple (b) K_2MnO_4, dark green
(c) MnO, colourless (d) Mn_2O_3, brown

171. When $KMnO_4$ solution is added to oxalic acid solution, the decolourisation is slow in the beginning but becomes instantaneous after some time because
(a) CO_2 is formed as the product.
(b) reaction is exothermic.
(c) MnO_4^- catalyses the reaction.
(d) Mn^{2+} acts as autocatalyst.

172. Which of the following oxidising reaction of $KMnO_4$ occurs in acidic medium?
(i) Fe^{2+} (green) is converted to Fe^{3+} (yellow).
(ii) Iodide is converted to iodate.
(iii) Thiosulphate oxidised to sulphate.
(iv) Nitrite is oxidised to nitrate.
(a) (i) and (iii) (b) (i) and (iv)
(c) (iv) only (d) (ii) and (iv)

173. Arrange the following increasing order of acidic character? Mn_2O_7(A), Mn_2O_3(B), MnO(C)?
(a) C, A, B (b) A, C, B
(c) B, A, C (d) C, B, A

174. Solution of oxalate is colourless. It is made acidic by adding excess of H^+, then titrated with $KMnO_4$. Now at a moment if someone has added large amount of $KMnO_4$, in it then no. of possible products are
(a) CO_2, Mn^{2+}, H_2O (b) CO_2, MnO_2, H_2O
(c) MnO_2, H_2O, CO_2 (d) CO_2, MnO_2, H_2O, Mn^{2+}

175. Knowing that the chemistry of lanthanoids(Ln) is dominated by its + 3 oxidation state, which of the following statements is incorrect?
(a) The ionic size of Ln (III) decrease in general with increasing atomic number
(b) Ln (III) compounds are generally colourless.
(c) Ln (III) hydroxide are mainly basic in character.
(d) Because of the large size of the Ln (III) ions the bonding in its compounds is predominantly ionic in character.

176. The +3 ion of which one of the following has half filled 4f subshell?
(a) La (b) Lu
(c) Gd (d) Ac

177. Although + 3 is the characteristic oxidation state for lanthanoids but cerium also shows + 4 oxidation state because _____ .
(i) it has variable ionisation enthalpy
(ii) it has a tendency to attain noble gas configuration
(iii) it has a tendency to attain f^0 configuration
(iv) it resembles Pb^{4+}
(a) (ii) and (iii) (b) (i) and (iv)
(c) (ii) and (iv) (d) (i), (ii) and (iii)

178. Dichromate [Cr(VI)] is a strong oxidizing agent whereas Mo(VI) and W(VI) are found to be not. This is due to
(a) Lanthanoid contraction
(b) Down the group metallic character increases
(c) Down the group metallic character decreases
(d) Both (a) and (b)

179. Which of the following conversions can be carried out by both acidified $K_2Cr_2O_4$ and acidified $KMnO_4$?
(i) $Fe^{2+} \rightarrow Fe^{3+} + e^-$ (ii) $I^- \rightarrow$
(iii) $I^- \rightarrow I_2$ (iv) $H_2S \rightarrow S$
(a) (i) and (iii) (b) (ii) and (iv)
(c) (i), (iii) and (iv) (d) (i), (ii) and (iii)

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

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

2. (b) $Cr(24) = 1s^2, 2s^2\ 2p^6, 3s^2\ 3p^6, 3d^5, 4s^1,$

3. (b) Configuration of Fe ($Z = 26$)
$1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^6, 4s^2$

4. (d) Ni^{3+} : [Ar] $3d^7$

Mn^{3+} : [Ar] $3d^4$

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

Co^{3+} : [Ar] $3d^6$

5. (c) Ag belongs to second transition series.

6. (c) **7. (a)**

8. (d) Transition elements due to similar (almost) sizes exhibit both vertical and horizontal similarities.

9. (a) Group number is given by $[ns + (n-1)d]$ electrons.

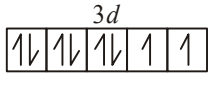
$\therefore [2+3] = 5$

10. (a) 3d series starts from $Sc(Z-21)$ and ends with Zn(Z–30).

11. (d) Since transition metals can lose electrons from $(n-1)d$ ns orbitals hence they are valence orbitals.

12. (b) Atomic no. of Ni = 28
Ni (Ground state) = $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^8, 4s^2,$

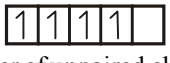
$Ni^{2+} = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^8, 4s^0$



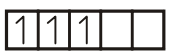
$\therefore$ It has 2 unpaired electrons

13. (c) Cerium (Ce) belongs to lanthanide series and is member of inner-transition metals.

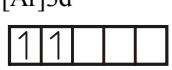
14. (c) $Mn^{3+} = [Ar]3d^4$

= [Ar] 

Number of unpaired electrons = 4
$Cr^{3+} = [Ar]3d^3$

= [Ar] 

No. of unpaired electrons = 3
$V^{3+} = [Ar]3d^2$

= [Ar] 

No. of unpaired electrons = 2

15. (a)

16. (b) $Zn^+[Ar]3d^{10}4s^1, Fe^{2+}[Ar]3d^6 4s^0, Ni^+[Ar]3d^8 4s^1$

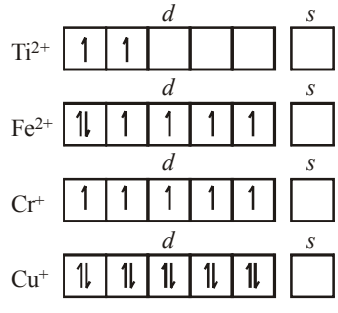
$Cu^+[Ar]3d^{10}4s^0;$

Fe^{2+} contain maximum number of unpaired electrons.

17. (a) $Ni(28)$ $Ni[Ar]3d^8 4s^2$ contain 2 unpaired electrons.

18. (c) Zn, Cd, Hg do not show properties of transition elements hence they are known as non typical transition elements.

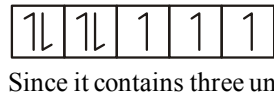
19. (c) The outer electronic configuration of the given ions is as



20. (c) **21. (a)**

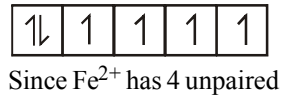
22. (a) $Mn^{7+} = 25 - 7 = 18e^- = [Ar]$
$\therefore$ 0 unpaired electrons.

23. (b) $Co \rightarrow [Ar]3d^7 4s^2$



Since it contains three unpaired electrons. Hence it is paramagnetic.

24. (a) The outermost electronic configuration of Fe is
$Fe = [Ar]\ 3d^6\ 4s^2$
$Fe^{2+} = [Ar]\ 3d^6\ 4s^0$



Since Fe^{2+} has 4 unpaired electrons it is paramagnetic in nature.
$Zn = [Ar]\ 3d^{10}\ 4s^2$ —— no unpaired e^-
$Hg^{2+} = [Ar]\ 4f^{14}\ 5d^{10}$ —— no unpaired e^-
$Ti^{4+} = [Ar]\ 3d^0\ 4s^0$ —— no unpaired e^-

25. (c) Due to d^5 configuration, Mn has exactly half filled d-orbitals. As a result the electronic configuration is stable means $3d$ electrons are more tightly held by the nucleus and this reduces the delocalization of electrons resulting in weaker metallic bonding.

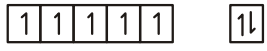
26. (d) All statements are correct.

27. (d) The minimum oxidation state in transition metal is equal to the number of electrons in 4*s* shell and the maximum oxidation state is equal to the sum of the 4*s* and 3*d* electrons.

Ti = [Ar] $3d^2 4s^2$

Hence minimum oxidation state is +2 and maximum oxidation state is +4. Thus the common oxidation states of Ti are +2, +3 and +4

28. (a) Os shows maximum oxidation state of +8.

29. (b) Mn - $3d^5\ 4s^2$ 

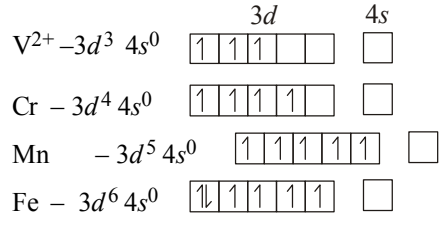
The no. of various oxidation states possible are + 2, + 3, + 4, + 5, + 6 and + 7.

30. (c) Due to lanthanide contraction, the size of Zr and Hf (atom and ions) become nearly similar.

31. (a)

32. (d) Fe^{3+} is easily hydrolysed than Fe^{2+} due to more positive charge.

33. (c) Electronic configuration



For third ionization enthalpy Mn has stable configuration due to half filled d-orbital.

34. (d) $(n-1)d^5ns^2$ attains the maximum O.S. of + 7.

35. (a) The ionisation energies increase with increase in atomic number. However, the trend is some irregular among *d*-block elements. On the basis of electronic configuration, the

Zn : $1s^2 2s^2 p^6 3s^2 p^6 d^{10} 4s^2$

Fe : $1s^2 2s^2 p^6 3s^2 p^6 d^6 4s^2$

Cu : $1s^2 2s^2 p^6 3s^2 p^6 d^{10} 4s^1$

Cr : $1s^2 2s^2 p^6 3s^2 p^6 d^5 4s^1$

IE_1 follows the order : Zn > Fe > Cu > Cr

36. (a) In a period on moving from left to right, ionic radii decreases.

(a) So order of cationic radii is $Cr^{2+} > Mn^{2+} > Fe^{2+} > Ni^{2+}$ and

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

(c) For unpaired electrons

Mn^{2+} (Five) > Ni^{2+} (Two)

< Co^{2+} (Three) < Fe^{2+} (Four)

(d) For unpaired electrons >

Fe^{2+} (Four) > Co^{2+} (Three) >

Ni^{2+} (Two) > Cu^{2+} (One)

37. (b) $_{30}Zn$ and $_{80}Hg$ have their d orbitals completely filled so they do not show any variable valency.

38. (a) Highest O.S. by Mn (+7)

39. (c) Zinc does not show variable oxidation state due to completely filled d-orbitals.

40. (d) Sc does not show variable valency.

41. (b) **42. (d)**

43. (b) Transition metals are generally paramagnetic since they contain unpaired electrons.

44. (b) Since reduction potential of fluorine is highest transition metals exhibit highest oxidation state with fluorine.

45. (a) Zn, Cd and Hg due to presence of completely filled *d*-orbitals in ground state as well as in their common oxidation states are not regarded as a transition metals but they are studied along with the transition metals.

46. (a) The +7 oxidation state of Mn is not represented in simple halides but MnO_3F is known

47. (d) Transition metals exhibit variable valency

48. (b) In transition metals *d* electrons also take part in bonding, so they show variable oxidation states.

49. (d) For chromium ion + 3 oxidation state is most stable.

50. (c) The melting points of the transition element first rise to a maximum and then fall as the atomic number increases manganese have abnormally low melting point.

51. (a) They may or may not be diamagnetic

52. (a) Mn^{++} –5 unpaired electrons

Fe^{++} – 4 unpaired electrons

Ti^{++} – 2 unpaired electrons

Cr^{++} – 4 unpaired electrons

Hence maximum no. of unpaired electron is present in Mn^{++}.

Magnetic moment $\propto$ number of unpaired electrons

53. (d) $E^\circ_{Cr^{3+}/Cr^{2+}} = -0.41\ V$ $E^\circ_{Fe^{3+}/Fe^{2+}} = +0.77\ V$

$E^\circ_{Mn^{3+}/Mn^{2+}} = +1.57\ V$, $E^\circ_{Co^{3+}/Co^{2+}} = +1.97\ V$

54. (d) Since Mn^{2+} contains maximum number of unparied electrons hence it has maximum magnetic moment

55. (d) Magetic moment $\mu = \sqrt{n(n+2)}$ where n = number of unpaired electrons $\sqrt{15} = \sqrt{n(n+2)}$ $\therefore$ n = 3

56. (c) Magnetic moment $\mu = \sqrt{n(n+2)}$BM

$1.73 = \sqrt{n(n+2)}$ $\therefore n = 1$, it has one unpaired electron hence electronic configuration is $[Ar]3d^1$ and electronic configuration for Z = 22 is $[Ar]3d^2 4s^2$. Hence charge on Ti is +3

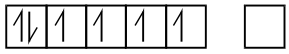
57. (b) The more the number of unpaired electrons, the more is magnetic moment. Therefore the answer is (b).

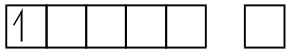
58. (a)

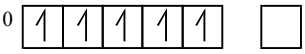
59. (d) $Fe^{3+}(d^5)$ has 5 unpaired electrons therefore magnetic moment $= \sqrt{n(n+2)} = \sqrt{5(5+2)} = 5.91$ which is maximum among given options. As Sc^{3+}, Ti^{3+}, Cr^{3+}, V^{3+} contains 0, 1, 3, and 2 number of unpaired electrons respectively.

60. (b) **61. (b)**

62. (a) $Sc^{3+} \rightarrow 3d^0 4s^0$ 

$Fe^{2+} \rightarrow 3d^6\ 4s^0$ 

$Ti^{3+} \rightarrow 3d^1 4s^0$ 

$Mn^{2+} \rightarrow 3d^5\ 4s^0$ 

In Sc^{3+} there is/are no unpaired electrons. So the aqueous solution of Sc^{3+} will be colourless.

63. (a) Transition elements form coloured ions due to *d-d* transitions. In the presence of ligands, there is splitting of energy levels of *d*-orbitals. They no longer remain degenerated. So, electronic transition may occur between two *d*-orbitals. The required amount of energy to do this is obtained by absorption of light of a particular wavelength in the region of visible light.

64. (c) The transition metals and their compounds are used as catalysts. Because of the variable oxidation states they may form intermediate compound with one of the readtants. These intermediate provides a new path with lowe activation energy. $V_2O_5 + SO_2 \rightarrow V_2O_4 + SO_3$

$2V_2O_4 + O_2 \rightarrow 2V_2O_5$

65. (d) Since Sc^{3+} does not contain any unpaired electron it is colourless in water.

66. (b) $Cu^{2+}[Ar]3d^9$, $Ti^{4+}[Ar]3d^0$, $Co^{2+}[Ar]3d^7$, $Fe^{2+}[Ar]3d^6$

1, 3, 4 are coloured ions hence the answer is b.

67. (a) In interstitial compounds small atoms like H, B and C enter into the void sites between the packed atoms of crystalline metal. They retain metallic conductivity and are chemically inert.

68. (d) A covalent bond is formed between small interstial non-metal and transition metal which make it hard

69. (c) If non metal is added to the interstital site the metal becomes less malleable due to formation of covalent bond between metal and non metal

70. (c) Gun metal is an alloy of Cu, Zn and Sn. It contains 88% Cu, 10% Sn and 2% Zn.

71. (b) Brass is an alloy of Cu and Zn

72. (b) Cu, Ag and Au are called coinage metals.

73. (b) Bronze is an alloy of Cu and Sn.

74. (b) Bronze - 10% Sn, 90% Cu
(Sn is a non transition element)

75. (b) $\overset{+4}{V}O^{2+} \simeq \overset{+4}{Ti}O^{2+} < \overset{+5}{V}O_2^{+} < \overset{+6}{Cr}O_4^{2-}$

76. (b)

77. (d) Ti^{4+} $(3d^0)$ and Zn^{2+} $(3d^{10})$ are colourless.

78. (d)

79. (b) $2Fe^{3+} + 2I^- \longrightarrow 2Fe^{2+} + I_2$

$2Fe^{2+} + S_2O_8^{2-} \longrightarrow 2Fe^{3+} + 2SO_4^{2-}$

80. (a)

81. (b)

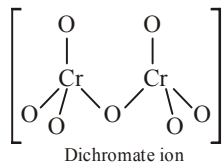
82. (a) $Cr_2O_7^{2-} + 2OH^- \longrightarrow 2CrO_4^{2-} + H_2O$

Hence CrO_4^{2-} ion is obtained.

83. (b) $CrO_3 + 2NaOH \rightarrow Na_2CrO_4 + H_2O$

84. (a) $Cr_2O_7^{2-} + 6I^- + 14H^+ \longrightarrow 3I_2 + 7H_2O + 2Cr^{3+}$

oxidation state of Cr is +3.

85. (d) 

Dichromate ion

There are six equivalent Cr — O bonds and one Cr — O — Cr bond.

86. (c) Solid potassium dichromate when heated with concentrated sulphuric acid and a soluble chloride gives orange red vapours of a volatile oily liquid CrO_2Cl_2

$K_2Cr_2O_7 + 4NaCl + 6H_2SO_4 \longrightarrow 2KHSO_4 + 4NaHSO_4 + 2CrO_2Cl_2$
chromyl chloride

87. (c) Mn_2O_7 is acidic, V_2O_5 is amphoteric acid and CrO is basic.

88. (a) CrO_2 is amphoteric in nature

89. (a) **90. (c)**

91. (b) In neutral or faintly alkaline medium thiosulphate is quantitatively oxidized by $KMnO_4$ to SO_4^{2-}

$8KMnO_4 + 3Na_2S_2O_3 + H_2O \longrightarrow 3K_2SO_4 + 8MnO_2 + 3Na_2SO_4 + 2KOH$

92. (b) HCl and SO_2 are reducing agents and can reduce MnO_4^-. CO_2 which is neither oxidising and nor reducing will provide only acidic medium. It can shift reaction in forward direction and reaction can go to completion.

93. (c) In laboratory, manganese (II) ion salt is oxidised to permagnate ion in aqueous solution by peroxodisulphate.

$2Mn^{2+} + S_2O_8^{2-} + 8H_2O \rightarrow 2MnO_4^- + 10SO_4^{2-} + 16H^+$
peroxodisulphate ion

94. (a) Pyrolusite (It is MnO_2)

95. (a) $2KMnO_4 + H_2SO_4\,(Conc) \longrightarrow K_2SO_4 + Mn_2O_7 + H_2O$
Explosive

96. (c) In acid medium $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

(O.S. of Mn changes form +7 to +2)

97. (c)

98. (b) Mn^{2+} (d^5)is more stable than Mn^{3+} (d^4), thus

$E^{-}_{Mn^{3+}/Mn^{2+}} = +ve$

99. (a) As the oxidation state of metal associated with oxygen increases, the acidic character of oxide increases.

100. (d)

101. (d) $PdCl_2$ is used as a catalyst in Wacker's process.

102. (c) Only Cu in its +2 oxidation state is able to oxidizes the I^- to I_2

103. (c) The number is 28(14 lanthanide +14 Actinides)

104. (b) La^{3+} : 54 e^- = [Xe]

Ti^{3+} : 19 e^- = [Ar] 3 d^1 (Coloured)

Lu^{3+} : 68 e^- = [Xe] 4 f^{14}

Sc^{3+} : 18 e^- = [Ar]

105. (c) A regular decrease in the size of the atoms and ions in lanthanoid series from La^{3+} to Lu^{3+} is called lanthanide contraction. The similarity in size of the atoms of Zr and Hf is due to the lanthanide contraction.

106. (d) We know that lanthanides La, Gd shows +3, oxidation state, while Eu shows oxidation state of +2 and + 3. Am shows +3, +4, +5 and +6 oxidation states. Therefore Americium (Am) has maximum number of oxidation states.

107. (c) Lanthanides are 4*f*-series elements starting from cerium (Z= 58) to lutetium (Z = 71). These are placed in the sixth period and in third group.

108. (b) In lanthanides, there is poorer shielding of 5*d* electrons by 4*f* electrons resulting in greater attraction of the nucleus over 5*d* electrons and contraction of the atomic radii.

109. (d) On going from left to right in lanthanoid series ionic, size decreases i.e.
$Ce^{+3} > Tb^{+3} > Er^{+3} > Lu^{+3}$.

110. (d)

111. (c) Lanthanide contraction results into decrease in atomic and ionic radii.

112. (a)

113. (a) 4*f* orbital is nearer to nucleus as compared to 5*f* orbital therefore, shielding of 4*f* is more than 5*f*.

114. (d)

115. (d) The configuration of Gd is [xe] $4f^7\ 5d^1\ 6s^2$.

116. (c) In lanthanide series there is a regular decrease in the atomic as well as ionic radii of trivalent ions (M^{3+}) as the atomic number increases. Although the atomic radii do show some irregularities but ionic radii decreases from La(103 pm) to Lu (86pm). Y^{3+} belong to second transition series there fore have greater ionic radii then other ions of third transition series.

117. (c) $Sm^{2+}(Z=62)$
$[Xe]4f^6\ 6s^2$ – 6 unpaired e^-
$Eu^{2+}(Z=63)$
$[Xe]4f^7\ 6s^2$ – 7 unpaired e^-
$Yb^{2+}(Z=70)$
$[Xe]4f^{14}\ 6s^2$ – 0 unpaired e^-
$Ce^{2+}(Z=58)$
$[Xe]4f^1\ 5d^1\ 6s^2$ – 2 unpaired e^-
Only Yb^{2+} is diamagnetic.

118. (b) Amongst the given elements, only Gd is a lanthanide .

119. (d) Mischmetal is an alloy which contains rare earth elements (94-95%), iron (5%) and traces of sulphur, carbon, silicon, calcium and aluminium. It is used in gas lighters, tracer bullets and shells.

120. (b) Cerium is the most common lanthanide

121. (a) La (lanthanum) is non lanthanide atom

122. (b) Eu^{2+} has electronic configuration $[Xe]4f^7$ hence stable due to half filled atomic orbitals.

123. (d) Actinides have variable valency due to very small difference in energies of 5*f*, 6*d* and 7*s* orbitals. Actinides are the elements from atomic number 89 to 103.

124. (c) Ac (89) = [Rn] [$6d^1$] [$7s^2$]

125. (b) The main reason for exhibiting larger number of oxidation states by actinoids as compared to lanthanoids is lesser energy difference between 5*f* and 6*d* orbitals as compared to that between 4*f* and 5*d* orbitals.
In case of actinoids we can remove electrons from 5*f* as well as from *d* and due to this actinoids exhibit larger number of oxidation state than lanthanoids.

126. (c) Actinoids exhibit variable oxidation states, which vary from +3 to +7.

127. (c) **128. (b)** **129. (c)**

130. (d) Mischmetall consists of a lanthanoid metal (~95%) and iron (~ 5%) and traces of S,C,Ca and Al.

131. (d)

132. (b) Curium (Cm) has configuration $5f^7\ 6d^1\ 7s^2$.

133. (d)

134. (a) $Tb^{4+} = 4f^7$ — 3 unpaired e^-
$Lu^{3+} = 4f^{14}$ — 0 unpaired e^-
$Ce^{4+} = 4f^0$ — 0 unpaired e^-
$La^{3+} = 4f^0$ — 0 unpaired e^-

STATEMENT TYPE QUESTIONS

135. (b) (i) Outer electronic configuration of Mn is $3d^5 4s^2$ and hence exhibits +7 oxidation state.
(ii) Zinc does not form coloured ions as it has completely filled $3d^{10}4s^7$ configuration.
(iii) In $[CoF_6]^{3-}$, Co^{3+} is a d^7 system. Fluoride is a weak field ligand and hence does not cause pairing of electrons.

Co^{3+} | ↑↓ | ↑↓ | ↑ | ↑ | ↑ |; Paramagnetic

(iv) Sc can form a maximum of +3 oxidation state as it has an outer electronic configuration of $3d^1 4s^2$.
(v) Zn exhibits only +2 oxidation state as this O.S. is the most stable one.

136. (d)

137. (b) In any row the melting points of transition metals rise to a maximum at d^5 except for anomalous values of Mn and Tc and falls regularly as the atomic number increases.

138. (a) Aqueous solution formed by Ti^{3+} ions has purple colour.

139. (a) Steel is an alloy of Fe and C (non-metal). Interstitial compounds are chemically inert.

140. (b) Heavier members of *d*-block elements unlike *p*-block elements shows higher oxidation states. For example W(VI) is more stable than Cr(VI).

141. (b) As a result of lanthanide contraction Zr^{4+} and Hf^{4+} possess almost the same ionic radii. Ce^{4+} is an oxidising agent. Ce^{4+} gains electron to acquire more stable Ce^{3+}state. $La(OH)_3$ is the most basic among lanthanide hydroxides.

142. (b) Ce^{4+} is a strong oxidant reverting to the common +3 state.
Ho does not show oxidation state of +4. Lanthanoids showing +4 oxidation state are Ce, Pr, Nd, Dy and Tb.

143. (a) Both Np and Pu shows oxidation state of +7.

144. (a) Atomic mass of Hf is greater than that of Zr, Hf is a series 3 metal, so for almost similar radius Hf has greater density, Lanthanoid contraction is responsible for almost similar radii.

MATCHING TYPE QUESTIONS

145. (b) **146. (c)** **147. (a)** **148. (d)**

ASSERTION-REASON TYPE QUESTIONS

149. (d)

150. (c) The assertion is correct but the reason is false. Actually transition metal show variable valency due to very small difference between the ns^2 and $(n-1)d$ electrons.

151. (b) Due to larger surface area and variable valencies to form intermediate absorbed complex easily, transition metals are used as catalysts.

152. (b) The magnetic moments are lesser than the fact that 5*f* electrons of actinides are less effectively shielded which results in quenching of orbital contribution.

CRITICAL THINKING TYPE QUESTIONS

153. (d) The electronic configuration of different species given in the question are

(a) $_{22}Ti^{3+} : 1s^2 2s^2 p^6 3s^2 p^6 d^1$

(b) $_{22}Ti^{+} : 1s^2 2s^2 p^6 3s^2 .p^6 d^2 4s^1$

(c) $_{22}Ti^{4+} : 1s^2 2s^2 p^6 3s^2 p^6$

(d) $_{22}Ti^{2+} : 1s^2 2s^2 p^6 3s^2 p^6 d^2$

Thus options (a) and (c) are discarded; now let us observe the second point of difference.

$_{23}V^{4+} : 1s^2 2s^2 p^6 3s^2 p^6 d^1$

Thus option (b) is discarded

$_{23}V^{3+} : 1s^2 2s^2 p^6 3s^2 p^6 d^2$

$_{24}Cr^{4+} : 1s^2 2s^2 p^6 3s^2 p^6 d^2$

$_{25}Mn^{5+} : 1s^2 2s^2 p^6 3s^2 p^6 d^2$

154. (a) **155. (d)**

156. (c) $E^o_{Cu^{+2}/Cu} = 0.34\,V$

other has – ve $E^o_{R.P.}$

$E^o_{Co^{++}/Co} = -0.28\,V$

$E^o_{Ni^{++}/Ni} = -0.25V$

$E^o_{Fe^{++}/Fe} = -0.44V$

157. (c)

	E°	nE°
$Mn^{2+} + 2e^- \rightarrow Mn$	–1.18	–2.36 V
$Mn^{3+} + e^- \rightarrow Mn^{2+}$	1.51	1.51 V
$Mn^{3+} + 3e^- \rightarrow Mn$	–0.28	–0.85 V

158. (a) Given magnetic moment of transition metal

$= \sqrt{n(n+2)} = 5.92$

i.e., $n = 5$

Number of unpaired electrons in $Mn^{2+} = 5$
Number of unpaired electrons in $Ti^{3+} = 1$
Number of unpaired electrons in $Cr^{3+} = 3$
Number of unpaired electrons in $Cu^{2+} = 1$
Number of unpaired electrons in $Co^{2+} = 3$
Thus Mn^{2+} have magnetic moment = 5.92 BM

159. (a) $Mn^{++} = 3d^5$ i.e. no. of unpaired $e^- = 5$
$Cu^{++} = 3d^9$ i.e. no. of unpaired $e^- = 1$
$Fe^{++} = 3d^6$ i.e. no. of unpaired $e^- = 4$
$Zn^{++} = 3d^{10}$ i.e. no. of unpaired $e^- = 0$
$Ni^{++} = 3d^8$ i.e. no. of unpaired $e^- = 3$
Higher the number of unpaired electrons higher will be the magnetic moment. Hence Mn^{++} having maximum unpaired electrons will have the maximum magnetic moment.

160. (d) Sc^{3+} : $1s^2, 2s^2p^6, 3s^2p^6d^0, 4s^0$; no unpaired electron.
Cu^{+} : $1s^2, 2s^2p^6, 3s^2p^6d^{10}, 4s^0$; no unpaired electron.
Ni^{2+}: $1s^2, 2s^2p^6, 3s^2p^6d^8, 4s^0$;
unpaired electrons are present.
Ti^{3+} : $1s^2, 2s^2p^6, 3s^2p^6d^1, 4s^0$;
unpaired electron is present
Co^{2+} : $1s^2, 2s^2p^6, 3s^2p^6d^7, 4s^0$;
unpaired electrons are present
So from the given options the only correct combination is Ni^{2+} and Ti^{3+}.

161. (d) The ions with unpaired electrons are colourled and those with paired electrons are colourless.

Zn^{2+} (No. of e^-s = 28) = $1s^2, 2s^2p^6, 3s^2p^6d^{10}$

Cr^{3+} (No. of e^-s = 21) = $1s^2, 2s^2p^6, 3s^2p^6d^3$

Ni^{2+} (No. of e^-s = 26) = $1s^2, 2s^2p^6, 3s^2p^6d^8$

Thus Zn^{2+}, Cr^{3+} and Ni^{2+} have zero, 3 and 2 unpaired electrons respectively.

162. (d) In $Cu^+[Ar]3d^{10}$ there is no unpaired electron, $Cu^{2+}[Ar]3d^9$ contains one unpaired electron hence coloured.

163. (d) V^{2+} – violet, V^{3+} – green V^{4+} – blue
Fe^{2+} – green Fe^{3+} – yellow

164. (a)

(a) $V = 3d^3 4s^2$; $V^{2+} = 3d^3 = 3$ unpaired electrons
$Cr = 3d^5 4s^1$; $Cr^{2+} = 3d^4 = 4$ unpaired electrons
$Mn = 3d^5 4s^2$; $Mn^{2+} = 3d^5 = 5$ unpaired electrons
$Fe = 3d^6 4s^2$; $Fe^{2+} = 3d^6 = 4$ unpaired electrons
Hence the correct order of paramagnetic behaviour
$V^{2+} < Cr^{2+} = Fe^{2+} < Mn^{2+}$

(b) For the same oxidation state, the ionic radii generally decreases as the atomic number increases in a particular transition series. hence the order is
$Mn^{++} > Fe^{++} > Co^{++} > Ni^{++}$

(c) In solution, the stability of the compound depends upon electrode potentials, SEP of the transitions metal ions are given as
$Co^{3+}/Co = +1.97$, $Fe^{3+}/Fe = +0.77$;
$Cr^{3+}/Cr^{2+} = -0.41$, Sc^{3+} is highly stable as it does not show + 2 O. S.

(d) Sc – (+2), (+3)
Ti – (+2), (+3), (+4)
Cr – (+1), (+2), (+3), (+4), (+5), (+6)
Mn – (+2), (+3), (+4), (+5), (+6), (+7)
i.e. Sc < Ti < Cr = Mn

165. (a) The green colour appears due to the formation of Cr^{+++}ion

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

166. (b) $Na_2Cr_2O_7$ is hygroscopic.

167. (c) $Mn_2O_7 \rightarrow$ acidic
$CrO \rightarrow$ basic
$V_2O_4 \rightarrow$ amphoteric
$Cr_2O_3 \rightarrow$ amphoteric

168. (d) Oxide Mn_2O_7 : Oxidation state of metal + 7
Oxide V_2O_3 : Oxidation state of metal + 3
Oxide V_2O_5 : Oxidation state of metal + 5
Oxide CrO : Oxidation state of metal + 2
Oxide Cr_2O_3 : Oxidation state of metal + 5

169. (b) $KMnO_4$ reacts with H_2SO_4 to form Mn_2O_7 which is highly explosive substance.

$$2KMnO_4 + H_2SO_4 \longrightarrow K_2SO_4 + Mn_2O_7 + H_2O$$

170. (b) $2MnO_2 + 4KOH + O_2 \longrightarrow \underset{\text{dark green}}{2K_2MnO_4} + 2H_2O$

171. (d)

172. (b) $5Fe^{2+} + MnO_4^- + 8H^+ \longrightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$

$$5NO_2^- + 2MnO_4^- + 6H^+ \longrightarrow 2Mn^{2+} + 5NO_3^- + 3H_2O$$

173. (d) As the oxidation state increases the acidity increases.

174. (d) If $KMnO_4$ was added slowly than option a was correct, but at a moment due to addition of large amount of $KMnO_4$, reduction of whole $KMnO_4$ added does not take place, it also react with Mn^{2+} which had formed in the solution to give MnO_2.

$$2MnO_4 + 3Mn^{2+} + 2H_2O \longrightarrow 5MnO_2 + 4H^+$$

175. (b) Most of the Ln^{3+} compounds except La^{3+} and Lu^{3+} are coloured due to the presence of *f*-electrons.

176. (c) **177. (a)**

178. (b) Down the group metallic character increases hence tendency to loose electron increases.

179. (c) I^- is converted to IO_3^- by neutral or faintly alkaline MnO_4^- as shown below.

$$2MnO_4^- + H_2O + I^- \longrightarrow 2MnO_2 + 2OH^- + IO_3^-$$