23
Chapter

THE d- AND f-BLOCK ELEMENTS

A SINGLE CORRECT CHOICE TYPE

Each of these questions has 4 choices (a), (b), (c) and (d) for its answer, out of which ONLY ONE is correct.

1. The transition elements are *not* characterised by
(a) tendency to form complexes
(b) ability to have several oxidation states
(c) greater reactivity from left to right in a period
(d) tendency to form coloured compounds

2. The paramagnetism of transition element compounds is due to
(a) paired eletrons spining in opposite directions
(b) unpaired eletrons in *d* and *f*-orbitals
(c) shared valance electrons
(d) unpaired electrons in *s* or *p*-orbitals.

3. A property common to all transition metals is that each of them
(a) is found in many different oxidation states
(b) produces coloured compounds
(c) has a high electronagativity
(d) exhibits one oxidation state equal to the group number

4. Which dissolve in both acidic and basic solutions?
(a) $Ni(OH)_2$ (b) MgO
(c) ZnO (d) Fe_2O_3

5. Which ion is not coloured?
(a) $Ni(DMG)_2$ (b) $[Co(SCN)_4]^{2-}$
(c) $[Fe(H_2O)_5SCN]^{2+}$ (d) $[Al(OH)_4]^-$

6. The number of *d*-electrons in Fe^{2+} is not equal to that of
(a) *p*-electrons in neon (b) *s*-electrons in Mg
(c) *d*-electrons in Fe (d) *p*-electrons in Cl^- ion

7. Zr and Hf have almost equal atomic and ionic radii because
(a) of actinide contraction
(b) of diagonal relationship
(c) of lanthanide contraction
(d) both belong to same transition series

8. The most stable oxidation state of +3 is shown by
(a) Mn (b) Co
(c) Ni (d) Fe

9. Of the following elements which is *not* expected to display an oxidation state of +6 in any of its compounds?
(a) Ti (b) Cr
(c) Mn (d) W

10. The dicharomate ion is in equlibrium with chromate ion in aqueous solution as :

$$Cr_2O^{2-}_{7(aq)} + H_2O \rightleftharpoons 2CrO^{2-}_{4(aq)} + 2H^+_{(aq)}$$

The oxoanion has
(a) same oxidizing property in acidic and alkaline solutions
(b) better oxidizing property in acidic solution
(c) better oxidizing property in alkaline solution
(d) no oxidizing property in acidic or alkaline solution

11. The electronic configuration of the element whgich is just above the element with atomic number 42 in the same periodic group is
(a) (Ar) $3d^4 4s^2$ (b) (Ar) $3d^3 4s^1$
(c) (Ar) $3d^5 4s^1$ (d) (Ar) $3s^{10} 4s^1$

12. Which of the following compounds is expected to be coloured?
(a) Ag_2SO_4 (b) Cu_2Cl_2
(c) MgF_2 (d) CuF_2

13. The yellow colour of chromates changes to orange on acidification due to the formation of
(a) CrO_2 (b) Cr_2O_3
(c) $Cr_2O_7{}^{2-}$ (d) $CrO^{2-}{}_4$

MARK YOUR RESPONSE	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ
	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ
	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13 ⓐⓑⓒⓓ		

14. The ability of transition elements to form coordination compounds is attributed to

(a) small size of the atom or ion
(b) high effective nuclear charge
(c) presence of vacant orbitals to accept lone pair of electrons from ligands
(d) all

15. $CrO_4^{2-} \xrightarrow{pH = x} CrO_7^{2-} \xrightarrow{pH = y} CrO_4^{2-}$. x and y can be

(a) 3 and 5 (b) 3 and 8
(c) 8 and 3 (d) 8 and 11

16. When $K_2Cr_2O_7$ is heated with concentrated H_2SO_4 and soluble chloride such as KCl

(a) Cl^- ion is oxidised to Cl_2 gas
(b) $C_2O_7^{2-}$ ion is reduced to green Cr^{3+} ion
(c) red vapour of CrO_2Cl_2 is evolved
(d) $CrCl_3$ is formed

17. When a salt X is added to the alkaline solution of red vapour obtained in the above question, brick red precipitate is formed. The precipitate is

(a) $BaCrO_4$ (b) $PbCrO_4$
(c) Ag_2CrO_4 (d) $CaCrO_4$

18. Which of the following reactions will not produce chlorine gas

(a) $K_2Cr_2O_7 + HCl \xrightarrow{\Delta}$
(b) $MnO_2 + HCl \xrightarrow{\Delta}$
(c) $KMnO_4 + HCl \xrightarrow{\Delta}$
(d) $K_2Cr_2O_7 + H_2SO_4(\text{conc.}) + NaCl \xrightarrow{\Delta}$

19. In alkaline medium, $KMnO_4$ oxidises iodide to

(a) I_2 (b) IO_3^-
(c) IO_4^- (d) none of these

20. Which of the following statements about the oxidising property of $KMnO_4$ in acidic medium is *not* correct?

(a) H_2S is oxidised to SO_4^{2-}
(b) H_2S is oxidised to S.
(c) SO_3^{2-} gets oxidised to SO_4^{2-}
(d) $C_2O_4^{2-}$ gets oxidised to CO_2

21. Which of the following can not be estimated by $KMnO_4$?

(a) Unsaturation in organic compounds
(b) Oxalates in aqeous solution
(c) $H_2O_{2(aq)}$
(d) $Fe^{2+}_{(aq)}$

22. The brown ring compound formed during the test of NO^-_3 or NO^-_2 is

(a) $[Fe(H_2O)_5ONO]^{2+}$ (b) $[Fe(H_2O)_4(NO)_2]^{2+}$
(c) $[Fe(H_2O)_5NO]^{3+}$ (d) $[Fe(H_2O)_5NO]^{2+}$

23. From the solution of red oxide CrO_3 in water

(a) chromate salt can be crystallized
(b) dichromate salt can be crystallized
(c) H_2CrO_4 can be crystallized
(d) none of these can be crystallized

24. Of Cr (VI) as $Cr_2O_7^{2-}$ and CrO_4^{2-}, which is better oxidising agent?

(a) CrO_4^{2-}, basic medium
(b) $Cr_2O_7^{2-}$, basic medium
(c) $Cr_2O_7^{2-}$, acidic medium
(d) CrO_3, basic medium

25. MnO^-_4 has the strongest and weakest oxidising power in

(a) alkaline and acidic medium
(b) alkaline and neutral medium
(c) acidic and neutral medium
(d) acidic and alkaline medium

26. The total spin and paramagnetism (BM) of ferrum (II) are respectively

(a) $0, 2\sqrt{6}$ (b) $\frac{5}{2}, \sqrt{35}$
(c) $2, \sqrt{24}$ (d) $1, 2\sqrt{2}$

27. Paramagnetism of Cr (Z = 24), Mn^{2+} (Z = 25) and Fe^{3+} (Z = 26) are x, y and z respectively. They are in the order

(a) $x = y = z$ (b) $x > y > z$
(c) $x = y > z$ (d) $x > y = z$

28. Maximum oxidation states of Cr, Mn and Os are respectively

(a) +3, +5 and +6 (b) +6, +5, +7
(c) +6, +7, +8 (d) none of these

MARK YOUR RESPONSE	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ	16. ⓐⓑⓒⓓ	17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ
	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ	21. ⓐⓑⓒⓓ	22. ⓐⓑⓒⓓ	23. ⓐⓑⓒⓓ
	24. ⓐⓑⓒⓓ	25. ⓐⓑⓒⓓ	26. ⓐⓑⓒⓓ	27. ⓐⓑⓒⓓ	28. ⓐⓑⓒⓓ

29. When H_2O_2 is added to acidified $K_2Cr_2O_7$, the solution immediately after

(a) turns yellow due to the formation of CrO_4^{2-}

(b) turns green due to the formation of Cr^{3+}

(c) turns deep blue violet due to the formaion of CrO_5

(d) turns green due to the formation of Cr_2O_3

30. In the dichromate ion $Cr_2O_7^{2-}$

(a) 4 Cr – O bonds are equivalent

(b) 6 Cr – O bonds are equivalent

(c) all Cr – O bonds are equivalent

(d) all Cr – O bonds are non-equivalent

31. In which of the following compounds iron can be estimated volumetrically by $KMnO_4$ or $K_2Cr_2O_7$?

(a) ferric alum (b) FeO. Fe_2O_3

(c) ferric sulfhate

(d) $FeSO_4.(NH_4)_2SO_4.6H_2O$

32. Which of the following compounds can be used to standardise $KMnO_4$ salution?

(a) $FeSO_4.7H_2O$ (b) Fe_3O_4

(c) Mohr's salt (d) $FeCl_3$

33. $KMnO_4$ can be decolourised by acidified

(a) $FeSO_4.7H_2O$

(b) $FeSO_4.(NH_4)_2SO_4.6H_2O$

(c) $FeCl_2$

(d) all

34. An iron piece treated with acidified $KMnO_4$

(a) displaces copper from a dilute H_2SO_4

(b) liberates hydrogen from dilute H_2SO_4

(c) displaces copper from $CuSO_4$ solution but does not liberate H_2 from dilute H_2SO_4

(d) neither displaces copper from $CuSO_4$ solution nor liberates H_2 from dilute H_2SO_4.

35. Fe(II) and Fe(III) salts can be distinguished by

(a) KCNS (b) NH_4CNS

(c) $K_4[Fe(CN)_6]$ (d) all of these

36. Which of the following statements is incorrect about the rusting of iron?

(a) Pure iron is more prone to rusting than the one containing impurities.

(b) Alkaline atmosphere slows down the process of rusting

(c) Presence of moisture and weakly acidic atmosphere are essential conditions for rusting

(d) Rusting is an electrochemical process involving an internal voltaic cell of standard emf 1.67 *V*.

37. Amongst the following salts of iron, which is most unstable in aqueous solutions?

(a) $K_3[Fe(CN)_6]$ (b) $Fe_2(SO_4).9H_2O$

(c) $FeSO_4.7H_2O$ (d) FeI_3

38. In $Fe_2(CO)_9$, the two iron atoms are

(a) linked only directly

(b) linked directly alongwith 3 CO molecules as bridging ligands

(c) linked only through 3 CO molecules as bridging ligands

(d) joined through one CO group as bridging ligands.

39. Which is *not* correct about FeO?

(a) It is non-stoichiometric compound

(b) Some of Fe^{2+} ions get replaced by as many two third Fe^{3+} ions

(c) It is metal excess solid

(d) It is metal deficient solid.

40. Amongst the following compounds, which is thermally stable?

(a) $FeCO_3$ (b) Fe_3O_4

(c) FeO (d) Fe_2O_3

41. $FeCl_3$ solution is acidic due to hydrolysis. Neutral $FeCl_3$ solution required for testing acetate ion in aqueous solution can be obtained by

(a) adding little of NaOH solution to $FeCl_3$ solution

(b) adding excess of NH_3 solution to $FeCl_3$ solution

(c) adding a few drops of dilute NH_3 to $FeCl_3$ solution till the brown precipitate formed ceases to redissolve

(d) none of these

42. Which of the following pairs have both the elements showing highest oxidation states equal to $[ns + (n-1)d]$ electrons?

(a) Ti and Fe (b) Cr and Co

(c) Cr and Mn (d) Co and Ni

43. The correct statement of the following is

(a) FeI_3 is stable is aqueous solution

(b) An acidified solution of K_2CrO_4 gives yellow precipitate on mixing with lead acetate

(c) The species $[CuCl_4]^{2-}$ exists but $[CuI_4]^{2-}$ does not

(d) Both copper (I) and copper (II) salts are known in aqueous solution

MARK YOUR RESPONSE	29. ⓐⓑⓒⓓ	30. ⓐⓑⓒⓓ	31. ⓐⓑⓒⓓ	32. ⓐⓑⓒⓓ	33. ⓐⓑⓒⓓ
	34. ⓐⓑⓒⓓ	35. ⓐⓑⓒⓓ	36. ⓐⓑⓒⓓ	37. ⓐⓑⓒⓓ	38. ⓐⓑⓒⓓ
	39. ⓐⓑⓒⓓ	40. ⓐⓑⓒⓓ	41. ⓐⓑⓒⓓ	42. ⓐⓑⓒⓓ	43. ⓐⓑⓒⓓ

44 Pick out the correct statement of the following

(a) The stability of either of $HgCl_2$ and $SnCl_2$ is not affected when present simultaneously in aqueous solution

(b) Both $Cu(OH)_2$ and $Fe(OH)_2$ are soluble in aqueous NH_3

(c) Copper (I) salts are not known in aqueous solution

(d) White precipitate of $Zn(OH)_2$ is obtained on adding excess of NaOH to aqueous $ZnSO_4$.

45. H_2S gas is passed through an acidified solution containing Hg^{2+}, Bi^{3+} and Mn^{2+}. The precipitate obtained will contain

(a) HgS and MnS
(b) Bi_2S_3 and MnS
(c) HgS and Bi_2S_3
(d) HgS, Bi_2S_3 & MnS

46. When excess of aqueous NH_3 is added to Hg_2Cl_2, which of the following is obtained?

(a) colourless and sparingly soluble $Hg(NH_2)Cl$
(b) $Hg(NH_3)_2Cl_2$
(c) $Hg_2Cl_2 . 2NH_3$
(d) black substance $Hg(NH_2)Cl + Hg$

47. Which of the following oxides does not dissolve both in dilute HCl and NaOH solutions?

(a) SnO_2
(b) ZnO
(c) Al_2O_3
(d) MgO

48. The magnet attracts

(a) K_2MnO_4
(b) TiO_2
(c) AgCl
(d) CuCl

49. Which of the following pair of elements have nearly equal atomic size?

(a) Sc and Cu
(b) Ti and Ni
(c) Cu and Ag
(d) Ag and Au

50. Amongst the following, the most ionic and basic compound is

(a) Cr_2O_3
(b) CrO_3
(c) CrO
(d) CrO_2

51. Ionization potential of Cu, Ag and Au are in the order

(a) $Cu < Ag < Au$
(b) $Au < Ag < Cu$
(c) $Ag < Cu < Au$
(d) none of these

52. In which of the following cases, the stability of two oxidation states is correctly represented

(a) $Ti^{3+} > Ti^{4+}$
(b) $Mn^{2+} > Mn^{3+}$
(c) $Fe^{2+} > Fe^{3+}$
(d) $Cu^{+} > Cu^{2+}$

53. A light green coloured salt soluble in water gives black precipitate on passing H_2S. The precipitate dissolves readily in HCl. Which of the following metal ion constitutes the salt?

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

54. Amongst the following ions which one has the highest paramagnetism?

(a) $[Cu(H_2O)_6]^{2+}$
(b) $[Zn(H_2O)_6]^{2+}$
(c) $[Cr(H_2O)_6]^{3+}$
(d) $[Fe(H_2O)_6]^{2+}$

55 Green Cr^{3+} solution changes to yellow CrO_4^{2-} on boiling with

(a) alkaline H_2O_2
(b) acidified H_2O_2
(c) both
(d) none of these

56. The ground state electronic configuration $[Ar]3d^5\,4s^1$ is that of

(a) Cr, Mn^{+} and Fe^{2+}
(b) Cr, Fe^{2+} and Co^{3+}
(c) Cr and Mn^{+}
(d) Cr only

57. The complex salt with no unpaired electrons is

(a) $[CoF_6]^{3+}$
(b) V_2O_5
(c) $[Ti\,F_6]^{3-}$
(d) none of these

58. Which of the following gives chocolate red precipitate with $K_4[Fe(CN)_6]$ in aqueous solution

(a) $Fe_2(SO_4)_3$
(b) $FeSO_4$
(c) $ZnSO_4$
(d) $CuSO_4$

59. For the manufacture of artificial silk, the reagent used for dissolving cellulose is

(a) $Fe_4[Fe(CN)_6]_3$
(b) $K_2[HgI_4]$
(c) $[Cu(NH_3)_4]SO_4$
(d) $[Ag(NH_3)_2]Cl$

60. In aqueous solution, Cu(I) salts are not known. This is because of the reason that free energy of the reaction

$$2Cu^{+}_{(aq)} \longrightarrow Cu_{(s)} + Cu^{2+}_{(aq)} \text{ is}$$

(a) zero
(b) positive
(c) negative
(d) none of these

61. Which of the following reactions is used to estimate copper volumetrically?

(a) $2Cu^{2+} + 4\,CN^{-} \rightarrow Cu_2(CN)_2 + (CN)_2$
(b) $Cu^{2+} + 4\,NH_3 \rightarrow [Cu(NH_3)_4]^{2+}$
(c) $2Cu^{2+} + 2\,CNS^{-} + SO_2 + 2\,H_2O \rightarrow Cu_2(CNS)_2 + H_2SO_4 + 2H^{+}$
(d) $2Cu^{2+} + 4I^{-} \rightarrow Cu_2I_2 + I_2$

MARK YOUR RESPONSE	44. ⓐⓑⓒⓓ	45. ⓐⓑⓒⓓ	46. ⓐⓑⓒⓓ	47. ⓐⓑⓒⓓ	48. ⓐⓑⓒⓓ
	49. ⓐⓑⓒⓓ	50. ⓐⓑⓒⓓ	51. ⓐⓑⓒⓓ	52. ⓐⓑⓒⓓ	53. ⓐⓑⓒⓓ
	54. ⓐⓑⓒⓓ	55. ⓐⓑⓒⓓ	56. ⓐⓑⓒⓓ	57. ⓐⓑⓒⓓ	58. ⓐⓑⓒⓓ
	59. ⓐⓑⓒⓓ	60. ⓐⓑⓒⓓ	61. ⓐⓑⓒⓓ		

62. Except copper, all elements of 3*d* series have negative reduction potential values but they are not good reducing agents. This is because of their

(a) high enthalpy of sublimation
(b) high enthalpy of ionization
(c) poor enthalpy of hydration
(d) all of these

63. When excess of CN^- is added to $CuSO_4$ solution, the complex ion formed is

(a) $[Cu(CN)_4]^{2-}$
(b) $[Cu(CN)_4]^{3-}$
(c) $[Cu(CN)_5]^{4-}$
(d) $[Cu(CN)_6]^{4-}$

64. Both Cu and K have the same configuration (4*s*) of the valence shell but the former has greater ionization potential. It is because of the reason that the *d*-electron in copper have

(a) strong shielding effect leading to increase in its atomic size
(b) strong shielding effect leading to decrease in its atomic size
(c) poor shielding effect leading to decrease in its atomic size
(d) poor shielding effect leading to increase in its atomic size.

65. When excess of KI is added to aqueous $CuSO_4$, the solution acquires dark brown colouration. This is due to the formation of

(a) $CuI_{2(s)}$
(b) $Cu_2I_{2(s)}$
(c) $I^-_{3(aq)}$
(d) $I_{2(s)}$

66. An excess of $Na_2S_2O_3$ reacts with aqueous $CuSO_4$ to give

(a) CuS_2O_3
(b) $Cu_2S_2O_3$
(c) $Na_2[Cu(S_2O_3)_2]$
(d) $Na_4[Cu_6(S_2O_3)_5]$

67. Which of the following compounds is formed on adding Na_2CO_3 to $CuSO_4$ solution?

(a) $Cu(OH)_2$
(b) $CuCO_3$
(c) Cu_2O
(d) $CuCO_3.Cu(OH)_2$

68. Atomic size of gold is almost the same as that of silver. It is due to

(a) the same crystal structure of silver and gold
(b) almost the same electro positive character of the two metals
(c) transition metals contraction in a series
(d) the effect of lanthanide contraction

69. Which of the following compounds is most sensitive to light?

(a) AgCl
(b) $AgNO_3$
(c) AgI
(d) AgBr

70. On heating $AgNO_3$ above its melting point, the gas evolved is

(a) NO_2 only
(b) NO_2 and O_2
(c) O_2 only
(d) N_2 and O_2

71. Which of the following reactions will occur on heating $AgNO_3$ at red heat

(a) $2Ag\,NO_3 \rightarrow 2\,AgNO_2 + O_2$
(b) $2Ag\,NO_3 \rightarrow 2\,Ag + 2NO_2 + O_2$
(c) $Ag\,NO_3 \rightarrow Ag + NO + O_2$
(d) $2Ag\,NO_3 \rightarrow 2\,Ag + N_2 + 3O_2$

72. Which of the silver salts are soluble in water

(a) Ag_2SO_4
(b) AgCN
(c) AgF
(d) Ag_2CrO_4

73. AgBr dissolves in the excess of KCN and $Na_2S_2O_3$ solutions due to the formation of complex ions. The ions are respectively

(a) $[Ag(CN)_2]^+$ and $[Ag(S_2O_3)_2]^{3-}$
(b) $[Ag(CN)_2]^-$ and $[Ag(S_2O_3)_2]^{3-}$
(c) $[Ag(CN)_4]^{3-}$ and $[Ag_2(S_2O_3)_2]^{2-}$
(d) $[Ag(CN)_3]^{2-}$ and $[Ag(S_2O_3)]^-$

74. In silver plating, the electrolytic bath contains the solution of

(a) silver nitrate
(b) ammonical silver nitrate
(c) potassium dicyanoargentate (I)
(d) AgF

75. Gold dissolves in 3:1 mixture of HCl and HNO_3 to produce

(a) $H_2[AuCl_5]$
(b) $H[AuCl_4]$
(c) $H[AuCl_2]$
(d) $H_2[AuCl_6]$

76. Tollen's reagent is

(a) $Na_3[Ag(S_2O_3)_2]$
(b) $K[Ag(CN)_2]$
(c) $[Ag(NH_3)_2]NO_3$
(d) $[Ag(NH_3)_2]Cl$

77. The latent image formed on exposure of photographic plate to light can be made visible by treating it with mild reducing agent like

(a) ferrous oxalate
(b) p-quinol
(c) pyrogallol
(d) all of these

MARK YOUR RESPONSE	62. ⓐⓑⓒⓓ	63. ⓐⓑⓒⓓ	64. ⓐⓑⓒⓓ	65. ⓐⓑⓒⓓ	66. ⓐⓑⓒⓓ
	67. ⓐⓑⓒⓓ	68. ⓐⓑⓒⓓ	69. ⓐⓑⓒⓓ	70. ⓐⓑⓒⓓ	71. ⓐⓑⓒⓓ
	72. ⓐⓑⓒⓓ	73. ⓐⓑⓒⓓ	74. ⓐⓑⓒⓓ	75. ⓐⓑⓒⓓ	76. ⓐⓑⓒⓓ
	77. ⓐⓑⓒⓓ				

78. A light blue coloured compound (*A*) on heating gives a black compound (*B*) which reacts with glucose to give a red a compound (*C*). (*A*), (*B*) and (*C*) are respectively

(a) $CuSO_4.5H_2O$

(b) $Cu(OH)_2, Cu_2O, CuO$

(c) $Cu(OH)_2, CuO, Cu_2O$

(d) $[Cu(NH_3)_4]SO_4, CuO, Cu_2O$

79. When copper sulphate solution is treated with excess of KI and excess of hypo solution is added, a white precipitate appears. The precipitate is

(a) CuI_2 (c) $Na_2S_4O_6$

(c) CuI (d) NaI

80. Given $E^{\circ}_{Au^{3+}/Au} = 1.52V$ and $E^{\circ}_{Au^{3+}/Au^{+}} = 1.36V$.

Point out the correct statement of the following

(a) Au^{3+} disproportionates into Au^{4+} and Au^{2+} in aqueous solution

(b) Au^{3+} disproportionates into Au^{4+} and Au^{+} in aqueous solution

(c) Au^{+} disproportionates into Au^{3+} and Au in aqueous solution

(d) Au^{+} disproportionates into Au^{2+} and Au in aqueous solution

81. Which of the following exists as dimer?

(a) Cd (II) salts (b) Hg(II) salts

(c) Hg(I) salts (d) Au(III) salts

82. Which of the following is not oxide of zinc?

(a) zinc white (b) chinese white

(c) phillospher's wool (d) calamine

83. The compound amongst the following that sublimes on heating, is

(a) Hg_2Cl_2 (b) Cu_2Cl_2

(c) $HgCl_2$ (d) $CuCl_2$

84. Iodine is liberated on adding KI solution to a solution of

(a) $ZnCl_2$ (b) $HgCl_2$

(c) $AlCl_3$ (d) $FeCl_3$

85. The compound that gets oxidised even on exposure to air, is

(a) $FeSO_4.(NH_4)_2SO_4 \cdot 6H_2O$

(b) Hg_2Cl_2

(c) $FeSO_4.7H_2O$

(d) Cu_2Cl_2

86. Which of the following oxides has the under mentioned characteristics?

(i) amphoteric nature

(ii) can be reduced by carbon

(iii) acquires yellow colour on heating

(a) Al_2O_3 (b) PbO

(c) HgO (d) ZnO

87. Red precipitate is obtained when $AgNO_3$ is added to

(a) Na_2CrO_4 (b) KI

(c) KBr (d) $Na_2S_2O_3$

88. $ZnCl_2$ reacts with excess of NH_3 solution to produce

(a) a precipitate of $Zn(OH)_2$

(b) a complex ion $[Zn(NH_3)_4]^{2+}$ with tetrahedral geometry

(c) a complex ion $[Zn(NH_3)_2]^{2+}$ with linear geometry

(d) a complex ion $[Zn(NH_3)_4]^{2+}$ with square planar geometry

89. Zinc oxide, a white powder, turns yellow on heating and again turns white on cooling. This is because of

(a) vigorous oscillations of Zn^{2+} about their mean positions

(b) vigorous oscillations of O^{2-} ions about their mean positions

(c) reversible loss of some oxide ion from the lattice sites leaving behind the electrons

(d) *d-d* transitions on heating

90. When $SnCl_2$ and $HgCl_2$ in the mole ratio of 1:2 are mixed in aqueous solution which of the following is obtained

(a) Hg (b) Hg_2Cl_2

(c) $[SnCl_4]^{2-}$ (d) Sn_2Cl_2

91. The covalent character of the following chlorides follow the order

(a) $HgCl_2 < CdCl_2 < ZnCl_2$

(b) $ZnCl_2 < CdCl_2 < HgCl_2$

(c) $CdCl_2 < ZnCl_2 < HgCl_2$

(d) $HgCl_2 < ZnCl_2 < CdCl_2$

92. Group 12 elements are included in d-block and have configuration $(n-1)\,d^{10}\,n\,s^2$. Hence

(a) They are high melting point solids

(b) They must form coloured compounds

(c) They and their compounds are paramagnetic

(d) They and their compounds are diamagnetic

MARK YOUR RESPONSE	78. ⓐⓑⓒⓓ	79. ⓐⓑⓒⓓ	80. ⓐⓑⓒⓓ	81. ⓐⓑⓒⓓ	82. ⓐⓑⓒⓓ
	83. ⓐⓑⓒⓓ	84. ⓐⓑⓒⓓ	85. ⓐⓑⓒⓓ	86. ⓐⓑⓒⓓ	87. ⓐⓑⓒⓓ
	88. ⓐⓑⓒⓓ	89. ⓐⓑⓒⓓ	90. ⓐⓑⓒⓓ	91. ⓐⓑⓒⓓ	92. ⓐⓑⓒⓓ

93. The metal '*X*' of the following dissolve in hot NaOH solution to form the compound '*Y*'. *X* and *Y* are respectively

(a) Zn and $Na_2[Zn(OH)_4]$ (b) Cd and $Na_2[Cd(OH)_4]$

(c) Zn and $Na[Zn(OH)_3]$ (d) Cr and $Na_3[Cr(OH)_6]$

94. Both the metal ions of the following pairs are coloured in case of

(a) Cu(I) and Cu(II) (b) Ti(IV) and Zn(II)

(c) Sc(III) and Fe(III) (d) Ti(III) and V(III)

95. First four ionization energies of Ni and Pt are given below:

	$(IE_1 + IE_2)$	$(IE_3 + IE_4)$
Ni	2.49×10^3 kJ mol^{-1}	8.8×10^3 kJ mol^{-1}
Pt	2.66×10^3 kJ mol^{-1}	6.7×10^3 kJ mol^{-1}

From the data it can be concluded that

(a) Ni(II) compounds are thermodynamically more stable than Pt(II) compounds

(b) Pt(IV) compounds are thermodynamically more stable than Ni(II) compounds.

(c) both correct

(d) none of these is correct

96. Chromium has moderately high negative reduction potential $(E^{\circ}_{Cr^{3+}/Cr} = -0.90\ V)$ but it does not liberate H_2 from dilute HCl. This is due the reason that

(a) Cr lies below hydrogen in the electrochemical series

(b) Cr is a noble metal

(c) Reduction potential of Cr is greater than that of hydrogen

(d) Formation of inert oxide (Cr_2O_3) film on the surface protects the metal

97. For which of the following species *d-d* transition does not account for its colour ?

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

(c) CrO_2Cl_2 (d) All

98. The strongest oxidizing species of the following is

(a) Cr (II) (b) Cr (VI)

(c) Mo (VI) (d) W (VI)

99. Chromyl chloride test can be used to confirm the presence of Cl^- ion in the compound

(a) $HgCl_2$ (b) AgCl

(c) $BaCl_2$ (d) $PbCl_2$

100. Aomic size of Zr and Hf is almost the same because of

(a) both have $(n-1)d^2ns^2$ configurations

(b) both have the same number of *d*-electrons in penultimate energy level

(c) lanthanide contraction

(d) large screening effect of 4*f*-electrons over the valence shell.

101. The transition metals have comparatively less tendency to form cations as compared to elements of I, II and IIIA (13th) groups. This is because of

(a) their high energies of ionization

(b) low heats of hydration of their ions

(c) high heats of sublimation

(d) all

102. Which of the following is false about the stability of oxidation states of manganese ?

(a) Mn (II) > Mn (VII) (acidic solution)

(b) Mn (II) < Mn (IV) (alkaline solution)

(c) Mn (VI) > Mn (IV) (acidic solution)

(d) Mn (VI) > Mn (VII) (alkaline solution)

103. Which of the following compounds can not be obtained in solid state ?

(a) $HMnO_4$ (b) K_2MnO_4

(c) $KMnO_4$ (d) Mn_3O_4

104. Which of the following compounds is not the substance of primary standard ?

(a) $K_2Cr_2O_7$

(b) $CuSO_4.5H_2O$

(c) $FeSO_4.7H_2O$

(d) $(NH_4)_2SO_4.FeSO_4.6H_2O$

105. Pyrolusite when fused with K_2CO_3 in presence of air gives a green mass *A*. When Cl_2 is passed into the solution of *A*, another coloured product *B* is obtained. *A* and *B* are respectively

(a) $K_2Mn(OH)_4$ and Mn_2O_3

(b) $K_2Mn(OH)_4$ and Mn_3O_4

(c) MnO(OH) and Mn_2O_7

(d) K_2MnO_4 and $KMnO_4$

MARK YOUR RESPONSE	93. ⓐⓑⓒⓓ	94. ⓐⓑⓒⓓ	95. ⓐⓑⓒⓓ	96. ⓐⓑⓒⓓ	97. ⓐⓑⓒⓓ
	98. ⓐⓑⓒⓓ	99. ⓐⓑⓒⓓ	100. ⓐⓑⓒⓓ	101. ⓐⓑⓒⓓ	102. ⓐⓑⓒⓓ
	103. ⓐⓑⓒⓓ	104. ⓐⓑⓒⓓ	105. ⓐⓑⓒⓓ		

106. Which of the following is correct ?

I. $[Cu(NH_3)_4]Cl$: Blue and paramagnetic

II. $[Cu(NH_3)_4]Cl_2$: Deep blue and paramagnetic

III. $CuCl_4^{3-}$: Colourless and diamagnetic

IV. $[Cu(NH_3)_4]Cl$: Colourless and diamagnetic

(a) I only (b) II only
(c) II and III (d) II, III and IV

107. The atomic radii of Cu and Ag are 1.17Å and 1.34Å respectively. The atomic radius of Au is expected to be

(a) 1.41 Å (b) 1.51 Å
(c) 1.34 Å (d) 1.12 Å

108. Cerium ($Z = 58$) is an important member of lanthanides. Which of the following statements about cerium is *not* correct ?

(a) The common oxidation states of Ce are + 3 and + 4.

(b) + 3 oxidation state is more stable than + 4 oxidation state.

(c) + 4 oxidation state is not known in solution.

(d) Ce (IV) acts as an oxidising agent.

109. The function of dil HNO_3 that we add, while preparing copper sulphate by blowing a current of air through copper scrap and dilute H_2SO_4, is

(a) to oxidise copper metal to cupric ion which then forms copper sulphate with dil H_2SO_4

(b) to oxidise ferrous ion so as to form ferric sulphate that remains in solution after crystallisation of $CuSO_4$

(c) to accelerate ionisation of H_2SO_4 to form SO_4^{2-} ions

(d) to obtain a very strong oxidising mixture of H_2SO_4 + HNO_3 for oxidation of copper metal to cuprous ion.

110. In the Mac-Arther Cyanide process for extraction of silver, a small amount of KNO_3 is added. The function of KNO_3 is

(a) to oxidise the sulphur present in argentite ore to SO_2

(b) to form anions with Ag^+ which is then reduced to metallic silver by zinc

(c) to oxidise Ag in natural form to Ag^+

(d) to oxidise the impurities of lead and zinc present in it

111. The correct statement about the change that occurs on oxidation of complex $K_3[(CN)_5 Co - O - O - Co (CN)_5]$ to $K_5[(CN)_5 Co - O - O - Co (CN)_5]$ using bromine as oxidising agent.

(a) Co^{2+} is oxidised to Co^{3+}

(b) there occurs an increase in O – O bond length

(c) the O – O bond length decreases

(d) none of the above

112. Consider the reaction given below and select the correct option about the products.

$$FeCl_3.6H_2O + C(CH_3)_2(CH_3O)_2 \longrightarrow \text{Products}$$

(a) $Fe(OH)_3, FeCl_3, CH_3COCH_3$

(b) $FeCl_3, CH_3OH, CH_3COCH_3$

(c) $(CH_3O)_3Fe, HCl, H_2O$

(d) all the above are incorrect

113. In which of the following will the oxidation state change ?

(a) Reaction of $Cu^{2+}$with NaOH

(b) Reaction of Cu^{2+} with iron metal

(c) Reaction of Cu^{2+} with KI

(d) both (b) and (c)

114. A metal gives two chlorides '*X*' and '*Y*'. The chloride '*X*' gives a black precipitate with NH_4OH. The chloride '*Y*' gives a white precipitate with NH_4OH. '*Y*' gives red precipitate with KI which is soluble in excess of KI. The formula of chlorides '*X*' and '*Y*' respectively are

(a) Hg_2Cl_2 and $HgCl_2$ (b) $HgCl_2$ and $ZnCl_2$
(c) $ZnCl_2$ and Hg_2Cl_2 (d) none of these

115. Consider the complexes given below and choose the correct order of paramagnetic moments (spin only)

I. $[FeF_6]^{3-}$; II. $[CrF_6]^{3-}$;
III. $[V(H_2O)_6]^{3+}$; IV. $[Ti(H_2O)_6]^{3+}$

(a) I > II > III > IV (b) I < II < III < IV
(c) I > III > IV > II (d) III > I > IV > II

MARK YOUR RESPONSE	106. ⓐⓑⓒⓓ	107. ⓐⓑⓒⓓ	108. ⓐⓑⓒⓓ	109. ⓐⓑⓒⓓ	110. ⓐⓑⓒⓓ
	111. ⓐⓑⓒⓓ	112. ⓐⓑⓒⓓ	113. ⓐⓑⓒⓓ	114. ⓐⓑⓒⓓ	115. ⓐⓑⓒⓓ

116. In the reduction of Au (III) from $AuCl_4^-$ ion, the solution is to be stirred rapidly during electrolysis. The stirring is quite important

(a) for separation of gold from chlorine

(b) for increasing the conductivity of the solution

(c) for increasing the movement of $AuCl_4^-$ ions towards the anode

(d) for overcoming the repulsive forces between the $AuCl_4^-$ and excess electrons at the electrode so as to help the deposition of Au (III)

117. It has been observed that writing on paper with an invisible ink containing ammonium thiocyanate becomes visible as red colour when the paper is brushed with an aqueous $FeCl_3$. If ammonium thiocyanate is first made alkaline instead of red colour, you get an orange colour which is less clear.

The above observation can be explained best by which of the following combinations

(a) Fe – CNS complex is formed in case of ammonium thiocyanate and Fe $(OH)_3$ is formed in case of alkaline ammonium thiocyanate

(b) Fe – CNS complex is formed in case of ammonium thiocyanate and $Fe(OH)_2$ is formed in case of alkaline ammonium thiocyanate

(c) In both cases same complex is formed but some of it gets dissolved in case of alkaline ammonium thiocyanate

(d) None of the above is correct

118. Consider the following oxides of transition elements and choose the correct order of their basic character.

$$\underset{(I)}{VO};\ \underset{(II)}{CrO};\ \underset{(III)}{TiO};\ \underset{(IV)}{FeO}$$

(a) I > II > III > IV (b) II > I > IV > III

(c) III > IV > I > II (d) III > I > II > IV

119. A transition metal with low oxidation number is most likely to act as

(a) a base (b) an acid

(c) an oxidising agent (d) none of the above

120. AgO obtained by oxidation of Ag_2O shows

(a) diamagnetic nature (b) paramagnetic nature

(c) ferromagnetic nature (d) ferrimagnetic nature

121. The reason for the existence of mercury metal in liquid state at 0°C is that

(a) mercury has high ionisation energy and posseses weak metallic bond

(b) mercury has low ionisation energy

(c) mercury has a very high atomic weight

(d) mercury has a high vapour pressure

122. Select the one that represents chlorodising roasting

(a) $PbS + 2O_2 \longrightarrow PbSO_4$

(b) $4Hg + 2AgCl \longrightarrow 2HgAg + Hg_2Cl_2$

(c) $2NaCl + Ag_2S \longrightarrow 2AgCl + Na_2S$

(d) both (b) and (c)

123. It has been found that a large number of tetrahedral complexes are formed by Ti^{3+}, V^{3+}, $Fe^{3+}$and Co^{2+} but tetrahedral complexes are never formed by Cr^{3+}. This is due to which of the following reason ?

(a) Cr^{3+} forces high crystal field splitting with a variation of ligands.

(b) the values of crystal field stabilisation energy in octahedral field and tetrahedral field of Cr^{3+} system is the major deciding factor.

(c) of the various tripositive ions (i.e., Ti^{3+}, V^{3+}, Fe^{3+} and Cr^{3+}) the Cr^{3+} ion has the maximum ionic radius.

(d) of the various tripositive ions (i.e., Ti^{3+}, V^{3+}, Fe^{3+} and Cr^{3+}) the Cr^{3+} ion has the minimum ionic radius.

124. The Guigret's green can be represented as

(a) $CuSO_4.2H_2O$ (b) $FeSO_4.7H_2O$

(c) $Cr_2O_3.2H_2O$ (d) $CrO.2H_2O$

125. A 22-carat gold ornament is being sold as 96% pure gold. This is marked approximately

(a) same (b) 4.5% more

(c) 4.5% less (d) can't predict

126. Which of the following is involved on formation of $[Fe(H_2O)_6]^{3+}$ from $[Fe(H_2O)_6]^{2+}$?

(a) The electron transfer occurs via **d-d transition**

(b) The inner sphere electron transfer occurs

(c) By S_N1 mechanism

(d) By outer sphere electron transfer

MARK YOUR RESPONSE	116. ⓐⓑⓒⓓ	117. ⓐⓑⓒⓓ	118. ⓐⓑⓒⓓ	119. ⓐⓑⓒⓓ	120. ⓐⓑⓒⓓ
	121. ⓐⓑⓒⓓ	122. ⓐⓑⓒⓓ	123. ⓐⓑⓒⓓ	124. ⓐⓑⓒⓓ	126. ⓐⓑⓒⓓ
	126. ⓐⓑⓒⓓ				

B COMPREHENSION TYPE

This section contains groups of questions. Each group is followed by some multiple choice questions based on a paragraph. Each question has 4 choices (a), (b), (c) and (d) for its answer, out of which ONLY ONE is correct.

PASSAGE-1

Silver is still one of the most versatile metals known to man, being used in almost everything from electrical wires to jewellery. It is also quite unreactive, and is resistant to attack by common agents such as acid and oxygen. Needless to say, the mining of this precious metal is the mainstay of the economy of many countries. Unfortunately, silver does not occur in its elemental state in nature. It is mined as argentite (Ag_2S containing ore) and horn silver ($AgCl$ containing ore).

The main method used in industry for separating silver from its ores involves complexation with cyanide ligand (CN^-). The cyanide ligand is used to produce the soluble silver cyanide complex according to Reaction I and Reaction II.

Reaction - I : $Ag_2S + 4CN^- \longrightarrow 2[Ag(CN)_2]^- + S^{2-}$

Reaction - II : $AgCl + 2CN^- \longrightarrow [Ag(CN)_2]^- + Cl^-$

The silver metal in its elemental form is then precipitated by adding zinc dust to the solution as shown in Reaction III.

Reaction - III : $2[Ag(CN)_2]^- + Zn \longrightarrow [Zn(CN)_4]^{2-} + 2Ag(s)$

Silver complexes provide one of the most fascinating demonstrations of the relative strengths of different ligands for a particular cation. This is a common occurrence with most complexes of this nature but what makes silver unique is that many of its complexes differ in color. Table 1 is a list of a few of the silver complexes and their colors.

Table 1 :

Complex	Color
$[Ag(CN)_2]^-$	Clear solution
AgI	Yellow precipitate
$[Ag(EDTA)]^-$	Clear solution
Ag_2S	Black precipitate

One will notice that precipitates are listed in the table. These can be regarded as neutral complexes and as is often the case with neutral complexes, they are quite insoluble and hence precipitate out of solution.

1. The ability of silver ions to form complexes of many different colors identifies it as being a :

(a) Univalent metal (b) Group IB element

(c) Period V element (d) Transition metal

2. Silverware tarnishes becuase of a reaction between silver and tiny amounts of a gas in air. What must that gas be?

(a) O_2 (b) N_2

(c) H_2O (d) H_2S

3. Given that $K_{a_1}(H_2S) = 9.1 \times 10^{-8}$ and $K_{a_2}(H_2S) = 1.2 \times 10^{-15}$, what would be the effect on Reaction-I if protons were added to the reaction mixture at equilibrium? (**Note :** the effect of protons of CN^- is relatively negligible).

(a) The equilibrium would shift to the left

(b) The equilibrium would shift to the right

(c) There would be no change in the equilibrium position of the reaction

(d) The change in the equilibrium position can not be determined from the information given

4. If Reaction - II is at equilibrium, which of the following is true?

(a) The change is entropy is zero

(b) The number of reacting molecules is zero

(c) The change in enthalpy is zero

(d) The change in free energy is zero

5. 12 grams of silver was extracted from a sample of an ore from which the only source of silver was Ag_2S. How many grams of Ag_2S were in the original sample?

(a) 27.6 g (b) 13.8 g

(c) 8.6 g (d) 5.2 g

6. One of the complexes formed by silver is silver bromide, AgBr. Why would you expect it to be insoluble?

(a) Because it is a neutral complex

(b) Because Br^- is a large anion

(c) Because the relative molecular mass AgBr is large

(d) Because most bromides are insoluble

MARK YOUR RESPONSE	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ
	6. ⓐⓑⓒⓓ				

7. Which of the following ligands will give a precipitate when added to the clear solution of the complexes detailed in Table - 1? Order of affinity for Ag^+ ions :

$EDTA > S^{2-} > CN^- > I^-$

(a) EDTA (b) S^{2-}
(c) CN^- (d) I^-

PASSAGE-2

Paramagnetic properties and colour of transition metal compounds :

The transition metals and their compounds have paramagnetic properties, i.e., they are attracted by the magnet. This is due to the reason that ions of transition metals have unpaired electrons in $(n - 1)d$ orbitals. As the number of unpaired electrons increases from one to five in moving from Sc to Mn, the paramagnetic character increases accordingly. From Mn onwards, this character decreases as electrons get paired up.

The paramagnetic behavior is expressed in terms of magnetic moment which is because of the spin of unpaired electrons (n). It is given as

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

Majority of transition metal compounds are coloured both in solid state as well as in aqueous solution. This is in contrast to the compound of s- and p-block elements, which are usually colourless. The colour of transition metal compound may be attributed to the presence of partly filled $(n - 1)d$-subshell. In these compounds, the energy of five d-orbitals in the $(n - 1)d$ shell does not remain the same. Under the influence of approaching ligands, the five d-orbitals belonging to the $(n - 1)d$-subshall split into two sets of energy levels. This is what is called crystal field splitting. For example, in case if octahedral complexes the six approaching ligands split five $(n - 1)$ d-orbitals into two sets of orbitals with slightly different energies. One set with lower energy has three orbitals (d_{xy}, d_{yz}, d_{zx}) whereas the other set with slightly higher energy have two orbitals $(d_{x^2-y^2}, d_{z^2})$. The energy difference between the two sets of orbitals correspond to the radiation in visible region. Thus, when white light falls on such a transition metal compound, some light energy corresponding to a particular colour is absorbed and one or more electrons are raised from lower energy set of orbitals to those of higher energy. With the absorptions of radiations corresponding to specific colour from the white light, a colour known as the complementary colours is observed or transmitted.

8. Which one of the following ions exhibit highest magnetic moment?

(a) Cu^{2+} (b) Ti^{3+}
(c) Ni^{2+} (d) Mn^{2+}

9. Which group contains coloured ions out of

1. Cu^{2+} 2. Ti^{4+}
3. Co^{2+} 4. Fe^{2+}

(a) 1, 2, 3, 4 (b) 1, 3, 4
(c) 2, 3 (d) 1, 2

10. A compound of metal ion M^{x+} (z = 24) has a spin only magnetic moment of $\sqrt{15}$ B.M. The number of unpaired electrons in the compound are

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

11. Amongst TiF_6^{2-}, CoF_6^{3-}, Cu_2Cl_2 and $NiCl_4^{2-}$ (At. No. Ti = 22, Co = 27, Cu = 29, Ni = 28), the colourless spcies are

(a) CoF_6^{3-} and $NiCl_4^{2-}$
(b) TiF_6^{2-} and CoF_6^{3-}
(c) TiF_6^{2-} and Cu_2Cl_2
(d) $NiCl_4^{2-}$ and Cu_2Cl_2

12. The ions of the transition metals compounds having $(n - 1)d$ subshell with zero or 10 electrons

(a) absorb green colour of white light
(b) absorb yellow colour of white light
(c) absorb red colour of white light
(d) absorb no colour of white light

PASSAGE-3

A water insoluble solid "*A*" turns yellow on heating and becomes white again on cooling. When "*A*" is treated with HCl (aq) it forms a clear solution "*B*". "*A*" when treated with NaOH (aq) also gives a clear solution "*C*". When H_2S (g) is bubbled through clear solution "*B*" no change is observed but when H_2S is bubbled through clear solution "*C*", a white precipitate of compound "*D*" is observed.

MARK YOUR RESPONSE	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ	11. ⓐⓑⓒⓓ
	12. ⓐⓑⓒⓓ				

13. The nature of compound "*A*" is

(a) acidic (b) basic
(c) amphoteric (d) neutral

14. The compound "*A*" is

(a) ZnO (b) PbO
(c) MnO (d) CdO

15. The compound "*B*" is

(a) $ZnCl_2$ (b) $PbCl_2$
(c) $MnCl_2$ (d) $NiCl_2$

PASSAGE-4

When we pass carbon dioxide gas through a green coloured solution of potassium manganate, the colour of solution changes to purple and a brown coloured solid gets precipitated.

The green colour of potassium manganate solution also becomes purple when it is subjected to electrolysis using iron rods as cathodes as well as anode.

16. The change of colour from green to purple is due to

(a) conversion of Mn^{+6} to Mn^{+7}
(b) conversion of Mn^{+6} to Mn^{+4}
(c) conversion of Mn^{+4} to Mn^{+7}
(d) conversion of Mn^{+4} to Mn^{+6}

17. In the brown solid precipitated out the oxidation state of Mn is

(a) +2 (b) +4
(c) +6 (d) +7

18. In following reaction

$$\underset{\text{(green)}}{3K_2MnO_4} + 2H_2O + 4CO_2 \longrightarrow$$

$$\underset{\text{(purple)}}{2KMnO_4} + MnO_2 + 4KHCO_3$$

the function of CO_2 is

(a) to make solution acidic by formation of $KHCO_3$
(b) to make solution basic by formation of CO_3^{2-}
(c) to act only as a medium of reaction
(d) none of the above

MARK YOUR RESPONSE	13. ⓐⓑⓒⓓ	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ	16. ⓐⓑⓒⓓ	17. ⓐⓑⓒⓓ
	18. ⓐⓑⓒⓓ				

C

REASONING TYPE

In the following questions two Statement-1 (Assertion) and Statement-2 (Reason) are provided. Each question has 4 choices (a), (b), (c) and (d) for its answer, out of which ONLY ONE is correct. Mark your responses from the following options:

(a) Both Statement-1 and Statement-2 are true and Statement-2 is the correct explanation of Statement-1.
(b) Both Statement-1 and Statement-2 are true and Statement-2 is not the correct explanation of Statement-1.
(c) Statement-1 is true but Statement-2 is false.
(d) Statement-1 is false but Statement-2 is true.

1. Statement-1 : $KMnO_4$ is stored in dark bottles.
Statement-2 : On heating with alkalies $KMnO_4$ is converted to manganate.

2. Statement-1 : Members of 4*d* and 5*d* series of transition elements have nearly same atomic radii.
Statement-2 : Atomic and ionic radii for transition elements are smaller than their corresponding s-block elements.

3. Statement-1 : Transition metals are strong reducing agents.
Statement-2 : Transition metals form numerous alloys with other metals.

4. Statement-1 : Zinc becomes dull in moist air.
Statement-2 : Zinc is coated by a thin film of its basic carbonate in moist air.

5. Statement-1 : Rusting of an iron is an example of corrosion.
Statement-2 : Rusting of iron is decreased by acid and electrolytes.

MARK YOUR RESPONSE	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ

6. **Statement-1** : Silver fluoride is soluble in water.

Statement-2 : Hydration energy of AgF is higher than its lattice energy.

7. **Statement-1** : Aqueous solution of $FeCl_3$ is acidic.

Statement-2 : The hydrated form of $FeCl_3$ consists of six water molecules $FeCl_3.6H_2O$.

8. **Statement-1** : A solution of ferric chloride on standing gives a brown precipitate.

Statement-2 : $FeCl_3$ possesses covalent bonds and chlorine bridge structure.

9. **Statement-1** : Na_2CrO_7 is not a primary standard in volumetric analysis.

Statement-2 : Na_2CrO_7 is hygrogroscopic.

10. **Statement-1** : Transition metals form complexes.

Statement-2 : Transition metals have unpaired electrons.

11. **Statement-1** : Ce^{4+} is used as an oxidising agent in volumetric analysis.

Statement-2 : Ce^{4+} has the tendency of attaining + 3 oxidation state.

12. **Statement-1** : Magnetic moment values of actinides are lesser than the theoretically predicted values.

Statement-2 : Actinide elements are strongly paramagnetic.

13. **Statement-1** : The degree of complex formation in actinides decreases in the order

$$M^{4+} > MO_2^{2+} > M^{3+} > MO_2^{+}$$

Statement-2 : Actinides form complexes with π-bonding ligands such as alkyl phosphines and thioethers.

14. **Statement-1** : In transition elements *ns* orbital is filled up first and $(n - 1)\ d$ afterwards, during ionization *ns* electrons are lost prior to $(n - 1)\ d$ electrons.

Statement-2 : The effective nuclear charge felt by $(n - 1)d$ electrons is higher as compared to that by *ns* electrons.

15. **Statement-1** : The reaction of oxalic acid with acidified $KMnO_4$ proceeds slowly in the beginning but speeds up after sometime.

Statement-2 : $KMnO_4$ decomposes to give MnO_2 under the influence of sunlight.

16. **Statement-1** : It is not possible to obtain anhydrous $ZnCl_2$ by heating $ZnCl_2.2H_2O$.

Statement-2 : $ZnCl_2.2H_2O$ undergoes hydrolysis to produce $Zn(OH)_2$ and HCl.

17. **Statement-1** : The orange colour of $K_2Cr_2O_7$ is due to polarisation.

Statement-2 : In $Cr_2O_7^{2-}$ ion all bonds between Cr and oxygen are not identical.

18. **Statement-1** : When $CuCl_2$ is dissolved in water it forms a green solution.

Statement-2 : In aqueous solution of $CuCl_2$, two complex ions [viz. $[Cu(H_2O)_4]^{2+}$ and $[CuCl_4]^{2-}$] are present in equilibrium.

19. **Statement-1** : Amongst Cu^{2+} and Cu^{+} ions, the more stable ion is Cu^{2+}.

Statement-2 : For determination of stability of an ion its electrode potential is more important factor than its electronic configuration.

MARK YOUR RESPONSE	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ
	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ
	16. ⓐⓑⓒⓓ	17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ	19. ⓐⓑⓒⓓ	

D MULTIPLE CORRECT CHOICE TYPE

Each of these questions has 4 choices (a), (b), (c) and (d) for its answer, out of which ONE OR MORE is/are correct.

1. The magnetic moment of a paramagnetic species is given by (n = number of unpaired electrons, S = total spin)

(a) $\sqrt{n(n+1)}$ B.M. (b) $\sqrt{n(n+2)}$ B.M.

(c) $2\sqrt{S(S+1)}$ B.M. (d) $\sqrt{2S(S+1)}$ B.M.

2. Which of the following statements is/are correct about the making of blue prints?

(a) ferric oxalate or citrate is reduced to ferrous salt on being exposed to light

(b) ferrous salts give blue colour with $K_3[Fe(CN)_6]$

(c) ferric salts give blue colour with $K_3[Fe(CN)_6]$

(d) white lines are obtained in place of the ink drawing on a deep blue ground.

3. Amongst the following statements, which is/are *not* corret?

(a) $[Fe(CN)_6]^{3-}$ is more stable than $[Fe(CN)_6]^{4-}$

(b) $[Fe(CN)_6]^{3-}$ is less stable than $[Fe(CN)_6]^{4-}$

(c) $[Fe(CN)_6]^{3-}$ gets easily oxidized to $[Fe(CN)_6]^{4-}$ in alkaline medium

(d) $[Fe(CN)_6]^{3-}$ is reduced to $[Fe(CN)_6]^{4-}$ in alkaline medium.

4. On going down the group from V to Nb, the metallic radius increases from 134 to 146 pm whereas the radius of Ta belonging to next higher period in the same group is the same as that of Nb. This is due to

(a) very poor shielding effect of *f*-electrons orbital

(b) high shielding effect of *f*-electrons orbital

(c) lanthanide contraction

(d) actinide contraction

5. Identify the correct statements of the following

(a) Transition metals have high enthalpies of sublimation

(b) The atomic sizes of third series of transition metals are not very much different from those of second series in respective groups

(c) Most of the transition metals of first series have negative reduction potentials and hence react readily with dilute acids to liberate H_2

(d) Cr, Mo and W are very hard metals because of greater number of covalent bonds involving unpaired electrons

6. Which of the follwoing statements is/are correct?

(a) Anhydrous ferric chloride can be obtained by heating hydrated ferric chloride

(b) A solution of ferric oxalate in dilute H_2SO_4 will decolorise $KMnO_4$

(c) Ferric salts are more stable than ferrous salts

(d) The Mohr's salt is resistant to oxidation by atmospheric oxygen

7. Which of the following ions disproportionate in aqueous solution?

(a) Cu^+ (b) Cu^{2+}

(c) Au^{3+} (d) Au^+

8. Fe(III) in solution can be detected by

(a) $K_3[Fe(CN)_6]$ (b) $K_4[Fe(CN)_6]$

(c) KSCN (d) NH_4SCN

9. Pick out the correct statements of the following

(a) Both Fe(II) and Fe(III) salts react with NO to give brown compound

(b) Fe(III) forms octahedral complexes but Fe(II) form either tetrahedral or square planar complexes

(c) Hexacyano ferrate(II) ion is diamagnetic but hexacyanoferrate(III) is paramagnetic

(d) $[Fe(H_2O)_6]^{3+}$ has greater degree of paramagnetism than $[Fe\ F_6]^{4-}$.

10. Which of the following statements is/are correct?

(a) Fe^{2+} and Fe^{3+} form octahedral complexes with NH_3

(b) A ferric chloride solution gives a brown turbidity on standing

(c) A pale yellow precipitate is formed when H_2S is passed through acidic solution of Fe(III)

(d) Mercury can not be transported in iron containers.

MARK YOUR RESPONSE	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ	5. ⓐⓑⓒⓓ
	6. ⓐⓑⓒⓓ	7. ⓐⓑⓒⓓ	8. ⓐⓑⓒⓓ	9. ⓐⓑⓒⓓ	10. ⓐⓑⓒⓓ

11. Which of the following complex ions that zinc can form

(a) $[Zn(CN)_6]^{4-}$ (b) $[Zn(CN)_4]^{2-}$

(c) $[Zn(NH_3)_4]^{2+}$ (d) $[Zn(CNS)_4]^{2-}$

12. Which of the following are correctly matched?

(a) $Hg_2Cl_2 \to$ corrosive sublimate

(b) $Hg_2Cl_2 \to$ calomel electrode

(c) $HgCl_2$+KI(excess) + $NH^{+}{}_{4} \to$ red precipitate

(d) $Hg_2Cl_2 \to$ purgative in medicine

13. Which of the following statements is/are true?

(a) Both Hg^{2+} and $Hg_2{}^{2+}$ ions show the divalency

(b) The ionization potentials of 12 group metals are fairly greater then those of coinage metals yet more reactive than the latter

(c) Ionization potential of Hg is smaller than that of Cd

(d) Zn, Cd and Hg exhibit positive oxidation potentials.

14. Pick out the correct statements of the following

(a) HgI_2 is red but turns yellow on heating above 400K

(b) HgI_2 is soluble in excess of I^- solution

(c) The interactions amongst Hg molecules are stronger than those between Hg and glass

(d) zinc oxide does not dissolve in excess of alkali solution.

15. NH_3 and its salts are identified by

(a) K_2HgI_4 and KOH

(b) $HgCl_2$ + KI(excess) + KOH

(c) $HgCl_2$ + KI(excess) + NH_4OH

(d) Hg_2Cl_2 + excess of NH_4OH

16. Which of the following statements is/are *not* correct about corrosive sublimate?

(a) Its aqueous solution gives red precipitate with KI (not in excess)

(b) It aqueous solution gives white precipitate with excess of $SnCl_4$

(c) It forms grey precipitate with excess of $SnCl_2$ solution

(d) It decomposes on heating to give Hg_2Cl_2 and Cl_2.

17. Which of the following is/are *not* thermally stable

(a) HgO (b) $HgCl_2$

(c) Hg_2Cl_2 (d) Fe_3O_4

18. For the equilibrium $Hg^{2+}_{2(aq)} \rightleftharpoons Hg_{(\ell)} + Hg^{2+}_{(aq)}$, the equilibrium constant is of the order of 10^3. It can be concluded that

(a) Hg(I) is fairly stable in aqueous solution

(b) Hg(I) in aqueous solution undergoes self reduction to Hg and oxidation to Hg^{2+}

(c) Addition of KCl causes the equilibrium to shift in left direction

(d) Addition of Hg(ℓ) makes the equilibrium to go in left direction.

19. Which of the following can be used for identification of ammonia and its salts ?

(a) $HgCl_2$ and NH_4Cl (b) KOH and K_2HgI_4

(c) Hg_2Cl_2 and NH_4OH

(d) $HgCl_2$, KI (excess) and KOH

20. Which of the following metal oxides decomposes on heating?

(a) HgO (b) Ag_2O

(c) ZnO (d) all of these

21. Choose the incorrect statement(s)

(a) Cinnabar is the chief ore of zinc

(b) Silver is extracted by Mac-Arther cyanide process

(c) Hypo is used in photography to remove unexposed silver bromide from the photographic film

(d) In Nessler's reagent zinc is present in +2 state

22. If we add a pinch of Na_2O_2 to an acidified solution of $K_2Cr_2O_7$ and shake it vigorously, we will observe

(a) a blue colour in solution

(b) bluish green precipitate

(c) the orange colour of $K_2Cr_2O_7$ solution changes to green

(d) evolution of oxygen gas

23. What for is copper pyrites roasted ?

(a) It is roasted for removal of moisture and volatile impurities present in it

(b) It is roasted to oxidise free sulphur present in it

(c) It is roasted to decompose pyrites into Cu_2S and FeS

(d) It is roasted to decompose Cu_2S into blister copper

24. Which of the following will give metal on heating ?

(a) Ag_2CO_3 (b) HgO

(c) $ZnCO_3$ (d) CuO

MARK YOUR RESPONSE	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ	14. ⓐⓑⓒⓓ	15. ⓐⓑⓒⓓ
	16. ⓐⓑⓒⓓ	17. ⓐⓑⓒⓓ	18. ⓐⓑⓒⓓ	19. ⓐⓑⓒⓓ	20. ⓐⓑⓒⓓ
	21. ⓐⓑⓒⓓ	22. ⓐⓑⓒⓓ	23. ⓐⓑⓒⓓ	24. ⓐⓑⓒⓓ	

E

MATRIX-MATCH TYPE

Each question contains statements given in two columns, which have to be matched. The statements in Column-I are labeled A, B, C and D, while the statements in Column-II are labelled p, q, r, s and t. Any given statement in Column -I can have correct matching with ONE OR MORE statement(s) in Column-II. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following example:
If the correct matches are A–p, s and t; B–q and r; C–p and q; and D–s then the correct darkening of bubbles will look like the given.

	p	q	r	s	t
A	●	ⓠ	ⓡ	●	●
B	ⓟ	●	●	ⓢ	ⓣ
C	●	●	ⓡ	ⓢ	ⓣ
D	ⓟ	ⓠ	ⓡ	●	ⓣ

1. **Match the following :**

Column I		**Column II**
(A) $[Cu(NH_3)_4]Cl$	p.	Deep blue
(B) $[Cu(NH_3)_4]Cl_2$	q.	Colourless
(C) $[CuCl_4]^{3-}$	r.	Diamagnetic
(D) $K_3[Cu(CN)_4]$	s.	Paramagnetic

2. For the reaction $Hg^{2+}_{2(aq)} \rightleftharpoons Hg_{(\ell)} + Hg^{2+}_{(aq)}$ equilibrium constant is of the order of 10^3. Based upon this match the following :

Column I		**Column II**
(A) $Hg^{2+}_{2(aq)}$	p.	Equilibrium shifts in left direction
(B) $Hg^{2+}_{(aq)}$	q	No effect
(C) Addition of Cl^- to equilibrium	r.	Stable
(D) Addition of $Hg_{(l)}$ to equilibrium	s	Unstable

3. To $HgCl_{2(aq)}$ the reagents listed in Column I are added. Match the observations listed in Column II.

Column I		**Column II**
(A) $KI_{(aq)}$ (not in excess)	p.	Brown red precipitate
(B) $KI_{(aq)}$ (excess)	q.	Dark red precipitate
(C) $KI_{(aq)}(excess) + KOH_{(aq)} + NH^+_{4(aq)}$	r.	Grey precipitate
(D) $SnCl_{2(aq)}$ (excess)	s.	Colourless solution

MARK YOUR RESPONSE

1.

	p	q	r	s
A	ⓟ	ⓠ	ⓡ	ⓢ
B	ⓟ	ⓠ	ⓡ	ⓢ
C	ⓟ	ⓠ	ⓡ	ⓢ
D	ⓟ	ⓠ	ⓡ	ⓢ

2.

	p	q	r	s
A	ⓟ	ⓠ	ⓡ	ⓢ
B	ⓟ	ⓠ	ⓡ	ⓢ
C	ⓟ	ⓠ	ⓡ	ⓢ
D	ⓟ	ⓠ	ⓡ	ⓢ

3.

	p	q	r	s
A	ⓟ	ⓠ	ⓡ	ⓢ
B	ⓟ	ⓠ	ⓡ	ⓢ
C	ⓟ	ⓠ	ⓡ	ⓢ
D	ⓟ	ⓠ	ⓡ	ⓢ

4. **Match the following :**

Column I	**Column II**
(A) $[Fe(CN)_6]^{4-}$	p. sp^3d^2 hybridization
(B) $[Fe(CN)_6]^{3-}$	q. d^2sp^3 hybridization
(C) $[Fe(H_2O)_6]^{3+}$	r. Diamagnetic
(D) $[FeF_6]^{4-}$	s. Paramagnetic

5. Match the reagents listed in Column II that can be used to estimate the compounds listed in Column I.

Column I	**Column II**
(A) $FeO.Fe_2O_3$	p. Iodometrically with $Na_2S_2O_3$
(B) FeC_2O_4	q. NaCl
(C) $CuSO_4$	r. $KMnO_4$ in acidic medium
(D) $AgNO_3$	s. $K_2Cr_2O_7$ in acidic medium

6.

Column - I	**Column - II**
(A) TiO	p. Ferromagnetic substance
(B) CrO_2	q. Antiferromagnetic substance
(C) ZnO	r. Resultant magnetic moment is zero
(D) MnO	s. Paramagnetic nature

7.

Column - 1	**Column - II**
(A) Left behind as waste in Kipp's apparatus	p. Mohr's salt
(B) It is green in colour	q. Green vitriol
(C) On heating it leaves a residue that is brown in colour	r. Basic copper carbonate
(D) On heating it leaves a residue that is black in colour	s. Hydrated cupric chloride

MARK YOUR RESPONSE

4.

	p	q	r	s
A	ⓟ	ⓠ	ⓡ	ⓢ
B	ⓟ	ⓠ	ⓡ	ⓢ
C	ⓟ	ⓠ	ⓡ	ⓢ
D	ⓟ	ⓠ	ⓡ	ⓢ

5.

	p	q	r	s
A	ⓟ	ⓠ	ⓡ	ⓢ
B	ⓟ	ⓠ	ⓡ	ⓢ
C	ⓟ	ⓠ	ⓡ	ⓢ
D	ⓟ	ⓠ	ⓡ	ⓢ

6.

	p	q	r	s
A	ⓟ	ⓠ	ⓡ	ⓢ
B	ⓟ	ⓠ	ⓡ	ⓢ
C	ⓟ	ⓠ	ⓡ	ⓢ
D	ⓟ	ⓠ	ⓡ	ⓢ

7.

	p	q	r	s
A	ⓟ	ⓠ	ⓡ	ⓢ
B	ⓟ	ⓠ	ⓡ	ⓢ
C	ⓟ	ⓠ	ⓡ	ⓢ
D	ⓟ	ⓠ	ⓡ	ⓢ

Answerkey

A Single Correct Choice Type

1.	c	**2.**	b	**3.**	d	**4.**	c	**5.**	d	**6.**	d	**7.**	c	**8.**	d	**9.**	a	**10.**	b
11.	c	**12.**	d	**13.**	c	**14.**	d	**15.**	b	**16.**	c	**17.**	c	**18.**	d	**19.**	c	**20.**	a
21.	a	**22.**	d	**23.**	b	**24.**	c	**25.**	c	**26.**	c	**27.**	d	**28.**	c	**29.**	c	**30.**	b
31.	d	**32.**	c	**33.**	d	**34.**	d	**35.**	d	**36.**	a	**37.**	d	**38.**	b	**39.**	c	**40.**	d
41.	c	**42.**	c	**43.**	c	**44.**	c	**45.**	c	**46.**	d	**47.**	d	**48.**	a	**49.**	d	**50.**	c
51.	c	**52.**	b	**53.**	c	**54.**	d	**55.**	a	**56.**	c	**57.**	b	**58.**	d	**59.**	c	**60.**	c
61.	d	**62.**	d	**63.**	b	**64.**	c	**65.**	c	**66.**	d	**67.**	d	**68.**	d	**69.**	d	**70.**	c
71.	b	**72.**	c	**73.**	b	**74.**	c	**75.**	b	**76.**	c	**77.**	d	**78.**	c	**79.**	c	**80.**	c
81.	c	**82.**	d	**83.**	c	**84.**	d	**85.**	c	**86.**	d	**87.**	a	**88.**	b	**89.**	c	**90.**	b
91.	b	**92.**	d	**93.**	a	**94.**	d	**95.**	c	**96.**	d	**97.**	d	**98.**	b	**99.**	c	**100.**	c
101.	d	**102.**	c	**103.**	a	**104.**	c	**105.**	d	**106.**	d	**107.**	c	**108.**	c	**109**	b	**110.**	d
111.	c	**112.**	b	**113.**	d	**114.**	a	**115.**	a	**116.**	d	**117.**	a	**118.**	d	**119.**	b	**120.**	b
121.	a	**122.**	d	**123.**	b	**124.**	c	**125.**	b	**126.**	b								

B Comprehension Type

1	d	**4**	d	**7**	b	**10**	b	**13**	c	**16**	a
2	d	**5**	b	**8**	d	**11**	c	**14**	a	**17**	b
3	b	**6**	a	**9**	b	**12**	d	**15**	a	**18**	a

C Reasoning Type

1	b	**5**	c	**9**	a	**13**	b	**17**	d
2	b	**6**	a	**10**	b	**14**	a	**18**	a
3	d	**7**	b	**11**	a	**15**	b	**19**	b
4	a	**8**	b	**12**	b	**16**	a		

D Multiple Correct Choice Type

1.	b, c	**2.**	a, b, d	**3.**	b, d	**4.**	a, c	**5.**	a,b,c, d	**6.**	b, c, d	**7.**	a, d	**8.**	b, c, d	**9.**	c, d	**10.**	b, c
11.	b, c, d	**12.**	b, d	**13.**	a, b	**14.**	a, b, c	**15.**	a, b	**16.**	b, d	**17.**	a, c, d	**18.**	b, c,	**19.**	b, c	**20.**	a, b
21.	a, b	**22.**	a, d	**23.**	a, b, c	**24.**	a, b												

E Matrix-Match Type

1. **A-q, r; B-p, s; C-q, r; D-q, r**

2.. **A-s; B-r; C-p; D-q**

3. **A-q; B-s; C-p; D-r**

4. **A-q, r; B-q, s; C-p, s; D-p, s**

5. **A-r, s; B-r, s; C-p; D-q**

6. **A-s; B-p, s; C-r; D-q, r**

7. **A-q; B-p, q, r, s; C-p, q; D-r**

Solutions

A SINGLE CORRECT CHOICE TYPE

4. **(c)** ZnO is amphoteric i.e., reacts with acid as well as alkali.

$$ZnO + 2H_2SO_4 \longrightarrow ZnSO_4 + 2H_2O;$$

$$ZnO + 2NaOH \longrightarrow Na_2ZnO_2 + H_2O$$

5. **(d)** Al^{3+} has no unpaired d -electrons.

6. **(d)** Fe^{2+} : [Ar] $3d^6$. (6 d-electrons) ; p-electrons in Cl = 11

8. **(d)** Fe^{3+} : [Ar] $3d^5$. Half filled d-subshell is very much stable.

9. **(a)** Ti = [Ar] $3d^2 4s^2$; The highest oxidation state will be + 4.

10. **(b)** $E^\circ_{Cr_2O_7^{2-}/Cr^{3+}} = 1.33\ V;\ E^\circ_{CrO_4^{2-}/Cr^{3+}} = -0.11\ V$

11. **(c)** Atomic number of the element = 42 – 18 = 24 (chromium).

12. **(d)** Cu^{2+} has one unpaired electron ($3d^9$).

16. **(c)** $K_2Cr_2O_7 + 6H_2SO_4 + 4KCl \longrightarrow 2KHSO_4$

$$+ 4NaHSO_4 + 2CrO_2Cl_2 + 3H_2O$$

17. **(c)** $CrO_2Cl_2 + 4NaOH \longrightarrow Na_2CrO_4$

$$+ 2NaCl + 2H_2O;$$

$Na_2CrO_4 + 2AgNO_3 \rightarrow 2NaNO_3 + Ag_2CrO_4$ (brick red ppt.)

18. **(d)** See Q. 16.

19. **(c)** $2MnO_4^- + I^- + H_2O \longrightarrow 2OH^- + 2MnO_2 + IO_3^-$

23. **(b)** Aqueous solution of CrO_3 is highly acidic and hence the following equilibrium shifts in forward direction.

$$2CrO_4^{2-} + 2H^+ \longrightarrow Cr_2O_7^{2-} + H_2O$$

24. **(c)** $CrO_{4(aq)}^{2-} + 4H_2O + 3e^- \longrightarrow Cr(OH)_3 + 5OH^-,$

$E^\circ = -0.13V$

$Cr_2O_{7(aq)}^{2-} + 14H_{(aq.)}^+ + 6e^- \longrightarrow 2Cr_{(aq)}^{3+} + 7H_2O,$

$E^\circ = 1.33V$

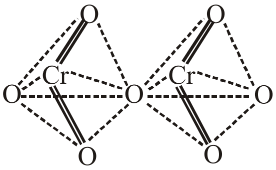
25. **(c)** $E^\circ_{MnO_4^-/Mn^{2+}}$ (acidic medium) = 1.51V ; $E^\circ_{MnO_4^-/MnO_2}$ (alkaline medium) = 0.60 V

$E^\circ_{MnO_4^-/MnO_4^{2-}}$ (neutral medium) = 0.56 V

26. **(c)** O.N. of Fe in $(Fe(CN)_6]^{4-}$ ion = +2 ; configuration of Fe(II) = $3d^6$; $n = 4$

27. **(d)** Number of unpaired electrons in Cr, Mn^{2+} and Fe^{3+} are 6, 5 and 5 respectively.

29. **(c)** $Cr_2O_7^{2-} + 4O_2^{2-} + 10H^+ \longrightarrow 2CrO_5$ (deep blue) + $5H_2O$

30. **(b)** 

Structure of dichromate ion

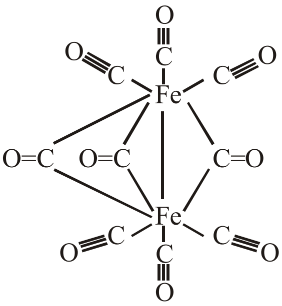
31. **(d)** Fe(II), and not Fe(III), is oxidised by acidified $KMnO_4$ or $K_2Cr_2O_7$.

32. **(c)** Only the Mohr's salt, containing Fe(II), is a substance of primary standard.

34. **(d)** Iron becomes passive on treatment with conc. HNO_3 or acidified $KMnO_4$, H_2O_2 or H_2CrO_4.

35. **(d)** Fe(III) gives red colour with CNS^- ion.

37. **(d)** I^- ion reduces Fe(III) to Fe(II). $FeI_3 \rightarrow FeI_2 + ½\ I_2$

38. **(b)** 

39. **(c)** Non-stoichiometric compound FeO is metal deficient solid.

40. **(d)** $FeCO_3 \xrightarrow{\Delta} FeO + CO_2;\ Fe_3O_4$ and $FeO \xrightarrow{\Delta} Fe_2O_3$

42. **(c)** Cr and Mn show the highest oxidation states to be + 6 and + 7 respectively.

43. **(c)** I^- ion is a stronger reducing agent than Cl^- ion. It reduces Cu^{2+} ion to Cu^+ ion. Thus, CuI_2 is reduced to CuI and the species $(CuI_4)^{2-}$ does not exist.

44. **(c)** Cu^+ ion in aqueous solution disproportionates to $Cu_{(s)}$ and $Cu^{2+}_{(aq)}$.

45. **(c)** In acidic medium, ionization of H_2S is supressed due to common ion effect of H^+ ion. As a result, $[S^{2-}]$ is not sufficient to cause precipitation of MnS with high K_{sp} value.

47. **(d)** MgO dissolves in HCl but not in NaOH solution.

49. **(d)** Due to lanthanide contraction, second and third series transition metals in respective groups have nearly the same atomic sizes.

50. **(c)** Lesser is the oxidation state of the metal in its oxide, more basic will be the oxide.

52. **(b)** Mn^{2+} $(3d^5)$ is more stable them Mn^{3+} $(3d^4)$.

55. **(a)** $2Cr(OH)_3 + 4NaOH + 3H_2O_2 \longrightarrow 2Na_2CrO_4 + 8H_2O$

58. **(d)** $2CuSO_4 + K_4[Fe(CN)_6] \longrightarrow Cu_2[Fe(CN)_6] + 2K_2SO_4$

61. **(d)** The liberated iodine is titrated with a standard hypo solution.

$$I_2 + 2Na_2S_2O_3 \longrightarrow Na_2S_4O_6 + 2NaI$$

63. **(b)** $2Cu^{2+} + 4CN^- \longrightarrow Cu_2(CN)_2 + (CN)_2$;

$$Cu_2(CN)_2 + 6CN^- \longrightarrow 2[Cu(CN)_4]^{3-}$$

65. **(c)** $2CuSO_4 + 4KI \longrightarrow Cu_2I_2 + 2K_2SO_4 + I_2$;

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

66. **(d)** $CuSO_4 + Na_2S_2O_3 \longrightarrow CuS_2O_3 + Na_2SO_4$

$$2CuS_2O_3 + Na_2S_2O_3 \longrightarrow Cu_2S_2O_3 + Na_2S_4O_6$$

$$3Cu_2S_2O_3 + 2Na_2S_2O_3 \longrightarrow Na_4[Cu_6(S_2O_3)_5]$$

70. **(c)** $2AgNO_3 \xrightarrow{\Delta} 2AgNO_2 + O_2$ (above the melting point)

72. **(c)** F^- ion has quite high heat of hydration.

74. **(c)** The complex ion $[Ag(CN)_2]^{2-}$ is very stable and gives very small concentration of Ag^+. With the result, slow and uniform deposition of silver takes place.

$$[Ag(CN)_2]^{2-} \rightleftharpoons Ag^+ + 2CN^-$$

78. **(c)** $\underset{\text{light blue}}{Cu(OH)_2} \xrightarrow{\Delta} \underset{\text{black}}{CuO} + H_2O$; $2CuO + \text{glucose} \longrightarrow \underset{\text{red}}{Cu_2O}$

79. **(c)** $CuSO_4 + 2KI \longrightarrow CuI_2 + K_2SO_4$;

$$2CuI_2 \longrightarrow Cu_2I_2 + I_2$$

$$I_2 + 2Na_2S_2O_3 \longrightarrow Na_2S_4O_6 + 2NaI$$

80. **(c)** $2Au^{3+} + 6e^- \longrightarrow 2Au,\ \Delta G^\circ = -6 \times 1.52F$ ......(i)

$$3Au^{3+} + 6e^- \longrightarrow 3Au^+,\ \Delta G^\circ = -6 \times 1.36F \text{ ......(ii)}$$

For the reaction $3Au^+ \longrightarrow 2Au + Au^{3+}, \Delta G^\circ$ = (i) – (ii) $= 8.16F - 9.12F = -0.96F$ (negative)

84. **(d)** $2Fe^{3+} + 2I^- \longrightarrow 2Fe^{2+} + I_2$

85. **(c)** Hydrated ferrous sulphate acquires brownish-yellow colour due to the formation of basic ferric sulphate by atmospheric oxygen.

$$4FeSO_4 + 2H_2O + O_2 \longrightarrow 4Fe(OH)SO_4$$

90. **(b)** $SnCl_{2(aq)} + 2HgCl_{2(aq)} \longrightarrow SnCl_{4(aq)} + Hg_2Cl_{2(s)}$

92. **(d)** Metals of 12 group and their ions (M^{2+}) do not have unpaired electrons.

95. **(c)** Smaller is the ionization energy of a metal to give a particular oxidation state, greater will be thermodyramic stability of that oxidation state.

97. **(d)** O.N. of Cr in all the species is + 6. Configuration of Cr (VI) is (Ar) $3d^0$. Hence no *d-d* electron transition.

99. **(c)** Other chlorides are not volatile enough to form CrO_2Cl_2.

102. **(c)** Mn (VI) disproportionates to Mn (VII) and Mn (IV) even in weakly acidic solution.

103. **(a)** $HMnO_4$ (Permanganic acid) is known only in solution.

104. **(c)** $FeSO_4 . 7H_2O$ is oxidised by oxygen of air and hence its composition changes with time.

$$4FeSO_4 + 2H_2O + O_2 \longrightarrow 4Fe(OH)SO_4$$

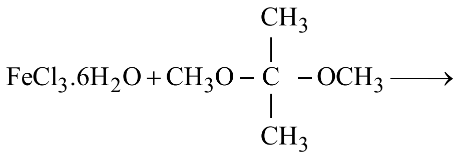
107. **(c)** This is due to lanthanide contraction associated with the filling of 4*f* subshell.

109. **(b)** HNO_3 is added to oxidise Fe^{2+} to Fe^{3+}.

110. **(d)** KNO_3 is added to oxidise the lead and zinc impurities.

111. **(c)** The bond length O – O decreases due to change of O_2^{2-} (ligand in initial complex) to O_2^- (ligand in oxidised complex).

112. **(b)**



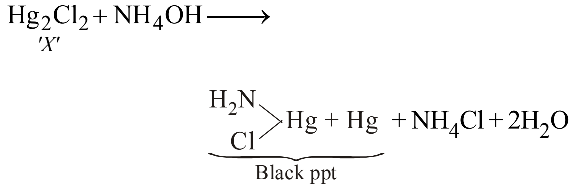
$$FeCl_3.6H_2O + CH_3O - \underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}} - OCH_3 \longrightarrow$$

$$FeCl_3 + 12CH_3OH + 6CH_3COCH_3$$

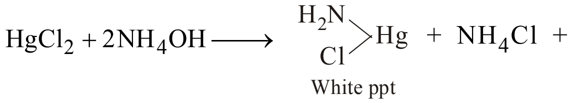
113. **(d)** $\underset{+2}{Cu^{2+}} + Fe \longrightarrow Fe^{2+} + \underset{0}{Cu}$

$$\underset{+2}{2Cu^{2+}} + 2KI \longrightarrow \underset{+1}{2Cu^+} + 2K^+ + I_2$$

114. (a)



$$\underset{'X'}{Hg_2Cl_2} + NH_4OH \longrightarrow \underbrace{\begin{matrix}H_2N\\Cl\end{matrix}{>}Hg + Hg}_{\text{Black ppt}} + NH_4Cl + 2H_2O$$



$$HgCl_2 + 2NH_4OH \longrightarrow \underset{\text{White ppt}}{\begin{matrix}H_2N\\Cl\end{matrix}{>}Hg} + NH_4Cl +$$

$2H_2O$

115. (a) Paramanganic moment is directly proportional to number of unpaired electrons present in the complex.

116. (d) Stirring is needed for reduction of Au (III) in $AuCl_4^-$ at the electrode.

117. (a) $Fe^{3+}(aq) + SCN^-(aq) \longrightarrow \underset{\text{Red}}{[Fe(SCN)]^{2+}(aq)}$

$Fe^{3+}(aq) + 3OH^-(aq) \longrightarrow \underset{\text{Brown}}{[Fe(OH)_3](s)}$

118. (d) Considering the size of metal atom we find that it decreases in the order Ti, V, Cr, Fe (atomic number increases). The basic character of monoxides also decreases in the same order as their atomic size.

119. (b) During complex formation, the transition metal atom is most likely to act as **Lewis acid** and the ligand acts as **Lewis base**.

120. (b) In AgO, Ag is in +2 state. Its configuration is $4d^9$ (Ag being $4d^{10}5s^1$). Thus in Ag^{2+} we find one unpaired electron and so it (AgO) will show paramagnetic nature.

121. (a) The reason for existence of mercury metal in liquid state even at 0°C is its very high ionisation energy and presence of weak metallic bond because of absence of unpaired electrons.

122. (d) The conversion of metal or its ore to metal chloride by heating metal or its ore with a chloride salt is called chlorodising roasting.

123. (b) The major deciding factor is the value of crystal field stabilisation energies in octahedral field and tetrahedral field.

124. (c) $Cr_2O_3.2H_2O$ is known as Guigret's green.

125. (b) The percentage of pure gold in 22-carat gold

$$= \frac{22}{24} \times 100 = 91.7\%$$

B COMPREHENSION TYPE

1. (d) Coloured complexes are a well known characteristics of most transition metals.

2. (d) H_2S gas, found is small amounts in air, reacts with silver to form black Ag_2S which tarnishes silverware.

3. (b) (i) $H_2S(aq) \rightleftharpoons 2H^+ + S^{2-}$;

$K_a = K_{a(1)} \times K_{a(2)} = 9.1 \times 10^{-8} \times 1.2 \times 10^{-15} = 1.1 \times 10^{-22}$

(ii) $HCN \rightleftharpoons H^+ + CN^-$; $K_a = \sim 10^{-10}$

On addition of protons (H^+ ions), equilibrium (i) is shifted to left heavily than (ii) resulting in the decrease in S^{2-} ion concentration. According to Le-Chatelier's principle, Reaction - 1 is shifted to the right to counteract the loss of sulphide ions.

4. (d) For a system (chemical or physical) in equilibrium, $\Delta G = 0$

5. (b) Mass of Ag_2S required

$$= \frac{\text{Molar mass of } Ag_2S \times 12}{2 \times 108} = 13.8\,g$$

$(2Ag^+ + S^{2-} \longrightarrow Ag_2S)$

7. (b) Sulphide ion has higher affinity for Ag^+ than CN^-. Hence, when S^{2-} is added to $[AgCN)_2]^-$, Ag_2S will be precipitated. S^{2-} ions will form no precipitate with $[Ag(EDTA)]^-$ because EDTA has greater affinity for Ag^+ as compared to S^{2-}.

8. (d) $Mn^{2+}(25): [Ar]\ 3d^5$; 5 unpaired electrons and hence highest magnetic moment.

9. (b) $Cu^{2+}(29): [Ar]\ 3d^9$ (coloured); $Ti^{4+}(22): [Ar]\ 3d^0$ (colourless)

$Co^{2+}(27): [Ar]\,3d^7$ (coloured); $Fe^{2+}(26): [Ar]\ 3d^6$ (coloured)

10. (b) Magnetic moment $= \sqrt{n(n+2)} = \sqrt{15}$ B.M. (given)

$\Rightarrow n = 3$

11. (c) $Ti^{4+}(22)$ in TiF_6^{2-} : $[Ar]\ 3d^0$ (colourless)

$Co^{3+}(27)$ in CoF_6^{3-} : $[Ar]\ 3d^6$ (coloured)

Cu^{+} (29) in Cu_2Cl_2 : [Ar] $3d^{10}$ (colourless)

Ni^{2+} (28) in $NiCl_4^{2-}$: [Ar] $3d^{8}$ (coloured)

12. **(d)** If $(n-1)d$-subshell is either empty or completely filled, no $d-d$ transition is possible and hence no absorption of light in visible region.

13. **(c)** It is amphoteric in nature as it shows reaction both with acid [i.e., HCl. (aq)] and alkali [i.e., NaOH (aq)].

14. **(a)** ZnO shows yellow colour on heating and becomes white on cooling.

15. **(a)** $ZnO + 2HCl(aq) \longrightarrow \underset{\text{(Soluble)}}{ZnCl_2(aq)} + H_2O$

16. **(a)** The green colour is due to presence of MnO_4^{2-} which changes to MnO_4^{-} which has a purple colour.

$$\underset{\substack{\text{(green)}\\ Mn^{+6}}}{3K_2MnO_4} + 2H_2O + 4CO_2 \longrightarrow$$

$$\underset{\substack{\text{(purple)}\\ Mn^{+7}}}{2KMnO_4} + \underset{Mn^{+4}}{MnO_2} + 4KHCO_3$$

17. **(b)** The brown solid is MnO_2.

18. **(a)** Its function is to make solution acidic.

C Reasoning Type

1. **(b)** $KMnO_4$ is stored in dark bottles because it is decomposed in light.

2. **(b)** It is due to lanthanide contraction.

3. **(d)** In actual practice transition metals react with acid very slowly and act as poor reducing agents. This is due to the protection of metal as a result of formation of thin oxide protective film. Further, their poor tendency as reducing agent is due to high ionisation energy, high heat of vapourization and low heat of hydration.

4. **(a)** Zinc in presence of moist air is coated by a thin film of its basic carbonate on its surface and becomes dull.

$$4Zn + 3H_2O + 2O_2 + CO_2 \rightarrow ZnCO_3.3Zn(OH)_2$$

5. **(c)** Rusting involves reduction of absorbed oxygen to OH^- ions and oxidation of iron to Fe^{2+} ions. The two ions combine to yield $Fe(OH)_2$ which gets oxidised to give $Fe_2O_3.nH_2O$ (rust). The presence of acid helps dissolution of pure iron to ferrous ions while electrolytes increase the conductivity and assist cell reaction.

6. **(a)** Hydration energy of AgF is appeciably higher than its lattice energy because of smaller F^- ion and thus AgF is soluble in water.

7. **(b)** $FeCl_3$ in water show acidic nature because of hydrolysis of F^{3+}

$$Fe^{3+} + 3H_2O \rightarrow Fe(OH)_3 + 3H^+$$

8. **(b)** Hydrated solution of $FeCl_3$ gets converted into brown $Fe_2O_3.xH_2O$ due to hydrolysis.

$$FeCl_3 + 3H_2O \rightarrow Fe(OH)_3 + 3HCl$$

$$2\,Fe(OH)_3 \rightarrow Fe_2O_3 + 3H_2O$$

9. **(a)** *ns* are electrons in transition elements experience lesser effective nuclear charge than $(n-1)$ d electrons and hence lost first in ionization.

10. **(b)** Complex ion formation is a typical property of transition elements because they posses small size, high nuclear charge, and vacant d-orbitals of equivalent energy.

11. **(a)** The element which can reduce itself acts as an oxidising agent.

12. **(b)** The magnetic moments are lesser than the theoetically predicted values. This is due to the fact that $5f$ electrons of actinides are less effectively shielded which result in quenching of orbital contribution.

13. **(b)** The higer the charge on the metal ion, smaller is the ionic size and more is the complex forming ability. Thus, the degree of complex formation decreases in the order $M^{4+} > MO_2^{2+} > M^{3+} > MO_2^{+}$. The higher tendency of complex formation of MO_2^{2+} as compared to M^{3+} is due to high concentration of charge on metal atom M in MO_2^{2+}.

14. **(a)** Because of hygroscopic nature the composition of $Na_2Cr_2O_7$ is not precisely known. Hence it is not a substance of primary standard to prepare a standard solution by weighing.

15. **(b)** Both assertion and reason are correct but reason is not the correct explanation of assertion. The correct explanation is that it is due to auto-catalysis, Mn^{2+} formed being auto-catalyst.

16. **(a)** Both assertion and reason are true and reason is the correct explanation of assertion.

17. **(d)** Assertion is wrong. Reason is correct. The orange colour of $K_2Cr_2O_7$ is due to $Cr_2O_7^{2-}$ ions.

18. **(a)** Both assertion and reason are true and reason is the correct explanation of assertion.

19. **(b)** Both assertion and reason are true but reason is not the correct explanation of assertion.

D MULTIPLE CORRECT CHOICE TYPE

1. **(b, c)** Magnetic moment

$$= 2\sqrt{S(S+1)} = \sqrt{n(n+2)} \ ; \ S = \frac{n}{2}$$

2. **(a, b, d)** $Fe_2(C_2O_4)_3 \xrightarrow{\text{Light}} 2FeC_2O_4 + 2CO_2$

$$3FeC_2O_4 + 2K_3[Fe(CN)_6] \longrightarrow \underset{\text{Blue coloured}}{Fe_3[Fe(CN)_6]_2} + 3K_2C_2O_4$$

6. **(b,c,d)** (a) Hydrated ferric chloride ($FeCl_3.6H_2O$) upon heating gets hydrolysed by its own molecules of water of crystallisation to give $Fe(OH)_3$, which changes to Fe_2O_3 on further heating. Hence, (a) is not true.

$$FeCl_3.6H_2O \longrightarrow Fe(OH)_3 + 3HCl + 3H_2O$$

$$2Fe(OH)_3 \longrightarrow Fe_2O_3 + 3H_2O$$

(b) $C_2O_4^{2-}$ ion gets oxidized by acidified $KMnO_4$ resulting in decolorization of the latter.

$$C_2O_4^{2-} \rightarrow 2CO_2 + 2e^-$$

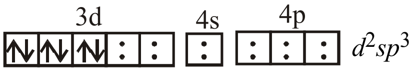
$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$

Thus (b) is true.

(c) Fe^{3+} salts are more stable than ferrous salts because Fe^{2+} easily oxidised by air.

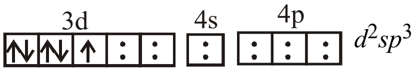
(d) Mohr's salt is resistant to aerial oxidation.

9. **(c, d)** $[Fe(CN)_6]^{4-}$



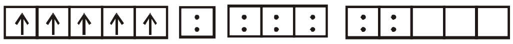
No unpaired electron(s)

$[Fe(CN)_6]^{3-}$



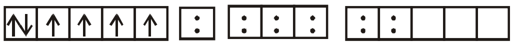
One unpaired electron

$[Fe(H_2O)_6]^{3+}$



sp^3d^2 hybridization

$[FeF_6]^{4-}$



sp^3d^2 hybridization

10. **(b, c)** (b)$FeCl_3$ hydrolyses on standing.

$$FeCl_3 + 3H_2O \longrightarrow Fe(OH)_{3(s)} + 3HCl$$

(c) $2FeCl_3 + H_2S \longrightarrow 2FeCl_2 + 2HCl + S$

12. **(b,d)** $HgCl_2$ + KI (excess) + KOH (Nessler's reagent) gives red precipitate with NH_3 or NH_4^+ ion.

13. **(a,b)** (a) $^+Hg - Hg^+$ is also a divalent ion.

(b) Except Hg, oxidation potentials of zinc and cadmium are positive and hence are more reactive than coinage metals (negative oxidation potentials).

14. **(a, b, c)** (a) HgI_2 exists in two forms, red and yellow

(b) $HgI_{2(s)} + 2I^-_{(aq)} \longrightarrow [HgI_4]^{2-}_{(aq)}$

15. **(a, b)** [K_2HgI_4+KOH] and [$HgCl_2$+KI (excess) + KOH] are Nessler's reagent which gives brown precipitate of $H_2N - Hg - O - Hg - I$ (iodide of Millon's base).

16. **(b,d)** (a) $HgCl_{2(aq)} + 2KI_{(aq)}$ (not in excess) $\rightarrow 2KCl_{(aq)}$ + $Hg\ I_{2(s)}$ (red ppt.)

(b) No reaction of $SnCl_4$ with $HgCl_2$.

(c) $HgCl_2 + SnCl_2 \rightarrow Hg_2Cl_2 + SnCl_4$;
$Hg_2Cl_2 + SnCl_2 \rightarrow 2Hg + SnCl_4$;
$Hg_2Cl_2 + Hg_{(\ell)}$ appears grey.

(d) $HgCl_2$ is thermally stable.

17. **(a, c, d)** (a) $HgO \xrightarrow{\Delta} Hg + \frac{1}{2}O_{2(g)}$

(b) $Hg_2Cl_2 \xrightarrow{\Delta} Hg + HgCl_2$

(c) $2Fe_3O_4 + \frac{1}{2}O_2(\text{air}) \xrightarrow{\Delta} 3Fe_2O_3$

18. **(b, c)** $Cl^-_{(aq)}$ from KCl combines with $Hg^{2+}_{2(aq)}$ to form $Hg_2Cl_{2(s)}$ with the result the equilibrium shifts in backward direction. Addition of $Hg_{(\ell)}$ causes no change in active mass of mercury and hence no effect.

19. **(b,d)** In both cases we will get brown ppt. due to formation of **Millon's base** ($H_2N-Hg-O-Hg-I$).

20. **(a,b)** Both these decompose on heating.

21. **(a,b)** Cinnabar is **not** an ore of zinc; zinc is **not** present in Nessler's reagent.

22. **(a,d)** The blue green appears due to the formation of CrO_5

$$\underset{\text{(Orange)}}{Cr_2O_7^2} + 10H^+ + 4Na_2O_2 \longrightarrow \underset{\text{(Blue)}}{CrO_5} + 8Na^+ + 5H_2O$$

In the absence of ether or amyl alcohol CrO_5 in acidic medium decomposes to give Cr^{3+} with the evolution of oxygen.

$$\underset{\text{(Blue)}}{4CrO_5} + 12H^+ \longrightarrow \underset{\text{(green)}}{4Cr^{3+}} + 7O_2 + 6H_2O$$

23. **(a,b,c)** When copper pyrites is roasted, it removes moisture and volatile impurities present in it. It also oxidises any free sulphur present in it as impurity and the pyrite decomposes to give Cu_2S and FeS.

E MATRIX-MATCH TYPE

1. **A-q, r; B-p, s; C-q, r; D-q, r**

(A) $[Cu(NH_3)_4]Cl$: $Cu^+ - 3d^{10}$ (colourless, diamagnetic)

(B) $[Cu(NH_3)_4]Cl_2$: $Cu^{2+} - 3d^9$ (one unpaired electron, deep blue, paramagnetic)

(C) $[Cu(Cl_4)]^{3-}$: $Cu^+ - 3d^{10}$ (colurless, diamagnetic)

(D) $K_3[Cu(CN)_4]$: $Cu^+ - 3d^{10}$ (colourless, diamagnetic)

2.. **A-s; B-r; C-p; D-q**

(A) Since *K* for $Hg_{2(aq)}^{2+} \longrightarrow Hg_{(aq)}^{2+} + Hg_{(\ell)}$ is of the order of 10^3, $Hg_{2(aq)}^{2+}$ is unstable and disproportionates to $Hg_{(aq)}^{2+}$ and $Hg_{(\ell)}$.

(B) $Hg_{(aq)}^{2+}$ is stable; *K* for reverse reaction is of the order of 10^{-3}.

(C) On addition of Cl^- ion, $Hg_2Cl_{2(s)}$ is precipitated out. Hence the equilibrium would shift to left direction.

(D) On addition of $Hg_{(\ell)}$, active mass of $Hg_{(\ell)}$ remains unchanged (= unity). Hence no effect.

3. **A-q; B-s; C-p; D-r**

(A) $HgCl_{2(aq)} + 2KI_{(aq)}$ (not in excess) $\longrightarrow$

$HgI_{2(s)}$ (Dark red) $+ 2KCl_{(aq)}$

(B) $HgCl_{2(aq)} + 4KI_{(aq)}$ (excess) $\longrightarrow$

$K_2[HgI_4] + 2KCl_{(aq)}$

(C) $K_2HgI_4 + 4KOH + NH_4Cl \longrightarrow$

$\rightleftharpoons H_2N - Hg - O - Hg - I + 7KI + KCl + 3H_2O$

(D) $2HgCl_{2(aq)} + SnCl_2 \longrightarrow Hg_2Cl_{2(s)} + SnCl_4$

$Hg_2Cl_{2(aq)} + SnCl_2 \longrightarrow Hg_{(\ell)} + SnCl_4$

4. **A-q, r; B-q, s; C-p, s; D-p, s**

(A) $[Fe(CN)_6]^{4-}$: $Fe^{2+} - 3d^6 (d^2sp^3)$, (No unpaired electrons diamagnetic)

(B) $[Fe(CN)_6]^{3-}$: $Fe^{3+} - 3d^5$ (d^2sp^3), one unpaired electron (paramagnetic)

(C) $[Fe(H_2O)_6]^{3+}$: $Fe^{3+} - 3d^5 (sp^3d^2)$, 5 unpaired electrons (paramagnetic)

(D) $(FeF_6)^{4-}$: $Fe^{2+} - 3d^6 (sp^3d^2)$, 4 unpaired electrons (paramagnetic)

5. **A-r, s; B-r, s; C-p; D-q**

(A) $FeO.Fe_2O_3 + 8H^+ \longrightarrow 3Fe^{3+} + 4H_2O + e^-$ (Reducing agent)

$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$ (Oxidising agent)

$Cr_2O_7^{2-} + 14H^+ + 6e^- \longrightarrow 2Cr^{3+} + 7H_2O$ (Oxidising agent)

(B) $FeC_2O_4 \longrightarrow Fe^{3+} + 2CO_2 + 3e^-$ (Reducing agent)

(C) $2CuSO_4 + 4KI \longrightarrow Cu_2I_2 + 2K_2SO_4 + I_2$;

$I_2 + 2Na_2S_2O_3 \longrightarrow 2NaI + Na_2S_4O_6$

(D) $AgNO_{3(aq)} + NaCl_{(aq)} \longrightarrow AgCl_{(s)} + NaNO_{3(aq)}$

6. **A-s; B-p, s; C-r; D-q, r**

TiO is paramagnetic in nature.

CrO_2 is ferromagnetic and is paramagnetic in nature.

ZnO has zero magnetic moment.

MnO is antiferromagnetic and has zero magnetic moment.

7. **A-q; B-p, q, r, s; C-p, q; D-r**

The substance left behind as waste in Kipp's apparatus is $FeSO_4.7H_2O$ which is known as green vitriol.

Both green vitriol ($FeSO_4.7H_2O$) and Mohr's salt $[FeSO_4(NH_4)_2SO_4.6H_2O]$ are green in colour and on heating they leave a brown residue.

Basic copper carbonate and hydrated cupric chloride are also green in colour.

Basic copper carbonate on heating leaves a black residue.