HINTS & SOLUTIONS

EXERCISE - 1

Single Choice

1. $SO_3^{2-} + Zn + 8H^+ \longrightarrow H_2S\uparrow + 3Zn^{2+} + 3H_2O$

$Pb^{2+} + S^{2-} \longrightarrow PbS\downarrow$ (black)

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

$2MnO_4^- + 5H_2S + 6H^+ \longrightarrow 2Mn^{2+} + 5S + 8H_2O$

3. $SO_3^{2-} + Ba(OH)_2 \longrightarrow BaSO_3\downarrow$ (white) $+ 2OH^-$.

$3SO_2 + Cr_2O_7^{2-} + 2H^+ \longrightarrow 2Cr^{3+}$ (green colour solution) $+ 3SO_4^{2-} + H_2O$.

5. **(i)** $Cr_2O_7^{2-} + 3SO_2 + 2H^+ \longrightarrow 2Cr^{3+}$ (green) $+ 3SO_4^{2-} + H_2O$; CO_2 and O_2 do not give reactions with acidified $K_2Cr_2O_7$

(ii) $Ca(OH)_2 + CO_2 \longrightarrow CaCO_3\downarrow$ (white) $+ H_2O$; O_2 does not give reaction with acidified $K_2Cr_2O_7$.

(iii) O_2 dissolves in pyrogallol.

8. **(A)** $Cd^{2+}(aq) + H_2S(g) \longrightarrow CdS\downarrow$ (yellow) $+ 2H^+(aq)$

(B) $Co_3^{2-} + 4Hg^{2+} + 3H_2O \longrightarrow Hg_4O_3CO_3\downarrow$ (reddish-brown) $+ 6H^+$

$HCO_3^-(aq)$ does not give precipitate.

(C) $SO_3^{2-} + 3Zn + 8H^+ \longrightarrow H_2S\uparrow + 3Zn^{2+} + 3H_2O$

(D) $5SO_2 + 2IO_3^- + 4H_2O \longrightarrow I_2 + 5SO_4^{2-} + 8H^+$

10. $Br^- + H_2SO_4 \longrightarrow HBr + HSO_4^-$;

$HBr + H_2SO_4 \longrightarrow Br_2 + SO_2 + 2H_2O$

11. $Ag^+ + Br^- \longrightarrow AgBr\downarrow$ (pale yellow) ;

$NaBr + Na_2CO_3 \longrightarrow$ No reaction.

$2NaBr + 2H_2SO_4 \longrightarrow Br_2\uparrow$ (reddish brown) $+ SO_2 + SO_4^{2-} + 2Na^+ + 2H_2O$.

12. $3AgCl + Na_3AsO_3 \longrightarrow Ag_3AsO_3\downarrow$ (yellow) $+ 3Cl^- + 3Na^+$.

$AsO_4^{3-} + 3Ag^+ \longrightarrow Ag_3AsO_4\downarrow$ (brownish-red).

15. $2NO_3^- + 4H_2SO_4 + 6Fe^{2+} \longrightarrow 6Fe^{3+} + 2NO\uparrow + 4SO_4^{2-} + 4H_2O$.

$Fe^{2+} + NO\uparrow + SO_4^{2-} \longrightarrow [Fe(NO)]^{2+}SO_4^{2-}$.

17. **(A)** $3AgCl\downarrow + AsO_3^{3-} \longrightarrow Ag_3AsO_3\downarrow$ (yellow) $+ 3Cl^-$

AgI is unaffected by this treatment.

(B) $AgCl + 2NH_3 \longrightarrow [Ag(NH_3)_2]Cl$

AgI is not soluble in dilute ammonia solution.

(C) Both soluble in potassium cyanide, forming soluble complexes.

(D) Both insoluble in dilute HNO_3.

19. $OCl^- + 3I^- + H_2O \longrightarrow I_3^- + 2OH^- + Cl^-$.

I_3^- + starch $\longrightarrow$ blue -black spot on starch paper due to the formation of iodine-starch adsorption complex.

20. $2I^- + Cl_2 \longrightarrow I_2$ (violet) $+ 2Cl^-$

$5Cl_2$ (excess) $+ I_2 + 6H_2O \longrightarrow 2HIO_3$ (colourless) $+ 10HCl$

22. $Ba^{2+} + CrO_4^{2-} \longrightarrow BaCrO_4\downarrow$ (yellow) ;

$Ag^+ + Cl^- \longrightarrow AgCl\downarrow$ (white)

23. $NH_4^+ + [PtCl_6]^{2-} \longrightarrow (NH_4)_2[PtCl_6]\downarrow$ (yellow).

$[Co(NO_2)_6]^{3-} + 3NH_4^+ \longrightarrow (NH_4)_3[Co(NO_2)_6]\downarrow$ (yellow).

25. $NH_4^+ + OH^- \xrightarrow{\Delta} NH_3\uparrow + H_2O$.

(A) NH_3, alkaline in nature turns red litmus blue;

$NH_3 + HCl \longrightarrow NH_4Cl$ (white fumes)

(B) $2HgNO_3 + 2NH_3 \longrightarrow \underset{\text{black}}{Hg(NH_2)NO_3} + Hg + NH_4NO_3$

$CuSO_4 + 4NH_3 \longrightarrow [Cu(NH_3)_4]SO_4$ (intense blue)

(C) $2K_2(HgI_4) + NH_3 + 3KOH \longrightarrow HgOHgNH_2I\downarrow$(brown) $+ 7KI + 2H_2O$

28. $Pb^{2+} + H_2S \longrightarrow PbS\downarrow$ (black) $+ 2H^+$;

$3PbS + 8HNO_3 \longrightarrow 3Pb(NO_3)_2 + 2NO\uparrow + 3S\downarrow + 4H_2O$.

$Pb^{2+} + SO_4^{2-} \longrightarrow PbSO_4\downarrow$ (white).

30. $Pb(NO_3)_2 + 2NH_4OH \longrightarrow Pb(OH)_2\downarrow$ (white) $+ 2NH_4NO_3$

$Pb(NO_3)_2 + 2NaCl \longrightarrow PbCl_2\downarrow$ (white) $+ 2NaNO_3$

$Pb(NO_3)_2 + H_2S \longrightarrow PbS\downarrow$ (black) $+ 2NaNO_3$

31 $AgCl + 2CN^- \longrightarrow [Ag(CN)_2]^- + Cl^-$;

$AgCl + 2S_2O_3^{2-} \longrightarrow [Ag(S_2O_3)_2]^{3-} + Cl^-$.

$AgCl + 2NH_3 \longrightarrow [Ag(NH_3)_2]^+ + Cl^-$.

AgCl is soluble in concentrated solution of KCl.

$AgCl + Cl^- \longrightarrow [AgCl_2]^-$ (soluble complex)

32. $HgI_2\downarrow$ (red) $+ 2I^- \rightarrow [HgI_4]^{2-}$ (soluble colourless complex) ;
$BiI_3\downarrow$ (black) $+ I^- \rightarrow [BiI_4]^-$ (soluble orange complex).

34. $Pb^{2+} + CrO_4^{2-} \longrightarrow PbCrO_4\downarrow$ (yellow) ;

$PbCrO_4\downarrow + 4OH^- \longrightarrow [Pb(OH)_4]^{2-} + CrO_4^{2-}$.

36. $H_2S \rightleftharpoons 2H^+ + S^{2-}$; $HCl \rightleftharpoons H_2^+ + Cl^-$.
Due to common ion effect, the ionisation of H_2S is suppressed and thus low concentration of S^{2-} ions is obtained. This much of S^{2-} ions concentration is enough to precipitate only IInd group cations (because of the low K_{SP} of IInd group sulphides).

40. **(A)** $Hg^{2+} + Co^{2+} + 4SCN^- \longrightarrow Co[Hg(SCN)_4]\downarrow$ (deep blue) ;

(B) $2Hg^{2+} + Sn^{2+} + 2Cl^- \longrightarrow Hg_2Cl_2\downarrow$ (white) $+ Sn^{4+}$;

$Hg_2Cl_2 + Sn^{2+} \longrightarrow Hg\downarrow$ (black) $+ Sn^{4+} + 2Cl^-$

(C) $2Hg^{2+} + NO_3^- + 4NH_3 + H_2O \longrightarrow HgO.Hg(NH_2)NO_3\downarrow$ (white)

(D) KCN no effect i.e. no reaction.

42. **(A)** $Bi^{3+} + 3I^- \longrightarrow BiI_3\downarrow$ (black)

(B) $2Cu^{2+} + 5I^- \longrightarrow Cu_2I_2\downarrow$ (white) $+ I_3^-$ (brown solution)

(C) $Pb^{2+} + 2I^- \longrightarrow PbI_2\downarrow$ (yellow)

(D) $Hg_2^{2+} + 2I^- \longrightarrow HgI_2$ (red/scarlet)

44. **(A)** $Cu^{2+} + S^{2-} \longrightarrow CuS\downarrow$ (black) ,

(B) $Cd^2 + S^{2-} \longrightarrow CdS\downarrow$ (yellow) ,

(C) $Zn^{2+} + S^{2-} \longrightarrow ZnS\downarrow$ (white) ,

(D) $2Fe^{3+} + H_2S \longrightarrow 2Fe^{2+} + 2H^+ + S\downarrow$ (milky white)

45. $2CuSO_4 + 4KI \longrightarrow 2CuI\downarrow$ (white) $+ 2K_2SO_4 + I_2$

$3SCN^- + Cu^{2+} \longrightarrow CuSCN\downarrow$ (white) $+ (SCN)_2$

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

47. Both dissolves in acids. $Cr(OH)_3$ is partially soluble while $Fe(OH)_3$ is not soluble in aqueous NH_3. Only $Cr(OH)_3$ not $Fe(OH)_3$ is soluble by $NaOH/H_2O_2$ according to the reaction.

$Cr(OH)_3\downarrow$ (green) $\xrightarrow{NaOH/\ H_2O_2}$ CrO_4^{2-} (yellow solution) $+ H_2O$.

50. $Fe^{3+} + [Fe(CN)_6]^{3-} \longrightarrow Fe[Fe(CN)_6]$ brown colouration

$3Fe^{3+} + 6CH_3COO^- + 2H_2O \rightleftharpoons [Fe_3(OH)_2(CH_3COO)_6]^+ + 2H^+$.

52. $Fe^{3+} + 3SCN^- \longrightarrow Fe(SCN)_3$ (deep red colouration)

$Co^{2+} + 4SCN^- \xrightarrow{\text{amyl alcohol}} [Co(SCN)_4]^{2-}$ (blue colouration)

$Cu^{2+} + 2SCN^- \longrightarrow Cu(SCN)_2\downarrow$(black) ;

$2Cu(SCN)_2 \longrightarrow 2CuSCN\downarrow$(white) $+ (SCN)_2$.

53. $Fe^{2+} + [Fe(CN)_6]^{4-} \rightarrow$ white precipitate ;
$Fe^{3+} + [Fe(CN)_6]^{4-} \rightarrow$ Prussian blue precipitate.
$Zn^{2+} + [Fe(CN)_6]^{4-} \rightarrow$ Bluish white/white precipitate ;
$Cu^{2+} + [Fe(CN)_6]^{4-} \rightarrow$ chocolate brown precipitate
$Ag^+ + [Fe(CN)_6]^{4-} \rightarrow$ white precipitate ;
$Ca^{2+} + K_4[Fe(CN)_6] \rightarrow$ white precipitate.

54. $Zn^{2+} + 2NH_4OH \longrightarrow Zn(OH)_2\downarrow$ (white) $+ 2NH_4^+$;

$Zn(OH)_2 + 4NH_4OH \longrightarrow Zn(NH_3)_4 + 6H_2O$

$Zn^{2+} + S^{2-} \longrightarrow ZnS$ (white)

56. $Na_2B_4O_7.10H_2O \xrightarrow{\Delta} Na_2B_4O_7 + 10H_2O$;

$Na_2B_4O_7 \xrightarrow{\Delta} 2NaBO_2 + B_2O_3$

$CuO + B_2O_3 \xrightarrow{\Delta} Cu(BO_2)_2$ (copper (II) metaborate) - blue bead in oxidising flame.

58. $2CoS + 6HCl + 2HNO_3 \longrightarrow 3CoCl_2 + 2NO + 3S + 4H_2O$

$CoCl_2 + 6NaHCO_3 \longrightarrow Na_4[Co(CO_3)_3] + 2NaCl + 3H_2O + 3CO_2$

$2Na_4[Co(CO_3)_3] + Br_2 \longrightarrow 2Na_3[Co(CO_3)_3] + 2NaBr$
(Green)

60. **(A)** $Zn(OH)_2\downarrow + 2OH^- \longrightarrow [Zn(OH)_4]^{2-}$

(B) $Zn(OH)_2\downarrow + 2H^+ \rightleftharpoons Zn^{2+} + 2H_2O$
(C) & **(D)** White precipitate of $Zn(OH)_2$ dissolves in excess of ammonia solution and in solutions of ammonium salts owing to the production of tetraamminezincate(II).

$Zn(OH)_2\downarrow + 4NH_3 \rightleftharpoons [Zn(NH_3)_4]^{2+} + 2OH^-$

61. Strontium chloride gives crimson colour flame in Bunsen burner.
$BaCl_2$ -apple green, $CaCl_2$ -brick red, KCl - lilac(violet).

63. **(A)** titan yellow is absorbed by magnesium hydroxide producing a deep-red colour or precipitate.

(B) $Mg^{2+} + NH_3 + HPO_4^{2-} \longrightarrow Mg(NH_4)PO_4\downarrow$ (white).
(C) Blue lake is formed by the adsorption of reagent on $Mg(OH)_2$.

64. $Ba^{2+} + CrO_4^{2-} \longrightarrow BaCrO_4\downarrow$ (yellow) ;

$Ag^+ + Br^- \longrightarrow AgBr\downarrow$ (pale yellow).

66. $BaCl_2 + 2AgNO_3 \longrightarrow 2AgCl\downarrow$ (white) $+ BaNO_3$

$BaCl_2 + H_2SO_4 \longrightarrow BaSO_4\downarrow$ (white) $+ 2HCl$

67. **(A)** $Pb(NO_3)_2 + 2NaCl \longrightarrow PbCl_2\downarrow$ (white) $+ 2NaNO_3$

$Ba(NO_3)_2 + 2NaCl \longrightarrow BaCl_2 + 2NaNO_3$;
$BaCl_2$ is soluble in water

(B) Na_2SO_4 gives white precipitate of $PbSO_4$ and $BaSO_4$ with $Pb(NO_3)_2$ and $Ba(NO_3)_2$ respectively.

(C) Disodium hydrogen phosphate gives white precipitate with both salts.

$HPO_4^{2-} + Ba^{2+} \longrightarrow BaHPO_4\downarrow$ (white) ;

$HPO_4^{2} + Pb^{2+} \longrightarrow PbHPO_4\downarrow$ (white)

(D) $Pb^{2+} + CrO_4^{2-} \longrightarrow PbCrO_4\downarrow$ (yellow) ;

$Ba^{2+} + CrO_4^{2-} \longrightarrow BaCrO_4\downarrow$ (yellow)

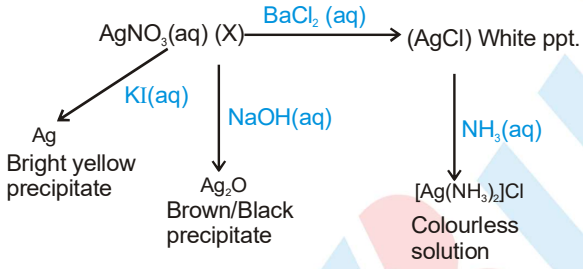
69. **(A)** $Hg_2^{2+} \xrightarrow{\text{Dil. HCl}} Hg_2Cl_2\downarrow$ (white) $\xrightarrow{NH_3(aq)}$

$Hg\downarrow$ (black) $+ Hg(NH_2)Cl\downarrow$ (white) .

1 4 4 4 4 4 4 4 2 4 4 4 4 4 4 4 3

Black

70.



71. $Hg_2Cl_2 + 2NH_3 \longrightarrow$

$Hg\begin{cases}Cl\\NH_2\end{cases}\downarrow$ (white) $+$ $Hg\downarrow$ (black) $+ NH_4Cl$

1 4 4 4 4 4 4 4 4 2 4 4 4 4 4 4 4 3

black

$Hg_2^{2+} + 2I^- \longrightarrow Hg_2I_2\downarrow$ (green)

72. **(A)** $Pb^{2+} + H_2S \longrightarrow PbS\downarrow$ (black) $+ 2H^+$.

(B) $Cr_2O_7^{2-} + 3H_2S + 8H^+ \longrightarrow 2Cr^{3+}$
(green colour solution) $+ 3S\downarrow + 7H_2O$.

(C) $S^{2-} + [Fe(CN)_5NO]^{2-} \longrightarrow [Fe(CN)_5NOS]^{4-}$
(purple colouration).

Reactions : $Na_2SO_4 + BaCl_2 \longrightarrow BaSO_4\downarrow + NaCl$.

$BaSO_4 + 4C + Na_2CO_3 \xrightarrow{\text{Fuse}} Na_2S +$
$BaCO_3\downarrow + 4CO\uparrow$.

$Na_2S + H_2SO_4 \longrightarrow Na_2SO_4 + H_2S$.

76. $Na_2B_4O_7 \xrightarrow{\Delta} 2NaBO_2 + B_2O_3$

$CuO + B_2O_3 \xrightarrow{\Delta} Cu(BO_2)_2$

$2Cu(BO_2)_2 + 4NaBO_2 + 2C \xrightarrow{\Delta} 2Cu$ (red and opaque)
$+ 2Na_2B_4O_7 + 2CO\uparrow$

77. Both belong to same group i.e. II[nd] group and their K_{SP} values are low ; so both are precipitated according to the following reactions.

$2Bi^{3+} + 3S^{2-} \longrightarrow Bi_2S_3\downarrow$ (black).

$Sn^{4+} + 2S^{2-} \longrightarrow SnS_2\downarrow$ (yellow).

83. As it provides NH_4^+ ions which suppresses the ionisation of NH_4OH so that only the group 3[rd] cations are precipitated as hydroxides because of their low solubility products and NO_3^- ions do not produce precipitate with the cations of IV[th], V[th] and VI[th] groups.

84. $[Fe(CN)_6]^{4-} + NO_3^- + 4H^+ \longrightarrow [Fe(CN)_5(NO)]^{2-} + NH_4^+ + CO_2$

86. **(A)** $2Fe^{3+} + H_2S \longrightarrow 2Fe^{2+} + 2H^+ + S\downarrow$ (white)

(B) $2Fe^{3+} + 3S^{2-} \longrightarrow 2FeS\downarrow$ (black) $+ S\downarrow$

(C) $Fe^{3+} + 3SCN^- \longrightarrow Fe(SCN)_3$ deep red colouration

89. $4Zn + 10H^+ + NO_3^- \longrightarrow 4Zn^{2+} + NH_4^+ + 3H_2O$.

$Zn^{2+} + 2OH^- \longrightarrow Zn(OH)_2\downarrow$ (white) ;

$Zn(OH)_2 + 2OH^- \longrightarrow [Zn(OH)_4]^{2-}$.

$[Zn(OH)_4]^{2-} + H_2S \longrightarrow ZnS\downarrow$ (white) $+ 2OH^- + 2H_2O$.

92. Ni^{2+} and Fe^{2+} both on reaction with alkaline solution of dimethyl glyoxime give red precipitate and red solution respectively but not zinc.

94. $Ba^{2+} + CrO_4^{2-} \longrightarrow BaCrO_4\downarrow$ (yellow) ;

$Ba^{2+} + SO_4 \longrightarrow BaSO_4$ (white).

$Ba^{2+} + 2Cl^- \longrightarrow BaCl_2$ (soluble in water).

K_{sp} of $SrCrO_4$ is high in acetic acid, so no precipitate is formed. Lead carbonate and basic lead carbonate both gives precipitate with K_2CrO_4 and NaCl.

95. $Cl^- + H_2SO_4 \longrightarrow HCl\uparrow$ (colourless) $+ HSO_4^-$

$MnO(OH)_2 + 2H_2SO_4 + 2Cl^- \longrightarrow Mn^{2+} + Cl_2\uparrow$
(yellowish green) $+ 2SO_4^{2-} + 3H_2O$

$Cl_2 + H_2O \longrightarrow 2HCl + [O]$

Litmus $+ [O] \longrightarrow$ colourless oxidised form

Cl_2 is a yellowish green gas which bleaches litmus paper by oxidation.

96. $CrO_2Cl_2 + 2H_2O \longrightarrow H_2CrO_4 + 2HCl$

$H_2CrO_4 + (CH_3COO)_2Ba \longrightarrow BaCrO_4\downarrow$ (Yellow) + $2CH_3COOH$

97. $5Cl_2 + I_2 + 6H_2O \longrightarrow 2HIO_3$ (colourless) + $10HCl$

$Br_2 + Cl_2 \rightleftharpoons 2BrCl$ (pale yellow)

98. SO_3^{2-} reduces $KMnO_4$ to colourless Mn^{2+}

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

99. Nitrite ion liberates I_2 from potassium iodide turning starch blue.

$2NO_2^- + 3I^- + 4CH_3COOH \longrightarrow I_3^- + 2NO\uparrow + 4CH_3COO^- + 2H_2O$

I_2 + starch $\longrightarrow$ blue colour

100. NO_3^- gives NO_2 with concentrated H_2SO_4 which on passing through water form colourless HNO_3(●) and HNO_2(●). Br^- + MnO_2 on heating with concentrated H_2SO_4 gives Br_2 gas which on passing through water imparts it a reddish brown colour.

101. Ag_3PO_4 is yellow precipitate which is soluble both in dilute ammonia solution and dilute HNO_3.

$HPO_4^{2-} + 3Ag^+ \longrightarrow Ag_3PO_4\downarrow + H^+$

$Ag_3PO_4 + 2H^+ \longrightarrow H_2PO_4^-\downarrow + 3Ag^+$;

$Ag_3PO_4\downarrow + 6NH_3 \longrightarrow 3[Ag(NH_3)_2]^+ + PO_4^{3-}$

Pale yellow precipitate of AgBr is not soluble in dilute HNO_3; bright yellow precipitate of AgI is not soluble in both; Ag_2CrO_4 is obtained as red precipitate.

102. $HgCl_2$ fails to give positive chromyl chloride test because of its covalent nature i.e., it does not dissociate to give Cl.

103. $NaCl + AgNO_3 \longrightarrow AgCl\downarrow$ (white) + $NaNO_3$; $Ag_2S\downarrow$ (black).

Ag_2CO_3 and Ag_2SO_3 dissolves in dilute HNO_3 liberating CO_2 and SO_2 respectively.

Both Ag_2CO_3 and Ag_2SO_3 are white. AgCl is white but insoluble in dilute HNO_3. NaCl solution is neutral to litmus as it is a salt of strong acid and strong base.

104. PbI_2 is yellow (known as golden spangles).

105. AgBr has the highest solubility in 10^{-3} M NH_4OH

AgBr dissolves in all other solvents poorly.

106. $Pb^{2+} + 2Cl^- \longrightarrow PbCl_2\downarrow$ (white) ;

$PbCl_2 + 2Cl^- \longrightarrow [PbCl_4]^{2-}$(colourless soluble complex)

$PbCl_2\downarrow + H_2S \longrightarrow PbS\downarrow$ (black) + $2HCl$

$PbS + 4H_2O_2 \longrightarrow PbSO_4\downarrow$ (white) + $4H_2O$

$PbSO_4\downarrow + 2CH_3COONH_4 \longrightarrow (NH_4)_2SO_4 + (CH_3COO)_2Pb$

107. Marble ($CaCO_3$) do not react, adsorb, absorb or dissolve Br_2. As such there is no change in colour of Br_2. Remaining dissolves or absorb or adsorb bromine.

108. $Hg_2Cl_2 + 2NH_3 \longrightarrow$

$Hg\begin{matrix}Cl\\ \diagdown\\ \diagup\\ NH_2\end{matrix}\downarrow$ (white) + $Hg\downarrow$ (black) + NH_4Cl

1 4 4 4 44 2 4 4 4 4 48

Black

109. The white precipitate obtained with H_2SO_4 is that of $PbSO_4$. The white crystalline substance may be that of $Pb(NO_3)_2$.

$Pb^{2+} + S^{2-} \longrightarrow PbS\downarrow$ (black) ; $3PbS\downarrow + 8HNO_3 \longrightarrow 3Pb^{2+} + 6NO_3^- + 3S\downarrow + 2NO + 4H_2O$

$Pb^{2+} + SO_4^{2-} \longrightarrow PbSO_4\downarrow$ (white)

$PbSO_4 + 2CH_3COONH_4 \longrightarrow (CH_3COO)_2Pb + (NH_4)_2SO_4$

BaS and SrS precipitates are not black in colour. Ag_2SO_4 is white precipitate but does not dissolve in ammonium acetate.

110. $Ag^+ + 2Cl^- \longrightarrow [AgCl_2]^-$ (soluble complex) ;

$Ag^+ + Cl^-$ (dilute HCl) $\longrightarrow AgCl\downarrow$ (white)

$2Ag^+ + CrO_4^{2-} \longrightarrow Ag_2CrO_4\downarrow$ (red) ;

$Ag_2CrO_4\downarrow + NH_3 \longrightarrow 2[Ag(NH_3)_2]^+ + CrO_4^{2-}$

$3Ag^+ + HPO_4^{2-} \longrightarrow Ag_3PO_4\downarrow$ (yellow) + H^+ ;

$Ag_3PO_4\downarrow + 6NH_3 \longrightarrow [Ag(NH_3)_2]^+ + PO_4^{3-}$

111. **(A)** Both are red precipitates

(B) $2Pb^{2+} + H_2S$ (not in excess) + $2Cl^-$ (from saturated KCl solution) $\rightarrow Pb_2SCl_2\downarrow$ (red) + $2H^+$

$Hg^{2+} + 2I^- \longrightarrow HgI_2\downarrow$ (red)

(C) $BiOI\downarrow$ (orange) and $Cu_2[Fe(CN)_6]\downarrow$ (brown)

112. Both Cd^{2+} and Sn^{2+} are precipitated as yellow sulphides in the presence of dilute HCl.

113. **(A)** $Bi^{3+} + 3NH_4OH \longrightarrow Bi(OH)_3\downarrow$ (white) $+ 3NH_4^+$

(B) $Bi^{3+} + C_6H_3(OH)_3 \longrightarrow Bi(C_6H_3O_3)\downarrow$ (yellow) $+ 3H^+$

(C) $Bi^{3+} + 3I^- \longrightarrow BiI_3\downarrow$ (black) ;

$BiI_3 + I^- \longrightarrow [BiI_4]^-$ (orange solution)

(D) $Bi^{3+} + 3OH^- \longrightarrow Bi(OH)_3\downarrow$ (white) ;

$2Bi(OH)_3\downarrow + 3[Sn(OH)_4]^{2-} \longrightarrow 2Bi\downarrow$ (black) $+ 3[Sn(OH)_6]^{2-}$

114. **(A)** $As^{3+} + 3Zn + 3H^+ \longrightarrow AsH_3\uparrow + 3Zn^{2+}$;

$4AsH_3 \xrightarrow{\Delta} 4As\downarrow + 6H_2\uparrow$

(B) $4[Ag(NH_3)_2]^+ + H_2N\text{–}NH_2.H_2SO_4 \longrightarrow 4Ag\downarrow + N_2\uparrow + 6NH_4^+ + 2NH_3\uparrow + SO_4^{2-}$

(C) $2Ag_2CrO_4\downarrow + 2H^+ \rightleftharpoons 4Ag^+ + Cr_2O_7^{2-} + H_2O$

$Ag_2CrO_4\downarrow + 4NH_3 \rightleftharpoons 2[Ag(NH_3)_2]^+ + CrO_4^{2-}$

So, all statements are correct.

115. The filter paper ash test is substitute for cobalt nitrate charcoal cavity test. Double oxide ZnO.CoO formed is green in colour. It is called Rinmann's green.

116. $Cd^{2+} + H_2S \longrightarrow CdS\downarrow + 2H^+$, reaction is reversible; if the concentration of strong acid in the solution is above 0.5 M, precipitation is incomplete. Concentrated acid dissolves the precipitate for the same reason.

117. $2Cu^{2+} + 4I^- \longrightarrow Cu_2I_2\downarrow + I_2$;

$Cu^{2+} + 3CN^- \longrightarrow CuCN\downarrow + (CN)_2$

118. $Cu^{2+} + 2SCN^- \longrightarrow Cu(SCN)_2\downarrow$ (black)

$2Cu(SCN)_2 \longrightarrow 2CuSCN\downarrow$ (white) $+ (SCN)_2$

$Cu^{2+} + H_2S \xrightarrow{H^+} CuS\downarrow$ (black) $+ 2H^+$

$2CuS\downarrow + 8CN^- \longrightarrow 2[Cu(CN)_4]^{3-} + S_2^{2-}$

119. Function of strong electrolyte NH_4Cl is to suppress the ionisation of NH_4OH so that the concentration of OH^- ions in the solution is decreased but it is sufficient to precipitate the third group basic radicals because the solubility product of group III hydroxides is lower than IV, V and VI group hydroxides. The $Cr(OH)_3\downarrow$ is slightly soluble in excess of precipitant, upon boiling the solution, $Cr(OH)_3$ is precipitated.

120. $CoCl_2 + 4NH_4SCN \xrightarrow{\text{ether}} (NH_4)_2[Co(SCN)_4]$ (blue colour in ethereal layer) $+ 2NH_4Cl$.

$Cu^{2+} + 3SCN^- \longrightarrow CuSCN\downarrow$ (white) $+ (SCN)_2$.

$FeCl_3 + 3NH_4SCN \xrightarrow{\text{ether}} Fe(SCN)_3$(blood red colour) $+ 3NH_4Cl$.

$Ag^+ + SCN^- \longrightarrow AgSCN\downarrow$ (white).

$Co^{2+} + 4SCN^- + Hg^{2+} \longrightarrow Co[Hg(SCN)_4]\downarrow$ (deep blue).

121. **(A)**, **(B)** and **(C)** all gives blue colouration in solution or blue precipitate.

(D) $AgCl\downarrow + 2NH_3 \longrightarrow [Ag(NH_3)_2]^+Cl^-$ (colourless solution)

122. $CrO_4^{2-} + 2H^+ + 2H_2O_2 \longrightarrow CrO_5$ (chromium peroxide) $+ 3H_2O$

It in etherial layer develops blue colouration.

123. $Mn(OH)_2 + 2HNO_3 \longrightarrow Mn(NO_3)_2 + 2H_2O$.

$2Mn(NO_3)_2 + 5PbO_2 + 6HNO_3 \longrightarrow 2HMnO_4$ (red – violet or purple colour) $+ 5Pb(NO_3)_2 + 2H_2O$.

124. **(i)** $Mn^{2+} + 2OH^- \longrightarrow 2Mn(OH)_2\downarrow$ (white)

$2Mn(OH)_2\downarrow + O_2 \longrightarrow MnO(OH)_2\downarrow$ (brown)

(ii) $Mn^{2+} + 2NH_3 + 2H_2O \rightleftharpoons Mn(OH)_2\downarrow + 2NH_4^+$

with NH_4^+ the reaction proceeds towards the left.

(iii) $2Mn^{2+} + 5S_2O_8^{2-} \longrightarrow 2MnO_4^- + 10SO_4^{2-} + 16H^+$

125. In first step with H_2S gas in acidic medium Cd^{2+} and Cu^{2+} will precipitate as CdS and CuS respectively. Thus the filtrate will now contain chromium, iron and aluminium.
In second step with NH_4Cl and NH_4OH, Cr^{3+}, Fe^{3+} and Al^{3+} will precipitate out as their hydroxides.
In third step on addition of excess of NaOH, $Al(OH)_3$ and $Cr(OH)_3$ precipitates will dissolve forming soluble complexes but $Fe(OH)_3$ precipitate is unaffected. Hence the filtrate will contain $Na[Al(OH)_4]$ and $Na[Cr(OH)_4]$.

$Al(OH)_3 + OH^- \longrightarrow [Al(OH)_4]^-$ (colourless solution);

$Cr(OH)_3 + OH^- \rightleftharpoons [Cr(OH)_4]^-$ (green solution)

126. $3Na_2O_2 + 2Cr(OH)_3 \xrightarrow{\Delta} 2NaOH + 2H_2O + 2Na_2CrO_4$ (yellow)

127. On adding H_2O_2 in alkaline medium or $SnCl_2$ solution in acidic medium, the $[Fe(CN)_6]^{3-}$ part of the compound is reduced and prussian blue is precipitated.

128. (A) $Zn(OH)_2\downarrow + 2OH^- \rightleftharpoons [Zn(OH)_4]^{2-}$

(B)and **(C)** $Zn(OH)_2\downarrow + 4NH_3 \rightleftharpoons [Zn(NH_3)_4]^{2+} + 2OH^-$ or NH_4^+

129. Ba^{2+} salts gives yellow precipitate with K_2CrO_4 solution and this precipitate is not soluble in CH_3COOH. Ba^{2+} ions gives apple green colour in the flame test.

130. (B) $BaCO_3$ + ZnS mixture dissolves in HCl but is insoluble in water. Further the solution in HCl will be colourless due to the formation of soluble $BaCl_2$ and $ZnCl_2$.

131. (A) No precipitate with K_2CrO_4 in acetic acid as its k_{sp} is high.

(B) $Ca^{2+} + 2K^+ + [Fe(CN)_6]^{4-} \longrightarrow K_2Ca[Fe(CN)_6]\downarrow$ (white)

(C) It imparts brick red colour to Bunsen flame.

(D) $Ca(HCO_3)_2$ is formed which is water soluble.

EXERCISE - 2

Part # I : Multiple Choice

4. (A) $Na_2S + H^+ \longrightarrow H_2S\uparrow + 2Na^+$. ;

Na_2SO_4 gives no reaction with H_2SO_4.

(B) $2MnO_4^-$ (pink solution) $+ 5H_2S + 6H^+ \longrightarrow 2Mn^{2+}$ (colourless) $+ 5S\downarrow + 8H_2O$.

No colour change is observed with Na_2SO_4.

(C) $S^{2-} + [Fe(CN)_5NO]^{2-} \longrightarrow [Fe(CN)_5NOS]^{4-}$ (purple or violet colouration).

No colour change is observed with Na_2SO_4.

(D) $S^{2-} + Cd^{2+} \longrightarrow CdS\downarrow$ (yellow).

Na_2SO_4 forms $CdSO_4$ which is water soluble.

5. (A) $Br^- + H^+ \longrightarrow HBr\uparrow$;

$2HBr + 2H_2SO_4 \longrightarrow Br_2\uparrow$ (reddish brown) $+ SO_2\uparrow + SO_4^{2-} + H_2O$.

(B) $4NO_3^- + 2H_2SO_4 \longrightarrow 4NO_2\uparrow$ (reddish brown) $+ O_2\uparrow + 2SO_4^{2-} + 2H_2O$.

(C) $SO_3^{2-} + 2H^+ \longrightarrow SO_2\uparrow$ (colourless) $+ H_2O$.

(D) $3I^- + 2H_2SO_4 \longrightarrow I_3^-\uparrow$ (violet/purple) $+ SO_4^{2-} + 2H_2O + SO_2$.

9. (A) AgCl dissolves completely forming $[Ag(NH_3)_2]Cl$;

$AgCl + 2NH_4OH \longrightarrow [Ag(NH_3)_2]Cl + 2H_2O$.

(B) AgBr dissolves completely forming $[Ag(NH_3)_2]$ Br soluble complex.

$AgBr + 2NH_4OH \longrightarrow [Ag(NH_3)_2]Br + 2H_2O$.

(C) $Ag_2CrO_4 + 4NH_3 \longrightarrow 2[Ag(NH_3)_2]^+ + CrO_4^{2-}$

(D) AgI is insoluble in concentrated aqueous NH_3.

11. (A) $Ag + 2CrO_4^{2-} \longrightarrow Ag_2CrO_4\downarrow$ (red) [X].

(B) $Ag_2CrO_4\downarrow + 4NH_3 \longrightarrow 2[Ag(NH_3)_2]^+ + CrO_4^{2-}$.

(C) $Cr^{3+} + 3OH^- \longrightarrow Cr(OH)_3\downarrow$ (green).

$Cr(OH)_3 + OH^- \longrightarrow [Cr(OH)_4]^-$ (green coloured soluble complex).

(D) $3\overset{+4}{S}O_2 + \overset{+7}{C}r_2O_7^{2-} + 2H^+ \longrightarrow 2Cr^{3+}[Y] + 3\overset{+6}{S}O_4^{2-} + H_2O$.

13. (A) Fe^{2+} responds to this test but not Fe^{3+}; Fe(II) gives soluble red iron(II) dimethylglyoxime in alkaline solution.

(D) $Ag_2O\downarrow + 4NH_3 + H_2O \longrightarrow 2[Ag(NH_3)_2]^+ + 2OH^-$

$Ag_2O\downarrow + 2H^+ \longrightarrow 2Ag^+ + H_2O$

(B) and **(C)** are correct statements.

14. (A) Red colour solution or precipitate is produced when reagent reacts in alkaline solution.

(B) $HO.SO_2.NH_2 + HNO_2 \longrightarrow N_2 + 2H^+ + SO_4^{2-} + H_2O$.

(C) $Fe^{2+} + [Fe(CN)_6]^{3-} \longrightarrow Fe^{3+} + [Fe(CN)_6]^{4-}$.

$4Fe^{3+} + [Fe(CN)_6]^{4-} \longrightarrow Fe_4[Fe(CN)_6]_3\downarrow$ (Turnbull's blue).

(D) $4Cr(OH)_3\downarrow + 5O_2^{2-} \longrightarrow 4CrO_4^{2-}$ (yellow solution) $+ 6H_2O$.

15. (A) $PbSO_4\downarrow + H_2SO_4$ (hot and concentrated) $\longrightarrow Pb^{2+} + 2HSO_4^-$ (soluble)

(B) It dissolves forming $Na_2[Pb(OH)_4]$ soluble complex.

16. $B_4O_7^{2-} + 4Ag^+ + H_2O \longrightarrow 4AgBO_2\downarrow$ (white) $+ 2H^+$

$2AgBO_2\downarrow + 3H_2O \xrightarrow[\Delta/H_2O]{\text{Hydrolysis}} Ag_2O\downarrow$ (brown) $+ 2H_3BO_3$

17. CuS dissolves in 50% HNO_3 ;

$3CuS + 8HNO_3 \longrightarrow 3Cu^{2+} + 6NO_3^- + 3S\downarrow + 2NO\uparrow + 4H_2O$

But NiS, CoS and HgS do not dissolve in 50% HNO_3 and dissolve in aquaregia forming their chlorides.

21. **(A)** Correct.

(B) $Cu^{2+} + 2CN^- \longrightarrow Cu(CN)_2\downarrow$ (yellow) ;

$2Cu(CN)_2\downarrow \longrightarrow 2CuCN\downarrow$ (white) $+ (CN)_2\uparrow$

(C) $BiI_3\downarrow + H_2O \xrightarrow{\text{boiled}} BiOI\downarrow$ (orange) $+ 2HI$

(D) $Bi(OH)_3\downarrow \xrightarrow{\Delta} BiO.OH\downarrow$ (yellowish white) $+ H_2O$

22. $(NH_4)_2CO_3$ and $(NH_4)_2SO_4$ can not be used as they would also precipitate the IV and Vth group cations.

23. **(A)** $Cr^{3+} + 3NH_3 + 3H_2O \longrightarrow Cr(OH)_3\downarrow + 3NH_4^+$

The reaction is reversible; on addition of NH_4^+ , shifts to backward direction. Thus if excess of NH_4^+ salt is added, then precipitation of $Cr(OH)_3$ will not take place. However, because of very small k_{sp} of iron (III) hydroxide complete precipitation will take place even in the presence of ammonium salts. ($k_{sp} = 3.8 \times 10^{-38}$)

(B) Concentration of CO_3^{2-} provided by Na_2CO_3 in aqueous solution is just sufficient to precipitate Mg^{2+} ion as $MgCO_3$ along with Ba^{2+} , Ca^{2+} and Sr^{2+} as their carbonates.

(C) The oxidising anions like MnO_4^-, $Cr_2O_7^{2-}$, ClO_4^-, etc., also respond to this test.

(D) $CrO_2Cl_2 + 2H_2O \longrightarrow H_2CrO_4$ (aq) $+ 2HCl$.

24. $Co^{2+} + 2CN^- \longrightarrow Co(CN)_2\downarrow$ (reddish - brown)

$Co(CN)_2\downarrow + 4CN^-$ (excess) $\longrightarrow [Co(CN)_6]^{4-}$ (brown solution)

$[Co(CN)_6]^{4-} + 4H^+ \longrightarrow Co(CN)_2\downarrow + 4HCN$.

25. **(A)** $Cu_2[Fe(CN)_6]$; $K_2Zn_3[Fe(CN)_6]_2$;

(B) $Fe_4[Fe(CN)_6]_3$; $K_2Ca[Fe(CN)_6]$

(C) $Ag_4[Fe(CN)_6]$; $K_2Zn_3[Fe(CN)_6]$;

(D) $Th[Fe(CN)_6]$; $Cu_2[Fe(CN)_6]$

26. **(A)** $Hg^{2+} + Co^{2+} + 4SCN^- \longrightarrow Co[Hg(SCN)_4]\downarrow$ (deep blue)

(B) Soluble in NaOH forming $[Al(OH)_4]^-$, not in NH_3 (aq)

(C) $Cr(OH)_3\downarrow$ (green) $+ OH^- \rightleftharpoons [Cr(OH)_4]^-$ (green solution)

(D) Correct statement.

27. Iron and NO exist as Fe(II) and NO^+ respectively.

28. Cr = Green ; Co = Blue.

29. **(A)** $5SO_2 + 2IO_3^- + 4H_2O \longrightarrow I_2 + 5SO_4^{2-} + 8H^+$;

I_2 + starch $\longrightarrow$ blue colour.

(B) $2H^+ + 3SO_2 + Cr_2O_7^{2-} \longrightarrow 2Cr^{3+}$ (green) $+ 3SO_4^{2-} + H_2O$

(C) $Pb^{2+} + SO_3^{2-} \longrightarrow PbSO_3\downarrow$ (white)

(D) $SO_2 + 2H_2O + Cl_2 \longrightarrow H_2SO_4 + HCl$

$HCl + NH_3 \longrightarrow NH_4Cl$

$Ni + H_2SO_4 + 2H^+ \longrightarrow Ni^{2+} + SO_2\uparrow [X] + 2H_2O$

With dilute H_2SO_4, hydrogen gas is liberated.

30. BF_3 colour the flame green ; $B(OC_2H_5)_3$ burns with green edged flame ; Barium chloride (volatile) gives apple green colour to flame.

31. $Co^{2+} + 7NO_2^- + 3K^+ + 2H^+ \longrightarrow K_3[Co(NO_2)_6]\downarrow$ (yellow) $+ NO\downarrow + H_2O$.

So [X] is $K_3[Co(NO_2)]_6$. It is called Fischer's reagent ; $[Co(III)(NO_2)_6]^{3-}$ has d^2sp^3 hybridisation and is diamagnetic. It's IUPAC name is potassium hexanitrito – N – cobaltate(III).

Part # II : Assertion & Reason

2. **Statement-1 :**

$Ba(OH)_2 + CO_2 \longrightarrow BaCO_3\downarrow$ (white) $+ H_2O$;

$BaCO_3 + H_2O + CO_2 \longrightarrow Ba(HCO_3)_2$

Statement-2 : $2Ag^+ + CO_3^{2-} \longrightarrow Ag_2CO_3\downarrow$ (white) ;

$Ag_2CO_3\downarrow \xrightarrow{\Delta} Ag_2O\downarrow$ (brown) $+ CO_2\uparrow$

3. **Statement-1 :** $Ag_2SO_3\downarrow + SO_3^{2-} \longrightarrow 2[Ag(SO_3)]^-$ (soluble complex)

Statement-2 : $5SO_3^{2-} + 2MnO_4^-$ (pink) $+ 6H^+ \longrightarrow 2Mn^{2+}$ (colourless) $+ 5SO_4^{2-} + 3H_2O$

5. **Statement-1 :** $Zn^{2+} + H_2S \rightleftharpoons ZnS + 2H^+$;

$H_2S \rightleftharpoons 2H^+ + S^{2-}$

Sulphide ion concentration obtained from the H_2S is depressed so much by the hydrogen-ion concentration from acid that it is too low to exceed the solubility product of ZnS and consequently precipitation ceases.

Statement-2 : ZnS is insoluble in caustic alkali solution, but dissolves according to the following reaction in dilute HCl.

$ZnS + 2HCl \longrightarrow ZnCl_2 + H_2S$.

7. **Statement-1 :** In the presence of NH_4^+ salts, no precipitation of Mg^{2+} occurs because the equilibrium

$$NH_4^+ + CO_3^{2-} \rightleftharpoons NH_3 + HCO_3^-$$

is shifted towards the formation of HCO_3^- ions. K_{sp} of the precipitate being high (K_{sp} of pure $MgCO_3$ is 1×10^{-5}), the concentration of carbonate ions necessary to produce a precipitate is not attained.

Statement-2 : NH_4OH turns red litmus blue.

$$NH_4OH \rightleftharpoons NH_4^+ + OH^-.$$

9. **Statement-1 :** $Cu^{2+} + 6CN^- \longrightarrow [Cu(CN)_4]^{3-} + (CN)_2$;

$$Cd^{2+} + 4CN^- \longrightarrow [Cd(CN)_4]^{2-}$$

Statement-2 : $[Cu(CN)_4]^{3-}$ being stable complex is not effected by H_2S gas but $[Cd(CN)_4]^{2-}$ is not so stable and gives yellow precipitate with H_2S.

$$[Cd(CN)_4]^{2-} + H_2S \longrightarrow CdS\downarrow \text{(yellow)} + 2H^+ + 4CN^-.$$

12. **Statement-1 :** In presence of ammonium salts the reaction proceeds in backward direction forming ammonia gas.

Statement-2 : $Mg(OH)_2\downarrow$ is insoluble in water.

EXERCISE - 3

Part # I : Matrix Match Type

1. **(A)** $AgCl\downarrow + Cl^- \longrightarrow [AgCl_2]^-$ soluble complex.

$$AgCl\downarrow + 2NH_3 \rightleftharpoons [Ag(NH_3)_2]^+ + Cl^-$$

$$AgCl\downarrow + 2CN^- \rightleftharpoons [Ag(CN)_2]^- + Cl^-$$

AgCl is insoluble in dilute HNO_3.

(B) $2CuS\downarrow + 8CN^- \longrightarrow 2[Cu(CN)_4]^{3-} + S_2^{2-}$.

$$3CuS\downarrow + 8HNO_3 \longrightarrow 3Cu^{2+} + 6NO_3^- + 3S\downarrow + 2NO\uparrow + 4H_2O$$

$$S\downarrow + 2HNO_3 \xrightarrow{\text{boiled for longer time}} 2H^+ + SO_4^{2-} + 2NO\uparrow$$

(C) $Zn(OH)_2\downarrow + 2H^+ \rightleftharpoons Zn^{2+} + 2H_2O$

$$Zn(OH)_2\downarrow + 4NH_3 \rightleftharpoons [Zn(NH_3)_4]^{2+} + 2OH^-$$

$$Zn(OH)_2\downarrow + 2OH^- \longrightarrow [Zn(OH)_4]^{2-}$$

(D) $BaCO_3 + 2H^+ \rightleftharpoons Ba^{2+} + CO_2 + H_2O$

$BaCO_3$ is slightly soluble in solution of ammonium salts of strong acids only.

3. **(A)** Mn^{2+} meta borate $\longrightarrow$ Amethyst red

$$Mn^{2+} + 2OH^- \longrightarrow Mn(OH)_2\downarrow \text{(white)}$$

$$Mn(OH)_2\downarrow \text{(white)} + O_2\text{(air)} \longrightarrow 2MnO(OH_2)\downarrow \text{(brown)}$$

(B) Cr^{3+} metaborate $\longrightarrow$ Green

$$Cr^{3+} + 3OH^- \longrightarrow Cr(OH)_3\downarrow \text{(green)}$$

$$Cr(OH)_3 + OH^- \longrightarrow [Cr(OH)_4]^- \text{ (green coloured soluble complex).}$$

$$[Cr(OH)_4]^- + H^+ \longrightarrow Cr(OH)_3\downarrow + H_2O$$

$$Cr(OH)_3\downarrow + 3H^+\downarrow \longrightarrow Cr^{3+} + 3H_2O$$

(C) $Al^3 + 3OH^- \longrightarrow Al(OH)_3\downarrow$ (white)

$$Al(OH)_3 + OH^- \longrightarrow [Al(OH)_4]^- \text{ (colourless soluble complex).}$$

$$[Al(OH)_4]^- + H^+ \longrightarrow Al(OH)_3\downarrow + H_2O$$

$$Al(OH)_3 + 3H^+\downarrow \longrightarrow Al^{3+} + 3H_2O$$

(D) Fe^{3+} metaborate $\longrightarrow$ Pale yellow

$$Fe^{3+} + 3CN^- \longrightarrow Fe(CN)_3\downarrow \text{(reddish brown)}$$

$$Fe(CN)^3\downarrow + 3CN^- \longrightarrow Fe(CN)_6]^{3-} \text{ (yellow colour soluble complex).}$$

$$Fe^{3+} + 3OH^- \longrightarrow Fe(OH)_3\downarrow \text{(reddish brown).}$$

Part # II : Comprehension

Comprehension # 1 :

1. Sample $\xrightarrow{NaCl}$ Precipitate 'A' **insoluble chloride** (AgCl) + Filtrate (Ba^{2+} and Zn^{2+})

$\downarrow Na_2SO_4$

ppt. 'C' insoluble hydroxide $(Zn(OH)_2) \xleftarrow{\text{aqueous } NH_3}$

Filtrate (Zn^{2+}) + **ppt. 'B' insoluble sulphate** ($BaSO_4$)

$$Ag^+ + Cl^- \longrightarrow AgCl\downarrow \text{(white)} ;$$

$$3AgCl + Na_3AsO_3 \longrightarrow Ag_3AsO_3\downarrow \text{(yellow)} + 3NaCl$$

$$Ba^{2+} + SO_4^{2} \longrightarrow BaSO_4\downarrow \text{(white)} ;$$

Ba^{2+} salts give apple green colour to the Bunsen flame.

$$Zn^{2+} + 2NH_3 + 2H_2O \longrightarrow Zn(OH)_2\downarrow \text{(white)} + 2NH_4\uparrow$$

$$Zn(OH)_2\downarrow + 4NH_4 \rightleftharpoons [Zn(NH_3)_4]^{2+} + 2OH^-$$

3. **(A)** CoO . ZnO = Rinmann's green reagent used as green pigment.

(B) $BaSO_4\downarrow + H_2SO_4$ (conc.) $\longrightarrow Ba^{2+} + HSO_4^-$

(C) $2AgCl\downarrow$ (white) $\xrightarrow{h\nu} 2Ag\downarrow$ (black) $+ Cl_2\uparrow$

Comprehension # 2 :

3. **(A)** $Bi^{3+} + 3\,OH^- \longrightarrow Bi(OH)_3\downarrow$;

$2Bi(OH)_3\downarrow + [Sn(OH)_4]^{2-} \longrightarrow 2Bi\downarrow + 3\,[Sn(OH)_6]^{2-}$

(B) is not correct as 'D' is precipitate of bismuth.

(C) $Bi^{3+} + C_6H_3(OH)_3 \longrightarrow Bi(C_6H_3O_3)\downarrow$ (yellow) $+ 3H^+$.

(D) $Bi^{3+} + C_9H_7ON + H^+ + 4I^- \longrightarrow C_9H_7ON.HBiI_4\downarrow$ (red)

4. **(A)** $Cl^- + Ag \longrightarrow AgCl\downarrow$ (white) ;

$3AgCl + AsO_3^{3-} \longrightarrow Ag_3AsO_3\downarrow$ (yellow) $+ 3Cl^-$

(B) $Bi^{3+} + 3OH^- \longrightarrow Bi(OH)_3$ (white) ;

$Bi(OH)_3 \xrightarrow{\Delta} BiO.OH\downarrow$ (yellowish-white) $+ H_2O$

(C) $BiOCl\downarrow$ (white) $+ 2H^+ \longrightarrow Bi^{3+} + H_2O + Cl^-$

EXERCISE - 4
Subjective Type

1. $3Zn^{2+} + 2K^+ + 2[Fe(CN)_6]^{4-} \longrightarrow K_2Zn_3[Fe(CN)_6]_2\downarrow$

2. **(i)** $Mg^{2+} + NH_3 + HPO_4^{2-} \longrightarrow Mg(NH_4)PO_4\downarrow$ (white)

(ii) $Zn^{2+} + 2NH_4OH \longrightarrow Zn(OH)_2\downarrow$ (white) $+ 2NH_4^+$

$Zn(OH)_2 + 4NH_4OH \longrightarrow [Zn(NH_3)_4](OH)_2 + 4H_2O$

(iii) $Bi^{3+} + 3I^- \longrightarrow BiI_3\downarrow$ (black).

$BiI_3\downarrow + H_2O \xrightarrow{\Delta} BiOI\downarrow$ (orange) $+ 2H^+ + 2I^-$.

(iv) $Na_2HPO_4 + 12\,(NH_4)_2MoO_4 + 23\,HNO_3 \longrightarrow$

$(NH_4)_3PMo_{12}O_{40}\downarrow + 2NaNO_3 + 21NH_4NO_3 + 12H_2O$

(canary yellow)

3. **(i)** $2Cu(BO_2)_2$ (blue) $+ C \longrightarrow 2CuBO_2$ (colourless) $+ B_2O_3 + CO$

$2Cu(BO_2)_2 + 2C \longrightarrow 2Cu$ (red and opaque) $+ 2B_2O_3 + 2CO$

(ii) $AgBr + 2NH_3 \longrightarrow [Ag(NH_3)_2]Br$

(iii) $2Cr(OH)_3 + 2Na_2CO_3 + 3KNO_3 \xrightarrow{\text{fused}} 2Na_2CrO_4 + 3KNO_2 + 2CO_2 + 3H_2O$

(iv) $2Cu(NO_3)_2 \longrightarrow 2\,CuO + 4NO_2 + O_2$

4. $2NO_2^- + H_2SO_4 \longrightarrow SO_4^{2-} + 2HNO_2$

$3HNO_2 \longrightarrow HNO_3 + 2NO + O_2$

$2NO + O \longrightarrow 2NO_2\uparrow$ (reddish brown)

$2KI + 2NO_2 \longrightarrow 2KNO_2 + I_2$

$Starch + I_2 \longrightarrow$ blue

5. $Hg_2Cl_2 + 2NH_3 \longrightarrow$

$\underbrace{Hg\downarrow\text{ (black)} + Hg(NH_2)Cl\downarrow\text{ (white)}}_{\text{(Black)}} + NH_4^+ + Cl^-$.

6. Bi^{3+} gives BiO^+ ion and Sb^{3+} gives SbO^+ ion. $Bi^{3+} + Cl^- + H_2O \longrightarrow BiO.Cl\downarrow + 2H^+$.

7. **(i)** $Na_2S + CdCO_3 \longrightarrow CdS\downarrow$ (yellow) $+ Na_2CO_3$

(ii) $CoCl_2 + 4NH_4SCN \xrightarrow{\text{Ether}} (NH_4)_2[Co(SCN)_4]$ (blue colour in etherial solution) $+ 2NH_4Cl$

8. $CuS + H_2SO_4 \longrightarrow CuSO_4 + H_2S$.

$2HNO_3 \longrightarrow 2NO_2 + H_2O + [O]$

$H_2S + [O] \longrightarrow H_2O + S\downarrow$ (white) (HNO_3 is strong oxidising agent).

$CuSO_4 + H_2S \longrightarrow CuS\downarrow + H_2SO_4$.

$3CuS + 8HNO_3 \longrightarrow 3Cu^{2+} + 6NO_3^- + 3S\downarrow + 2NO\uparrow + 4H_2O$.

$2NO_3^{2-} + Cu^{2+} + 4NH_4OH \longrightarrow [Cu(NH_3)_4]^{2+}(NO_3)_2$ (intense blue coloured solution) $+ 4H_2O$;

$[Cu(NH_3)_4](NO_3)_2 + K_4[Fe(CN)_6] \longrightarrow Cu_2[Fe(CN)_6]\downarrow$ (chocolate brown).

$Ba^{2+} + CuSO_4 \longrightarrow BaSO_4\downarrow$ (white) $+ Cu^{2+}$.

9. A - $FeSO_4.7H_2O$; B - $BaSO_4\downarrow$; C - SO_2 ; D - SO_3

E - Fe_2O_3 ; F - $FeCl_3$; G - $Fe(SCN)_3$

10. **(i)** $CuCO_3$ **(A)** $\xrightarrow{\Delta}$ CuO **(B)** $+ CO_2$ **(C)** ;

(ii) CuO **(B)** $+ H_2 \xrightarrow{\Delta} Cu\downarrow$ **(D)** $+ H_2O$

(iii) $2Cu^{2+} + [Fe(CN)_6]^{4-} \longrightarrow 2Cu_2[Fe(CN)_6]\downarrow$ (chocolate brown) (E)

(iv) $CO_2 + Ca(OH)_2 \longrightarrow CaCO_3\downarrow + H_2O$;

$CaCO_3 + H_2O + CO_2 \longrightarrow Ca(HCO_3)_2$ (soluble)

11. This gives black cobalt oxide, Co_3O_4 , upon ignition and this mask the colour of thernad blue ($CoAl_2O_4$).

12. $CrO_2Cl_2 + 4NaOH \longrightarrow Na_2CrO_4$ **(A)** $+ 2NaCl + 2H_2O$

$Na_2CrO_4 + H_2SO_4 \longrightarrow 2Na_2Cr_2O_7$ **(B)** $+ Na_2SO_4 + H_2O$

$Na_2Cr_2O_7 + 2NaOH \longrightarrow 2Na_2CrO_4$ **(C)** $+ H_2O$

$Na_2CrO_4 + 2AgNO_3 \longrightarrow Ag_2CrO_4$ **(D)** $+ 2NaNO_3$

13. $ZnS + H_2SO_4 \longrightarrow ZnSO_4 + H_2S$.

$Cr_2O_7^{2-} + 3H_2S + 8H^+ \longrightarrow 2Cr^{3+}$ (green solution) $+ 3S\downarrow + 7H_2O$.

$S + O_2 \longrightarrow SO_2$; $2H_2S + SO_2 \longrightarrow 2H_2O + 3S$.

$Zn^{2+} + 2OH^- \rightarrow Zn(OH)_2\downarrow$ (white) ;

$Zn(OH)_2 + 2OH^- \rightarrow [Zn(OH)_4]^{2-}$.

$Zn^{2+} + 2NH_3 + H_2O \rightleftharpoons Zn(OH)_2\downarrow$ (white) $+ NH_4^+$.

$Zn(OH)_2\downarrow + 4NH_3 \rightleftharpoons [Zn(NH_3)_4]^{2+} + 2OH^-$.

14. The given unknown mixture contains NH_4^+, Fe^{2+} and Cl^- ions or NH_4Cl and $FeCl_2$

15. **(i)** $FeCl_3 + 3H_2O \longrightarrow Fe(OH)_3\downarrow$ (reddish brown) $+ 3HCl$; so solution is acidic in nature.

(ii) $Fe^{3+} + 3SCN^- \longrightarrow Fe(SCN)_3$ (red colouration).

$4Fe^{3+} + 3[Fe(CN)_6]^{4-} \longrightarrow Fe_4[Fe(CN)_6]_3$ (Prussian blue).

(iii) $Cr_2O_7^{2-} + 4Cl^- \; 6H^+ \longrightarrow 2CrO_2Cl_2\uparrow$ (deep red) $+ 3H_2O$.

(iv) $CrO_2Cl_2\uparrow + 4OH^- \longrightarrow CrO_4^{2-} + 2Cl^- + 2H_2O$.

$Pb^{2+} + CrO_4^{2-} \longrightarrow PbCrO_4\downarrow$ (yellow).

16. **(a)** Violet (or blackish–purple) precipitate consisting of $Zn[Hg(SCN)_4]$ and $Cu[Hg(SCN)_4]$ is formed.

(b) $Zn^{2+} + [Hg(SCN)_4]^{2-} \longrightarrow Zn\,[Hg(SCN)_4]\downarrow$ (white).

17. **(A)** $Ag_2CrO_4\downarrow$ (yellow) $+ NH_3 \longrightarrow [Ag(NH_3)_2]^+ + CrO_4^{2-}$

(B) $Cu(OH)_2.CuSO_4\downarrow$ (blue) $+ 8NH_3 \longrightarrow 2[Cu(NH_3)_4]^{2+} + SO_4^{2-} + 2OH^-$

(C) $PbSO_3\downarrow$ (white) $+ 4OH^- \longrightarrow [Pb(OH)_4]^{2-} + SO_3^{2-}$

Soluble in sodium hydroxide not in NH_3.

(D) Soluble in sodium hydroxide not in NH_3.

(E) $Ni(OH)_2\downarrow$ (green) $+ 6NH_3 \longrightarrow [Ni(NH_3)_6]^{2+}$ (deep blue colouration) $+ 2OH^-$

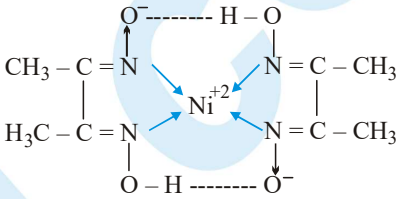
(F) $Zn_3(PO_4)_2\downarrow$ (white) $+ 12NH_3 \longrightarrow 3[Zn(NH_3)_4]^{2+} + 2PO_4^{3-}$

(G) Insoluble in NH_3, soluble appreciably in boiling concentrated H_2SO_4.

(H) $Bi(OH)_2NO_3$ is insoluble in NH_3.

(I) Insoluble in NH_3 but soluble in ammonium salts liberating NH_3.

18. $Ni^{2+} + 2dmg \xrightarrow{NH_4OH} [Ni(dmg)_2]\downarrow$ (bright red).



rosy red ppt

19. Here NO is NO^+; so in $[Fe(H_2O)_5NO^+]^{2+}$, the oxidation state of iron is +1.

20. NaCl-Golden yellow ; KCl-Lilac ; $CuCl_2$-bluish-green, $BaCl_2$-Apple green ; $SrCl_2$-Crimson ; $CaCl_2$-Brick red.

21. **(i)** $4Cl^- + Cr_2O_7^{2-} + 6H^+ \longrightarrow 2CrO_2Cl_2\uparrow$ (deep red) $+ 3H_2O$

(ii) $NO_2^- + H^+ \longrightarrow HNO_2$;

$3HNO_2 \longrightarrow HNO_3 + NO\uparrow + H_2O$

$2NO\uparrow + O_2\uparrow \longrightarrow NO_2\uparrow$ (brown)

(iii) $3I^- + 2H_2SO_4 \longrightarrow I_3^-\uparrow$ (violet) $+ SO_4^{2-} + 2H_2O + SO_2$

(iv) $2KBr + 2H_2SO_4 \longrightarrow Br_2\uparrow$ (reddish brown) $+ SO_2\uparrow + NO_4^{2-} + 2K^+ + 2H_2O$

(v) $Cl^- + H_2SO_4 \longrightarrow HCl\uparrow$ (colourless) $+ HSO_4^-$

(vi) $2KBr + MnO_2 + 2H_2SO_4 \longrightarrow Br_2\uparrow$ (reddish-brown) $+ 2K^+ + Mn^{2+} + 2SO_4^{2-} + 2H_2O$

(vii) $4NO_3^- + 2H_2SO_4 \longrightarrow Br_2\uparrow$ (reddish-brown) $+ 2K^+ + Mn^{2+} + 2SO_4^{2-} + 2H_2O$

(viii) $KCl + MnO(OH)_2 + 2H_2SO_4 + 2Cl^-$ (brown) $\longrightarrow Mn^{2+} + Cl_2\uparrow$ (yellowish green) $+ 2SO_4^{2-} + 3H_2O$

(ix) $SO_3^{2-} + 2H^+ \longrightarrow SO_2\uparrow$ (colourless) $+ H_2O$

22. **(1)** Al^{3+} and $Hg^{2+} \xrightarrow[H_2S]{H^+} HgS\downarrow$ (black) + Al^{3+} (in solution)

(2) Cd^{2+} and $Zn^{2+} \xrightarrow[H_2S]{H^+} CdS\downarrow$ (yellow) + Zn^{2+} (in solution)

(3) Fe^{3+} and $Cu^{2+} \xrightarrow[H_2S]{H^+} CuS\downarrow$ (black) + Fe^{3+} (in solution).

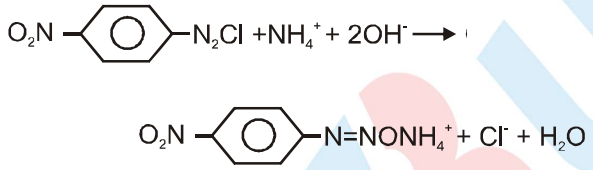
23. $Pb^{2+} + 2Cl^- \longrightarrow PbCl_2\downarrow$ (white);

$Hg_2^{2+} + 2Cl^- \longrightarrow Hg_2Cl_2\downarrow$ (white)

$Ag^+ + Cl^- \longrightarrow AgCl\downarrow$ (white)

K_{sp} of chlorides of Pb^{2+} and Hg_2^{2+} is low as compared to K_{sp} of Hg^{2+} and Cd^{2+}. Chloride ion concentration provided by dilute HCl is just enough to exceed the K_{sp} of $PbCl_2$ and Hg_2Cl_2. Thus Pb^{2+} and Hg_2^{2+} are precipitated as their chlorides.

24. A red colouration is obtained.



25. **(i)** $Co^{2+} + S^{2-} \xrightarrow{NH_4OH/NH_4Cl} CoS\downarrow$ (black)

(ii) $CoS\downarrow + HNO_3 + 3HCl \longrightarrow Co^{2+} + S\downarrow + NOCl\uparrow + 2Cl^- + 2H_2O$

(iii) $Co^{2+} + 2CN^- \longrightarrow Co(CN)_2\downarrow$ (reddish-brown)

$Co(CN)_2\downarrow + 4CN^- \longrightarrow [Co(CN)_6]^{4-}$ (brown solution)

(iv) $4[Co(CN_6]^{4-} + H_2O + O_2 \longrightarrow 4[Co(CN)_6]^{3-}$ (yellow solution) $+ 4OH^-$

(v) $Co^{2+} + 6HCO_3^- \longrightarrow [Co(CO_3)_3]^{4-} + 3H_2O + 3CO_2$

$[Co(CO_3)_3]^{4-} \xrightarrow{[O]} [Co(CO_3)_3]^{3-}$ (green solution)

EXERCISE - 5

Part # I : AIEEE/JEE-MAIN

1. Methyl orange shows Red (pinkish) color in Acidic medium & yellow color in basic medium since original solution is basic so

initial color $\Rightarrow$ yellow

& Titrated with acid so

Final color $\Rightarrow$ pinkish (red)

Part # II : IIT-JEE ADVANCED

1. $Mg^{2+} + 2HCO_3^-$ (from sodium salt) $\longrightarrow Mg(HCO_3)_2$ (soluble) $\xrightarrow{\Delta} MgCO_3\downarrow$ (white) $+ H_2O + CO_2$

2. Hg^{2+} gives red precipitate of HgI_2 which dissolves in excess KI forming colourless $[HgI_4]^{2-}$ ions.

$Bi^{3+} + 3I^- \longrightarrow BiI_3\downarrow$ (black);

$BiI_3 + I^- \longrightarrow [BiI_4]^-$ (orange solution)

Pb^{2+} gives yellow precipitate of PbI_2 . Cu^{2+} gives white precipitate of Cu_2I_2 with evolution of iodine.

3. $[Zn(OH)_4]^{2-} \xrightarrow{H_2O\text{-boiled}} Zn(OH)_2$ (white) $+ 2OH^-$

$Zn(OH)_2$ precipitate is readily soluble in excess of ammonia and in solutions of ammonium salts due to the formation of tetraamminezinc(II).

$Zn(OH)_2 + 4NH_3 \longrightarrow [Zn(NH_3)_4]^{2+}$ (soluble complex) $+ 2OH^-$

or

$Zn(OH)_2 + 4NH_4OH \xrightarrow{NH_4Cl} [Zn(NH_3)_4]^{2+} + 4H_2O + 2OH^-$.

But $Al(OH)_3$, $Mg(OH)_2$ and $Ca(OH)_2$ don't dissolves in excess of NH_3 solution.

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

$Cu^{2+} + 2CN^- \longrightarrow Cu(CN)_2\downarrow$ (yellow); $2Cu(CN)_2\downarrow \longrightarrow 2CuCN\downarrow$ (white) $+ (CN)_2\downarrow$

$CuCN\downarrow + CN^- \longrightarrow [Cu^I(CN)_4]^{3-}$ (colourless soluble complex).

5. $MgSO_4$ on reaction with Na_2HPO_4 in presence of NH_4OH gives white precipitate of $Mg(NH_4)PO_4$.

$$MgSO_4 + Na_2HPO_4 + NH_4OH \longrightarrow Mg(NH_4)PO_4\downarrow + Na_2SO_4 + H_2O.$$

6. $Hg^{2+} + 2I^- \longrightarrow HgI_2\downarrow$ (scarlet / red)

$HgI_2 + 2I^-$ (excess) $\longrightarrow [HgI_4]^{2-}$ (soluble complex)

$Hg^{2+} + Co(SCN)_2 \longrightarrow Co[Hg(SCN)_4]\downarrow$ (deep blue)

7. All ammonium salts on reaction with alkali produce ammonia. The nitrate and nitrite also on reduction with nascent hydrogen (produced by the reaction of zinc and sodium hydroxide) produce the ammonia gas according to the following reactions.

$$NH_4NO_2 + NaOH \longrightarrow NaNO_2 + NH_3 + H_2O$$

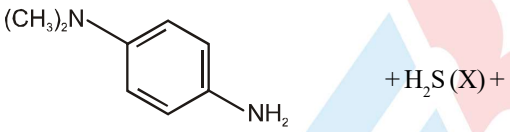
$$NH_4NO_3 + NaOH \longrightarrow NaNO_3 + NH_3 + H_2O$$

$$NaNO_2 + 6[H] \xrightarrow{Zn/NaOH} NaOH + NH_3 + H_2O$$

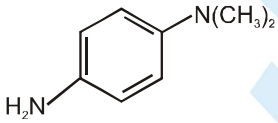
$$NaNO_3 + 8[H] \xrightarrow{Zn/NaOH} NaOH + NH_3 + 2H_2O$$

So options **(A)** and **(B)** are correct.

8 to 10 $S^{2-}(X) + 2H^+ \longrightarrow H_2S$

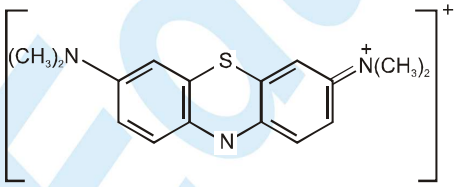


$+ H_2S(X) +$



$+ 6Fe^{3+}(Y)$

$\longrightarrow 6Fe^{2+} + NH_4^+ + 4H^+ +$



(methylene blue).

The compound **X** is Na_2S and **Y** is $FeCl_3$.

11, 12 & 13

$Cu(M) + AgNO_3(N)$ (aqueous colourless solution) $\longrightarrow$

Resultant solution contains $Cu(NO_3)_2$ (blue solution) and $AgNO_3$ (colourless solution)

(N)

Note : Here it is considered that complete $AgNO_3$ is not utilized in the reaction.

$AgNO_3(aq) + NaCl(aq) \longrightarrow AgCl\downarrow$ (white) (O) $+ NaNO_3$

Solution containing white ppt. of AgCl also contains $Cu(NO_3)_2$ which developed deep blue colouration with aqueous NH_3 solution

$AgCl\downarrow$ (white) $+ 2NH_3$ (aq.) $\longrightarrow [Ag(NH_3)_2]^+$

$Cu(NO_3)_2$ (aq.) $+ 4NH_3$ (aq.) $\longrightarrow [Cu(NH_3)_4](NO_3)_2$ (deep blue solution)

So, Metal rod M is Cu.

The compound N is $AgNO_3$ and the final solution contains $[Ag(NH_3)_2]^+$ and $[Cu(NH_3)_4]^{2+}$

14. In presence of acidic medium, ionisation of H_2S is suppressed so less number of S^{2-} ions are produced. So only those sulphides are precipitated which have low solubility product (K_{SP}) value, For example CuS and HgS.

15. Precipitation of insoluble cuprous salts pushes the equilibrium backwards (i.e. towards the left)

16. $KI(aq) + K_3[Fe(CN)_6](aq) \longrightarrow \underset{\text{Brownish - yellow}}{KI_3(aq)} + K_4[Fe(CN)_6(aq)$

$\downarrow + ZnSO_4(aq)$

$K_2Zn_3[Fe(CN)_6]_2\downarrow$ white ppt $+ KI_3(aq)$

OR $\downarrow Na_2S_2O_3$

$\{K_2Zn[Fe(CN)_6]\downarrow\}$ $I^-(aq) + S_4O_6^{2-}(aq)$ Colourless

(D) with NaOH

$K_2Zn[Fe(CN)_6] + NaOH \longrightarrow [Zn(OH)_4]^{2-}(aq) + [Fe(CN)_6]^{4-}(aq)$

17. $8MnO_4^- + 3S_2O_3^{2-} + H_2O \rightarrow 8MnO_2 + 6SO_4^{2-} + 2OH^{\ominus}$

22. **(A)** Cu^{2+} show characteristic green colour in the flame test.

(B) Only Cu^{2+} can give precipitate in acidic medium on passing H_2S

(C) Both Cu^{2+} and Mn^{2+} show the formation of precipitate by passing H_2S in faintly basic medium.

(D) $E^{\circ}_{Cu^{2+}/Cu} > E^{\circ}_{Mn^{2+}/Mn}$, as per electrochemical series.

MOCK TEST

1. (A)

$$SO_3^{2+} + Zn + 8H^+ \longrightarrow H_2S\uparrow + 3Zn^{2+} + 3H_2O$$

$$Pb^{2+} + S^{2-} \longrightarrow PbS\downarrow \text{(black)}$$

2. (A)

$$MgCl_2 + 2NaHCO_3 \longrightarrow Mg(HCO_3)_2 \text{ (soluble)} + 2NaCl$$

$$Mg(HCO_3)_2 \xrightarrow{\Delta} MgCO_3\downarrow \text{(white)} + CO_2 + H_2O$$

3. (B)

$$CuSO_4 + H_2S \longrightarrow CuS\downarrow \text{(black)} + H_2SO_4$$

$$CuS + 2HNO_3 \longrightarrow Cu(NO_3)_2 \text{ (blue solution)} + NO + S + H_2O$$

$$2Cu^{2+} + 4I^- \longrightarrow Cu_2I_2\downarrow \text{(white)} + I_2\uparrow$$

(colour of solution is yellow/brown)

4. (D)

$$Pb^{2+} + OH^- \longrightarrow Pb(OH)_2\downarrow \text{(white)};$$

$$Pb^{2+} + CO_3^{2-} \longrightarrow PbCO_3\downarrow \text{(white)}$$

$$Pb^{2+} + 2\,Cl^- \longrightarrow PbCl_2\downarrow \text{(white)};$$

$$Pb^{2+}\ (aq.) + SO_4^{2-} \longrightarrow PbSO_4\downarrow \text{(white)}$$

5. (D)

(A) (B) (C) can be precipitated by HCl as well as H_2S as their insoluble chlorides and sulphides respectively.

(D) $Sn^{2+} + 2HCl \longrightarrow SnCl_2$ (soluble) $+ 2H^+$.

It can be precipitated only by H_2S as its insoluble sulphide (brown).

6. (B)

$$Bi(NO_3)_2 + KI \longrightarrow KNO_3 + BiI_3\downarrow \text{(black)}$$

$$BiI_3 + KI \longrightarrow K[BiI_4] \text{ (orange)}$$

7. (A)

$$MnO_4^-/H^+ \longrightarrow [O] : Fe^{2+} \xrightarrow{[O]} Fe^{3+} + [Fe(CN)_6]^{4-} \longrightarrow Fe_4[Fe(CN)_6]_3$$

8. (B)

On adding HCl the equilibrium will shift in backward direction.

9. (A)

ZnS & MnS are soluble in conc. HCl. Ni^{2+} & Co^{2+} are insoluble in conc. HCl but dissolves when $KClO_3$ is added, forming corresponding chlorides.

$CoCl_2 + 2KCN \longrightarrow Co(CN)_2 \downarrow$ (buff. coloured) $+ 2KCl$

$Co(CN)_2 + 4KCN \longrightarrow K_4[Co(CN)_6]$ (yellowish brown)

Ni^{2+} forms white precipitate which is soluble in excess KCN.

10. (D)

$Mn^{2+} + H_2S \longrightarrow MnS \downarrow$ (buff/light coloured)

$\xrightarrow{HCl} MnCl_2 \xrightarrow[[O]]{NaOH} MnO_2 \downarrow$ (Brown/black)

$MnO_2 + 2KNO_3 + Na_2CO_3 \xrightarrow{fusion} Na_2MnO_4$ (green compound) $+ KNO_2 + 2NaOH + CO_2$

11. (B)

$Fe_4[Fe(CN)_6]_3 + 2\,OH^- \longrightarrow 4\,Fe(OH)_3 \downarrow + 3\,[Fe(CN)_6]^{4-}$

12. (B, C, D)

(A) $2HCO_3^- + Mg^{2+} \xrightarrow{cold} Mg(HCO_3)_2$ (soluble)

$\xrightarrow{\Delta} MgCO_3 \downarrow + CO_2 + 2H_2O$

(B) $Ca(HCO_3)_2 + 2NH_3 \longrightarrow (NH_4)_2CO_3 + CaCO_3 \downarrow$

(C) True statement

(D) $CO_3^{2-} + 4Hg^{2+} + 3H_2O \longrightarrow Hg_4O_3CO_3 \downarrow$ (reddish brown) $+ 6H^+$

basic mercury(II) carbonate

13. (C,D)

$2I^- + Cl_2 \longrightarrow I_2$ (purple/violet) ;

$2I^- + Br_2 \longrightarrow I_2$ (purple/violet)

14. (C, D)

(C) Heavy metal chlorides like AgCl does not give chromyl chloride.

(D) $2NaCl + MnO_2 + 3H_2SO_4 \longrightarrow 2\,NaHSO_4 + MnSO_4 + Cl_2$

15. (A,B)

(A) $H_3PO_2 + 2H_2O \longrightarrow H_3PO_4 + 4H$

$HgCl_2 + 2H \longrightarrow Hg_2Cl_2 \downarrow$ (white) $+ 2HCl$

$Hg_2Cl_2 + 2H \longrightarrow 2Hg \downarrow$ (grey) $+ 2HCl$

(B) $HgCl_2 + SnCl_2 \longrightarrow Hg_2Cl_2 \downarrow$ (white) $+ SnCl_4$

$HgCl_2 + SnCl_2 \longrightarrow Hg \downarrow$ (grey) $+ SnCl_4$

(C) Red precipitate is formed which dissolves in excess of KI.

(D) White precipitate of $Hg(NH_3)Cl$ is formed.

16. (A, B, D)

(A) $AlCl_3 + 3H_2O \longrightarrow Al(OH)_3 + 3HCl \uparrow$ (fumes)

(B) $AlCl_3 + K_2Cr_2O_7 + H_2SO_4 \longrightarrow Al_2(SO_4)_3 + K_2SO_4 + CrO_2Cl_2 \uparrow$ (deep red or orange red vapour) $+ H_2O$

(D) Gives blue bead of $Al_2O_3.CoO$

17. (A, B, D)

(A) $Bi^{3+} + 3NH_4OH \longrightarrow Bi(OH)_3 \downarrow$ (white) $+ 3NH_4^+$

(B) $Pb^{2+} + 2NH_4OH \longrightarrow Pb(OH)_2 \downarrow$ (white) $+ 2NH_4^+$

(C) Due to common ion effect of NH_4^+, the OH^- ion concentration is not excess enough to precipitate Mg^{2+} as $Mg(OH)_2$ because of its high solubility product.

(D) $Fe^{3+} + 3NH_4OH \longrightarrow Fe(OH)_3 \downarrow$ (reddish brown) $+ 3NH_4^+$

(E) $Cu^{2+} + 4NH_3 \longrightarrow [Cu(NH_3)_4]^{2+}$

In presence of ammonium salts, precipitation does not occur at all, but blue colour solution is formed right away.

18. (A,B,C,D)

(A) $CaSO_4 + (NH_4)_2SO_4 \longrightarrow (NH_4)_2[Ca(SO_4)_2]$ (soluble)

(B) $BaCrO_4$ is insoluble in dilute acetic acid & thus gets precipitated with K_2CrO_4 (low K_{sp} in K_2CrO_4 solution in acetic acid).

(C) $Cr(OH)_3$ is soluble in NaOH & Br_2 water forming sodium chromate while $Fe(OH)_3$ is insoluble.

(D) $[Cu(CN)_4]^{3-}$ is more stable than $[Cd(CN)_4]^{2-}$ gives yellow precipitate with H_2S.

19. (A)

20. (B)

$PbI_2 + 2I^- \rightleftharpoons [PbI_4]^{2-}$ soluble complex

Reaction is reversible and shifts in backward direction on dilution with water.

21. (D)

Dilute solution contains more of water thus precipitate formed gets dissolved.

22. (A)

23. (D)

All are black and gives gas with dil. H_2SO_4

$S^{2-} + 2H^+ \longrightarrow H_2S\uparrow$

24. (D)

(A) $SO_4^{2-} + (CH_3COO)_2Pb \longrightarrow PbSO_4\downarrow + 2CH_3COO^-$

(B) $2CuSO_4 + 4KI \longrightarrow 2K_2SO_4 + Cu_2I_2\downarrow + I_2$

(C) $CuSO_4 . 5H_2O \xrightarrow{-2H_2O} CuSO_4 .3H_2O$

25. (D)

(C) $2H\overset{+5}{N}O_3 \longrightarrow H_2O + 2\overset{+4}{N}O_2 + [O]$

(B) $H_2\overset{-2}{S} + [O] \longrightarrow H_2O + \overset{0}{S}\downarrow$

26. (A)

$Cu(NO_3)_2 + Zn \longrightarrow Zn(NO_3)_2 + Cu\downarrow$ (reddish brown)

$AgS, FeS, CuS \text{ or } PbS + H_2SO_4 \longrightarrow FeSO_4 + H_2S$

(A) **(B)**

$H_2S + 2HNO_3 \longrightarrow 2NO_2 + 2H_2O + S$

(C) **(D)**

$CuSO_4 + BaCl_2 \longrightarrow CuCl_2 + BaSO_4\downarrow$ (white)

(E)

$CuSO_4 + H_2S \longrightarrow CuS\downarrow$ (black) $+ H_2SO_4$

(F)

$3CuS\downarrow + 8HNO_3 \longrightarrow 3Cu^{2+} + 6NO_3^- + 3S\downarrow + 2NO\uparrow + 4H_2O$

$Cu^{2+} + 4NH_3 \longrightarrow [Cu(NH_3)_4]^{2+}$ (blue colour soluble complex)

(G)

$Cu^{2+} + [Fe(CN)_6]^{4-} \longrightarrow Cu_2[Fe(CN)_6]\downarrow$ (chocolate brown)

27. (D)

(A) $NH_3 + HCl \longrightarrow NH_4Cl$ (white fumes)

(B) $(NH_4)_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2NH_3 + 2H_2O$

(C) Nitrogen gas is obtained

28. (C)

$4[Ag(NH_3)_2]^+ + NH_2 - NH_2.H_2SO_4$ (saturated solution) $\longrightarrow 4Ag\downarrow + N_2 + NH_3 + 6NH_4^+ + 2NH_3 + SO_4^{2-}$

This is called silver mirror test. Finely divided silver metal adhere to the glass walls forming an attractive mirror.

29. (D)

Silver is precipitated.

30. $SO_3^{2-} + H_2SO_4 \longrightarrow SO_4^{2-} + SO_2 + H_2O$;

$K_2Cr_2O_7 + H_2SO_4 + 3SO_2 \longrightarrow Cr_2(SO_4)_3$ (green) $+ K_2SO_4 + H_2O$

$NO_3^- + H_2SO_4 \longrightarrow HSO_4^- + HNO_3$;

$4HNO_3 \longrightarrow 2H_2O + O_2 + 4NO_2$

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

$Ag + HCl \longrightarrow AgCl\downarrow$ (white) $+ H^+$

$AgCl + 2NH_4OH \longrightarrow [Ag(NH_3)_2]Cl$;

$[Ag(NH_3)_2]Cl + HNO_3 \longrightarrow AgCl\downarrow + 2NH_4NO_3$

$[Ag(NH_3)_2Cl + KI \longrightarrow AgI\downarrow 2NH_3 + KCI$;

$Zn^{2+} + H_2S \longrightarrow ZnS\downarrow$ (white) $+ 2H^+$

$3Zn^{2+} + 2K^+ + 2[Fe(CN)_6]^4 \longrightarrow K_2Zn_3[Fe(CN)_6]_2\downarrow$

31. $[A] = k^+$ and I^-, $[B] = Hg^{2+}$ and Cl^-

As black su;phide is only soluble in aquaregia and further it gives greyish black ppt with $SnCl_2$ the one of the cation may be Hg^{2+}. As salt mixture gives lilac colour in flame, the other cation is K^+.

$2KI + Cl_2 \longrightarrow 2KCl + I_2 \longrightarrow CCl_4$ (violet colour)

$KI + AgNO_3 \longrightarrow AgI\downarrow$ (bright colour) $+ KNO_3$