20 Qualitative Estimations

In order to identify a given inorganic compound, following tests characterise different radicals in it.

Test for acid radicals:

[A] Add dil. HCl or H_2SO_4 to a small amount of substance and warm gently, observe.

Carbonate or CO_3^{2-}:

(i) Brisk effervescences of colourless gas CO_2; may be carbonate.

$$CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + H_2O + CO_2 \uparrow$$

(ii) The gas turns lime water milky.

$$CO_2 + Ca(OH)_2 \longrightarrow \underset{\text{Milky}}{CaCO_3 \downarrow} + H_2O$$

(iii) Excess of passage of gas through lime water disappears milkyness.

$$CaCO_3 + CO_2 + H_2O \longrightarrow Ca(HCO_3)_2 \quad \text{(Soluble)}$$

Sulphite or SO_3^{2-}:

(i) Colourless gas with suffocating odour of burning sulphur; may be sulphite.

$$CaSO_3 + H_2SO_4 \longrightarrow CaSO_4 + H_2O + SO_2 \uparrow$$

(ii) The gas turns moistened paper with acidified $K_2Cr_2O_7$ green.

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

(iii) The sulphites also give white ppt. with $BaCl_2$, soluble in dil. HCl.

$$Na_2SO_3 + BaCl_2 \longrightarrow 2NaCl + BaSO_3 \downarrow$$

Sulphide or S^{2-}:

(i) Colourless gas with rotten egg smell, may be sulphide.

$$CaS + H_2SO_4 \longrightarrow CaSO_4 + H_2S \uparrow$$

(ii) The gas turns lead acetate paper black.

$$(CH_3COO)_2Pb + H_2S \longrightarrow \underset{\text{Black}}{PbS \downarrow} + 2CH_3COOH$$

(iii) The sulphide also turns sodium nitroprusside solution violet.

$$Na_2S + Na_2[FeNO(CN)_5] \longrightarrow \underset{\text{Violet}}{Na_4[Fe(NOS)(CN)_5]}$$

Acetate or CH_3COO^-:

(i) Smell of vinegar comes out, may be acetate.

$$(CH_3COO)_2Ca + H_2SO_4 \longrightarrow \underset{\text{Vinegar smell}}{2CH_3COOH} + CaSO_4$$

(ii) The acetate gives blood red colour with neutral $FeCl_3$ solution.

$$3(CH_3COO)_2Ca + 2FeCl_3 \longrightarrow 2Fe(CH_3COO)_3 + 3CaCl_2$$

Nitrite or NO_2^-:

(i) Reddish, brown vapours of NO_2 comes out, may be nitrite.

$$2KNO_2 + H_2SO_4 \longrightarrow K_2SO_4 + 2HNO_2$$
$$3HNO_2 \longrightarrow HNO_3 + 2NO \uparrow + H_2$$
$$2NO + O_2 \longrightarrow 2NO_2 \uparrow$$

(ii) The gas turns acidified KI + starch paper blue.

$$2KI + 2NO_2 \longrightarrow 2KNO_2 + I_2 \uparrow$$
$$\text{Starch} + I_2 \longrightarrow \text{Blue colour}$$

[B] Add concentrated H_2SO_4 to a small amount of the substance and warm gently, observe.

Chloride or Cl^-:

(i) Colourless fuming gas (HCl) with pungent smell; may be chloride.

$$2NaCl + H_2SO_4 \longrightarrow Na_2SO_4 + 2HCl \uparrow$$

(ii) The chlorides give white precipitate with $AgNO_3$, soluble in NH_4OH.

$$NaCl + AgNO_3 \longrightarrow \underset{\text{White ppt.}}{AgCl \downarrow} + NaNO_3$$
$$AgCl + 2NH_4OH \longrightarrow \underset{\text{Soluble}}{Ag(NH_3)_2Cl} + 2H_2O$$

(iii) Chlorides also give **chromyl chloride test**—On heating chloride salt with $K_2Cr_2O_7$ and concentrated H_2SO_4, orange-red vapours of chromyl chloride (CrO_2Cl_2) come out which on passing in NaOH gives yellow solution of Na_2CrO_4. Acidified solution of Na_2CrO_4 gives yellow precipitate with $(CH_3COO)_2Pb$.

$$4NaCl + K_2Cr_2O_7 + 3H_2SO_4 \longrightarrow 2CrO_2Cl_2 + 2Na_2SO_4 + K_2SO_4 + 3H_2O$$

$$CrO_2Cl_2 + 4NaOH \longrightarrow Na_2CrO_4 + 2NaCl + 2H_2O$$

$$Na_2CrO_4 + (CH_3COO)_2Pb \longrightarrow 2CH_3COONa + \underset{\text{Yellow ppt.}}{PbCrO_4}\downarrow$$

Note : Chlorides of Hg, Ag, Pb and Sn do not give chromyl chloride test.

Bromide or Br^-:

(i) Brown vapours come out; may be bromide or nitrate.

$$2NaBr + H_2SO_4 \longrightarrow Na_2SO_4 + 2HBr$$

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

(ii) The bromides give light yellow precipitate, partially soluble in NH_4OH.

$$NaBr + AgNO_3 \longrightarrow \underset{\text{Light yellow}}{AgBr}\downarrow + NaNO_3$$

(iii) Brown vapours of Br_2 on passing in H_2O give brown colour whereas of NO_2 does not impart colour to water.

Iodide or I^-:

(i) Dark violet fumes (I_2) come out; may be iodide.

$$2NaI + H_2SO_4 \longrightarrow Na_2SO_4 + 2HI$$

$$2HI + H_2SO_4 \longrightarrow I_2\uparrow + 2H_2O + SO_2\uparrow$$

(ii) Iodides give yellow precipitate with $AgNO_3$; insoluble in NH_4OH.

$$NaI + AgNO_3 \longrightarrow \underset{\text{Yellow}}{AgI}\downarrow + NaNO_3$$

Note : Sodium carbonate extract of bromide and iodide on addition of $CHCl_3$ and Cl_2 water gives brown or violet layer to $CHCl_3$ respectively.

$$2NaBr + Cl_2 \longrightarrow 2NaCl + Br_2;$$

$$Br_2 + CHCl_3 \longrightarrow \text{Brown colour}$$

$$2NaI + Cl_2 \longrightarrow 2NaCl + I_2;$$

$$I_2 + CHCl_3 \longrightarrow \text{Violet colour}$$

Nitrate or NO_3^-:

(i) Brown fumes come out; may be nitrate.

$$NaNO_3 + H_2SO_4 \longrightarrow NaHSO_4 + HNO_3$$

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

(ii) **Ring test:** An aqueous solution of salt (all nitrates are water soluble) is mixed with freshly prepared $FeSO_4$ and concentrated H_2SO_4 is poured in test tube from sides, brown ring is developed at the junction of two solutions.

$$NaNO_3 + H_2SO_4 \longrightarrow NaHSO_4 + HNO_3$$

$$6FeSO_4 + 2HNO_3 + 3H_2SO_4 \longrightarrow 3Fe_2(SO_4)_3 + 2NO + 4H_2O$$

$$FeSO_4 + NO \longrightarrow \underset{\text{Brown ring}}{Fe(NO)SO_4}$$

Oxalate or $C_2O_4^{2-}$:

(i) Colourless gases ($CO + CO_2$) come out.

$$Na_2C_2O_4 + H_2SO_4 \longrightarrow H_2O + CO + CO_2 + Na_2SO_4$$

(ii) These gases burn with blue flame at the mouth of test tube.

$$2CO + O_2 \longrightarrow 2CO_2$$

(iii) A solution of oxalates gives white precipitate with $CaCl_2$ solution. This precipitate gets dissolved in dil. H_2SO_4 and decolourises $KMnO_4$ (acidified) solution.

$$Na_2C_2O_4 + CaCl_2 \longrightarrow \underset{\text{White}}{CaC_2O_4}\downarrow + 2NaCl$$

$$CaC_2O_4 + H_2SO_4 \longrightarrow CaSO_4 + H_2C_2O_4$$

$$2KMnO_4 + 3H_2SO_4 + 5H_2C_2O_4 \longrightarrow 2MnSO_4 + K_2SO_4 + 8H_2O + 10CO_2$$

[C] Sulphate or SO_4^{2-}:

Add concentrated HNO_3 to a small amount of substance, heat and then add $BaCl_2$; white precipitate insoluble in any acid or alkali, sulphate is confirmed.

$$Na_2SO_4 + 2HNO_3 \longrightarrow 2NaNO_3 + H_2SO_4$$

$$H_2SO_4 + BaCl_2 \longrightarrow \underset{\text{White}}{BaSO_4}\downarrow + 2HCl$$

[D] Phosphate or PO_4^{3-}:

Add concentrated HNO_3 to a small amount of substance, heat and then add ammonium molybdate; canary yellow precipitate confirms the presence of phosphate.

$$Na_3PO_4 + 3HNO_3 \longrightarrow 3NaNO_3 + H_3PO_4$$

$$H_3PO_4 + 12(NH_4)_2MoO_4 + 21HNO_3 \longrightarrow \underset{\text{Yellow ppt.}}{(NH_4)_3PO_4.12MoO_3}\downarrow + 12H_2O + 21NH_4NO_3$$

Test for basic radicals:

[A] I group: Hg^+, Ag^+ and Pb^{2+}:

(i) Add dil. HCl to clear solution of substance. White precipitate indicates the presence of Hg^+, Ag^+ or Pb^{2+}.

$$2HgNO_3 + 2HCl \longrightarrow Hg_2Cl_2\downarrow + 2HNO_3$$

$$AgNO_3 + HCl \longrightarrow AgCl\downarrow + HNO_3$$

$$Pb(NO_3)_2 + 2HCl \longrightarrow PbCl_2\downarrow + 2HNO_3$$

(ii) Pb^{2+} ions give yellow precipitate with K_2CrO_4 and KI separately.

$$PbCl_2 + K_2CrO_4 \longrightarrow \underset{\text{Yellow}}{PbCrO_4}\downarrow + 2KCl$$

$$PbCl_2 + 2KI \longrightarrow \underset{\text{Yellow}}{PbI_2}\downarrow + 2KCl$$

(iii) Hg^+ ions give black precipitate with NH_3.

$$Hg_2Cl_2 + 2NH_4OH \longrightarrow \underset{\text{Black}}{Hg(NH_2)Cl} + Hg\downarrow + NH_4Cl + 2H_2O$$

(iv) Ag^+ ions give yellow precipitate with KI.

$$Ag^+ + I^- \longrightarrow \underset{\text{Yellow}}{AgI\downarrow}$$

[B] II group: Hg^{2+}, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, As^{3+}, Sb^{3+}, Sn^{2+} and Sn^{4+}:

(i) On passing H_2S in presence of HCl to a solution containing these ions give:

Yellow ppt. : CdS, As_2S_3, SnS_2
Orange ppt. : Sb_2S_3
Brown ppt. : SnS
Black ppt. : HgS, PbS, Bi_2S_3, CuS

(ii) Hg^{2+} ions in solution, on addition of $SnCl_2$, give white precipitate turning black.

$$2Hg^{2+} + SnCl_2 \longrightarrow Sn^{4+} + \underset{\text{White}}{Hg_2Cl_2\downarrow}$$

$$Hg_2Cl_2 + SnCl_2 \longrightarrow SnCl_4 + \underset{\text{Black}}{Hg_2\downarrow}$$

(iii) (a) Pb^{2+} ions in solution give white precipitate with H_2SO_4.

$$Pb^{2+} + H_2SO_4 \longrightarrow PbSO_4 + 2H^+$$

(b) Pb^{2+} ions in solution give yellow precipitate with K_2CrO_4 and KI.

$$Pb^{2+} + CrO_4^{2-} \longrightarrow \underset{\text{Yellow}}{PbCrO_4\downarrow}$$

$$Pb^{2+} + 2I^{1-} \longrightarrow \underset{\text{Yellow}}{PbI_2\downarrow}$$

(iv) Cu^{2+} ions in solution give deep blue colour with excess of NH_4OH.

$$Cu^{2+} + 4NH_4OH \longrightarrow \underset{\text{Deep blue in colour}}{Cu(NH_3)_4^{2+}} + 4H_2O$$

(v) Cu^{2+} ions give chocolate precipitate with $K_4Fe(CN)_6$.

$$2Cu^{2+} + K_4Fe(CN)_6 \longrightarrow Cu_2[Fe(CN)_6] + 4K^+$$

(vi) Bi^{3+} ions in solution of HCl on addition of water give white cloudy precipitate.

$$BiCl_3 + H_2O \longrightarrow \underset{\text{White ppt.}}{BiOCl\downarrow} + 2HCl$$

(vii) Cd^{2+} ions in solution, with H_2S give yellow precipitate.

$$Cd^{2+} + H_2S \longrightarrow \underset{\text{Yellow}}{CdS} + 2H^+$$

(viii) As^{3+} ions in solution give yellow precipitate with ammonium molybdate and HNO_3.

$$As^{3+} \xrightarrow[\text{Oxidation}]{HNO_3} As^{5+} \text{ (as } H_3AsO_4)$$

$$H_3AsO_4 + 12(NH_4)_2MoO_4 + 21HNO_3 \longrightarrow \underset{\text{Yellow ppt.}}{(NH_4)_3AsMo_{12}O_{40}\downarrow} + 21NH_4NO_3 + 12H_2O$$

(ix) Sn^{2+} ions in solution as $SnCl_2$ give white precipitate with $HgCl_2$, turning black on standing.

$$SnCl_2 + 2HgCl_2 \longrightarrow SnCl_4 + \underset{\text{White}}{Hg_2Cl_2\downarrow}$$

$$Hg_2Cl_2 + SnCl_2 \longrightarrow SnCl + \underset{\text{Black}}{Hg_2\downarrow}$$

(x) Sb^{3+} ions in solution as $SbCl_3$, on addition of water give white precipitate.

$$SbCl_3 + H_2O \longrightarrow \underset{\text{White}}{SbOCl\downarrow} + 2HCl$$

[C] III group: Fe^{3+}, Cr^{3+} and Al^{3+}:

(i) These ions are precipitated as hydroxides on addition of NH_4Cl and NH_4OH.

$Fe^{3+} + 3OH^- \longrightarrow Fe(OH)_3$ Red ppt.
$Cr^{3+} + 3OH^- \longrightarrow Cr(OH)_3$ Green ppt.
$Al^{3+} + 3OH^- \longrightarrow Al(OH)_3$ White ppt.

(ii) White precipitate of $Al(OH)_3$ is soluble in NaOH.

$$Al(OH)_3 + NaOH \longrightarrow NaAlO_2 + 2H_2O$$

(iii) Precipitate of $Cr(OH)_3$ is soluble in $NaOH + Br_2$ water and addition of $BaCl_2$ to this solution gives yellow precipitate.

$$Br_2 + H_2O \longrightarrow 2HBr + O$$
$$2Cr(OH)_3 + 4NaOH + 3O \longrightarrow 2Na_2CrO_4 + 5H_2O$$
$$Na_2CrO_4 + BaCl_2 \longrightarrow \underset{\text{Yellow ppt.}}{BaCrO_4\downarrow} + 2NaCl$$

(iv) Brown precipitate of $Fe(OH)_3$ is dissolved in HCl and addition of KCNS to this solution gives blood red colour.

$$Fe(OH)_3 + 3HCl \longrightarrow FeCl_3 + 3H_2O$$
$$FeCl_3 + 3KCNS \longrightarrow Fe(CNS)_3 + 3KCl$$

Also on addition of $K_4Fe(CN)_6$ to this solution, a prussian blue colour is obtained.

$$FeCl_3 + 3K_4Fe(CN)_6 \longrightarrow Fe_4[Fe(CN)_6]_3 + 12KCl$$

[D] IV group : Zn^{2+}, Mn^{2+}, Co^{2+} and Ni^{2+}:

(i) These ions are precipitated as sulphides on passing H_2S in presence of NH_4OH.

$$MCl_2 + H_2S \longrightarrow MS\downarrow + 2HCl$$

CoS and NiS : Black Soluble in aqua regia
ZnS : White Soluble in HCl
MnS : Pink Soluble in HCl

(ii) Ni^{2+} and Co^{2+} ions in solution, on addition of $KHCO_3$ and Br_2 water give apple green colour if Co^{2+} is present and black precipitate if Ni^{2+} is present.

$$CoCl_2 + 6KHCO_3 \longrightarrow K_4[Co(CO_3)_3] + 2KCl + 3CO_2\uparrow + 3H_2O$$

$$2K_4[Co(CO_3)_3] + 2KHCO_3 + [O] \longrightarrow \underset{\text{Apple green colour}}{2K_3[Co(CO_3)_3]} + 2K_2CO_3 + H_2O$$

$$NiCl_2 + 2KHCO_3 \longrightarrow NiCO_3 + 2KCl + H_2O + CO_2\uparrow$$

$$2NiCO_3 + 4NaOH + [O] \longrightarrow \underset{\text{Black ppt.}}{Ni_2O_3\downarrow} + 2Na_2CO_3 + 2H_2O$$

(iii) Zn^{2+} ions in solution give white precipitate with NaOH, which dissolve in excess of NaOH.

$$Zn^{2+} + 2NaOH \longrightarrow \underset{\text{White}}{Zn(OH)_2\downarrow} + 2Na^+$$

$$Zn(OH)_2 + 2NaOH \longrightarrow \underset{\text{Soluble}}{Na_2ZnO_2} + 2H_2O$$

(iv) Mn^{2+} ions in solution give pink precipitate with NaOH turning black or brown on heating.

$$Mn^{2+} + 2NaOH \longrightarrow \underset{\text{Pink}}{Mn(OH)_2} + 2Na^+$$

$$Mn(OH)_2 + [O] \xrightarrow{\Delta} \underset{\text{Brown or black}}{MnO_2} + H_2O$$

[E] V group: Ba^{2+}, Sr^{2+} and Ca^{2+}.

(i) These ions are precipitated as carbonates on addition of $(NH_4)_2CO_3$ solution.

$$M^{2+} + (NH_4)_2CO_3 \longrightarrow MCO_3 + 2NH_4^+$$

$BaCO_3$, $CaCO_3$ and $SrCO_3$: White; Soluble in CH_3COOH

(ii) Ba^{2+} ions in solution give:

(a) Yellow precipitate with K_2CrO_4.

$$Ba^{2+} + K_2CrO_4 \longrightarrow \underset{\text{Yellow}}{BaCrO_4\downarrow} + 2K^+$$

(b) White precipitate with $(NH_4)_2SO_4$.

$$Ba^{2+} + (NH_4)_2SO_4 \longrightarrow \underset{\text{White}}{BaSO_4\downarrow} + 2NH_4^+$$

(c) White precipitate with $(NH_4)_2C_2O_4$.

$$Ba^{2+} + (NH_4)_2C_2O_4 \longrightarrow \underset{\text{White}}{BaC_2O_4\downarrow} + 2NH_4^+$$

(iii) Sr^{2+} ions give white precipitate with:

(a) $(NH_4)_2SO_4$

$$Sr^{2+} + (NH_4)_2SO_4 \longrightarrow \underset{\text{White ppt.}}{SrSO_4\downarrow} + 2NH_4^+$$

(b) $(NH_4)_2C_2O_4$

$$Sr^{2+} + (NH_4)_2C_2O_4 \longrightarrow \underset{\text{White ppt.}}{SrC_2O_4\downarrow} + 2NH_4^+$$

(iv) Ca^{2+} ions give white precipitate with only $(NH_4)_2C_2O_4$.

$$Ca^{2+} + (NH_4)_2C_2O_4 \longrightarrow \underset{\text{White}}{CaC_2O_4\downarrow} + 2NH_4^+$$

(F) VI group: Mg^{2+}

Mg^{2+} ions give white precipitate with NH_4OH and $(NH_4)_2HPO_4$.

$$Mg^{2+} + (NH_4)_2HPO_4 + NH_4OH \longrightarrow MgNH_4PO_4\downarrow + 2NH_4^+ + H_2O$$

(G) Zero group: NH_4^+

(i) All ammonium salts on treating with any alkali (say NaOH) give smell of NH_3.

$$NH_4Cl + NaOH \xrightarrow{\Delta} NaCl + NH_3\uparrow + H_2O$$

(ii) The gas coming out (NH_3) shows white fumes with HCl.

$$NH_3 + HCl \longrightarrow \underset{\text{White fumes}}{NH_4Cl\uparrow}$$

(iii) On passing this gas to:

(a) $Hg_2(NO_3)_2$, a black colour is formed.

$$Hg_2(NO_3)_2 + 2NH_3 \longrightarrow \underset{\text{Black}}{Hg + Hg(NH_2)\cdot NO_3} + NH_4NO_3$$

(b) With Nessler's reagent, a brown precipitate is noticed.

$$NH_3 + 3NaOH + 2K_2HgI_4 \longrightarrow \underset{\text{Brown (Iodide of millions base)}}{\begin{matrix} & Hg & \\ O & & NH_2I \\ & Hg & \end{matrix}} + 4KI + 2H_2O + 3NaI$$

Some general hints on the basis of characteristics of anions and cations present in inorganic substances:

1. Physical appearance of inorganic salts :

(a) Cu^{2+} salts are blue in colour.

(b) Cr^{3+} and Cr^{6+} salts are generally dark green.

(c) Fe^{2+} salts are green Fe^{3+} salts are yellow or brown.

(d) Mn^{2+} salts are light pink.

(e) Co^{2+} salts are pink, Ni^{2+} salts are green or blue.

(f) HgO, HgI_2 and Pb_3O_4 are red in colour.

(g) Salts of Pb, Hg and Ba are relatively heavier.

(h) The colours of some important compounds are given below:

Colour	Examples
Blue	Copper salts, *e.g.*, $CuSO_4 \cdot 5H_2O$, some anhydrous cobaltous salts and some complex salts : $[Co(SCN)_4]^{2-}$, $Fe_3[Fe(CN)_6]_2$, $Fe_4[Fe(CN)_6]_3$, $[Ni(NH_3)_6]^{2+}$, $[Cu(NH_3)_4]^{2+}$ etc.
Dark green	Chromium salts (Cr^{3+} and Cr^{6+}), *e.g.*, $Cr_2(SO_4)_3$ and some copper salts : $CuCl_2$, $Cu(C_2H_3O_2)_2$, $Cu_3(AsO_3)_2$; Manganese oxides : MnO, MnO_4^{2-}.
Yellow	Ferric salts : $FeCl_3$, $[Fe(CN)_6]^{4-}$; silver salts : AgBr, AgI, Ag_2S_3, Ag_2S_5, Ag_2CO_3, Ag_3PO_4, Ag_3AsO_3; PbO, PbI_2; S, As_2S_3, As_2S_5, CdS, SnS_2; $K_3[Co(NO_2)_6]$; Na_2CrO_4, $PbCrO_4$, $BaCrO_4$.
Red	HgO, HgI_2, Hg_2CrO_4; Ag_2CrO_4, Ag_3AsO_4; Cu_2O; SbI_3, Sb_2S_3; SnI_2; AsI_3; Fe_2O_3; Pb_3O_4; BiOI.
Black	FeO, FeS, Fe_3O_4; CoS; CuO, CuS, Cu_2S; Ag_2S; NiO, NiS; MnO_2; HgS; PbS; BiI_3.
Pink	Salts of CO, complex of Ni with dimethyl glyoxime.
Brown	$Fe_2(CrO_4)_3$; $CuCrO_4$; $Hg_2[Fe(CN)_6]$; Bi_2O_5; Bi_2S_3; $MnCO_3$; SnS; $SnCrO_4$; CdO; PbO_2; $Cu_2[Fe(CN)_6]$.

2. Solubility of salts:

(a) Nitrates and Nitrites of all the metals are water soluble.

(b) All sulphates except (Pb, Ba and Sr) are water soluble. $CaSO_4$ is slightly soluble in water.

(c) Halides of Ag, Pb, Hg(ous) and Cu(ous) are insoluble. The order of solubility is:

Fluoride > Chloride > Bromide > Iodide

(d) CaF_2 is insoluble, other halides of Ca are soluble.

(e) Some common insoluble substances with their colours are given below:

S.No.	Examples of some insoluble salts	Colour
1.	CaF_2, $BaSO_4$, $SrSO_4$, Sb_2O_3, Al_2O_3, SnO_2, SiO_2, AgCl, $PbSO_4$	White
2.	HgS	Black
3.	Fe_2O_3	Red
4.	$PbCrO_4$, AgBr, AgI	Yellow
5.	Cr_2O_3, $Cr_2(SO_4)_3$	Green
6.	$CrCl_3$	Violet

3. Action of heat:

(a) All carbonates except (Na, K, Rb and Cs) decompose on heating, giving CO_2.

$$Li_2CO_3 \xrightarrow{\Delta} Li_2O + CO_2\uparrow$$

$$MgCO_3 \xrightarrow{\Delta} MgO + CO_2\uparrow$$

(b) All bicarbonates decompose to give carbonates and CO_2.

$$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O + CO_2$$

(c) Halides are normally stable to heat, however some halides decompose as:

$$2FeCl_3 \xrightarrow{\Delta} 2FeCl_2 + Cl_2$$

$$AuCl_3 \xrightarrow{\Delta} AuCl + Cl_2$$

$$MgCl_2 \cdot 6H_2O \xrightarrow{\text{Strong heating}} MgO + 2HCl + 5H_2O$$

$$Hg_2Cl_2 \xrightarrow{\Delta} HgCl_2 + Hg$$

$$NH_4Cl \xrightarrow{\Delta} NH_3 + HCl$$

(d) Nitrates decompose on heating.

$$NH_4NO_3 \longrightarrow N_2O + 2H_2O$$

$$2MNO_3 \longrightarrow 2MNO_2 + O_2 \quad \text{(except Li)}$$

$$2LiNO_3 \longrightarrow Li_2O + 2NO_2 + \frac{1}{2}O_2$$

$$\left.\begin{aligned} 2Mg(NO_3)_2 &\longrightarrow 2MgO + 4NO_2 + O_2 \\ 2Cu(NO_3)_2 &\longrightarrow 2CuO + 4NO_2 + O_2 \end{aligned}\right\}$$

(all bivalent nitrates except Hg)

$$2AgNO_3 \longrightarrow 2Ag + 2NO_2 + O_2$$

$$Hg(NO_3)_2 \longrightarrow Hg + 2NO_2 + O_2$$

(e) Silver salt on heating gives Ag.

$$Ag_2CO_3 \longrightarrow 2Ag + CO_2 + \frac{1}{2}O_2$$

(f) Some hydrated halides decompose to give oxy-salts.

$$2MgCl_2 \cdot 6H_2O \xrightarrow{\Delta} MgO \cdot MgCl_2 + 2HCl + 11H_2O$$

$$MgCl_2 \cdot 6H_2O \xrightarrow[\text{Heating}]{\text{Strong}} MgO + 2HCl + 5H_2O$$

$$2FeCl_3 \cdot 6H_2O \xrightarrow{\Delta} Fe_2O_3 + 6HCl + 9H_2O$$

$$\underset{\text{Pink}}{CoCl_2 \cdot 6H_2O} \xrightarrow{50^\circ C} \underset{\text{Pink}}{CoCl_2 \cdot 4H_2O} \xrightarrow{58^\circ C}$$

$$\underset{\text{Red-Violet}}{CoCl_2 \cdot 2H_2O} \xrightarrow{140^\circ C} \underset{\text{Blue}}{CoCl_2}$$

$$2CdI_2 + O_2 \xrightarrow{\Delta} 2CdO + 2I_2$$

$$2CdBr_2 + O_2 \xrightarrow{\Delta} 2CdO + 2Br_2$$

(g) **Alkali and alkaline earth metal bicarbonates** on heating decompose to give the respective metal carbonates and CO_2.

$$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + CO_2 + H_2O$$

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

$$2KHCO_3 \xrightarrow{\Delta} K_2CO_3 + CO_2 + H_2O$$

(h) Metal sulphides on strong heating gives metal oxides and SO_2.

$$4FeS + 7O_2 \xrightarrow{\Delta} 2Fe_2O_3 + 4SO_2$$

$$2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2$$

(i) Some metal sulphates on heating decompose to metal oxides.

$$\underset{\text{Blue-vitriol}}{CuSO_4 \cdot 5H_2O} \xrightarrow{100^\circ C} CuSO_4 \cdot H_2O + 4H_2O$$

$$CuSO_4 \cdot H_2O \xrightarrow{300^\circ C} CuO + SO_3 + H_2O$$

$$2FeSO_4 \xrightarrow{\Delta} Fe_2O_3 + SO_2 + SO_3$$

$$Fe_2(SO_4)_3 \xrightarrow{\Delta} Fe_2O_3 + 3SO_3$$

$$\underset{\text{Epsom salt}}{MgSO_4 \cdot 7H_2O} \xrightarrow{\Delta} MgSO_4 + 7H_2O$$

$$\underset{\text{Gypsum}}{2CaSO_4 \cdot 2H_2O} \xrightarrow{\Delta,\ 120^\circ C} 2CaSO_4 \cdot H_2O + 3H_2O$$

$$2CaSO_4 \cdot H_2O \xrightarrow{\Delta} 2CaSO_4 + H_2O$$

$$2NaHSO_4 \xrightarrow{\Delta} Na_2SO_4 + H_2O + SO_3$$

(j) Thiosulphates on strong heating decomposes as follows:

$$Na_2S_2O_3 \cdot 5H_2O \xrightarrow{220°C} Na_2S_2O_3 + 5H_2O$$

$$4Na_2S_2O_3 \xrightarrow{230°C} 3Na_2SO_4 + Na_2S_5$$

(k) Ammonium dichromate on heating yields N_2 and Cr_2O_3.

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

4. Characteristic flame colour and other properties of some metals:

(a) Pb imparts pale greenish colour to flame.

(b) Ag turns black in light due to the formation of Ag_2O.

(c) Cu salts impart blue or green colour to flame. Also BO_3^{3-} does so.

(d) Cu^{2+} ions in presence of NH_4OH impart blue colour to solution.

(e) ZnO turns yellow on heating and white on cooling.

(f) Zn^{2+} ions give light blue ppt. with $K_4Fe(CN)_6$.

$$2(CH_3COO)_2Zn + K_4Fe(CN)_6 \longrightarrow Zn_2[Fe(CN)_6] + 4K^+$$

(g) Ba imparts apple green colour to flame.

(h) Sr imparts crimson red colour to flame.

(i) Ca imparts brick red colour to flame.

(j) Na imparts yellow colour to flame.

(k) K imparts pink-violet (lilac) colour to flame.

(l) The white salt with colourless solution cannot have Cu, Ni, Co, Fe, Mn, Cr.

(m) The substance which swells up are alums, borates and phosphates.

(n) The substances sublime and the colour of sublimate is:

White	$HgCl_2$, Hg_2Cl_2, As_2O_3, Sb_2O_3
Yellow	$AlCl_3$ and NH_4 halides
Grey	HgO, $Hg(NO_3)_2$
Blue, black and violet	Iodides
Black	As, Sb, Hg sulphides and iodides.

• NUMERICAL PROBLEMS •

1. A compound on heating with an excess of caustic soda solution liberates a gas (*B*), which gives white fumes on exposure to HCl. Heating is continued to expel the gas completely. The resultant alkaline solution again liberates the same gas (*B*), when heated with zinc powder. However, the compound (*A*), when heated alone, does not give nitrogen. Identify (*A*) and (*B*).
2. An aqueous solution of a salt (*A*) gives a white crystalline precipitate (*B*) with NaCl solution. The filtrate gives a black precipitate (*C*) when H_2S is passed into it. Compound (*B*) dissolves in hot water and the solution gives yellow precipitate (*D*) on treatment with sodium iodide and cooling. The compound (*A*) does not give any gas with dilute HCl but liberates a reddish brown gas on heating. Identify the compounds (*A*) to (*D*) and give an equation for the liberation of the reddish brown gas.
3. An unknown solid mixture contains one or two of the following: $CaCO_3$, $BaCl_2$, $AgNO_3$, Na_2SO_4, $ZnSO_4$ and NaOH. The mixture is completely soluble in water and the solution gives pink colour with phenolphthalein. When dilute hydrochloric acid is gradually added to the above solution, a precipitate is formed which dissolves with further addition of the acid. What is/are present in the solid?
   Give equations to explain the appearance of the precipitate and its dissociation.
4. A mixture of two salts was treated as follows:
   (i) The mixture was heated with manganese dioxide and concentrated sulphuric acid, when yellowish green gas was liberated.
   (ii) The mixture on heating with sodium hydroxide solution gave a gas which turned red litmus blue.
   (iii) Its solution in water gave blue precipitate with potassium ferricyanide and red colouration with ammonium thiocynate.
   (iv) The mixture was boiled with potassium hydroxide and the liberated gas was bubbled through an alkaline solution of K_2HgI_4 to give brown precipitate. Identify the two salts. Give ionic equations for reactions involved in the tests (i), (ii) and (iii).
5. A compound (*A*) is greenish crystalline salt, which gave the following results:
   (i) Addition of $BaCl_2$ solution to the solution of (*A*) results in the formation of a white ppt. (*B*), which is insoluble in dil. HCl.
   (ii) On heating (*A*), water vapours and two oxides of sulphur, (*C*) and (*D*) are liberated leaving a red brown residue (*E*).
   (iii) (*E*) dissolves in warm conc. HCl to give a yellow solution (*F*).
   (iv) With H_2S, the solution (*F*) yields a pale yellow ppt. (*G*), which when filtered leaves a greenish filtrate (*H*).
   (v) Solution (*F*) on treatment with thiocyanate ions gives blood red coloured compound (*I*).
   Identify the substances from (*A*) to (*I*).
6. To a solution containing Ca^{2+}, Ag^+, Cu^{2+} and K^+, 2*M* HCl is added when a white precipitate (*A*) is obtained. After filtration H_2S is passed through the filtrate, a black ppt. (*B*) is formed. On removing (*B*) by filtration, it gave white ppt. (*C*) with conc. Na_2CO_3 solution. Identify (*A*), (*B*) and (*C*).
7. A gaseous mixture containing (*X*), (*Y*) and (*Z*) gases, when passed into acidified $K_2Cr_2O_7$ solution, gas (*X*) was absorbed and the solution was turned green. The remainder gas mixture was then passed through lime water, which turns milky by absorbing gas (*Y*). The residual gas when passed through alkaline pyrogallol solution, it turned black. Identify gas (*X*), (*Y*) and (*Z*) and explain the reaction involved.
8. When 16.8 g of a white solid (*X*) were heated, 4.4 g of a gas (*A*) that turned lime water milky was driven off together with 1.8 g of a gas (*B*), which condensed to a colourless liquid. The solid that remained (*Y*), dissolved in water to give an alkaline solution, which with excess of $BaCl_2$ solution gave a white ppt. (*Z*). The precipitate effervesced with acid giving off CO_2. Identify (*A*), (*B*) and (*Y*) and write down the equation for thermal decomposition (*X*).
9. When 20.02 g of a white solid (*X*) is heated, 4.4 g of an acid gas (*A*) and 1.8 g of a neutral gas (*B*) are evolved leaving behind a solid residue (*Y*) of mass 13.8 g. (*A*) turns lime water milky and (*B*) condenses into a liquid which changes anhydrous copper sulphate blue. The aqueous solution of (*Y*) is alkaline to litmus and gives 19.7 g of white precipitate (*Z*) with barium chloride solution. (*Z*) gives carbon dioxide with an acid. Identify (*A*), (*B*), (*X*), (*Y*) and (*Z*).
10. The gas liberated on heating a mixture of two salts with NaOH, gives a reddish brown precipitate with an alkaline solution of K_2HgI_4. The aqueous solution of the mixture on treatment with $BaCl_2$ gives a white precipitate which is sparingly soluble in conc. HCl. On heating the mixture with $K_2Cr_2O_7$ and conc. H_2SO_4, red vapours (*A*) are produced. The aqueous solution of the mixture gives a deep blue colouration (*B*) with potassium ferricyanide solution. Identify the radicals in the given mixture and write the balanced equations for the formation of (*A*) and (*B*). **(IIT 1991)**

11. Write the balanced equations for the following:
(i) Excess of ammonia added to a solution of $HgCl_2$ in water.
(ii) $AgNO_3$ solution reacts with excess of KCNS.
(iii) Reaction of potassium ferrocyanide in concentrated solution with 50% HNO_3.
(iv) Reaction of red lead with nitric acid.
(v) Reaction of sodium hydride with methyl borate in tetrahydrofuran (THF).

12. A light bluish green crystalline solid responds the following tests :
(i) Its aqueous solution gives brown precipitate or colour with alkaline K_2HgI_4 solution.
(ii) Its aqueous solution gives blue colour with $K_3Fe(CN)_6$ solution.
(iii) Its solution in HCl gives white ppt. with $BaCl_2$ solution.
Identify the ions present and suggest formula of compound. **(IIT 1992)**

13. An orange solid (*A*) on heating gives a green residue (*B*), a colourless gas (*C*) and water vapour. The dry gas (*C*) on passing over heated Mg gave a white solid (*D*). (*D*) on reaction with water gave a gas (*E*) which formed dense white fumes with HCl. Identify (*A*) to (*E*) giving reactions. **(IIT 1993)**

14. An unknown inorganic compound (*X*) gave the following reactions:
(i) The compound (*X*) on heating gave a residue, oxygen and oxide of nitrogen.
(ii) An aqueous solution of compound (*X*) on addition to tap water gave a turbidity which did not dissolve in HNO_3.
(iii) The turbidity dissolved in NH_4OH.
Identify the compound (*X*) and give equations for the reactions (i), (ii) and (iii).

15. (i) A powdered substance (*A*) on treatment with fusion mixture gives a green coloured compound (*B*).
(ii) The solution of (*B*) in boiling water on acidification with dilute H_2SO_4 gives a pink coloured compound (*C*).
(iii) The aqueous solution of (*A*) on treatment with excess of NaOH and bromine water gives a compound (*D*).
(iv) A solution of (*D*) in conc. HNO_3 on treatment with lead peroxide at boiling temperature produced a compound (*E*) which was of the same colour as that of (*C*).
(v) A solution of (*A*) in dilute HCl on treatment with a solution of barium chloride gave a white precipitate of compound (*F*) which was insoluble in conc. HNO_3 and conc: HCl.
Identify (*A*) to (*F*) and give balanced chemical equations for the reactions at steps (i) to (v). **(Roorkee 2001)**

16. Starting from $SiCl_4$, prepare the following in steps not exceeding the number given in parentheses (give reactions only):
(i) silicon (I).
(ii) linear silicon containing methyl groups only (IV).
(iii) Na_2SiO_3 (III). **(IIT 2001)**

17. A black coloured compound (*A*) on reaction with dil. H_2SO_4 gives a gas (*B*) which on passing in a solution of an acid (*C*) gives a white turbidity (*D*). Gas (*B*) when passed in an acidified solution of a compound (*E*) gives a ppt. (*F*) soluble in dil. HNO_3. After boiling this solution when an excess of NH_4OH is added, a blue coloured compound (*G*) is formed. To this solution on addition of acetic acid and aq. $K_4Fe(CN)_6$ a chocolate precipitate (*H*) is obtained. On addition of an aqueous solution of $BaCl_2$ to an aqueous solution of (*E*), a white ppt. insoluble in HNO_3 is obtained. Identify the compounds from (*A*) to (*H*).

18. On the basis of following reactions, identify (*A*), (*B*), (*C*) and (*D*) and write down their chemical formulae:

(i) $(A)\text{aq.} + Zn \xrightarrow{\text{Heat}} (B)\,\text{gas}$

(ii) $(A)\text{aq.} + (C) \xrightarrow{\text{Heat}} PH_3$

(iii) $(A)\text{aq.} + NH_4Cl \xrightarrow{\text{Heat}} (D)\,\text{gas}$

19. A soluble compound of a poisonous element *M*, when heated with Zn / H_2SO_4 gives a colourless and extremely poisonous gaseous compound *N*, which on passing through a heated tube gives a silvery mirror of element *M*. Identify *M* and *N*. **(IIT July 1997)**

20. Element (*A*) burns in nitrogen to give ionic compound (*B*). Compound (*B*) reacts with water to give (*C*) and (*D*). A solution of (*C*) becomes milky on bubbling CO_2. Identify (*A*), (*B*), (*C*) and (*D*). **(IIT July 1997)**

21. An aqueous solution of an unknown compound (*X*) gives the following reactions:
(i) It gives brown ppt. with alkaline $KMnO_4$ solution.
(ii) It forms HCl and evolves O_2 when reacted with Cl_2 gas.
(iii) It liberates I_2 from an acidified KI solution.
(iv) It gives orange yellow colour with acidified titanic sulphate solution.
Identify (*X*) and give the chemical equations for the reactions (i), (ii) and (iii).

22. An aqueous blue coloured solution of inorganic compound (*X*) gives following reactions:
(i) With an aqueous solution of barium chloride a precipitate insoluble in dil. HCl is obtained.

(ii) Addition of excess of KI gives a brown ppt. which turns white on addition of excess of hypo.

(iii) With an aqueous solution of $K_4Fe(CN)_6$ a chocolate coloured precipitate is obtained.

Identify (X) and give equations for the reactions for (i), (ii) and (iii) observations. **(IIT 2000)**

23. (i) Sodium salt of an acid (A) is formed on boiling white phosphorus with NaOH solution.

(ii) On passing chlorine through phosphorus kept fused under water, another acid (B) is formed which on strong heating gives metaphosphorus acid.

(iii) Phosphorus on treatment with conc. HNO_3 gives an acid (C) which is also formed by the action of dilute H_2SO_4 on powdered phosphorite rock.

(iv) (A) on treatment with a solution of $HgCl_2$ first gives a white precipitate of compound (D) and then a grey precipitate of (E).

Identify (A) to (E) and write balanced chemical equations for the reactions at steps (i) to (iv). **(Roorkee 2001)**

24. Two ores of same metal (M) are A_1 and A_2.

(a) $A_1 \xrightarrow{\text{Calcination}} \text{Black ppt.}\,(C) + CO_2 + H_2O$

$$A_1 \xrightarrow[KI]{HCl} I_2 + \text{ppt.}\,(D)$$

(b) $A_2 \xrightarrow{\text{Roasting}} \text{Gas}\,(G) + \text{Metal}\,(M)$

$$(G) + K_2Cr_2O_7 \xrightarrow{\text{Acidified}} \text{Green solution}$$

Identify M, (A_1), (A_2), C, D and G. **(IIT 2004)**

25. A compound (X) imparts a golden yellow flame and shows the following reactions:

(1) Zinc powder when boiled with a concentrated aqueous solution of (X), dissolves and hydrogen is evolved.

(2) When an aqueous solution of (X) is added to an aqueous solution of stannous chloride, a white precipitate is obtained first which dissolves in excess of solution of (X).

Identify (X) and write equations at steps (1) and (2). **(Roorkee 1990)**

26. A certain metal (A) is boiled in dilute nitric acid to give a salt (B) and an oxide of nitrogen (C). An aqueous solution of (B) with brine gives a precipitate (D) which is soluble in NH_4OH. On adding aqueous solution of (B) to hypo solution, a white precipitate (E) is obtained. (E) turns black on standing. Identify (A) to (E). **(Roorkee 1990)**

27. A metal chloride (X) shows the following reactions:

(i) When H_2S is passed in an acidified aqueous solution of (X), a black precipitate is obtained.

(ii) The precipitate obtained in step (i) is not soluble in yellow ammonium sulphide.

(iii) When a solution of stannous chloride is added to an aqueous solution of (X), a white precipitate is obtained which turns grey on addition of more of stannous chloride.

(iv) When an aqueous solution of KI is added to a solution of (X), a red precipitate is obtained which dissolves on addition of excess of KI.

Identify (X) and write down the equations for the reactions at steps (i), (iii) and (iv). **(Roorkee 1991)**

28. An aqueous solution of a gas (X) shows the following reactions:

(i) It turns red litmus blue.

(ii) When added in excess to a copper sulphate solution, a deep blue colour is obtained.

(iii) On addition of $FeCl_3$ solution a brown precipitate, soluble in dilute nitric acid, is obtained.

Identify (X) and give equations for the reactions at steps (ii) and (iii). **(Roorkee 1991)**

29. A mixture consists 'A' (yellow solid) 'B' (colourless solid) which gives lilac colour in flame.

(a) Mixture gives black precipitate 'C' on passing H_2S gas.

(b) 'C' is soluble in aquaregia and on evaporation of aquaregia and adding $SnCl_2$ gives greyish black precipitates 'D'.

(c) The salt solution with NH_4OH gives a brown precipitate.

(d) The sodium carbonate extract of the salt with CCl_4/ $FeCl_3$ gives a violet colour layer.

(e) The sodium carbonate extract gives yellow precipitate with $AgNO_3$ solution which is insoluble in NH_3. Identify 'A', 'B' and the precipitates 'C' and 'D'. **(IIT 2003)**

30. A certain salt (X) gives the following tests:

(i) Its aqueous solution is alkaline to litmus.

(ii) On strongly heating it swells to give glassy material.

(iii) When concentrated H_2SO_4 is added to a hot concentrated solution of (X), white crystals of a weak acid separate out. Identify (X) and write down the chemical equations for reactions at steps (i), (ii) and (iii). **(Roorkee 1991)**

31. An inorganic compound (X) gives brick red flame on performing the flame test. This (X) also shows the following reactions:

(i) Smell of chlorine when placed in moist air.

(ii) When KI is added to a aqueous suspension of (X) containing acetic acid, iodine is liberated.

(iii) When CO_2 is passed through an aqueous suspension of (X), the turbidity transforms to a ppt.

(iv) When a paste of (X) in water is heated with ethyl alcohol, a product of anaesthetic use is obtained.

Identify (X) and write down chemical equations for reactions at steps (i), (ii) and (iii). **(Roorkee 1992)**

32. An aqueous solution of an inorganic compound (X) shows the following reactions:
(i) It decolourizes an acidified $KMnO_4$ solution accompanied with evolution of oxygen.
(ii) It liberates I_2 from acidified KI solution.
(iii) It gives brown precipitate with alkaline $KMnO_4$ solution with evolution of CO_2.
(iv) It removes black stains from old oil paintings. Identify (X) and give chemical reactions for the steps (i) to (iv). **(Roorkee 1993)**

33. A solid laboratory reagents (A) give following reactions: **(Roorkee 1993)**
(i) On strongly heating, it gives two oxides of sulphur.
(ii) On adding aqueous NaOH solution to its aqueous solution, a dirty green precipitate is obtained which starts turning brown on exposure to air.

34. Identify (A) to (D) in following steps giving chemical equations:
(i) A white amorphous powder (A) on strongly heating gives a colourless non-combustible gas (B) and solid (C).
(ii) The gas (B) turns lime water milky and turbidity disappears with the passage of excess of gas.
(iii) The solution of (C) in dilute HCl gives a white precipitate with an aqueous solution of $K_4Fe(CN)_6$.
(iv) The solution of (A) in dilute HCl gives a white precipitate (D) on passing H_2S in presence of excess of NH_4OH.

35. Identify the following:

$$Na_2CO_3 \xrightarrow{SO_2} (A) \xrightarrow{Na_2CO_3} (B) \xrightarrow{\text{Elementals}} (C) \xrightarrow{I_2} (D)$$

Also mention the oxidation state of S in all the compounds. **(IIT 2003)**

36. How is boron obtained from borax? Give chemical equations with reaction conditions? Write the structure of B_2H_6 and its reaction with HCl. **(IIT 2002)**

37. A pale yellow inorganic compound (A) is insoluble in mineral acid but is soluble in aq. NH_3 forming (B). It also dissolves in $Na_2S_2O_3$ solution and forms (C). On boiling an aqueous solution of (C), a black ppt. (D) is obtained. When (D) is dissolved in HNO_3 and HCl is added, a white ppt. (E) is obtained. (A) on heating with conc. H_2SO_4 and MnO_2 yields brown fumes of (F). Identify (A) to (F).

38. (i) Write down the structure of molecule having butterfly shape.
(ii) What is the volume strength of 1 molar solution of H_2O_2?
(iii) Complete the following :

$$LiH + CO_2 \longrightarrow$$
$$LiH + SO_2 \longrightarrow$$
$$H_3PO_3 + D_2O \longrightarrow$$

(iv) Draw the structure of $CuSO_4 \cdot 5H_2O$ and point out the nature of bonds in it.
(v) What happens when As_2S_3 is mixed with yellow ammonium sulphide and then resulting mixture is acidified with HCl?
(vi) Conc. H_2SO_4 is not recommended to dry H_2 gas unless cooled in a freezing mixture. Explain.
(vii) Write the hydrogen bonded lattice structure of H_3BO_3 and polymeric metaborate $[B_3O_3(OH)_4]^-$.

39. A white substance (A) reacts with dilute H_2SO_4 to produce a colourless gas (B) and a colourless solution (C). The reaction between (B) and acidified $K_2Cr_2O_7$ solution produces a green solution and a slightly coloured precipitate (D). The substance (D) burns in air to produce a gas (E) which reacts with (B) to yield (D) and a colourless liquid. Anhydrous copper sulphate is turned blue on addition of this colourless liquid. Addition of aqueous NH_3 or NaOH to (C) produces first a precipitate, which dissolves in the excess of the respective reagent to produce a clear solution in each case. Identify (A), (B), (C), (D) and (E). Write the equations of the reactions involved. **(IIT 2001)**

40. An inorganic compound (A), transparent like glass is a strong reducing agent. Its hydrolysis in water gives a white turbidity (B). Aqueous solution of (A) gives white ppt. (C) with NaOH(aq.) which is soluble in excess NaOH. (A) reduces auric chloride to produce purple of cassius, (A) also reduces I_2 and gives chromyl chloride test.

41. An inorganic Lewis acid (X) shows the following reactions:
(i) It fumes in moist air.
(ii) The intensity of fumes increases when a rod dipped in NH_4OH is brought near it.
(iii) An acidic solution of (X) on addition of NH_4Cl and NH_4OH gives a precipitate which dissolves in NaOH solution.
(iv) An acidic solution of (X) does not give a precipitate with H_2S. Identify (X) and give chemical equation for steps (i) to (iii). **(Roorkee 1994)**

42. A certain inorganic compound (X) shows the following reactions:
(i) On passing H_2S through an acidified solution of (X), a brown precipitate is obtained.
(ii) The precipitate obtained in first step dissolves in excess of yellow amm. sulphide.
(iii) On adding an aqueous solution of NaOH to a solution of (X), first a white precipitate is obtained which dissolves in excess of NaOH.
(iv) The aqueous solution of (X) reduces ferric chloride. Identify the cation of (X) and give chemical equations for the steps (i), (iii) and (iv).
(Roorkee 1994)

43. (i) An inorganic iodide (*A*) on heating with a solution of KOH gives a gas (*B*) and the solution of compound (*C*).
(ii) The gas (*B*) on ignition in air gives a compound (*D*) and water.
(iii) Copper sulphate is finally reduced to the metal on passing (*B*) through its solution.
(iv) A precipitate of compound (*E*) is formed on reaction of (*C*) with copper sulphate solution. Identify (*A*) to (*E*) and give chemical equations for steps (i) to (iv). **(Roorkee 1994)**

44. (i) A black mineral (*A*) on heating in presence of air gives a gas (*B*).
(ii) The mineral (*A*) on reaction with dil. H_2SO_4 gives a gas (*C*) and solution of compound (*D*).
(iii) On passing gas (*C*) into an aqueous solution of (*B*), a white turbidity is obtained.
(iv) The aqueous solution of compound (*D*) on reaction with potassium ferricyanide gives a blue compound (*E*).
Identify (*A*) to (*E*) and give chemical equations to steps (i) to (iv). **(Roorkee 1994)**

45. Write down the reactions involved in extraction of Pb. What is oxidation number of lead in litharge? **(IIT 2003)**

46. (*A*) is binary compound of a univalent metal. 1.422 g of (*A*) reacts completely with 0.321 g of sulphur in an evacuated and sealed tube to give 1.743 g of a white crystalline solid (*B*) that formed a hydrated double salt (*C*) with $Al_2(SO_4)_3$. Identify (*A*), (*B*) and (*C*). **(IIT 1994)**

47. A scarlet compound (*A*) is treated with conc. HNO_3 to give a chocolate brown precipitate (*B*). The precipitate is filtered and the filtrate is neutralised with NaOH. Addition of KI to the resulting solution gives a yellow precipitate (*C*). The precipitate (*B*) on warming with conc. HNO_3 in the presence of $Mn(NO_3)_2$ produces a pink-coloured solution due to the formation of (*D*). Identify (*A*), (*B*), (*C*) and (*D*). Write the reaction sequence. **(IIT 1995)**

48. (i) A white precipitate (*B*) is formed when a mineral (*A*) is boiled with Na_2CO_3 solution.
(ii) The precipitate is filtered and the filtrate contains two compounds (*C*) and (*D*). The compound (*C*) is removed by crystallisation and when CO_2 is passed through the mother liquor left (*D*) changes to (*C*).
(iii) The compound (*C*) on strong heating gives two compounds (*D*) and (*E*).
(iv) (*E*) on heating with cobalt oxide produces blue coloured substance (*F*).
Identify (*A*) to (*F*) and give chemical equations for the reactions at steps (i) to (iv). **(Roorkee 1995)**

49. (i) A black mineral (*A*) on treatment with dilute sodium cyanide solution in presence of air gives a clear solution of (*B*) and (*C*).
(ii) The solution of (*B*) on reaction with zinc gives precipitate of a metal (*D*).
(iii) (*D*) is dissolved in dil. HNO_3 and the resulting solution gives a white precipitate (*E*) with dil. HCl.
(iv) (*E*) on fusion with sodium carbonate gives (*D*).
(v) (*E*) dissolves in aqueous solution of ammonia giving a colourless solution of (*F*).
Identify (*A*) to (*F*) and give chemical equations for reactions at steps (i) to (v). **(Roorkee 1995)**

50. Calcium burns in nitrogen to produce a white powder which dissolves in sufficient water to produce a gas (*A*) and an alkaline solution. The solution on exposure to air produces a thin solid layer of (*B*) on the surface. Identify the compounds (*A*) and (*B*). **(IIT 1996)**

51. Gradual addition of KI solution to $Bi(NO_3)_3$ solution initially produces a dark brown precipitate which dissolves in excess of KI to give a clear yellow solution. Write chemical equations for the above reactions. **(IIT 1996)**

52. A colourless inorganic salt (*A*) decomposes completely at about 250°C to give only two products, (*B*) and (*C*), leaving no residue. The oxide (*C*) is a liquid at room temperature and neutral to moist litmus paper while the gas (*B*) is a neutral oxide. White phosphorus burns in excess of (*B*) to produce a strong white dehydrating agent. Write balanced equations for the reactions involved in the above process. **(IIT 1996)**

53. (i) An inorganic compound (*A*) is formed on passing a gas (*B*) through a concentrated liquor containing sodium sulphide and sodium sulphite.
(ii) On adding (*A*) into a dilute solution of silver nitrate, a white precipitate appears which quickly changes into a black coloured compound (*C*).
(iii) On adding two or three drops of ferric chloride into the excess of solution of (*A*), a violet coloured compound (*D*) is formed. This colour disappears quickly.
(iv) On adding a solution of (*A*) into the solution of cupric chloride, a white precipitate is first formed which dissolves on adding excess of (*A*) forming a compound (*E*).
Identify (*A*) to (*E*) and give chemical equations for the reactions at steps (i) to (iv). **(Roorkee 1996)**

54. (i) A black coloured compound (*B*) is formed on passing hydrogen sulphide through the solution of a compound (*A*) in NH_4OH.
(ii) (*B*) on treatment with hydrochloric acid and potassium chlorate gives (*A*).

(iii) (*A*) on treatment with potassium cyanide gives a buff coloured precipitate which dissolves in excess of this reagent forming a compound (*C*).

(iv) The compound (*C*) is changed into a compound (*D*) when its aqueous solution is boiled.

(v) The solution of (*A*) was treated with excess of sodium bicarbonate and then with bromine water. On cooling and shaking for sometime, a green colour of compound (*E*) is formed. No change is observed on heating.

Identify (*A*) to (*E*) and give chemical equations for the reactions at steps (i) to (v). **(Roorkee 1996)**

55. Give complete and balanced chemical equations for the following: Sodium chromite solution reacts with H_2O_2 in presence of NaOH.

56. Nickel chloride is mixed with dimethyl glyoxime. When ammonium hydroxide is slowly added, a shining red precipitate is formed.

(a) Give the structure of the complex showing hydrogen bonds.

(b) Give the charge and the state of hybridisation of the central metal ion.

(c) Predict the magnetic behaviour of complex.

(IIT 2004)

57. (i) A blue coloured compound (*A*) on heating gives two products, (*B*) and (*C*).

(ii) A metal (*D*) is deposited on passing hydrogen through heated (*B*).

(iii) The solution of (*B*) in HCl on treatment with $K_4[Fe(CN)_6]$ gives a chocolate brown coloured precipitate of compound (*E*).

(iv) (*C*) Turns lime water milky which disappears on continuous passage of (*C*) forming a compound (*F*).

Identify (*A*) to (*F*) and give chemical equations for the reactions at steps (i) to (iv). **(Roorkee 1997)**

58. (i) An aqueous solution of a white coloured compound (*A*) on reaction with HCl gives a white precipitate of compound (*B*).

(ii) (*B*) becomes soluble in chlorine water with the formation of (*C*).

(iii) (*C*) reacts with KI to give a precipitate which becomes soluble in excess of it forming a compound (*D*). The compound (*D*) is used for detecting ammonium salts.

(iv) (*B*) and (*C*) both, on treatment with $SnCl_2$ give a grey precipitate of (*E*).

(v) When conc. H_2SO_4 is added slowly into a mixture of cold solutions of (*A*) and $FeSO_4$, a brown ring of compound (*F*) is formed. Identify (*A*) to (*F*) and give chemical equations for the reactions at steps (i) to (v). **(Roorkee 1997)**

59. Compound (*X*) on reduction with $LiAlH_4$ gives a hydride (*Y*) containing 21.72% hydrogen along with other products. The compound (*Y*) reacts with air explosively resulting in boron trioxide. Identify (*X*) and (*Y*). Give balanced reactions involved in the formation of (*Y*) and its reaction with air. Draw the structure of (*Y*). **(IIT 2001)**

60. Hydrogen peroxide acts both as an oxidising and as a reducing agent in alkaline solution towards certain first row transition metal ions. Illustrate both these properties of H_2O_2 using chemical equations. **(IIT 1998)**

61. When the ore haematite is burnt in air with coke around 2000°C along with lime, the process not only produces steel but also produces a silicate slag that is useful in making building materials such as cement. Discuss the same and show through balanced chemical equations. **(IIT 1998)**

62. Thionyl chloride can be synthesized by chlorinating SO_2 using PCl_5. Thionyl chloride is used to prepare anhydrous ferric chloride starting from its hexahydrated salt. Alternatively, the anhydrous ferric chloride can also be prepared from its hexahydrated salt by treating with 2,2-dimethoxypropane. Discuss all this using balanced chemical equations. **(IIT 1998)**

63. (i) An aqueous solution of a compound (*A*) is acidic towards litmus and (*A*) is sublimed at about 300°C.

(ii) (*A*) on treatment with an excess of NH_4SCN gives a red coloured compound (*B*) and on treatment with a solution of $K_4[Fe(CN)_6]$ gives a blue coloured compound (*C*).

(iii) (*A*) on heating with excess of $K_2Cr_2O_7$ in presence of concentrated H_2SO_4 evolves deep red vapours of (*D*).

(iv) On passing the vapours of (*D*) into a solution of NaOH and then adding the solutions of acetic acid and lead acetate, a yellow precipitate of compound (*E*) is obtained.

Identify (*A*) to (*E*) and give chemical equations for the reaction at steps (ii) to (iv). **(Roorkee 1998)**

64. (i) The yellow coloured precipitate of compound (*A*) is formed on passing H_2S through a neutral solution of a salt (*B*).

(ii) (*A*) is soluble in hot dilute HNO_3, but insoluble in yellow ammonium sulphide.

(iii) The solution of (*B*) on treatment with small quantity of NH_3 gives white precipitate which becomes soluble in excess of it forming a compound (*C*).

(iv) The solution of (*B*) gives white precipitate with small concentration of KCN which becomes soluble in excess of this reagent forming a compound (*D*).

(v) The solution of (*B*) on treatment with H_2S gives (*A*).

(vi) The solution of (*B*) in dilute HCl on treatment with a solution of $BaCl_2$ gives white precipitate of compound (*E*) which is insoluble in conc. HNO_3.

Identify (*A*) to (*E*) and give chemical equations for the reactions at steps (i) and (iii) to (vi). **(Roorkee 1998)**

65. A white solid is either Na_2O or Na_2O_2. A piece of red litmus paper turns white when it is dipped into a freshly made aqueous solution of the white solid.
(i) Identify the substance and explain with balanced equation.
(ii) Explain what would happen to the red litmus if the white solid were the other compound? **(IIT 1999)**

66. (*A*), (*B*) and (*C*) are three complexes of chromium (III) with the empirical formula $H_{12}O_6Cl_3Cr$. All the three complexes have water and chloride ion as ligands. Complex (*A*) does not react with concentrated H_2SO_4, whereas complexes (*B*) and (*C*) lose 6.75% and 13.5% of their original mass, respectively, on treatment with concentrated H_2SO_4. Identify (*A*), (*B*) and (*C*). **(IIT 1999)**

67. An aqueous solution containing one mole of HgI_2 and two mole of NaI is orange in colour. On addition of excess NaI the solution becomes colourless. The orange colour reappears on subsequent addition of NaOCl. Explain with equations. **(IIT 1999)**

68. Pyrolusite on heating with KOH in the presence of air gives a dark green compound (*A*). The solution of (*A*) on treatment with H_2SO_4 gives a purple coloured compound (*B*), which gives following reactions:
(i) KI on reaction with alkaline solution of (*B*) changes into a compound (*C*).
(ii) The colour of the compound (*B*) disappears on treatment with the acidic solution of $FeSO_4$.
(iii) With conc. H_2SO_4 compound (*B*) gives (*D*) which can decompose to yield (*E*) and oxygen.
Identify (*A*) to (*E*) and write balanced chemical equations for the formation of (*A*) and (*B*) and for the steps (i) to (iii). **(Roorkee 1999)**

69. A crystalline inorganic compound (*A*), when it comes in contact with skin leaves a black stain. (*A*) is freely soluble in water and when to this solution some sodium chloride is added, a white precipitate appears which is insoluble in HNO_3 but soluble in NH_4OH. When hydrogen sulphide is passed through a solution of (*A*), a black precipitate appears. When potassium chromate is added to the solution of (*A*), a brick red precipitate results. To another portion of solution (*A*), mixed with ferrous sulphate in a test tube, concentrated sulphuric acid is added through the sides of the test tube, a brown ring results. Identify the compound and give equations for the various reactions involved.

70. An inorganic compound, dark red in anhydrous state, absorbs moisture to become yellow. On heating it sublimes to form dimeric state in vapour phase. It acts as oxidant for $SnCl_2$, liberates I_2 from KI and converts H_2S to S. Its aqueous solution is acidic. On heating aqueous solution with $K_4Fe(CN)_6$, a characteristic blue colour is obtained. What is the compound and give all the reactions involved?

71. (i) Show that XeF_4 and IF_4^- are isostructural.
(ii) Lithium does not form alum. Explain.
(iii) Write a balanced equation for the reaction of sodium thio sulphate with Cl_2 in water.
(iv) Explain with reason the chromium hydroxide is treated with H_2O_2 in presence of NaOH (aq.)
(v) Explain with reason the relative Lewis acid order for boron halides.
(vi) Why is the graphite called most stable allotrope of carbon?
(vii) Which among PbO, PbO_2 and Pb_3O_4 is the strongest oxidising agent?

72. A metallic oxide (*A*) is strongly acidic and forms violet vapours on warming and explodes violently at 55°C giving out oxygen and a weak acidic oxide. The compound (*A*) on dissolution in water gives characteristic purple colour. What is (*A*)?

73. In the contact process for industrial manufacture of sulphuric acid some amount of sulphuric acid is used as a starting material. Explain briefly. What is the catalyst used in the oxidation of SO_2 ? **(IIT 1999)**

74. When a white crystalline compound (*X*) is heated with $K_2Cr_2O_7$ and concentrated H_2SO_4, a reddish brown gas (*A*) is evolved. On passing (*A*) into caustic soda solution, a yellow coloured solution of (*B*) is obtained. Neutralizing the solution of (*B*) with acetic acid and on subsequent addition of lead acetate, a yellow precipitate (*C*) is obtained. When (*X*) is heated with NaOH solution, a colourless gas is evolved and on passing this gas into K_2HgI_4 solution, a reddish brown precipitate (*D*) is formed. Identify (*A*), (*B*), (*C*), (*D*) and (*X*). Write the equations of reactions involved. **(IIT 2002)**

75. Complete and balance the following equations:
(i) $H_2SO_4 + HI \longrightarrow ...+...+...$
(ii) $CaOCl_2 + NaI + HCl \longrightarrow ...+ CaCl_2 + H_2O + NaCl.$
(iii) $Ag_2S + 2CuCl_2 + 2Hg \longrightarrow ...+...+S + 2Ag$ **(Roorkee 1998)**

76. Complete and balance the following equations:
(i) $H_2S + H_2SO_4$ (conc.) $\longrightarrow$ .....+.....+.....
(ii) NaOH (excess) + $I_2 \longrightarrow$ .....+.....+H_2O
(iii) $NH_3 + NaOCl \longrightarrow$ .....+ NaCl + H_2O **(Roorkee 1997)**

77. Complete and balance the following equations:
(i) $I_2 + HNO_3$ (conc.) $\longrightarrow$ .....+.....+.....
(ii) $SF_6 + H_2O \longrightarrow$ .....+.....
(iii) $SF_4 + Cl_2 \longrightarrow$ .....+.....+.....

78. (a) Reaction of phosphoric acid with $Ca_5(PO_4)_3F$ yields a fertilizer "triple superphosphate".

Represent the same through a balanced chemical equation.

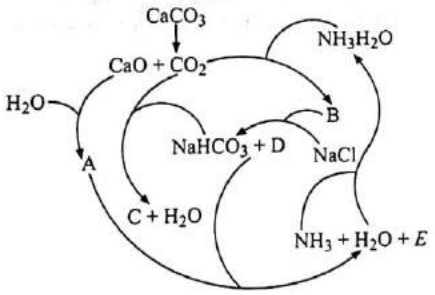
(b) Complete and balance the following chemical equations:
(i) $P_4O_{10} + PCl_5 \longrightarrow$
(ii) $SnCl_4 + C_2H_5Cl + Na \longrightarrow$

(c) Work out the following using chemical equations:
(i) In moist air copper corrodes to produce a green layer on the surface.
(ii) Chlorination of calcium hydroxide produces bleaching powder. **(IIT 1998)**

79. Complete and balance the following chemical equations:
(i) $Au + HCl + HNO_3 \longrightarrow ... + ... + H_2O$
(ii) $C + HNO_3$ (conc.) $\longrightarrow CO_2 + ... + H_2O$
(iii) $Sn + KOH$ (hot) $+ H_2O \longrightarrow ... + ...$
(iv) $Cu(OH)_2 + NH_4NO_3 + NH_4OH(aq.) \longrightarrow ... + H_2O$
(Roorkee 1999)

80. In the following equation,
$$A + 2B + H_2O \longrightarrow C + 2D$$
($A = HNO_2$, $B = H_2SO_3$, $C = NH_2OH$). Identify D. Draw the structures of A, B, C and D. **(IIT 1999)**

81. The Haber process can be represented by the following scheme:



Identify A, B, C, D and E. **(IIT 1999)**

82. Match the following choosing one item from Column X and the appropriate item from Column Y: **(Roorkee 2000)**

X	Y
A. SO_2Cl_2	(i) Paramagnetic
B. Ice	(ii) Refrigeration
C. $CuSO_4$ (anhydrous)	(iii) Testing NH_3
D. $K_2HgI_4 + NaOH$	(iv) Testing H_2O
E. Fluorocarbons	(v) Hydrogen bonding
F. NO	(vi) Tetrahedral

83. Complete the following by identifying (A) to (H):
(i) $CuSO_4 \cdot 5H_2O \xrightarrow{100°C} (A) \xrightarrow{230°C} (B) \xrightarrow{800°C} (C) + (D)$
(ii) $AgNO_3 \xrightarrow{\text{Red heat}} (E) + (F) + O_2$
(iii) $Na_2B_4O_7 \xrightarrow{740°C} (G) + (H)$ **(Roorkee 2000)**

84. During the qualitative analysis of a mixture containing Cu^{2+} and Zn^{2+} ions, H_2S gas is passed through an acidified solution containing these ions in order to test Cu^{2+} alone. Explain briefly. **(IIT 1998)**

85. Give reasons for the following:
(i) The solubility of calcium acetate decreases while that of lead nitrate increases with increase in temperature.
(ii) Magnesium is not precipitated from a solution of its salt by NH_4OH in the presence of NH_4Cl.
(iii) Yellow phosphorus is kept under water but not the red phosphorus.
(iv) Bleaching of flowers with SO_2 gas is temporary while that with Cl_2 gas is permanent.
(Roorkee 2000)

86. (a) Write down the IUPAC nomenclature of the given complex along with its hybridisation and structure
$K_2[Cr(NO)(NH_3)(CN)_4]$; $\mu = 1.73$ BM.
(IIT 2003)

(b) Draw the structures of $[Co(NH_3)_6]^{3-}$, $[Ni(CN)_4]^{2-}$ and $[Ni(CO)_4]$. Write the hybridisation of atomic orbitals of the transition metal in each case.
(IIT 2000)

87. (a) AlF_3 is not soluble in anhydrous HF but soluble in KF. When BF_3 is added to the above solution, AlF_3 is precipitated. Write the balanced chemical equation. **(IIT 2004)**

(b) Predict whether Me_3N and $(SiMe_3)_3N$ are isostructural or not. Also justify your answer.
(IIT 2005)

88. Write the order of Bronsted basic nature for the following oxides: CO_2, BaO, Cl_2O_7, SO_3, B_2O_3
(IIT 2004)

89. (a) Give an example of oxidation of one halide by another halogen. Explain the feasibility of the reaction.

(b) Write the M.O., electron distribution of O_2. Specify its bond order and magnetic property. **(IIT 2000)**

90. Write balanced equations for the reactions of the following compounds with water:
(i) Al_4C_3 (ii) CaNCN (iii) BF_3 (iv) NCl_3 (v) XeF_4
(IIT 2002)

91. (a) (i) Write the chemical reactions involved in the extraction of metallic silver from argentite.
(IIT 2000)

(ii) Write the balanced chemical equation for developing of black and white photographic films.

When sodium thiosulphate solution is treated with acidic solution, it turns milky. Explain.

(IIT 2000, 05)

(b) Write the chemical reactions associated with the 'borax bead test' of cobalt(II) oxide. **(IIT 2000)**

(c) Draw the shape of PCl_5 and BrF_5 using VSEPR theory. **(IIT 2003)**

(d) Write structure of P_4O_{10}. **(IIT 2005)**

92. (B) (White fumes having pungent smell) $\xleftarrow{\text{Moist air}}$ MCl_4 (M = transition element colourless) $\longrightarrow$ (A) (Purple colour)

Identify the metal M and hence, MCl_4. Explain the difference in colours of MCl_4 and A. **(IIT 2005)**

93. Identify (A) and (B) in the given sequence of reaction. Also write their IUPAC names and calculate only spin magnetic moment for B.

$$Fe^{3+}_{(aq.)} \xrightarrow{SCN^- \text{ excess}} \text{Blood - red } (A) \xrightarrow{F^- \text{ excess}} \text{Colourless } (B)$$

(IIT 2005)

94. Explain the following:

(i) Ammonium salts are much more soluble than the corresponding sodium salts.

(ii) $Ag(CN)_2^-$ is stable while $AgCl_2^-$ is unstable.

(iii) Why do bond angles of NH_3, PH_3, AsH_3 and SbH_3 are 106.5°, 93.3°, 91.8° and 91.3°, although each show sp^3 hybridisation?

(iv) Write an example of tridentate ligand.

(v) Arrange in their increasing acidic nature : Mn_2O_3, MnO, MnO_2, MnO_3, Mn_2O_7. Also point out strongly basic and strongly acidic oxides of Mn.

95. (a) Interhalogen compounds AX are more reactive than halogens (except F_2).

(b) What product is formed when SO_2 react with ethyl magnesium bromide and the product is hydrolysed?

(c) How many sulphur atoms in polythionic acid $H_2S_nO_6$ have only S—S bonds?

(d) Complete the reaction: $CS_2 + NaOH \rightarrow ...+...+...$

(e) What happens when cyanogen gas is passed through NaOH?

(f) How you will convert Na_2SO_4 to NaCl?

96. Explain why?

(i) Concentrated HNO_3 acquires yellow colour on standing.

(ii) Hard water consumes more soap.

(iii) BeO reacts with acids and alkali both.

(iv) Lead pollution is caused by car exhaust.

(v) Tin vessels are not useful for packing in cold countries.

SOLUTIONS (Numerical Problems)

1. (i) (A) on heating with excess of NaOH gives gas (B) which forms white fumes with HCl and thus, (B) is NH_3 and (A) is ammonium salt.

(ii) The product formed in reaction between (A) and NaOH, on treating with Zn + NaOH gives NH_3 and thus, it should be nitrate or nitrite. Thus (A), should be ammonium nitrate or nitrite, however (A) does not give N_2 on heating and thus, it is nitrate.

Reactions:

(i) $\underset{(A)}{NH_4NO_3} + NaOH \longrightarrow NaNO_3 + H_2O + \underset{(B)}{NH_3}\uparrow$

$NH_3 + HCl \longrightarrow \underset{\text{White fumes}}{NH_4Cl}$

(ii) $NaNO_3 + 8H \xrightarrow{Zn/NaOH} NaOH + 2H_2O + NH_3$

2. (1) Since (A) gives white ppt. (B) with NaCl solution, soluble in hot water as well as filtrate of this with H_2S gives black ppt. and thus, (A) has Pb^{2+} ion in it.

(2) (A) liberates reddish brown gas on heating and thus it should have NO_3^- ion in it, *i.e.*, (A) is $Pb(NO_3)_2$.

Reactions:

$\underset{(A)}{Pb(NO_3)_2} + 2NaCl \longrightarrow \underset{(B)}{PbCl_2} + 2NaNO_3$

$PbCl_2 + H_2S \longrightarrow \underset{(C)}{PbS} + 2HCl$

$Pb(NO_3)_2 \xrightarrow{\Delta} PbO + 2NO_2 + \frac{1}{2}O_2$

$PbCl_2 + 2KI \longrightarrow \underset{(D)\text{ Yellow ppt.}}{PbI_2} + 2KCl$

3. (1) The mixture is soluble in water to give strong alkali, it must contain NaOH as one of the constituent.

(2) The aqueous solution of mixture gives white ppt. with dil. HCl which dissolves in excess of dil. HCl and thus, it must have Zn salt, *i.e.*, $ZnSO_4$.

(3) Thus, mixture is NaOH + $ZnSO_4$.

Reactions:

(i) $ZnSO_4 + 4NaOH \longrightarrow \underset{\text{Soluble}}{Na_2ZnO_2} + Na_2SO_4 + 2H_2O$

(ii) $Na_2ZnO_2 + 2HCl \longrightarrow 2NaCl + Zn(OH)_2\downarrow$

$Zn(OH)_2 + 2HCl \longrightarrow \underset{\text{Soluble}}{ZnCl_2} + 2H_2O$

4. (1) Step (i) of the problem indicates the presence of Cl^- in mixture. (A test for Cl^-).

(2) Step (ii) of the problem indicates the presence of NH_4^+ in mixture (A test for NH_4^+).

(3) Step (iii) of the problem indicates the presence of Fe^{2+} ion in mixture.

(4) Thus, mixture has Fe^{2+}, Cl^- and NH_4^+ ions, *i.e.*, it is a mixture of $FeCl_2$ and NH_4Cl.

Reactions:

(1) $2NH_4Cl + MnO_2 + 2H_2SO_4 \xrightarrow{\Delta} MnSO_4 + Cl_2\uparrow + 2H_2O + (NH_4)_2SO_4$

$NH_4Cl + NaOH \xrightarrow{\Delta} \underset{\text{Turns red litmus to blue}}{NH_3\uparrow} + H_2O + NaCl$

(2) $3FeCl_2 + 2K_3Fe(CN)_6 \longrightarrow \underset{\text{Blue colour}}{Fe_3[Fe(CN)_6]_2} + 6KCl$

$Fe^{2+} \xrightarrow[\text{aqueous sol.}]{\text{Oxidation in}} Fe^{3+}$

$Fe^{3+} + 3CNS^- \longrightarrow \underset{\text{Blood-red colour}}{Fe(CNS)_3}$

Note : If mixture already contains Fe^{3+} ion, it should give brown ppt. with $K_3Fe(CN)_6$. Thus, Fe^{3+} ions are believed to be formed by the oxidation of Fe^{2+} ions in solution.

(3) $KOH + NH_4Cl \longrightarrow NH_3 + KCl + H_2O$

$NH_3 + 3NaOH + 2K_2HgI_4 \longrightarrow \underset{\text{Brown}}{O(Hg)(Hg)NH_2I} + 4KI + 2H_2O + 3NaI$

5. (1) Compound (A) forms white insoluble ppt. with $BaCl_2$. So it is a sulphate.

(2) (A) produces red colouration with thiocyanate, so it may be iron sulphate.

(3) Since it is greenish in colour, so it is crystalline $FeSO_4 \cdot 7H_2O$.

Reactions:

(i) $\underset{(A)}{FeSO_4} + BaCl_2 \longrightarrow FeCl_2 + \underset{\text{White ppt. } (B)}{BaSO_4}$

(ii) $FeSO_4 \cdot 7H_2O \xrightarrow{\text{Heat}} FeSO_4 + 7H_2O$

$2FeSO_4 \xrightarrow{\text{Heat}} \underset{\text{Brown residue}}{\underset{(E)}{Fe_2O_3}} + \underset{(C)}{SO_2} + \underset{(D)}{SO_3}$

(iii) $\underset{(E)}{Fe_2O_3} + 6HCl \longrightarrow \underset{\text{Yellow solution}}{\underset{(F)}{2FeCl_3}} + 3H_2O$

(iv) $\underset{(F)}{2FeCl_3} + H_2S \longrightarrow \underset{\text{Green}}{\underset{(H)}{2FeCl_2}} + 2HCl + \underset{\text{Pale yellow}}{\underset{(G)}{S}}$

(v) $\underset{(F)}{FeCl_3} + 3NH_4CNS \longrightarrow \underset{\text{Blood-red colour}}{\underset{(H)}{Fe(CNS)_3}} + 3NH_4Cl$

Hence, (A) is $FeSO_4 \cdot 7H_2O$.

6. (i) Ag^+ ions with HCl will form a white ppt. of AgCl, *i.e.*,

$Ag^+ + Cl^- \longrightarrow \underset{\text{White ppt. } (A)}{AgCl}$

(ii) After filtration AgCl is filtered out and filtrate contains Cu^{2+}, Ca^{2+} and K^+ ions. With H_2S, Cu^{2+} ions form a black ppt. of CuS, *i.e.*,

$Cu^{2+} + S^{2-} \longrightarrow \underset{\text{Black ppt. } (B)}{CuS}$

(iii) On filtration the filtrate has Ca^{2+} and K^+ ions. With conc. Na_2CO_3, Ca^{2+} ions will form white ppt. of $CaCO_3$, *i.e.*,

$$Ca^{2+} + CO_3^{2-} \longrightarrow \underset{\text{White ppt. } (C)}{CaCO_3}$$

So, $(A) = AgCl$, $(B) = CuS$, $(C) = CaCO_3$.

7. (1) Gas (X) is absorbed in acidified $K_2Cr_2O_7$ and the solution turns green. So, (X) is SO_2.

(2) Gas (Y) is absorbed in lime water turning it white so (Y) is CO_2.

(3) Gas (Z) is absorbed in pyrogallol so (Z) is O_2.

Reactions:

(1) $\underset{(X)}{3SO_2} + K_2Cr_2O_7 + H_2SO_4 \longrightarrow K_2SO_4 + \underset{\text{Green}}{Cr_2(SO_4)_3} + H_2O$

(2) $Ca(OH)_2 + \underset{(Y)}{CO_2} \longrightarrow \underset{\text{White}}{CaCO_3\downarrow} + H_2O$

(3) $\underset{(Z)}{O_2} + \text{Pyrogallol} \longrightarrow \text{Absorbed}$

8. (1) (A) turns lime water milky, so (A) is CO_2 or SO_2 gas.

(2) (Y) gives alkaline solution and its solution forms white ppt. (Z) with $BaCl_2$ and (Z) on heating with acid gives effervescences of CO_2, so (Z) is $BaCO_3$ and (Y) is metal carbonate.

(3) Since, (Y) and (A) are formed from (X) and thus, (X) is metal bicarbonate and (A) is CO_2.

(4) $\underset{16.8\text{ g}}{X} \xrightarrow{\Delta} \underset{4.4\text{ g}}{A} + \underset{1.8\text{ g}}{B} + Y$

(5) The above data reveal that,

$2MHCO_3 \longrightarrow CO_2 + H_2O + M_2CO_3$

4.4 g CO_2 is obtained by 16.8 g $MHCO_3$

44 g CO_2 is obtained by 168 g $MHCO_3$

Molar mass of $MHCO_3 = \frac{168}{2} = 84\text{ g mol}^{-1}$

$\therefore$ Atomic mass of metal = 23

Hence, metal is Na.

Reactions: $\underset{(X)}{2NaHCO_3} \longrightarrow \underset{(A)}{CO_2} + \underset{(B)}{H_2O} + \underset{(Y)}{Na_2CO_3}$

9. (1) (A) turns lime water milky so (A) is CO_2 or SO_2.

(2) (B) condenses into liquid turning anhydrous $CuSO_4$ to blue, so (B) is H_2O.

(3) (Y) gives alkaline solution and its solution forms white ppt. (Z) with $BaCl_2$ and (Z) on heating with acid gives CO_2 so (Z) is $BaCO_3$ and (Y) is metal carbonate.

(4) Since, (Y) and (A) are formed from (X) and thus, (X) is metal bicarbonate.

(5) $\underset{20.02\text{ g}}{X} \xrightarrow{\Delta} \underset{4.4\text{ g}}{A} + \underset{1.8\text{ g}}{B} + \underset{13.8\text{ g}}{Y}$

(6) The above data reveal that,

$\underset{(X)}{2MHCO_3} \longrightarrow \underset{(A)}{CO_2} + \underset{(B)}{H_2O} + \underset{(Y)}{M_2CO_3}$

4.4 g CO_2 is obtained by 20.02 g $MHCO_3$

44 g CO_2 is obtained by 200.2 g $MHCO_3$

Molar mass of $MHCO_3 = \frac{200.2}{2} = 100.1\text{ g mol}^{-1}$

$\therefore$ Atomic mass of $M = 39.1$

Thus, metal is potassium.

Reactions: $\underset{(X)}{2KHCO_3} \longrightarrow \underset{(A)}{CO_2} + \underset{(B)}{H_2O} + \underset{(Y)}{K_2CO_3}$

10. (1) The gas liberated on heating the mixture with NaOH gives red ppt. with K_2HgI_4, so gas is NH_3 and mixture contains NH_4^+ ions.

(2) The aqueous solution gives white ppt. with $BaCl_2$, so mixture contains SO_4^{2-} ions.

(3) Mixture on heating with $K_2Cr_2O_7$ and H_2SO_4 gives red vapours (of CrO_2Cl_2), so mixture contains Cl^- ions.

(4) Aqueous solution of mixture gives blue colour with $K_3Fe(CN)_6$ and thus, it contains Fe^{2+} ions.

(5) Thus, mixture has NH_4^+, Fe^{2+}, SO_4^{2-} and Cl^-.

Reactions:

(I) $NH_4^+ + NaOH \longrightarrow NH_3 + Na^+ + H_2O$

$$2K_2HgI_4 + 3NaOH + NH_3 \longrightarrow \underset{\text{Brown}}{\overset{\text{Hg}}{\underset{\text{Hg}}{\text{O}}}\!\!<\!\!\begin{matrix}\\ \\ \end{matrix}\!\!>\!\!NH_2I} + 4KI + 2H_2O + 3NaI$$

(II) $SO_4^{2-} + BaCl_2 \longrightarrow BaSO_4 + 2Cl^-$

(III) $4Cl^- + K_2Cr_2O_7 + 3H_2SO_4 \longrightarrow \underset{(A)\text{ Red}}{2CrO_2Cl_2} + K_2SO_4 + 3H_2O + 2SO_4^{2-}$

(IV) $3Fe^{2+} + 2K_3Fe(CN)_6 \longrightarrow \underset{(B)\text{ Blue}}{Fe_3[Fe(CN)_6]_2} + 6K^+$

11. (i) $HgCl_2 + 2NH_3 \longrightarrow Hg(NH_2)Cl + NH_4Cl$

(ii) $AgNO_3 + 2KCNS \longrightarrow KNO_3 + K[Ag(SCN)_2]$

(iii) $3K_4[Fe(CN)_6] + 4HNO_3 \longrightarrow 3K[Fe(CN)_6] + NO + 3KNO_3 + 2H_2O$

(iv) $Pb_3O_4 + 4HNO_3 \longrightarrow PbO_2 + 2Pb(NO_3)_2 + 2H_2O$

(v) $4NaH + 4B(OCH_3)_3 \xrightarrow{THF} NaBH_4 + 3NaB(OCH_3)_4$

12. (i) Compound gives brown ppt. with alkaline K_2HgI_4 and so contains NH_4^+ ions.

(ii) Compound gives blue colour with $K_3Fe(CN)_6$ and so contains Fe^{2+} ions.

(iii) Solution of compound in HCl gives white ppt. with $BaCl_2$ and so it contains SO_4^{2-} ions.

(iv) Bluish green compound with NH_4^+, Fe^{2+} and SO_4^{2-} is Mohr's salt, *i.e.*,

$FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O \longrightarrow Fe^{2+} + SO_4^{2-} + 2NH_4^+ + SO_4^{2-} + 6H_2O$

Reactions:

$$3NaOH + NH_3 + 2K_2HgI_4 \longrightarrow \underset{\text{Brown ppt.}}{\overset{\text{Hg}}{\underset{\text{Hg}}{\text{O}}}\!\!<\!\!\begin{matrix}\\ \\ \end{matrix}\!\!>\!\!NH_2I} + 4KI + 3NaI + 2H_2O$$

$$3Fe^{2+} + 2K_3Fe(CN)_6 \longrightarrow \underset{\text{Blue ppt.}}{Fe_3[Fe(CN)_6]_2} + 6K^+$$

$$SO_4^{2-} + BaCl_2 \longrightarrow \underset{\text{White ppt.}}{BaSO_4} + 2Cl^-$$

13. (1) Assume compound $(A)\ (NH_4)_2Cr_2O_7$.

Reactions: $\underset{(A)}{(NH_4)_2Cr_2O_7} \xrightarrow{\Delta} \underset{(C)}{N_2} + \underset{\text{Green } (B)}{Cr_2O_3} + 4H_2O$

$$N_2 + 3Mg \xrightarrow{\Delta} \underset{(D)}{Mg_3N_2}$$

$$\underset{(D)}{Mg_3N_2} + 6H_2O \longrightarrow 3Mg(OH)_2 + \underset{(E)}{2NH_3}$$

$$\underset{(E)}{NH_3} + HCl \longrightarrow \underset{\text{(White fumes)}}{NH_4Cl}$$

14. (1) Step (ii) suggests, (X) to be a compound of Ag as it gives turbidity with tap water which contains Cl^- and the turbidity is soluble in NH_4OH.

(2) (X) may be $AgNO_3$ since, it gives oxide of nitrogen.

Reactions: $\underset{(X)}{2AgNO_3} \longrightarrow \underset{\text{Residue}}{2Ag} + O_2 + 2NO_2$

$$\underset{(X)}{AgNO_3} + \underset{\text{Tap water}}{Cl^-} \longrightarrow \underset{\text{Turbidity}}{AgCl} + NO_3^-$$

$$AgCl + 2NH_4OH \longrightarrow \underset{\text{(Soluble)}}{Ag(NH_3)_2Cl} + 2H_2O$$

15. (i) $\underset{(A)}{MnSO_4} + 2Na_2CO_3 + 2KNO_3 \longrightarrow \underset{(B)}{Na_2MnO_4} + 2KNO_2 + Na_2SO_4 + 2CO_2$

(ii) $3Na_2MnO_4 + 2H_2SO_4 \longrightarrow \underset{(C)}{2NaMnO_4} + MnO_2 + 2Na_2SO_4 + 2H_2O$

(iii) $MnSO_4 + 4NaOH + Br_2 \longrightarrow \underset{(D)}{MnO_2} + Na_2SO_4 + 2NaBr + 2H_2O$

(iv) $2MnO_2 + 4HNO_3 \longrightarrow 2Mn(NO_3)_2 + 2H_2O + O_2$

$2Mn(NO_3)_2 + 5PbO_2 + 6HNO_3 \longrightarrow \underset{(E)}{2HMnO_4} + 5Pb(NO_3)_2 + 2H_2O$

(v) $MnSO_4 + BaCl_2 \longrightarrow \underset{(F)}{BaSO_4}\downarrow + MnCl_2$

16. (i) $3SiCl_4(v) + 4Al(\text{molten}) \longrightarrow 4AlCl_3 + 3Si$

(ii) (a) $3SiCl_4 + 4Al \longrightarrow 4AlCl_3 + 3Si$

(b) $Si + CH_3Cl \xrightarrow[570\ K]{\text{Cu powder}} (CH_3)_2SiCl_2$

(c) $(CH_3)_2SiCl_2 \xrightarrow{HOH} HO{-}\underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{\overset{|}{\underset{|}{Si}}}}{-}OH$

(d) $n\,HO{-}\underset{\displaystyle CH_3}{\overset{\displaystyle CH_3}{\overset{|}{\underset{|}{Si}}}}{-}OH \xrightarrow{\text{Polymerisation}}$

$$HO\left[-Si(CH_3)_2-O-\right]_n-Si(CH_3)_2-O-$$

Linear silicone
(Thermoplastic polymer)

(iii) (a) $SiCl_4 + 4H_2O \longrightarrow \underset{\text{ortho-silicic acid}}{H_4SiO_4} + 4HCl$

(b) $H_4SiO_4 \xrightarrow{\Delta} SiO_2 + 2H_2O$

(c) $SiO_2 + Na_2CO_3 \longrightarrow Na_2SiO_3 + H_2O$

17. (1) The black coloured compound may be FeS, CuS or PbS CoS, NiS because it reacts with dil. H_2SO_4 to produce H_2S.

$$\underset{(A)}{MS} + H_2SO_4 \longrightarrow MSO_4 + \underset{(B)}{H_2S}$$

(2) Gas H_2S on passing through HNO_3 (an oxidant) gives turbidity of S.

$$\underset{(B)}{H_2S} + \underset{(C)}{2HNO_3} \longrightarrow 2NO_2 + 2H_2O + \underset{(D)}{S}$$

(3) (E) is $CuSO_4$ because it gives white ppt. of $BaSO_4$ with $BaCl_2$ and blue colour with NH_4OH (A test for SO_4^{2-} and Cu^{2+} respectively).

$$\underset{(E)}{CuSO_4} + BaCl_2 \longrightarrow CuCl_2 + \underset{\text{White}}{BaSO_4}$$

(4) Gas (B) *i.e.*, H_2S gives black ppt. with $CuSO_4$.

$$\underset{(E)}{CuSO_4} + H_2S \longrightarrow \underset{\substack{(F)\\ \text{Black}}}{CuS} + H_2SO_4$$

(5) Compound (F) (CuS) gives $Cu(NO_3)_2$ with HNO_3 which on treating with NH_4OH gives blue colour.

$$\underset{(F)}{CuS} + 2HNO_3 \longrightarrow Cu(NO_3)_2 + H_2S$$

$$Cu(NO_3)_2 + 4NH_4OH \longrightarrow \underset{(G)\ \text{Blue}}{Cu(NH_3)_4(NO_3)_2} + 4H_2O$$

(6) (G) on acidifying with CH_3COOH and then treating with $K_4Fe(CN)_6$ gives chocolate coloured ppt. of $Cu_2Fe(CN)_6$.

$$Cu(NH_3)_4(NO_3)_2 + 4CH_3COOH \longrightarrow Cu(NO_3)_2 + 4CH_3COONH_4$$

$$2Cu(NO_3)_2 + K_4Fe(CN)_6 \longrightarrow \underset{\text{Chocolate ppt.}}{Cu_2[Fe(CN)_6]} + 4KNO_3$$

Thus, (A) FeS, CuS, PbS, HgS, CoS, NiS, (B) H_2S, (C) HNO_3, (D) S, (E) $CuSO_4$, (F) CuS, (G) $Cu(NH_3)_4(NO_3)_2$, (H) $Cu_2Fe(CN)_6$.

18. (i) (A) is an alkali and the equation is,

$$\underset{(A)}{2NaOH} + Zn \xrightarrow{\text{Heat}} Na_2ZnO_2 + \underset{(B)}{H_2}$$

(ii) (A) is NaOH and (C) is phosphorus. The equation will be,

$$\underset{(A)}{3NaOH} + 3H_2O + \underset{(C)}{P_4} \xrightarrow{\text{Heat}} PH_3 + 3NaH_2PO_2$$

(iii) (D) is NH_3 gas and (A) is NaOH. The equation will be,

$$\underset{(A)}{NaOH} + NH_4Cl \xrightarrow{Heat} \underset{(D)}{NH_3} + NaCl + H_2O$$

19. M is As; $AsCl_3 + 6H \xrightarrow[(N)]{Zn/H_2SO_4} AsH_3 + 3HCl$

$$2AsH_3 \xrightarrow{\Delta} \underset{\text{Silvery mirror } (M)}{2As} + 3H_2$$

20. $\underset{\text{or Ba}}{3Ca} + N_2 \longrightarrow \underset{\text{or } Ba_3N_2}{Ca_3N_2} \xrightarrow{6H_2O} \underset{\text{or } 3Ba(OH)_2}{3Ca(OH)_2} + 2NH_3$

$$\xrightarrow{CO_2} \underset{\text{or } BaCO_3}{CaCO_3} + H_2O$$

21. From the (iv) point it is clear that the compound (X) is H_2O_2.

$$Ti(SO_4)_2 + 2H_2O + \underset{(X)}{H_2O_2} \longrightarrow \underset{\substack{\text{Pertitanic acid}\\ \text{(Yellow solution)}}}{H_2TiO_4} + 2H_2SO_4$$

(i) $2KMnO_4 + 2KOH \longrightarrow 2K_2MnO_4 + H_2O + O$

$$\underset{(X)}{H_2O_2} + O \longrightarrow H_2O + O_2$$

or $2KMnO_4 + 2KOH + \underset{(X)}{H_2O_2} \longrightarrow 2K_2MnO_4 + 2H_2O + O_2$

$$2K_2MnO_4 + 2H_2O \longrightarrow \underset{\text{Brown ppt.}}{2MnO_2} + O_2 + 4KOH$$

(ii) $\underset{(X)}{H_2O_2} + Cl_2 \longrightarrow 2HCl + O_2$

(iii) $\underset{(X)}{H_2O_2} + 2KI + H_2SO_4 \longrightarrow K_2SO_4 + 2H_2O + I_2\uparrow$

Hence, (X) is H_2O_2.

22. (i) Step (i) suggests that compound (X) contains SO_4^{2-} radical.

(ii) Step (iii) suggests that the compound (X) contains Cu^{2+} radical.

(iii) Hence, the salt is $CuSO_4$.

Reactions:

(i) $\underset{(X)}{CuSO_4} + BaCl_2 \longrightarrow \underset{\substack{\text{White ppt.}\\ \text{(Insoluble in HCl)}}}{BaSO_4} + CuCl_2$

(ii) $\underset{(X)}{2CuSO_4} + 4KI \longrightarrow 2CuI_2 + 2K_2SO_4$

$$\underset{\text{Unstable}}{2CuI_2} \longrightarrow Cu_2I_2 + I_2$$

$$I_2 + 2Na_2S_2O_3 \longrightarrow \underset{\text{Colourless}}{Na_2S_4O_6} + 2NaI$$

(iii) $\underset{(X)}{2CuSO_4} + K_4Fe(CN)_6 \longrightarrow \underset{\substack{\text{Chocolate coloured}\\ \text{ppt.}}}{Cu_2[Fe(CN)_6]} + 2K_2SO_4$

23. (i) $P_4 + 3NaOH + 3H_2O \longrightarrow \underset{\text{(Sodium hypophosphite)}}{3NaH_2PO_2} + PH_3$

Thus, acid (A) is H_3PO_2, *i.e.*, hypophosphorus acid.

(ii) $2P + 3Cl_2 + 6H_2O \longrightarrow \underset{\text{(Phosphorus acid)}}{2H_3PO_3} + 6HCl$

Thus, acid (B) is H_3PO_3.

$$H_3PO_3 \longrightarrow HPO_2 + H_2O$$

(iii) $P_4 + 20HNO_3 \longrightarrow \underset{(C)}{4H_3PO_4} + 20NO_2 + 4H_2O$

$$P_4 + 10H_2SO_4 \longrightarrow \underset{\substack{\text{Phosphoric acid}\\ (C)}}{4H_3PO_4} + 10SO_2 + 4H_2O$$

Thus, acid (C) is H_3PO_4.

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

$$HgCl_2 + 2H \longrightarrow \underset{\text{(White) } (D)}{Hg_2Cl_2} + 2HCl$$

$$Hg_2Cl_2 + 2H \longrightarrow \underset{\text{(Grey) } (E)}{2Hg} + 2HCl$$

24. (a) $CuCO_3 \cdot Cu(OH)_2 \longrightarrow \underset{\text{Black ppt.}}{2CuO} + CO_2\uparrow + H_2O$

A_1 is malachite, an ore of Cu.

$$CuCO_3 \cdot Cu(OH)_2 + 4HCl \longrightarrow 2CuCl_2 + CO_2 + 3H_2O$$

$$2CuCl_2 + 4KI \longrightarrow \underset{\text{ppt.}}{2CuI} + 4KCl + I_2$$

(b) $2Cu_2S + 3O_2 \xrightarrow{\text{Roasting}} \underset{(G)}{2SO_2}\uparrow + 2Cu_2O$

A_2 is copper glance an ore of Cu.

$$2Cu_2O + Cu_2S \xrightarrow[\text{During roasting}]{\text{Auto reduction}} 6Cu + SO_2\uparrow$$

$$\underset{(G)}{3SO_2} + K_2Cr_2O_7 + H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O$$

25. (i) (X) imparts golden yellow flame and so contains Na^+.

(ii) Step 1 suggests that (X) is NaOH because it reacts with Zn to give H_2.

$$Zn + \underset{(X)}{2NaOH} \longrightarrow Na_2ZnO_2 + H_2$$

(iii) (X) is also justified by step 2 reactions.

$$\underset{(X)}{2NaOH} + SnCl_2 \longrightarrow \underset{\text{White ppt.}}{Sn(OH)_2} + 2NaCl$$

$$Sn(OH)_2 + \underset{\substack{(X)\\ \text{(Excess)}}}{2NaOH} \longrightarrow \underset{\text{Soluble}}{Na_2SnO_2} + 2H_2O$$

26. (i) The compound (B) reacts with NaCl solution (brine) to give white precipitate (D) soluble in NH_4OH so (D) is AgCl.

(ii) Thus, (B) must contain Ag^+ ion.

(iii) (B) is obtained from (A) and dilute HNO_3, so (B) is $AgNO_3$ and (A) is Ag.

Reactions: $\underset{(A)}{3Ag} + 4HNO_3 \longrightarrow \underset{(B)}{3AgNO_3} + \underset{(C)}{NO} + 2H_2O$

$$\underset{(B)}{AgNO_3} + NaCl \longrightarrow \underset{(D)}{AgCl} + NaNO_3$$

$$\underset{(D)}{AgCl} + 2NH_4OH \longrightarrow \underset{\text{Soluble}}{Ag(NH_3)_2Cl} + 2H_2O$$

$$\underset{(B)}{2AgNO_3} + Na_2S_2O_3 \longrightarrow \underset{(E)\text{ White}}{Ag_2S_2O_3} + 2NaNO_3$$

$$\underset{(E)}{Ag_2S_2O_3} \longrightarrow \underset{\text{Black}}{Ag_2S} + SO_3$$

27. (1) (X) gives black ppt. in acid medium with H_2S and thus, it may be $HgCl_2$, $PbCl_2$, $CuCl_2$ or $SnCl_2$.

(2) Black ppt. is insoluble in yellow ammonium sulphide and thus, it is not $SnCl_2$.

(3) Steps (iii) and (iv) suggest that (X) is $HgCl_2$.

Reactions:

(i) $\underset{(X)}{HgCl_2} + H_2S \longrightarrow \underset{\text{Black ppt.}}{HgS} + 2HCl$

(ii) $\underset{(X)}{2HgCl_2} + SnCl_2 \longrightarrow SnCl_4 + \underset{\text{White ppt.}}{Hg_2Cl_2}$

$Hg_2Cl_2 + SnCl_2 \longrightarrow SnCl_4 + \underset{\text{Grey ppt.}}{2Hg}$

(iii) $\underset{(X)}{HgCl_2} + 2KI \longrightarrow \underset{\text{Red ppt.}}{HgI_2} + 2KCl$

$HgI_2 + 2KI \longrightarrow \underset{\substack{\text{Nessler's reagent (solution)}\\ \text{(Red)}}}{K_2HgI_4}$

28. (i) Aqueous solution of gas (X) turns red litmus blue, the solution is alkaline in nature. So the gas may be NH_3.

(ii) With $CuSO_4$, NH_4OH gives deep blue coloured $Cu(NH_3)_4SO_4$.

i.e.,

$CuSO_4 + 4NH_4OH \longrightarrow \underset{\text{(Deep blue complex)}}{Cu(NH_3)_4SO_4} + H_2O$

(iii) $FeCl_3 + 3NH_4OH \longrightarrow \underset{\text{(Brown ppt.)}}{Fe(OH)_3} + 3NH_4Cl$

The brown precipitate of $Fe(OH)_3$ form soluble $Fe(NO_3)_3$ with dil. HNO_3.

$Fe(OH)_3 + 3HNO_3 \longrightarrow \underset{\text{(Soluble)}}{Fe(NO_3)_3} + 3H_2O$

Hence, (X) is NH_3.

29. 'A' is KI and 'B' is HgI_2

(a) $HgI_2 + H_2S \longrightarrow \underset{\text{Black '}C\text{'}}{HgS} + 2HI$

(b) $HgS \xrightarrow{\text{Aquaregia}} HgCl_2$

$HgCl_2 + SnCl_2 \longrightarrow SnCl_4 + \underset{\text{Grey black '}D\text{'}}{Hg}$

(c) $2KI(aq.) + HgI_2(aq.) \longrightarrow K_2HgI_4$

$K_2HgI_4 + NH_4OH + 3KOH \longrightarrow O\begin{matrix}Hg\\ \diagup\quad\diagdown\\ Hg\end{matrix}NH_2I + 7KI + 2H_2O$

Sodium carbonate extract contains NaI.

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

(e) $I^- + AgNO_3 \longrightarrow NO_3^- + AgI$

(Yellow ppt. insoluble in NH_4OH)

30. (i) Aqueous solution of (X) is alkaline, so (X) may be an alkali metal salt.

(ii) On strong heating, (X) swells upto give a glassy mass, it may be borax.

(iii) This is further supported by the fact that its concentrated solution on treatment with concentrated solution of H_2SO_4 yields crystals of boric acid (a weak monobasic acid).

(iv) Hence, (X) is borax $(Na_2B_4O_7 \cdot 10H_2O)$.

Reactions:

(i) $\underset{(X)}{Na_2B_4O_7} + 7H_2O \longrightarrow \underset{\text{Alkali}}{2NaOH} + 4H_3BO_3$

(ii) $Na_2B_4O_7 \cdot 10H_2O \xrightarrow{\text{Heat}} Na_2B_4O_7 + 10H_2O$

$Na_2B_4O_7 \xrightarrow{\text{Heat}} 2NaBO_2 + \underset{\text{Glassy mass}}{B_2O_3}$

(iii) $Na_2B_4O_7 + H_2SO_4 + 5H_2O \longrightarrow Na_2SO_4 + \underset{\text{Weak acid}}{4H_3BO_3}$

31. (X) gives brick red flame so, it contains Ca^{2+}. Reactions (i), (ii) and (iii) suggest that the probable compound is bleaching powder $(CaOCl_2)$.

Reactions:

(i) $CaOCl_2 + H_2O \longrightarrow Ca(OH)_2 + \underset{\text{Smell}}{Cl_2}\uparrow$

(ii) $\underset{(X)}{CaOCl_2} + 2CH_3COOH \longrightarrow Ca(CH_3COO)_2 + Cl_2 + H_2O$

$2KI + Cl_2 \longrightarrow 2KCl + I_2$

(iii) $\underset{\text{Turbid}}{CaOCl_2(aq.)} + CO_2 \longrightarrow \underset{\text{White ppt.}}{CaCO_3} + Cl_2$

(iv) $\underset{(X)}{CaOCl_2} + H_2O \longrightarrow Ca(OH)_2 + Cl_2$

$C_2H_5OH + Cl_2 \longrightarrow CH_3CHO + 2HCl$

$CH_3CHO + 3Cl_2 \longrightarrow CCl_3CHO + 3HCl$

$2Ca(OH)_2 + 2CCl_3CHO \longrightarrow \underset{\text{Anaesthetic}}{2CHCl_3} + (HCOO)_2Ca$

32. (i) (X) removes black stains from old oil painting, so (X) is H_2O_2.

Reactions:

(i) $\underset{(X)}{5H_2O_2} + 2KMnO_4 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 5O_2$

(ii) $\underset{(X)}{H_2O_2} + 2KI + H_2SO_4 \longrightarrow I_2 + K_2SO_4 + 2H_2O$

(iii) $\underset{(X)}{3H_2O_2} + 2KMnO_4 \longrightarrow 2MnO_2 + 2KOH + 3O_2 + 2H_2O$

(iv) $\underset{(X)}{4H_2O_2} + \underset{\text{Black}}{PbS} \longrightarrow \underset{\text{White}}{PbSO_4} + 4H_2O$

33. **Compound (A):** (i) (A) gives on heating two oxides of sulphur and so (A) is $FeSO_4 \cdot 7H_2O$.

(ii) $\underset{(A)}{FeSO_4 \cdot 7H_2O} \xrightarrow{\Delta} FeSO_4 + 7H_2O$

$2FeSO_4 \xrightarrow{\Delta} Fe_2O_3 + SO_2 + SO_3$

(iii) $FeSO_4 + 2NaOH \longrightarrow \underset{\text{green}}{Fe(OH)_2} + Na_2SO_4$

$Fe^{2+} \xrightarrow[\text{Alkaline medium}]{\text{Oxidation/air}} \underset{\text{brown}}{Fe^{3+}} + e$

34. (1) Gas (B) is formed on heating (A) and it turns lime water milky so (B) is CO_2 and (A) has CO_3^{2-} ions.

(2) Solution of (A) in alkaline medium gives white ppt. with H_2S and so (A) may have Zn^{2+} ions.

(3) The compound (A), if taken $ZnCO_3$, is also justified by the other reactions.

Reactions:

(i) $\underset{(A)}{ZnCO_3} \longrightarrow \underset{(C)}{ZnO} + \underset{(B)}{CO_2}$

(ii) $\underset{(B)}{CO_2} + Ca(OH)_2 \longrightarrow \underset{\text{White}}{CaCO_3} + H_2O$

$CaCO_3 + H_2O + \underset{\text{Excess}}{CO_2} \longrightarrow \underset{\text{Soluble}}{Ca(HCO_3)_2}$

(iii) $ZnO + 2HCl \longrightarrow ZnCl_2 + H_2O$

$2ZnCl_2 + K_4Fe(CN)_6 \longrightarrow \underset{\text{White ppt.}}{Zn_2[Fe(CN)_6]} + 4KCl$

(iv) $ZnCl_2 + H_2S \longrightarrow \underset{(D)\ \text{White ppt.}}{ZnS} + 2HCl$

35. $Na_2CO_3 + SO_2 \xrightarrow{H_2O} \underset{(A)}{2NaHSO_3} + CO_2$

$NaHSO_3 + Na_2CO_3 \longrightarrow \underset{(B)}{2Na_2SO_3} + H_2O + CO_2$

$\underset{(B)}{Na_2SO_3} + S \longrightarrow \underset{(C)}{Na_2S_2O_3}$

$\underset{(C)}{2Na_2S_2O_3} + I_2 \longrightarrow \underset{(D)}{Na_2S_4O_6} + 2NaI$

Oxidation states of S are +4 in $NaHSO_3$ and Na_2SO_3 and Na_2SO_3 +6 and −2 (an average +2) in $Na_2S_2O_3$ and +5 and 0 (an average +5/2) in $Na_2S_4O_6$.

36. $\underset{\text{(Borax)}}{Na_2B_4O_7 \cdot 10H_2O} \xrightarrow{\Delta} Na_2B_4O_7$

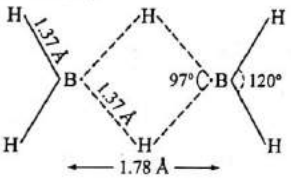
$Na_2B_4O_7 + 2HCl \longrightarrow 2NaCl + \underset{\text{Tetraboric acid}}{H_2B_4O_7}$

$H_2B_4O_7 + 5H_2O \longrightarrow \underset{\text{Boric acid}}{4H_3BO_3}$

$2H_3BO_3 \xrightarrow{\text{Red hot}} \underset{\text{Boric anhydride}}{B_2O_3} + 3H_2O$

$B_2O_3 + 3Mg \xrightarrow{\text{Fusion}} \underset{\text{Boron}}{2B} + 3MgO$

Structure of B_2H_6:



(H---B---H is hydrogen bridge bond, *i.e.*, 3 centre-two electron bond)

Reaction with HCl:

$B_2H_6 + HCl \longrightarrow B_2H_5Cl + H_2$

37. (1) (*A*) on heating with conc. H_2SO_4 and MnO_2 yields brown fumes and so it contains Br^- ions.

(2) (*A*) is pale yellow solid insoluble in mineral acid but soluble in NH_3 and thus, it is AgBr.

Reactions:

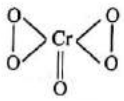
(1) $\underset{(A)}{AgBr} + 2NH_3 \longrightarrow \underset{(B)}{Ag(NH_3)_2}\,Br$ (Partially soluble)

(2) $2AgBr + Na_2S_2O_3 \longrightarrow \underset{(C)}{Ag_2S_2O_3} + 2NaBr$

$Ag_2S_2O_3 \xrightarrow{\text{Boil}} \underset{\text{Black ppt.}\ (D)}{Ag_2S} + SO_3$

(3) $Ag_2S + 2HCl \longrightarrow \underset{\text{White ppt.}\ (E)}{2AgCl} + H_2S$

38. (i) CrO_5 :



(ii) 1 *M* H_2O_2 means 34 g/litre H_2O_2,

$\because$ 34 g H_2O_2 or 1 litre H_2O_2 gives 11200 mL O_2

$\therefore$ Volume strength = 11.2

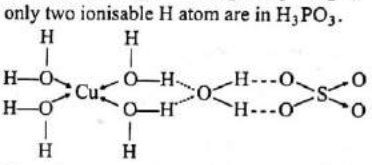
(iii) $LiH + CO_2 \longrightarrow HCOOLi$

$LiH + 2SO_2 \longrightarrow \underset{\text{Lithium sulphosulphite}}{Li_2S_2O_4} + H_2\uparrow$

$H_3PO_3 + D_2O \longrightarrow D_2HPO_3 + H_2O$;

only two ionisable H atom are in H_3PO_3.

(iv)



Co-ordinate bond $4H_2O$ with Cu^{2+} fifth H_2O molecule bond with SO_4^{2-} and H bond between 2 of the co-ordinated H_2O.

The pentahydrate has a hydrogen bonded water molecule between the square planar $Cu(H_2O)_4^{2+}$ and tetrahedral SO_4^{2-} ion. In this anion is also hydrated and has anion water.

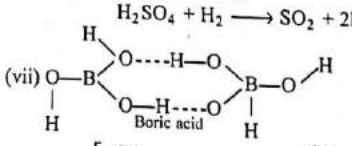
(v) $As_2S_3 + 3(NH_4)_2S + 2S \longrightarrow \underset{\text{Soluble}}{2(NH_4)_3 \cdot AsS_4}$

$2(NH_4)_3AsS_4 + 6HCl \longrightarrow 6NH_4Cl + 3H_2S + \underset{\text{ppt.}}{As_2S_5}$

(vi) At ordinary temperature it reacts with H_2 to form some SO_2 due to its reduction

$H_2SO_4 + H_2 \longrightarrow SO_2 + 2H_2O$

(vii)



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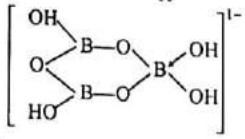


39. (*A*) is ZnS,

$\underset{(A)}{ZnS} + H_2SO_4 \longrightarrow \underset{(C)}{ZnSO_4} + \underset{(B)}{H_2S}$

$$\underset{(B)}{3H_2S} + K_2Cr_2O_7 + 4H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O + \underset{\text{White-grey}\ (D)}{3S}$$

$$\underset{(D)}{S} + \underset{(Air)}{O_2} \longrightarrow \underset{(E)}{SO_2}$$

$$\underset{(E)}{SO_2} + \underset{(B)}{2H_2S} \longrightarrow \underset{\text{Colourless liquid } (C)}{2H_2O} + \underset{(D)}{3S}$$

$$5H_2O + \underset{\text{White}}{CuSO_4} \longrightarrow \underset{\text{Blue}}{CuSO_4 \cdot 5H_2O}$$

$$ZnSO_4 + 2NaOH \longrightarrow Zn(OH)_2 + Na_2SO_4$$

$$Zn(OH)_2 + NaOH \longrightarrow Na_2ZnO_2 \text{ (Soluble)}$$

Also in excess of NH_4OH it forms soluble complex $[Zn(NH_3)_4](OH)_2$.

40. (1) Since, (A) gives chromyl chloride test and thus, it has Cl^- ions.

(2) Since, (A) is strong reducing agent so (A) is $SnCl_2$.

Reactions:

(1) $\underset{\substack{\text{White transparent}\\ \text{Solid } (A)}}{SnCl_2} + H_2O \longrightarrow \underset{\substack{(B)\\ \text{White turbidity}}}{Sn(OH)Cl} + HCl$

(2) $\underset{(A)}{SnCl_2} + 2NaOH \longrightarrow \underset{(C)\ \text{White ppt.}}{Sn(OH)_2} + 2NaCl$

$$\underset{(C)}{Sn(OH)_2} + 2NaOH \longrightarrow \underset{\text{Soluble}}{Na_2SnO_2} + 2H_2O$$

(3) $3SnCl_2 + 2AuCl_3 \longrightarrow 3SnCl_4 + \underset{\substack{\text{Purple of cassius}\\ \text{(Colloidal gold)}}}{2Au}$

(4) $SnCl_2 + 2HCl + I_2 \longrightarrow SnCl_4 + 2HI$

41. (X) is $AlCl_3$, a Lewis acid which exist as dimer (Al_2Cl_6), sublimes at 180° C and forms monomer $AlCl_3$ at 400° C.

(i) $AlCl_3 + 3H_2O \longrightarrow Al(OH)_3 + \underset{\text{Fumes}}{3HCl\uparrow}$

(ii) $HCl + NH_4OH \longrightarrow \underset{\text{White fumes}}{NH_4Cl\uparrow} + H_2O$

(iii) $AlCl_3 + 3NH_4OH \longrightarrow \underset{\text{White ppt.}}{Al(OH)_3} + 3NH_4Cl$

$$Al(OH)_3 + NaOH \longrightarrow \underset{\text{Soluble}}{NaAlO_2} + 2H_2O$$

(iv) Dissociation of H_2S is suppressed in acidic medium and thus does not provide sufficient $[S^{-2}]$ to cross over the K_{sp} of Al_2S_3.

42. The cation of (X) is Sn^{2+}.

(i) $Sn^{2+} + H_2S \xrightarrow{H^+} SnS$

(Brown ppt. soluble in yellow ammonium sulphide step ii)

(iii) $Sn^{2+} + 2NaOH \longrightarrow 2Na^+ + \underset{\text{White ppt.}}{Sn(OH)_2}$

$$Sn(OH)_2 + 2NaOH \longrightarrow \underset{\text{Soluble}}{Na_2SnO_2} + 2H_2O$$

(iv) $Sn^{2+} + 2Fe^{3+} \longrightarrow Sn^{4+} + 2Fe^{2+}$

43. (A) is PH_4I.

(i) $\underset{(A)}{PH_4I} + KOH \longrightarrow \underset{(C)}{KI} + \underset{(B)}{PH_3} + H_2O$

(ii) $\underset{(B)}{2PH_3} + 4O_2 \longrightarrow \underset{(D)}{P_2O_5} + 3H_2O$

(iii) $3CuSO_4 + 2PH_3 \longrightarrow 3H_2SO_4 + Cu_3P_2 \longrightarrow Cu$

(iv) $2CuSO_4 + 4KI \longrightarrow \underset{\substack{(E)\\ \text{Precipitate}}}{Cu_2I_2} + 2K_2SO_4 + I_2$

44. (A) is FeS.

(i) $\underset{(A)}{4FeS} + 7O_2 \longrightarrow 2Fe_2O_3 + \underset{(B)}{4SO_2}$

(ii) $FeS + H_2SO_4 \longrightarrow \underset{(D)}{FeSO_4} + \underset{(C)}{H_2S}$

(iii) $\underset{(C)}{2H_2S} + \underset{(B)}{SO_2} \longrightarrow 2H_2O + \underset{\text{Turbidity}}{3S}$

or $2H_2S + H_2SO_3 \longrightarrow S + 3H_2O$

(iv) $\underset{(D)}{3FeSO_4} + 2K_3[Fe(CN)_6] \longrightarrow \underset{\substack{\text{Ferro ferricyanide}\\ \text{(Blue)}}}{Fe_3[Fe(CN)_6]_2} + 3K_2SO_4$

45. $\underset{\text{Galena}}{2PbS} + O_2 \longrightarrow 2PbO + 2SO_2$ (Roasting)

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

$PbS + 2PbO \longrightarrow 3Pb + SO_2$ (Auto reduction)

$PbS + PbSO_4 \longrightarrow 2Pb + 2SO_2$ (Auto reduction)

Oxidation number of Pb in litharge (PbO) = +2.

46. (i) (B) forms double salt with $Al_2(SO_4)_3$ and thus, may be K_2SO_4.

(ii) $(A) + S \longrightarrow (B)\ K_2SO_4$

$\because$ 1.743 g K_2SO_4 is obtained by 1.422 g (A)

$\therefore$ 174 g K_2SO_4 is obtained by $\dfrac{1.422 \times 174}{1.743} = 142\text{ g } (A)$

$\because$ 174 g K_2SO_4 requires 32 g S

$\therefore$ 1.743 g K_2SO_4 requires $\dfrac{32 \times 1.743}{174} = 0.321\text{ g S}$

Thus, given data confirms that (B) is K_2SO_4.

Now $\underset{\text{(A potassium salt)}}{2(A)} + S \longrightarrow K_2SO_4$

Molar mass of $(A) \times 2 = 142$

$\therefore$ Molar mass of $(A) = 71$

Since, (A) is pot. salt

$\therefore$ Molar mass of left component = 71 – 39 = 32

Thus, salt is KO_2.

$$\underset{(A)}{2KO_2} + S \longrightarrow \underset{(B)}{K_2SO_4} \xrightarrow[Aq.]{Al_2(SO_4)_3} \underset{(C)}{K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O}$$

47. The scarlet red compound (A) is Pb_3O_4.

The reactions are,

$Pb_3O_4 + \underset{\text{Conc.}}{4HNO_3} \longrightarrow \underset{\text{Solution}}{2Pb(NO_3)_2} + \underset{\text{(Brown ppt.) } (B)}{PbO_2\downarrow} + H_2O$

$Pb(NO_3)_2 + 2KI \longrightarrow \underset{\text{Yellow ppt. } (C)}{PbI_2\downarrow} + 2KNO_3$

$5PbO_2 + 2Mn(NO_3)_2 + 4HNO_3 \longrightarrow 4Pb(NO_3)_2 + \underset{\text{Purple colour } (D)}{Pb(MnO_4)_2} + 2H_2O$

48. The mineral (A) and other compounds are:

(A) $Ca_2B_6O_{11}\cdot 5H_2O$ (Colemanite)
(B) $CaCO_3$ (Calcium carbonate)
(C) $Na_2B_4O_7$ (Borax)
(D) $NaBO_2$ (Sodium metaborate)
(E) B_2O_3 (Boric anhydride)
(F) $Co(BO_2)_2$ (Cobalt metaborate)

The reactions are,

$$Ca_2B_6O_{11} + 2Na_2CO_3\,(aq.) \longrightarrow \underset{(B)}{2CaCO_3}\downarrow + \underbrace{\underset{(C)}{Na_2B_4O_7} + \underset{(D)}{NaBO_2}}_{\text{Soluble}}$$

$$\underset{(D)}{4NaBO_2} + CO_2 \longrightarrow \underset{(C)}{Na_2B_4O_7} + Na_2CO_3$$

$$\underset{(C)}{Na_2B_4O_7} \xrightarrow{\Delta} \underset{(D)}{2NaBO_2} + \underset{(E)}{B_2O_3}$$

$$\underset{(E)}{B_2O_3} + CoO \longrightarrow \underset{(Blue)}{Co(BO_2)_2}$$

49. (A) Ag_2S (a black mineral)
(B) $NaAg(CN)_2$
(C) Na_2S
(D) Ag
(E) AgCl
(F) $Ag(NH_3)_2Cl$

The reactions are,

(1) $\underset{(A)}{Ag_2S} + 4NaCN \longrightarrow \underset{(B)}{2NaAg(CN)_2} + \underset{(C)}{Na_2S}$

(2) $2NaAg(CN)_2 + Zn \longrightarrow Na_2Zn(CN)_4 + \underset{(D)}{2Ag}$

(3) $3Ag + 4HNO_3 \longrightarrow 3AgNO_3 + NO + 2H_2O$

(4) $AgNO_3 \xrightarrow{HCl} \underset{(E)}{AgCl} + HNO_3$

(5) $\underset{(E)}{AgCl} + 2NH_3 \longrightarrow \underset{(F)}{Ag(NH_3)_2Cl}$

(6) $4AgCl + 2Na_2CO_3 \longrightarrow 4Ag + 4NaCl + 2CO_2 + O_2$

50. $3Ca + N_2 \longrightarrow Ca_3N_2 \xrightarrow{6H_2O} \underset{\text{Alkali}}{3Ca(OH)_2} + \underset{(A)}{2NH_3}$

$$Ca(OH)_2 \xrightarrow{CO_2} \underset{\text{Solid}}{CaCO_3} + H_2O$$

51. $Bi(NO_3)_2 + H_2O \longrightarrow Bi[(OH)(NO_3)_2] + HNO_3$

$$NO_3^- + 4H^+ + 3e \longrightarrow NO + 2H_2O$$

$$2I^- \longrightarrow I_2 + 2e$$

$$I_2 + KI \longrightarrow KI_3 \quad \text{(Yellow solution)}$$

52. $NH_4NO_3 \longrightarrow \underset{(B)}{N_2O} + \underset{(C)}{2H_2O}$

$$10N_2O + P_4 \longrightarrow \underset{\text{(Dehydrating agent)}}{P_4O_{10}} + 10N_2$$

53. (i) $Na_2S + Na_2SO_3 + \underset{(B)}{I_2} \longrightarrow \underset{(A)}{Na_2S_2O_3} + 2NaI$

(ii) $Na_2S_2O_3 + 2AgNO_3 \longrightarrow \underset{\text{(White)}}{Ag_2S_2O_3} + 2NaNO_3$

$$Ag_2S_2O_3 + H_2O \longrightarrow \underset{(C)\ \text{Black}}{Ag_2S} + H_2SO_4$$

(iii) $3Na_2S_2O_3 + 2FeCl_3 \longrightarrow \underset{\text{Violet}\ (D)}{Fe_2(S_2O_3)_3} + 6NaCl$

$$Fe_2(S_2O_3)_3 \xrightarrow[\text{disappears}]{\text{Colour}} 2Fe^{2+} + S_4O_6^{2-}$$

(iv) $Na_2S_2O_3 + CuCl_2 \longrightarrow CuS_2O_3 + 2NaCl$

$$2CuS_2O_3 + Na_2S_2O_3 \longrightarrow \underset{\text{White}}{Cu_2S_2O_3} + Na_2S_4O_6$$

$$3Cu_2S_2O_3 + 2Na_2S_2O_3 \longrightarrow \underset{(E)\ \text{(Soluble)}}{Na_4[Cu_6(S_2O_3)_5]}$$

54. (i) $\underset{(A)}{CoCl_2} + H_2S \xrightarrow{NH_4OH} \underset{(B)\ \text{Black}}{CoS} + 2HCl$

(ii) $CoS + 2HCl \xrightarrow{KClO_3} CoCl_2 + H_2S$

(iii) $CoCl_2 + 2KCN \longrightarrow \underset{\text{Buff ppt.}}{Co(CN)_2} + 2KCl$

$$Co(CN)_2 + 4KCN \longrightarrow \underset{(C)\ \text{Soluble}}{K_4Co(CN)_6}$$

(iv) $\underset{(C)}{2K_4Co(CN)_6} \xrightarrow[[O]]{H_2O,\,\Delta} \underset{(D)}{2K_3Co(CN)_6} + 2KOH$

(v) $CoCl_2 + 2NaHCO_3 \longrightarrow Co(HCO_3)_2 + 2NaCl$

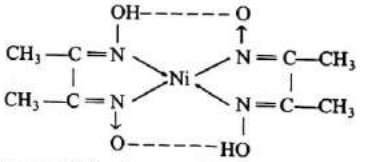
$$Co(HCO_3)_2 + 4NaHCO_3 \longrightarrow Na_4[Co(CO_3)_3] + 3H_2O + 3CO_2$$

$$2Na_4Co(CO_3)_3 + H_2O + O \longrightarrow 2Na_3[Co(CO_3)_3] + 2NaOH$$

55. $Na_2CrO_3 + H_2O_2 \longrightarrow Na_2CrO_4 + H_2O$

56. (a) Ni^{2+} ions react with dimethyl glyoxime in slightly alkaline medium as:

$$Ni^{2+} + \underset{CH_3-C=NOH}{\overset{CH_3-C=NOH}{|\quad\quad|}} + 2NH_4OH \longrightarrow$$



(b) The charge on Ni in the complex is +2 and the hybridisation of Ni^{2+} in the given complex is dsp^2 having square planar nature.

(c) The complex is diamagnetic as it has no unpaired electron.

57. (i) $\underset{(A)}{CuCO_3} \longrightarrow \underset{(B)}{CuO} + \underset{(C)}{CO_2}$

(ii) $CuO + H_2 \longrightarrow \underset{(D)}{Cu} + H_2O$

(iii) $CuO + 2HCl \longrightarrow CuCl_2 + H_2O$

$$2CuCl_2 + K_4Fe(CN)_6 \longrightarrow \underset{\text{Chocolate}\ (E)}{Cu_2Fe(CN)_6} + 4KCl$$

(iv) $Ca(OH)_2 + \underset{(C)}{CO_2} \longrightarrow \underset{\text{White}}{CaCO_3} + H_2O$

$$CaCO_3 + CO_2 + H_2O \longrightarrow \underset{(F)\ \text{Soluble}}{Ca(HCO_3)_2}$$

58. (i) $\underset{(A)}{Hg_2(NO_3)_2} + HCl \longrightarrow \underset{(B)}{Hg_2Cl_2} + 2HNO_3$

(ii) $Hg_2Cl_2 + Cl_2 \longrightarrow \underset{(C)}{2HgCl_2}$ (Soluble)

(iii) $HgCl_2 + 2KI \longrightarrow 2KCl + HgI_2$ (ppt.)

$HgI_2 + 2KI \longrightarrow \underset{(D)}{K_2HgI_4}$ (used for test of NH_3; Nessler's reagent)

(iv) $\underset{(B)}{Hg_2Cl_2} + SnCl_2 \longrightarrow SnCl_4 + \underset{(E)\text{ Grey}}{Hg_2}$

$2HgCl_2 + 2SnCl_2 \longrightarrow 2SnCl_4 + \underset{(E)}{Hg_2}$

(v) $Hg_2(NO_3)_2 + 2H_2SO_4 \longrightarrow 2HgHSO_4 + 2HNO_3$

$6FeSO_4 + 2HNO_3 + 3H_2SO_4 \longrightarrow 3Fe_2(SO_4)_3 + 4H_2O + 2NO$

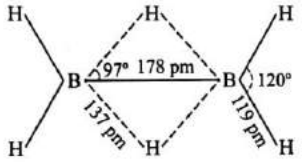
$FeSO_4 + NO \longrightarrow \underset{(F)\text{ Brown ring}}{FeSO_4 \cdot NO}$

59. $\underset{(X)}{4BCl_3} + 3Li[AlH_4] \longrightarrow \underset{(Y)}{2B_2H_6} + 3AlCl_3 + 3LiCl$

$$\%\text{ of H in } B_2H_6 = \frac{6}{27.62} \times 100 = 21.72\%$$

$$B_2H_6 + 3O_2 \xrightarrow[\text{in air}]{\text{Explosion}} 2B_2O_3 + 3H_2O;\ \Delta H = -2008\text{ kJ}$$

Structure of B_2H_6:



Dotted line represents three centre-2-electron pair bond or banana bond.

60. Oxidising nature of H_2O_2:

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

Reducing nature of H_2O_2 :

$2K_3Fe(CN)_6 + 2KOH + H_2O_2 \longrightarrow 2K_4Fe(CN)_6 + 2H_2O + O_2$

61. Haematite (Fe_2O_3) on burning with coke and lime at 2000° C results in the following:

$C + O_2 \longrightarrow CO_2$

$CO_2 + C \longrightarrow 2CO$

$3CO + Fe_2O_3 \longrightarrow \underset{(\text{Steel})}{2Fe} + 3CO_2$

[Reduction of Fe_2O_3 to form steel]

$SiO_2 + \underset{(\text{Lime})}{CaO} \longrightarrow \underset{(\text{Slag})}{CaSiO_3}$

[Slag, ($CaSiO_3$) is used as building material]

62. $SO_2 + PCl_5 \longrightarrow SOCl_2 + POCl_3$

$FeCl_3 \cdot 6H_2O + 6SOCl_2 \longrightarrow FeCl_3 + 6SO_2 + 12HCl$

$FeCl_3 \cdot 6H_2O + 6CH_3C(OCH_3)_2 \cdot CH_3 \longrightarrow FeCl_3 + 12CH_3OH + 6CH_3COCH_3$

63. An observation of the experimental data reveals that A is $FeCl_3$; Red colour of $Fe(CNS)_3$ with NH_4SCN from (ii) and chromyl chloride test for Cl from (iii). The reactions are:

(i) $\underset{(A)}{FeCl_3} + 3H_2O \longrightarrow Fe(OH)_3 + 3HCl$

(acidic solution due to hydrolysis of Fe^{3+})

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

$FeCl_3$ sublimes at 300° C.

(ii) $FeCl_3 + 3NH_4SCN \longrightarrow \underset{(B)\text{ Red}}{Fe(CNS)_3} + 3NH_4Cl$

$4FeCl_3 + 3K_4[Fe(CN)_6] \longrightarrow \underset{(C)\text{ Blue}}{Fe_4[Fe(CN_6)]_3} + 12KCl$

(iii) $4FeCl_3 + 9H_2SO_4 + 3K_2Cr_2O_7 \longrightarrow \underset{(D)\text{ (Red yellow vapours)}}{6CrO_2Cl_2} + 2Fe_2(SO_4)_3 + 3K_2SO_4 + 9H_2O$

(iv) $CrO_2Cl_2 + 4NaOH \longrightarrow 2NaCl + Na_2CrO_4 + 2H_2O$

$Na_2CrO_4 + (CH_3COO)_2Pb \longrightarrow \underset{(E)\text{ (Yellow ppt.)}}{PbCrO_4\downarrow} + 2CH_3COONa$

64. An observation of the experimental data reveals that (A) is $CdSO_4$; yellow ppt. of CdS from observation (i) and sulphate from observation (vi). The reactions are:

(i) $\underset{(B)}{CdSO_4} + H_2S \longrightarrow \underset{(A)}{CdS} + H_2SO_4$

(ii) $CdS + 2HNO_3 \longrightarrow \underset{\text{Soluble}}{Cd(NO_3)_2} + H_2S$

$CdS + \underset{\text{Yellow amm. sulphide}}{(NH_4)_2S_x} \longrightarrow \text{Insoluble}$

$CdSO_4 + 2NH_4OH \longrightarrow Cd(OH)_2 + (NH_4)_2SO_4$

(iii) $Cd(OH)_2 + 4NH_4OH \longrightarrow \underset{(C)\text{ Soluble}}{[Cd(NH_3)_4](OH)_2} + 4H_2O$

(iv) $CdSO_4 + 2KCN \longrightarrow \underset{\text{White ppt.}}{Cd(CN)_2} + K_2SO_4$

$Cd(CN)_2 + KCN \longrightarrow \underset{(D)\text{ Soluble}}{K_2[Cd(CN)_4]}$

(v) $K_2[Cd(CN)_4] + H_2S \longrightarrow CdS + 2KCN + 2HCN$

(vi) $CdSO_4 + BaCl_2 \longrightarrow \underset{(E)}{BaSO_4} + CdCl_2$

Insoluble in HNO_3

65. (i) Na_2O_2 is a powerful oxidant and bleaching agent and bleaches red litmus paper to white in aqueous solution state.

$Na_2O_2 + 2H_2O \longrightarrow 2NaOH + H_2O_2$

H_2O_2 + litmus red $\longrightarrow$ White (Bleaching)

(ii) The other compound Na_2O will give NaOH on dissolution in water. The red litmus will turn to blue.

66. (A) $[Cr(H_2O)_6]Cl_3$ (Violet)

(B) $[Cr(H_2O)_5Cl]Cl_2 \cdot H_2O$ (Green)

(molar mass = 266.5 g mol^{-1})

(C) $[Cr(H_2O)_4Cl_2]Cl \cdot 2H_2O$ (Dark green)

Compound (A) contains six water molecules as coordinated water and thus, does not lose H_2O on treatment with H_2SO_4. Compound (B) contains five water molecules as coordinated water and one molecule as lattice water which is lost to H_2SO_4 showing a loss of 18 g out of 266.5 g, *i.e.*, 6.75% loss. Similarly, compound (C) contains four coordinated water molecules and two molecules of lattice water which are taken out by H_2SO_4 to show a loss of 13.5%.

67. A solution containing one mole of HgI_2 and two mole of NaI is orange in colour due to the partial solubility of HgI_2. On addition of excess of NaI, the colourless complex Na_2HgI_4 is formed.

$$\underset{\text{Excess}}{2NaI} + HgI_2 \longrightarrow Na_2HgI_4$$

The Na_2HgI_4 on addition of NaOCl, oxidises as:

$$3Na_2HgI_4 + 2NaOCl + 2H_2O \longrightarrow 3HgI_2 + 2NaCl + 4NaOH + 2NaI_3$$

Thus, colour of partially soluble HgI_2 is restored.

68. $$\underset{\text{Pyrolusite}}{MnO_2} + KOH \xrightarrow{[O]} \underset{\substack{\text{Dark green}\\(A)}}{K_2MnO_4} + H_2O$$

$$3K_2MnO_4 + 2H_2O \xrightarrow{\text{Dil. } H_2SO_4} \underset{\text{Purple } (B)}{2KMnO_4} + MnO_2 + 4KOH$$

(i) $2KMnO_4 + KI + H_2O \longrightarrow \underset{(C)}{KIO_3} + 2MnO_2 + 2KOH$

(ii) $2KMnO_4 + 8H_2SO_4 + 10FeSO_4 \longrightarrow 2MnSO_4 + K_2SO_4 + 5Fe_2(SO_4)_3 + 8H_2O$

(iii) $2KMnO_4 + 2H_2SO_4\ (\text{conc.}) \longrightarrow 2K_2SO_4 + \underset{(D)}{Mn_2O_7} + H_2O$

$$\underset{(D)}{2Mn_2O_7} \longrightarrow \underset{(E)}{4MnO_2} + 3O_2$$

69. The compound can be **$AgNO_3$.**

Solution of $A + NaCl \rightarrow$ a white precipitate insoluble in HNO_3 but dissolves in NH_4OH, indicating the presence of Ag^+ ions in solution.

Solution of $A + H_2S \rightarrow Ag_2S$—a black precipitate soluble in HNO_3.

Solution of $A + K_2CrO_4 \rightarrow Ag_2CrO_4$—a brick red precipitate. Presence of Ag^+ is confirmed.

Solution of $A + FeSO_4 + \text{conc. } H_2SO_4 \rightarrow$ a brown ring indicates the presence of nitrate. The compound is therefore identified as $AgNO_3$.

$$2AgNO_3 + H_2SO_4 \longrightarrow Ag_2SO_4 + 2HNO_3$$

$$6FeSO_4 + 3H_2SO_4 + 2HNO_3 \longrightarrow 3Fe_2(SO_4)_3 + 4H_2O + 2NO$$

$$FeSO_4 + NO \longrightarrow \underset{\text{A brown ring}}{[FeSO_4 \cdot NO]}$$

70. The given statements suggest that given compound is **$FeCl_3$.**

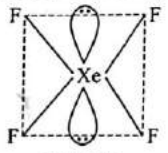
$$2FeCl_3 + SnCl_2 \longrightarrow SnCl_4 + 2FeCl_2$$

$$2FeCl_3 + 2KI \longrightarrow 2FeCl_2 + 2KCl + I_2$$

$$2FeCl_3 + H_2S \longrightarrow 2FeCl_2 + 2HCl + S$$

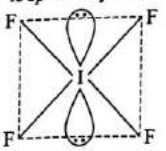
$$4FeCl_3 + 3K_4Fe(CN)_6 \longrightarrow Fe_4[Fe(CN)_6]_3 + 12KCl$$

71. (i) **XeF_4** : Xe in XeF_4^- is sp^3d^2 hybridised.



Lone pair

IF_4^- : I in IF_4^- is sp^3d^2 hybridised.



(ii) Lithium is too smaller in size to have a co-ordination number six.

(iii) $Na_2S_2O_3 + Cl_2 + H_2O \longrightarrow Na_2SO_4 + S + 2HCl$

(iv) $2Cr(OH)_3 + 4NaOH + 3H_2O_2 \longrightarrow 2Na_2CrO_4 + 8H_2O$

(v) Boron halides being electron deficient compounds are Lewis acid. The order of basic nature is

$$BF_3 < BCl_3 < BBr_3 < BI_3$$

The order is just reverse to the normal expected order on the basis of electronegativity of halogens. This anomalous nature has been explained on the relatively decreasing tendency of halogens from F_2 to I_2 to back donate the unutilised electrons to the vacant p-orbitals of boron atom.

(vi) In graphite the sp^2 hybridisation takes place giving rise to 3σ and 1π bond. The sigma bonds formed possess more s-character and thus, show more extent of overlapping in comparison to diamond which possesses sp^3 hybridised state. Thus graphite possesses lower energy level.

(vii) Pb in Pb^{4+} state is a strong oxidising agent and thus PbO_2 is the strongest among given oxidants and oxidises even HCl to Cl_2.

72. $$Mn_2O_7 \longrightarrow 2MnO_2 + \frac{3}{2}O_2;$$

$$Mn_2O_7 + H_2O \longrightarrow \underset{\text{Purple}}{2HMnO_4}$$

73. The SO_2 is obtained by burning sulphur in air as,

$$S + O_2 \longrightarrow SO_2$$

The SO_2 so obtained is impure. Dust present in sulphur is removed by allowing the gas to expand, when some dust settles down by passage through electrostatic precipitators and finally washing with water. The moistened gas is now treated with conc. H_2SO_4 to dry it which is kept in use until its concentration falls to 94%.

The SO_2 so obtained is then catalytically converted to SO_3.

$$2SO_2 + O_2 \xrightarrow[\substack{\text{Finely divided Pt. deposited on } MgSO_4\\ \text{or } Fe_2O_3 \text{ and } CuO\\ \text{or Pt.-silica gel}}]{\text{Pt. asbestos or}} 2SO_3$$

74. $$\underset{(X)}{4NH_4Cl} + K_2Cr_2O_7 + 6H_2SO_4 \longrightarrow \underset{\substack{\text{Reddish brown gas}\\(A)}}{2CrO_2Cl_2} + 4NH_4HSO_4 + 2KHSO_4 + 3H_2O$$

[This is chromyl chloride test]

$$CrO_2Cl_2 + 2NaOH \longrightarrow \underset{\substack{\text{Yellow}\\(B)}}{Na_2CrO_4} + 2HCl$$

$Na_2CrO_4 + (CH_3COO)_2Pb \longrightarrow \underset{(C)}{\underset{\text{Yellow ppt.}}{PbCrO_4}} + 2CH_3COONa$

$\underset{(X)}{NH_4Cl} + NaOH \longrightarrow \underset{\text{Colourless gas}}{NH_3} + NaCl + H_2O$

$K_2HgI_4 + NH_3 + 3KOH \longrightarrow \underset{\text{Reddish brown ppt.}}{\underset{(D)}{NH_2HgO\cdot HgI}} + 7KI + 3H_2O$

75. (i) $H_2SO_4 + 2HI \longrightarrow I_2 + SO_2 + 2H_2O$

(ii) $CaOCl_2 + 2NaI + 2HCl \longrightarrow I_2 + CaCl_2 + H_2O + 2NaCl$

(iii) $Ag_2S + 2CuCl_2 + 2Hg \longrightarrow Cu_2Cl_2 + Hg_2Cl_2 + 2Ag + S$

76. (i) $H_2S + H_2SO_4\ (conc.) \longrightarrow 2H_2O + SO_2 + S$

(ii) $6NaOH\ (excess) + 3I_2 \longrightarrow 5NaI + NaIO_3 + 3H_2O$

(iii) $2NH_3 + 3NaOCl \longrightarrow N_2 + 3NaCl + 3H_2O$

77. (i) $I_2 + 10HNO_3\ (conc.) \longrightarrow 2HIO_3 + 10NO_2 + 4H_2O$

(ii) $SF_6 + 3H_2O \longrightarrow SO_3 + 6HF$

(iii) $3SF_4 + 8Cl_2 \longrightarrow 4BF_3 + 3SCl_2 + 3Cl_2$

78. (a) $Ca_5(PO_4)_3F + 7H_3PO_4 + 5H_2O \longrightarrow 5Ca(H_2PO_4)_2\cdot H_2O + HF$

(b) (i) $P_4O_{10} + 6PCl_5 \longrightarrow 10POCl_3$

(ii) $SnCl_4 + 4C_2H_5Cl + 8Na \longrightarrow (C_2H_5)_4Sn + 8NaCl$

(c) (i) $2Cu + CO_2 + H_2O + O_2 \longrightarrow CuCO_3\cdot Cu(OH)_2$

(ii) $3Ca(OH)_2 + 2Cl_2 \longrightarrow Ca(OCl)_2 + CaCl_2\cdot Ca(OH)_2\cdot H_2O + H_2O$

79. (i) $Au + 4HCl + 3HNO_3 \longrightarrow HAuCl_4 + 3NO_2 + 3H_2O$

(ii) $C + 4HNO_3\ (conc.) \longrightarrow CO_2 + 4NO_2 + 2H_2O$

(iii) $Sn + 2KOH(hot) + H_2O \longrightarrow K_2SnO_3 + 2H_2$

(iv) $Cu(OH)_2 + 2NH_4NO_3 + 2NH_4OH(aq.) \longrightarrow Cu(NH_3)_4(NO_3)_2 + 4H_2O$

80. $\underset{(A)}{HNO_2} + \underset{(B)}{2H_2SO_3} + H_2O \longrightarrow \underset{(C)}{NH_2OH} + \underset{(D)}{2H_2SO_4}$

(*A*) HNO_2 : HO—N=O

(*B*) H_2SO_3 : HO—S(=O)—OH

(*C*) NH_2OH: H—N(—H)—OH

(*D*) H_2SO_4 : HO—S(=O)(=O)—OH

81.

A	:	$Ca(OH)_2$
B	:	NH_4HCO_3
C	:	Na_2CO_3
D	:	NH_4Cl
E	:	$CaCl_2$

82.

A.	SO_2Cl_2	(vi) Tetrahedral
B.	Ice	(v) H-bonding
C.	$CuSO_4$ (anhy.)	(iv) Testing H_2O
D.	$K_2HgI_4 + NaOH$	(iii) Testing NH_3
E.	Fluorocarbons	(ii) Refrigeration
F.	NO	(i) Paramagnetic

83. (i) $CuSO_4\cdot 5H_2O \xrightarrow{100^\circ C} \underset{(A)}{CuSO_4\cdot H_2O} \xrightarrow{230^\circ C} \underset{(B)}{CuSO_4} \xrightarrow{800^\circ C} \underset{(C)}{CuO} + \underset{(D)}{SO_3}$

(ii) $2AgNO_3 \xrightarrow{\text{Red heat}} \underset{(E)}{2Ag} + \underset{(F)}{2NO_2} + O_2$

(iii) $Na_2B_4O_7 \xrightarrow{740^\circ C} \underset{(G)}{NaBO_2} + \underset{(H)}{B_2O_3}$

84. K_{sp} of CuS is less than K_{sp} of ZnS. On passing H_2S in acidic medium, the dissociation of H_2S is suppressed due to common ion effect and it provides $[S^{2-}]$ which is just sufficient to cross over K_{sp} of CuS and not K_{sp} of ZnS. Thus, only CuS gets precipitated.

85. (i) $(CH_3COO)_2Ca$ shows exothermic dissolution whereas $Pb(NO_3)_2$ shows endothermic dissolution. According to Le-Chatelier principle the solubility of $(CH_3COO)_2Ca$ decreases and solubility of $Pb(NO_3)_2$ increases with temperature.

(ii) The dissociation of NH_4OH (a weak electrolyte) is suppressed in presence of NH_4Cl due to common ion effect. Thus, $[OH^-]$ in solution becomes low. The ionic product of concentrations of Mg^{2+} and OH^- ions does not exceed the solubility product of $Mg(OH)_2$ and thus $Mg(OH)_2$ is not precipitated.

(iii) Yellow phosphorus is very reactive (ignition temperature 30° C) towards air whereas red phosphorus is quite unreactive (ignition temperature 260° C). Thus, to avoid contact of yellow phosphorus from air, it is kept under water.

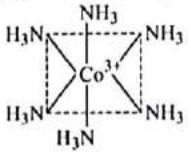
(iv) Bleaching of flower by SO_2 follows reduction. The colour of bleached material is regained due to oxidation by air and is thus, temporary. The bleaching of flower by Cl_2 follows oxidation and is thus permanent.

86. (a) Potassium ammine tetra cyano nitrosonium chromium (I).

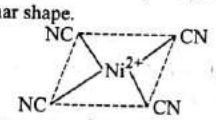
Cr is in +1 oxidation state and possesses d^2sp^3 hybridisation with one unpaired electron.

$\mu = \sqrt{n(n+2)} = \sqrt{1(1+2)} = \sqrt{3} = \mathbf{1.73\ BM}$

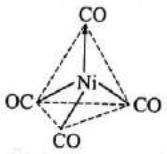
(b) $[Co(NH_3)_6]^{3+}$: Co^{3+} is d^2sp^3 hybridised to show octahedral shape.



$[Ni(CN)_4]^{2-}$: Ni^{2+} is dsp^2 hybridised to show square planar shape.



$[Ni(CO)_4]$: Ni is sp^3 hybridised to show tetrahedral shape.



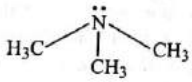
87. (a) AlF_3 dissolves in ionic KF due to the formation of K_3AlF_6. On the other hand anhydrous

$$AlF_3 + 3KF \longrightarrow \underset{\text{Soluble}}{K_3[AlF_6]}$$

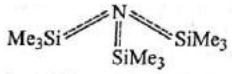
HF being weak acid does not dissociate to appreciable extent and AlF_3 does not form $[AlF_4]$ or $H[AlF_4]$. Addition of BF_3 in $K_3[AlF_6]$ forms AlF_3 as insoluble mass because BF_3 is more acidic than AlF_3.

$$K_3[AlF_6] + BF_3 \longrightarrow AlF_3 + 3K[BF_4]$$

(b) Me_3N or $(CH_3)_3N$ has three σ-bonds between sp^3 hybridised nitrogen and carbon atom of CH_3 gp. The lone pair on N atom give rise to pyramidal shape.



In $(SiMe_3)_3N$, three Si—N bonds are present and lone pair on N atom is involved in back bonding with vacant 3*d*-orbitals of Si giving rise to trigonal planar geometry.



88. $BaO > B_2O_3 > CO_2 > SO_3 > Cl_2O_7$

89. (a) $2KI(aq.) + Cl_2 \longrightarrow 2KCl(aq.) + I_2$

In the reaction Cl_2 oxidises iodide ion (−1 oxidation state) to I_2 (0 oxidation state). Cl_2 has higher reduction potential than I_2 and thus oxidises iodide to iodine getting itself reduced to chloride ion. Similarly,

$$2KI + X_2\ (X = Cl, Br, F) \longrightarrow 2KX + I_2$$

(b) M.O. configuration of O_2 :

$$\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p^2, \pi 2p_x^2, \pi 2p_y^2, \pi^* 2p_x^1, \pi^* 2p_y^1$$

Bond order $= \frac{1}{2}$ [No. of bonding electrons − No. of antibonding electrons]

$$= \frac{1}{2}[10 - 6] = 2$$

Also, O_2 molecule is paramagnetic as it possesses two unpaired electrons.

90. (i) $Al_4C_3 + 12H_2O \longrightarrow 4Al(OH)_3 + 3CH_4$

(ii) $CaNCN + 3H_2O \longrightarrow CaCO_3 + 2NH_3$

(iii) $BF_3 + 2H_2O \longrightarrow [BF_3OH]^- H_3O^+$

(iv) $NCl_3 + 3H_2O \longrightarrow NH_3 + 3HOCl$

(v) $3XeF_4 + 6H_2O \longrightarrow 2Xe + XeO_3 + \left(\frac{1}{2}\right)O_2 + 12HF$

91. (a) (i) Argentite ore is Ag_2S

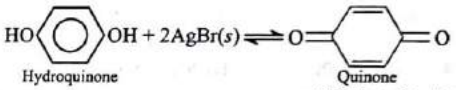
$$Ag_2S + 4NaCN \underset{}{\overset{\text{Leaching}}{\rightleftharpoons}} 2Na[Ag(CN)_2] + Na_2S$$

$$2Na[Ag(CN)_2] + Zn \longrightarrow Na_2[Zn(CN)_4] + 2Ag$$

(ii) A developer is usually a weak reducing agent such as potassium ferrous oxalate or an alkaline solution of pyragallol or an alkaline solution of quinol.

$$K_2\overset{II}{Fe}(C_2O_4)_2 + AgBr(s) \rightleftharpoons K\overset{III}{Fe}(C_2O_4)_2 + Ag(s) + KBr$$

or



Hydroquinone Quinone

$$+ 2HBr + 2Ag(s)$$

Therefore, silver bromide is fixed with $Na_2S_2O_3$ or developed image is made stable by fixing with $Na_2S_2O_3$.

$$AgBr + 2Na_2S_2O_3 \longrightarrow Na_3[Ag(S_2O_3)_2] + NaBr$$

On acidification of hypo, insoluble turbidity of colloidal sulphur (milky-white is formed).

$$Na_2S_2O_3 + 2H^+ \longrightarrow 2Na^+ + H_2O + SO_2\uparrow + \underset{\text{(Milky white sol.)}}{S}$$

(b) Borax is heated on loop of platinum wire to give **borax bead.**

$$Na_2B_4O_7 \cdot 10H_2O \xrightarrow{740°C} \underset{\text{Bead}}{NaBO_2} + B_2O_3 + 10H_2O$$

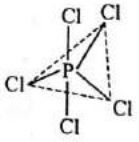
Cobalt (II) salts are placed on this bead and heated strongly on bunsen flame to produce blue flame.

$$Co\ (salt) \xrightarrow{\Delta} CoO + gas\uparrow$$

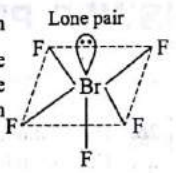
$$CoO + B_2O_3 \xrightarrow{\Delta} \underset{\text{(Blue)}}{Co(BO_2)_2};$$

Cobalt metaborate is blue in oxidising as well as in reducing flame.

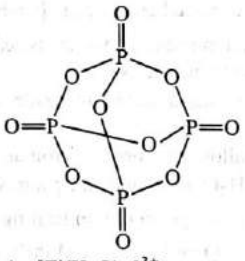
(c) PCl_5 : sp^3d hybridisation having trigonal bipyramidal shape with five $3sp^3d - 3p$ bonds.



BrF_5 : sp^3d^2 hybridisation having distorted octahedral shape with arc position occupied by lone pair (*i.e.*, square pyramidal) with five $4sp^3d^2 - 2p$ bonds.



(d) P_4O_{10} :



92. $M = Ti$, $A = [Ti(H_2O)_6]^{3+}$, $B = TiO_2$

Ti(+IV) ion contains no *d*-electrons, while *d*—*d* transition of single electron of Ti(+III) will cause colour change.

93. $Fe^{3+}_{(aq.)} \xrightarrow{\text{Excess of } SCN^-} \underset{\substack{\text{Blood-red}\\ \text{colour } (A)}}{Fe(SCN)_3} \xrightarrow{\text{Excess } F^-} \underset{\text{Colourless } (B)}{[FeF_6]^{3-}}$

(*A*) : Trithiocyanato ferrum (III)

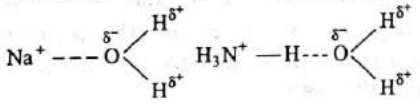
(*B*) : Hexafluoro ferrate (III) ion

Spin magnetic moment of

$$B = \sqrt{n(n+2)} = \sqrt{5(5+2)} = \sqrt{35}\ BM$$

$[FeF_6]^{3-}$ has five unpaired electrons.

94. (i) NH_4^+ is solvated by H—bonding and ion-dipole forces whereas Na^+ is solvated merely by an ion-dipole interaction.



(ii) Ag^+ is soft acid, CN^- is soft base whereas Cl^- is hard base. A complex of soft acid and soft base is more stable.

(iii) Electronegativity also plays a part in the distortion of molecules from the ideal shape. With decreasing electronegativity of the central atom as in the series NH_3, PH_3, AsH_3, SbH_3 (N > P > As > Sb), the bonding electron pairs are drawn closer to H atom and further away from central atom. Thus, repulsion between bonding pairs of electrons decreases and so the bond angle decreases progressively.

(iv) $CH_2—CH_2—\ddot{N}H—CH_2—CH_2$ (with NH_2 and $\ddot{N}H_2$ groups)

(Diethylene triamine)

(v) $\underset{\text{Strong basic}}{MnO} < \underset{\text{Weak basic}}{Mn_2O_3} < \underset{\text{Amphoteric}}{MnO_2} < \underset{\text{Acidic}}{MnO_3} < \underset{\text{Strong acidic}}{Mn_2O_7}$

95. (a) $A—X$ bond is polar; $X—X$ bond is non-polar.

(b) $O=S=O + C_2H_5MgBr \xrightarrow{\text{Ether}} O=S(OMgBr)—C_2H_5 \xrightarrow{HOH} O=S(OH)—C_2H_5$ (Sulphinic acid)

(c) $n-2$; $HO—\overset{\overset{O}{\|}}{\underset{\underset{O}{\|}}{S}}—\underset{(n-2)}{\overset{\overset{O}{\|}}{\underset{\underset{O}{\|}}{S}}}—\overset{\overset{O}{\|}}{\underset{\underset{O}{\|}}{S}}—OH$

(d) $3CS_2 + 6NaOH \longrightarrow Na_2CO_3 + 2Na_2CS_3 + 3H_2O$

(e) $(CN)_2 + 2NaOH \longrightarrow NaCN + NaCNO + H_2O$; Disproportionation like halogens

(f) $Na_2SO_4 + 4C \longrightarrow Na_2S + 4CO$

$Na_2S + 2HCl \longrightarrow 2NaCl + H_2S$

96. (i) NO_2 formed get dissolved in HNO_3 to give brown or yellow colour.

(ii) Soaps get precipitated in presence of hard water to give Ca or Mg salts.

(iii) BeO is amphoteric in nature.

(iv) TEL used as antinock compound in petrol comes out from exhaust as $PbBr_4$.

(v) Tin becomes brittle at low temperature.

• SINGLE INTEGER ANSWER PROBLEMS •

1. Red lead Pb_3O_4 contains lead oxide and lead dioxide in the ratio .....
2. 'n' factor of O_3 in the reaction $I_2 + 5O_3 + H_2O \longrightarrow 2HIO_3 + 5O_2$.
3. Total number of lone pair of electrons in valence shells of oxygen atoms in ozonide O_3^- ion are .....
4. Atomicity of arsenic is .....
5. Total number of H-bonding sites available in H_2O are .....
6. Number of nearest neighbour NH_3 molecules in solid NH_3 are .....
7. Number of iron atoms involved in one molecule of ferri-ferrocyanide.
8. Number of P = O in cyclotetraphosphate ion ($P_4O_{12}^{-4}$) are .....
9. Number of oxygen atoms in molybdate ion is .....
10. Oxidation number of P in peroxydiphosphoric acid ($H_4P_2O_8$) is .....
11. One mole of As_2O_5 on treatment with fuming hydrochloric acid gives how much mole of Cl_2 ?
12. Liquid HF shows an equilibrium at 15-19°C $HF_{(l)} \rightleftharpoons (HF)_{n(V)}$. The value of n is .....
13. Iodine iodate an ionic compound on heating decomposes to give how much mole of gases?
14. Total number of gases obtained on heating ammonium iodate.
15. Number of S = O bonds in cyclic trimer S_3O_9 are .....
16. Number of canonical forms of CO_2 are .....
17. Number of H-bond formed in trimer form of H_2O, *i.e.*, $(H_2O)_3$.
18. In medicine and first aid of shock, gas poisoning and asphyxiation a mixture of O_2 and CO_2 is administered in gas mask to stimulate natural respiration. The percentage of CO_2 in mixture is:
19. Number of CO molecules in bridged carbonyl of iron having two iron atoms is .....
20. Number of B—O—B bonds in sodium metaborate, *i.e.*, $Na_3B_3O_6$ is .....
21. Number of H_2O molecule per molecule of bauxite in bauxite ore of Al is .....
22. The co-ordination number of Al in Al_2Cl_6 is .....
23. Oxidation number of Cu in potassium tetracyanocuprate is .....
24. The mole ratio of the two gases NO_2 and O_2 obtained on heating copper nitrate is .....
25. The co-ordination number of Be in aqueous solution of $BeCl_2$ is .....
26. The atomicity of Hg vapours is .....
27. The atomicity of mercurous ion is .....
28. Number of unpaired electrons in $[Cr(NH_3)_6]^{3+}$ is:
29. The oxidation number of Mn in its oxide which posses strongest acidic nature is .....
30. In which oxidation state Mn oxide show amphoteric nature?
31. Number of allotropic forms of iron are .....
32. Number of H_2O molecules in Epsom salt is .....
33. Number of gases given out on heating $FeSO_4$ strongly.
34. Number of H_2O molecules in Mohr's salt.
35. Number of mole of gas given out on heating one mole of ferric sulphate.
36. Number of mole of SO_2 formed on heating one mole of iron pyrite in air.
37. The number of Fe^{3+} ions in one molecule of prussian blue is .....
38. Oxidation number of Fe in sodium nitroprusside is .....
39. Number of canonical forms in Resonating structure of N_3^- is .....
40. Bond order of NO^+ is .....
41. A species has magnetic moment 1.73 B M. The number of unpaired electron in it is .....
42. The bond length of H—I is 1.61×10^{-8} cm and partial charge is 3.8×10^{-7} esu cm. The percentage ionic character of HI is ..... (Assume charge on electron 4.8×10^{-10} esu)
43. At 300 K and 1.0 atm pressure, the density of $HF_{(v)}$ is 3.1 g / litre. If $R = 0.08$, the no. of HF molecules associated in vapour phase are .....
44. No. of unpaired electrons in complex ion $[CoF_6]^{3-}$.
45. Effective atomic no. of $_{42}Mo$ is 54. The formula of its carbonyl is $Mo(CO)_x$. The value of x is .....
46. No. of unpaired electrons in $[Mn(CN)_6]^{3-}$ is .....
47. Number of geometrical isomers of $Co(en)Cl_3\ Br^-$ are .....
48. Number of isomers of $Co(en)\ Cl_2\ Br_2^-$ are .....
49. No. of ions furnished by an electrolyte (2 +, 3 −) on dissolution in water is .....
50. A sample of alloy contains a% copper (as $CuAl_2$) by mass. If % of $CuAl_2$ in alloy is 7.40 then what is a?

51. The number of water molecules directly bonded to metal centre in $CuSO_4 \cdot 5H_2O$: **[IIT 2009]**

52. The coordination number of Al in the crystalline state of $AlCl_3$ is: **[IIT 2009]**

53. Total number of geometrical isomers for the complex $[RhCl(CO)(PPh_3)(NH_3)]$: **[IIT 2010]**

54. Among the following, the number of compounds that can react with PCl_3 to give $POCl_3$ is: **[IIT 2011]**

$O_2, CO_2, SO_2, H_2O, H_2SO_4, P_4O_{10}$

55. The numerical value of the factor effective atomic number of Mn in $[Mn_2(CO)_{10}] \times \frac{1}{5}$ is:

ANSWERS

1. Two	**2.** Two	**3.** Six	**4.** Four	**5.** Four	**6.** Six	**7.** Seven	**8.** Four	**9.** Four	**10.** Five	**11.** Two	**12.** Six
13. Five	**14.** Three	**15.** Six	**16.** Three	**17.** Two	**18.** Five	**19.** Nine	**20.** Three	**21.** Two	**22.** Four	**23.** One	**24.** Four
25. Four	**26.** One	**27.** Two	**28.** Three	**29.** Seven	**30.** Four	**31.** Three	**32.** Seven	**33.** Two	**34.** Six	**35.** Three	**36.** Two
37. Four	**38.** Two	**39.** Three	**40.** Three	**41.** One	**42.** Five	**43.** Four	**44.** Four	**45.** Six	**46.** Two	**47.** Two	**48.** Four
49. Five	**50.** Four	**51.** Four	**52.** Four	**53.** Three	**54.** Four	**55.** Seven					

OBJECTIVE PROBLEMS (One Answer Correct)

1. Which statement about zirconium hydride is not correct?
   (a) It is non stoichiometric mixture
   (b) It is non stoichiometric compound
   (c) It has distinct properties from those of its element
   (d) It has definite composition
2. For the reaction $PI_3 + 3H_2O \longrightarrow H_3PO_3 + 3HI$: the correct statement is:
   (a) It is intramolecular redox
   (b) It is disproportional reaction
   (c) It is salt hydrolysis
   (d) It is double decomposition
3. Normally highest oxidation states are seen with fluorine and oxygen but OsO_4 exist and OsF_8 not. This is because:
   (a) the size of fluorine atom is large than oxygen atom
   (b) electronegativity of F is more than oxygen atom
   (c) Os cannot accomodate 8 fluorine atoms due to crowding of atoms
   (d) the size of fluorine atom is smaller than oxygen atom
4. Which is a characteristic of silicones?
   (a) Water repellant (b) Weak Si—C bond
   (c) Si—Si bond (d) Less stable to heat
5. Which is not correct for hydroxyl amine?
   (a) It disproportionates slowly in acid medium
   (b) It is strong oxidant
   (c) It disproportionate readily in alkaline medium
   (d) It is very poisonous
6. pK_a of which halogen acid is positive :
   (a) HF (b) HCl
   (c) HBr (d) HI
7. During hydration of alkali metal cations:
   (a) ΔG, ΔH, ΔS are –ve
   (b) ΔG, ΔH, are –ve, ΔS is +ve
   (c) ΔG, ΔH, ΔS are +ve
   (d) ΔG, ΔS, are –ve, ΔH is +ve
8. Which carbonate of alkaline earth metals decomposes on heating 373 K?
   (a) $BeCO_3$ (b) $MgCO_3$
   (c) $CaCO_3$ (d) $SrCO_3$
9. Which one is not an application of boron carbide?
   (a) As an abrasive for polishing
   (b) Possesses enormous tensile strength and used in making bullet proof cloth
   (c) In brake lining of cars
   (d) In paints
10. Which one is not a characteristic of R_3Al?
   (a) It shows sp^2-hybridisation
   (b) It exist as dimer
   (c) It shows sp^3-hybridisation
   (d) Used as catalyst in the dimerisation of propene to give finally isoprene
11. Which are correct for boric oxide?
   (a) It is anhydride of boric acid as well as also called sesquioxide
   (b) It reacts with metal oxides forming metaborates
   (c) It acts as basic oxide and reacts with strong acidic oxides to form boron salts
   (d) All of the above
12. Bi^{3+} and Sb^{3+} ions:
   (a) are stable in acid medium
   (b) are stable in neutral medium
   (c) are stable in water
   (d) slows the equilibrium $Bi^{3+} \overset{HCl}{\rightleftharpoons} [BiO]^+$
13. Which one is not correct about calgon?
   (a) It is a high molar mass polymer $[NaPO_3]_n$
   (b) It is a water softener
   (c) It is called Graham's salt
   (d) It is used as catalyst
14. About Lapis lazuli, which one is not correct?
   (a) It is $Na_8[(AlSiO_4)_6]S_2$ and named as ultramarine
   (b) It was a precious pigment for oil paintings in middle age
   (c) Presence of polysulphide ion imparts blue colour to it
   (d) It possesses chain silicate structure
15. Which of the following is not correct?
   (a) P_4S_6 exists like P_4O_6
   (b) In P_4S_3, there exists 3P—S—P bond whereas in P_4S_5, there exists four P—S—P bonds
   (c) Both P_4S_{10} and P_4O_{10} have same structure
   (d) P_4S_3 is most stable sulphide of phosphorus
16. Which of the following chromium oxide is acidic?
   (a) CrO (b) Cr_2O_3
   (c) CrO_3 (d) None of these
17. Which of the following statements is wrong about CO ?
   (a) It acts as Lewis base in the formation of metal carbonyls
   (b) It is a neutral oxide
   (c) It acts as acid with NaOH under high P, T to give sodium formate
   (d) It acts as π acceptor by accepting electrons from the central metal during complex formation
18. Cyclic trimer structure of SO_3 contains :
   (a) 6S = O bonds at three S—O—S bonds

(b) 3S = O bonds and six S—O—S bonds
(c) 6S = O bonds and six S—O—S bonds
(d) none of the above

19. Which of the following sulphuryl halides is not known?
(a) SO_2F_2 (b) SO_2Cl_2
(c) SO_2FBr (d) SO_2Br_2

20. Tellurium hydride on dissolution in water gives :
(a) $H_2Te + H_2O \rightleftharpoons H_3O^+ + HTe^-$
(b) $H_2Te + H_2O \rightleftharpoons H_3Te^+ + OH^-$
(c) $H_2Te + H_2O \rightleftharpoons TeO + 2H_2$
(d) none of the above

21. H_2O_2 cannot be formed by the following reaction:
(a) electrolysis of 50% $H_2S_2O_8$ (*aq.*)
(b) hydrolysis of H_2SO_5
(c) action of H_2O on BaO_2
(d) action of H_2O on MnO_2

22. Which characteristic is not shown by S_4N_4?
(a) It has cage structure
(b) It has two S—S strong bonds
(c) Thermochromic
(d) Stable in air but detonates on shock, grinding or sudden heating

23. Which does not show thermochromic property?
(a) ZnO (b) S_4N_4
(c) $CuSO_4 \cdot 5H_2O$ (d) $KMnO_4$

24. Among the following gps., the last element of which group is not radioactive :
(a) gp 1 (b) gps 17
(c) gps 18 (d) gps 14

25. Which of the following does not give oxygen on heating?
(a) $KClO_3$ (b) $Zn(ClO_3)_2$
(c) $K_2Cr_2O_7$ (d) $(NH_4)_2Cr_2O_7$

26. Which compounds of Xe contain lone pair of electron?
(a) $[XeO_6]^{4-}$ (b) XeO_3F_2
(c) XeO_4 (d) XeO_2F_2

27. Which of the following does not contain $p\pi - d\pi$ bonding?
(a) PF_3
(b) Oxoacid of sulphur
(c) Oxoacid of phosphorus
(d) PF_5

28. The oxidation number and hybridisation of xenon in barium perxenate is:
(a) +6, sp^3 (b) +8, sp^3d^2
(c) +6, sp^3d (d) +8, sp^3

29. Which among the following the transition elements have their density more than 5 g / cm^3?
(a) Sc (b) Y
(c) Ti (d) Ir

30. Which of the transition metal element has highest density?
(a) Os (b) Ir
(c) Pt (d) Au

31. Highest m. pt. of transition element exists for:
(a) Ta (b) W
(c) Re (d) Zn

32. The colours of AgCl (white), AgBr (pale yellow) and AgI (yellow) is due to the fact that:
(a) Cl_2, Br_2 and I_2 are green, brown and violet respectively
(b) Ag^+ polarises the anions in the order: $I^- > Br^- > Cl^-$
(c) Ag^+ have $4d^{10}$, configuration
(d) the anions Cl^-, Br^- and I^- have np^6 configuration

33. VO_4^-, CrO_4^{2-} and MnO_4^- are pale yellow, strong yellow and intense purple respectively in aqueous solution. The darkening of colour is due to:
(a) charge transfer
(b) d—d transition
(c) half-filled d-sub-shells
(d) increasing number of unpaired electron

34. The complex $[Fe(H_2O)_5NO]^{2+}$ formed during brown ring test for NO_3^-; select the wrong statement:
(a) Is coloured due to charge transfer
(b) has no unpaired electrons
(c) Has magnetic moment 3.9 BM
(d) Has Fe in +1 oxidation state and NO in +1 oxidation state

35. For the given values, the correct statement is:
$[Fe(H_2O)_6]^{3+} + e \longrightarrow [Fe(H_2O)_6]^{2+}$ $E° = +0.77$ V
$[Fe(CN)_6]^{3-} + e \longrightarrow [Fe(CN)_6]^{4-}$ $E° = +0.36$ V
(a) It is easier to oxidise $[Fe(H_2O)_6]^{2+}$ than $[Fe(CN)_6]^{4-}$
(b) It is easier to oxidise $[Fe(CN)_6]^{4-}$ than $Fe[(H_2O)_6]^{2+}$
(c) $[Fe(CN)_6]^{3-}$ is more stable than $Fe[(H_2O)]_6^{3+}$
(d) $[Fe(CN)_6]^{3-}$ is less stable than $Fe[(H_2O)_6]^{3+}$

36. Select the incorrect statement for $FeCl_3$:
(a) It is yellow-brown in colour in solid state
(b) It is used as mordant in dyeing and as an oxidant
(c) It is used as catalyst in manufacture of CCl_4
(d) It does not sublimes on heating

37. Select the correct statements :
(a) Vitamin B-12 has Co
(b) Co^{2+} ions are very stable and difficult to oxidise
(c) $[Co(NH_3)_6]^{2+}$ are readily oxidised to $[Co(NH_3)_6]^{3+}$
(d) All of the above

38. The stable oxidation state of Cu, Ag and Au are respectively:
(a) Cu^+, Ag^+, Au^+ (b) Cu^{2+}, Ag^+, Au^{2+}
(c) Cu^+, Ag^+, Au^{3+} (d) Cu^{2+}, Ag^+, Au^{3+}

39. Select the incorrect statement :
(a) H_2O_2 can be detected by Ti^{4+} ion where a yellow-orange solution of $[TiO_2 \cdot OH(H_2O)_n]^+$ is formed
(b) BrF_3 is potential non-aqueous ionising solvent
(c) ICl can be used for iodination as well chlorination of organic compounds
(d) NaBr on reaction with ICl gives NaCl

40. The reaction which do not occur is:
(a) $Ni(CO)_4 + 4PF_3 \longrightarrow Ni(PF_3)_4 + 4CO$
(b) $PCl_3 + 6NH_3 \longrightarrow P(NH_2)_3 + 3NH_4Cl$
(c) $PCl_3 + 3H_2O \longrightarrow H_3PO_3 + 3HCl$
(d) $SbCl_3 + 3H_2O \longrightarrow H_3SbO_3 + 3HCl$

41. The reaction which do not occur is:
(a) $COCl_2 + 2NH_3 \longrightarrow NH_2CONH_2 + 2HCl$
(b) $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$
(c) $5CO + I_2O_5 \longrightarrow 5CO_2 + I_2$
(d) $NaNH_2 + C \xrightarrow{750°C} NaH + HCN$

42. Select the correct statement:
(a) Lithopone is $BaS + ZnSO_4$
(b) Ammoniacal CuCl absorbs CO and CO_2
(c) H_2 can be dried by conc. H_2SO_4
(d) Wood metal melts at b.pt. of water

43. The decreasing order of molar conductances of the given compounds in their aqueous solution is:
(I) : $K[Co(NH_2)_2(NO_2)_4]$;
(II) : $[Cr(NH_3)_3(NO_2)_3]$;
(III) : $[Cr(NH_3)_5NO_2]_3[Co(NO_2)_6]_2$;
(IV) : $Mg[Cr(NH_3)(NO_2)_5]$
(a) III > IV > I > II (b) I < II < IV < III
(c) II > I > IV > III (d) III < II < IV < I

44. Which complex of Co^{2+} will show the weakest crystal field splitting?
(a) $Co(CN)_6]^{4-}$ (b) $[Co(NH_3)_6]^{2+}$
(c) $[Co(en)_3]^{2+}$ (d) $[CoCl_6]^4$

45. The effective atomic number rule (EAN) is obeyed by :
(a) $[PtCl_6]^{2-}$ (b) $[Ni(NH_3)_6]^{2+}$
(c) $[Fe(CN)_6]^{3-}$ (d) $[Pt(NH_3)_4]^{2+}$

46. The EAN rule is not obeyed by :
(a) $Fe(CO)_5$ (b) $CO_2(CO)_8$
(c) $H_2[Cr(CO)_5]$ (d) $[Cr(NH_3)_6]Cl_3$

47. Select the wrong statement about $[CoI_4]^{2-}$ ion:
(a) It is high spin complex
(b) It is a low spin complex
(c) It is sp^3-hybridised with three unpaired electron
(d) Its magnetic moment is 3.5 BM

48. Which of the following forms square planar complex and diamagnetic in nature?
(a) Cr^{2+} in weak field ligand
(b) Ag^{2+} in weak or strong field ligand
(c) Ni^{2+} in strong field
(d) Co^{2+} in strong field

49. Which one is not correct?
(a) Purification of Ti using I_2 is called zone refining
(b) Extraction of Ti from $TiCl_4$ by Mg is called Kroll process
(c) Extraction of Ti from $TiCl_4$ by Na is called IMI process
(d) Purification of Ni using CO is called Mond's process

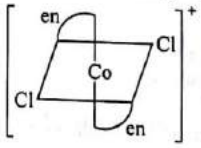
50. Select the incorrect statement:
(a) Salt like hydrides on reaction with water give H_2
(b) H_2 is obtained in excess in chlor-alkali industries
(c) CO is oxidised by NaH
(d) CO acts as acid on reaction with NaOH at high P and T

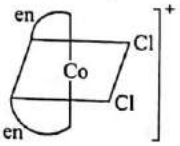
51. Select the incorrect statement:
(a) Melting point order : $(CH_4 > SiH_4) < GeH_4 < SnH_4$
(b) Boiling point order : $CH_4 < SiH_4 < GeH_4 < SnH_4$
(c) Hydrides of carbon family are mostly covalent and sp^3-hybridised
(d) PbH_4 is ionic hydride

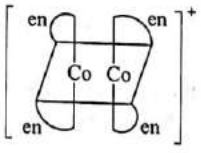
52. Carbonatoaquotetraammine cobalt (III) chloride does not show ..... isomerism:
(a) geometric (b) hydrate
(c) coordination (d) optical

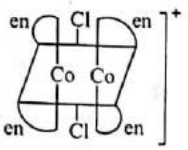
53. The possible number of isomers of the complex $[Cr(NH_3)(OH)_2Cl_3]^{2-}$ are:
(a) 1 (b) 2
(c) 3 (d) 4

54. Which of the following is optically active?

(a) 

(b) 

(c) 

(d) 

55. The IUPAC name for $[Pt(py)_4][PtCl_4]$ is:
(a) tetrapyridinium platinum (II) tetrachloroplatinate (II)
(b) tetrapyridinium platinum (II) tetrachloroplatinum (II)
(c) tetrachloroplatinum (II) tetrapyridine platinum (II)
(d) tetrachloroplatinate (II) tetrapyridine platinum (II)

56. Coordination number for which ion cannot exceed than two:
(a) Cu^+ (b) Cu^{2+}
(c) Al^{3+} (d) Zn^{2+}

57. EDTA in form of its dihydrogen calcium salt is used as antidote for ..... poisoning in body:
(a) Pb (b) Sn
(c) Ca (d) Ba

58. Which of the following change shows an increase in bond order and a change in magnetic behaviour?
(a) $N_2 \rightarrow N_2^+$ (b) $C_2 \rightarrow C_2^+$
(c) $NO \rightarrow NO^+$ (d) $O_2 \rightarrow O_2^+$

59. The species having bond order different from that in CO is:
(a) NO^- (b) NO^+
(c) CN^- (d) N_2

60. Which of the following pairs have isostructural nature:
(a) SO_3^{2-} and NO_3^- (b) BF_3 and NF_3
(c) BrO_3^- and XeO_3 (d) SF_4 and XeF_4

61. Which of the following oxide is neutral?
(a) MnO_2 (b) N_2O_3
(c) CO_2 (d) Mn_2O_7

62. Which of the following statements about pH of salt solution is incorrect?
(a) pH of NaF < pH of NaCN
(b) pH of Na_2SO_3 < pH of Na_2TeO_3
(c) pH of NaOBr < pH of NaOCl
(d) pH of CH_3COONa < pH of NaCN

63. Select the incorrect statement about terminology of meta, pyro, hypo, ortho and peroxyacids:
(a) The meta acid has one water molecule fewer than an ortho acid of the same element is same oxidation state per atom of central element, *e.g.*, HPO_3 is meta phosphoric acid
(b) The pyro acid has one half water molecule fewer than an ortho acid per atom of central element, *e.g.*, $H_4P_2O_7$ pyrophosphoric acid
(c) The hypo acid has an oxidation state lower than the ic acid, *e.g.*, H_3PO_2 is hypo phosphorus acid
(d) The per acid has same oxidation state as in, ic acid, *e.g.*, $HClO_4$

64. Select the incorrect statement:
(a) Pure $HClO_4$ does not conduct electricity
(b) Solid hydrate $HClO_4 \cdot H_2O$ on melting conducts electricity
(c) H-bonding is extensive in pure $HClO_4$
(d) H-bonding is more powerful in $HClO_4 \cdot H_2O$ than $HClO_4$

65. Which of the following does not favour to call CN^- as pseudohalide ion?
(a) Cyanogen undergoes disproportionation like disproportionation of halogens
(b) It forms a wide variety of complexes like halide ions
(c) CN^- acts as oxidising agent like halogens
(d) CN^- acts as reducing agent like halide ions

66. Alkali metals conduct current in liquid NH_3 at $-33°C$. Which is wrong about this fact?
(a) The conductance increases on lowering the temperature
(b) The solution conduct like metallic conductor
(c) The current is carried out by electrons and not by ions
(d) The solution conduct like electrolytic conductor

67. Which represents incorrect reaction?
(a) $Cu_2O + 2HCl(dil.) \longrightarrow CuCl_2 + Cu + H_2O$
(b) $Cu_2O + 2HCl(conc.) \longrightarrow 2HCuCl_2 + 2H_2O$
(c) $Cu_2O + 2HI \longrightarrow CuI_2 + Cu + H_2O$
(d) $2Cu^+ \xrightarrow{H_2O} Cu^{2+} + Cu^+$

68. Which of the following statements is incorrect?
(a) To remove impurities of SO_2 and P_4O_{10}, a SiO_2 lining in furnace is preferred
(b) To remove impurities of MgO and CaO, a SiO_2 lining in furnace is preferred
(c) To remove impurities of metal oxide, a lining of SiO_2 is preferred
(d) To remove impurities of SiO_2, a lining of MgO or CaO is preferred

69. Pd $(NH_3)_2Cl_2$ does not conduct electricity in aqueous solution. Therefore:
(a) it is weak electrolyte
(b) Cl-atoms are covalently bonded in the coordination sphere
(c) the structure involves covalent bonding only
(d) all of the above

70. In which hybridization is not d^2sp^3 ?
(a) $[V(H_2O)_6]^{3+}$ (b) $[Cr(CN)_6]^{3-}$
(c) $Cr(CO)_6$ (d) $[MnBr_4]^{2-}$

71. Which of the following does not involve innershell hybridisation?
(a) $[CoF_6]^{3-}$ (b) $[Co(CN)_6]^{3-}$
(c) $[Fe(CN)_6]^{4-}$ (d) $[Ni(NH_3)_6]^{2+}$

72. Which of the following d^n ions will have the smallest crystal field stabilization energy, if Δ is greater than P, the pairing energy ?
(a) d^6 (b) d^8
(c) d^9 (d) d^{10}

73. One of the constituent of German silver is:
(a) Ag (b) Cu
(c) Mg (d) Al

74. The value of X in $Mo(CO)_X$ is:
(a) 2 (b) 4
(c) 5 (d) 6

75. Which of the following is incorrect?
(a) NO^+ is more stable than NO
(b) CO^+ is more stable than CO
(c) OF is less stable than F_2
(d) CN is more stable than CN^+

76. Which of the following is incorrect about O_2 and O_2^{2-}?
(a) Bond order of O_2^{2-} and O_2 are 1 and 2 respectively
(b) O_2^{2-} have longer bond than O_2
(c) O_2^{2-} has weaker bond than O_2
(d) Both have same number of antibonding electrons

77. Pick up the incorrect statement:
(a) Bond length of N_2^+ > bond length of N_2
(b) Bond length of NO^+ < bond length of NO
(c) Bond length of CN^- < bond length of CN
(d) Bond length of CO < bond length of CO^+

78. In which of the following, fact is incorrectly reported about N_2, NO^+, CN^- and CO?
(a) Bond order for all these is three
(b) M.O. diagram for all these is same
(c) No. of bonding electrons and antibonding electrons in each is same
(d) σ^*2s-orbital in CO has higher energy the $\sigma 2p_x$ as well as $\pi 2p_y$ and $\pi 2p_z$ orbitals whereas in rest all it has lower energy

79. Which of the following salts containing either of the ion reported below are water soluble?
(a) NH_4^+ (b) ClO_4^-
(c) NO_3^- (d) All of these

80. Which metal chloride is water soluble?
(a) $NiCl_2$ (b) AgCl
(c) $PbCl_2$ (d) $HgCl_2$

81. Which of the following chloride will not fume in air?
(a) $BiCl_3$ (b) $SbCl_3$
(c) PCl_5 (d) CCl_4

82. In diborane the two H—B—H angles are nearly:
(a) 60°, 120° (b) 95°, 120°
(c) 95°, 150° (d) 120°, 180°

83. Tear gas is:
(a) $COCl_2$ (b) CCl_3NO_2
(c) N_2O (d) NO

84. Phosphorus glass in dark, the cold light emission is the phenomenon of:
(a) chemiluminescence (b) phosphorescence
(c) fluorescence (d) all of these

85. S—S bond is present in:
(a) $S_2O_7^{2-}$ (b) S_3O_9
(c) $S_2O_4^{2-}$ (d) $S_2O_3^{2-}$

86. Which of the following species possess $p\pi - d\pi$ bonding?
(a) NO_3^- (b) SO_3^{2-}
(c) BO_3^{3-} (d) CO_3^{2-}

87. Among NO_3^-, AsO_3^{3-}, CO_3^{2-}, ClO_3^-, SO_3^{2-} and BO_3^{3-}, the non-planar species are:
(a) CO_3^{2-}, SO_3^{2-}, BO_3^{3-} (b) AsO_3^{3-}, ClO_3^-, SO_3^{2-}
(c) NO_3^-, CO_3^{2-}, BO_3^{3-} (d) SO_3^{2-}, NO_3^-, BO_3^{3-}

88. Which one is not correct about the reaction of K_2MnF_6 with SbF_5?
(a) It gives F_2
(b) It involves acid-base reaction
(c) It gives acidialysis of MnF_4
(d) It involves redox change

89. Maximum number of lone pair of electrons on central atom exists in:
(a) Br_3^- (b) XeF_6
(c) XeF_4 (d) ClO_4^-

90. The same number of lone pair of electrons but different hybridisation state exist in:
(a) XeO_3, $XeOF_4$, XeF_6
(b) XeO_3, XeO_2F_2, XeF_4
(c) $XeOF_2$, XeO_2F_2, XeF_4
(d) XeF_2, XeF_4 and XeF_6

91. Radon is not formed as intermediate in one of the radioactive series called:
(a) Thorium series (b) Naptunium series
(c) Uranium series (d) Actinium series

92. Which one is incorrect?
(a) SF_4, CF_4 and XeF_4 show sp^3d, sp^3 and sp^3d^2-hybridisation respectively
(b) SF_4 = 1 lone pair; CF_4 = 0 lone pair; XeF_4 = 2 lone pairs
(c) SF_4 is T-shaped; CF_4 is tetrahedral; XeF_4 square planar
(d) Only in SF_4 S—F bonds energy in different and is rest all it is same

93. Which one is not correct about $Cr_2O_7^{2-}$?
(a) It has 6Cr—O bonds of equal bond energy
(b) The 6Cr—O bond lengths are 161 pm and Cr—O bonds are 180 pm
(c) The Cr—O—Cr angle is 131°
(d) Its structure contains 6π bonds and 6σ bonds

94. The reaction of KI and $KMnO_4$ in alkaline medium results in the formation of:
(a) KIO_3 and MnO_2 (b) I_2 and MnO_2
(c) KIO and MnO_2 (d) KIO_4^- and K_2MnO_4

95. Among the following pairs of ions, the lower oxidation state in aqueous solution is more stable than the other in:
(a) Tl^+ and Tl^{3+} (b) Cu^+ and Cu^{2+}
(c) Cr^{2+} and Cr^{3+} (d) V^{2+} and VO^{2+}

96. The highest paramagnetic character is noticed in:
(a) $MnSO_4 \cdot 4H_2O$ (b) $CuSO_4 \cdot 5H_2O$
(c) $FeSO_4 \cdot 6H_2O$ (d) $NiSO_4 \cdot 6H_2O$

97. Which is correct about the reaction of KCN with $CuSO_4$?
(a) It involves a redox reaction
(b) The reaction yields $K_3[Cu(CN)_4]$ and pseudo halogen
(c) The reaction involves complex formation
(d) All of the above

98. Which does not dissolve in hot dilute HNO_3?
(a) CuS (b) PbS
(c) HgS (d) CdS

99. The phenomenon in which white transparent crystal changes to white powder is called:
(a) Deliquescence (b) Efflorescence
(c) Allotropy (d) Sublimation

100. Which gives red colour with KCNS?
(a) Cu^{2+} (b) Fe^{3+}
(c) Al^{3+} (d) Zn^{2+}

101. Solder is an alloy of:
(a) 70% lead + 30% tin (b) 33% lead + 67% tin
(c) 80% lead + 20% tin (d) 90% Cu + 10% tin

102. Laughing gas is:
(a) $COCl_2$ (b) CCl_3NO_2
(c) N_2O (d) NO_2

103. Supercritical CO_2 is used as:
(a) dry ice
(b) solvent for extraction of organic compound from natural sources
(c) fire fighting
(d) to provide inert medium for carrying out various reactions

104. The basic character of transition metal monoxide follows the order:
(a) VO > CrO > TiO > FeO
(b) CrO > VO > FeO > TiO
(c) TiO > VO > CrO > FeO
(d) TiO > FeO > VO > CrO

105. Litharge is chemically:
(a) PbO (b) PbO_2
(c) Pb_3O_4 (d) $Pb(CH_3COO)_2$

106. An aqueous solution of $CoCl_2$ on addition of excess of conc. HCl turns blue due to the formation of:
(a) $[Co(H_2O)_4Cl_2]$ (b) $[Co(H_2O)_2Cl_4]^{2-}$
(c) $[CoCl_4]^{2-}$ (d) $[Co(H_2O)_2Cl_2]$

107. Number of P — O — P bonds in P_4O_{10} and P_4O_6 are respectively:
(a) 6, 6 (b) 5, 5
(c) 5, 6 (d) 6, 5

108. Which of the following oxides of nitrogen is coloured?
(a) N_2O (b) NO
(c) N_2O_4 (d) NO_2

109. The correct order for the wavelength of absorption in visible region is:
(a) $[Ni(NO_2)_6]^{4-} < [Ni(NH_3)_6]^{2+} < [Ni(H_2O)_6]^{2+}$
(b) $[Ni(NO_2)_6]^{4-} < [Ni(H_2O)_6]^{2+} < [Ni(NH_3)_6]^{2+}$
(c) $[Ni(H_2O)_6]^{2+} < [Ni(NH_3)_6]^{2+} < [Ni(NO_2)_6]^{4-}$
(d) $[Ni(NH_3)_6]^{2+} < [Ni(H_2O)_6]^{2+} < [Ni(NO_2)_6]^{4-}$

110. Which of the following will give more H_2 if equal masses of each of the following react with H_2O?
(a) LiH (b) NaH
(c) CaH_2 (d) BaH_2

111. Zeolite, *i.e.*, hydrated sodium aluminium silicate on treatment with hard water shows exchange of Na^+ ion with:
(a) H^+ (b) Ca^{2+}
(c) SO_4^{2-} (d) OH^-

112. Which of the halide is least stable and has a doubtful existence?
(a) CI_4 (b) GeI_4
(c) SnI_4 (d) PbI_4

113. On heating ammonium dichromate, the gas evolved is:
(a) O_2 (b) NH_3
(c) N_2 (d) N_2O

114. One mole of calcium phosphide on reaction with excess water gives:
(a) one mole of phosphine
(b) two mole of phosphoric acid
(c) two mole of phosphine
(d) one mole of P_2O_5

115. There is no S—S bond in:
(a) $S_2O_4^{2-}$ (b) $S_2O_6^{2-}$
(c) $S_2O_3^{2-}$ (d) $S_2O_7^{2-}$

116. Which of the following is not pseudo halide?
(a) CNO^- (b) $RCOO^-$
(c) OCN^- (d) NNN^-

117. The correct decreasing acidic strength is:
(a) ClOH > BrOH > IOH (b) BrOH > ClOH > IOH
(c) IOH > BrOH > ClOH (d) ClOH > IOH > BrOH

118. Chlorine acts as bleaching agent only in presence of:
(a) dry air (b) moisture
(c) sunlight (d) pure O_2

119. In the dichromate dianion:
(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

120. An aqueous solution of $FeSO_4 \cdot Al_2(SO_4)_3$ and chrome alum is heated with excess of Na_2O_2 and filtered. The materials obtained are:
(a) a colourless filtrate and a green residue
(b) a yellow filtrate and a brown residue
(c) a green filtrate and a brown residue
(d) none of the above

121. An aqueous solution contains Hg^{2+}, Hg_2^{2+}, Pb^{2+} and Cd^{2+}. The addition of 6 *N* HCl will precipitate:
(a) Hg_2Cl_2 only (b) $PbCl_2$ only
(c) $PbCl_2$ and Hg_2Cl_2 (d) $PbCl_2$ and $HgCl_2$

122. The geometries of $Ni(CO)_4$ and $Ni(PPH_3)_2Cl_2$ are:
(a) both square planar
(b) tetrahedral and square planar respectively
(c) both tetrahedral
(d) square planar and tetrahedral respectively

123. Refining of Pb is made by :
(a) Bett's process (b) Polling process
(c) Serpeck's process (d) Cyanide process

124. Which of the following is known as spring reaction :
(a) $Na_2SO_3 + Na_2S + I_2 \longrightarrow Na_2S_2O_3 + 2NaI$
(b) $2CaOCl_2 \xrightarrow{COCl_2} 2CaCl_2 + O_2$
(c) $2FeS + 3O_2 \longrightarrow 2FeO + 2SO_2$
(d) $2CuFeS_2 + O_2 \longrightarrow Cu_2S + 2FeS + SO_2$

125. Which of the following is not a component of German silver :
(a) Ag (b) Cu
(c) Zn (d) Ni

126. Which one does not contain Al :
(a) Feldspar (b) Mica
(c) Fluorspar (d) Cryolite

127. Total no. of donor atoms in EDTA is :
(a) 2 (b) 4
(c) 6 (d) 8

128. Number of H-bonds present in complex formed by Ni^{2+} with DMG legand is :
(a) 2 (b) 3
(c) 4 (d) 5

129. The number of unpaired electrons in $[Co(NH_3)_6]^{3+}$ an inner orbital complex and in $[CoCl_6]^{3-}$, an outer orbital complex are respectively :
(a) 0, 4 (b) 4, 2
(c) 2, 4 (d) 4, 4

130. The formula of Xenon hexafluoro platinate (V) is :
(a) $Xe[PtF_4]$ (b) $Xe[PtF_5]$
(c) $Xe[PtF_6]$ (d) $Xe[PtF_3]$

131. The *d*-orbitals which is used by central metal during formation of MnO_4^- :
(a) $d_{x^2-y^2}, d_{xy}, d_{zx}$ (b) $d_{x^2-y^2}, d_{yz}, d_{xz}$
(c) d_{xy}, d_{xz}, d_{yz} (d) d_{z^2}, d_{xy}, d_{zy}

132. AgCl on fusion with Na_2CO_3 gives :
(a) Ag_2O (b) Ag_2CO_3
(c) Ag (d) silver carbide

133. CO although being neutral but acts as acid on reaction with solid caustic soda heated to 200°C to give :
(a) Na_2CO_3 (b) HCOONa
(c) $NaHCO_3$ (d) Na_2O

134. Products (*A*) and (*B*) in the reaction :

$$KO_2 + CO_2 + H_2O \xrightarrow[\text{of } CO_2]{\text{Excess}} [A] + [B]$$

(a) $KHCO_3, CO$ (b) $KHCO_3, O_2$
(c) K_2CO_3, CO (d) K_2CO_3, KOH

135. Dissolution of sulphur in hot and concentrated H_2SO_4 gives:
(a) SO_2 (b) SO_3
(c) $H_2S_2O_6$ (d) $H_2S_2O_3$

136. A gas which exists in three allotropic forms (*i.e.*, α, β and γ) is :
(a) SO_2 (b) SO_3
(c) CO_2 (d) NH_3

137. Which one is called mixed anhydride of nitrogen :
(a) N_2O (b) NO_2
(c) N_2O_3 (d) N_2O_5

138. Which one is not a constituent of tincture of iodine :
(a) I_2 (b) KI
(c) Rectified sprit (d) CCl_4

139. Pure boron can be obtained by :
(a) Heating B_2O_3 with H_2
(b) Heating KBF_4 with Na or K
(c) Heating BBr_3 with Na or K
(d) Heating B_2O_3 with Na or K

140. Which of the following is not known :
(a) IPO_4 (b) $(CH_3COO)_3I$
(c) IF_7 (d) ICl_7

141. Which of the following reaction represents plumbosolvency :
(a) $2Pb + O_2 + 2H_2O \longrightarrow 2Pb(OH)_2$
(b) $2Pb + O_2 \longrightarrow 2PbO$
(c) $Pb + 2HCl \longrightarrow PbCl_2 + H_2$
(d) none of the above

142. Both P_2O_5 and PCl_5 on passing through excess of water gives :
(a) H_3PO_3 (b) H_3PO_2
(c) H_3PO_4 (d) $H_4P_2O_7$

143. NH_3 can be dried by :
(a) CaO (b) H_2SO_4
(c) P_4O_{10} (d) $CaCl_2$

144. Which of the following is correct for N_2O_5 :
(a) N_2O_5 in solid state has nitronium ion (NO_2^+)
(b) N_2O_5 in gaseous state N — O — N bond is linear
(c) N_2O_5 in solid state has nitrate ion NO_3^-
(d) all of the above

145. Select the incorrect statement :
(a) Li can be obtained by the electrolysis of LiCl solution in pyridine
(b) Oxides of metals placed below H in electrochemical series are thermally unstable
(c) Cucumber contains vanadium metal
(d) Thomas slag is $CaSO_4$

146. Which of the following is incorrect?
(a) Metals of 7, 8 and 9 groups do not form hydride
(b) Water gas shift reaction is :

$$CO + H_2O \xrightarrow[FeO/CoO]{673\ K} CO_2 + H_2$$

(c) Glauber salt is deliquescent
(d) Epsom salt is efflorescent

147. Free flow salt contains small amount of ..... with NaCl.
(a) $Ca_3(PO_4)_2$ (b) Na_3PO_4
(c) Mg_3PO_4 (d) Li_3PO_4

148. In fire crackers, which of the following is used to develop green fire :
(a) KNO_3 (b) $Ba(NO_3)_2$
(c) $Ni(NO_3)_2$ (d) $Al(NO_3)_3$

149. Which is not correct for SF_4 :
(a) It is a gas
(b) It acts as Lewis acid
(c) It acts as Lewis base
(d) It neither acts as Lewis acid or Lewis base

150. Pure chlorine can be obtained by :
(a) $KClO_3 + MnO_2$
(b) $PtCl_4$ or $AuCl_4$
(c) $HCl + O_2$
(d) $KClO_3 + KX$ in alk. medium

151. Select the incorrect statement :
(a) Liquid He is cryogenic liquid
(b) Fluorine is only halogen which reacts with noble gases
(c) Xe has + 6 Ox. no. in perxenates
(d) $He + O_2$ mixture is used for as ethane pahent

152. Copper can be extracted from :
(a) Kupfernickel (b) Dolomite
(c) Cinnabar (d) Malachite

153. In the manufacture of iron from haematite, the function of lime stone is as :
(a) a reducing agent (b) slag
(c) flux (d) gangue

154. In the metallurgy of iron, when limestone is added to the blast furnace, the calcium ion ends up in :
(a) slag (b) gangue
(c) metallic calcium (d) calcium carbonate

155. In the aluminothermite process, aluminium acts as :
(a) an oxidizing agent (b) a flux
(c) a reducing agent (d) a solder

156. Hydrogen gas will not reduce :
(a) heated cupric oxide (b) heated ferric oxide
(c) heated stannic oxide (d) heated aluminium oxide

157. The major role of fluorspar (CaF_2) which is added in small quantities in the electrolytic reduction of alumina dissolved in fused cryolite (Na_3AlF_6) is :
(a) as a catalyst
(b) to make the fused mixture very conducting
(c) to lower the temperature of the melt
(d) to decrease the rate of oxidation of carbon at the anode

158. Among the following statements, the incorrect one is :
(a) Calamine and siderite are carbonates
(b) Argenite and cuprite are oxides
(c) Zinc blende and pyrites are sulphides
(d) malachite and azurite are ores of copper

159. In the commercial electrochemical process for aluminium extraction, the electrolyte used is :
(a) $Al(OH)_3$ in NaOH solution
(b) an aqueous solution of $Al_2(SO_4)_3$
(c) a molten mixture of Al_2O_3 and Na_3AlF_6
(d) a molten mixture of Al_2O_3 and $Al(OH)_3$

160. The element with the highest first ionization potential is:
(a) Boron (b) Carbon
(c) Nitrogen (d) Oxygen

161. Which one of the following is the smallest in size?
(a) N^{3-} (b) O^{2-}
(c) F^- (d) Na^+

162. Which of the following is the strongest base :
(a) AsH_3 (b) NH_3
(c) PH_3 (d) SbH_3

163. The statement that is not correct for the periodic classification of elements is :
(a) The properties of elements are the periodic functions of their atomic numbers
(b) Non-metallic elements are lesser in number than metallic elements

(c) The first ionization energies of elements along a period do not vary in a regular manner with increase in atomic number
(d) For transition elements the *d*-sub shells are filled with electrons monotonically with increase in atomic number

164. Which has most stable + 2 oxidation state :
(a) Sn (b) Pb
(c) Fe (d) Ag

165. The correct order of ionic radii of Y^{3+}, La^{3+}, Eu^{3+} and Lu^{3+} is :
(a) $Y^{3+} < Lu^{3+} < Eu^{3+} < La^{3+}$
(b) $Lu^{3+} < Eu^{3+} < La^{3+} < Y^{3+}$
(c) $La^{3+} < Eu^{3+} < Lu^{3+} < Y^{3+}$
(d) $Y^{3+} < La^{3+} < Eu^{3+} < Lu^{3+}$

166. Complete combustion of H_2S in air results in the production of :
(a) S and H_2O (b) SO_2, H_2
(c) H_2SO_4 (d) H_2O, SO_2

167. N_2O is an :
(a) acidic (b) basic
(c) amphoteric (d) neutral oxide

168. The gas least soluble in water is :
(a) HCl (b) N_2
(c) NH_3 (d) CO_2

169. The formula of indian salt petre is :
(a) KNO_3 (b) $NaNO_3$
(c) NaCl (d) NH_4NO_3

170. The substance having the lowest boiling point is :
(a) NH_3 (b) H_2S
(c) H_2O (d) none of these

171. Gypsum is :
(a) $MgSO_4 \cdot 7H_2O$ (b) $CuSO_4 \cdot 5H_2O$
(c) $CaSO_4 \cdot \frac{1}{2} H_2O$ (d) $CaSO_4 \cdot 2H_2O$

172. Among the following the coloured compound is :
(a) CuCl (b) $K_3[Cu(CN)_4]$
(c) CuF_2 (d) $[Cu(CH_3CN)_4]BF_4$

173. Hydrogen is evolved by the action of cold dil. HNO_3 on :
(a) Fe (b) Cu
(c) Mn (d) Al

174. The temporary hardness of water due to calcium bicarbonate can be removed by adding :
(a) $CaCO_3$ (b) $Ca(OH)_2$
(c) $CaCl_2$ (d) HCl

175. The reddish-brown coloured gas formed when nitric oxide is oxidised by air is :
(a) N_2O_5 (b) N_2O_4
(c) NO_2 (d) N_2O_3

176. Which of the following is most stable to heat :
(a) HCl (b) HOCl
(c) HBr (d) HI

177. A gas '*X*' is passed through water to form a saturated solution. The aqueous solution on treatment with silver nitrate gives a white precipitate. The saturated aqueous solution also dissolves magnesium ribbon with evolution of a colourless gas '*Y*'. Identify '*X*' and '*Y*' :
(a) $X = CO_2, Y = Cl_2$ (b) $X = Cl_2, Y = CO_2$
(c) $X = Cl_2, Y = H_2$ (d) $X = H_2, Y = Cl_2$

178. Calcium is obtained by :
(a) electrolysis of molten $CaCl_2$
(b) electrolysis of a solution of $CaCl_2$ in water
(c) reduction of $CaCl_2$ with carbon
(d) roasting of limestone

179. Which of the following dissolve in hot concentrated NaOH solution.
(a) Fe (b) Zn
(c) Cu (d) Ag

180. "Lead pencil" contains :
(a) Pb (b) FeS
(c) Graphite (d) PbS

181. Which of the following are coloured?
(a) NO (b) N_2O
(c) CO (d) None of these

182. HCl is added to the following oxides which one would give H_2O_2 ?
(a) MnO_2 (b) PbO_2
(c) BaO (d) None of these

183. An aqueous solution of a substance gives a white precipitate on treatment with dilute hydrochloric acid, which dissolves on heating. When hydrogen sulphide is passed through the hot acidic solution, a black precipitate is formed. The substance in a :
(a) Hg_2^+ salt (b) Cr^{2+} salt
(c) Ag^+ salt (d) Pb^{2+} salt

184. White phosphorus reacts with caustic soda. The products are PH_3 and NaH_2PO_2. This reaction is an example of :
(a) Oxidation
(b) Reduction
(c) Oxidation and reduction
(d) Neutralization

185. In nitroprusside ion the iron and NO exist. As Fe^{II} and NO^+ rather than Fe^{III} and NO. These forms can be differentiated by :
(a) estimating the concentration of iron
(b) measuring the concentration of CN
(c) measuring the solid state magnetic moment
(d) thermally decomposing the compound

186. A solution of sodium metal in liquid ammonia is strongly reducing due to the presence of :

(a) Sodium atoms (b) Sodium hydride
(c) Sodium amide (d) Solvated electrons

187. HBr and HI reduce sulphuric acid, HCl can reduce $KMnO_4$ and HF can reduce :
(a) H_2SO_4 (b) $KMnO_4$
(c) $K_2Cr_2O_7$ (d) None of these

188. Which of the following statements about anhydrous aluminium chloride is correct?
(a) It exists as $AlCl_3$ molecules
(b) It is not easily hydrolysed
(c) It sublimes at 100°C under vacuum
(d) It is a strong Lewis base

189. Sodium thiosulphate is used in photography because of its :
(a) Reducing behaviour
(b) Oxidising behaviour
(c) Complex forming behaviour
(d) Reaction with light

190. Moderate electrical conductivity is shown by :
(a) Silica (b) Graphite
(c) Diamond (d) Carborundum

191. The ion that can not be precipitated by both HCl and H_2S :
(a) Pb^{2+} (b) Cu^{+}
(c) Ag^{+} (d) Sn^{2+}

192. Heavy water is :
(a) H_2O^{18}
(b) Water obtained by repeated distillation
(c) D_2O
(d) Water at 4°C

193. Chlorine is used as a bleaching agent only in presence of :
(a) Dry air (b) Moisture
(c) Sunlight (d) Pure oxygen

194. Nitrogen dioxide cannot be obtained by heating :
(a) KNO_3 (b) $Pb(NO_3)_2$
(c) $Cu(NO_3)_2$ (d) $AgNO_3$

195. A gas that cannot be collected over water is :
(a) N_2 (b) O_2
(c) SO_2 (d) PH_3

196. Molecular formula of Glauber's salt is :
(a) $MgSO_4 \cdot 7H_2O$ (b) $CuSO_4 \cdot 5H_2O$
(c) $FeSO_4 \cdot 7H_2O$ (d) $Na_2SO_4 \cdot 10H_2O$

197. The oxide that gives H_2O_2 on treatment with a dilute acid is :
(a) PbO_2 (b) Na_2O_2
(c) MnO_2 (d) TiO_2

198. The compound which gives off oxygen on moderate heating is :
(a) Cupric oxide (b) Mercuric oxide
(c) Zinc oxide (d) Aluminium oxide

199. The bonds present in N_2O_5 are :
(a) Only ionic (b) Covalent and coordinate
(c) Only covalent (d) Covalent and ionic

200. The compound whose 0.1 *M* solution is basic is :
(a) Ammonium acetate (b) Ammonium chloride
(c) Na_2CO_3 (d) NaCl

201. Which of the following oxides of nitrogen is a coloured gas?
(a) N_2O (b) NO
(c) N_2O_5 (d) NO_2

202. The aqueous solution of $FeSO_4 \cdot Al_2(SO_4)_3$ and chrome alum is heated with excess of Na_2O_2 and filtered. The material obtained are :
(a) A colourless filtrate and green residue
(b) A yellow filtrate and green residue
(c) A yellow filtrate and brown residue
(d) A green filtrate and brown residue

203. Amongst the trihalides of nitrogen which one is least basic?
(a) NF_3 (b) NCl_3
(c) NBr_3 (d) NI_3

204. Bromine can be liberated from potassium bromide solution by the action of :
(a) Iodine solution (b) Chlorine water
(c) Sodium chloride (d) Potassium iodide

205. The only cations present in a slightly acidic solution are Fe^{3+}, Zn^{2+}, Cu^{2+}. The reagent when added in excess to this solution would identify to seperate Fe^{3+} in one step.
(a) 2*M* HCl (b) 6*M* NH_3
(c) 6*M* NaOH (d) H_2S

206. An aqueous solution contains Hg^{2+}, Hg_2^{2+}, Pb^{2+} and Cd^{2+}. The addition of HCl (6*N*) will precipitate :
(a) Hg_2Cl_2 only (b) $PbCl_2$ only
(c) $PbCl_2$ and Hg_2Cl_2 (d) $PbCl_2$ and $HgCl_2$

207. There is no S—S bond in :
(a) $S_2O_4^{2-}$ (b) $S_2O_5^{2-}$
(c) $S_2O_3^{2-}$ (d) $S_2O_7^{2-}$

208. The species that do not contain peroxide ions are :
(a) PbO_2 (b) H_2O_2
(c) SrO_2 (d) BaO_2

209. H_2SO_4 cannot be used to prepare HBr from NaBr as it :
(a) reacts slowly with NaBr
(b) oxidises HBr
(c) reduces HBr
(d) disproportionates HBr

210. Arrange

List A	List B
I. Explosive	A. NaN_3
II. Artificial gem	B. Fe_3O_4
III. Self reduction	C. Cr

IV. Magnetic material
D. Al_2O_3
E. $Pb(N_3)_2$
F. Fe_2O_3
G. Cu
H. SiC

(a) I-A, II-D, III-G, IV-B (b) I-E, II-D, III-G, IV-F
(c) I-A, II-D, III-G, IV-F (d) I-E, II-H, III-C, IV-B

211. Hydrolysis of one mole of peroxodisulphuric acid produces:
(a) two mole of sulphuric acid
(b) two mole of peroxomonosulphuric acid
(c) one mole of sulphuric acid and one mole of peroxomonosulphuric acid
(d) one mole of sulphuric acid, one mole of peroxomonosulphuric acid and one mole of hydrogen peroxide

212. The following compounds have been arranged in order of their increasing thermal stabilities. Identify the correct order :
K_2CO_3 (I), $MgCO_3$ (II), $CaCO_3$ (III), $BeCO_3$ (IV)
(a) I < II < III < IV (b) IV < II < III < I
(c) IV < II < I < III (d) II < IV < III < I

213. The following acids have been arranged in the order of decreasing acid strength. Identify the correct order :
ClOH (I), BrOH (II), IOH (III)
(a) I > II > III (b) II > I > III
(c) III > II > I (d) I > III > II

214. Sodium thiosulphate is prepared by :
(a) reducing Na_2SO_4 solution with H_2S
(b) boiling Na_2SO_3 solution with S in alkaline medium
(c) neutralising $H_2S_2O_3$ solution with NaOH
(d) boiling Na_2SO_3 solution with S in acidic medium

215. Which of the following halides is least stable and has doubtful existence?
(a) Cl_4 (b) GeI_4
(c) SnI_4 (d) PbI_4

216. Which one of the following oxides is neutral?
(a) CO (b) SnO_2
(c) ZnO (d) SiO_2

217. Which one of the following species is not pseudohalide?
(a) CNO^- (b) $RCOO^-$
(c) OCN^- (d) NNN^{-1}

218. On heating ammonium dichromate, the gas evolved is :
(a) Oxygen (b) Ammonia
(c) Nitrous oxide (d) Nitrogen

219. Amongst the following hydroxides, the one which has the lowest value of K_{sp} at ordinary temperature (at 25°C) is :
(a) $Mg(OH)_2$ (b) $Ca(OH)_2$
(c) $Ba(OH)_2$ (d) $Be(OH)_2$

220. Which one amongst the following pairs of ions cannot be separated by H_2S in dilute HCl?
(a) Bi^{3+}, Sn^{4+} (b) Al^{3+}, Hg^{2+}
(c) Zn^{2+}, Cu^{2+} (d) Ni^{2+}, Cu^{2+}

221. Polyphosphates are used as water softening agents because they :
(a) From soluble complexes with anionic species
(b) Precipitate anionic species
(c) Form soluble complexes with cationic species
(d) Precipitate cationic species

222. Identify the correct order of acidic strength of CO_2, CuO, CaO, H_2O :
(a) CaO < CuO < H_2O < CO_2
(b) H_2O < CuO < CaO < CO_2
(c) CaO < H_2O < CuO < CO_2
(d) H_2O < CO_2 < CaO < CuO

223. For H_3PO_3 and H_3PO_4 the correct choice is :
(a) H_3PO_3 is dibasic and reducing
(b) H_3PO_3 is dibasic and non-reducing
(c) H_3PO_4 is tribasic and reducing
(d) H_3PO_3 is tribasic and non-reducing

224. The pair of compounds which cannot exist together in solution is :
(a) $NaHCO_3$ and NaOH
(b) Na_2CO_3 and $NaHCO_3$
(c) Na_2CO_3 and NaOH
(d) $NaHCO_3$ and NaCl

225. $(Me)_2SiCl_2$ on hydrolysis will produce :
(a) $(Me)_2Si(OH)_2$
(b) $(Me)_2Si=O$
(c) $-[-O(Me)_2Si-O-]_n-$
(d) $Me_2SiCl(OH)$

226. When same mass of zinc is treated separately with excess of sulphuric acid and excess of sodium hydroxide, the ratio of volume of H_2 evolved is :
(a) 1 : 1 (b) 1 : 2
(c) 2 : 1 (d) 9 : 4

227. Which of the following is the weakest base?
(a) NaOH (b) $Ca(OH)_2$
(c) KOH (d) $Zn(OH)_2$

228. The compound insoluble in acetic acid is :
(a) calcium oxide (b) calcium carbonate
(c) calcium oxalate (d) calcium hydroxide

229. Iron is rendered passive by treatment with concentrated:
(a) H_2SO_4 (b) H_3PO_4
(c) HCl (d) HNO_3

230. The types of bonds present in $CuSO_4 \cdot 5H_2O$ are only :
(a) electrovalent and covalent
(b) electrovalent and coordinate covalent
(c) electrovalent, covalent and coordinate covalent
(d) covalent and coordinate covalent

231. Zinc-copper couple that can be used as a reducing agent is obtained by :
(a) mixing zinc dust and copper gauze

(b) zinc coated with copper
(c) copper coated with zinc
(d) zinc and copper wires welded together

232. Amongst the following, the lowest degree of paramagnetism per mole of the compound at 298 K will be shown by :
(a) $MnSO_4 \cdot 4H_2O$ (b) $CuSO_4 \cdot 5H_2O$
(c) $FeSO_4 \cdot 6H_2O$ (d) $NiSO_4 \cdot 6H_2O$

233. Ferric sulphate on heating gives :
(a) SO_2 and SO_3 (b) SO_2 only
(c) SO_3 only (d) none of these

234. Amongst $Ni(CO)_4$, $[Ni(CN)_4]^{2-}$ and $NiCl_4^{2-}$:
(a) $Ni(CO)_4$ and $NiCl_4^{2-}$ are diamagnetic and $[Ni(CN)_4]^{2-}$ is paramagnetic
(b) $NiCl_4^{2-}$ and $[Ni(CN)_4]^{2-}$ are diamagnetic and $Ni(CO)_4$ is paramagnetic
(c) $Ni(CO)_4$ and $[Ni(CN)_4]^{2-}$ are diamagnetic and $NiCl_4^{2-}$ is paramagnetic
(d) $Ni(CO)_4$ is diamagnetic and $NiCl_4^{2-}$ and $[Ni(CN)_4]^{2-}$ are paramagnetic

235. Among the following ions which one has the highest paramagnetism?
(a) $[Cr(H_2O)_6]^{3+}$ (b) $[Fe(H_2O)_6]^{2+}$
(c) $[Cu(H_2O)_6]^{2+}$ (d) $[Zn(H_2O)_6]^{2+}$

236. Which one is solder?
(a) Cu + Pb (b) Zn + Cu
(c) Pb + Sn (d) Fe + Zn

237. Which pair gives Cl_2 at room temperature?
(a) Conc. HCl + $KMnO_4$
(b) NaCl + Conc. H_2SO_4
(c) NaCl + MnO_2
(d) NaCl + Conc. HNO_3

238. Which of the following is formed when excess of KCN is added to aqueous solution of copper sulphate?
(a) $Cu(CN)_2$ (b) $K_2[Cu(CN)_4]$
(c) $K[Cu(CN)_2]$ (d) $K_3[Cu(CN)_4]$

239. Which compound does not dissolve in hot, dilute HNO_3?
(a) HgS (b) PbS
(c) CuS (d) CdS

240. Ammonium dichromate is used in some fireworks. The green coloured powder blown in the air is :
(a) CrO_3 (b) Cr_2O_3
(c) Cr (d) $CrO(O_2)$

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

242. Which of the following is an organometallic compound?
(a) Lithium methoxide
(b) Lithium acetate
(c) Lithium dimethylamide
(d) Methyl lithium

243. Among the following, the compound that is both paramagnetic and coloured is :
(a) $K_2Cr_2O_7$ (b) $(NH_4)_2(TiCl_6)$
(c) $CoSO_4$ (d) $K_3[Cu(CN)_4]$

244. A black sulphide is formed by the action of H_2S on :
(a) Sodium chloride (b) Cadmium chloride
(c) Zinc chloride (d) Cupric chloride

245. In the dichromate anion :
(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

246. The geometry in $Ni(CO)_4$ and $Ni(PPh_3)_2Cl_2$ are :
(a) both square planar
(b) tetrahedral and square planar, respectively
(c) both tetrahedral
(d) square planar and tetrahedral, respectively

247. Animal charcoal used is decolorising agent contains carbon and .....
(a) $Ca_3(PO_4)_2$ (b) $MgCl_2$
(c) $KMnO_4$ (d) $K_2Cr_2O_7$

248. Which of the following is called super acid.
(a) HI (b) SbF_5
(c) H_3SbO_4 (d) H_3AsO_4

249. A complex $[CoL_6]^{n+}$, where L is neutral ligand has a magnetic moment $\mu = 4.5$ B.M. Hence :
(a) Co must be in +2 oxidation state
(b) Co must be in +3 oxidation state
(c) The complex is diamagnetic
(d) L must be a strong ligand

250. CrO_4^{2-} is yellow in colour because :
(a) Cr is a transition metal
(b) Cr and O are π-bonded and the allowed $\pi \rightarrow \pi^*$ transition occurs in visible region
(c) of charge transfer from $Cr \rightarrow O$
(d) of its strong tendency of absorption ~ 640 nm wavelength

251. Number of unpaired electrons in $[Cr(en)_2]^{2+}$ are :
(a) 4 (b) 2
(c) 3 (d) 1

252. MnO_4^{2-} ion shows ..... colour in aqueous solution :
(a) Green (b) Purple
(c) Organge (d) Blue

SOLUTIONS (One Answer Correct)

1. (a) Zirconium hydride is $ZrH_{1.9}$.
2. (d) The reaction is neither redox nor PI_3 is a salt.
3. (c) Steric hinderance prevents 8 fluorine atoms to form OsF_8.
4. (a) Silicones have strong Si—C bonds as well as Si—O—Si bond. These are stable to heat, insulators and water repellent.
5. (b) NH_2OH is strong reductant and poisonous.

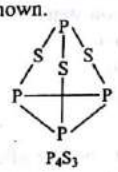
$$4NH_2OH \xrightarrow[\text{Slow}]{2H^+} N_2O + 2NH_4^+ + 3H_2O$$

$$3NH_2OH \xrightarrow[\text{Fast}]{OH^-} N_2 + NH_3 + 3H_2O$$

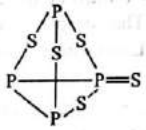
6. (a) pK_a for HF, HCl, HBr and HI are 3, −7, −9, −10 respectively.
7. (a) Hydration is exothermic and spontaneous. Also randomness decreases.
8. (a) The decomposition temperature for Be, Mg, Ca, Sr and Ba carbonates are 373, 813, 1173, 1563 and 1633 K.
9. (d) Rest all are applications of B_4C.
10. (c) Rest all are facts.
11. (d) $CoO + B_2O_3 \longrightarrow Co(BO_2)_2$; B_2O_3 is anhydride of H_3BO_3

$$P_2O_5 + B_2O_3 \longrightarrow 2BPO_4$$

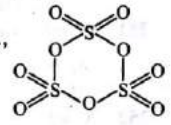
12. (a) $Bi^{3+} \underset{HCl}{\overset{H_2O}{\rightleftharpoons}} [BiO]^+$
13. (d) Rest all are characteristics of calgon.
14. (d) Ultramarine possesses three dimensional silicate structure like Zeolites and Feldspar.
15. (a) The existence of P_4S_6 is not reported although P_4O_6 is known.



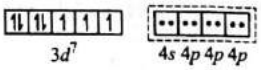
P_4S_3



16. (c) It forms H_2CrO_4; $CrO_3 + H_2O \longrightarrow H_2CrO_4$
17. (a) CO is not electron donor. See point (d).
18. (a) Cyclic trimer of SO_3 is $(SO_3)_3$, *i.e.*,



19. (d) It is a fact.
20. (a) H_2Te belongs to hydride of sulphur family (H_2S, H_2Se).
21. (d) MnO_2 is dioxide and does not contain O—O bond.
22. (b) S_4N_4 has two weak S—S bonds in cage structure. It is thermochronic, *i.e.*, its colour changes with temperature, *i.e.*, colourless at liq. N_2 temperature, orange-yellow at room temperature, red at 100° C.
23. (d) Rest all show colour change on heating.
24. (d) Pb is not radioactive.
25. (d) $(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} N_2 + Cr_2O_3 + 4H_2O$
26. (d) Follow their geometry.
27. (d) PF_5 has no p—d π bonding.
28. (b) Perxenate ion is $[XeO_6]^{4-}$ having no peroxide bond.
29. (d) Transition elements Sc = 3, Y and Ti = 4.5 g / cm^3 have density less than 5 g / cm^3
30. (b) Os (22.57 g / cm^3) and Ir (22.61 g / cm^3) have highest densities.
31. (b) Only the three transition elements have m.pt. > 3000° C. These are Ta = 3000° C, W = 3410° C and Re = 3180° C. Zn has 420° C.
32. (b) The colour arises due to different degree of polarisation by Ag^+ ion.
33. (a) In MnO_4^- an electron is momentarily transferred from O to the metal and the momentarily changing O^{2-} to O^- and reducing the oxidation state of metal.
34. (b) Rest all are correct.
35. (b) More is $E°_{OP}$ (−0.36 > −0.77 V) and thus easier is oxidation. Stability of complex can be evaluated if stability constants are given.
36. (d) $FeCl_3$ sublimes at 300° C.
37. (d) All are correct.
38. (d) This is experimental fact.
39. (d) $NaBr + ICl \longrightarrow Na^+ [BrICl]^-$
40. (d) $SbCl_3 + H_2O \longrightarrow SbOCl + 2HCl$
41. (d) $NaNH_2 + C \longrightarrow NaCN + H_2$
42. (d) Wood metal an alloy of Bi, Pb, Sn and Cd has m. pt. 71° C.
43. (a) II has non-ionisable nature and thus minimum conductance.
44. (d) Cl^- ligand is listed at bottom in spectrochemical series of ligand.
45. (a) EAN of Pt = 78 − 4 + 12 = 86 (*i.e.*, Rn)
46. (d) EAN of Cr = 24 − 3 + 12 = 33 (nearest noble gas 36, *i.e.*, Kr)
47. (b) Co^{2+} in $[CoI_4]^{2-}$ is



$3d^7$

$4s\ 4p\ 4p\ 4p$

sp^3

48. (c) Cr^{2+}, Ag^{2+}, Ni^{2+} and Co^{2+} have 4, 1, 2, 1 unpaired electrons and thus Ni^{2+} can show pairing of electron in

strong field to give diamagnetic nature. Cr^{2+} is in weak field.

49. (a) It is called van Arkel process.

50. (c) $2CO + NaH \longrightarrow HCOONa + C$; CO is reduced.

51. (d) PbH_4 too is covalent hydride.

52. (d) $\underset{I}{[Co(NH_3)_4CO_3Cl]\cdot 2H_2O}$;

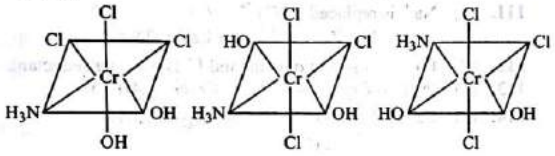
$\underset{II}{[Co(NH_3)_4(H_2O)_2]CO_3\cdot Cl}$;

$\underset{III}{[Co(NH_3)_4H_2OCl]CO_3\cdot H_2O}$;

$\underset{IV}{[Co(NH_3)_4CO_3\cdot H_2O]Cl\cdot H_2O}$

see all shows geometrical isomerism; each having *cis*-and *trans*- form. Also notice hydrate isomerism and coordination isomerism.

53. (c)



54. (b) Rest all possess symmetry.

55. (a) Follow IUPAC rules.

56. (a) Coordination numbers of Cu^+, Cu^{2+}, Al^{3+} and Zn^{2+} are 2, 4, 6, 4 respectively.

57. (a) It is a fact.

58. (c) Bond order for NO is $+\frac{1}{2}$ (15 electrons paramagnetic)

Bond order for NO^+ is zero (14 electrons diamagnetic)

59. (a) Bond order for NO^- is 2. Rest all has bond order 3.

60. (c) Both have sp^3-hybridisation and pyramidal in shape.

61. (a) MnO_2 is neutral oxide.

62. (c) HOCl is stronger acid than HOBr

$\therefore$ OCl^- is weak base than OBr^-

63. (d) The per acids has an oxidation state higher than, ic acid.

64. (d) In $HClO_4\cdot H_2O$, the ions are localised because of the lattice forces and thus, H-bonding is not extensive as in $HClO_4$.

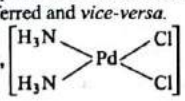
65. (c) $C_2N_2 + 2OH^- \longrightarrow CN^- + CNO^- + H_2O|CN^-$ acts as reducing agent like X^-.

$Cl_2 + 2OH^- \longrightarrow Cl^- + ClO^- + H_2O$

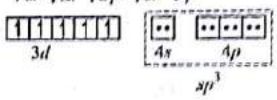
66. (d) $Na + (X+Y)NH_3 \longrightarrow [Na(NH_3)_X]^+ + [e(NH_3)_Y]^-$ conductor of current.

67. (c) $Cu_2O + 2HI \longrightarrow 2CuI + H_2O$

68. (a) To remove impurities of acidic oxide, basic lining in furnace is preferred and *vice-versa*.

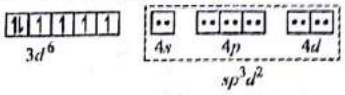
69. (d) All are correct, 

70. (d) $_{25}Mn^{2+}: 1s^2, 2s^2, 2p^6, 3s^2 3p^6$



sp^3

71. (a) $Co^{3+}: 1s^2, 2s^2, 2p^6, 3s^2 3p^6$



sp^3d^2

72. (d) According to crystal field theory, the total energy separation $\Delta = Y - X$ where XY is energy of destabilization and X is energy of stabilisation if d^{10}, *i.e.*, completely filled orbitals have zero stabilisation energy (CFSE) whatever be the value of Δ.

73. (b) German silver is an alloy of Cu.

74. (d) EAN = Atomic number of metal – electrons lost in forming cation + 'e' gained during complex formation

$54 = 42 - 0 + 2 \times$ No. of ligand

$\therefore$ No. of ligand = 6 (one CO donate 2 electrons)

75. (c) OF is more stable as it has less antibonding electrons.

76. (d) Bonding and antibonding electrons are different in both.

77. (d) Bond order for N_2, N_2^+, NO^+, NO, CN^- and CN are 3, 2.5, 3, 2.5, 3, 2.5 respectively. Higher is bond order smaller is bond length bond order of CO and CO^+ are 3 and 3.5.

78. (b) MO diagram for CO is : $\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma 2p_x^2, \pi 2p_y^2, \pi 2p_z^2 \sigma^* 2s^2$. This is due to the fact that 2*s*-orbital of O (lower energy) than 2*s*-orbital of C (higher energy) on mixing give rise $\sigma^* 2s$ with higher energy than $\sigma 2p_x$, $\pi 2p_y$ and $\pi 2p_z$.

79. (d) Nitrates, per chlorates of all metals are water soluble. Ammonium salts are water soluble.

80. (a) Chlorides of Ag, Pb and Hg are water insoluble.

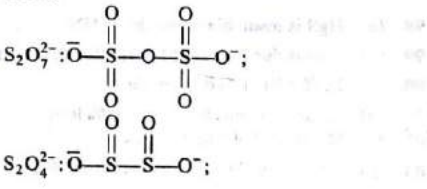
81. (d) Rest all reacts with moisture to give fumes of HCl.

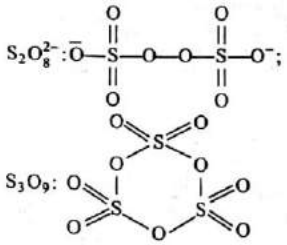
82. (b) $H_t - B - H_t = 120°$, $H_b - H - H_b = 97°$ C;

t = terminal; b = bridge.

83. (b) Chloroprene $CCl_3\cdot NO_2$ is used as tear gas.

84. (a) $P + O_2 \longrightarrow P_2O_5$; the light is released during oxidation of P. The phenomenon of evolution of light as a result of chemical change is chemiluminescence and not phosphorescence. It is wrongly written is books.

85. (c) 



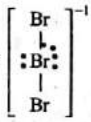
86. (b) Only S has *d*-orbitals.

87. (b) AsO_3^{3-}, ClO_3^- and SO_3^- have sp^3-hybridisation with one lone pair and thus pyramidal.

88. (c) $\underset{\text{Base}}{2K_2MnF_6} + \underset{\text{(Strong Lewis acid)}}{4SbF_5} \longrightarrow 4KSbF_6 + 2MnF_4$

$$2MnF_4 \longrightarrow 2MnF_3 + F_2 \quad \text{(redox)}$$

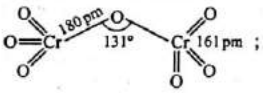
$$2K_2MnF_6 + 4SbF_5 \longrightarrow 4KSbF_6 + 2MnF_3 + F_2$$

89. (a) Br_3^- has 3 lone pairs of electrons 

90. (a) Each has one lone pair of electron but hybridisation is sp^3, sp^3d and sp^3d^3 in XeO_3, $XeOF_4$ and XeF_6 respectively.

91. (b) Thorium series—thoron as ($^{220}_{86}Rn$); actinium series—actinon as ($^{219}_{86}Rn$); uranium series—radon $^{226}_{86}Ra$.

92. (c) SF_4 has see-saw structure.

93. (d)  ;

It caution two tetrahedron joined together.

94. (a) $$I^- \longrightarrow I^{5+} + 6e$$

$$Mn^{7+} + 3e \longrightarrow Mn^{4+} + 2e$$

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

95. (d) Tl^+ does not exist; Cu^+ disproportionates; Cr^{2+} is less stable than Cr^3.

96. (a) No. of unpaired electron in Mn^{2+}, Cu^{2+}, Fe^{2+} and Ni^{2+} are 5, 1, 4, 2 electrons respectively.

97. (d) $2CuSO_4 + 10KCN \longrightarrow 2K_3[Cu(CN)_4] + 2K_2SO_4 + \underset{\text{Pseudohalogen}}{C_2N_2}$

98. (c) HgS is insoluble in hot dilute HNO_3.

99. (b) This is due to loss of H_2O molecules to atmosphere.

100. (b) $Fe(CNS)_3$ is red in colour.

101. (b) Solder contains 67% tin + 33% lead.

102. (c) N_2O is called laughing gas.

103. (b) Supercritical CO_2 is liquid below its T_c.

104. (c) Larger is the size of cation, lesser is polarising power, *i.e.*, more ionic character. A compound with more ionic nature is more basic.

$$Ti^{2+} > V^{2+} > Cr^{2+} > Fe^{2+}$$

Ionic radii decrease along the period.

105. (a) Litharge (PbO) is amphoteric oxide and is used in making flint glass, as a drier in paints and varnishes.

106. (a) The hybridisation of Co becomes sp^3d^2 and $[Co(H_2O)_4Cl_2]$ is blue.

107. (a) Follow structure of P_4O_6 and P_4O_{10}.

108. (d) NO_2 is brown.

109. (c) In a spectrochemical series the order is $H_2O < NH_3 < NO_2^-$.

110. (a) Mole of LiH in same mass is lowest (Mole $= \frac{w}{m}$ and m is minimum for LiH).

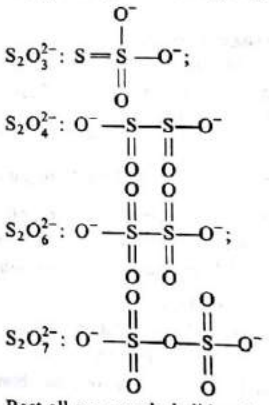
111. (b) Na^+ is replaced by Ca^{2+}

$$Na_2Z + Ca^{2+} \longrightarrow CaZ + 2Na^+$$

112. (d) Pb^{4+} is a strong oxidant and I^- is a strong reductant.

113. (c) $(NH_4)_2Cr_2O_7 \longrightarrow N_2 + Cr_2O_3 + 4H_2O$.

114. (c) $Ca_3P_2 + 6H_2O \longrightarrow 3Ca(OH)_2 + 2PH_3$

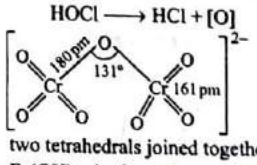
115. (d) 

116. (b) Rest all are pseudo halides, *i.e.*, behave like a halide ion.

117. (a) More is the electronegativity of central atom, more is acidic nature.

118. (b) $Cl_2 + H_2O \longrightarrow HCl + HOCl$; OCl^- acts as oxidant

$$HOCl \longrightarrow HCl + [O]$$

119. (b) 

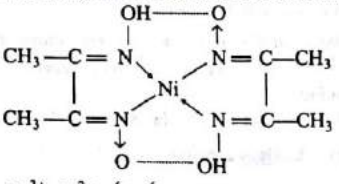
two tetrahedrals joined together

120. (b) $Fe(OH)_3$ is formed as a brown residue with light yellow colour filtrate.

121. (c) $PbCl_2$ and Hg_2Cl_2 are insoluble.

122. (b) Follow hybridisation.

123. (a) It is a fact. (Electrolytic refining)
124. (a) It is so called spring reaction.
125. (a) German silver has Cu, Zn and Ni.
126. (c) Fluorspar is CaF_2.
127. (c) It is a fact; two N atom and four O atoms.
128. (a)



129. (a) $Co^{3+}: 3s^2 3p^6 3d^6$ configuration. It has d^2sp^3 hybridisation having no unpaired electrons in $[Co(NH_3)_6]^{3+}$; In $[CoCl_6]^{3-}$ it has four unpaired electrons and sp^3d^2 hybridisation.
130. (c) Xe^+ and $[Pt\,F_6]^-$
131. (c) l_{2g} of d_{xy}, d_{yz} and d_{zx} is closer to 4*s* and 4*p*. Thus d^3s hybridization.
132. (c) Ag_2CO_3 decomposes on heating to Ag.
133. (b) $NaOH_{(s)} + CO \xrightarrow{200^\circ C} HCOONa$
134. (b) $4KO_2 + 4CO_2 + 2H_2O \xrightarrow{\text{Excess of } CO_2} 4KHCO_3 + 3O_2$
135. (a) $3S + H_2SO_4 \longrightarrow 3SO_2 + 2H_2O$
136. (b) It is a fact.
137. (b) $2NO_2 + H_2O \longrightarrow HNO_3 + HNO_2$
138. (d) Tincture of iodine has I_2 + KI dissolved in sprit.
139. (d) $2B_2O_3 + 6Na \longrightarrow 3Na_2O_2 + 4B$
140. (d) I shows + 7 oxidation state with O and F. Large size of Cl resist to get attached 7Cl atoms on I.
141. (a) This reaction shows dissolution of Pb in water.
142. (c) $PCl_5 + 4H_2O \longrightarrow H_3PO_4 + 5HCl$
$P_2O_5 + 3H_2O \longrightarrow 2H_3PO_4$
143. (a) Rest all also reacts with NH_3.
144. (d) In solid state N_2O_5 has $NO_2^+NO_3^-$ structure.
145. (d) Thomas slag is $Ca_3(PO_4)_2$
146. (c) $Na_2SO_4 \cdot 10H_2O$ is efflorescent *i.e.*, looses water on exposure to air.
147. (a) It is a fact.
148. (b) Ba imparts green colour to flame.
149. (d) $SF_4(g) + BF_3 \longrightarrow [F_4S \longrightarrow BF_3]$
$SF_4(g) + 2F^- \longrightarrow [SF_6]^{2-}$
150. (b) $PtCl_4 \xrightarrow{374^\circ C} PtCl_2 + Cl_2 \xrightarrow{582^\circ C} Pt + 2Cl_2$
$AuCl_3 \xrightarrow{175^\circ C} 2AuCl + 2Cl_2 \xrightarrow{185^\circ C} 2Au + 3Cl_2$
151. (c) Ox. No. of Xe in perxenates $[XeO_6]^{4-}$ is +8.
152. (d) Malachite is $CuCO_3 \cdot Cu(OH)_2$.
153. (c) Flux ($\underset{\text{flux}}{CaCO_3 + SiO_2} \longrightarrow \underset{\text{slag}}{CaSiO_3} + CO_2$)
154. (a) —do—
155. (c) Al acts as reducing agent.
$2Al + Cr_2O_3 \rightarrow Al_2O_3 + 2Cr$
156. (d) Al, Fe and Sn are more electropositive than H_2 but Al is more electropositive in comparison to Fe and Sn. Therefore, they are reduced from Fe^{3+} to Fe^{2+} and from Sn^{4+} to Sn^{2+} by H_2.
157. (b) CaF_2 is used to lower fusion temperature of fused mixture.
158. (b) Argentite (Ag_2S) and cuprite ($CuFeS_2$) are sulphides not oxides.
159. (c) It is a fact, Na_3AlF_6 is used to decrease the melting point as well as to increase the conductivity of Al_2O_3.
160. (c) Nitrogen has half filled configuration.
161. (d) For isoelectronic ions, as the ENC increases, the size decreases, Ionic size $\propto \frac{1}{Z_{eff}}$
$Z_{eff} = Z - \sigma$
Z = Atomic number, σ = Screening cons.
162. (b) In NH_3 'N' has no '*d*' orbitals. So, lone pair of electron concentrates only on 'N' therefore N can provide easily lone pair of electron. Basic character of hydrides decreases down the gp.
163. (d) Among transition elements, electrons are not filled in *d*-subshell monotonically with increasing atomic number.
164. (b) Heavy *p*-block elements shows inert pair effect in which valence '*s*' electrons become inert. This effect becomes more prominent down the group. Secondly completely filled electronic configurations are comparatively more stable.
$Pb^{2+} \rightarrow 5d^{10}\,6s^0$ $Fe^{2+} \rightarrow 3d^6$
$Sn^{2+} \rightarrow 4d^{10}\,5s^0$ $Ag^{2+} \rightarrow$ is not easily obtained.
165. (a) Due to lanthanoid contraction the covalent radii shows the order, $Y^{3+} < Lu^{3+} < Eu^{3+} < La^{3+}$. The element Y belongs to Vth period and Lu belongs to VIth period, therefore $Y^{3+} < Lu^{3+}$. The lanthanide contraction is caused by the poor shielding effect of 'f' electrons.
166. (d) $2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$
167. (d) N_2O and NO are neutral, while N_2O_3, N_2O_4, N_2O_5 are acidic in nature.
168. (b) N_2 is almost inert due to its high bond dissociation energy. Hence sparingly soluble in water.
169. (a) KNO_3 is called Indian salt peter. $NaNO_3$ is chilie salt petre.
170. (b) H_2S does not form hydrogen bonding, while in water and ammonia, intermolecular hydrogen bonding exists.
171. (d) $CaSO_4 \cdot 2H_2O$ is called gypsum.

172. (c) CuF_2, Cu^{2+} contains one unpaired electron. While in other complexes Cu exists as Cu^+ which has no unpaired electron hence colourless.

173. (c) $Mn + \underset{(dil)}{2HNO_3} \longrightarrow Mn(NO_3)_2 + H_2$

174. (b) $Ca(OH)_2 + Ca(HCO_3)_2 \rightarrow 2CaCO_3\downarrow + 2H_2O$

175. (c) $2NO + O_2 \longrightarrow \underset{\text{raddish brown}}{2NO_2}$

176. (a) It is fact.

177. (c) $\underset{(X)}{Cl_2} + H_2O \longrightarrow HCl + HOCl$

$HCl + AgNO_3 \longrightarrow \underset{\text{White ppt.}}{AgCl_{(s)}} + HNO_3$

$2HCl + Mg \longrightarrow MgCl_2 + \underset{(Y)}{H_2}$

178. (a) Electrolysis of molten $CaCl_2 \xrightarrow{\text{fused}} Ca^{2+} + 2Cl^-$

At Cathode : $Ca^{2+} + 2e \longrightarrow Ca$

At Anode : $2Cl^- \longrightarrow Cl_2 + 2e$

179. (b) $Zn + 2NaOH \longrightarrow Na_2ZnO_2 + H_2$

180. (c) Graphite is used inlead pencil.

181. (d) None of these is coloured.

182. (d) None of these is peroxide.

183. (d) $Pb^{2+} + 2HCl\,(dil) \rightarrow \underset{\text{white ppt}}{PbCl_2}\downarrow 2H^+$

$PbCl_2$ ppts. dissolve on heating

$\underset{\text{hot solution}}{PbCl_2} + H_2S \xrightarrow[\text{medium}]{\text{acidic}} \underset{\text{black ppt.}}{PbS}\downarrow + 2HCl$

Hence, substance is Pb^{2+} salt.

184. (c) Oxidation and reduction (Auto redox)

$P_4 + 3NaOH + 3H_2O \rightarrow 3NaH_2PO_2 + PH_3$

185. (c) The magnetic moment (μ) of a species is related to its number of unpaired electrons (n).

$Fe^{2+} \rightarrow 3d^6$ (4 unpaired electron)

$Fe^{3+} \rightarrow 3d^5$ (5 unpaired electron)

$\mu = \sqrt{n(n+2)}$ B.M. (B.M. = Bohr Magnetons)

The number of unpaired electrons in the given pairs are: as follows :

NO or $\overset{+}{\underset{\times\times}{N}} = \ddot{O}:$ $\quad n = 0$

NO or $\overset{\times}{\underset{\times}{N}} = \ddot{O}:$ $\quad n = 1$

The given combination differs in the unpaired electrons. Hence these can be differentiated by measurement on the solid state magnetic moment of nitroprusside ion.

186. (d) Solvated electrons $Na \longrightarrow Na^+ + e$

$e + x\,NH_3 \longrightarrow \underset{\text{(Blue colour)}}{e(NH_3)_x^-}$

187. (d) None of the above. HF is a weak acid.

188. (c) It sublimes at 100°C under vacuum.

189. (c) Complex forming behaviour.

190. (b) Graphite has mobile free electrons.

191. (d) Sn^{2+} cannot be precipitated out by H_2S and HCl.

192. (c) D_2O. It .s a fact.

193. (b) Chlorine reacts with moisture to give nascent oxygen which bleaches coloured substances

$Cl_2 + H_2O \longrightarrow HCl + HClO$

$HOCl \longrightarrow HCl + O$

194. (a) $2KNO_3 \longrightarrow 2KNO_2 + O_2$

195. (c) It is because SO_2 reacts with water to form H_2SO_4

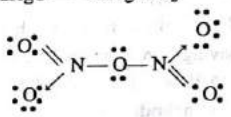
$SO_2 + 2H_2O \longrightarrow H_2SO_4 + 2H$

196. (d) It is a fact.

197. (b) $Na_2O_2 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O_2$

198. (b) $2HgO \xrightarrow{\Delta} 2Hg + O_2$

199. (b)



200. (c) Na_2CO_3 & NaOH are strong bases.

201. (d) NO_2 is a brown coloured gas.

202. (c) The filtrate is yellow due to CrO_4^{2-} and residue is brown due to $Fe(OH)_3$.

203. (a) NF_3 is least basic because of the high electronegativity of fluorine which give rise to +ve charge on N atom.

204. (b) The reduction potential of Cl_2 is more than Br_2, therefore Cl_2 replaces Br^- from solution.

205. (b) Fe^{3+} is precipitated in its hydroxide form. Cu forms complex with NH_3.

$Fe^{3+} + 3NH_4OH \rightarrow Fe(OH)_3 + 3NH_4^+$

206. (c) Both Pb^{2+} and Hg_2^{2+} has lower value of K_{sp} than Cd^{2+} and Hg^{2+} hence precipitated as chlorides.

207. (b) $\bar{O}-\overset{O}{\overset{\|}{S}}-O-\overset{O}{\overset{\|}{S}}-\bar{O}$

208. (a) It is an oxide (PbO_2).

209. (b) Because it oxidises HBr to Br_2.

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

210. (b) It is a fact.

211. (c) $H_2S_2O_8 + H_2O \longrightarrow H_2SO_5 + H_2SO_4$

212. (b) The thermal stability increases down the group.

213. (a) The acidic strength decreases with the decrease of electronegativity.

214. (b) $Na_2SO_3 + S \xrightarrow{\text{Oxidation}} Na_2S_2O_3$

215. (d) Because Pb^{4+} is a strong oxidant while I^- is a strong reductant. So Pb^{4+} get reduced to Pb^{+2}.

216. (a) It is a fact.

217. (b) Several uninegative groups which show certain characteristic of halide ions, called as pseudohalides.

218. (d) $(NH_4)_2Cr_2O_7 \rightarrow N_2 + Cr_2O_3 + 4H_2O$

219. (d) It is due to high lattice energy of $Be(OH)_2$.

220. (a) (i) Both Bi^{3+} and Sn^{4+} (belongs II group) are precipitated by H_2S in presence of dil. HCl hence can

not be separated out while Al^{3+}, Zn^{2+}, Ni^{2+} does not precipitate out by H_2S in presence of dil. HCl.

221. (c) They from soluble complex salt with cationic species.

$$Na_2[Na_4(PO_3)_6] + CaSO_4 \rightarrow \underset{\text{soluble complex salt}}{Na_2[CaNa_2(PO_3)_6]} + Na_2SO_4$$

222. (a) The acidic strength of oxides increases from left to right. CaO = Highly basic; CuO = weak base; H_2O = Neutral; CO_2 = acidic.

223. (a) $HO-\underset{\underset{H}{|}}{\overset{\overset{O}{||}}{P}}-OH$. Dibasic acids have reducing nature.

224. (a) Acidic salt ($NaHCO_3$) and base (NaOH) cannot exist together in solution, because both reacts.

$$NaHCO_3 + NaOH \rightarrow Na_2CO_3 + H_2O$$

225. (c) Product is linear silicones

$$Me_2SiCl_2 + 2H_2O \rightarrow HO-\underset{\underset{Me}{|}}{\overset{\overset{Me}{|}}{Si}}-OH$$

$$HO-\underset{\underset{Me}{|}}{\overset{\overset{Me}{|}}{Si}}-OH + HO-\underset{\underset{Me}{|}}{\overset{\overset{Me}{|}}{Si}}-OH \longrightarrow \left[-O-\underset{\underset{Me}{|}}{\overset{\overset{Me}{|}}{Si}}-O-\underset{\underset{Me}{|}}{\overset{\overset{Me}{|}}{Si}}-O-\right]_n$$

Linear Silicones

226. (a) $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

$Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2$

In both reactions, the H_2 ratio is 1 : 1.

227. (d) Alkali and alkaline earth metal hydroxides are highly basic as compared to the hydroxides of transition metals.

228. (c) Calcium oxalate is insoluble in acetic acid.

229. (d) Fe is passive in conc. HNO_3 because a thin layer of oxide is formed on its surface.

230. (c) $Cu^{2+} \cdot H_2O\left[O=\underset{\underset{O}{\downarrow}}{\overset{\overset{O}{\uparrow}}{S}}=O\right]^{2-} \cdot 4H_2O$

Copper sulphate has three types of bonds *i.e.*, electrovalent, covalent and coordinate bond.

231. (a) Zn—Cu couple is obtained by mixing zinc dust and copper gauze.

232. (b) As the number of unpaired electron increases, the paramagnetic character also increases.

In $MnSO_4 \cdot 4H_2O$

Mn^{2+} = $3d^5$ $4s^0$ (Unpaired $e^- = 5$)

In $CuSO_4 \cdot 5H_2O$

Cu^{2+} = $3d^9$ $4s^0$ (Unpaired $e^- = 1$)

In $FeSO_4 \cdot 6H_2O$

Fe^{2+} = $3d^6$ $4s^0$ (Unpaired $e^- = 4$)

In $NiSO_4 \cdot 6H_2O$

Ni^{2+} = $3d^8$ $4s^0$ (Unpaired $e^- = 2$)

Paramagnetic character $\propto$ unpaired electrons

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

n = no. of unpaired electron.

233. (c) SO_3 only.

$$Fe_2(SO_4)_3 \longrightarrow Fe_2O_3 + 3SO_3$$

234. (c)

Ni^{2+} = $3d$ $4s$ $4p$

$[Ni(CN)_4]^{2-}$ = $3d$ $4s$ $4p$ (CN CN CN CN) dsp^2

(No unpaired electron, diamagnetic)

$[Ni(CO)_4]$ = $3d$ $4s$ $4p$ (CO CO CO CO) dsp^3

(No unpaired electron, diamagnetic)

$[NiCl_4]^{2-}$ = $3d$ $4s$ $4p$ (Cl Cl Cl Cl) sp^3

(2 unpaired electron, paramagnetic)

A strong field ligand can pair up the unpaired electron of central atom while weak ligand cannot.

CN^- and CO are strong field ligands, hence they bring about the pairing of 3*d*-electrons, whereas, Cl is a weak field ligand and fails to do so.

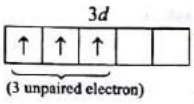
235. (b) Paramagnetic character increases as the number of unpaired electrons in *d*-sub-shells increases.

In these complex ions :

In $[Cr(H_2O)_6]^{3+}$, Cr is present as

Cr^{3+} (O.N. of Cr = + 3)

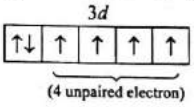
$_{24}Cr^{3+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^3$



In $[Fe(H_2O)_6]^{2+}$, Fe is present as

Fe^{2+} (O.N. of Fe = + 2)

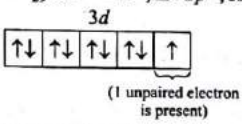
$_{26}Fe^{2+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^6$



In $[Cu(H_2O)_6]^{2+}$, Cu is present as

Cu^{2+} (O.N. of Cu = + 2)

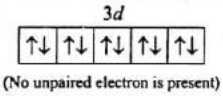
$_{29}Cu^{2+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^9$



In $[Zn(H_2O)_6]^{2+}$, Zn is present as

Zn^{2+} (O.N. of Zn = + 2)

$_{30}Zn^{2+} = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}$



So, paramagnetic character is maximum in $[Fe(H_2O)_6]^{2+}$.

236. (c) Solder is an alloy of Pb and Sn.

237. (a) $2KMnO_4 + 6HCl \rightarrow 2KCl + 2MnCl_2 + 5Cl_2 + 8H_2O$

238. (d) The product is a complex compound

$$CuSO_4 + 2KCN \rightarrow Cu(CN)_2 + K_2SO_4$$

$$2Cu(CN)_2 \rightarrow Cu_2(CN)_2 + CN{-}CN$$

(Cyanogen gas)

$$Cu_2(CN)_2 + 6KCN \rightarrow 2K_3[Cu(CN)_4]$$

239. (a) HgS does not dissolved in hot dilute HNO_3.

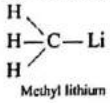
240. (b) The green colour is due to Cr_2O_3

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

241. (b) CuF_2 is coloured because it contains unpaired valence *d* electron.

$$Cu^{2+} = 1s^2 2s^2, 2p^6, 3s^2 3p^6 3d^9$$

242. (d) Organometallic compounds are those compounds in which metal atom is directly bonded with C-atom



243. (c) $_{27}Co^{2+} = 2, 8, 15$

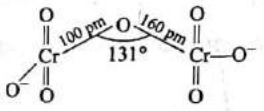
$3s^2, 3p^6, 3d^7$ ⇅ ⇅ 1 1 1

It is paramagnetic and coloured due to presence of unpaired electrons.

244. (d) Cupric chloride

$$CuCl_2 + H_2S \longrightarrow \underset{\text{Black ppt.}}{CuS} + 2HCl$$

245. (b) In the dichromate dianions, 6 Cr — O bonds are equivalent



Due to resonace, six Cr — O bonds are equivalent, two bridged Cr — O bonds are equivalent.

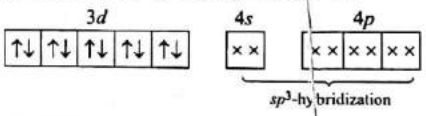
246. (c) Both the complexes have tetrahedral shape and sp^3 hybridisation.

In $Ni(CO)_4$ O.N. of Ni = 0

$Ni = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^8, 4s^2$

CO is strong field ligand and thus unpaired electrons in *d*-orbital are paired. Therefore,

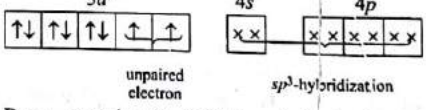
In excitation $Ni = 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^{10}$



In $Ni(PPh_3)_2Cl_2$, O.N. of Ni = + 2

(Its coordination number = 4)

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



247. (a) Bones contain $Ca_3(PO_4)_2$. Animal charcoal is obtained from bone ash.

248. (b) SbF_5 has strongest tendency to accept lone pair of electron.

$$SbF_5 + F^- \longrightarrow [SbF_6]^-$$

249. (b) Co exist as Co^{3+}. Since μ = 4.5 B.M.

$\therefore 4.5 = \sqrt{n(n+2)}$

$\therefore n = 4$ *i.e.*, number of unpaired electron = 4.

$_{27}Co^{3+}: 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^6$

250. (c) It is a fact.

251. (b) Cr in $[Cr(en)_3]^{2+}$ is low spin complex having d^4 configuration of Cr^{2+} ion.

252. (a) MnO_4^{2-} ion is green in colour.

PREVIOUS YEAR OBJECTIVE PROBLEMS (One Answer Correct)

1. The chemical process in the production of steel from haematite ore involves: **(IIT 2000)**
   (a) reduction
   (b) oxidation
   (c) reduction followed by oxidation
   (d) oxidation followed by reduction

2. Electrolyte reduction of alumina to aluminium by Hall-Heroult process is carried out: **(IIT 2000)**
   (a) in the presence of NaCl
   (b) in the presence of fluorite
   (c) in the presence of cryolite which forms a melt with lowers melting temperature
   (d) in the presence of cryolite which forms a melt with higher melting temperature

3. Ammonia can be dried by: **(IIT 2000)**
   (a) conc. H_2SO_4 (b) P_4O_{10}
   (c) CaO (d) anhydrous $CaCl_2$

4. The correct order of acidic nature is: **(IIT 2000)**
   (a) $Cl_2O_7 > SO_2 > P_4O_{10}$
   (b) $CO_2 > N_2O_5 > SO_3$
   (c) $Na_2O > MgO > Al_2O_3$
   (d) $K_2O > CaO > MgO$

5. The number of P — O — P bonds in cyclic meta phosphoric acid is: **(IIT 2000)**
   (a) zero (b) two
   (c) three (d) four

6. The number of S — S bonds in trimer of sulphur trioxide (S_3O_9) is: **(IIT 2001)**
   (a) 3 (b) 2
   (c) 1 (d) 0

7. The chemical composition of slag formed during melting process in the extraction of Cu is: **(IIT 2001)**
   (a) $Cu_2O + FeS$ (b) $FeSiO_3$
   (c) $CuFeS_2$ (d) $Cu_2S + FeO$

8. The complex ion which has no '*d*' electron in the central metal atom is: **(IIT 2001)**
   (a) $[MnO_4]^-$ (b) $[Co(NH_3)_6]^{3+}$
   (c) $[Fe(CN)_6]^{3-}$ (d) $[Cr(H_2O)_6]^{3+}$

9. Which process is used in the extractive metallurgy of Mg? **(IIT 2002)**
   (a) Fused salt electrolysis
   (b) Self reduction
   (c) Aqueous solution electrolysis
   (d) Thermite reduction

10. Polyphosphates are used as water softening agents because they: **(IIT 2002)**
    (a) form soluble complexes with anionic species
    (b) precipitate anionic species
    (c) form soluble complexes with cationic species
    (d) precipitate cationic species

11. Anhydrous ferric chloride is prepared by: **(IIT 2002)**
    (a) heating hydrated ferric chloride at a high temperature in a stream of air
    (b) heating metallic iron in a stream of dry chlorine gas
    (c) reactions of ferric oxide with $HCl_{(aq.)}$
    (d) reaction of metallic iron with $HCl_{(aq.)}$

12. An aqueous solution of a substance gives a white precipitate on treatment with dilute hydrochloric acid, which dissolves on heating. When hydrogen sulphide is passed through the hot acidic solution, a black precipitate is obtained. The substance is a: **(IIT 2002)**
    (a) Hg_2^{2+} salt (b) Cu^{2+} salt
    (c) Ag^+ salt (d) Pb^{2+} salt

13. Identify the correct order of solubility of Na_2S, CuS and ZnS in aqueous medium: **(IIT 2002)**
    (a) $CuS > ZnS > Na_2S$ (b) $ZnS > Na_2S > CuS$
    (c) $Na_2S > CuS > ZnS$ (d) $Na_2S > ZnS > CuS$

14. A gas '*X*' is passed through water to form a saturated solution. The aqueous solution on treatment with silver nitrate gives a white precipitate. The saturated aqueous solution also dissolves magnesium ribbon with evolution of a colourless gas '*Y*'. Identify '*X*' and '*Y*': **(IIT 2002)**
    (a) $X = CO_2, Y = Cl_2$ (b) $X = Cl_2, Y = CO_2$
    (c) $X = Cl_2, Y = H_2$ (d) $X = H_2, Y = Cl_2$

15. $(Me)_2SiCl_2$ on hydrolysis produces: **(IIT 2003)**
    (a) $(Me)_2Si(OH)_2$
    (b) $(Me)_2Si = 0$
    (c) $+O-(Me)_2Si-O+_n$
    (d) $Me_2SiCl(OH)$

16. When MnO_2 is fused with KOH, a coloured compound is formed. The product and its colour is: **(IIT 2003)**
    (a) K_2MnO_4, purple (b) $KMnO_4$, purple
    (c) Mn_2O_3, brown (d) Mn_3O_4, black

17. Between H_3PO_3 and H_3PO_4: **(IIT 2003)**
    (a) H_3PO_3—reductant and monobasic acid
    (b) H_3PO_3—reductant and dibasic acid
    (c) H_3PO_4—not reductant and monobasic acid
    (d) H_3PO_4—reductant and tribasic acid

18. Roasted gold ore $+ CN^- + H_2O \xrightarrow{O_2} [X] + OH^-$ $[X] + Zn \longrightarrow [Y] + Au$ $[X]$ and $[Y]$ are: **(IIT 2003)**
    (a) $X = [Au(CN)_2]^-$; $Y = [Zn(CN)_4]^{2-}$
    (b) $X = [Au(CN)_4]^{3-}$; $Y = [Zn(CN)_4]^{2-}$
    (c) $X = [Au(CN)_2]^-$; $Y = [Zn(CN)_6]^{4-}$
    (d) $X = [Au(CN)_4]^{3-}$; $Y = [Zn(CN)_6]^{2-}$

19. Mixture X of 0.02 mole of $[Co(NH_3)_5SO_4]Br$ and 0.02 mole of $[Co(NH_3)_5Br]SO_4$ was prepared in 2 litre of solution:
1 litre of mixture X + Excess of $AgNO_3 \rightarrow Y$
1 litre of mixture X + Excess of $BaCl_2 \rightarrow Z$
Number of mole of Y and Z respectively are: **(IIT 2003)**
(a) 0.01, 0.01 (b) 0.02, 0.01
(c) 0.01, 0.02 (d) 0.02, 0.02

20. $[X] + H_2SO_4 \longrightarrow [Y]$ a colourless gas with irritating smell, $[Y] = K_2Cr_2O_7 + H_2SO_4 \longrightarrow$ Green solution, $[X]$ and $[Y]$ are: **(IIT 2003)**
(a) SO_3^{2-}, SO_2 (b) Cl^-, HCl
(c) S^{2-}, H_2S (d) CO_3^{2-}, CO_2

21. A solution which is 10^{-3} M each in Mn^{2+}, Fe^{2+}, Zn^{2+} and Hg^{2+} is treated with 10^{-16} M sulphide ion. If K_{sp} of MnS, FeS, ZnS and HgS are 10^{-13}, 10^{-18}, 10^{-24} and 10^{-53} respectively, which one will precipitate first: **(IIT 2003)**
(a) FeS (b) MgS
(c) HgS (d) ZnS

22. By which process Pd and Sn are extracted respectively by? **(IIT 2004)**
(a) carbon reduction : self reduction
(b) self reduction : carbon reduction
(c) electrolytic reduction : cyanide process
(d) cyanide process : electrolyte reduction

23. A sodium salt on treatment with $MgCl_2$ gives white precipitate only on heating. The anion of sodium salt is: **(IIT 2004)**
(a) HCO_3^- (b) CO_3^{2-}
(c) NO_3^- (d) SO_4^{2-}

24. The species having tetrahedral shape is: **(IIT 2004)**
(a) $[PdCl_4]^{2-}$ (b) $[Ni(CN)_4]^{2-}$
(c) $[Pb(CN)_4]^{2-}$ (d) $[NiCl_4]^{2-}$

25. The spin magnetic moment of cobalt in $Hg[Co(SCN)_4]$ is: **(IIT 2004)**
(a) $\sqrt{3}$ (b) $\sqrt{8}$
(c) $\sqrt{15}$ (d) $\sqrt{24}$

26. $(NH_4)_2Cr_2O_7$ on heating gives a gas which is also given by: **(IIT 2004)**
(a) heating NH_4NO_2 (b) heating NH_4NO_3
(c) $Mg_3N_2 + H_2$ (d) $Na + H_2O_2$

27. The acid having O — O bond is: **(IIT 2004)**
(a) $H_2S_2O_3$ (b) $H_2S_2O_8$
(c) $H_2S_2O_6$ (d) $H_2S_4O_6$

28. The product of oxidation of I^- with MnO_4^- in alkaline medium is: **(IIT 2004)**
(a) IO_3^- (b) I_2
(c) IO^- (d) IO_4^-

29. Which ore contains both iron and copper? **(IIT 2005)**
(a) Cuprite (b) Chalcocite
(c) Chalcopyrite (d) Malachite

30. Which pair of compounds is expected to show similar colour in aqueous solution? **(IIT 2005)**
(a) $FeCl_2, CuCl_2$ (b) $VOCl_2, CuCl_2$
(c) $VOCl_2, FeCl_2$ (d) $FeCl_2, MnCl_2$

31. Which kind of isomerism is exhibited by octahedral $[Co(NH_3)_4Br_2]Cl$? **(IIT 2005)**
(a) Geometrical and ionization
(b) Geometrical and optical
(c) Optical and ionization
(d) Geometrical only

32. A metal nitrate reacts with KI to give a black precipitate which on addition of excess of KI converts into orange colour solution. The cation of metal nitrate is: **(IIT 2005)**
(a) Hg^{2+} (b) Bi^{3+}
(c) Pb^{2+} (d) Cu^+

33. When PbO_2 reacts with conc. HNO_3, the gas evolved is: **(IIT 2005)**
(a) NO_2 (b) O_2
(c) N_2 (d) N_2O

34. Name of the structure of silicate in which three oxygen atoms of $[SiO_4]^{4-}$ are shared: **(IIT 2005)**
(a) Pyrosilicate
(b) Sheet silicate
(c) Linear chain silicate
(d) Three dimensional silicates

35. The most thermodynamically stable allotropic form of phosphorus is: **(IIT 2005)**
(a) red (b) white
(c) black (d) yellow

36. Which blue liquid is obtained on reacting equimolar amounts of NO and NO_2 gases at $-30°C$? **(IIT 2005)**
(a) N_2O (b) N_2O_3
(c) N_2O_4 (d) N_2O_5

37. Which of the following is not oxidised by O_3? **(IIT 2005)**
(a) KI (b) $FeSO_4$
(c) $KMnO_4$ (d) K_2MnO_4

38. How the reaction below can be made to proceed in forward direction?
$B(OH)_3 + NaOH \longrightarrow [NaB(OH)_4]$
or $[NaBO_2 + H_2O]$ **(IIT 2006)**
(a) Addition of *cis*-1, 2-diol
(b) Addition of borax
(c) Addition of *trans*-1,2-diol
(d) Addition of Na_2HPO_4

39. A solution is when diluted with H_2O and boiled a white precipitate is obtained. On addition of excess NH_4Cl / NH_4OH, the volume of precipitate decreases

leaving behind a gelatinous precipitate. The precipitate is: **(IIT 2006)**

(a) $Zn(OH)_2$ (b) $Al(OH)_3$
(c) $Mg(OH)_2$ (d) $Ca(OH)_2$

40. If the bond length of C — O in carbon monoxide is 1.128 Å, the bond length of C — O in $Fe(CO)_5$ is: **(IIT 2006)**

(a) 1.15 Å (b) 1.128 Å
(c) 1.72 Å (d) 1.118 Å

41. The species present in solution when CO_2 is dissolved in water are: **(IIT 2006)**

(a) $CO_2, H_2CO_3, HCO_3^-, CO_3^{2-}$
(b) H_2CO_3, CO_3^{2-}
(c) CO_3^{2-}, HCO_3^-
(d) CO_2, H_2CO_3

42. $CuSO_4$ decolourises on addition of KCN. The product is: **(IIT 2006)**

(a) $[Cu(CN)_4]^{2-}$
(b) Cu^{2+} get reduced to form $[Cu(CN)_4]^{3-}$
(c) $Cu(CN)_2$
(d) CuCN

43. $MgSO_4$ on reaction with NH_4OH and Na_2HPO_4 forms a white ppt. It is: **(IIT 2006)**

(a) $Mg(NH_4)PO_4$ (b) $Mg_3(PO_4)_2$
(c) $MgCl_2 \cdot MgSO_4$ (d) $MgSO_4$

44. Among the following, the paramagnetic compound is: **(IIT 2007)**

(a) Na_2O_2 (b) O_3
(c) N_2O (d) KO_2

45. The species having bond order different than CO is: **(IIT 2007)**

(a) NO^- (b) NO^+
(c) CN^- (d) N_2

46. Extraction of zinc from zinc blende is achieved by: **(IIT 2007)**

(a) electrolytic reduction
(b) roasting followed by reduction with carbon
(c) roasting followed by reduction with another metal
(d) roasting followed by self reduction

47. The percentage of *p*-character in the orbitals forming P—P bonds in P_4 is: **(IIT 2007)**

(a) 25 (b) 33
(c) 50 (d) 75

48. Among the following metal carbonyls, the C—O bond order is lowest in: **(IIT 2007)**

(a) $[Mn(CO)_6]^+$ (b) $[Fe(CO)_5]$
(c) $[Cr(CO)_6]$ (d) $[V(CO)_6]^-$

49. A solution of metal ion when treated with KI gives a red ppt. which dissolves in excess KI to give a colourless solution. Moreover, the metal ion on treatment with a solution of cobalt (II) this cyanate gives rise to deep blue crystalline ppt. The metal ion is: **(IIT 2007)**

(a) Pb^{2+} (b) Hg^{2+}
(c) Cu^{2+} (d) Co^{2+}

50. Native silver metal forms a water soluble complex with a dilute aqueous solution of NaCN in presence of: **(IIT 2008)**

(a) nitrogen (b) oxygen
(c) CO_2 (d) Ar

51. Aqueous solution of $Na_2S_2O_3$ on reaction with Cl_2 gives: **(IIT 2008)**

(a) $Na_2S_4O_6$ (b) $NaHSO_4$
(c) NaCl (d) NaOH

52. Among the following, the coloured compound is: **(IIT 2008)**

(a) CuCl (b) $K_3C_4(CN)_4$
(c) CuF_2 (d) $[Cu(CH_3CN)_4]BF_3$

53. The IUPAC name of $[Ni(NH_3)_4][NiCl_4]$ is: **(IIT 2008)**

(a) Tetrachloronickel (II)-tetraamminenickel (II)
(b) Tetraamminenickel (II)-tetrachloronickel (II)
(c) Tetraamminenickel (II)-tetrachloronickelate (II)
(d) Tetrachloronickel (II)-tetraamminenickelate (O)

54. Both $[Ni(CO)_4]$ and $[Ni(CN)_4]^{2-}$ are diamagnetic. The hybridization of nickel in the compounds respectively are: **(IIT 2008)**

(a) sp^3, sp^3 (b) sp^3, dsp^2
(c) dsp^2, sp^3 (d) dsp^2, dsp^2

55. The co-ordination number of Al in crystalline state of $AlCl_3$ is: **(IIT 2009)**

(a) 2 (b) 4
(c) 6 (d) 8

56. The spin only magnetic moment value (in Bohr magneton units) of $Cr(CO)_6$ is: **(IIT 2009)**

(a) 0 (b) 2.84
(c) 4.90 (d) 5.92

57. The reaction of P_4 with *X* leads selectively to P_4O_6. The *X* is: **(IIT 2009)**

(a) Dry O_2
(b) A mixture of O_2 and N_2
(c) Moist O_2
(d) O_2 in the presence of aqueous NaOH

58. The number of water molecule(s) directly bonded to the metal centre in $CuSO_4 \cdot 5H_2O$ is: **(IIT 2009)**

(a) 5 (b) 4
(c) 1 (d) 3

59. The complex showing a spin only magnetic moment of 2.82 BM is: **(IIT 2010)**

(a) $Ni(CO)_4$ (b) $[NiCl_4]^{2-}$
(c) $Ni(PPh_3)_4$ (d) $[Ni(CN)]_4^{2-}$

60. The ionisation isomer of $[Cr(H_2O)_4ClNO_2]Cl$ is: **(IIT 2010)**

(a) $[Cr(H_2O)_4NO_2]Cl_2$
(b) $[Cr(H_2O)_6Cl_2]NO_2$
(c) $[Cr(H_2O)_4Cl(ONO)]Cl$
(d) $[Cr(H_2O)_3Cl_2NO_2]H_2O$

61. Extra pure N_2 can be obtained by heating : **(IIT 2011)**
(a) NH_3 with CuO (b) NH_4NO_3
(c) $(NH_4)_2Cr_2O_7$ (d) $Ba(N_3)_2$

62. Geometrical shapes of the complexes formed by the reaction of Ni^{2+} with Cl^-, CN^- and H_2O respectively are : **(IIT 2011)**
(a) Octahedral, tetrahedral and squareplanar
(b) Tetrahedral, squareplanar and octahedral
(c) Squareplanar, tetrahedral and octahedral
(d) Octahedral, squareplanar and octahedral

63. Oxidation state of the metal in the mineral haematite and magnetite respectively are : **(IIT 2011)**
(a) II, III in haematite and III in magnetite
(b) II, III in haematite and II in magnetite
(c) II in haematite and II, III in magnetite
(d) III in haematite and II, III in magnetite

64. Among the following complexes **(K-P)**, $K_3[Fe(CN)_6]$**(K)**, $[Co(NH_3)_6]Cl_3$**(L)**, $Na_3[Co(oxalate)_3]$**(M)**, $[Ni(H_2O)_6]Cl_2$**(N)**, $K_2[Pt(CN)_4]$**(O)**, and $[Zn(H_2O)_6](NO_3)_2$**(P)** the diamagnetic complexes are : **(IIT 2011)**
(a) K, L, M, N (b) K, M, O, P
(c) L, M, O, P (d) L, M, N, O

65. Passing H_2S gas into a mixture of $Mn^{2+}, Ni^{2+}, Cu^{2+}$ and Hg^{2+} ions in an acidified aqueous solution precipitates : **(IIT 2011)**
(a) CuS and HgS (b) MnS and CuS
(c) MnS and NiS (d) NiS and HgS

66. As per IUPAC nomenclature, the name of the complex $[Co(H_2O)_4(NH_3)_2]Cl_3$ is : **(IIT 2012)**
(a) Tetraaquadiaminecobalt (III) chloride
(b) Tetraaquadiamminecobalt (III) chloride
(c) Diaminetetraaquacobalt (III) chloride
(d) Diamminetetraaquacobalt (III) chloride

67. In the cyanide extraction process of silver from argentite ore, the oxidizing and reducing agents used are : **(IIT 2012)**
(a) O_2 and CO respectively
(b) O_2 and Zn dust respectively
(c) HNO_3 and Zn dust respectively
(d) HNO_3 and CO respectively

68. $NiCl_2\{P(C_2H_5)_2(C_6H_5)\}_2$ exhibits temperature dependent magnetic behaviour (paramagnetic/ diamagnetic). The coordination geometries of Ni^{2+} in the paramagnetic and diamagnetic states are respectively : **(IIT 2012)**
(a) tetrahedral and tetrahedral
(b) square planar and square planar
(c) tetrahedral and square planar
(d) square planar and tetrahedral

69. The colour of light absorbed by an aqueous solution of $CuSO_4$ is : **(IIT 2012)**
(a) orange-red (b) blue-green
(c) yellow (d) violet

70. The gas leaked from a storage tank of the Union Carbide plant in Bhopal gas tragedy was : **[JEE (Main) 2013]**
(a) Ammonia (b) Phosgene
(c) Methylisocyanate (d) Methylamine

71. Which of the following complex species is not expected to exhibit optical isomerism ? **[JEE (Main) 2013]**
(a) $[Co(NH_3)_3Cl_3]$ (b) $[Co(en)(NH_3)_2Cl_2]^+$
(c) $[Co(en)_3]^{3+}$ (d) $[Co(en)_2Cl_2]^+$

72. Which of the following is the wrong statement ? **[JEE (Main) 2013]**
(a) Ozone is violet-black in solid state.
(b) Ozone is diamagnetic gas.
(c) $\overset{1}{O}\overset{2}{N}\overset{3}{Cl}$ and $\overset{1}{O}\overset{2}{N}\overset{3}{O}^-$ are not isoelectronic.
(d) O_3 molecule is bent

73. Which of the following arrangements does not represent the correct order of the property stated against it ? **[JEE (Main) 2013]**
(a) $Co^{3+} < Fe^{3+} < Cr^{3+} < Sc^{3+}$: stability in aqueous solution
(b) $Sc < Ti < Cr < Mn$: number of oxidation states
(c) $V^{2+} < Cr^{2+} < Mn^{2+} < Fe^{2+}$: paramagnetic behaviour
(d) $Ni^{2+} < Co^{2+} < Fe^{2+} < Mn^{2+}$: ionic size

74. Consider the following complex ions, P, Q and R. $P = [FeF_6]^{3-}$, $Q = [V(H_2O)_6]^{2+}$ and $R = [Fe(H_2O)_6]^{2+}$, the correct order of the complex ions, according to their spin only magnetic moment values (in B.M.) is : **[JEE (Advanced) I 2013]**
(a) $R < Q < P$ (b) $Q < R < P$
(c) $R < P < Q$ (d) $Q < P < R$

75. Sulphide ores are common for the metals : **[JEE (Advanced) I 2013]**
(a) Ag, Cu and Pb (b) Ag, Cu and Sn
(c) Ag, Mg and Pb (d) Al, Cu and Pb

76. Concentrated nitric acid, upon long standing, turns yellow-brown due to the formation of : **[JEE (Advanced) I 2013]**
(a) NO (b) NO_2
(c) N_2O (d) N_2O_4

77. Upon treatment with ammoniacal H_2S, the metal ion that precipitates as a sulphide is : **[JEE (Advanced) I 2013]**
(a) Fe(III) (b) Al(III)
(c) Mg(II) (d) Zn(II)

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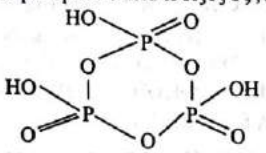
1. (d) Haematite (Fe_2O_3) having little FeO is first oxidised to Fe_2O_3 and then reduced to Fe by CO.

2. (c) Cryolite is added to lower the m. pt. of alumina as well as to make it a good conductor of current.

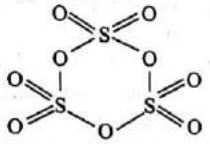
3. (c) Rest all react with NH_3.

4. (a) Acidic character of non-metal oxides increases along the period.

5. (c) Cyclic metaphosphoric acid is $H_3P_3O_9$, *i.e.*,



6. (d) Trimer of SO_3 (S_3O_9) is:



7. (b) The non-fusible mass (basic gangue) FeO is removed by acidic flux SiO_2 in the form of slag $FeSiO_3$.

8. (a) Co^{3+}, Fe^{3+} and Cr^{3+} have 6, 5 and 3 '*d*' electrons respectively.

9. (a) Highly electropositive metals (*e.g.*, alkali metals, alkaline earth metals and aluminium metals) are extracted by the electrolysis of their fused salts. In aqueous state H^+ is discharged.

Anode $\underset{\text{(fused)}}{Mg^{2+}} + 2e \longrightarrow Mg$

10. (a) $Na_2[Na_4(PO_3)_6] + 2Ca^{2+} \longrightarrow 4Na^+ + \underset{\text{Soluble}}{Na_2[Ca_2(PO_3)_6]}$

Ca^{2+} ions are removed from water by reacting with anionic species $Na_4[(PO_3)_6]^2$

11. (b) $2Fe + 3Cl_2 \longrightarrow 2FeCl_3$. In (c) and (d) hydrated ferric chloride ($FeCl_3 \cdot 6H_2O$) is formed.

12. (d) $PbCl_2$ is soluble in hot water but insoluble in cold water.

$$Pb^{2+} + 2HCl \longrightarrow \underset{\substack{\text{White ppt.}\\ \text{soluble on}\\ \text{heating}}}{PbCl_2\downarrow} \longrightarrow \underset{\text{Black ppt.}}{PbS}$$

13. (d) The K_{sp} value of CuS is less than ZnS and thus ZnS is more soluble. Also sodium salts are highly soluble in water.

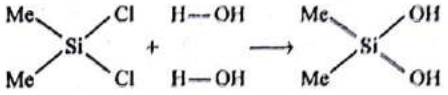
14. (c)

$$\underset{(X)}{Cl_2} + H_2O \longrightarrow HOCl + HCl$$

$$AgNO_3 + HCl \longrightarrow \underset{\text{White ppt.}}{AgCl} + HNO_3$$

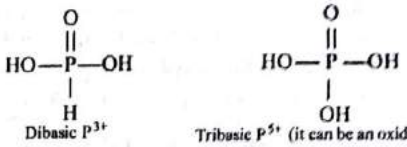
$$Mg + 2HCl \longrightarrow \underset{(Y)}{MgCl_2} + H_2\uparrow$$

15. (a)



16. (a) $2MnO_2 + 2KOH + O_2 \longrightarrow \underset{\text{Purple}}{2K_2MnO_4} + 2H_2O$

17. (b)



Dibasic P^{3+} Tribasic P^{5+} (it can be an oxidant only)

18. (a) $2Au + 4CN^- + H_2O + \frac{1}{2}O_2 \longrightarrow 2[Au(CN)_2]^- + 2OH^-$

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

19. (a) Only primary valencies are ionised. Also normality of each salt = 0.01 *M*

$$[Co(NH_3)_5Br]SO_4 \xrightarrow{BaCl_2} [Co(NH_3)_5Br]^{2+}, BaSO_4$$

$$[Co(NH_3)_5SO_4]Br \xrightarrow{AgNO_3} [Co(NH_3)_5SO_4] + AgBr$$

The mole ratio of complex : *X* or *Y* is 1 : 1.

20. (a) $SO_3^{2-} + H_2SO_4 \longrightarrow \underset{\substack{\text{Burning sulphur smell}\\ \text{(irritating)}}}{SO_2} + SO_4^{2-} + H_2O$

or $S^2 + H_2SO_4 \longrightarrow H_2S + SO_4^{2-}$ Rotten egg smell

SO_2 turns $K_2Cr_2O_7$ solution in acidic medium green.

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

21. (c) $[S^{2-}]$ needed for precipitation of

$$MnS = \frac{10^{-13}}{10^{-3}} = 10^{-10}\ M$$

$$FeS = \frac{10^{-18}}{10^{-3}} = 10^{-15}\ M$$

$$ZnS = \frac{10^{-24}}{10^{-3}} = 10^{-21}\ M$$

$$HgS = \frac{10^{-53}}{10^{-3}} = 10^{-50}\ M$$

Thus, minimum $[S^{2-}]$ is for HgS and so it will be precipitated first.

22. (b)

$$\left.\begin{aligned} 2PbS + 3O_2 &\longrightarrow 2PbO + 2SO_2\\ 2PbO + PbS &\longrightarrow 3Pb + SO_2 \end{aligned}\right\} \text{Self reduction}$$

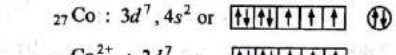
$$SnO_2 + 2C \xrightarrow{\Delta} \underset{\text{Carbon reduction}}{Sn + 2CO_2\uparrow}$$

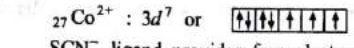
23. (a) $2NaHCO_3 + MgCl_2 \xrightarrow{\Delta} \underset{\text{Insoluble}}{MgCO_3} + 2NaCl + H_2O + CO_2$

24. (d) The magnetic moment of $[NiCl_4]^{2-}$ seveals that the species is paramagnetic having two unpaired electrons,

i.e., Ni^{2+} is $3d^8$. The four electron pairs by Cl^- ligand lead to sp^3-hybridisation in Ni^{2+} and do not disturb Ni^{2+} configuration to give tetrahedral geometry.

25. (c) In $Hg[Co(SCN)_4]$, Co exists as Co^{2+}

$_{27}Co : 3d^7, 4s^2$ or 

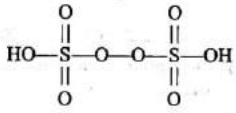
$_{27}Co^{2+} : 3d^7$ or 

SCN^- ligand provides four electron pairs to show sp^3-hybridisation in $[Co(SCN)_4]^{2-}$ and thus three unpaired electrons exist on Co^{2+}.

Magnetic moment $= \sqrt{n(n+2)} = \sqrt{3(3+2)} = \sqrt{15}$

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

$NH_4NO_2 \xrightarrow{\Delta} N_2 + 2H_2O$

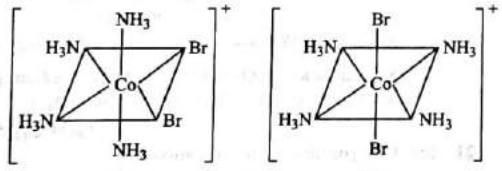
27. (b) $H_2S_2O_8$ is: 

28. (a) $2MnO_4^- + I^- + H_2O \rightarrow 2MnO_2 + IO_3^- + 2OH^-$

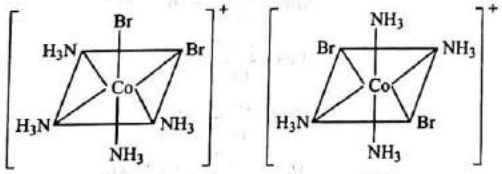
29. (c) Cuprite (Cu_2O), chalcocite (Cu_2S), chalcopyrite ($CuFeS_2$) and malachite $[Cu(OH)_2 \cdot CuCO_3]$.

30. (a) $FeCl_2$ and $CuCl_2$ are green.

31. (a)



cis *trans*



cis *trans*

32. (b) $Bi(NO_3)_{3(aq.)} + 3KI_{(aq.)} \longrightarrow BiI_{3(s)} + 3KNO_{3(aq.)}$

$BiI_3 + KI \longrightarrow \underset{\text{Soluble}}{K[BI_4]}$

33. (b) $PbO_2 + 2HNO_3 \longrightarrow Pb(NO_3)_2 + H_2O + \frac{1}{2}O_2$

34. (b) Two dimensional sheet structures are formed when three oxygen atoms of each $[SiO_4]^{4-}$ tetrahedral are shared.

35. (c) $\Delta G = 0$ for white P assumed arbitrarily, but most stable form is black P.

36. (b) $NO + NO_2 \longrightarrow N_2O_3$ (blue liquid)

37. (c) Mn in $KMnO_4$ is already in highest oxidation state, *i.e.*, Mn^{7+}.

38. (a) Due to formation of chelated complex, the reaction proceeds in forward direction.

39. (a) Due to the formation of $[Zn(NH_3)_4]^{2+}$.

40. (a) Due to synergic bond formation between metal and CO, the bond order of CO decreases a little.

41. (a) $CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$

42. (b) $CuSO_4 + KCN \longrightarrow Cu(CN)_2$

$2Cu(CN)_2 \longrightarrow CuCN + (CN)_2$

$3KCN + CuCN \longrightarrow K_3Cu(CN)_4$

43. (a) $Mg^{2+} + NH_4OH + Na_2HPO_4 \longrightarrow Mg(NH_4)PO_4$ (A test of Mg^{2+})

44. (d) KO_2 has O_2^- ion having one unpaired electron.

45. (a) Bond order of CO is 3 and of NO^- is 2.0.

46. (b) ZnO is reduced by carbon.

47. (d) P_4 has sp^3-hybridisation and thus has 75% *p*-character.

48. (d) The carbon metal bond in carbonyls is due to donation of electron pair from C-atom of CO [:C::O:], *i.e.*, $M \leftarrow C \equiv O$. The lone pair of electrons of *d*-orbitals left on metal involves back bonding where the metal donates electron pair to empty antibonding orbitals of CO thus forming a π ($M \rightarrow C$) bond. The total bonding with metal is thus $M = C = O$. The partial filling of the antibonding orbitals on C reduces the bond order of C—O bond. The negative charge density on V-atom favours easy donation of an electron pair.

49. (b) $Hg^{2+} + 2I^- \longrightarrow HgI_2$ (scarlet red ppt.)

$HgI_2 + \underset{\text{Excess}}{2I^-} \longrightarrow [HgI_4]^{2-}$ (soluble)

$Hg^{2+} + Co(SCN)_2 \longrightarrow \underset{\text{deep blue ppt.}}{Co[Hg(SCN)_4]}$

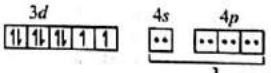
50. (b) $4Ag + 8NaCN + 2H_2O + O_2 \longrightarrow 4Na[Ag(CN)_2] + 4NaOH$

51. (b) $Na_2S_2O_3 + 4Cl_2 + 5H_2O \longrightarrow 2NaHSO_4 + 8HCl$

52. (c) CuF_2 is blue coloured crystalline solid.

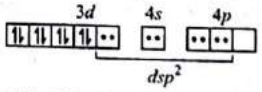
53. (c) Follow IUPAC rules.

54. (b) Ni in $[Ni(CO)_4]$: $...3s^2, 3p^6, 3d^8 4s^2$



sp^3

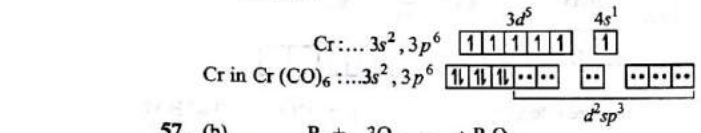
Ni in $[Ni(CN)_4]^{2-}$: $...3s^2, 3p^6, 3d^8 4s^2$



dsp^2

55. (b) $AlCl_3(Al_2Cl_6)$ in solid state has co-ordination number four.

56. (a) CO is strong ligand and thus, Cr possesses no unpaired electron.

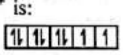


57. (b) $P_4 + \underset{\text{(from air)}}{3O_2} \longrightarrow P_4O_6$

A rapid stream of air (not pure O_2) is passed over phosphorus sticks. N_2 present in air retards further oxidation of P_4O_6 to P_4O_{10}.

58. (b) $[Cu(H_2O)_4]\cdot SO_4H_2O$ Co-ordination no. of Cu is four.

59. (b) Cl is weak ligand and thus, Ni^{2+} is:

Ni^{2+} :[Ar] 

No. of unpaired electron = 2

$\mu = \sqrt{n(n+2)} = \sqrt{8} = 2.82$ B.M.

60. (b) Cl^- is replaced by NO_2^- in ionisation sphere.

61. (d) Except NH_4NO_3 rest all gives N_2 but extra pure N_2 can be obtained by heating $Ba(N_3)_2$.

$$2NH_3 + 3CuO \xrightarrow{\Delta} N_2 + 3Cu + 3H_2O$$

$$NH_4NO_3 \xrightarrow{\Delta} N_2O + H_2O$$

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

$$Ba(N_3)_2 \xrightarrow{\Delta} Ba + 3N_2$$

62. (b) Ni^{2+} forms $[NiCl_4]^{2-}$, $[Ni(CN)_4]^{2-}$ and $[Ni(H_2O)_6]^{2+}$ complexes.

Ni^{2+} has $3d^8$ configuration, *i.e.*, two unpaired electrons.

In $[NiCl_4]^{2-}$, Cl^- being weak field ligand and thus complex with sp^3-hybridisation has tetrahedral geometry.

In $[Ni(CN)_4]^{2-}$, CN^- being strong field ligand and thus all the eight electrons are paired to give dsp^2 hybridisation leading to square planar geometry.

In $[Ni(H_2O)_6]^{2+}$, H_2O being weak field ligand and thus complex with sp^3d^2 (outer) hybridisation leads to octahedral geometry.

63. (d) **Haematite :** Fe_2O_3; oxidation number of Fe is +3.

Magnetite : Fe_3O_4 or $FeO\cdot Fe_2O_3$; oxidation number of Fe are +2 (in FeO) and +3 in (Fe_2O_3).

64. (c) **[K]** : $K_3[Fe(CN)_6]$: Fe^{3+} has $3d^5$ configuration; CN^- is strong field ligand and thus four electrons are paired leaving one unpaired electron with d^2sp^3 hybridisation and thus **paramagnetic.**

[L] : $[Co(NH_3)_6]Cl_3$: Co^{3+} has $3d^6$ configuration; NH_3 is strong field ligand and thus all the six electrons are paired with d^2sp^3-hybridisation and therefore **diamagnetic.**

[M] : $Na_3[Co(ox)_3]$; Co^{3+} has $3d^6$ configuration; $C_2O_4^{2-}$ is strong field ligand and thus all the six electrons are paired with d^2sp^3-hybridisation and therefore **diamagnetic.**

[N]: $[Ni(H_2O)_6]Cl_2$: Ni^{2+} has $3d^8$ configuration with two unpaired electrons. H_2O is weak field ligand and thus sp^3d^2-hybridisation and **paramagnetic.**

[O] : $K_2[Pt(CN)_4]$: Pt^{2+} has $3d^8$ configuration; CN^- is strong field ligand and thus all the eight electrons are paired with dsp^2-hybridisation and therefore **diamagnetic.**

[P] : $[Zn(H_2O)_6](NO_2)_2$: Zn^{2+} has $3d^{10}$ configuration and thus all are paired showing sp^2d^2 hybridisation and so **diamagnetic.**

65. (a) In presence of HCl, dissociation of H_2S is suppressed (common ion effect) and thus $[S^{2-}]$ ions present in solution are less. K_{sp} of CuS and HgS being low and thus the product of ionic concentrations of $[Cu^{2+}][S^{2-}]$ and $[Hg^{2+}][S^{2-}]$ becomes more than their respective K_{sp}. Thus only CuS and HgS are precipitated. MnS and NiS can be precipitated in presence of higher $[S^{2-}]$, *i.e.*, in alkaline medium.

66. (d) Follow IUPAC rules for complex compounds

$[Co(H_2O)_4(NH_3)_2]Cl_3$

Diamminetetraaquacobalt (III) chloride.

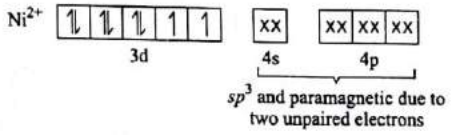
67. (b) The reactions involved in cyanide extraction process are:

$$\underset{\text{(argentite ore)}}{Ag_2S} + 4NaCN \longrightarrow 2Na[Ag(CN)_2] + Na_2S$$

$$4Na_2S + \underset{\text{(oxidising agent)}}{5[O_2]} + 2H_2O \longrightarrow 2Na_2SO_4 + 4NaOH + 2S$$

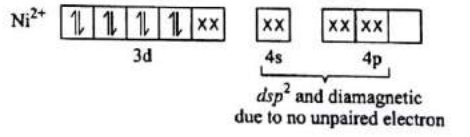
$$2Na[Ag(CN)_2] + \underset{\text{(reducing agent)}}{Zn} \longrightarrow Na_2[Zn(CN)_4] + 2Ag\downarrow$$

68. (c) Ni exists as Ni^{2+} in the complex when paramagnetic showing sp^3 (tetrahedral) hybridization



xx represents electron pair donated in form of pair by the ligands

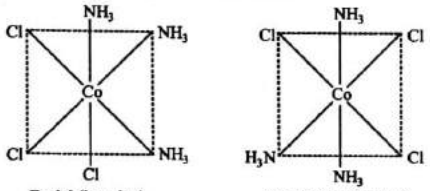
Ni exists as Ni^{2+} in the complex when diamagnetic showing dsp^2 (square planar geometry) hybridization.



69. (a) Aqueous solution of copper sulphate absorbs orange red light and shows complementary colour *i.e.*, blue-green.

70. (c) $CH_3—N=C=O$ (methyl isocyanate) was leaked.

71. (a) $[Co(NH_3)_3Cl_3]$ is MA_3B_3 type and show fac and mer isomers and not optical isomerism.



Facial (inactive) Merdonial (inactive)

72. (c) ONCl has 32 electrons whereas O NO^- has 24 electrons.

73. (c) Sc^{3+} is most stable due to noble gas configuration
Fe^{3+} is more stable due to half filled nature

Mn shows	+7,+6,+5,+4,+3,+2, states
Cr shows	+6,+5,+4,+3,+2,+1, states
Ti shows	+4,+3,+2,
Se shows	+3,+2,

V^{2+}, Cr^{2+}, Mn^{2+} and Fe^{2+} have 3, 4, 5 and 4 unpaired electrons respectively and thus

$$V^{2+} < Cr^{2+} = Fe^{2+} < Mn^{2+}$$

Ionic size in Å :	Ni^{2+}	Co^{2+}	Fe^{2+}	Mn^{2+}
	0.72	0.74	0.76	0.80

74. (b) $[FeF_6]^{-3} \longrightarrow Fe^{+3} \longrightarrow d^5$ configuration,

(*P*)

F^- is weak field ligand | 1 | 1 | 1 | 1 | 1 |

unpaired electrons = 5; $\therefore \mu = \sqrt{5(5+2)} = 5.92$ B.M.

$[V(H_2O)_6]^{2+} \longrightarrow V^{+2} \longrightarrow d^3$ configuration,

(*R*)

H_2O is weak field ligand | 1 | 1 | 1 | | |

unpaired electron = 3; $\therefore \mu = \sqrt{3(3+2)} = 3.87$ B.M.

$[Fe(H_2O)_6]^{2+} \longrightarrow Fe^{+2} \longrightarrow d^6$ configuration,

(*Q*)

H_2O is weak field ligand | ↿⇂ | 1 | 1 | 1 | 1 |

unpaired electron = 4; $\therefore \mu = \sqrt{4(4+2)} = 4.90$ B.M.

Therefore only spin magnetic moment $(\mu) = \sqrt{n(n+2)}$ B.M. (n = unpaired electron)

So, μ of $P > R > Q$

75. (a) Metals having high polarising power (Z_{eff}) exist in ore with anions having high polarisibility
Ag, Cu, Pb → Sulphide ores ($Ag_2S, CuFeS_2, PbS$)
Sn → Oxide ore (SnO_2)
Mg → Sea water and dolomite ($CaCO_3, MgCO_3$)
Al → Oxide ore ($Al_2O_3 \cdot 2H_2O$)

76. (b) On standing, HNO_3 decomposes to liberate yellow colour gas NO_2 which dissolves in HNO_3 to impart brown colour to it.

$$HNO_3 \longrightarrow H_2O + NO_2 + 1/2\, O_2$$

77. (d) In analytical chemistry II group and IV group metals ions are precipitated in form of sulphides whereas III group metals (Fe, Al, Cr) are precipitated as hydroxides.
Fe (III) and Al (III) → III group
Zn (II) → IV group (precipitated as sulphide, ZnS)
Mg (II) → V group

OBJECTIVE PROBLEMS (More Than One Answer Correct)

1. Which are correct for C_{60} form of carbon and other crystalline forms of carbon like C_{50}.
   (a) It is a crystalline state of carbon
   (b) It has 20 hexagons and 12 pentagons having a truncated icosahedron (soccer ball) structure
   (c) It is known as buckminsterfullerene
   (d) Other crystalline forms of C such as C_{50}, etc., have also been discovered
2. Which are correct for the CNT form of carbon?
   (a) It is a crystalline state of carbon
   (b) It has 20 hexagons and 5 pentagons structure and is called carbon nanotube
   (c) It is 100 times stronger than steel
   (d) The size of carbon atoms in CNT ranges from 1 – 10 nm
3. Which of the following are correct statements?
   (a) A reaction between an oxidant and a reductant gives a compound of lower oxidation state if reductant is in excess
   (b) A reaction between an oxidant and a reductant gives a compound of higher oxidation state if oxidant is in excess
   (c) A reaction between an oxidant and a reductant gives a compound of lower oxidation state if oxidant is in excess
   (d) A reaction between an oxidant and a reductant gives a compound of higher oxidation state if reductant is in excess
4. Which of the following are amphoteric oxides?
   (a) Na_2O (b) BaO
   (c) Al_2O_3 (d) ZnO
5. Which of the following are acidic oxides?
   (a) CO_2 (b) P_2O_3
   (c) Mn_2O_7 (d) CrO_3
6. Select the neutral oxides:
   (a) H_2O (b) CO_2
   (c) NO (d) N_2O
7. Which of the followings are named after the names of planets and are radioactive?
   (a) Np (b) Pu
   (c) Po (d) Fr
8. Which properties are correctly matched?
   (a) Ionisation energy : $N > O$ and $N^+ < O^+$
   (b) Electron affinity : $N < O$ and $N^- < O^-$
   (c) Atomic radius : $Ne > F$ and $Al \simeq Ga$
   (d) Electron affinity : $Cl > F$ and $S > O$
9. In which bond angles are correctly matched?
   (a) $PI_3 > AsI_3 > SbI_3$
   (b) $NH_3 > PH_3 > AsH_3$
   (c) $PF_3 > PCl_3 < PBr_3 < PI_3$
   (d) $NO_2^+ > NO_2 > NO_2^-$
10. Which of the following statements are correct?
   (a) PF_3 acts as electron pair donor
   (b) Electron pair donor tendency of NF_3 is lesser than PF_3
   (c) SbF_3 acts as electron pair acceptor
   (d) $SbCl_3$ on dissolving in water gives $Sb(OH)_3$
11. Select the correct statements:
   (a) CO_2 and N_3^- are isoelectronic
   (b) CO_2 and N_3^- are isostructural
   (c) Both have bond order equal to two
   (d) Both have two σ and two π bonds and show *sp*-hybridisation
12. Which of the following in each has more polarising nature?
   (a) $Fe^{3+} > Fe^{2+}$ (b) $Mn^{2+} > Mn^{7+}$
   (c) $Sn^{4+} > Sn^{2+}$ (d) $V^{4+} > V^{3+}$
13. Which of the following do not give NH_3 on heating?
   (a) NH_4NO_3 (b) $(NH_4)_2Cr_2O_7$
   (c) NH_4Cl (d) $(NH_4)_2SO_4$
14. Shielding constant Ne is equal to 4.15. Which of the following have same shielding constant?
   (a) Na (b) Na^+
   (c) F (d) F^-
15. Select the correct statements:
   (a) All of the halogens are oxidised in O_2
   (b) $BiCl_5$ does not exist
   (c) Pb^{4+} salts are better oxidants than Ge^{4+} salts
   (d) EA_1 for Zn is +ve whereas for Cu it is –ve
16. Select the incorrect reactions:
   (a) $CH_3I + H_2O \longrightarrow CH_3OH + HI$
   (b) $CF_3I + H_2O \longrightarrow CF_3OH + HI$
   (c) $SbCl_3 + 3H_2O \longrightarrow Sb(OH)_3 + 3HCl$
   (d) $PCl_3 + 3H_2O \longrightarrow P(OH)_3 + 3HCl$
17. Select the correct reactions:
   (a) $SiO_2 + 2Mg \longrightarrow Si + 2MgO$
   (b) $Si + 2MgO \xrightarrow{1000°C} SiO_2 + 2Mg$
   (c) $SiO_2 + CaO \longrightarrow CaSiO_3$
   (d) $HgS + Fe \longrightarrow FeS + Hg$
18. Which are not used to prepare H_2 by the action over Zn?
   (a) Conc. H_2SO_4 (b) Conc. HCl
   (c) Dil. H_2SO_4 (d) HNO_3

19. Addition of which salt in substantial amount will cause hardness in water?
(a) $Th(NO_3)_4$ (b) $Ca(NO_3)_2$
(c) $Mg(NO_3)_2$ (d) $La(NO_3)_2$

20. Which of the following forms alums?
(a) Li^+ (b) Na^+
(c) Al^{3+} (d) Cr^{3+}

21. Select the correct reactions:
(a) $KF + BrF_3 \longrightarrow K[BrF_4]$
(b) $4KO_2 + 4CO_2 + 2H_2O \longrightarrow 4KHCO_3 + 3O_2$
(c) $2NaNO_3 \xrightarrow{500°C} 2NaNO_2 + O_2$
(d) $4NaNO_3 \xrightarrow{800°C} 2Na_2O + 5O_2 + 2N_2$

22. Which one are correctly represented?
(a) $Ag_2S_2O_3$—white (b) $Fe_2(S_2O_3)_3$—violet
(c) $Cu_2S_2O_3$—white (d) Ag_2S—white

23. Which are correct for the reaction $M^+ + Aq. \longrightarrow M^+_{(aq.)}$?
(a) $\Delta G = -$ ve (b) $\Delta H = -$ ve
(c) $\Delta S = -$ ve (d) $\Delta S = +$ ve

24. The metal bicarbonates which do not exist in solid state are:
(a) $LiHCO_3$ (b) $Ca(HCO_3)_2$
(c) $Zn(HCO_3)_2$ (d) $Ag(HCO_3)$

25. Which orders are correctly matched?
(a) Solubility in water : $BaF_2 < MgF_2 < BeF_2$
(b) Hydrolysis nature : $CaCl_2 < MgCl_2 < BeCl_2$
(c) Covalent nature : $CaCl_2 > MgCl_2 > BeCl_2$
(d) Lattice energy : $BaF_2 < CaF_2 < MgF_2$

26. An element (*A*) burns in N_2 to give ionic compound (*B*). Compound (*B*) reacts with water to give (*C*) and (*D*). Solution of (*C*) becomes milky on boiling CO_2. Element (*A*) may be:
(a) Ca (b) Mg
(c) Ba (d) Be

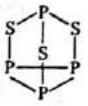
27. Which of the followings are pseudo alums?
(a) $MnSO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$
(b) $FeSO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$
(c) $(NH_4)_2SO_4 \cdot Fe_2(SO_4)_3 \cdot 24H_2O$
(d) $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$

28. Select the correct statements about $B(OH)_3$:
(a) It is a weak Bronsted base
(b) It is a weak Lewis acid
(c) It's acidic nature increases in presence of diols
(d) It's basic nature increases in presence of diols

29. Which of the following are slippery solids?
(a) Boron nitride (b) Graphite
(c) Carborundum (d) Diamond

30. Which are correct about diborane structure?
(a) Boron is approximately sp^3-hybridised
(b) There are two terminal B—H bonds on each boron atom
(c) There are only 12 bonding electrons
(d) It has one 3 centred banana bond (3C—2*e* bond)

31. Select the correct statement about CO :
(a) It acts as Lewis acid in formation of carbonyls
(b) It is a neutral oxide of carbon
(c) It reacts with NaOH at high *P*, *T* to give HCOONa
(d) It acts as π acceptor by accepting electron from the central metal during complex formation

32. Which are correct about P_4S_3?
(a) P is trivalent and S is divalent
(b) It has structure 
(c) Average oxidation number of P and S are +3/2 and −2 respectively
(d) It is used in match industry

33. Select the correct statements:
(a) NF_3 and NCl_3 are exothermic compounds
(b) NF_3 and NCl_3 are endothermic compounds
(c) NF_3 is exothermic compound
(d) NCl_3 is endothermic compound

34. Which of the following are known?
(a) SO_2F_2 (b) SO_2Cl_2
(c) SO_2FBr (d) SO_2I_2

35. Which are the characteristics of S_4N_4?
(a) It has two S—S weak bonds
(b) It is thermochromic
(c) It has a cage structure
(d) It detonates on shock, grinding or sudden heating

36. Cyclic trimer of SO_3 has:
(a) 4 (S = O) bonds (b) 3 (S—O—S) bonds
(c) one (S—S) bond (d) 6 (S—O) bonds

37. Which of the following halogen oxides are known?
(a) F_2O (b) Cl_2O_7
(c) Cl_2O_5 (d) I_2O_7

38. Which of the halogen acids have pK_a values −ve?
(a) HF (b) HCl
(c) HBr (d) HI

39. Which of the following are ionic compounds?
(a) $I(CH_3COO)_3$ (b) $I(IO_3)_3$
(c) IPO_4 (d) ICl_3

40. Which of the following are correctly matched?
(a) $XeOF_4$: sp^3d^2, square pyramidal
(b) $XeOF_2$: sp^3d, T-shaped
(c) XeO_3 : sp^3, Trigonal pyramid
(d) XeO_2F_2 : sp^3d, See-saw

41. Which of the following are correct for liquid He?
(a) He (liq.) exists in two forms He (I) and He (II)
(b) He (II) is called superfluid. It is a low conducting and high surface tension liquid
(c) He (II) is used for cryogenic applications
(d) He (I) on cooling at 2.19 K and 38 mm pressure changes to He (II)

42. Select the correct statements:
(a) $[Co(NH_3)_6]^{2+}$ is readily oxidised to $[Co(NH_3)_6]^{3+}$
(b) Co^{2+} is very stable and difficult to oxidise
(c) Ni^{2+} compounds are more stable than Pt^{2+}
(d) Ni^{4+} compounds are less stable than Pt^{4+}

43. CN^- acts as:
(a) reducing agent (b) oxidising agent
(c) complexing agent (d) ligand

44. A square planar complex uses the hybridisation of:
(a) *s*-orbitals (b) p_x-orbitals
(c) d_{z^2}-orbitals (d) $d_{x^2-y^2}$-orbitals

45. Which of the following have EAN equal to next inert gas?
(a) $Fe(CO)_5$ (b) $Co_2(CO)_8$
(c) $H_2Cr(CO)_5$ (d) $Cr(NH_3)_6Cl_3$

46. Which of the following are used in preparing iodised salt?
(a) KIO_3 (b) KI
(c) I_2 (d) HI

47. The chemicals used in preparation of MIC, *i.e.*, methyl isocyanate component of Bhopal gas tragedy are:
(a) CH_3NH_2 (b) $COCl_2$
(c) PH_3 (d) $(CH_3)_2NH$

48. $NaNO_3$ decomposes above 800°C to give:
(a) N_2 (b) O_2
(c) NO_2 (d) Na_2O

49. Addition of high proportions of Mn makes steel useful in making rails of rail roads because manganese:
(a) gives hardness to steel
(b) helps the formation of oxides of iron
(c) can remove oxygen and sulphur
(d) can show highest oxidation state of +7

50. Which of the following statements are correct when a mixture of NaCl and $K_2Cr_2O_7$ is gently warmed with conc. H_2SO_4?
(a) Deep red vapours are evolved
(b) Cl_2 gas is evolved
(c) Chromyl chloride is formed
(d) Evolved vapours on passing in NaOH give yellow solution of Na_2CrO_4

51. Which of the following are coloured?
(a) $Ti(NO_3)_4$ (b) $[Cu(NC\cdot CH_3)_4]^+BF_4^-$
(c) $[Cr(NH_3)_6]Cl_3^-$ (d) $K_3[VF_6]$

52. Nitrogen (I) oxide is produced by:
(a) thermal decomposition of NH_4NO_3
(b) disproportionation of N_2O_4
(c) thermal decomposition of NH_4NO_2
(d) interaction of hydroxyl amine and HNO_2

53. When zeolite (a hydrated sodium aluminium silicate) is treated with hard water, the sodium ions are exchanged with:
(a) H^+ ions (b) Ca^{2+} ions
(c) SO_4^{2-} ions (d) Mg^{2+} ions

54. The materials used in solar cell contains:
(a) Cs (b) Si
(c) Sn (d) Ti

55. Highly pure dilute solution of Na in liquid NH_3:
(a) shows blue colour
(b) exhibits electrical conductivity
(c) produces sodium amide
(d) produces H_2 gas

56. White phosphorus (P_4) has:
(a) six P—P single bonds
(b) four P—P single bonds
(c) four lone pairs of electron
(d) PPP bond angle of 60°

57. NH_3 on reaction with hypochlorite ion, can form:
(a) NO (b) NH_4Cl
(c) N_2H_4 (d) HNO_2

58. Which of the following alloys contains Cu and Zn:
(a) Bronze (b) Brass
(c) Gun metal (d) Type metal

59. The aqueous solution of which salts are coloured:
(a) $Co(NO_3)_2$ (b) $CrCl_3$
(c) $Zn(NO_3)_2$ (d) $CaCl_2$

60. Potassium manganate (K_2MnO_4) is formed when:
(a) Cl_2 is passed in $KMnO_4$ aq.
(b) MnO_2 is fused with KOH in air
(c) HCHO reacts with $KMnO_4$ in presence of strong alkali
(d) $KMnO_4$ reacts with conc. H_2SO_4

61. The statements that are true for the long form of the periodic table are :
(a) It reflects the sequence of filling the electrons in the order of sub-energy level *s*, *p*, *d* and *f*
(b) It helps to predict the stable valency states of the elements
(c) It reflects trends in physical and chemical properties of the elements
(d) It helps to predict the relative ionicity of the bond between any two elements

62. In the electrolysis of alumina, cryolite is added to :
(a) lower the melting point of alumina
(b) increase the electrical conductivity

(c) minimise the anode effect
(d) remove impurities from alumina

63. Of the following the metals that cannot be obtained by electrolysis of the aqueous solution of their salts are :
(a) Ag (b) Mg
(c) Cu (d) Al

64. The compounds used as refrigerant are :
(a) NH_3 (b) CCl_4
(c) CF_4 (d) CF_2Cl_2

65. The major role of fluorspar (CaF_2), which is added in small quantities in the electrolytic reduction of alumina dissolved in fused cryolite (Na_3AlF_6) is :
(a) As a catalyst
(b) To make the fused mixture very conducting
(c) To lower the temperature of the melt
(d) To decrease the rate of oxidation carbon at the anode

66. $MgSO_4$ on reaction with NH_4OH and Na_2HPO_4 forms a white crystalline precipitate. What is its formula?
(a) $Mg(NH_4)PO_4$ (b) $Mg_3(PO_4)_2$
(c) $MgCl_2 \cdot MgSO_4$ (d) $MgSO_4$

67. The aqueous solution of the following salts will be coloured in the case of :
(a) $Zn(NO_3)_2$ (b) $LiNO_3$
(c) $Co(NO_3)_2$ (d) $CrCl_3$

68. If the bond length of CO bond in carbon monoxide is 1.128Å, then what is the value of CO bond length in $Fe(CO)_5$?
(a) 11.28 pm (b) 110 pm
(c) 113 pm (d) 120 pm

69. The reagents, NH_4Cl and aqueous NH_3 will precipitate :
(a) Ca^{2+} (b) Al^{3+}
(c) Bi^{3+} (d) Zn^{2+}

70. Which of the following statement(s) is (are) correct with reference to the ferrous and ferric ions :
(a) Fe^{3+} gives brown colour with potassium ferricyanide
(b) Fe^{2+} gives blue precipitate with potassium ferricyanide
(c) Fe^{3+} gives red colour with potassium thiocyanate
(d) Fe^{2+} gives brown colour with ammonium thiocyanate

71. The species present in solution when CO_2 is dissolved in water are :
(a) $CO_2, H_2CO_3, HCO_3^-, CO_3^{2-}$
(b) H_2CO_3, CO_3^{2-}
(c) CO_3^{2-}, HCO_3^-
(d) CO_2, H_2CO_3

72. In which of the following oxides P-atom has two different oxidation states.
(a) P_4O_6 (b) P_4O_7
(c) P_4O_{10} (d) P_4O_8

73. Select the correct statements :
(a) O_2 is a weak field ligand
(b) ClF_3 is used in enrichment of uranium
(c) ICl is more reactive than I_2
(d) $O_3, CO, CO_2, NO_2, N_2O, CH_4, CFCl_3$ are green house gases

74. Select the correct statements :
(a) oxyhaemoglobin is bright red
(b) deoxyhaemoglobin is purple
(c) oxyhaemoglobin is low spin complex
(d) oxyhaemoglobin absorbs hight of longer wave length

75. Select the correct statements :
(a) Solubility of salts containing anions *i.e.*, Cl^-, SO_4^{2-} that do not hydrolyse are unaffected by pH
(b) Solubility of BaF_2 in water increases in presence of H^+ ions
(c) Solubility of $Mg(OH)_2$ may increase or decrease with pH
(d) On adding lime juice into tea, the colour of tea becomes darker

76. When PbO_2 reacts with conc. HNO_3, the gas evolved is: **(IIT 2005)**
(a) NO_2 (b) O_2
(c) N_2 (d) N_2O

77. A solution of colourless salt H on boiling with excess NaOH produces a non-inflammable gas. The gas evolution ceases after sometime. Upon addition of Zn dust to the same solution, the gas evolution restarts. The colourless salts (H) is/are: **(IIT 2008)**
(a) NH_4NO_3 (b) NH_4NO_2
(c) NH_4Cl (d) $(NH_4)_2SO_4$

78. Which are correct about $[Fe(H_2O)_5NO]SO_4$? **(Modified IIT 2008)**
(a) It is diamagnetic as it has no unpaired electron
(b) It is paramagnetic as it has three unpaired electrons
(c) Ox. no. of Fe is +2
(d) Ox. no. of Fe is +1

79. The nitrogen oxide(s) that contain(s) N—N bond(s) is(are): **(IIT 2009)**
(a) N_2O (b) N_2O_3
(c) N_2O_4 (d) N_2O_5

80. The compound(s) formed upon combustion of sodium metal in excess air is(are): **(IIT 2009)**
(a) Na_2O_2 (b) Na_2O
(c) NaO_2 (d) NaOH

81. The compound(s) that exhibit(s) geometrical isomerism is(are): **(IIT 2009)**
(a) $[Pt(en)Cl_2]$ (b) $[Pt(en)_2]Cl_2$
(c) $[Pt(en)_2Cl_2]Cl_2$ (d) $[Pt(NH_3)_2Cl_2]$

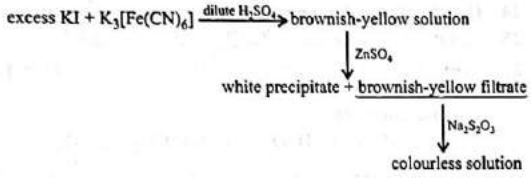
82. The reagents used for softening the temporary hardness of water is (are): **(IIT 2010)**

(a) $Ca_3(PO_4)_2$ (b) $Ca(OH)_2$
(c) Na_2CO_3 (d) NaOCl

83. Extraction of meta from the ore cassiterite involves : **(IIT 2011)**
(a) Carbon reduction of an oxide ore
(b) Self reduction of a sulphide ore
(c) removal of copper impurity
(d) removal of iron impurity

84. Which of the following hydrogen halides react(s) with $AgNO_3(aq)$ to give a precipitate that dissolves in $Na_2S_2O_3(aq)$? **(IIT 2012)**
(a) HCl (b) HF
(c) HBr (d) HI

85. For the given aqueous reactions, which of the statement(s) is (are) true? **(IIT 2012)**



(a) The first reaction is a redox reaction.
(b) White precipitate is $Zn_3[Fe(CN)_6]_2$.
(c) Addition of filtrate to starch solution gives blue colour.
(d) White precipitate is soluble in NaOH solution.

86. With respect to graphite and diamond, which of the statement(s) given below is (are) correct? **(IIT 2012)**
(a) Graphite is harder than diamond.
(b) Graphite has higher electrical conductivity than diamond.
(c) Graphite has higher thermal conductivity than diamond.
(d) Graphite has higher C—C bond order than diamond.

87. The pair(s) of coordination complexes/ions exhibiting the same kind of isomerism is (are) : **[JEE (Advanced) I 2013]**
(a) $[Cr(NH_3)_5Cl]Cl_2$ and $[Cr(NH_3)_4Cl_2]Cl$
(b) $[Co(NH_3)_4Cl_2]^+$ and $[Pt(NH_3)_2(H_2O)Cl]^+$
(c) $[CoBr_2Cl_2]^{2-}$ and $[PtBr_2Cl_2]^{2-}$
(d) $[Pt(NH_3)_3(NO_3)]Cl$ and $[Pt(NH_3)_3Cl]Br$

88. The correct statement(s) about O_3 is/are : **[JEE (Advanced) II 2013]**
(a) O—O bond lengths are equal
(b) Thermal decomposition of O_3 is endothermic
(c) O_3 is diamagnetic in nature
(d) O_3 has a bent structure

89. The carbon-based reduction method is NOT used for the extraction of: **[JEE (Advanced) II 2013]**
(a) tin from SnO_2
(b) iron from Fe_2O_3
(c) aluminium from Al_2O_3
(d) magnesium from $MgCO_3 \cdot CaCO_3$

SOLUTIONS (More Than One Answer Correct)

1. (a,b,c,d) These are facts.
2. (a,b,c,d) —do—
3. (a,b,c,d) $\underset{\text{red-oxi.}}{\overset{0}{Cl_2}} + 2NaOH \longrightarrow Na\overset{-1}{Cl} + Na\overset{+1}{ClO} + H_2O$

$$\underset{\text{red-oxi.}}{\overset{0}{3Cl_2}} + NaOH \longrightarrow Na\overset{-1}{Cl} + Na\overset{+3}{ClO_3} + 3H_2O$$

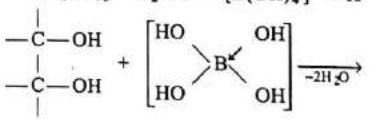
4. (c,d) ZnO, Al_2O_3, BeO, SnO_2 and As_2O_3 are amphoteric. Alkali and alkaline earth metal oxides (except BeO) are strong bases.
5. (a,b,c,d) Non-metal oxides (NO_2, N_2O_3, N_2O_5, CO_2, P_2O_3, P_2O_5,...etc.) are acidic. Mn_2O_7 and CrO_3 are acidic oxides although metal oxides are basic or amphoteric.
6. (a,c,d) CO_2 is acidic but CO is neutral.
7. (a,b) Np is naptunium (Naptune) and Pu is plutonium (Pluto).
8. (a,b,c,d) Follow text.
9. (a,b,c,d) PI_3, AsI_3, SbI_3 : 102°, 100.2°, 99° (P being smallest exerts b.p.-b.p. repulsion strongly)
   NH_3, PH_3, AsH_3: 106°51′, 93.5°, 91.5° (Due to decreasing electronegativity of central atom)
   PF_3, PCl_3, PBr_3, PI_3 : 102°, 100°, 101.5°, 102° (Due to back bonding in PF_3)
   NO_2^+, NO_2, NO_2^- :180°, 134°, 115° (b.p.–b.p. < b.p.–electron < b.p.–l.p.)
10. (a,b,c) $Ni(CO)_4 + 4PF_3 \longrightarrow Ni(PF_3)_4 + 4CO$
    Due to small size of N—F bond than P—F bond
    $SbF_3 + 2F^- \longrightarrow (SbF_5)^{2-}$;
    $SbCl_3 + H_2O \longrightarrow SbOCl + 2HCl$
11. (a,b,c,d) $\underset{sp}{O=C=O}$ $[\underset{sp}{N=N=N}]^-$; both are linear and have 22 electrons.
12. (a,b,c) More is the charge on cation more is the polarising power. However a metal ion with noble gas configuration has less polarising power due to increased shielding effect in noble gas configuration ion.
13. (a,b) $NH_4NO_3 \xrightarrow{\Delta} N_2O + 2H_2O$
    $(NH_4)_2Cr_2O_7 \longrightarrow N_2 + Cr_2O_3 + 4H_2O$
14. (b,d) Both have $1s^2, 2s^2, 2p^6$ configuration like Ne.
15. (b,c,d) F_2 is reduced, Bi^{5+} is not possible due to inert pair effect. Stability order of $Pb^{4+} < Ge^{4+}$ due to inert pair effect . Zn has completely filled orbitals and Cu has $3d^{10}, 4s^1$.
16. (b,c) $[CF_3]^{-\delta}I^{+\delta} + H_2O \longrightarrow CF_3H + IOH$
    $SbCl_3 + H_2O \longrightarrow SbOCl + 2HCl$
17. (a,b,c,d) All are used in extraction of metals.
18. (a,b,d) Conc. H_2SO_4 and HNO_3 oxidises H_2, conc. HCl forms a coating of $ZnCl_2$ over Zn and thus the reaction stops after little time.
    $Zn + \text{dil. } H_2SO_4 \longrightarrow ZnSO_4 + H_2$
19. (a,b,c,d) All these cations forms insoluble $(RCOO)_X M$ salt.
20. (b,c,d) Alum is $M_2'(SO_4)\cdot M_2''(SO_4)_3\cdot 24H_2O$. However, Li does not form alum as it cannot co-ordinate $6H_2O$ molecules due to small size of Li^+.
21. (a,b,c,d) All occurs as shown.
22. (a,b,c) Ag_2S is black.
23. (a,b,c) Hydration of ion is spontaneous and exothermic. Also, randomness decreases.
24. (b,c,d) Only alkali metal bicarbonates exis in solid state.
25. (a,b,d) Covalent nature $CaCl_2 < MgCl_2 < BeCl_2$.
26. (a,c) $3M + N_2 \longrightarrow \underset{B}{M_3N_2}$; $Mg(OH)_2$ and $Be(OH)_2$ are insoluble

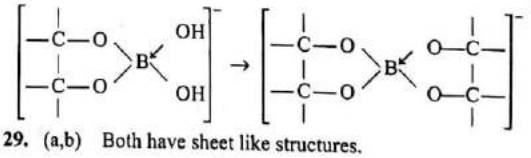
$$M_3N_2 + 6H_2O \longrightarrow \underset{C}{3M(OH)_2} + \underset{D}{2NH_3}$$

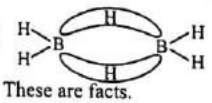
$$M(OH)_2 + CO_2 \longrightarrow \underset{\text{Milky}}{MCO_3} + H_2O$$

27. (a,b) Alums are $M_2'SO_4\cdot M_2'''(SO_4)_3\cdot 24H_2O$. If M' is bivalent then it is pseudo alum.
28. (b,c) $B(OH)_3$ is H_3BO_3, *i.e.*, boric acid, a weak Lewis monoboric acid. It forms 1:1 complex with diols.

$$B(OH)_3 + H_2O \rightleftharpoons [B(OH)_4]^- + H^+$$





29. (a,b) Both have sheet like structures.
30. (a,b,c,d) 
31. (b,c,d) These are facts.
32. (a,b,c,d) One P has +3 ox. no. and 3P has +1 ox. no.

$$\therefore \quad \text{Aq.} = \frac{1\times 3 + 3\times 1}{4} = +\frac{6}{4} = +\frac{3}{2}$$

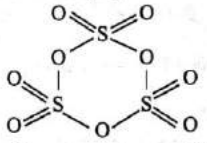
33. (c,d) $\frac{1}{2}N_2 + \frac{3}{2}F_2 \longrightarrow NF_3$; $\Delta H_f = -109\,\text{kJ}$

$$\frac{1}{2}N_2 + \frac{3}{2}Cl_2 \longrightarrow NCl_3;\ \Delta H_f = +230\,\text{kJ}$$

N—F bond energy > F—F bond energy; N — Cl bond energy < Cl—Cl bond energy.

34. (a,b,c) SO_2Br_2 and SO_2I_2 are unstable.

35. (a,b,c,d) All are facts about S_4N_4.

36. (a,b,d) $(SO_3)_3$ is 

37. (a,b) Cl_2O_5 and I_2O_7 are not known. OF_2 is oxygen difluoride.

38. (b,c,d) pK_a for HF, HCl, HBr and HI are 3, −7, − 9, − 10 respectively.

39. (a,b,c) I^{+3} and anions are CH_3COO^-, IO_3^-, PO_4^{3-}.

40. (a,b,c,d) All are facts.

41. (a,b,c,d) — do —

42. (a,b,c,d) — do —

43. (a,c,d) CN^- does not act as oxidant.

44. (a,b,d) Square planar complex involves s, p_x, p_y and $d_{x^2-y^2}$ orbitals.

45. (a,b,c) EAN of Cr = 24 − 3 + (2 × 6) = 33

46. (a,b) It is fact.

47. (a,b) $CH_3NH_2 + COCl_2 \longrightarrow \underset{\text{MIC}}{CH_3N{=}C{=}O} + 2HCl$

48. (a,b,d) $NaNO_3 \xrightarrow{\Delta} NaNO_2 + \frac{1}{2}O_2$

$2NaNO_3 \longrightarrow Na_2O + N_2 + \frac{5}{2}O_2$

49. (a,c,d) Manganese (Mn) imparts hardness to steel as well as removes oxygen and sulphur from steel by forming slag as $MnSiO_3$.

$Fe_2O_3 + 3Mn \longrightarrow 3MnO + 2Fe$

$MnO + SiO_2 \longrightarrow \underset{\text{(slag)}}{MnSiO_3}$

50. (a,c,d) This is chromyl chloride test

$K_2Cr_2O_7 + 4NaCl + 3H_2SO_4 \longrightarrow K_2SO_4 + 2CrO_2Cl_2 + 2Na_2SO_4 + 3H_2O$

51. (c,d) Cu^+ and Ti^{4+} have no unpaired electron, thus colourless.

52. (a,d) $NH_4NO_3 \xrightarrow{\Delta} \mathbf{N_2O} + 2H_2O$

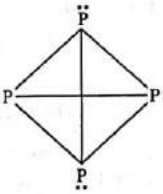
$NH_2OH \cdot HCl + NaNO_2 \longrightarrow NaCl + 2H_2O + \mathbf{N_2O}$

53. (b,d) Ca^{2+} and Mg^{2+} ions are exchanged.

$Na_2Z + Ca^{2+} \longrightarrow CaZ + 2Na$

54. (a) In solar cells **Cs** is used.

55. (a,b) $Na + (X + Y)NH_3(l) \longrightarrow \underset{\text{Solvated cation}}{[Na(NH_3)_x]^+} + \underset{\text{Solvated electron (blue colour)}}{[Y(NH_3)(l)\cdot e]^-}$

56. (a,c,d)  is P_4

57. (c) $2NH_3 + OCl^- \longrightarrow N_2H_4 + H_2O + Cl^-$

58. (b,c) Bronze : Cu + Sn; Type metal : $\underset{60\%}{Pb} + \underset{30\%}{Sn} + \underset{10\%}{Sb}$.

Gun metal : $\underset{90\%}{Cu} + \underset{8-10\%}{Sn} + \underset{4\%}{Zn}$; Brass : Cu + Zn

59. (a,b) Co^{2+} and Cr^{3+} have unpaired electron.

60. (b,c) $2KOH + MnO_2 + O_2 \longrightarrow K_2MnO_4 + H_2O$

$HCHO + 2KMnO_4 + 2KOH \longrightarrow K_2MnO_4 + H_2O + HCOOH$

61. (a,b,c,d) In the long form of periodic table, elements are arranged in increasing order of their atomic number (*i.e.*, increasing order of energy).

Physical and chemical properties are the periodic functions of their electronic configuration (*i.e.*, atomic number) of element.

62. (a,b) Cryolite is added during the electrolysis of alumina. The functions of cryolite are to lower the melting point and to decrease the conductivity as well.

63. (b,d) These metals are not discharged in aqueous solutions as $E^0_{RP}H^+ > E^0_{RP}(M^{n+})$.

64. (a,d) These are facts.

65. (b,c) These are facts.

66. (a) The product is white ppt. of magnesium ammonium phosphate.

$MgSO_4 + Na_2HPO_4 + NH_4OH \rightarrow Mg(NH_4)PO_4 + Na_2SO_4 + H_2O$

67. (c,d) $Co(NO_3)_2$ and $CrCl_3$ has unpaired '*d*' electron, hence they are coloured; while $Zn(NO_3)_2$, $LiNO_3$ and potash alum have no unpaired electron (completely filled shell) hence they are colourless.

68. (c) In Carbonyls double bonding takes place.

$$OC \underset{\pi}{\overset{\sigma}{\rightleftharpoons}} M$$

For this type of back bonding CO should have filled '*sp*' hybrid orbital as well as vacant antibonding Pi molecular orbital (π^x_y or π^x_2) and metal atoms should be in low oxidation state and should have vacant hybrid and filled '*d*' orbitals.

Due to this back bonding CO bond strengthens and so bond order decreases and bond length slightly increases.

69. (b,c) $Al^{3+} + 3NH_4OH \rightarrow Al(OH)_3\downarrow + 3NH_4^+$

$Bi^{3+} + 3NH_4OH \rightarrow Bi(OH)_3\downarrow + 3NH_4^+$

Al^{3+} and Bi^{3+} are precipitated as their hydroxides.

70. (a,b,c) $3FeCl_2 + 2K_3Fe(CN)_6 \longrightarrow$

$Fe_3^{2+}[Fe^{3+}(CN)_6]_2 + 6KCl$

Turn bull's blue — Femous ferricyanide

$FeCl_3 + K_3Fe(CN)_6 \longrightarrow Fe[Fe(CN)_6] + 3KCl$

Ferric ferricyanide (Brown colour)

The blue, precipitate of Fe^{2+} ions with potassium ferricyanide is due to formation of turnbull's blue.

The red colouration of Fe^{2+} ions with potassium thiocyanate is due to the formation of $[Fe(CNS)Cl_2]$

$Fe^{3+} + KCNS \longrightarrow [Fe(CNS)]^{2+} + K^+$

Blood red colour

71. (a) When CO_2 is dissolved in water, it forms dibasic carbonic acid, which gives HCO_3^- and CO_3^{2-} ions on ionisation. Hence in solution CO_2, H_2CO_3, HCO_3^- and CO_3^{2-} are present.

$$CO_2 + H_2O \rightleftharpoons H_2CO_3$$

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

$$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$$

72. (b,d) In both these P shows +3 and +5 oxidation state.

73. (b,c,d) Rest all are correct. O_2 is strong field ligand (enrichment of uranium is made by converting uranium to UF_{6g})

$U_{(s)} + 3ClF_3 \longrightarrow UF_{6(g)} + 3ClF_{(g)}$

74. (a,b,c) Oxyhaemoglobin is Red and absorbs light of smaller wave length.

75. (a,b,c) Tea contains polyphenols which are weak acids. Lemon juice contains citric acid and thus dissociation of polyphenols decreases in presence of lime juice. The ionised polyphenols are darker in colour and unionised polyphenols are lighter in colour.

$$BaF_2 \rightleftharpoons Ba^{2+} + 2F^-$$

$$F^- + H^+ \longrightarrow HF$$

Weak acid and there for solubility equilibrium shifts to the right.

76. (b) $2PbO_2 \longrightarrow 2PbO + O_2$

$PbO + 2HNO_3 \longrightarrow Pb(NO_3)_2 + H_2O$

77. (a,b) $NH_4NO_3 + NaOH \longrightarrow NH_3\uparrow + NaNO_3 + H_2O$

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

NH_3 is non-inflammable

$NaNO_3 + 4Zn + 7NaOH \longrightarrow 4Na_2ZnO_2 + NH_3 + 2H_2O$

$NaNO_2 + 3Zn + 5NaOH \longrightarrow 3Na_2ZnO_2 + NH_3 + H_2O$

78. (b,d) In iron complex ox. no. of NO = +1 and the Fe is in Fe^+ state, *i.e.*, $3d^6, 4s^1$. 1 electron of *d* is paired by $4s^1$

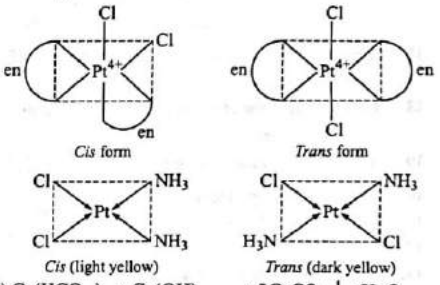
$\boxed{\bullet\bullet}\boxed{\bullet\bullet}\boxed{\bullet}\boxed{\bullet}\boxed{\bullet}$ in presence of NO^+.

79. (a,b,c) $N \equiv N \longrightarrow O$; $O=N-N\overset{O}{\underset{O}{<}}$;

$O\overset{O}{\underset{O}{>}}N-N\overset{O}{\underset{O}{<}}$; $O\overset{O}{\underset{O}{>}}N-O-N\overset{O}{\underset{O}{<}}$

80. (a) $2Na + O_2 \xrightarrow[air]{} Na_2O_2$

81. (c,d)



82. (b,c,d) $Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow 2CaCO_3\downarrow + H_2O$

(Clark's method)

$Ca(HCO_3)_2 + Na_2CO_3 \longrightarrow CaCO_3\downarrow + 2NaHCO_3$

(Both permanent and temporary hardness are removed by Na_2CO_3)

$NaOCl + H_2O \longrightarrow HOCl + NaOH$ (–do–)

$2NaOH + Ca(HCO_3)_2 \longrightarrow CaCO_3\downarrow + Na_2CO_3 + H_2O$ (–do–)

83. (a,c,d) Cassiterite is an ore of SnO_2. The extraction of Sn involves the following steps.

$SnO_2 + 2C \longrightarrow Sn + 2CO$ (Smelting)

The liquid metal Sn contains impurities Cu, iron, tungsten which are removed by flowing liquid metal on inclined plane, leaving behind iron, copper and tungsten. The molten metal is then stirred with a green wood pole to oxidise impurities of S, As.

84. (a,c,d)

$HX + AgNO_3 \longrightarrow AgX\downarrow + HNO_3$ (X = Cl, Br, I)

$AgX + 2Na_2S_2O_3 \longrightarrow Na_3[Ag(S_2O_3)_2] + NaX$

sodium argentothiosulphate colourless solution

AgF is water soluble.

85. (a,c,d)

$K_3[\overset{+3}{Fe}(CN)_6] + KI(\text{excess}) \longrightarrow K_4[\overset{+2}{Fe}(CN)_6] + KI_3$ (redox reaction)

(Brownish yellow solutions)

$I_3^- + 2Na_2S_2O_3 \longrightarrow Na_2S_4O_6 + 2NaI + I^-$

(Brownish yellow filterate) — Clear solution

$K_4[Fe(CN)_6] + ZnSO_4 \longrightarrow K_2Zn_3[Fe(CN)_6]_3$

(White ppt.)

$\xrightarrow{NaOH} Na_2[Zn(OH)_4]$ Soluble

Starch gives blue colour with I_2 present with I_3^- ($I_2 + I^-$)

86. (b,d)

- Diamond is harder than graphite.
- Graphite is good conductor of electricity as each carbon is attached to three C-atoms involving sp^2 hybridization leaving one p-orbital electron free, which is responsible for electrical conduction, while in diamond, all the four valencies of carbon are satisfied, hence insulator.
- Diamond is better thermal conductor than graphite. Electrical conduction is due to avialability of free p-orbital electrons; whereas thermal conduction is due to transfer of thermal vibrations from atom to atom. A compact and precisely aligned crystal structure of diamond facilitates fast movement of heat.
- In graphite, C—C bond acquires double bond character, hence higher bond order than in diamond.

87. (b,d)

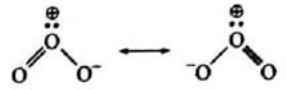
(a) $[Cr(NH_3)_5Cl]Cl_2$ shows ionisation isomerism with $[Cr(NH_3)_4Cl_2]Cl$, but $[Cr(NH_3)_4Cl_2]Cl$ also show geometrical isomerism

(b) Both $[Co(NH_3)_4Cl_2]^+$ and $[Pt(NH_3)_2(H_2O)Cl]^+$ show geometrical isomerism

(c) $[CoBr_2Cl_2]^{2-}$ is sp^3 hybridised and does not show any isomerism
$[PtBr_2Cl_2]^{2-}$ is dsp^2 hybridised and show geometrical isomerism

(d) Both $[Pt(NH_3)_3(NO_3)]Cl$ and $[Pt(NH_3)_3Cl]Br$ show ionisation isomerism

88. (a,c,d)



both bonds are equal due to resonance, central O-atom is sp^2 hybridised with 2σ and 1π along with one lone pair. Thus O_3 has bent structure. Also it is diamagnetic as it has no unpaired electron.

$\because$ $O_2 \longrightarrow O_3$ $\Delta H = +ve$ (silent electric charge)

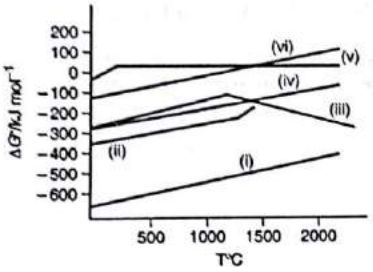
So, $O_3 \longrightarrow O_2$ $\Delta H = -ve$ (exothermic)

89. (c,d)

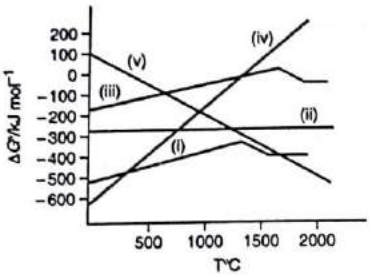
More electropositive metals like Al, Mg, Ca, Na are reduced by electrolytic reductions not by carbon reduction because these forms carbide with carbon.

COMPREHENSION BASED PROBLEMS

Comprehension 1 : Some metals e.g., Ag, Au, Pt are found in native state whereas most of the metals are found in nature in their compound state oxides, sulphides, halides, etc. Metals always exhibit positive oxidation states and therefore metals are extracted from their ores either by chemical or electrolytic reduction $M^{n+} + ne \longrightarrow M$. Chemically metal compounds can be reduced by treating them with carbon, CO, H_2, etc. The following two diagrams schematically shows as to which reduction method is suitable for some of the metals. These diagrams are called Ellingham diagrams. The more active metals like Na, K, Mg, Al, etc., are better reduced by electrolysis of their fused salts. Metals which reacts with carbon are easily obtained by reducing their compounds with Al.



(i) $2O_2 + S_2 \longrightarrow 2SO_2$
(ii) $2Zn + S_2 \longrightarrow 2ZnS$
(iii) $2Pb + S_2 \longrightarrow 2PbS$
(iv) $2Fe + S_2 \longrightarrow 2FeS$
(v) $C + S_2 \longrightarrow CS_2$
(vi) $2H_2 + S_2 \longrightarrow 2H_2S$



(i) $2Fe + O_2 \longrightarrow 2FeO$
(ii) $C + O_2 \longrightarrow CO_2$
(iii) $2Pb + O_2 \longrightarrow 2PbO$
(iv) $2Zn + O_2 \longrightarrow 2ZnO$
(v) $C + \frac{1}{2}O_2 \longrightarrow CO$

[1] Which of the following is a suitable method for reduction of galena (PbS)?
(a) $2PbS + C \longrightarrow 2Pb + CS_2$
(b) $PbS + H_2 \longrightarrow Pb + H_2S$
(c) (i) $2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2$
(ii) $PbO + C \longrightarrow Pb + CO$
(d) Electrolytic reduction

[2] Which of the following is a suitable method for reduction of zinc blende (ZnS)?
(a) (i) $2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2$
(ii) $ZnO + C \longrightarrow Zn + CO$
(b) $2ZnS + C \longrightarrow 2Zn + CS_2$
(c) $ZnS + H_2 \longrightarrow Zn + H_2S$
(d) None of the above

[3] Which of the following set represent maximum true statements?
(I) Zinc blende can be reduced by hydrogen at around 1500°C
(II) The reaction, $PbO + C \longrightarrow Pb + CO$, is feasible only above 500°C
(III) Iron can be produced by the reduction of FeS with Pb above approximately 1400°C
(IV) Alkali metals can be obtained by the electrolysis of their aqueous solution
(V) Under certain conditions Mg can reduce SiO_2 and Si can reduce MgO
(a) I, II, III, V (b) I, II, V
(c) III, V (d) I, III, IV

[4] Which of the following is not correct?
(a) An alloy represents a heterogeneous mixture of two or more metals or a metal and non-metal
(b) Metal ores are rarely found in form of nitrates form
(c) FeO can be reduced by carbon above 1123 K
(d) P_4O_{10} is used in steel manufacture to remove MgO in basic furnace lining

[5] Select the correct statements:
(1) Cr, Mn and Fe oxides can be reduced by carbon or CO
(2) Cr and Mn reacts with carbon to form carbides
(3) Al is used as reducing agent in the reduction of Cr_2O_3 to Cr and Mn_3O_4 to Mn
(4) Galena shows auto-reduction to give lead if heated with oxygen
(a) 1, 2, 3 (b) 3, 4
(c) 1, 2, 4 (d) 1, 2, 3, 4

[6] Select the correct statements:
(1) Ni, Ti, Zr is obtained by vapour phase refining
(2) The vapour phase refining leads to preparation of ultrapure samples of metals
(3) Acidic flux are used to remove the impurities of SiO_2 in ore

(4) In Kroll's process Mg is used as reducing agent for $TiCl_4$ to Ti
(5) In IMI process Na is used as reducing agent for $TiCl_4$ to Ti
(a) 1, 2, 4, 5 (b) 1, 2, 3, 4
(c) 1, 2, 4 (d) 1, 2, 5

Comprehension 2 : Hydrogen resembles in many of its properties with alkali metals as well as halogens. However it also differ markedly in some of its property with these two group elements. H—H bond energy in dihydrogen molecule is maximum. Dihydrogen acts as strong reducing agent. Two oxides of H are known as H_2O, neutral or amphoteric and H_2O_2 a dibasic acid. The strength of H_2O_2 solution is expressed in terms of by volume H_2O_2, *i.e.*, V volume H_2O_2 means 1 mL of H_2O_2 on decomposition gives V mL O_2 or in terms of percentage, *i.e.*, g/100 mL

[1] Reducing power is maximum in case of:
(a) H_2 (b) Atomic H
(c) Nascent H (d) Occluded H_2

[2] Which form of H is produced at elevated temperature?
(a) Atomic H (b) Nascent H
(c) Occluded H_2 (d) None of these

[3] Which are correct statements?
(1) Pure H_2 is obtained by the action of Al on KOH
(2) Pure H_2 is obtained by the action of NaH on H_2O
(3) Electrolysis of warm solution of $Ba(OH)_2$ using Ni electrodes gives pure H_2
(4) Moist H_2 can be dried by H_2SO_4
(a) 1, 2, 3, 4 (b) 1, 4
(c) 1, 2, 3 (d) 2, 3, 4

[4] Which are correct statements?
(1) H_2O_2 is less associated liquid than H_2O
(2) H_2O_2 is paramagnetic in nature
(3) H_2O_2 acts as oxidant and reductant both
(4) H_2O_2 reacts with $K_2Cr_2O_7$ in acidic medium to give blue colour solution
(a) 3, 4 (b) 1, 3, 4
(c) 2, 3, 4 (d) 1, 2, 3

[5] An H_2O_2 solution is labelled as 30 vol H_2O_2. Its strength in terms of % is:
(a) 9.105 (b) 6.07
(c) 3.035 (d) 12.14

[6] The normality of H_2O_2 solution labelled as 6.07% is:
(a) 4.57 N (b) 3.57 N
(c) 2.57 N (d) 5.57 N

[7] In which reaction water acts as catalyst?
(a) $NH_3 + HCl$ (b) $CaO + CO_2$
(c) $F_2 + H_2O$ (d) $Na_2O + CO_2$

Comprehension 3 : s-block elements having ns^1 (alkali metals) or ns^2 (alkaline earth metals) include Li, Na, K, Rb, Cs, Fr and Be, Mg, Ca, Sr, Ba, Ra respectively. These metals are soluble in NH_3 and their ammonia solution is strongly conducting, paramagnetic as well as show colour. All of these are reactive metals due to low values of ionisation energy. The physical properties of alkali metals almost describe a regular trend from Li to Cs whereas no such trend is noticed in alkaline earth metals. Also the properties such as density m.pt, b.pt for alkaline earth metals are more than alkali metals. Li in alkali metals and Be in alkaline earth metals differ markedly in many of their properties with their respective group elements.

[1] The conductivity of alkali metals in liq. NH_3 at $-33°C$:
(a) Increases with increase in temperature
(b) Decreases with increase in temperature
(c) Remains same with increase or decrease in temperature
(d) Due to ions furnished by metals

[2] The ΔH_{hyd} is maximum for:
(a) Li^+ (b) Na^+
(c) K^+ (d) Rb^+

[3] Which set of statements are correct?
(I) ΔH_{hyd} for $Sr^{2+} > \Delta H_{hyd}$ for Ag^+
(II) $Ca(OH)_2$ is less soluble in water than $Ba(OH)_2$
(III) Ba^{2+} is more powerful reducing agent than Ca^{2+} in acidic solution
(IV) Ca^{2+} is more powerful reducing agent in alkali medium
(a) I, II, III, IV (b) I, II
(c) I, III, IV (d) II, IV

[4] Which set of statements is correct?
(I) Oxidation number of Cs in $CsCl_3$ and $CsBrCl_2$ is +1
(II) Density of K < density of Na
(III) Alkali metals except Li and Na form superoxide on combustion
(IV) Ash obtained by burning Mg in air on dissolution in water gives odour of NH_3
(a) I, II (b) II, III, IV
(c) II, III (d) I, II, III, IV

[5] Which set of statements is correct?
(I) All alkaline earth metals gives characteristic flame colour
(II) IE_2 for alkaline earth metals are lower than IE_2 of alkali metals
(III) Addition of NaCl to fused $MgCl_2$ lowers the fusion point
(IV) Baking powder is a mixture of pot hydrogen tartarate and Na_2CO_3
(a) I, II, III, IV (b) II, III, IV
(c) II, III (d) I, IV

[6] Which set of statements is correct?
(I) Bicarbonates of alkali and alkaline earth metals are known in solid state
(II) SO_2 gives white precipitate on passing through baryta water
(III) Thermal decomposition of $CaCO_3$ is reversible in closed vessel but irreversible in lime kiln
(IV) American baking powder is $Ca(H_2PO_4)_2$

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

[7] Select the wrong statements:
(a) Hydration energy : $Mg^{2+} > Mg^{+} > Na^{+}$
(b) λ released during flame colour :
$Li > Na > K > Rb > Cs$
(c) Conducting power in solution :
$Cs^{+} > Rb^{+} > K^{+} > Na^{+} > Li^{+}$
(d) Density : $Be > Mg > Ca > Sr > Ba > Ra$

[8] $Be(NO_3)_2$ on heating to 125° gives:
(a) $BeO + NO_2 + O_2$
(b) $BeO + NO_2$
(c) $[Be_4O(NO_3)_6] + N_2O_5$
(d) $BeO + N_2O_5$

[9] Which statement is not correct?
(a) Be_2C gives CH_4 on dissolution in water
(b) Mg_2C_3 gives propyne on dissolution in water
(c) CaC_2 gives acetylene on dissolution in water
(d) Mg_2C_3 is called magnesium acetylide

Comprehension 4 : Group 13 of periodic table consists of boron or aluminium family. Boron being the first member, shows anomalous behaviour due to its small size and high nuclear charge/size ratio, high electronegativity and non availability of *d*-electrons. All the group 13 members forms hydrides, hydroxides, halides showing +3 covalency, however boron forms electron deficient species.

[1] Boron and aluminium differ from each other except:
(I) Both B and Al forms anionic hydrides
(II) Both form alkaline hydroxide of formula $M(OH)_3$
(III) Both B and Al forms a series of polymeric hydrides
(IV) Both forms monomeric halides MX_3
(a) I, IV (b) I, II, III
(c) II, III (d) I, II, IV

[2] Which one is not correct chemical change?
(a) $H_3BO_3 + 3NaOH \longrightarrow Na_3BO_3 + 3H_2O$
(b) $H_3BO_3 + 3ROH \longrightarrow R_3BO_3 + 3H_2O$
(c) $4BCl_3 + 3LiAlH_4 \longrightarrow 2B_2H_6 + 3AlCl_3 + 3LiCl$
(d) $3B_2H_6 + 6NH_3 \xrightarrow{450\ K} 2B_3N_3H_6 + 12H_2$

[3] Diborane does not have in its structure:
(a) A three centre electron pair bond
(b) A multi centre bond or banana bond
(c) Two bridging H-atom below or above the plane of four B—H bonds
(d) Two bridging H-atom in the same plane of four B—H bonds

[4] Which set of statements is correct among group 13 members?
(I) Boron does not decompose steam while other members do it
(II) Boron shows a maximum covalency of four while others members exhibit a covalency of six
(III) Borates are more stable than aluminates
(IV) Borax is $Na_2B_4O_7 \cdot 7H_2O$
(a) I, III (b) I, IV
(c) III, IV (d) I, II, IV

[5] The correct order for acidic strength of boron trihalides is:
(a) $BF_3 < BCl_3 < BBr_3 < BI_3$
(b) $BI_3 < BBr_3 < BF_3 < BCl_3$
(c) $BF_3 > BCl_3 > BBr_3 > BI_3$
(d) $BF_3 > BBr_3 > BCl_3 > BI_3$

Comprehension 5 : Group-14 of periodic table includes C, Si, Se, Te and Po. Carbon forms two oxides CO (neutral) and CO_2 (acidic) whereas other members of group 14 forms amphoteric oxides. Both CO and CO_2 are covalent compounds. Si does not form monoxide.

[1] The bond energy is maximum in:
(a) CO (b) O_2
(c) H_2 (d) N_2

[2] CO although neutral acts as acid as well as π-electron acceptor in the reactions respectively:
(I) $CO + NaOH \xrightarrow{High\ P,\ T} HCOONa$
(II) $Ni + 4CO \xrightarrow{80^{\circ}C} Ni(CO)_4$
(III) $PbO + CO \longrightarrow Pb + CO_2$
(IV) $I_2O_5 + 5CO \longrightarrow I_2 + 5CO_2$
(a) I, II (b) II, III
(c) III, II (d) I, IV

[3] Which of the following reaction in not correct?
(a) $PbO_2 + 2NaOH \longrightarrow Na_2PbO_3 + H_2O$
(b) $PbO_2 + 2HNO_3 \longrightarrow Pb(NO_3)_2 + H_2O + \frac{1}{2}O_2$
(c) $PbO_2 + 2HCl \longrightarrow PbCl_2 + Cl_2 + 2H_2O$
(d) $2CO_2 + 2Na \longrightarrow Na_2CO_3 + CO$

[4] Which statement is not correct?
(a) The CO_2 molecule possesses *sp*-hybridization and also shows resonating structure
(b) The structure of CO is $[:C \rightleftharpoons O:]$
(c) Ammoniacal CuCl absorbs CO and forms adduct product
(d) Asphyxia is low level poisoning produced in a atmosphere of CO_2

[5] Which statement is not correct?
(a) CO is isoelectronic with N_2 but less reactive than N_2
(b) CO is isoelectronic with N_2 and possesses more bond energy
(c) CO is isoelectronic with N_2 and more reactive than N_2
(d) CO is isoelectronic with N_2 and required for respiration

[6] The mole ratio of gases obtained on dehydration of $H_2C_2O_4$ and HCOOH respectively is:
(a) 2 : 1 (b) 1 : 2
(c) 3 : 1 (d) 1 : 3

Comprehension 6 : Group 15 includes pnicogens *i.e.*, N, P, As, Sb and Bi elements with ns^2np^3 configuration. N_2 is gas. All these elements except Bi shows allotropy. Phosphorus exists in three allotropic forms, white phosphorus, red phosphorus and black phosphorus. The later being most stable (thermodynamically) form of P. Each member of this forms hydrides of the molecular formula MH_3. Nitrogen however forms three hydrides NH_3, N_3H and N_2H_4. The thermal stability, basic nature and solubility in water of hydrides (MH_3) however decreases from N to Bi.

[1] Which one is wrong statement?
(a) White phosphorus possesses P_4 molecular state having P—P—P angle 60°
(b) White phosphorus is most reactive form because of maximum strain
(c) Red P neither shows chemiluminescence nor reacts with alkalies
(d) White P is insoluble in CS_2 but red phosphorus is soluble in CS_2

[2] For which form of phosphorus the standard enthalpy has been assumed to be zero?
(a) Red (b) Black
(c) White (d) Yellow

[3] The correct order for acidic nature is:
(a) $NH_4^+ < PH_4^+ < AsH_4^+$ (b) $NH_4^+ > PH_4^+ > AsH_4^+$
(c) $AsH_4^+ > NH_4^+ > PH_4^+$ (d) $AsH_4^+ < NH_4^+ < PH_4^+$

[4] Which hydride of groups 15 is most powerful reducing agent?
(a) NH_3 (b) PH_3
(c) AsH_3 (d) SbH_3

[5] The correct order of bond angles is:
(a) $NH_3 > PH_3 > AsH_3 > SbH_3$
(b) $SbH_3 > AsH_3 > PH_3 > NH_3$
(c) $SbH_3 > PH_3 > AsH_3 > NH_3$
(d) $PH_3 > NH_3 < SbH_3 < BiH_3$

[6] Which reaction is not possible?
(a) $NH_3 + NaOCl \longrightarrow N_2H_4 + NaCl + H_2O$
(b) $PCl_5 + Cl^- \longrightarrow [PCl_6]^-$
(c) $PH_4I + KOH \longrightarrow PH_3 + KI + H_2O$
(d) $CuSO_4 + 2PH_3 \longrightarrow Cu(PH_3)_2SO_4$

Comprehension 7 : Group 16 includes chalcogens O, S, Se, Te and Po each showing different allotropic forms. Both oxygen and sulphur shows catenation but it is more pronounced in sulphur. Each member of this forms oxides of the formula MO_2, MO_3 (except O), MO (except Se). The acidic nature of oxides of these metals decreases down the group, *i.e.*, from O to Po. Each di and tri oxide involves $p\pi$-$d\pi$ bonding in addition to $p\pi$-$p\pi$ bonds.

[1] The thermodynamically more stable form of Se is:
(a) Red monoclinic
(b) Grey hexagonal
(c) Grey polymeric hexagonal
(d) Se_8 staggered

[2] Which forms of sulphur has been proposed boat and chair structure respectively?
(a) S_8-Rhombic, S_8-staggered
(b) S_8-Rhombic, Cyclo-S_6
(c) Cyclo-S_6, S_8-staggered
(d) Cyclo-S_6, Catena-S_n

[3] Number of S—S bonds present in poly sulphuric acid ($H_2S_nO_6$) is:
(a) n (b) $n-1$
(c) $n-2$ (d) $n+1$

[4] Which element of group 15 forms only two series of oxides?
(a) Po (b) S
(c) Se (d) Te

[5] $p\pi$-$p\pi$ and $p\pi$-$d\pi$ bonds are not present in:
(a) PCl_5 (b) SO_2
(c) NCl_3 (d) SO_3

[6] Colloidal sulphur is not obtained by:
(a) $2HNO_3 + H_2S \longrightarrow 2NO_2 + 2H_2O + S$
(b) $SO_2 + 2H_2S \longrightarrow 2H_2O + 3S$
(c) $Na_2S_2O_3 + 2HCl \longrightarrow 2NaCl + SO_2 + H_2O + S$
(d) $3SO_2 \longrightarrow 2SO_3 + S$

(7) The hybridization of S in SO_2 and H_2SO_3 is respectively:
(a) sp^2, sp^3 (b) sp^2, sp^2
(c) sp^3, sp^2 (d) sp, sp^2

Comprehension 8 : Ionic character of metallic halides tends toward covalent nature as per Fajan's rule. Such covalent halides behave as non-metallic in their higher oxidation states. The property to hydrolyse to give oxo-acids of the element and corresponding hydro halogen acid for most non-metallic elements proceeds exceptionally in the way keeping oxidation number of element and halide same.

$$MX_a + aH_2O \longrightarrow MH_a + aHOX$$
$$MH_a + HOX \rightleftharpoons MH_{a+1}^+ + OX^-$$

If element M is more electronegative than halogens.

Non-polar halides are immiscible in water, it does not undergoes hydrolysis, but halides of some elements with empty d-orbital undergo hydrolysis. Stability of halides of higher oxidation state are governed by inert-pair effect.

Pseudohalides are anions having resemblance with halide ions. Group IA metals can formed salts with pseudohalides. Pseudohalides can act as ligands and form co-ordinate complexes. Their hydrides are weakly acidic and can be prepared in analogous way as halogen hydrides are prepared. Azides, cyanides, selenocyanides are examples of pseudo halides. Interhalogen compounds are the compounds in which

two halogens interact covalently due to difference in electronegativity giving AB, AB_3, AB_5 and AB_7 compounds where B is more electronegative.

[1] Which halide undergoes hydrolysis to give oxo-acids of underlined elements?
(a) $\underline{C}Cl_4$ (b) $\underline{P}Cl_3$
(c) $\underline{N}I_3$ (d) $\underline{Sb}Cl_3$

[2] Which one undergoes hydrolysis to form oxo-acids of the underlined element?
(a) $\underline{N}F_3$ (b) $\underline{N}Cl_3$
(c) $\underline{N}I_3$ (d) $\underline{B}Cl_3$

[3] Which one is not correct?
(a) $SiCl_4 + 4H_2O \longrightarrow Si(OH)_4 + 4HCl$
(b) $SbCl_5 + 4H_2O \longrightarrow (OH)_3SbO + 5HCl$
(c) $SbCl_3 + 3H_2O \longrightarrow Sb(OH)_3 + 3HCl$
(d) $XeF_2 + H_2O \longrightarrow Xe + 2HF + \frac{1}{2}O_2$

[4] Which one is stable and known?
(a) $PbCl_2$ (b) $PbCl_4$
(c) $GeCl_4$ (d) CCl_2

[5] Which one does not exist and not known?
(a) $PbCl_4$ (b) PbF_4
(c) PbI_4 (d) $PbBr_4$

[6] The reaction of cyanogens with alkali gives:
(a) CN^-, OCN^- (b) NH_3, H_2CO_3
(c) $HCOO^-, NH_3$ (d) HCN, H_2O

[7] When sodium cyanide reacts with H_2SO_4. The products are:
(a) HCN and Na_2SO_4 (b) HCN and $NaHSO_4$
(c) $(CN)_2, Na_2SO_4, H_2O$ (d) none of these

[8] When sodium pseudohalide salts are dissolved in water it resembles with:
(a) NaCl (b) NaBr
(c) NaF (d) NaI

[9] When CN_2 reacts with Na metal, the product is:
(a) NaCN (b) Na_2C, N_2
(c) NaN_3, carbon black (d) $[Na(CN)_2]^-$

[10] When sodium azide reacts with conc. sulphuric acid, the product is:
(a) $(NH_4)_2SO_4, Na_2SO_4$
(b) NH_3, Na_2SO_4
(c) $N_3H, NaHSO_4$
(d) none of the above

[11] Which compound does not exists?
(a) IF_7 (b) IF_5
(c) IF_3 (d) ClF_7

[12] Which the species is not a pseudohalide?
(a) CNO^- (b) $RCOO^-$
(c) OCN^- (d) NNN^-

[13] $KICl_2$ on heating gives:
(a) $KI + Cl_2$ (b) $KCl + ICl$
(c) no effect (d) $K^+ + ICl_2^-$

[14] Which halogen acid forms two series of salts?
(a) HF (b) HCl
(c) HBr (d) HI

[15] Interhalogen compounds are:
(a) hydrolysed easily
(b) acts as oxidant
(c) volatile and fumes in air
(d) all of the above

Comprehension 9. Group 18 includes noble gases He, Ne, Ar, Kr, Xe and Rn. The credit of discovery for maximum number of this group element goes to Ramsay. Dorn discovered the last member Rn as one of the disintegration product of Ra. Xe having nearly same ionisation energy as oxygen forms a large number of compounds like xenon fluorides, oxy fluorides, oxides and perxenates. Coconut charcoal adsorbs noble gases at different temperature and thus used to separate them from each other. Liquid He exist in two forms He(I) and He(II). Inversion temperature of liquid He is 35 K.

[1] The first noble gas compound prepared was ..... by .....:
(a) Xe PtF_6, Bartlet (b) XeF_2, Bartlet
(c) XeO_3, Bartlet (d) XeF_4, Bartlet

[2] In addition to Xe, the fluorides of noble gas known are:
(a) Ar (b) Kr
(c) Ne (d) He

[3] The number of lone pairs of electrons in XeF_2, XeF_4, XeF_6 and $XeOF_2$ are respectively:
(a) 3, 2, 1, 2 (b) 2, 1, 1, 2
(c) 3, 2, 1, 1 (d) 3, 2, 2, 2

[4] The hybridization of Xe in XeO_2F_2 and shape of XeO_2F_2 respectively as:
(a) sp^3d^2, T-shaped (b) sp^3d, seasaw
(c) sp^3, tetrahedral (d) sp^3d, V-shape

[5] Liquid He is obtained by Joule-Thomson effect at:
(a) 2.19 K (b) 37 K
(c) 40 K (d) 42 K

[6] The wrong statement is:
(a) Perxenates are XeO_6^{4-}
(b) Perxenates are yellow and powerful oxidants
(c) Perxenates are yellow and powerful reductants
(d) Oxidation number of Xe in perxenates is +8

[7] Which reaction does not take place?
(a) $XeF_2 + PF_5 \longrightarrow [XeF]^+[PF_6]^-$
(b) $XeF_6 + 2NOF \longrightarrow [NO_2]^+[XeF_8]^2$
(c) $2HXeO_4^- + OH^- \longrightarrow XeO_6^{4-} + Xe + O_2 + 2H_2O$
(d) $XeO_3 + 2H^+ \longrightarrow XeO_2 + H_2O$

[8] Which statement is wrong about He?
(a) He(II) is super fluid having no thermal motion of atoms
(b) He(II) has negligible interatomic forces

(c) He(II) has 600 times more conductance than Cu
(d) He(II) has high surface tension

Comprehension 10 : $KMnO_4$ and $K_2Cr_2O_7$ are strong oxidant in acidified medium:

$MnO_4^- + 8H^+ + 5e \longrightarrow Mn^{2+} + 4H_2O$; $E^\circ_{RP} = +1.51\,V$

$Cr_2O_7^{2-} + 14H^+ + 6e \longrightarrow 2Cr^{3+} + 7H_2O$; $E^\circ_{RP} = +1.31\,V$

Both are important reagents for analytical chemistry. $KMnO_4$ acts as self indicator in titration against oxalic acid and $FeSO_4$ solution. It also acts as oxidant in alkaline medium as $MnO_4^- + 2H_2O + 3e \longrightarrow MnO_2 + 2OH^-$ as well as in neutral medium as:

$$MnO_4^- + 4H^+ + 3e \longrightarrow MnO_2 + 2H_2O$$

H_2O_2 and O_3 also acts as oxidant as:

$H_2O_2 \longrightarrow 2H^+ + O_2 + 2e$; $E^\circ_{OP} = -0.68\,V$

$2OH^- + H_2O_2 \longrightarrow 2H_2O + O_2 + 2e$; $E^\circ_{OP} = -0.22\,V$

$O_3 + 2H^+ + 2e \longrightarrow O_2 + H_2O$; $E^\circ_{RP} = +2.07\,V$

[1] Addition of Zn to acidified $K_2Cr_2O_7$ solution show change in colour on standing for some time:
(a) Green to blue and then orange and finally blue
(b) Orange to green and then blue and finally green
(c) Orange to blue and then green and finally blue
(d) Orange to yellow and then green and finally blue

[2] The reaction,
$3CrO_4^{3-} + 8H^+ \longrightarrow 2CrO_4^{2-} + Cr^{3+} + 4H_2O$ shows:
(a) oxidation of Cr^{5+}
(b) intermolecular redox
(c) intramolecular redox
(d) disproportionation reaction

[3] $KMnO_4$ dissolution in conc. H_2SO_4 results in explosion due to:
(a) formation of Mn_2O_7 which explodes
(b) formation of MnO_2 which explodes
(c) formation of MnO_4^{2-} which explodes
(d) formation of $MnSO_4$ gives violent reaction

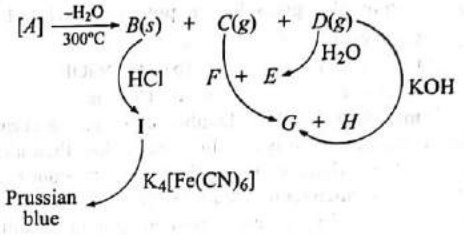
[4] On passing CO_2 to green solution of K_2MnO_4 gives:
(a) purple colour with brown solid
(b) brown colour with yellow solid
(c) purple colour with green solid
(d) pink colour with green solid

[5] Eq. mass of $KMnO_4$ in its reaction with KI in alkaline medium and the I^- are oxidized to:
(a) $M/3, IO_3^-$ (b) $M/6, I_2O_3^-$
(c) $M/1, IO_3^-$ (d) $M/2, I_2$

[6] The best oxidant in acidified medium is:
(a) $KMnO_4$ (b) $K_2Cr_2O_7$
(c) H_2O_2 (d) O_3

[7] Which one is wrong reaction?
(a) $2K_2MnO_4 + H_2O + O_3 \longrightarrow 2KMnO_4 + 2KOH + O_2$
(b) $K_2Cr_2O_7 + 6FeSO_4 + 7H_2SO_4 \longrightarrow Cr_2(SO_4)_3 + 3Fe_2(SO_4)_3 + 7H_2O + K_2SO_4$
(c) $2CrO_4^{2-} + 2H^+ \underset{Base}{\overset{Acid}{\rightleftharpoons}} Cr_2O_7^{2-} + H_2O$
(d) $2KOH + 2MnO_2 + 2H_2O + 3O_2 \longrightarrow 2KMnO_4 + 3H_2O_2$

Comprehension 11 : A sequence of reaction has been represented in the given chart. A hydrated salt [*A*] is heated strongly.



(I) *F* is an oxidizing agent which gives colloidal sulphur with H_2S gas and it also gives reddish brown gas with NaCl and H_2SO_4
(II) *C* gives temporary bleaching action with moisture
(III) *G* is a white ppt. and *H* is a green colour substance

[1] The number of hydrated water molecules in [*A*] is:
(a) 7 (b) 10
(c) 5 (d) 2

[2] The nature of compound *C* is:
(a) oxidant
(b) reductant
(c) oxidant and reductant
(d) solvent

[3] Aqueous solution of [*A*] does not acts as reducing agent for:
(a) $AuCl_3$ (b) $HgCl_2$
(c) $KMnO_4$ (d) NO

[4] Prussian blue compound has molecular formula:
(a) $K_2Fe[Fe(CN)_6]$ (b) $Fe_4[Fe(CN)_6]_3$
(c) $KFe[Fe(CN)_6]$ (d) (b) and (c) both

[5] Bleaching action of compound *C* is because of liberation of:
(a) nascent H (b) nascent O
(c) nascent Cl (d) O_3

[6] Compound *F* is:
(a) HNO_3 (b) $K_2Cr_2O_7$
(c) $KMnO_4$ (d) H_2SO_4

[7] Compound *E* is:
(a) H_2SO_4 (b) Cl_2
(c) HNO_3 (d) H_2CO_3

[8] Aqueous solution of compound [*A*] is slightly acidic due to:
(a) hydrolysis of SO_4^{2-}
(b) reducing nature

(c) hydrolysis of Fe^{2+} ion
(d) oxidizing nature

[9] Compound $K_4[Fe(CN)_6]$ is formed when excess KCN reacts with:
(a) *D* (b) *A*
(c) *E* (d) *G* + *H*

[10] When gas '*C*' is heated with *K* metal, it gives:
(a) K_2SO_3 (b) K_2CO_3
(c) K_2SO_4 (d) $K_2SO_3 + K_2S_2O_3$

[11] Compound *I* gives brown ppt. with NH_4OH, which dissolves in:
(a) Dil. HCl (b) Dil. NaOH
(c) Cl_2 gas (d) CO gas

Comprehension 12 : Double salts are the compounds which retain their identity in solid state but lose their identity in solution state whereas. Co-ordination compounds are the complex salts which retain their identity in solid state as well as in solution state. In a co-ordination compound the number of ions or molecules (ligand) attached to the central metal atom or ion (central atom) is beyond the number possible, on the basis of electrovalent or covalent bonding. The extra groups or ions are linked to the metal by co-ordination bonds in which the linked group (*L*) is the donor and the metal (*M*) is the acceptor. *i.e.*, $M \leftarrow L$. Co-ordination compounds are mainly of two types:

(i) Neutral compounds like $[Fe(CO)_5]$.

(ii) Ionic compounds, which consists of ions in which atleast one is a complex ion, *e.g.*, cationic complex $[Ag(NH_3)_2]Cl$ or anionic complex $Na[BH_4]$.

Complex ion: A complex ion is an electrically charged radical which consists of a metal atom or ion surrounded by a group of ions or neutral molecules. For example, $[Cu(NH_3)_4]^{2+}$, $[Fe(CN)_6]^{3-}$.

Ligand : Ligands are defined as molecules or ions having atleast one pair of electrons for donation. Ligands are also known as Lewis bases. There are two main classes of ligands:

(a) Classical or simple donor ligands: These are the ligands which act as electron pair donor to acceptor ions or molecules and form complexes with all types of Lewis acids, metal ions or molecules.

(b) Non-classified ligands, π-bonding or π-acid ligands: These refer to those ligands which form compounds largely with transition metal atoms. This type of interaction is possible due to special properties of both metal and ligand. The metal has *d*-orbitals that can be used in bonding and the ligand has not only donor capacity but also has acceptor orbitals. Ligand can be negative ions, positive ions or neutral molecules.

Co-ordination number : The total number of ligands attached to the central metal atom in co-ordination sphere is called co-ordination number. The species out side the co-ordination number are ionizable species.

[1] How many ions are produced by $[Co(NH_3)_6]Cl_3$ in solution?
(a) 6 (b) 4
(c) 3 (d) 2

[2] Which of the following is non-ionizable?
(a) $[Co(NH_3)_3Cl_3]$ (b) $[Co(NH_3)_4Cl_2]Cl$
(c) $[Co(NH_3)_5Cl]Cl_2$ (d) $[Co(NH_3)_6]Cl_2$

[3] The complex $CoCl_3 \cdot 3NH_3$ ionizes to give:
(a) $2Cl^-$ ions (b) $1Cl^-$ ion
(c) $3Cl^-$ ions (d) zero Cl^- ion

[4] AgCl dissolves in NH_4OH due to the formation of:
(a) $[Ag(NH_4)_2Cl]$ (b) $[Ag(NH_4)_3]Cl$
(c) $[Ag(NH_3)_2]Cl$ (d) $[Ag(NH_3)_2OH]$

[5] Which is not π-bonded complex?
(a) Zeise's salt (b) Ferrocene
(c) Dibenzene chromium (d) Tetraethyl lead

[6] The correct IUPAC name for $K_3[Fe(C_2O_4)_3]$ is:
(a) Potassium trioxalatoferrate (II)
(b) Potassium trioxalatoferrate (I)
(c) Potassium trioxalatoferric (III)
(d) Potassium trioxalatoferrate (III)

[7] The oxidation number, co-ordination number and effective atomic number respectively of central metal atom in $K_2[HgI_4]$ is:
(a) 0, 2, 86 (b) +2, 4, 86
(c) +2, 2, 84 (d) +2, 2, 86

[8] Maximum co-ordination number of a central atom can be:
(a) 2 (b) 4
(c) 6 (d) > 6

[9] The numerical value of '*X*' in $H_XCr(CO)_4$ is:
(a) 0 (b) 1
(c) 2 (d) 3

[10] Which of the following is ambidentate ligand?
(a) NO_2 (b) $C_2O_4^{2-}$
(c) CO (d) N_2

Comprehension 13: The noble gases have closed-shell electronic configuration and are monoatomic gases under normal conditions. The low boiling points of the lighter noble gases are due to weak dispersion forces between the atoms and the absence of other interatomic interactions.

The direct reaction of xenon with fluorine leads to a series of compounds with oxidation numbers +2, +4 and +6. XeF_4 reacts violently with water to give XeO_3. The compounds of xenon exhibit rich stereochemistry and their geometries can be deduced considering the total number of electron pairs in the valence shell. **(IIT 2007)**

[1] Argon is used in arcwelding because of its:
(a) low reactivity with metal
(b) ability to lower the melting point of metal
(c) flammability
(d) high calorific value

[2] The structure of XeO_3 is:
(a) linear (b) planar
(c) pyramidal (d) T-shaped

[3] XeF_4 and XeF_6 are expected to be:
(a) oxidising (b) reducing
(c) unreactive (d) strongly basic

Comprehension 14 : Ni^{2+} ions form the following complexes.

$$Ni^{2+} \xrightarrow{KCN} \text{Complex I}$$

$$Ni^{2+} \xrightarrow[\text{excess}]{KCl} \text{Complex II}$$

Both the complexes have co-ordination number 4. **(IIT 2008)**

[1] The IUPAC names of the complexes respectively are:
(a) potassium tetracyanonickel(II) and potassium tetrachloronickelate(II)
(b) potassium tetracyanonickelate(II) and potassium tetrachloronickel(II)
(c) potassium tetracyanonickel(II) and potassium tetrachloronickel(II)
(d) potassium tetracyanonickelate(II) and potassium tetrachloronickelate(II)

[2] Which of the following statements is correct?
(a) The cyano complex is diamagnetic and the chloro complex is paramagnetic.
(b) The cyano complex is paramagnetic and the chloro complex is diamagnetic.
(c) Both the complexes are diamagnetic
(d) Both the complexes are paramagnetic

[3] Nickel ion involves:
(a) dsp^2-hybridization in both complexes
(b) sp^3-hybridization in both complexes
(c) dsp^2-hybridization in cyano complex and sp^3 - hybridization in chloro complex
(d) sp^3-hybridization in cyano complex and dsp^2 - hybridization in chloro complex

Comprehension 15 : There are some deposits of nitrates and phosphates in earth's crust. Nitrates are more soluble in water. Nitrates are difficult to reduce under the laboratory conditions but microbes do it easily. Ammonia forms larger number of complexes with transition metal ions. Hybridization easily explains the ease of sigma donation capability of NH_3 and PH_3. Phosphine is a flammable gas and is prepared from white phosphorus. **(IIT 2008)**

[1] Among the following, the correct statement is:
(a) Phosphates have no biological significance in humans
(b) Between nitrates and phosphates, phosphates are less abundant in earth's crust
(c) Between nitrates and phosphates, nitrates are less abundant in earth's crust
(d) Oxidation of nitrates is possible in soil

[2] Among the following, the correct statement is:
(a) Between NH_3 and PH_3, NH_3 is a better electron donor because the lone pair of electrons occupies spherical '*s*' orbital and is less directional
(b) Between NH_3 and PH_3, PH_3 is a better electron donor because the lone pair of electrons occupies sp^3 orbital and is more directional
(c) Between NH_3 and PH_3, NH_3 is a better electron donor because the lone pair of electrons occupies sp^3 orbital and is more directional
(d) Between NH_3 and PH_3, PH_3 is a better electron donor because the lone pair of electrons occupies spherical '*s*' orbital and is less directional

[3] White phosphorus on reaction with NaOH gives PH_3 as one of the products. This is a:
(a) dimerization reaction
(b) disproportionation reaction
(c) condensation reaction
(d) precipitation reaction

Comprehension 16. *P*-Amino-*N*, *N*-dimethylaniline is added to a strongly acidic solution of **X**. The resulting solution is treated with a few drops of aqueous solution of **Y** to yield blue coloration due to the formation of methylene blue. Treatment of the aqueous solution of **Y** with the reagent potassium hexacyanoferrate(II) leads to the formation of an intense blue precipitate. The precipitate dissolves on excess addition of the reagent. Similarly, treatment of the solution of **Y** with the solution of potassium hexacyanoferrate(III) leads to a brown colouration due to the formation of **Z.** **(IIT 2009)**

[1] The compound **X** is:
(a) $NaNO_3$ (b) NaCl
(c) Na_2SO_4 (d) Na_2S

[2] The compound **Y** is:
(a) $MgCl_2$ (b) $FeCl_2$
(c) $FeCl_3$ (d) $ZnCl_2$

[3] The compound **Z** is:
(a) $Mg_2[Fe(CN)_6]$ (b) $Fe[Fe(CN)_6]$
(c) $Fe_4[Fe(CN)_6]_3$ (d) $K_2Zn_3[Fe(CN)_6]_2$

Comprehension 17 : Copper is the most noble of the first row transition metals and occurs in small deposits in several countries. Ores of copper include chalcanthite ($CuSO_4 \cdot 5H_2O$), atacamite ($Cu_2Cl(OH)_3$), cuprite (Cu_2O), copper glance (Cu_2S) and malachite ($Cu_2(OH)_2CO_3$). However, 80% of the world copper production comes from the ore chalcopyrite ($CuFeS_2$). The extraction of copper from

chalcopyrite involves partial roasting, removal of iron and self-reduction. **(IIT 2010)**

[1] Partial roasting of chalcopyrite produces:
(a) Cu_2S and FeO (b) Cu_2O and FeO
(c) CuS and Fe_2O_3 (d) Cu_2O and Fe_2O_3

[2] Iron is removed from chalcopyrite as:
(a) FeO (b) FeS
(c) Fe_2O_3 (d) $FeSiO_3$

[3] In self-reduction, the reducing species is:
(a) S (b) O^{2-}
(c) S^{2-} (d) SO_2

Comprehension 18 : When a metal rod *M* is dipped into an aqueous colourless concentrated solution of compound *N*, the solution turns light blue. Addition of aqueous NaCl to the blue solution gives a white precipitate *O*. Addition of aqueous NH_3 dissolves *O* and gives an intense blue solution. **[IIT 2011]**

[1]. The final solution contains :
(a) $[Pb(NH_3)_4]^{2+}$ and $[CoCl_4]^{2-}$
(b) $[Al(NH_3)_4]^{3+}$ and $[Cu(NH_3)_4]^{2+}$
(c) $[Ag(NH_3)_2]^{+}$ and $[Cu(NH_3)_4]^{2+}$
(d) $[Ag(NH_3)_2]^{+}$ and $[Ni(NH_3)_6]^{2+}$

[2]. The compound *N* is :
(a) $AgNO_3$ (b) $Zn(NO_3)_2$
(c) $Al(NO_3)_3$ (d) $Pb(NO_3)_2$

[3]. The metal rod *M* is :
(a) Fe (b) Cu
(c) Ni (d) Co

Comprehension 19 : The reactions of Cl_2 gas with cold-dilute and hot-concentrated NaOH in water give sodium salts of two (different) oxoacids of chlorine, *P* and *Q*, respectively. The Cl_2 gas reacts with SO_2 gas, in presence of charcoal, to give a product *R*. *R* reacts with white phosphorus to give a compound *S*. On hydrolysis, *S* gives an oxoacid of phosphorus, *T*. **[JEE (Advanced) II 2013]**

[1]. *R*, *S* and *T*, respectively, are :
(a) SO_2Cl_2, PCl_5 and H_3PO_4
(b) SO_2Cl_2, PCl_3 and H_3PO_3
(c) $SOCl_2$, PCl_3 and H_3PO_2
(d) $SOCl_2$, PCl_5 and H_3PO_4

[2]. *P* and *Q*, respectively, are the sodium salts of :
(a) hypochlorus and chloric acids
(b) hypochlorus and chlorus acids
(c) chloric and perchloric acids
(d) chloric and hypochlorus acids

Comprehension 20 : An aqueous solution of a mixture of two inorganic salts, when treated with dilute HCl, gave a precipitate (*P*) and a filtrate (*Q*). The precipitate *P* was found to dissolve in hot water. The filtrate (*Q*) remained unchanged, when treated with H_2S in a dilute mineral acid medium. However, it gave a precipitate (*R*) with H_2S in an ammoniacal medium. The precipitate *R* gave a coloured solution (*S*), when treated with H_2O_2 in an aqueous NaOH medium. **[JEE (Advanced) II 2013]**

[1]. The coloured solution *S* contains :
(a) $Fe_2(SO_4)_3$ (b) $CuSO_4$
(c) $ZnSO_4$ (d) Na_2CrO_4

[2]. The precipitate *P* contains :
(a) Pb^{2+} (b) Hg_2^{2+}
(c) Ag^{+} (d) Hg^{2+}

SOLUTIONS

Comprehension 1

[1] (c) Galena (PbS) is first converted to PbO.
ΔG = – ve at high temperature for reduction of PbO to Pb

[2] (a) ΔG = – ve for reduction of ZnO to Zn at high temperature

[3] (a) Alkali metals cannot be reduced from their aqueous salt solution. Also

$$SiO_2 + 2Mg \longrightarrow Si + 2MgO$$

$$2MgO + Si \xrightarrow{1000°C} 2Mg + SiO_2$$

[4] (d) MgO is used to remove acidic impurities such as P_4O_{10} in basic furnace lining. Nitrates of all metals are water soluble and thus metals never found in form of nitrates.

[5] (b) These are facts

[6] (a) Acidic flux are used to remove basic impurities.

Comprehension 2

[1] (b) $H_2 \xrightarrow[\text{high temp}]{\text{electric arc}} 2H;\ \Delta H = 104.0\ \text{kcal}$

[2] (a) Follow answer [1]

[3] (c) Moist H_2 cannot be dried by H_2SO_4;

$$H_2SO_4 + H_2 \longrightarrow SO_2 + 2H_2O$$

[4] (a) H_2O_2 is more associated liquid, diamagnetic and form blue CrO_5 with acidified $K_2Cr_2O_7$

$$K_2Cr_2O_7 + H_2SO_4 + 4H_2O_2 \longrightarrow 2CrO_5 + K_2SO_4 + 5H_2O$$

[5] (a) $\% = \frac{17}{56} \times \text{Volume strength} = \frac{17}{56} \times 30 = 9.105$

[6] (b) $\text{Normality} = \frac{\text{Volume strength}}{5.6}$

$$= \frac{56}{17} \times \frac{\%}{5.6} = \frac{56}{17} \times \frac{6.07}{5.6} = 3.57$$

[7] (a) NH_3 and HCl combines only in presence of moisture.

Comprehension 3

[1] (b) The passage of current in the system is due to electronic conduction.

[2] (a) Li^+ is smaller cation. Smaller is cation more is hydration.

[3] (c) Sr^{2+} has more charge, $Ca(OH)_2$ is more soluble than $Ba(OH)_2$ in water. The reducing nature depends upon E°_{OP} values in acidic and alkaline solution.

[4] (d) Alkali metal has +1 oxidation state $Cs^+Cl_3^-$, $Cs^+BrCl_2^-$; density of K, Na are 0.86, 0.97 respectively Li forms Li_2O and Na form Na_2O_2, ash contains Mg_3N_2 and MgO

[5] (b) These all are facts

[6] (a) Bicarbonates of alkaline earth metals are known only in solution state.

[7] (d) Density order

Be	Mg	Ca	Sr	Ba	Ra
1.84	1.74	1.55	2.54	3.75	6.00 g / cm^3

[8] (c) $4Be(NO_3)_2 \xrightarrow{125°C} [Be_4O(NO_3)_6] + N_2O_5$

[9] (d) Mg_2C_3 is magnesium allylide containing C_3^{4-} ion (allylide ion)

Comprehension 4

[1] (a) $NaBH_4$ and $LiAlH_4$ are anionic hydrides. Al does not form a series of polymeric hydride. Only one hydride of Al as $(AlH_3)_n$ is known. $B(OH)_3$ is acid. AlX_3 exists as dimer.

[2] (a) $H_3BO_3 + NaOH \longrightarrow NaB(OH)_4 \longrightarrow NaBO_2 + 2H_2O$

[3] (d) Rest all are facts about B_2H_6.

[4] (a) Borax is $Na_2B_4O_7 \cdot 10H_2O$

[5] (a) BF_3 is least acidic due to back bonding.

Comprehension 5

[1] (a) CO has highest bond energy among all diatomic molecules.

[2] (a) CO reacts with alkali to form salt. CO is π-electron pair acceptor in $Ni(CO)_4$

[3] (d) $4Na + CO_2 \longrightarrow 2Na_2O + C$

[4] (d) Asphyxia is due to CO which combines with haemoglobin to form cherry coloured carbon haemoglobin complex and reduces the capacity of O_2 to be absorbed.

[5] (a) CO and N_2 are isoelectronic. No doubt bond energy of CO > bond energy of N_2 but because of lower nuclear charge on carbon (compared to N or O), the lone pair on carbon is loosely held in CO.

[6] (a) $H_2C_2O_4 \xrightarrow{H_2SO_4} H_2O + CO + CO_2$

$$HCOOH \xrightarrow{H_2SO_4} H_2O + CO$$

Comprehension 6

[1] (d) White P is soluble in CS_2 but red P is not.

[2] (c) Black phosphorus is most stable form but for P_w, $H^\circ = 0$ has been assumed.

[3] (a) The basic character of hydrides decreases from N to Bi because of increasing size of central atom and thus electron density of lone pair is diffused over larger region. Stronger is base, weaker is its conjugate acid.

[4] (d) The reducing character of hydrides increases from N to Bi because of decrease in M—H bond strength with decrease in electronegativity from N to Bi.

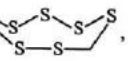
[5] (a) The decrease in bond angle down the group is due to increasing size of central atom having lone pair which reduces repulsion between bond pair-lone pair.

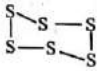
NH_3	PH_3	AsH_3	SbH_3
106.5°	93.5°	91.5°	90.3°

[6] (d) $3CuSO_4 + 2PH_3 \longrightarrow Cu_3P_2 + 3H_2SO_4$

Comprehension 7

[1] (c) It is a fact.

[2] (b) S_8-Rhombic is  ,

cyclo-S_6 is 

[3] (b) $HO_3S—S_{(n-2)}—SO_3H$ [$(n-1)$ only S—S bonds]

[4] (c) S forms SO, SO_2, SO_3; Te forms TeO, TeO_2 and TeO_3; Po forms PoO, PoO_2, PoO_3, Se forms SeO_2, SeO_3

[5] (c) N has no *d*-orbitals.

[6] (d) In this sulphur powder is formed. Note that H_2O or medium is necessary for getting colloidal sulphur.

[7] (b) In both S is sp^2-hybridised.

Comprehension 8

[1] (b) $PCl_3 + 3H_2O \longrightarrow \underset{\text{Oxo-acid}}{H_3PO_3} + 3HCl$;

$SbCl_3 + H_2O \longrightarrow SbOCl + 2HCl$

[2] (d) $BCl_3 + 3H_2O \longrightarrow H_3BO_3 + 3HCl$

[3] (c) $SbCl_3 + H_2O \longrightarrow SbOCl + 2HCl$

[4] (a) $PbCl_2$ is stable and known.

[5] (c) PbI_4 has Pb^{4+} (strong oxidant) and I^- (strong reductant) and thus does not exist.

[6] (a) $(CN)_2 + NaOH \longrightarrow NaOCN + HCN$

[7] (a) $2NaCN + H_2SO_4 \longrightarrow 2HCN + Na_2SO_4$

[8] (c) $NaCN + H_2O \longrightarrow NaOH + \underset{\text{Weak acid}}{HCN}$;

$NaF + H_2O \longrightarrow NaOH + \underset{\text{Weak acid}}{HF}$;

HCl., HBr, HI are strong acids

[9] (a) $2Na + (CN)_2 \longrightarrow 2NaCN$

[10] (c) $NaN_3 + H_2SO_4 \longrightarrow NaHSO_4 + N_3H$

[11] (d) Heptavalent nature of halogen (iodine) is shown in IF_7.

[12] (b) Rest all are pseudo halide.

[13] (b) $KICl_2 \longrightarrow KCl + ICl$ (smaller halogen forms anionic part)

[14] (a) HF exists as H_2F_2 and forms KHF_2 and KF.

[15] (d) These are characteristics of inter halogen compounds.

Comprehension 9

[1] (a) On the formation of $O_2^+ [Pt F_6]^-$, Bartlet prepared $Xe^+ [PtF_6]^-$

[2] (b) KrF_2 is known.

[3] (a) XeF_2, XeF_4, XeF_6 and $XeOF_2$ have sp^3d (linear), sp^3d^2 (square planar), sp^3d^3 (pentagonal pyramidal) and sp^3d (T-shaped) with 3, 2, 1 and 2 lone pairs respectively.

[4] (b) sp^3d-hybridisation with one lone pair at equatorial position and thus sea saw structure.

[5] (a) Ti of He is 35 K; For cooling by J.T. effect $T_{He} < T_i$

[6] (c) XeO_6^{4-} have Xe in highest oxidation state of +8 and can act as oxidant only.

[7] (d) Rest all are correct.

[8] (d) He (II) has flat maniscus due to low surface tension as intermolecular forces are negligible.

Comprehension 10

[1] (b)

$$Zn \longrightarrow Zn^{2+} + 2e$$

$$\underset{\text{Orange}}{Cr_2O_7^{2-}} + 14H^+ + 6e \longrightarrow \underset{\text{Green}}{2Cr^{3+}} + 7H_2O$$

$$\underset{\text{Green}}{Cr^{3+}} + e \longrightarrow \underset{\text{Blue}}{Cr^{2+}}$$

$$4Cr^{2+} + O_2 + 4H^+ \longrightarrow \underset{\text{Green}}{4Cr^{3+}} + 2H_2O$$

[2] (d) $Cr^{5+} + 2e \longrightarrow Cr^{3+}$ and $Cr^{5+} \longrightarrow Cr^{6+} + e$

[3] (a) $2KMnO_4 + H_2SO_4 \longrightarrow K_2SO_4 + Mn_2O_7 + H_2O$

$$2Mn_2O_7 \xrightarrow{\text{Explodes}} 4MnO_2 + 3O_2$$

[4] (a) $CO_2 + H_2O \longrightarrow H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$

$$3MnO_4^{2-} + 4H^+ \longrightarrow \underset{\text{Purple}}{2MnO_4^-} + \underset{\text{Brown solid}}{MnO_2} + 2H_2O$$

[5] (a) $2KMnO_4 + KI + H_2O \longrightarrow KIO_3 + MnO_2 + 2KOH$

[6] (d) E°_{RP} for $KMnO_4$ or $K_2Cr_2O_7$, H_2O_2 and O_3 are +1.51 V, +1.31 V, +0.68 V and +2.07 V. More is E°_{RP} more is the tendency to get reduced and more is oxidising power.

[7] (d) The $KMnO_4$ oxidises H_2O_2 as E°_{RP} of $KMnO_4$ is more

$$2KMnO_4 + 3H_2O_2 \longrightarrow 2KOH + 2MnO_2 + 2H_2O + 3O_2$$

Comprehension 11

The reaction sequence is:

$$\underset{[A]}{2FeSO_4 \cdot 5H_2O} \xrightarrow{-5H_2O} \underset{[B]}{Fe_2O_3(s)} + \underset{[C]}{SO_2(g)} + \underset{[D]}{SO_3(g)}$$

$$\underset{[B]}{Fe_2O_3} + 6HCl \longrightarrow \underset{[I]}{2FeCl_3} + 3H_2O$$

$$\underset{[I]}{4FeCl_3} + 3K_4Fe(CN)_6 \longrightarrow \underset{\text{Prussian blue}}{Fe_4[Fe(CN)_6]_3} + 12KCl$$

$$\underset{[C]}{3SO_2} + \underset{(F)\text{ Oxidant}}{K_2Cr_2O_7} + \underset{[E]}{H_2SO_4} \longrightarrow \underset{(G)\text{ White}}{K_2SO_4} + \underset{(H)\text{ Green}}{Cr_2(SO_4)_3} + H_2O$$

$$\underset{[D]}{SO_3} + H_2O \longrightarrow \underset{[E]}{H_2SO_4}$$

$$\underset{[C]}{3SO_2} + 4K \longrightarrow K_2SO_3 + K_2S_2O_3$$

$$\underset{[D]}{SO_3} + 2KOH \longrightarrow \underset{[G]}{K_2SO_4} + H_2O$$

[1] (a) The compound is $FeSO_4 \cdot 7H_2O$

[2] (c) SO_2 acts as oxidant and reductant both as ox no. of S is +4 (between) +6 (max) and −2 (min)

[3] (d) Fe^{2+} reduces Au^{3+} to Au, Hg^{2+} to Hg_2^{2+}, Mn^{7+} to Mn^{2+}. It absorbs NO to form $FeSO_4 \cdot NO$.

[4] (b) Prussian blue is $Fe_4[Fe(CN)_6]_3$

[5] (a) $SO_2 + 2H_2O \longrightarrow H_2SO_4 + 2H$

[6] (b) Follow sequence of reaction.

[7] (a) do

[8] (c) $Fe^{2+} + 2H_2O \longrightarrow Fe(OH)_2 + \underset{\text{Strong acid}}{4H^+}$

[9] (b) $FeSO_4 + \underset{\text{Excess}}{6KCN} \longrightarrow K_4Fe(CN)_6 + K_2SO_4$

[10] (d) Follow sequence of reaction.

[11] (a) $\underset{[I]}{FeCl_3} + NH_4OH \longrightarrow \underset{\text{Brown ppt.}}{Fe(OH)_3} \xrightarrow{HCl} \text{Soluble}$

Comprehension 12

[1] (b) $[Co(NH_3)_6]Cl_3 \rightleftharpoons [Co(NH_3)_6]^{3+} + 3Cl^-$

[2] (a) All ligands (NH_3 and Cl) are in side co-ordination sphere.

[3] (d) Co^{2+} has six co-ordination number thus it is $[Co(NH_3)_3Cl_3]$.

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

[5] (d) Tetra ethyl lead $[(C_2H_5)_4Pb]$ has no π-bonding in it.

[6] (d) Follow IUPAC rule.

[7] (b) $K_2[HgI_4] \rightleftharpoons 2K^+ + [HgI_4]^{2-}$

$\therefore$ Oxidation no. of $Hg^{2+} = +2$, no. of ligands = 4.

EAN = Atomic number of Hg − electrons lost in the formation of $Hg^{2+} + 4 \times$ Number of electrons in co-ordination $= 80 - 2 + 4 \times 2 = 86$

[8] (d) It is a fact.

[9] (b) In carbonyls, the effective atomic number = Atomic number of next noble gas

EAN of Cr = 36 [EAN of Cr]

$\therefore$ In $H_X\,Cr(CO)_4$; $X + 27 + 4 \times 2 = 36$

$\therefore \quad X = 1$

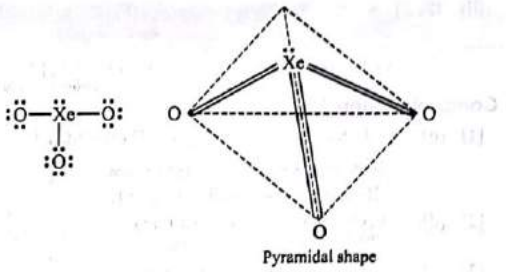
[10] (a) An ambidentate ligand possesses two donor atoms, but in forming complex only one atom is involved.

$\leftarrow NO_2$ or $\leftarrow ONO$

Comprehension 13

[1] (a) Argon is used to provide an inert atmosphere in arc welding.

[2] (c) XeO_3 is sp^3-hybridized with one lone pair on Xe. Hence, these electrons acquire tetrahedral orientations. The shape of the molecule is pyramidal.

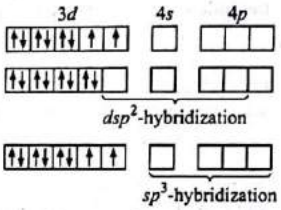


[3] (a) XeF_4 and XeF_6 are oxidising agents. These can oxidise H_2 to H^+, Cl^- to Cl_2, I to I_2 and Ce(III) to Ce(IV).

Comprehension 14

[1] (d) The complexes are $K_2[Ni(CN)_4]$ and $K_2[Ni(Cl)_4]$. Hence, their names are potassium tetracyanonickelate(II) and potassium tetrachloro nickelate(II).

[2] (a) $_{28}Ni^{2+}(3d^8)$



[3] (c) See solution of [2].

Comprehension 15

[1] (c) Between nitrates and phosphates, nitrates are less abundant in earth's crust because all nitrates are soluble in water.

[2] (c) NH_3 is a better electron donor than PH_3 because the lone pair of electrons occupies sp^3 orbital formed from the more compact $2s$ and $2p$ orbitals as compared to $3s$ and $3p$ orbitals of phosphorus in PH_3.

[3] (b) The reaction of

$$P_4 + 3OH^- + 3H_2O \longrightarrow PH_3 + 3H_2PO_2^-$$

The oxidation state of phosphorus in P_4, PH_3 and $H_2PO_2^-$ are 0, −3 and +1, respectively, thus, the reaction is disproportionation reaction.

Comprehension 16

[1] (d)

[2] (c)

[3] (b)

(i) $\underset{(X)}{Na_2S} + 2H^+ \longrightarrow 2Na^+ + H_2S$

(ii) 

$+ H_2S + 6Fe^{3+} \longrightarrow 6Fe^{2+} + NH_4^+ + 4H^+$
+ methylene blue (a dye)

(iii) $4FeCl_3 + 3K_4[Fe(CN)_6] \longrightarrow \underset{\text{Ferri ferrocyanide}}{Fe_4[Fe(CN)_6]_3} + 2KCl$

Or $FeCl_3 + K_3[Fe(CN)_6] \longrightarrow \underset{(Z)\text{ Brown colour}}{Fe[Fe(CN)_6]} + 3KCl$

Comprehension 17

[1] (b) $2CuFeS_2 + O_2 \longrightarrow Cu_2S + 2FeS + SO_2\uparrow$

$2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2$

$2FeS + 3O_2 \longrightarrow 2FeO + 2SO_2$

[2] (d) $\underset{\text{gangue}}{FeO} + \underset{\text{flux}}{SiO_2} \longrightarrow \underset{\text{slag}}{FeSiO_3(l)}$

[3] (c) $Cu_2S + 2Cu_2O \longrightarrow 6Cu + SO_2$

$\underset{\text{Reductant}}{S^{2}} \longrightarrow \underset{\text{Oxidant}}{S^{4+}}$

Comprehension 18

[1] (c)

[2] (a)

[3] (b)

The paragraph given and the problems asked suggests that the following changes are possible.

$\underset{(M)}{Cu} + 2AgNO_3 \longrightarrow \underset{(N)}{Cu(NO_3)_2} + 2Ag$

$\underset{(\text{Blue})}{}$

On addition of aqueous NaCl to blue aqueous solution a white precipitate of AgCl is formed.

$AgNO_3 + NaCl \longrightarrow \underset{\text{White}}{AgCl\downarrow} + NaNO_3$

As the blue solution contains $Cu(NO_3)_2$ and left $AgNO_3$, addition of NH_3 to this solution, AgCl and $Cu(NO_3)_2$ form complexes of $[Ag(NH_3)_2]^+$ and $[Cu(NH_3)_4]^{2+}$

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

$Cu(NO_3)_2 + 4NH_3 \longrightarrow [Cu(NH_3)_4]^{2+} + 2NO_3^-$

Comprehension 19

[1] (a)

[2] (a) $\underset{\text{cold dil.}}{Cl_2 + NaOH} \longrightarrow \underset{(P)}{NaCl + NaOCl}$

$\underset{\text{hot conc.}}{3Cl_2 + 6NaOH} \longrightarrow \underset{(Q)}{5NaCl + NaClO_3 + 3H_2O}$

Sodium hypoclorite (NaOCl) is salt of hypochlorous acid (HOCl)

Sodium chlorate ($NaClO_3$) is salt of chloric acid ($HClO_3$)

$Cl_2 + SO_2 \xrightarrow{\text{charcoal}} \underset{(R)}{SO_2Cl_2}$

$10SO_2Cl_2 + P_4 \longrightarrow \underset{(S)}{4PCl_5} + 10SO_2$

$PCl_5 + 4H_2O \longrightarrow \underset{(T)}{H_3PO_4} + 5HCl$

Comprehension 20

[1] (d) Cr^{3+} does not give precipitate with dil. HCl, also does not give precipitate with H_2S in acid medium but gives green coloured precipitate with H_2S in alkaline medium of $Cr(OH)_3$, The green precipitate being soluble in NaOH which on reacting with H_2O_2 gives yellow coloured solution of Na_2CrO_4.

$Cr(OH)_3 + 2NaOH + H_2O_2 \longrightarrow \underset{\text{green colour}}{\underset{(S)}{Na_2CrO_4}} + 3H_2O$

[2] (a) Pb^{2+} gives precipitate with dil HCl, which is soluble in hot water but insoluble in cold water. Among Pb^{2+}, Hg_2^{2+}, Ag^+, Hg^{2+}only Pb^{2+}

also give precipitate with dil. H^+ / H_2S

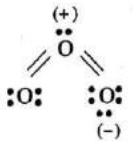
$Pb^{2+} + H_2S \xrightarrow{H^+} \underset{\text{precipitate}}{\underset{(P)}{PbS}} + 2H^+$

STATEMENT EXPLANATION PROBLEMS

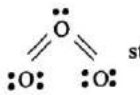
In each sub question given below a statement (**S**) and explanation (**E**) is given. Choose the correct answers from the codes (a), (b), (c) and (d) given for each question:

(a) **S** is correct but **E** is wrong
(b) **S** is wrong but **E** is correct
(c) Both **S** and **E** are correct and **E** is correct explanation of **S**
(d) Both **S** and **E** are correct but **E** is not correct explanation of **S**

1. **S :** F atom has a less negative electron affinity than Cl atom.
   E : Additional electrons are repelled more effectively by 3*p* electrons in Cl atom than by 2*p* electrons in F.
2. **S :** The first ionization energy of Be is greater than that of B.
   E : 2*p* orbital is lower in energy than 2*s*.
3. **S :** Although PF_5, PCl_5 and PBr_5 are known, the pentahalides of nitrogen have not been observed.
   E : Phosphorus has lower electronegativity than nitrogen.
4. **S :** The alkali metal can form ionic hydrides which contain the H^-.
   E : The alkali metals have low electronegativity, their hydrides conduct electricity when fused and liberate hydrogen at the anode.
5. **S :** F—F bond in F_2 molecule is strong.
   E : F-atom is small in size.
6. **S :** $Al(OH)_3$ is amphoteric in nature.
   E : Al—O and O—H bonds can be broken with equal ease in $Al(OH)_3$.
7. **S :** Sulphate is estimated as $BaSO_4$ and not as $MgSO_4$.
   E : Ionic radii of Mg^{2+} is smaller than Ba^{2+}.
8. **S :** The electronic structure of O_3 is



   E :



   structure is not allowed because octet around O cannot be expanded.
9. **S :** LiCl is predominantly a covalent compound.
   E : Electronegativity difference between Li and Cl is too small.
10. **S :** HNO_3 is a stronger acid than HNO_2.
    E : In HNO_3 there are two nitrogen to oxygen bonds where as in HNO_2 there is only one.
11. **S :** A very dilute acidic solution of Cd^{2+} and Ni^{2+} gives yellow ppt. of CdS on passing H_2S.
    E : Solubility product of CdS is more than that of NiS.
12. **S :** To a solution of potassium chromate if a strong acid is added it changes its colour from yellow to orange.
    E : The colour changes is due to the oxidation of potassium chromate.
13. **S :** A very dilute solution of Cd^{2+} and Ni^{2+} gives yellow ppt. on passing H_2S.
    E : Solubility product of CdS is less than of NiS.
14. **S :** NH_3 can be dried by $CaCl_2$.
    E : $CaCl_2$ is a good dehydrating agent.
15. **S :** Both H_3PO_4 and H_3PO_3 possess the same number of hydrogen atoms, but H_3PO_4 is tribasic acid and H_3PO_3 is dibasic.
    E : In oxyacids only those H atoms are replaceable which are attached to O atom.
16. **S :** HF forms two series of salts but HCl not.
    E : F atom is more electronegative than Cl atom.
17. **S :** Among alkali metal cations, $Li^+(aq)$ has highest electrical conductance.
    E : $Li^+(aq)$ is largest alkali metal cation because of greater degree of hydration.
18. **S :** CO is neutral molecule.
    E : CO forms salt with NaOH at high *P* and high *T*.
19. **S :** LiCl is predominantly covalent compound.
    E : Electronegativity difference between Li and Cl is too small.
20. **S :** HNO_3 is a stronger acid than HNO_2.
    E : In HNO_3, there are two N—O bonds whereas in HNO_2 there is only one.
21. **S :** Sulphate is estimated as $BaSO_4$ and not $MgSO_4$.
    E : Ionic radius of Mg^{2+} is smaller than that of Ba^{2+}.
22. **S :** Iodine does not displace Cl_2 or Br_2 from their chloride and bromides but displaces them from their oxy salts.
    E : E°_{OP} of $I_2 > E^\circ_{OP}$ of Cl_2 or Br_2.
23. **S :** H_2 molecule is more stable than He—H molecule.
    E : The antibonding electron in He—H molecule decreases the bond order and thereby the stability.
24. **S :** Super oxide ion is paramagnetic whereas peroxide ion is diamagnetic.

E : Super oxide ion $[O{=}O]^-$ has one unpaired electron whereas peroxide ion $[O{=}O]^{2-}$ has no unpaired electron.

25. S : Graphite is thermodynamically more stable than diamond.

E : $C_D \longrightarrow C_G$; $\Delta H = -1.9$ kJ/mol.

26. S : PCl_3 $\left[\begin{array}{c} Cl-P-Cl \\ | \\ Cl \end{array}\right]$ on hydrolysis gives

$$HO-\overset{\overset{O}{\|}}{\underset{\underset{H}{|}}{P}}-OH \text{ and not } HO-\underset{\underset{OH}{|}}{P}-OH$$

E : H_3PO_3 exists in two tautomeric forms:

$$HO-\underset{\underset{OH}{|}}{\overset{\overset{H}{|}}{P}}-OH \rightleftharpoons HO-\overset{\overset{H}{|}}{\underset{\underset{O}{\|}}{P}}-OH$$ and the latter is more stable due to resonance.

27. S : On throwing aluminium powder in air, it catches fire.

E : $2Al + \frac{3}{2}O_2 \longrightarrow Al_2O_3$; ΔH = –ve.

The reaction is highly exothermic and once started continues to develop fire.

28. S : Equivalent mass of H_2SO_4 in lead storage battery is 49.

E : In lead storage battery, H_2SO_4 acts both as oxidant and reductant.

29. S : Magnesium and oxygen do not react at 0°C but on heating to 200°C, an exothermic reaction occurs.

E : The heat is used to cross the energy barrier of the reaction of Mg and oxygen.

30. S : Sometimes a white precipitate is obtained when a solution is prepared in conc. HCl and then diluted, even if first group is absent.

E : This is due to insoluble nature of $PbCl_2$.

31. S : Ba^{2+} ion is poisonous, yet $BaSO_4$ is given to patient prior to taking stomach X-ray.

E : $BaSO_4$ is extremely insoluble and does not pass from digestive systems into circulatory system.

32. S : C_3O_2 has linear structure.

E : Each C atom in C_3O_2 is *sp*-hybridised.

33. S : Phosphine is prepared in an inert atmosphere of CO_2 and H_2.

E : Phosphine is highly inflammable in air.

34. S : During diazotisation, excess of HCl is used with $NaNO_2$.

E : Excess of HCl prevents the hydrolysis of diazonium salt.

35. S : The formula of iron (III) ferro-cyanide is $Fe_4[Fe(CN)_6]_3$.

E : 860 g of iron (III) ferro-cyanide contains 7 atoms of iron.

36. S : Li resembles with Mg.

E : Both have nearly same charge/size ratio.

37. S : Boron does not show univalent nature but unipositive nature of thallium is quite stable.

E : Inert pair effect predominates in thallium.

38. S : $BeCl_2$ cannot be easily hydrolysed.

E : $BeCl_2$ is electron deficient compound.

39. S : The melting point of LiCl is lower than that of NaCl.

E : LiCl has predominantly covalent nature, whereas NaCl is ionic.

40. S : Pb^{4+} is easily reduced to Pb^{2+}.

E : Pb^{4+} is strong oxidant.

41. S : LiCl is soluble in organic solvent.

E : LiCl is a covalent compound.

42. S : A fresh stain of iodine is washed with hypo solution.

E : Hypo is a bleaching agent and it oxidises I_2 to I^-.

43. S : Iodine is sparingly soluble in water but fairly soluble in KI.

E : Iodine is non-polar in nature.

44. S : H_2SO_4 is more viscous than water.

E : In H_2SO_4, S has highest oxidation state.

45. S : White phosphorus is less stable whereas red phosphorus is more stable.

E : White phosphorus exist as individual P_4 having more strained geometry while red phosphorus has P_4 tetrahedron structure linked together.

46. S : Iodine is liberated when KI is added to Cu^{2+} ions but Cl_2 is not liberated when KCl is added to Cu^{2+} ions.

E : The reducing power of I^- is more than Cl^-.

47. S : Sulphur (IV) oxide can act as reducing as well as oxidising agent.

E : S in SO_2 has its oxidation number +4 lying between –2 (minimum) and +6 (maximum).

48. S : $HgCl_2$ and $SnCl_2$ exist together in an aqueous solution.

E : $SnCl_2$ is a strong reducing agent.

49. S : $AgNO_3$ produces a black stain on the skin.

E : $AgNO_3$ is a dye.

50. S : The surface of aluminium metal get tarnished when exposed to air for long time.

E : The aluminium metal is coated with Al_2O_3.

51. **S :** Sodium fire in laboratory cannot be extinguished by pouring water.
E : Sodium reacts with water violently.

52. **S :** Ores of metals are not found as nitrates.
E : All the metal nitrates are insoluble in water.

53. **S :** The IUPAC name of $K_3[Cr(CN)_6]$ is potassium hexacyanochromate (III).
E : It is an anion complex.

54. **S :** $Ti(H_2O)^{3+}$ is coloured ion while $Sc(H_2O)_6^{3+}$ is colourless.
E : Ti^{3+} has $3d^1$ configuration whereas Sc^{3+} has no unpaired electron and thus *d-d* transition is not possible.

55. **S :** Mn_2O_7 is acidic oxide of manganese.
E : Mn_2O_7 reacts with water to give $HMnO_4$.

56. **S :** $FeSO_4(aq)$ is not a primary standard.
E : In aqueous medium Fe^{2+} ions are not present.

57. **S :** $[Al(NH_3)_6]^{3+}$ does not exist in aqueous solution.
E : Al^{3+} being smaller ion possesses high degree of hydration.

58. **S :** H_2S can be dried by H_2SO_4.
E : A basic drying agent absorbs moisture from basic substance and an acidic drying agent is needed for acidic substance to be dried.

59. **S :** $BeCl_2$ is linear but $SnCl_2$ is angular.
E : $BeCl_2$ has *sp*-hybridised Be atom whereas $SnCl_2$ has sp^3-hybridised Sn atom.

60. **S :** NH_3 is more basic than PH_3 as well as H_2O is less acidic than H_2S.
E : Basic character of hydrides decreases along the period as well as down the group.

61. **S :** H_2 exists in two isomeric forms known as ortho and para forms.
E : The ortho and para H_2 differ in the spin of their electron.

62. **S :** Helium (II) is unique liquid with properties of gas.
E : He (II) is super fluid having so low energy that thermal motion of atom do not take place, however, interatomic forces are also so weak that it does not occupy solid state.

63. **S :** Fe_3O_4 is paramagnetic at room temperature and becomes ferrimagnetic at 850 K.
E : The randomisation of spin takes place with temperature.

64. **S :** In fused state, calcium chloride can not be used to dry alcohol or NH_3.
E : $CaCl_2$ is not a good dessicant.

65. **S :** Lead and bismuth are purified by liquation method.
E : Lead, tin and bismuth have low m.pt. as compared to impurities.

66. **S :** $NH_2—NH_2$ is a chelating ligand.
E : A chelating ligand must have two or more lone pairs of electrons at such a distance that it may from suitable strain free jumps at the metal ions.

67. **S :** Order of H—*X* bond length : HI > HBr > HCl > HF
Order of dipole moment : HF > HCl > HBr > HI.
E : The increase in partial charge from F to I predominates over the increase in bond length from HF to HI.

68. **S :** The stability order for Co^{2+} complex with halides shows the order $Cl^- > Br^- > I^-$ but for Pt^{2+} complex it is $I^- > Br^- > Cl^-$.
E : A blue coloured complex $K[CoCl_4]$ on treatment with $HgCl_2$ gives another blue coloured complex.

69. **S :** Electrolysis of $CaH_2(s)$ is made in eutectic mixture of LiCl/KCl.
E : $CaH_2(s)$ decomposes on heating before its melting.

70. **S :** Nitrates ores are less abundant in the earth crust.
E : Nitrates of all the metal are water soluble.

71. **S :** P_2O_5 is acidic anhydride of many oxoacids of phosphorus.
E : H_3PO_3 is stronger acid than H_3PO_4.

72. **S :** $:NH_2\overset{\bullet\bullet}{N}H_2$ although possesses two electron pair for donation but does not act as chelating agent.
E : The coordination of $NH_2 \cdot NH_2$ leads to a highly unstable three membered strained ring.

73. **S :** $Al(NH_3)_6^{3+}$ exists in aqueous solutions.
E : Al^{3+} ion has lesser tendency for NH_3 than H_2O and thus ligand NH_3 is repaced by H_2O.

74. **S :** A small quantity of H_2SO_4 is added during preparation of standard solution of ferrous ammonium sulphate.
E : It Prevents hydrolysis of sulphate ions and provides a clear solution.

75. **S :** CrO_4^{2-} is yellow coloured anion.
E : The colour is due to *d-d* transition.

76. **S :** Cu^+ is more stable than Cu^{2+} in solid state, whereas $Cu^+_{aq.}$ is less stable than $Cu^{2+}_{aq.}$.
E : $CuI_2(aq.)$ is less stable than $Cu_2I_2(aq.)$ but $CuCl_2(aq.)$ is more stable than $Cu_2Cl_2(aq.)$.

77. **S :** Between $SiCl_4$ and CCl_4, only $SiCl_4$ reacts with water. **(IIT 2001)**
E : $SiCl_4$ is ionic and CCl_4 is covalent.

78. **S :** In water, orthoboric acid behaves as a weak monobasic acid. **(IIT 2007)**
E : In water, orthoboric acid acts as a proton donor.

79. **S :** Boron always forms covalent bond. **(IIT 2007)**

E : The small size of B^{3+} favours formation of covalent bond.

80. **S :** Alkali metals dissolved in liquid ammonia to give blue solutions. **(IIT 2007)**

E : Alkali metals in liquid ammonia give solvated species of the type $[M(NH_3)_n]^+$ (M = alkali metals).

81. **S :** $[Fe(H_2O)_5NO]SO_4$ is paramagnetic.

E : The Fe in $[Fe(H_2O)_5NO]SO_4$ has three unpaired electrons. **(IIT 2008)**

82. **S :** The geometrical isomers of the complex $[M(NH_3)_4Cl_2]$ are optically inactive.

E : Both geometrical isomers of the complex $[M(NH_3)_4Cl_2]$ possess axis of symmetry. **(IIT 2008)**

83. **S :** Pb^{4+} compounds are stronger oxidizing agents than Sn^{4+} compounds.

E : The higher oxidation states for the group 14 elements are more stable for the heavier members of the group due to 'inert pair effect'. **(IIT 2008)**

ANSWERS (Statement Explanation Problems)

1. (a) It is due to higher interelectronic repulsion forces. The additional electrons are repelled more effectively by $2p$-electrons in F-atom (due to small size) than by $3p$-electrons in Cl-atom.

2. (a) Statement is correct but explanation is incorrect because a large amount of energy is required for the removal of $2s$ electrons in comparison to $2p$ electron, *i.e.*, energy level of $2s$ is less than $2p$-orbital.

3. (d) Both are the facts.

4. (d) Both are the facts.

5. (c) Explanation is correct explanation.

6. (a) Statement is correct but explanation is incorrect.

7. (d) Both are correct but the explanation is not the correct explanation.

8. (d) Both are correct.

9. (a) Statement is correct but explanation is incorrect.

10. (a) $H-O-N\begin{matrix}O\\O\end{matrix}$; $H-O-N=O$

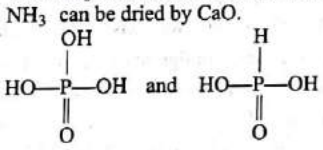
11. (a) Statement is correct but explanation is wrong.

$$K_{sp} \text{ of NiS} > K_{sp} \text{ of CdS}$$

12. (a) $\underset{\text{yellow}}{CrO_4^{2-}} + 2H^+ \longrightarrow \underset{\text{orange}}{Cr_2O_7^{2-}} + H_2O$

13. (c) $[Cd^{2+}][S^{2-}] > K_{sp}$ CdS, then only CdS can give yellow precipitate. The dissociation of H_2S provides appreciable $[S^{2-}]$ to precipitate CdS. NiS can be precipitated only in alkaline medium because K_{sp} of NiS is high.

14. (b) No doubt $CaCl_2$ is a dehydrating agent but it reacts with NH_3 and thus it cannot be used by drying NH_3, NH_3 can be dried by CaO.

15. (c)  and

16. (d) HF forms $NaHF_2$ and NaF salts due to its dimerised formula H_2F_2 on account of H-bonding. No doubt F is more electronegative than Cl.

17. (b) Explanation is correct and thus, conductance of Li^+ is lowest among alkali metal cations.

18. (d) CO is neutral but the only reaction where it acts as acid is $CO + NaOH \xrightarrow{P,T} HCOONa$.

19. (a) LiCl is predominantly covalent because small cation (Li^+) causes more polarisation of Cl^- to develop covalent nature.

20. (a) N in HNO_3 has higher oxidation state (+5) than in HNO_2(+3). More is oxidation number of central atom in oxyacid, more is acidic nature.

21. (d) $MgSO_4$ is water soluble; $BaSO_4$ is insoluble, thus estimation can be made by $BaSO_4$. The insoluble nature of $BaSO_4$ is due to its higher lattice energy inspite of larger size of Ba^{2+}.

22. (d) $2KClO_3 + I_2 \longrightarrow 2KIO_3 + Cl_2$

$KCl + I_2 \longrightarrow$ No reaction $\longrightarrow E^\circ_{op}$ of Cl < E°_{op} of I;

Thus,

I will oxidise and Cl will reduce.

23. (c) Bond order for $H_2 = 1$

Bond order for $He—H = \frac{1}{2}$

24. (c) $[O=O]^-$ has M.O. configuration

$$\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2 \sigma^* 2s^2, \sigma 2p^2 \pi 2p_x^2 \pi 2p_y^2 \pi^* 2p_x^2 \pi^* 2p_y^1$$

$[O=O]^{2-}$ has M.O. configuration

$$\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2 \sigma^* 2s^2, \sigma 2p^2 \pi 2p_x^2 \pi 2p_y^2 \pi^* 2p_x^2 \pi^* 2p_y^2$$

25. (c) Graphite form of carbon possess lower energy level.

26. (c) Explanation is correct reason for statement.

27. (c) Explanation is correct reason for statement.

28. (b) Anode:

$Pb(s) + HSO_4^- + H_2O \longrightarrow PbSO_4 + 2e + H_3O^+$

Cathode :

$PbO_2(s) + HSO_4^- + 3H_3O^+ + 2e \longrightarrow PbSO_4(s) + 5H_2O$

Net $Pb + 2HSO_4^- + 2H_3O^+ + PbO_2 \longrightarrow PbSO_4 + 4H_2O$

Thus, $2H_2SO_4$ consumes 2 electrons

$\therefore$ Equivalent mass $= \frac{\text{Molar mass}}{1} = 98$

29. (c) A reaction occurs only when threshold energy barrier is crossed.

30. (a) The white precipitate formed is due to the formation of oxychlorides of Bi or Sb.

$$BiCl_3 + H_2O \longrightarrow BiOCl + 2HCl$$

31. (c) Explanation is correct reason for statement.

32. (c) C_3O_2 has O=C=C=C=O geometry.

33. (c) Explanation is correct reason for statement.

34. (c) Explanation is correct reason for statement.

35. (a) 1 mole of $Fe_4[Fe(CN)_6]_3$ has 7 g atoms of Fe.

36. (c) Explanation is correct reason for statement.

37. (c) Explanation is correct reason for statement.

38. (d) Salts of strong acid and strong base cannot be hydrolysed. Also $BeCl_2$ is electron deficient compound.

39. (c) Explanation is correct reason for statement.

40. (c) Explanation is correct reason for statement.

41. (c) Explanation is correct reason for statement.

42. (c) Explanation is correct reason for statement.

43. (d) Iodine is more soluble in KI due to complex (KI_3) formation.

44. (d) H_2SO_4 shows extensive H-bonding and thus more viscous.

45. (c) Explanation is correct reason for statement.

46. (c) Explanation is correct reason for statement.

47. (c) Explanation is correct reason for statement.

48. (b) $SnCl_2$ will reduce $HgCl_2$ to Hg_2Cl_2 and finally to Hg.

49. (a) $AgNO_3$ reduces to Ag on coming in contact with protein.

50. (c) Explanation is correct reason for statement.

51. (c) Explanation is correct reason for statement.

52. (a) All the metal nitrates are water soluble.

53. (d) $[Cr(CN)_6]^{3-}$ is an anionic complex.

54. (c) Explanation is correct reason for statement.

55. (c) Explanation is correct reason for statement.

56. (a) A standard solution of $FeSO_4(aq)$ cannot be prepared by simple weighing as some of the Fe^{2+} are readily oxidised to Fe^{3+} ions.

57. (c) Al^{3+} ion being smaller possess high degree of hydration and therefore, the ligand H_2O takes position of NH_3.

$$[Al(NH_3)_6]^{3+} + 6H_2O \longrightarrow [Al(H_2O)_6]^{3+} + 6NH_3$$

58. (b) H_2S (acid) can not be dried by H_2SO_4 (acid) as the later oxidises H_2S. However, given explanation is correct.

$$3H_2S + H_2SO_4 \longrightarrow 4H_2O + 4S$$

59. (a) Be atom in $BeCl_2$ is *sp*-hybridised whereas Sn atom in $SnCl_2$ has sp^2-hybridisation.

60. (c) The given statement and explanation both are correct and explanation is correct for given statement.

61. (a) The two forms ortho and para hydrogen differ from each other in spin of their proton or nucleus.

62. (c) The given statement and its explanation are correct.

63. (b) Fe_3O_4 is ferrimagnetic at room temperature and becomes paramagnetic at 850K due to randomisation of spin with temperature.

64. (a) $CaCl_2$ is good dessicant and forms addition product with NH_3 and alcohol. It also absorbs water.

65. (c) Explanations is correct reason for statement.

66. (b) $NH_2 \cdot NH_2$ leads to 3-membered highly unstable strained ring.

67. (c) $\mu = \overrightarrow{\delta \times d}$.

68. (a) $K_2[CoCl_4] + HgCl_2 \longrightarrow Co[HgCl_4] + 2KCl$; $Co^{2+}(aq.)$ is pink.

69. (a) CaH_2 is ionic hydride.

70. (c) Explanantion is correct order for statement.

71. (d) Both are correct due to different explanation.

72. (c) Explanation is correct reason for statement.

73. (b) $[Al(NH_3)_6]^{3+} + H_2O \longrightarrow [Al(H_2O)_6]^{3+} + NH_3$

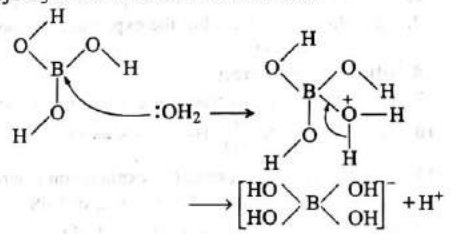
74. (c) Explanation is correct reason for statement.

75. (a) The color is not due to *d-d* transition.

76. (d) Both are correct and have different explanation.

77. (a) Both are covalent. $SiCl_4$ hydrolyses due to presence of *d*-orbitals.

78. (a) H_3BO_3 is weak monobasic Lewis acid.



79. (c) Boron always forms covalent bond because boron requires very high energy to form B^{3+} and again B^{3+} due to its very small size having high polarising power thus cause greater polarisation and eventually significant covalent characteristics. (Fajans rule).

80. (d) Alkali metals with ammonia give blue colour due to ammoniated e^-

$$Na + (x+y)NH_3 \longrightarrow [Na(NH_3)_y]^+ + [e(NH_3)_x]^-$$

solvated (blue colour) electron.

81. (c) Iron in $[Fe(H_2O)_5NO]SO_4$ exists in +2 oxidation state having electronic configuration $(3d)^6$. The unpaired electron of NO is shifted to Fe^{2+} changing it to Fe^+ and also changes NO to NO^+. The electronic configuration of iron in the complex thus, becomes $(3d)^7$ with three unpaired electrons as in the complex, sp^3d^2 hybridization exists.

82. (c) Both statements are correct and explanation is correct reason for statement.

83. (a) Due to inert-pair effect, the higher oxidation states for the group 14 elements are less stable for the heavier members of the group and have a tendency to reduce to lesser oxidation state (*i.e.*, these are stronger oxidizing agent).

MATCHING TYPE PROBLEMS

Type I : Only One Match is Possible

1.

Name	Formula
1. Orthosilicate	a. $[Si_2O_7]^{6-}$
2. Pyro silicate	b. $[SiO_4]^{4-}$
3. Cyclic silicate	c. $[Si_nO_{3n}]^{2n-}$
4. Infinite chain silicate	d. $[Si_4O_{11}]^{6-}$
5. Infinite sheet silicate	e. $[SiO_3^{2-}]_n$

2.

List A	List B
(a) Magnetite	(i) Fe_2O_3
(b) Haematite	(ii) Fe_3O_4
(c) Limonite	(iii) $FeCO_3$
(d) Siderite	(iv) $Fe_2O_3 \cdot 3H_2O$

3.

List A	List B
(a) Amatol	(i) Explosive
(b) Bronsted acid	(ii) $B(OH)_3$
(c) Hypo	(iii) H_3PO_4
(d) Lewis acid	(iv) Photography

4.

Column-I	Column-II
(a) Lignite	(p) Bhilai
(b) Ammonium sulphate	(q) Copper
(c) Blast furnance	(r) Neyveli
(d) Chalcopyrite	(s) Sindri

5.

Column-I	Column-II
(a) Silver	(p) Fused-salt electrolysis
(b) Calcium	(q) Carbon reduction
(c) Zinc	(r) Carbon monoxide reduction
(d) Iron	(s) Amalgamation
(e) Copper	(t) Self-reduction

6.

Column-I	Column-II
(a) $KCl \cdot MgCl_2 \cdot 6H_2O$	(p) Cassiterite
(b) SnO_2	(q) Carnallite

7.

X	Y
(a) Al	(p) Calamite
(b) Cu	(q) Cryolite
(c) Mg	(r) Malachite
(d) Zn	(s) Carnallite

8.

Column-I	Column-II
(a) Spinel	(p) $MgAl_2O_4$
(b) Felspar	(q) $PbCO_3$
(c) Cerussite	(r) $K_2O \cdot Al_2O_3 \cdot 6SiO_2$
(d) Malachite	(s) $MgSO_4 \cdot H_2O$
(e) Kisserite	(t) $Cu(OH)_2 \cdot CuCO_3$

9.

Column-I	Column-II
(a) Anhydrous $AlCl_3$	(p) Air pollutant
(b) Carbon monoxide	(q) Lubricant
(c) Graphite	(r) Deliquescent

10.

Column-I	Column-II
(a) Bleaching agent	(p) Carbon
(b) Smelling salt	(q) Tin
(c) Bell metal	(r) Ammonium carbonate
(d) Fluorspar	(s) Calcium
(e) Fertilizer	(t) Chlorine
(f) Anthracite	(u) Ammonium phosphate

11.

Column X	Column Y
(a) $(NaPO_3)_n$	(p) Cassiterite
(b) NO_3^-	(q) Producer gas
(c) SnO_2	(r) Water softener
(d) $KCl \cdot MgCl_2 \cdot 6H_2O$	(s) Brown ring test
(e) $CO + N_2$	(t) Carnallite

Type II : More Than One Match Are Possible

12.

Column-I	Column-II
(A) $Cu + dil.\ HNO_3$	(p) NO
(B) $Cu + conc.\ HNO_3$	(q) NO_2
(C) $Zn + dil.\ HNO_3$	(r) N_2O
(D) $Zn + conc.\ HNO_3$	(s) $Cu(NO_3)_2$
	(t) $Zn(NO_3)_2$

[IIT 2009]

13.

Column-I	Column-II
(A) B_2	(p) Paramagnetic
(B) N_2	(q) Undergoes oxidation
(C) O_2^-	(r) Undergoes reduction
(D) O_2	(s) Bond order ≥ 2
	(t) Mixing of 's' and 'p' orbitals

[IIT 2009]

14.

Column-I	Column-II
(A) $(CH_3)_2SiCl_2$	(p) Hydrogen halide formation
(B) XeF_4	(q) Redox reaction
(C) Cl_2	(r) Reacts with glass
(D) VCl_5	(s) Polymerization
	(t) O_2 formation

[IIT 2010]

15.

Column-I	Column-II
(a) Self reduction	(p) Lead
(b) Carbon reduction	(q) Silver
(c) Complex formation and displacement by metal	(r) Copper
(d) Decomposition of iodide	(s) Boron

16.

Column-I	Column-II
(a) $Bi^{3+} \rightarrow (BiO)^+$	(p) Heat
(b) $[AlO_2]^- \rightarrow Al(OH)_3$	(q) Hydrolysis
(c) $[SiO_4]^{4-} \rightarrow [Si_2O_7]^{6-}$	(r) Acidification
(d) $[B_4O_7]^{2-} \rightarrow [B(OH)_3]$	(s) Dilution by water

17.

Column-I	Column-II
(a) $[Co(NH_3)_4(H_2O)_2]Cl_2$	(p) geometrical isomers
(b) $[Pt(NH_3)_2Cl_2]$	(q) paramagnetic
(c) $[Co(H_2O)_5Cl]Cl$	(r) diamagnetic
(d) $[Ni(H_2O)_6]Cl_2$	(s) metal ion with +2 oxidation state

Type III : One Match From Each List

18.

Column X	Column Y	Column Z
A. Invar	p. Co, Ni	a. Cutlery
B. Nichrome	q. Fe, Ni	b. Heating element
C. Stainless steel	r. Fe, Cr, Ni	c. Watch spring

19. Each entry in column X is in some way related to the entries in column Y and Z. Match the appropriate entries :

Column X	Column Y	Column Z
A. Yeast	p. Fermentation	a. Ethanol
B. Mica	q. Graphite	b. Abrasive
C. Superphosphate	r. Crystallite cubic	c. Insulator
D. Carbon fibres	s. Layer structure	d. Fertilizer
E. Rock salt	t. Diamond structure	e. Reinforced plastics
F. Carborundum	u. Bone ash	f. Preservative

20. The unbalanced chemical reactions given in List I show missing reagent or condition (?) which are provided in List II. Match List I with List II and select the correct answer using the code given below the lists :

List I	List II
(P) $PbO_2 + H_2SO_4 \xrightarrow{?} PbSO_4 + O_2 +$ other product	(1) NO
(Q) $Na_2S_2O_3 + H_2O \xrightarrow{?} NaHSO_4 +$ other product	(2) I_2
(R) $N_2H_4 \xrightarrow{?} N_2 +$ other product	(3) Warm
(S) $XeF_2 \xrightarrow{?} Xe +$ other product	(4) Cl_2

[JEE (Advanced) II 2013]

Codes:

	P	Q	R	S
(a)	4	2	3	1
(b)	3	2	1	4
(c)	1	4	2	3
(d)	3	4	2	1

ANSWERS

1. 1–b; 2–a; 3–c; 4–d; 5–e
2. a–ii; b–i; c–iv; d–iii
3. a–i; b–iii; c–iv; d–ii
4. a–r; b–s; c–p; d–q
5. a–s; b–p; c–q; d–r; e–t
6. a–q; b–p
7. a–q; b–r; c–s; d–p
8. a–p; b–r; c–q; d–t; e–s
9. a–r; b–p; c–q
10. a–t; b–r; c–q; d–s; e–u; f–p
11. a–r; b–s; c–p; d–t; e–q
12. A–p, r, s; B–q, s; C–p, r, t; D–q, t

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

Cold dil. 1 : 1 $3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 4H_2O + 2NO$

Cold dil. $4Cu + 10HNO_3 \rightarrow 4Cu(NO_3)_2 + 5H_2O + N_2O$

Hot conc. $Zn + 4HNO_3 \rightarrow Zn(NO_3)_2 + 2H_2O + 2NO_2$

Cold dil. $3Zn + 8HNO_3 \rightarrow 3Zn(NO_3)_2 + 2H_2O + 2NO$

Cold V dil.

$4Zn + 10HNO_3 \rightarrow 4Zn(NO_3)_2 + 3H_2O + NH_4NO_3$

$\hookrightarrow N_2O + 2H_2O$

13. A–p, q, r, t;

(i) B_2 has bond order 1, two unpaired electrons.

(ii) $3Mg + B_2 \longrightarrow Mg_3B_2$

(iii) $B_2 + N_2 \xrightarrow{\Delta} 2BN$

B–q, r, s, t;

(i) N_2 has bond order 3, no unpaired electron.

(ii) $N_2 + 3H_2 \longrightarrow 2NH_3$

(iii) $3Mg + N_2 \longrightarrow Mg_3N_2$

(iv) $N_2 + O_2 \xrightarrow{arc} 2NO$

C–p, q, r, t;

(i) O_2^- has bond order 1.5, one unpaired electron.

(ii) $KO_2 + 2H_2O \longrightarrow KOH + H_2O_2 + \frac{1}{2}O_2$

(disproportionation of O_2^{-1})

D–p, q, r, s, t

(i) O_2 has bond order 2, two unpaired electrons.

(ii) $2F_2 + O_2 \longrightarrow 2F_2O$

(iii) $2Mg + O_2 \longrightarrow 2MgO$

14. A–p, s; B–p, q, r, t; C–p, q; D–p
15. a–p, r; b–p, r; c–q; d–s
16. a–q, s; b–s; c–r; d–q, r
17. a–p, q, s; b–p, r; c–q; d–q, s
18. A–q–c; B–p–b; C–r–a
19. A–p–a; B–s–c; C–u–d; D–q–e; E–r–f; F–t–b
20. (d)

(*P*) $PbO_2 + H_2SO_4 \xrightarrow{\Delta} PbSO_4 + \frac{1}{2}O_2 + H_2O$

(*Q*) $Na_2S_2O_3 + 5H_2O \xrightarrow{4Cl_2} 2NaHSO_4 + 8HCl$

(*R*) $N_2H_4 \xrightarrow{2I_2} N_2 + 4HI$

(*S*) $XeF_2 \xrightarrow{NO} Xe + NOF$

IIT-JEE MODEL PAPER CHEMISTRY 1-A

Time : 60 Minutes **M.M. : 73**

Section A : Single Correct Answer **[2 × 9 = 18]**

1. Select the incorrect statement :
   (a) All the Al—Cl bonds are not identical in Al_2Cl_6
   (b) Both BF_4^- and CH_4 have regular tetrahedron geometry
   (c) Ionic radius of a cation decreases with increase in ox. no.
   (d) Ionic radius of a cation increases with increase in co-ordination number
2. Select the incorrect statement :
   (a) Adiabatic process can not be made in isolated systems
   (b) Isolated system does not allow exchange of mass or energy with the surroundings
   (c) The process occuring in an open system are always isobaric
   (d) In an open system, the system remains in equilibrium with atmospheric pressure
3. Select the incorrect statement :
   (a) Rate of evaporation of a liquid is directly proportional to surface area and temperature
   (b) Vapour pressure of a liquid does not depends upon surface area
   (c) Vapour pressure is the pressure exerted by liquid vapours when rate of evaporation = rate of condensation
   (d) Higher is the rate of evaporation of a liquid more will be its vapour pressure
4. Select the incorrect statement :
   (a) Ionisation energy of lithium is higher than sodium
   (b) It is easier to oxidise Li(*s*) to $Li^+(aq.)$ as compared to Na(*s*) to $Na^+(aq.)$
   (c) Hydration energy of Li^+ is lesser than Na^+
   (d) I_2 can replace Cl from $KClO_3$
5. Which one is incorrect about nitrogen(II) oxide :
   (a) It is diamagnetic in liquid state but paramagnetic in gaseous state
   (b) NO acts only as oxidant
   (c) It works as ligand in complex formation
   (d) It has bond order equal to NO^{2+} (*i.e.* 2.5) but bond length greater than NO^{2+}
6. Which of the following has maximum dipole moment :
   (a) *trans*-1,2-dichloro ethene
   (b) *cis*-1,2-dichloro ethene
   (c) *cis*-2,3-dichloro-2-butene
   (d) *cis*-1,2-dibromo-1,2-dichloro ethene
7. The major product formed on reaction of $(CH_3)_3 \cdot C \cdot CH_2OH$ with acid is :
   (a) 2-methyl but-1-ene
   (b) 2-methyl but-2-ene
   (c) 2,2-dimethyl but-1-ene
   (d) 2-methyl propene
8. In which of the following reactions in sulphonation of benzene, equilibrium is far to the left :
   (a) $2H_2SO_4 \rightleftharpoons H_3O^+ + HSO_4^- + SO_3$
   (b) $SO_3 + C_6H_6 \rightleftharpoons C_6\overset{+}{H}_5\!<\!\begin{matrix}H\\SO_3^-\end{matrix}$
   (c) $C_6\overset{+}{H}_5\!<\!\begin{matrix}H\\SO_3^-\end{matrix} + HSO_4^- \rightleftharpoons C_6H_5SO_3^- + H_2SO_4$
   (d) $C_6H_5SO_3^- + H_3O^+ \rightleftharpoons C_6H_5SO_3H + H_2O$
9. 0.1 *M* solution of weak acid H*A* is 1% dissociated at 25°C. If this solution is with respect to Na*A* 0.2 *M*, what is degree of dissociation of H*A* :
   (a) 2×10^{-5} (b) 10^{-4}
   (c) 4×10^{-5} (d) 5×10^{-5}

Section B : More than One Correct Answers **[3 × 5 = 15]**

10. Which of the following are true about the reaction :
    $CH_2 = CH - CH = CH_2 + HBr \longrightarrow$
    $CH_3 - CHBr - \underset{(P)}{CH = CH_2} + CH_3 - \underset{(Q)}{CH = CH} \cdot CH_2Br$
    (a) At low temperature ($\simeq -80°C$) product (*P*) is major product
    (b) At high temperature ($\simeq 40°C$) product (*Q*) is major product
    (c) At low temperature, the rate of addition is responsible for major product
    (d) At high temperature, major product is decided by the equilibrium between the two isomers
11. Select the correct statements :
    (a) O_2 and N_2^{2-} have same number of electrons and same MO configuration
    (b) O_2 and N_2^{2-} have bond order equal to two
    (c) N_2 is almost inert at room temperature but becomes reactive at high temperature or in presence of catalyst
    (d) There occurs extensive delocalisation of π-electrons in N_2 molecule
12. Select the correct statements :
    (a) P_4 molecule is tetrahedral with P–P–P angle of 60°
    (b) P_4 molecule has sp^3 hybridization
    (c) Black phosphorus is good conductor of current
    (d) Red phosphorus is good conductor of current
13. Which of the following gas on addition in air will decrease average molar mass of air ?

(a) Ar (b) He
(c) $H_2O_{(v)}$ (d) Ne

14. Which of the following are not correct ?
(a) The ratio of molar gas constant and Avogadro's no. is called Boltzman constant
(b) 1 equivalent of $K_2Cr_2O_7$ has seven equivalent of oxygen
(c) The ratio of mole and equivalent for a substance is called valence factor
(d) The value of $\frac{RT}{PV}$ at critical conditions is 3/8

Section C : Matrix Match Type Problems: [4×2=8]

More than one choice are possible:

15.

List A	List B
A. Sweating	P. Evaporation
B. Hoar frosting	Q. Endothermic
C. Roasting	R. $H_2O_{(v)} \longrightarrow H_2O_{(s)}$
D. Sintering	S. High temperature

16.

List A	List B
A. Thermal decomposition of $KClO_3$	P. Intramolecular redox
B. Thermal decomposition of $KClO_4$	Q. Inter molecular redox
C. Thermal decomposition of $(NH_4)_2Cr_2O_7$	R. Auto redox
D. Thermal decomposition of H_3PO_2	S. Disproportionation

Sintering is roasting with incipient fusion at comparatively high *T*. Black *P* consists of coagulated sheet each *P* bonded to neighbours in sheet.

Section D: Statement- Explanation [2×4=8]

Read the given statement and explanation and answer accordingly to choices given below :
(a) **S** is correct, but **E** is wrong
(b) **S** is wrong, but **E** is correct
(c) Both **S** and **E** are correct and **E** is correct explanation of **S**
(d) Both **S** and **E** are correct but **E** is not correct explanation of **S**

17. **S:** N_2O_3 is pale blue liquid at –30°C.
E: At room temperature N_2O_3, gives NO and NO_2 and dissociation increases with temperature.

18. **S:** NH_2OH is a weaker base than NH_3.
E: NH_2OH acts as oxidant in acid medium and mild reductant in alkaline medium.

19. **S:** Water of water fall is more cooler at the top rather than at the bottom.
E: During fall of water from top to bottom, the potential energy is converted into kinetic energy as it just hits the surface of bottom to give rise an increase in temperature.

20. **S:** Hypohalites are used to bring in oxidation as well as halogenation.
E: Hypohalite have halogens in +1 oxidation state.

Section E: Single Integer Answer Type [3×8=24]

S-1 : Ratio of P— O and P=O bonds in $H_4P_2O_7$ is :

S-2 : Number of tetrahedrals involved in $Cr_2O_7^{2-}$ structure

S-3 : A sample of SF_n mass 54 mg is supposed to contain 3×10^{20} molecules. Assuming Av. no. $=6\times10^{23}$, calculate the value of *n* (Atomic mass of F is 19)

S-4 : Number of water molecules associated with crystal hydrate of NaCl.

S-5 : A simplest alkene showing isomerism on monosubstitution has number of carbon atoms.

S-6: 0.22 g of organic compound C_xH_yO which occupied 112 mL at NTP and on combustion gave 0.44 g CO_2. The ratio of *y* to *x* is.....

S-7: 500 mL of 2 *M* K_2SO_4 and 500 mL of 4 *M* KCl are mixed. The solution is now diluted to 2 litre. The molarity of K^+ ions in the resultant solution is.....

S-8: 15 g impure sample of $Ba(MnO_4)_2$ is used to completely oxidise 10 mL of 11.2V H_2O_2 solution. What is percentage purity of $Ba(MnO_4)_2$?

SOLUTION OF MODEL PAPER 1-A

Section A

1. (b) BF_4^- does not possess regular tetrahedron structure due to the presence of co-ordinate bond.

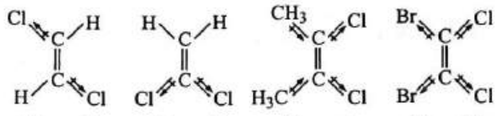
2. (c) The atmospheric pressure may be disturbed at any time due to sudden weather change or due to temperature.

3. (d) Vapour pressure is characteristic constant at given temperature. Larger surface area shows higher rate of evaporation then smaller surface area at constant *T*.

4. (c) $2KClO_3 + I_2 \longrightarrow 2KIO_3 + Cl_2$
Hydration energy: $Li^+ > Na^+$ due to smaller size.

5. (b) $10NO + 2CS_2 \longrightarrow 2CO + 4SO_2 + 5N_2$ (as oxidant)
$2NO + 5H_2 \longrightarrow 2NH_3 + 2H_2O$ (as oxidant)
$3MnO_4^- + 5NO + 4H^+ \longrightarrow 3Mn^{2+} + 5NO_3^- + 2H_2O$ (as reductant)

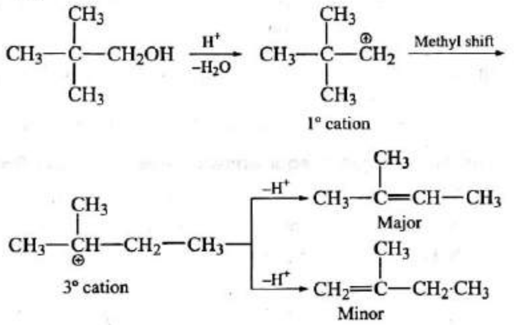
6. (c)



(a) $\mu = 0$ (b) $\mu \neq 0$ (c) $\mu \neq 0$ (d) $\mu \neq 0$

$\mu_{(c)} > \mu_{(b)}$ because dipole moment of CH_3 and Cl are additive (in same direction). Also $\mu_{(c)} > \mu_{(d)}$ because dipole moment of Br and Cl are subtractive (in opposite direction)

7. (b)



8. (d) $C_6H_5SO_3H$ is strong acid and exist as ions in water.

9. (d) $K_a = C\alpha^2 = 0.1 \times (0.01)^2 = 10^{-5}$

Also, In NaA: $K_a = \dfrac{[H^+][A^-]}{[HA]} = \dfrac{C \cdot \alpha \times 0.2}{C(1-\alpha)} = 10^{-5}$

$\therefore \quad \alpha = 5 \times 10^{-5}$

Section B

10. (a,b,c,d) Follow point c,d for the results in (a) and (b).
11. (b,c) Both N_2^{2-} and O_2 have different M.O.
12. (a,b,c) Red phosphorus is bad conductor of current.
13. (b,c,d) Argon has molar mass 40, higher than air (28.8).
14. (b, d)1 *eq.* of $K_2Cr_2O_7$ = 1*eq.*K^+ = 1*eq.*Cr^{6+} = 1*eq.*O^{2-} ;

$\dfrac{P_cV_c}{RT_c} = \dfrac{3}{8}$ and $\dfrac{RT_c}{P_cV_c} = \dfrac{8}{3}$

Section C

15. A : P, Q
B : R
C : Q, S
D : Q, S

16. A : P, R, S $2KClO_3 \longrightarrow KClO_4 + KCl + 2O_2$
$\quad \longrightarrow KCl + 2O_2$

B : P $KClO_4 \longrightarrow KCl + 2O_2$

C : P $(\overset{-2}{N}H_4)_2\overset{+6}{Cr_2}O_7 \longrightarrow \overset{0}{N_2} + \overset{+3}{Cr_2}O_3 + 4H_2O$

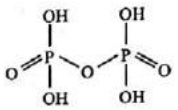
D : R,S $4H_3PO_2 \longrightarrow PH_3 + 3H_3PO_4$

Section D

17. (d) Both are facts.
18. (d) Both are facts.
19. (c) Explanation is correct reason for statement.
20. (c) —do—

Section E

S-1. Three:



$\frac{6}{2} = 3$

S-2. Two : Two tetrahedron units are present in $Cr_2O_7^{2-}$

S-3. Four : $3 \times 10^{20} \equiv 54 \times 10^{-3}$ g

$6 \times 10^{23} = 108$g

$\therefore \quad 32 + n \times 19 = 108$

$n = 4$

S-4. Two : $NaCl \cdot 2H_2O$

S-5. Three : $CH_3 \cdot CH_2 \cdot CH_3$; forms two compounds *i.e.,* $CH_3CHClCH_3$ and $CH_3 \cdot CH_2 \cdot CH_2Cl$ (Position isomerism)

S-6. Two : molar mass of $C_xH_yO = \dfrac{22400 \times 0.22}{112} = 44$g (*i.e.,* C_2H_4O)

S-7. Two : Meq. of K^+ in solution $= 500 \times 2 \times 2 + 500 \times 4 = 4000$

$\therefore M_{K^+} = \dfrac{4000}{2000} = 2$

S-8. Five : $10e + (Mn^{7+})_2 \longrightarrow 2Mn^{+2}$

$(O^{-1})_2 \longrightarrow O_2^0 + 2e$

Meq. of $Ba(MnO_4)_2$ = Meq.of $H_2O_2 = 10 \times N$

$= 10 \times \dfrac{11.2}{5.6}$ (V.strength $= N \times 5.6$)

$\dfrac{w}{E} \times 1000 = 20$

$\dfrac{w}{375/10} \times 1000 = 20$

$w = \dfrac{375 \times 2}{1000} = 0.750$

$\therefore \quad$ % purity $= \dfrac{0.750}{15} \times 100 = 5\%$

IIT-JEE MODEL PAPER CHEMISTRY 1-B

Time : 60 Minutes **M.M. : 73**

Section A : Single Correct Answer **[2×8 = 16]**

1. Which of the following is not known ?
   (a) SO_2F_2 (b) SO_2Cl_2
   (c) SO_2FBr (d) SO_2I_2

2. The C—$\ddot{\underset{\cdot\cdot}{O}}$—C bond angles in ether is :
   (a) >109.5° (b) 109.5°
   (c) 105° (d) 107°

3. Select the correct statement :
   (a) For each 10° rise of temperature, the specific reaction rate constant is nearly doubled.
   (b) Rate of reaction decreases with rise in temperature for exothermic reaction.
   (c) Rate of reaction decreases with rise in temperature for endothermic reaction.
   (d) The reaction $2N_2O_5 \longrightarrow 4NO_2 + O_2$ having rate constant $3.0\times10^{-5}\,sec^{-1}$ goes for completion in 3.0×10^{4} sec.

4. Which of the following statement is correct ?
   (a) pH of 1.0×10^{-8} *M* NaOH is 8
   (b) Autoprotolysis constant of water is 3.23×10^{-18}
   (c) Equilibrium constant for dissociation of water is 1.0×10^{-14}
   (d) 10 mL of 0.1 *M* H_2SO_4+20 mL of 0.1 *M* NH_4OH mixture is buffer

5. Which of the following are mass independent ?
   (a) *P* (b) *V*
   (c) $\frac{PV}{n}$ (d) *PV*

6. If the energy of H-atom in the ground state is $-E$, the velocity (u) of photo-electron emitted when a photon having energy E_p strikes a stationary Li^{2+} ion in ground state is given by :
   (a) $u=\sqrt{\frac{2(E_P-E)}{m}}$ (b) $u=\sqrt{\frac{2(E_P+9E)}{m}}$
   (c) $u=\sqrt{\frac{2(E_P-9E)}{m}}$ (d) $u=\sqrt{\frac{2(E_P-3E)}{m}}$

7. Aqueous solution of two compounds M_1-O-H and M_2-O-H are prepared in two different beakers. If the electronegativity of $M_1=3.4$, $M_2=1.2$, O = 3.5 and H = 2.1, then the nature of two solutions will be respectively :
   (a) acidic, basic (b) acidic, acidic
   (c) basic, acidic (d) basic, basic

8. $(C_6H_5)_2—C=CHBr \xrightarrow{KNH_2}$ Product formed is :
   (a) Diphenyl ether
   (b) Diphenyl ethyne
   (c) $C_6H_5CH=CBrC_6H_5$
   (d) None of these

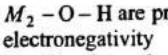
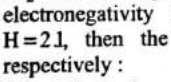
Section B: More Than One Correct Answer **[3 x 5 = 15]**

9. Which of the following are correct ?
   (a) In Cr atom, 15 electrons have a spin of one type and 9 electrons of the opposite type
   (b) All the four quantum numbers were proposed before the origin of quantum theory
   (c) The azimuthal quantum number of a poly electronic atom is related to shape and energy of orbital.
   (d) The azimuthal quantum number of a one electron system is related to shape and energy level

10. Select the correct statement :
    (a) The pH of a buffer mixture obtained by 1 *M* NH_4OH and 1 *M* $(NH_4)_3PO_4$ is equal to (pK_w-pK_b) where K_b is dissociation constant of NH_4OH
    (b) The amount of adsorbate per unit mass of adsorbent is a function of temperature at constant pressure.
    (c) For free radical combination rate constant is independent of temperature.
    (d) Molar heat capacity of water in equilibrium with vapour at constant pressure is infinite.

11. Which one is not correct about N_2O_3 ?
    (a) It is pale blue compound
    (b) It exists only in solid state
    (c) It disproportionates on heating ($N_2O_3 \rightarrow NO + NO_2$)
    (d) The degree of dissociation increases with temperature

12. Select the correct chemical changes :
    (a) $2NH_4F \xrightarrow{\Delta} NH_3 + NH_4HF_2$
    (b) $NH_4Cl \xrightarrow{\Delta} NH_3 + HCl$
    (c) $(NH_4)_2SO_4 \xrightarrow{\Delta} 2NH_3 + H_2SO_4$
    (d) $3NH_2OH \xrightarrow{\Delta} N_2 + NH_3 + 3H_2O$

13. Hydration of cyclobutyl ethene in dil. H_2SO_4 gives :
    (a) *cis*-2-methyl pentanol
    (b) *trans*-2-methyl pentanol
    (c) 
    (d) 

Section C : Single Integer Answer Problem **[3×8 = 24]**

14. A mixture of NaOH and Na_2CO_3 was first neutralised with 25 mL of *N*/10 HCl in presence of phenolphthalein as indicator. The same amount of mixture required 30 mL of

N/10 HCl using methyl orange as indicator. The ratio of milli equivalent NaOH and Na_2CO_3 in the mixture is:

15. The ratio of vertices in truncated octahedron and truncated tetrahedron is :

16. If $T_1 = 800$ K and $T_2 = 300$ K, the ratio of U_{rms} : U_{mp} at T_1, T_2 respectively for He is :

17. λ_{He^+} for a transition is 22.8 nm. The λ_H for the corresponding transition will be ..... times of λ_{He^+}.

18. Number of regular hexagonal faces in a truncated tetrahedron.

19. How much of the following will reduce $-CONH_2$ to $-NH_2$
Br_2 + NaOH, H_2 / Ni, Na / C_2H_5OH,
$LiAlH_4$ / ether, $NaOBr_{aq.}$?

20. How much of the following are condensation polymers : terelene, bakelite, glyptal, malamine, polyacrolonitrile, polyvinyl chloride ?

21. How much of the following leaves no residue on strong heating: dryice, NH_4NO_3, NH_4NO_2, NH_4Cl, $(NH_4)_2Cr_2O_7$?

Section D : **[4×2 = 8]**

Match the following (one or more matches are possible) :

22.

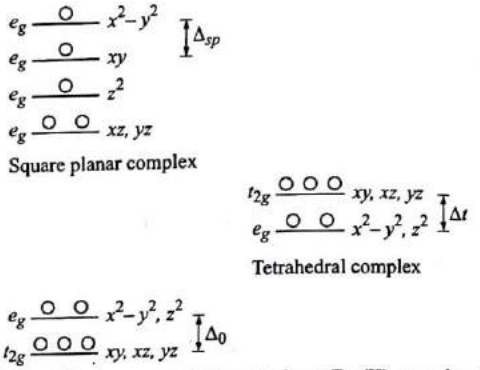
A. Zone refining	(a) Boron
B. Van Arkel method	(b) Silicon
C. Pyrometallurgy	(c) Hg
D. Self reduction	(d) Cu
	(e) Pb

23.

A. E_1 elimination reactions	(a) II order
B. E_2 elimination reactions	(b) *trans* chloro fumaric acid $\xrightarrow{NaOH}$ But-2-yne-1, 4-di oic acid
C. $S_{N}1$ reaction	(c) $(CH_3)_3C-X \xrightarrow{KOH} (CH_3)_2C=CH_2$
D. $S_{N}2$ reaction	(d) $CH_3CH_2OH \xrightarrow[\text{agent}]{\text{Dehydrating}} CH_2=CH_2$
	(e) I order
	(f) $R-X + :Nu \rightarrow$ Product + $\bar{X}$

Section E : Comprehension **[2×5 = 10]**

d-orbital configuration in transition metals is the key to understand many properties of these metal ions. In complex transition metal ions, electrons are placed into the set of *d*-orbitals according to Hund's rule and the values of Δ_0. The value of Δ_0 and the ligand determine whether a *d*-electron configuration will be low spin or high spin. A schematic diagram for the splitting patterns of the *d*-orbitals in square planar (*SP*) tetrahedral complex and octahedral complex are given ahead :



24. Select the incorrect statement about Fe (II) complex in haemoglobin :
(a) It is square planar complex
(b) $e_g > t_{2g}$
(c) It is high spin complex
(d) Δ_{sp} is large

25. If Δ_0 is large compared to the pairing energy then which one is correct :
(a) The *d*-electrons will fill e_g orbitals completely before they occupy t_{2g} level in high spin complex
(b) The *d*-electrons will fill t_{2g} orbitals completely before they pair up in the e_{2g} orbital in low spin
(c) The high spin configuration has the maximum number of unpaired *d*-electrons
(d) The high spin configuration has the minimum number of unpaired *d*-electrons

26. Select the incorrect fact :
(a) All d^8 square planar complex are low spin
(b) All d^8 square planar complex has Δ_{sp} relatively high
(c) There are no low spin tetrahedral complexes
(d) In tetrahedral complex Δ_t is relatively large

27. Select the incorrect statement :
(a) The t_{2g} set of orbitals can accommodate a maximum of six electrons
(b) The five *d*-orbitals in a metal ions develops non-degeneracy in presence of ligand
(c) The value of Δ_0 depends upon the nature of ligand in an octahedral complex
(d) A high spin d^6 complex is diamagnetic

28. For the reaction :
$[Pb_2Fe(CN)_6]_{(s)} + 4I^- \rightleftharpoons 2PbI_{2s} + [Fe(CN)_6]^{4-}_{aq.}$,
equilibrium constant is given by K_1. If K_{sp_1} and K_{sp_2} are solubility product of PbI_2 and $Pb_2[Fe(CN)_6]$, respectively then :

(a) $K_1 = \dfrac{K_{sp_2}}{K_{sp_1}}$ (b) $K_1 = \dfrac{K_{sp_1}}{K_{sp_2}}$

(c) $K_1 = \dfrac{K_{sp_2}}{(K_{sp_1})^2}$ (d) $K_1 = \dfrac{(K_{sp_1})^2}{(K_{sp_2})}$

SOLUTION OF MODEL PAPER (Part 1- B)

Section A

1. (d) SO_2I_2 is unstable.
2. (a) As size of alkyl group bonded to O increases, the repulsive forces between them increases, causing an expansion of the angle.
3. (a) Rate of reaction always increases with temperature as $r = KC_R{}^n$. Also $K = Ae^{-Ea/RT}$. I order reaction never goes for completion.
4. (b) $(H_2O + H_2O \rightleftharpoons \overset{+}{H_3O} + OH^-)$

$$K_{a.p.} = \frac{K_w}{[H_2O]^2} = \frac{10^{-14}}{(55.6)^2} = 3.23 \times 10^{-18}$$

Also $K_c = \frac{K_w}{[H_2O]} = \frac{10^{-14}}{55.6}$

$= 1.8 \times 10^{-16}$

Rest all are wrong.

5. (c) $PV = nRT$

$\frac{PV}{n} = RT$ = constant since T is mass independent

6. (c) $h\nu = h\nu^0 + \frac{1}{2}mu^2$

$E_p = 9E + \frac{1}{2}mu^2$ [For $Li^{+2}, E_1 = E_{1_H} \times z^2$]

$u = \sqrt{\frac{2(E_p - 9E)}{m}}$

7. (a) M_2 is metal and M_1 is non metal.

M_2OH is base; (*e.g.*, NaOH); M_1OH is acid (*e.g.*, HOCl).

8. (b) $(C_6H_5)_2C = C(H)Br \xrightarrow[-HBr]{KNH_2} C_6H_5—C \equiv C—C_6H_5$

Section B

9. (a,c) $_{24}Cr : 1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^5, 4s^1$; Also signifies for shape and energy level for poly electronic atom.
10. (b,c,d) $\frac{x}{m}$ is $f(T)$ at constant; P; E_a for free radical combination is zero;

At equilibrium $C_p = \infty, C_p = \frac{\Delta H}{\Delta T}; \Delta T = 0;$

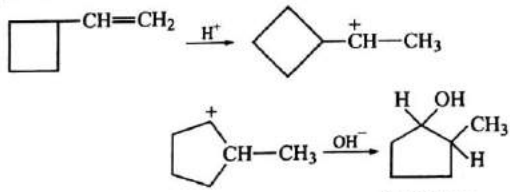
Also $pOH = pK_b + \log \frac{[C \cdot A]}{[Base]}; [C.A.] = [NH_4^+] = 3M$

and [Base] = 1 M

11. (a,c,d) All are facts.
12. (a, b, d) $(NH_4)_2SO_4 \longrightarrow NH_3 + NH_4HSO_4$

$NH_2OH \longrightarrow N_2 + NH_3 + 3H_2O$

13. (a, b)



cis and *trans*

Section C

14. Two : *Meq.* of NaOH + 1/2 *Meq.* of $Na_2CO_3 = 25 \times 0.1 = 2.5$ (HPh is indicator)

Meq. of NaOH + *Meq.* of $Na_2CO_3 = 30 \times 0.1 = 3.0$ (MeOH is indicator)

$\therefore$ *Meq.* of $Na_2CO_3 = 0.5 \times 2 = 1.0$

Meq. of NaOH = 2

15. Two : A truncated octahedron has 24 vertices and 36 edges whereas a truncated tetrahedron has 12 vertices and 18 edges.
16. Two : $\frac{u_{rms}}{u_{Av.}} = \sqrt{\frac{3 \times 800}{2 \times 300}} = 2$
17. Four : $\lambda_H = \lambda_{He^+} \times Z_{He}^2$
18. Four
19. Two
20. Four
21. Four

Section D

22. A-a, b; B-b, c; C-c, d, e; D-c, d, e
23. A-c, d, e; B-a, b; C-e, f; D-a, f

Section E

24. (d)
25. (c)
26. (d)
27. (d)
28. (c)

IIT-JEE MODEL PAPER CHEMISTRY 2-A

Time : 60 Minutes **M.M. : 72**

Section A : One Answer Correct **[2 ×9 = 18]**

1. Which one is not correct about the reaction :
   $RC \equiv CLi + R'X \longrightarrow RC \equiv CR'$
   (a) C—C bond formed in product is heterolytically
   (b) Carbon atom attached to Li in $RC \equiv CLi$ acts as nucleophilic
   (c) Carbon atom attached to X in $R'X$ acts as electrophilic
   (d) Carbon atom attached to X is electron rich
2. Select the incorrect statement :
   (a) Lithium acetylide is stronger base than water
   (b) $LiNH_2$ is stronger base than lithium acetylide
   (c) Acetylene is stronger acid than NH_3
   (d) $Li^+NH_2^-$ is a salt of strong acid
3. The value of molal ebullioscopic constant for a solvent determined using solution of solute A is found to be 5.12 K molality^{-1}. The value of molecular ebullioscopic constant for same solvent using solution of solute B in same solvent will be:
   (a) 51.2 $K^{-1}mol^{-1}$, 0.1 kg solvent
   (b) 512 K^{-1} mol^{-1}, 0.1 kg solvent
   (c) 5.12 K^{-1} mol^{-1}, 0.1 kg solvent
   (d) cannot be predicted
4. Which of the following is strongest oxidant :
   (a) FeO_4^{2-} (b) MnO_4^{2-}
   (c) VO_4^{3-} (d) CrO_4^{2-}
5. $AlCl_3 \cdot 6H_2O$ on heating liberates :
   (a) Cl_2 (b) HCl
   (c) H_2O (d) None of these
6. Which reaction occurs if Fe rod is placed in $Fe(NO_3)_3$ solution :
   (a) $Fe^{3+} + 3e \longrightarrow Fe$
   (b) $Fe \longrightarrow Fe^{3+} + 3e$
   (c) $2Fe^{3+} + Fe \longrightarrow 3Fe^{2+}$
   (d) $Fe^{2+} \longrightarrow Fe^{3+} + e$
7. The complex $[Co(NH_3)_5Br]^{2+}$ having purple colour, in presence of acidic water produces the solution having colour:
   (a) Pink (b) Blue
   (c) Red (d) Green
8. Which of the following is incorrect :
   (a) Na_3BO_3 exist but Na_3PO_3 not
   (b) H_3BO_3 is monobasic but H_3PO_3 is dibasic
   (c) H-atoms attached on the O-atom in oxoacids usually represents their 'n' factor
   (d) n-factor of a substance is independent of chemical reaction.
9. Select the incorrect statement :
   (a) $\left[\frac{\partial T_f}{\partial m}\right]_{m\to 0}$ depends on the characteristic of solvent.
   (b) For solvents obeying Trouton's rule $K_b \propto MT_b$.
   (c) The classification of solute and solvent in a solution is a matter of convenience only.
   (d) Trouton's rule $= \frac{\Delta_f H}{T_f}$

Section B: More Than One Answer Correct **[3 x 4 = 12]**

10. Which of the following metal chlorides does not give chromyl chloride test :
    (a) $HgCl_2$ (b) $SnCl_2$
    (c) $SbCl_3$ (d) AgCl
11. Which of the following gases turns KI-soaked starch paper blue :
    (a) NO_2 (b) F_2
    (c) Cl_2 (d) O_3
12. Select the correct statements :
    (a) In the electrolytic cell cathode works as electron sink like electrochemical cell
    (b) In the electrolytic cell electrons are sucked out of the anode by the positive terminal of external battery
    (c) In the electrolytic cells the electrons flow from cathode to anode through external wires
    (d) Cathode of electrolytic cell is negative electrode
13. Select the correct statements about hexagonal closest packed structure and cubic closest packed structure for a given element :
    (a) Both have same density
    (b) Both have the same co-ordination number
    (c) Both have the same packing fraction
    (d) Both have different co-ordination number

Section C : Matrix Match Type Problems : **[4 × 2 = 8]**

14. Match the following :

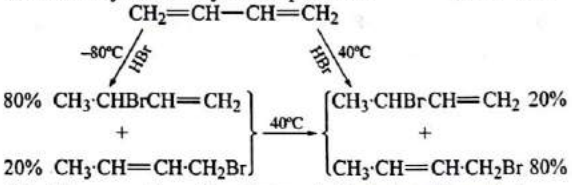
A. BrF_5	1. Distorted geometry
B. PCl_5	2. Non polar
C. SF_6	3. Polar
D. $XeOF_4$	4. One lone pair

15. Match the following :

A. CH_3^+	1. sp
B. $CH_3^\bullet$	2. sp^2
C. CH_3^-	3. sp^3
D. CH_4	4. sp^3d

Section D : Comprehension

Addition of HBr to 1,3-butadiene yields both 1,2- and 1,4-products. The proportion in which 1,2- and 1,4-products are markedly affected by the temperature : **[5×2 = 10]**



16. The proportion of products actually isolated from the low temperature addition is determined by :
(a) Equilibrium between two isomers
(b) Higher value of rate constant for 1,4-addition
(c) Higher value of rate constant for 1,2-addition
(d) None of the above

17. The proportion of products for the high temperature addition is determined by :
(a) Equilibrium between two isomers
(b) Higher value of rate constant of 1,4-addition
(c) Higher value of rate constant of 1,2-addition
(d) None of the above

Section E : Single digit answer **[3×8 = 24]**

18. Total number of structural isomers of the compound $C_5H_{10}O$.

19. Total number of stereoisomers of the compound $C_5H_{10}O$.

20. How much salts given below during electrolysis will produce a solution of pH > 7 ?
$NaCl(aq.)$; $(NH_4)_2SO_4(aq.)$; $FeCl_3(aq.)$; CH_3COONa
$CuSO_4(aq.)$; $KNO_3(aq.)$; $Ni(NO_3)_2(aq.)$; KCN

21. How much compounds possess weak electrolyte nature ?
CH_3COONH_4; Phenolphthalein; $H_2C_2O_4$; CCl_3COOH
NH_4CN; Methyl orange; NH_4OH; CH_3COOH

22. Number of compounds which can be used only as oxidant from the given list :
$HClO_4$; HNO_3; H_2S; SO_3; CO_2;
SO_2; H_3PO_4; F_2; CO; HNO_2

23. What is the value of X in $H_XCr(CO)_5$?

24. Number of positrons given out during nuclear fusion of $_1^1H$ to produce one particle of $_2^4He$.

25. How much of the following salts will show an increase in their solubility in presence of $1N$ HNO_3?
AgCN, AgCl, AgBr, CaF_2, AgF, Ag_2CO_3, AgI, $CaCl_2$

SOLUTION OF MODEL PAPER 2-A

Section A

1. (d) Carbon atom attached to X (electronegative) becomes electron deficient because X pulls electron pair towards it self.

2. (d) $Li + NH_3 \longrightarrow Li^+NH_2^-$ (Salt of weak acid $H—NH_2$)

3. (a) Molecular ebullioscopic constant = 10× molal ebullioscopic constant.

4. (a) Fe normally exist in +2 or +3. In ferrate it exists as +6 and thus easily reduced to Fe^{3+}.
Also stability order $VO_4^{3-} > CrO_4^{2-} > MnO_4^{2-}$
$> FeO_4^{2-} > CoO_4^{2-}$

5. (b) $AlCl_3 \cdot 6H_2O \rightarrow AlCl_3 + 6H_2O \rightarrow Al(OH)_3 + 3HCl$

6. (c) $2Fe^{3+} + Fe \rightarrow 3Fe^{2+}$ $E^0 = 1.21$ V a miniature cell is formed.

7. (a)
$[\underset{\text{Purple}}{Co(NH_3)_5Br}]^{2+} + H_2O_{(l)} \longrightarrow \underset{\text{Pink-orange}}{[Co(NH_3)_5H_2O]^{3+}_{aq.}} + Br^-_{aq.}$

8. (d) $HNO_3 \longrightarrow H^+ + NO_3^-$ (n factor = 1)
$2HNO_3 \longrightarrow H_2O + 2NO + 3O$ (n factor = 3)

9. (d) Trouton's rule is : $\frac{\Delta_v H}{T_b} = 10.5R$ and

$$K_b = \frac{RT_b^2 \times M}{\Delta H_v \times 1000} = \frac{RMT_b}{1000 \times 10.5R} \propto MT_b$$

Section B

10. (a,b,c) All these are covalent chlorides. Only ionic chlorides gives chromyl chloride test.

11. (b, c, d) gives $2KI + X_2 \longrightarrow 2KX + I_2$ (X is F, Cl, Br)
$NO_2 + H_2SO_4 + 2KI \longrightarrow K_2SO_4 + H_2O + NO + I_2$
(only in acid medium)
$O_3 + 2KI + H_2O \longrightarrow 2KOH + I_2 + O_2$

12. (a, b, d) Electrons sucked out from anode and flow towards cathode through external wire.

13. (a, b, c) b, c are explanations to a.

Section C

14. A-1, 3, 4; B-2; C-2; D-1, 3, 4

15. A-2; B-3; C-3; D-3

Section D

16. (c) The fact that 1,2-product is more than 1,4-product at –80° C that formation of 1,2-product is faster, since each compound remains unchanged at –80°C.The proportion in which they are isolated shows the proportion in which they are formed.

17. (a) As the temperature rises, the conversion of 1,2-product into 1,4-product becomes more to attain equilibrium. There occurs faster conversion of products initially formed into the equilibrium mixture at higher temperature.

Section E

18. Seven

19. Two

20. Two

21. Five

22. Six

23. Two : EAN of Cr = 36
$\therefore 36 = 24 + (2 \times 5) + x$
$\therefore x = 2$

24. Two : $4_1^1H \longrightarrow {}_2^4He + 2_{+1}^0e + h\nu$

25. Four : AgCN, AgF, Ag_2CO_3, CaF_2 (These which possess strong basic nature of anion.)

IIT-JEE MODEL PAPER CHEMISTRY 2-B

Time : 60 Minutes **M.M. : 72**

Section A : Single Correct Answer **[2 × 8 = 16]**

1. Acid dehydration of cyclobutyl carbinol is :

(a)  (b) 

(c)  (d) None of these

2. Arrange the following in the increasing order of *s*-character in central atom (hybrid orbital) :

(a) $PH_3 = NH_3 = NCl_3 > N_3^-$

(b) $PH_3 < NCl_3 < NH_3 < N_3^-$

(c) $NH_3 < PH_3 < NCl_3 < N_3^-$

(d) $PH_3 = NCl_3 = NH_3 < N_3^-$

3. The correct order of bond length of Si–O, P–O, S–O and Cl–O in SiO_4^{4-}, PO_4^{3-}, SO_4^{2-} and ClO_4^- is :

(a) $ClO_4^- > SO_4^{2-} > PO_4^{3-} > SiO_4^{4-}$

(b) $PO_4^{3-} > SiO_4^{4-} > SO_4^{2-} > ClO_4^-$

(c) $SiO_4^{4-} > PO_4^{3-} > SO_4^{2-} > ClO_4^-$

(d) $SO_4^{2-} > SiO_4^{4-} > PO_4^{3-} > ClO_4^-$

4. In O_2F_2, which of the following statement is correct?

(a) O-F bond length in O_2F_2 is longer than O-F bond length in OF_2

(b) The O.N. of oxygen in O_2F_2 is +1

(c) The O—O bond length in O_2F_2 is shorter than O—O bond length in H_2O_2

(d) All of the above

5. Select the incorrect reaction :

(a) $CH_2 = CH_2 + Br_2 \xrightarrow[H_2O]{NaCl} BrCH_2{\cdot}CH_2Br + BrCH_2{\cdot}CH_2Cl + BrCH_2{\cdot}CH_2OH$

(b) $CH_2 = CH_2 + Br_2 \xrightarrow{NaI_{aq.}} BrCH_2CH_2Br + BrCH_2{\cdot}CH_2I$

(c) $CH_2 = CH_2 + I_2 \xrightarrow{CCl_4} CH_2I - CH_2I$

(d) $CH_2 = CH_2 + I_2 \xrightarrow{CCl_4} CH_2Cl - CH_2I$

6. A sample of H_2O_2 solution labelled as 33.6 volume has density (*d*)g litre^{-1}. Mark the incorrect option representing concentration of same solution in other units. (Assume that solution contains only H_2O and H_2O_2).

(a) Mole fraction of H_2O_2 in the solution = $\frac{54}{(1000d - 102)}$

(b) Normality = $6N$

(c) Molarity (M) = $6M$

(d) Molality (m) = $\frac{3000}{(1000d - 102)}$

7. Number of regular hexagonal faces and regular tetrahedral faces in truncated tetrahedron are respectively :

(a) 2, 4 (b) 4, 4

(c) 6, 4 (d) 4, 6

8. Virial equation of state for one mole of real gas $Z = 1 + \frac{B}{V} + \frac{C}{V^2} + \frac{D}{V^3} .....$

Where B = IInd virial coefficient

C = IIIrd virial coefficient

D = IVth virial coefficient

Find out the value of $\frac{B}{Z}$ at Boyle's temperature :

(a) 0 (b) 1

(c) $\left(b - \frac{a}{RT}\right)$ (d) $\frac{a}{bR}$

Section B : More than One Correct Answer **[4 × 5 = 20]**

9. Which of the following statements is incorrect ?

(a) All C—O bonds in CO_3^{2-} are equal but not in H_2CO_3

(b) All C—O bonds in HCO_2H are equal but not in HCO_2^-

(c) C—O bond length in HCO_2^- is longer than C—O bond length in CO_3^{2-}

(d) C—O bond length in HCO_2^- and C—O bond length in CO_3^{2-} are equal.

10. In I_3^- :

(a) I_2 is Lewis acid and I^- is Lewis base

(b) I_2 is Lewis base and I^- is Lewis acid

(c) I_3^- itself behaves as amphoteric anion

(d) I_3^- is linear

11. Which of the following have non zero dipole moment ?

(a) 1,4-dihydroxy benzene

(b) 1,4-dichloro benzene

(c) 1,4-dinitro benzene

(d) 1,4-dimethoxy benzene

12. Which of the following are correct?
(a) For a reaction involving only condensed phase $\Delta_r H = \Delta_r U$
(b) Bond enthalpy and bond dissociation energy of a triatomic molecule are identical
(c) Enthalpy of an ideal gas is a function of temperature only
(d) There is no entropy change during allotropic change

13. Select the correct reaction :
(a) $CH_3 \cdot CH_2 \cdot CH = CHCHO \xrightarrow{Zn/Hg\text{-}HCl} CH_3CH_2CH_2 \cdot CH_2CHO$
(b) $CH_3 \cdot CH_2 \cdot CH = CHCHO \xrightarrow{Zn/Hg\text{-}HCl} CH_3 \cdot CH_2 \cdot CH_2 \cdot CH_2CH_3$
(c) $CH_3COCH_2 \cdot CO \cdot CH_3 \xrightarrow{I_2+NaOH} CHI_3 + CH_3COONa$
(d) $C_6H_5CHO + HCHO \xrightarrow{NaOH} C_6H_5CH_2OH + HCOONa$

Section C : Comprehension-1 **[3×2=6]**

The sums of first and second ionization energies and those of third and fourth ionization energies (in kJ mol^{-1}) of nickel and platinum are;

	$(IE)_1 + (IE)_2$	$(IE)_3 + (IE)_4$
Ni	2.49	8.80
Pt	2.66	6.70

Also both Ni and Pt have co-ordination number = 4

14. Which is most stable complex of Ni?
(a) $[Ni(CN)_4]^{2-}$ (b) $[Ni(CN)_6]^{2-}$
(c) $[Ni(CN)_3]^-$ (d) $[Ni(CO)_6]$

15. Which is least stable complex of Pt?
(a) $K_2[PtCl_6]$ (b) $[Pt(en)_3]Cl_4$
(c) $K_2[Pt(Cl_4)]$ (d) $K_2[Pt(C_2O_4)_3]$

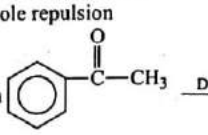
Comprehension-2 **[2×3=6]**

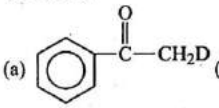
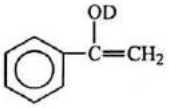
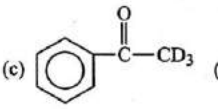
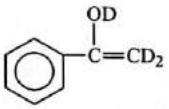
A molecular formula having H-atom may represent an equilibrium mixture of two compounds due to migration of mobile H-atom between two polyvalent gps. These two molecules show interconversion of one into other so quickly that their isolation in independent state can not be made. However at equilibrium the ratio of their concentration depends on the characteristic value of their equilibrium constant *e.g.*

$$CH_3\overset{O}{\overset{\|}{C}}-CH_2 \cdot COOCH_3 \rightleftharpoons CH_3-\overset{OH}{\overset{|}{C}}=CHCOOCH_3$$

16. The solubility of methyl acetoacetate in dilute NaOH is due to the formation of :
(a) $Na \cdot CH_2 \cdot CO \cdot CH_2 \cdot COOCH_2Na$
(b) $CH_3COCH_2COOCH_2Na$
(c) $CH_3-\overset{ONa}{\overset{|}{C}}=CHCOOCH_3$
(d) $CH_3 \cdot CO \cdot CH_2 \cdot COONa$

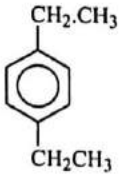
17. Enolic form of acetyl acetone is stabilized by :
(a) van der Waals' forces
(b) Intermolecular H-bonding
(c) Intramolecular H-bonding
(d) dipole-dipole repulsion

18. In the reaction  the product formed is :

(a) 
(b) 
(c) 
(d) 

Section D: Single Integer Answer Problems **[3×8=24]**

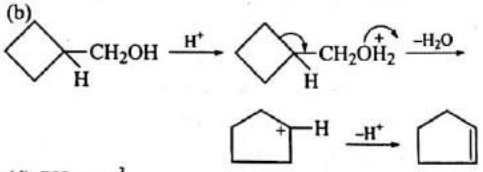
19. Number of acidic hydrogen atoms in pentan-2,4-diene is .....
20. Number of atoms in upper layer of hexagonal close pack type arrangement is.....
21. On monochlorination of 2-methylbutane, the total number of chiral carbon atoms formed in the product molecule is.....
22. The uncertainty in location of an electron in an orbit is equal to its de Broglie wavelength. The minimum per cent error in its velocity measurement would be.....
23. A gas is present in a piston fitted vessel at 3 atm. How much pressure should be increased so that its volume is reduced to 25% of initial volume.....
24. Molarity of 10% mass/volume $CaCO_3$ solution is.....
25. A mixture having 100 mL of 0.5 *M*HCl and 12.5 mL of 0.2 *M* H_2SO_4 requires 50 mL of baryta water solution. What is molarity of baryta water solution ?
26. How many kinds of non equivalent H-atoms are there in



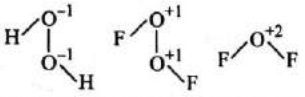
SOLUTION OF MODEL PAPER 2-B

Section A

1. (b)



2. (d) PH_3 : sp^3
   NCl_3 : sp^3
   NH_3 : sp^3
   N_3^- : sp^2
3. (c) Atomic radius decreases along the period;
4. (d)



   The facts are based upon their geometry. Size of O^- > size of O^+ > Size of O^{2+}.
5. (c) Iodine in presence of CCl_4 gives chloro-iododerivative (mixed halides)
6. (c) $M_{H_2O_2} = \dfrac{\text{Volume strength}}{11.2} = \dfrac{33.6}{11.2} = 3M \quad \therefore N_{H_2O_2} = 6N$

   i.e. 3 mol H_2O_2 in 1 litre solution or $1000 \times d$ g solution

   $\therefore$ mass of water = $(1000d - 34 \times 3)$ g

   $\therefore \quad m_{H_2O_2} = \dfrac{3 \times 1000}{(1000d - 34 \times 3)}$ g

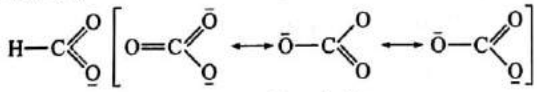
   mole fraction of $H_2O_2 = \dfrac{3}{3 + \dfrac{(1000d - 102)}{18}}$

   $= \dfrac{54}{54 + (1000d - 102)} = \dfrac{54}{(1000d - 48)}$
7. (b) These are facts about truncated tetrahedron.
8. (a) At Boyle's temperature, $PV = RT\,(B, C \ldots = 0)$

   $\therefore \quad \dfrac{B}{Z} = 0$

Section B

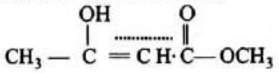
9. (b, c, d)



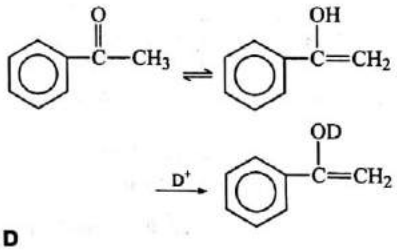
   Resonance Canonical forms
10. (a,d) I_3^- is linear (sp^3d) $\underset{\text{Lewis acid}}{I_2} + \underset{\text{Lewis base}}{I^-} \longrightarrow I_3^-$
11. (a,d) Due to different orientation of attached gps.
12. (a,c) Entropy of C_G and C_D are different. Average bond enthalpy and bond dissociation energy are different.
13. (d) This is crossed cannizzaro reaction. In clemmensen reduction (Zn–Hg/HCl), only $>C=O$ gp. are reduced to $-CH_2$. Pent-2,3-dione will not give iodoform reaction.

Section C

14. (a) Ni forms Ni^{2+} more readily than Pt^{2+} due to lower values of $(IE_1 + IE_2)$
15. (c) Pt forms Pt^{4+} more readily than Ni^{4+} due to lower values of $(IE_1 + IE_2 + IE_3 + IE_4)$
16. (c) –OH gp is attacked by Na.
17. (c) intramolecular H–bonding



18. (b)



Section D

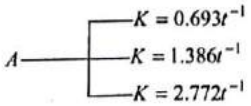
19. Two
20. Three
21. Two
22. Eight
23. Nine
24. One
25. One
26. Three (1°, 2° sp^3 and 2° sp^2)

IIT-JEE MODEL PAPER CHEMISTRY 3-A

Time : 60 minutes **M.M. : 80**

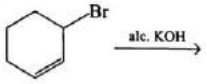
Section A : Single Correct Answer [2×9 = 18]

1. Which of the following statement is correct ?
   (a) The dipole moment of CH_3F is greater than CH_3Cl
   (b) Photobromination of 2-methyl propane gives a mixture of 1-bromo-2-methyl propane and 2-bromo-2-methyl propane in the ratio 9 : 1
   (c) Acetate ion is stronger base than methoxide ion
   (d) Sulphanilic acid is dipolar in nature
2. Which of the following is incorrect ?
   (a) Molar mass of NaCl determined experimentally is 58.5
   (b) SF_4 possess the bond angles 90°, 102° and 173°
   (c) Band gap in germanium is small
   (d) CuI_2 is less stable compound in aqueous medium
3. Select the incorrect statement :
   (a) Carbon nanotube has 20 hexagon and 5 pentagon.
   (b) Molar mass of Buckminster fullerene isotope of carbon is 720.
   (c) Liquid O_2 is pink in colour.
   (d) H_3PO_2 is stronger acid than H_3PO_4.
4. The volume in dm^3 of given mass of an ideal gas at 760 mm of Hg pressure and 298 K divided by 24.47 dm^3 gives :
   (a) Avogadro no. (b) mole of gas
   (c) mass of gas (d) pressure of gas
5. The specific volume of water is 1.003 cm^3g^{-1}. The density of water in g/cm^3 is :
   (a) 1.003 (b) 18×1.003
   (c) $\frac{1.003}{18}$ (d) 0.9970
6. Number of P—O, P = O and P—P bonds in P_4O_{10} are respectively :
   (a) 12, 4, 0 (b) 12, 4, 3
   (c) 6, 6, 3 (d) 6, 6, 0
7. u_{AV}, u_{rms} and u_{MP} are respectively average, root mean square and most probable speed of the molecule of an ideal monoatomic gas at absolute temperature T. The molecule mass of gas is M, then :
   (a) no molecule can have a speed greater than u_{rms}
   (b) no molecule can have a speed greater than u_{MP}
   (c) no molecule can have a speed greater than u_{AV}
   (d) average kinetic energy of a molecule is $\frac{3M}{4N}(u_{MP})^2$
8. The nuclear fusion which is not correct :
   (a) $4{}_1^1H \longrightarrow {}_2^4He + 2{}_{-1}^0e + 2$ neutrino + energy
   (b) ${}_6^{12}C + {}_1^1H \longrightarrow {}_7^{13}N$ + energy
   (c) ${}_7^{14}N + {}_1^1H \longrightarrow {}_8^{15}O$ + energy
   (d) ${}_5^{13}C + {}_1^1H \longrightarrow {}_6^{14}C$ + energy
9. Rate constants for a parallel path I order reactions are given as :



   The average half life of A is :
   (a) 0.693 t (b) 0.406 t
   (c) 0.306 t (d) 0.206 t

Section B : More Than One Correct Answers [3×5 = 15]

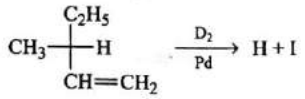
10. Disproportionation of Cu^+ ion into Cu^{2+} ion and Cu in aqueous solution can be prevented by the addition of :
    (a) Cu + HCl (b) thiourea
    (c) NaCl (d) benzene
11. Pick up the correct statements :
    (a) The magnitude of the potential energy of the electron in any orbit is greater than its kinetic energy.
    (b) Even when the metal surface is fainlly illuminated with suitable frequency of radiations, the photo electrons leave the surface immediately.
    (c) The time required for revolution of an electron in 4th Bohr's orbit is 8 times of the time required for revolution in 2nd Bohr's orbit.
    (d) Transition of electron from 4d orbital to 2s orbital is not possible.
12. Which of the following reaction produces conjugated dienes ?
    (a) 

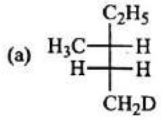
    (b) $CH_3CH(Br)\cdot CH = CH_2 \xrightarrow{\text{alc. KOH}}$
    (c) $Br\cdot CH_2\cdot CH = CH_2 \xrightarrow{\text{alc. KOH}}$
    (d) $Br\cdot CH_2\cdot CH_2\cdot CH = CH_2 \xrightarrow{\text{alc. KOH}}$
13. Which statement is correct about the following reaction ?

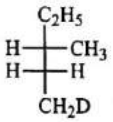
$$^{14}CH_2 = CH—CH_3 + Cl_2 \xrightarrow[\text{low conc. of } Cl_2]{\Delta} P + Q$$

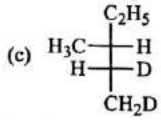
    (a) P and Q are $^{14}CH_2 = CH—CH_2Cl$ and $^{14}CH_2—\underset{\displaystyle Cl}{\underset{|}{CH}} = CH_2$.
    (b) The reaction obeys free radical allylic substitution.
    (c) P and Q formed are in 1 : 1 ratio.
    (d) Rearrangement of free radical takes place.

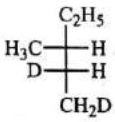
14. Which are the correct products of the reaction ?



(a) 

(b) 

(c) 

(d) 

Section C : Statement-Explanation Type Problems

Read the information given below and select the correct choice in terms of (a), (b), (c) and (d) for each question. **[4 × 3 = 12]**

(a) **S** is correct but **E** is wrong.
(b) **S** is wrong but **E** is correct.
(c) Both **S** and **E** are correct and **E** is correct explanation of **S**.
(d) Both **S** and **E** are correct but **E** is not correct explanation of **S**.

15. **S:** $Cl_3C{\cdot}CH = CH_2 \xrightarrow{HCl} Cl_3{\cdot}C{\cdot}CHClCH_3$

E: $Cl_3C{\cdot}\overset{+}{C}H_2CH_2$ (1°) is more stable than $Cl_3C{\cdot}\overset{+}{C}H{\cdot}CH_3$ (2°).

16. **S:** Conversion of $CH{\equiv}CH \longrightarrow CH_3CHO$ is a redox change.

E: Hydration is never redox reaction.

17. **S:** All the detergents are surfactants but all the surfactants are not detergents.

E: Detergents possess surface activity as well as cleansing action.

Section D : Matching Type Problems [1 × 4 = 4]

18. **More than one match are possible :**

List A	List B
A. $2KClO_3(s) \xrightarrow{MnO_2(s)} 2KCl + 3O_2(g)$	1. Homogeneous catalysis
B. $2H_2O_2(l) \xrightarrow{Hg(l)} 2H_2O(g) + O_2(g)$	2. Heterogeneous catalysis
C. $2H_2O_2(l) \xrightarrow{Pt} 2H_2O + O_2(g)$	3. $\Delta n_{reaction} \geq 1$
D. $2SO_2(g) + O_2(g) \xrightarrow{NO(g)} 2SO_3(g)$	4. $\Delta n_{reaction} \leq 1$

19. **More than one match are possible** **[1 × 4 = 4]**

List A	List B
A. Work	1. Boundary phenomenon
B. Heat	2. Path function
C. Temperature	3. Intensive property
D. $q + w$	4. Extensive property

Section E : Comprehension [3 × 3 = 9]

Organic compounds may be saturated or unsaturated. The degree of unsaturation or sometimes called as index of hydrogen deficiency represents the number of pairs of H's a molecular formula lacks to be an alkane (C_nH_{2n+2}). Presence of ring and multiple bonds always brings in the index of hydrogen deficiency in molecule. More the number of multiple bonds more is hydrogen deficiency.

20. Which of the following possess degree of unsaturation as reported ?

(a)  ; 1° (b)  ; 3°

(c) ; 3° (d)  ; 4°

21. C_4H_5N has degree of unsaturation equal to :
(a) 1° (b) 2°
(c) 3° (d) 4°

22. A hydrocarbon (A) has 2° unsaturation. It is treated with 1 mole of H_2 catalytic hydrogenation. Experiment shows that there is no reaction. The hydrocarbon has :
(a) two double bond (b) one triple bond
(c) one ring (d) two rings

Section F : Single Integer Answer [3 × 6 = 18]

23. The number of cells which can be produced involving the redox change :

$Fe + 2Fe^{3+} \longrightarrow 3Fe^{2+}$ are :

24. Number of mole of As_2S_3 required to reduce 56 mole of HNO_3 according to reaction.

$As_2S_3 + HNO_3 \longrightarrow H_3AsO_4 + H_2SO_4 + NO$

25. The '*n*' factor of O_3 in the redox change, $2O_3 \longrightarrow 3O_2$ is :

26. The vapour pressure of a mixture of two volatile liquids is given by $P_m = 4.0X_A + 3.0$. The vapour pressure of pure *B* is:

27. The resistance of mercury becomes almost zero at ... K.

28. The relative strength of two weak acids $HA(K_a = 8 \times 10^{-5})$ and $HB(K_b = 2 \times 10^{-5})$ is :

SOLUTION OF MODEL PAPER 3-A

Section A

1. (d) Sulphanilic acid is H_3N—C$_6$H$_4$—SO_3H

possess Zwitter ion structure as H_3^+N—C$_6$H$_4$—SO_3^-

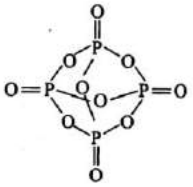
2. (a) Exp. molar mass of electrolytes > cal. molar mass of electrolyte.

3. (c) Liquid O_2 is blue in colour.

4. (b) At 1 atm and 298 K volume of 1 mole of gas is 24.47 dm^3
∴No. of mole × volume of 1 mole = volume of n mole

5. (d) $\text{density} = \frac{1}{\text{specific volume}} = \frac{1}{1.003} = 0.9970$

6. (a)



7. (d) $\text{Av. K.E.} = \frac{3}{2}\frac{RT}{N} = \frac{3\times 2RTM}{4N\cdot M} = \frac{3M(U_{MP})^2}{4N}$

8. (d) Carbon has atomic no. 6.

9. (d) Av. $K = 0.693 + 1.386 + 2.772 = 4.851$

$\therefore \quad T = \frac{1}{K} = 0.206$

Section B

10. (a,b) Due to complex formation, *e.g.*, $[CuCl_2]^-$ and $[Cu\{SC(NH_2)_2\}_3]^+$.

11. (a, b, c, d) For transition $\Delta l = \pm 1$

12. (a, b, d) In (c) cumulitive diene $CH_2 = C = CH_2$ is formed.

13. (a, b, c, d) $^{14}CH_2 = CH—CH_3 \longrightarrow {}^{14}CH_2 = CH—\dot{C}H_2$

$\longrightarrow {}^{14}\dot{C}H_2—CH = CH_2$

$^{14}CH_2 = CH—\dot{C}H_2 \xrightarrow{Cl_2} {}^{14}CH_2 = CH—CH_2Cl$

$^{14}\dot{C}H_2—CH = CH_2 \xrightarrow{Cl_2} {}^{14}CH_2Cl—CH = CH_2$

Thus, 1 : 1 mixture of two is obtained.

14. (c, d) This is addition of D_2 on C = C.

Section C

15. (b) The stability of 1° is more due to –ve *IE* of 3Cl than 2° and thus product formed is $Cl_3\cdot CH_2\cdot CH_2Cl$.

16. (b) S is wrong, the average oxidation number in CH ≡ CH and CH_3CHO is –1. Also hydration is never a redox reaction.

17. (c) Surfactants possess surface activity only whereas detergents possess surface activity and detergency, *i.e.*, cleansing action.

Section D

18. A—2, 3; B—2, 3; C—2, 3; D—1,4

19. A—1, 2, 4; B—1, 2, 4; C—3; D—4

Section E

20. (d) (a) is C_4H_6 having 2°, (b) is C_4H_8 having 1°, (c) C_5H_8 having 2°, (d) C_6H_8 having 4°.

21. (c) Disregard N but remove one H for each N.

22. (d) Two rings has 2° unsaturation and do not react with H_2.

Section F

23. **Three :** Electrode : $PtFe^{2+}|Fe^{3+}$ $Fe^{2+} \longrightarrow Fe^{3+} + e$

Electrode : $Fe|Fe^{2+}$ $Fe \longrightarrow Fe^{2+} + 2e$

Electrode : $Fe|Fe^{3+}$ $Fe \longrightarrow Fe^{3+} + 3e$

use any two at one time and get three cells with same redox change.

24. **Six :** $(As^{3+})_2 \longrightarrow 2As^{5+} + 4e; 3e + N^{5+} \longrightarrow N^{2+}]\times 28$ ...(i)

$(S^{2-})_3 \longrightarrow 3S^{6+} + 24e$

$As_2S_3 \longrightarrow 2H_2AsO_4 + 3H_2SO_4 + 28e]\times 3$ ...(ii)

By (i) and (ii)

$3As_2S_3 + 28HNO_3 \longrightarrow 6H_3AsO_4 + 9H_2SO_4 + 28NO$

$\therefore 3As_2S_3 \equiv 28HNO_3$

25. **Six :** $2O_3 \longrightarrow 3O_2$

2 mol $O_3 \equiv 3$ mol $O_2 \equiv 4\times 3$ eq. O_2

$\equiv 12$ eq. O_3

1 mol $O_3 \equiv 6$ eq. O_3

26. **Three :** $P_M = 4.0X_A + 3.0$

if $X_A = 0$, $P_M = P_B^\circ$

$\therefore \quad P_B^\circ = 3.0$

27. **Four :** It is a fact.

28. **Two :** Relative strength of two weak acids $= \frac{\sqrt{K_{a_1}\cdot C_1}}{\sqrt{K_{a_1}\cdot C}}$

if $C_1 = C_2$

$\text{R.S.} = \sqrt{\frac{K_{a_1}}{K_{a_2}}} = \sqrt{\frac{8\times 10^{-5}}{2\times 10^{-5}}} = 2$

IIT-JEE MODEL PAPER CHEMISTRY 3-B

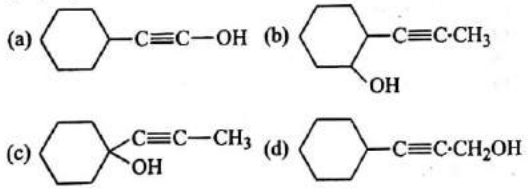
Time : 60 minutes **M.M. : 80**

Section A : Single Correct Answer [2×9 = 18]

1. Which of the following is incorrect ?
   (a) Enthalpy is an extensive property
   (b) Zeroth law suggest for thermal equilibrium
   (c) First law of thermodynamics fails to explain systems away from equilibrium
   (d) First law of thermodynamics predicts the feasibility of change and rate of reaction.
2. The no. of neutrons (n) and no. of protons (p) in a nucleus can be depicted as :
   (a) n is always greater than p
   (b) n is always equal to p
   (c) $n \gtrless p$ or $n = p$
   (d) The ratio of n and p is always 1.5
3. At very high pressure helium (He) crystallises as :
   (a) bcc (b) ccp
   (c) fcc (d) can not be crystallised
4. Analysis shows that a non stoichiometric compound exists as $Ni_{0.98}O_{1.0}$. The ratio of fraction Ni^{2+} and Ni^{3+} present in $Ni_{0.98}O_{1.0}$ is :
   (a) 98.04 (b) 23.51
   (c) 49.02 (d) 24.01
5. The temperature of a bomb calorimeter was found to rise by 1.617 K, when a current of 3.2 ampere was passed for 27.0 second from a source of 12.0 volt. Assuming heat is taken only by bomb calorimeter, the calorimeter constant is :
   (a) 19.155 JK^{-1} (b) 191.5 JK^{-1}
   (c) 641.18 JK^{-1} (d) 1.915 JK^{-1}
6. Which of the following metal does not give the following reaction ?

$$M \xrightarrow{\text{Dissolved in } NH_3} M^{2+} + 2[e(NH_3)_X]^{-1}$$

   (a) Be (b) Mg
   (c) Ca (d) Ba
7. The product formed during action of cyclohexanone with propenyl ion followed by hydrolysis is :



8. Glyoxal on reaction with dil. NaOH gives :
   (a) 
   (b) 
   (c)
   (d)
9. Select the incorrect statement :
   (a) Central C—C bond in buta-1, 3-diene is shorter than n-butane.
   (b) $CH_2 = CH^-$ is more basic than $^-C \equiv CH$.
   (c) Diphenyl bromoethene on reaction with KNH_2 gives diphenyl ethane.
   (d) Vinyl chloride on reaction with dimethyl copper gives an alkene.

Section B : More Than One Correct Answers [4 × 3 = 12]

10. Select the correct statements :
    (a) Dipole moment of NH_3 is greater than dipole moment of NF_3.
    (b) Solvents with high dielectric constants tend to be more polar.
    (c) Wave functions are used to calculate the quantised energy of orbit.
    (d) In MO theory conservation of orbitals takes place.
11. Contributing canonical forms of diazomethane CH_2N_2, towards its resonance structure are :
    (a) $H_2\overset{}{C}=\overset{+}{N}=\overset{\bullet\bullet}{N}\overset{-}{:}$ (b) $H_2\overset{\bullet\bullet}{\overset{-}{C}}-\overset{+}{N}\equiv N$
    (c) $H_2\overset{\bullet\bullet}{C}-N\equiv\overset{+}{N}$ (d) $H_2\overset{+}{C}-N=\overset{-}{N}:$
12. Select the correct statements :
    (a) E_a is small and ΔH_r is negative, reaction is fast and exothermic.
    (b) E_a is large and ΔH_r is negative, reaction is slow and exothermic.
    (c) Catalyst can increase rate by increasing entropy of activation.
    (d) For an exothermic reaction $\Delta H < E_a$.

Section C : Comprehension Type Problems [2×5 = 10]

Indicators are the substances used to detect the end point or completion point of a reaction. Acid-base indicators are themselves weak acid or weak base. Phenolphthalein is not a good indicator for weak acid titrations, whereas methyl orange is not a good indicator for weak alkali titrations.

13. Methyl organge on dissociation gives :
    (a) coloured cation
    (b) coloured anion
    (c) both coloured ions
    (d) both colourless ions

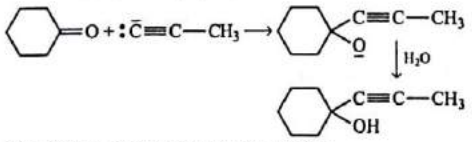
14. Select the incorrect statement about quantitative estimation by volumetric analysis :
    (a) Equivalence point is theoretical value.
    (b) End point is experimental value.
    (c) Both these point are exactly same.
    (d) Both these points are almost same.
15. For which titration phenolphthalein can not be used :
    (a) $CH_3COOH + NaOH$ (b) $H_2C_2O_4 + KOH$
    (c) $HCl + NH_4OH$ (d) $H_2SO_4 + KOH$
16. For which titration methyl orange can not be used ?
    (a) HCl *vs* NH_4OH (b) HCl *vs* NaOH
    (c) $FeSO_4$ *vs* $KMnO_4$ (d) H_2SO_4 *vs* KOH
17. Select the correct statement :
    (a) Phenolphthalein is more dissociated in NH_4OH than in NaOH.
    (b) The degree of dissociation of phenolphthalein is more in HCl than in KOH.
    (c) Phenolphthalein gives coloured cation on dissociation.
    (d) The degree of dissociation of phenolphthalein is more is strong base than in weak base.

Section D : Single Integer Answer **[4 × 10 = 40]**

18. Number of possible isomers of the complex ion $[Cr(NH_3)(OH)_2Cl_3]^{2-}$ are ...
19. Number of phases of a substance (*e.g.*, S_R, S_M, S_l, S_V) can exist together in equilibrium for one component system.
20. Disproportionation of P_4 in alkaline medium produces how much mole of HPO_3^{2-}?
21. '*n*' factor for Fe_2O_3 in its reaction with HCl (*aq.*) to produce $FeCl_3$ and H_2O is ...
22. Number of nearest neighbours NH_3 molecules to each molecule of NH_3 in solid ammonia.
23. At what pH a $1.0\times10^{-3}\,M$ solution of a basic indicator ($K_{ind} = 1.0\times10^{-10}$) change colour ?
24. Following electrodes are coupled to from a cell. The standard E° for the given cell is ...
    $A^{3+} + 3e \longrightarrow A;\ E^\circ = 1.50$ V
    $B^{2+} + 2e \longrightarrow B;\ E^\circ = -2.50$ V
25. Ionisation constants for acids HA and BH^+ are 10^{-7} and 10^{-3} respectively. The $pK_{eq.}$ for the reaction $HA + B \rightleftharpoons BH^+ + A^-$ is ...
26. Specific rotation of a pure enantiomer is +10°. If the isomer is isolated from a reaction showing 80% retention and 20% recemisation, the observed rotation will be plus.
27. How many kinds of H's are there in $CH_3—CH=CH_2$?

SOLUTION OF MODEL PAPER 3-B

Section A

1. (d) Ist law of thermodynamics does not suggest about rate of reaction.
2. (c) $\frac{n}{p} = 1$ for ${}_1^1H$ and $\frac{n}{p} = 2$ maximum for ${}_1^3H$.
3. (c) It is a fact.
4. (b) Oxidation no. of Ni in $Ni_{0.98}O_{1.0} = \frac{200}{98}$
   Let, % of Ni^{2+} and Ni^{3+} be a and b respectively. Thus, $a + b = 100$.
   Thus, $a\times2 + (100-a)\times3 = \frac{200}{98}\times100$
   $\therefore \quad a = 95.92$
   $\therefore \quad b = 4.08$
   $\therefore \quad \frac{a}{b} = 23.51$
5. (c) Energy given $= 3.2\times27\times12.0 = 1036.8$
   Heat taken by calorimeter $= mS\times1.617$
   $\therefore mS$ of calorimeter $= \frac{1036.8}{1.617} = 641.18$ J
6. (a) Be does not show this property.
7. (c) 
8. (c) This is intramolecular Cannizzaro reaction.
9. (c) $(C_6H_5)_2C=C(H)Br \xrightarrow{KNH_2} C_6H_5—C\equiv C—C_6H_5$

Section B

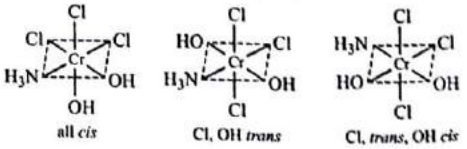
10. (a,b, d) $\mu_{NH_3} = 1.46$D; $\mu_{NF_3} = 0.24$ D No. of orbitals mixed = No. of MO formed; wave functions are used to calculate quantised energy of an electron in an orbital.
11. (a,b) Rest all are unstable forms and do not contributes significantly.
12. (a, b, c) For an exothermic reaction $\Delta H \gtrless E_a$.

Section C

13. (a) $MeOH \rightleftharpoons Me^+ + OH^-$
14. (c) Equivalence point ≃ Experimental value of end point.
15. (c) Phenolphthalein is not a good indicator for weak acid titration.
16. (c) Methyl orange is an acid-base indicator. This is redox change.
17. (d) Phenolphthalein is weak acid and thus dissociates more in base.
    $HPh \rightleftharpoons H^+ + Ph^-$

Section D

18. **Three**



19. Three : F + P = C + 2; F = 0 (minimum); C = 1

$\therefore$ P = 3

20. Two : $P_4 + 4OH^- + 2H_2O \longrightarrow 2PH_3 + 2HPO_3^{-2}$

21. Six : $Fe_2O_3 + 6HCl \longrightarrow 2FeCl_3 + 3H_2O$

$$E = \frac{M}{6}$$ [Fe_2O_3 is base]

22. Six : It is a fact.

23. Four : $K_b = \frac{[B^+][OH^-]}{[BOH]}$; At 50% $[OH^-] = 1 \times 10^{-10}$

$\therefore$ pOH = 10 and pH = 4

24. Four : $3B + 2A^{3+} \longrightarrow 3B^{2+} + 2A$

$E^\circ = 2.50 + 1.50 = 4.0$ volt

25. Four : $K_{a_{HA}} = \frac{[H^+][A^-]}{[HA]} = 10^{-7}$ ...(1)

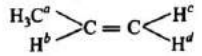
$$K_{BH^+} = \frac{[B][H^+]}{[BH^+]} = 10^{-3}$$

$$\therefore \quad \frac{K_{a_{HA}}}{K_{a_{BH^+}}} = \frac{[A^-][BH^+]}{[HA][B]} = K_{eq.} = \frac{10^{-7}}{10^{-3}} = 10^{-4}$$

or $-\log K_{eq.} = pK_{eq.} = 4$.

26. Eight : $0.8 \times (+1^\circ) = +8^\circ$

27. Four :

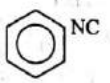
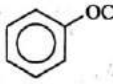


The H atoms on right of double bond are not equivalent since, one is *cis* to CH_3 and other is *trans*. Replacement of H^c by *X* gives the *cis*-diastereomer. Replacement of H^d gives *trans*-diastereomer.

IIT-JEE MODEL PAPER CHEMISTRY 4-A

Time : 60 minutes **M.M. : 82**

Section A : Single Correct Answer [2×9 = 18]

1. Which of the following does not show Lewis acid-base reaction ?
   (a) $BrF_3 + F^-$ (b) $AlCl_3 + BF_3$
   (c) $I_2 + I^-$ (d) $KH + H_2O$
2. Which of the following is finger print of an atom ?
   (a) Molecular spectrum (b) X-ray spectrum
   (c) IR spectrum (d) Line spectrum
3. Ziegler-Natta catalyst used in polymerisation of ethylene is :
   (a) $TiCl_4(C_2H_5)_3B$ (b) $TiCl_4(C_2H_5)_3Na$
   (c) $TiCl_4(C_2H_5)_3Zn$ (d) $TiCl_4(C_2H_5)_3Al$
4. If X is the mole fraction of solute when dissolved in water. The molality of a solution can be given by :
   (a) $\frac{500X}{9(1-X)}$ (b) $\frac{500(1-X)}{9\cdot X}$
   (c) $\frac{1000(1-X)}{9\cdot X}$ (d) $\frac{1000X}{9(1-X)}$
5. Which one is not correct about N_2Cl_4?
   (a) It is a non-planar molecule
   (b) Both the N atoms are sp^3-hybridized
   (c) Both are pyramidal N atoms
   (d) One N is sp^3 and the other is sp^2 hybridized
6. Pure PCl_5 is introduced into an evacuated chamber and attains the equilibrium at 250°C and 2 atm pressure. The equilibrium mixture contains 40% chlorine by volume. K_p of reaction at 250°C is :
   (a) 0.133 (b) 1.6
   (c) 1.78 (d) 0.266
7. The pH of solution by mixing 50 mL of 0.6 M NH_4OH and 50 mL of 0.1 M H_2SO_4 is : (Given K_a for $NH_4^+ = 10^{-9}$)
   (a) 4.39 (b) 6.61
   (c) 9.30 (d) 7.39
8. Select the wrong statement about Cannizzaro reactions :
   (a) It is a disproportionation reaction.
   (b) Addition of OH^- occurs in I step on the carbonyl gp. to form complex anion.
   (c) The complex anion formed acts as H^- donor to other molecule of aldehyde reducing it to methoxide ion while the anion is itself oxidised to formic acid.
   (d) The resulting methoxide ion and formic acid acts as Lewis base-Lewis acid to form methyl formate ion.
9. Phenols on treatment with diazomethane in presence of ether gives :
   (a)  (b) 
   (c)  (d) 

Section B : More Than One Correct Answers [3×4 = 12]

10. Point out the correct reactions :
    (a) $BrCCl_3 + ROOR \longrightarrow ROBr + {:}CCl_3$
    (b) $BrC\cdot Cl_3 + ROOR \longrightarrow ROCl + {:}CBrCl_2$
    (c) $HCCl_3 + ROOR \longrightarrow ROH + {:}CCl_3$
    (d) $HCCl_3 + ROOR \longrightarrow ROCl + {:}CHCl_2$
11. The nature of H's in $CH_3\cdot CH = CHCH_2CH_2CH(CH_3)_2$ can be correctly represented as :
    (a) it has two types of allylic and one type of vinylic H-atoms, along with 3°, 2° and 1° H-atoms
    (b) both the vinylic H-atoms are equivalent
    (c) the reactivity order of H's is allylic 2° > allylic 1° > 3° > 2° > 1° > vinylic
    (d) both the allylic H's are equivalent
12. IUPAC name of $[Ni(NH_3)_6]_3[Co(NO_3)_6]_2$ is :
    (a) Hexaamine nickel (III) hexanitrocobaltate (II)
    (b) Hexaamine nickellette (III) hexanitrocobalt (II)
    (c) Hexaamine nickel (II) hexanitrocobaltate (III)
    (d) Hexaamine nickellete (II) hexanitrocobalt (III)
13. Select the correct statements :
    (a) K-electron capture always leads to γ-rays emission.
    (b) K-electron capture shows a decrease in atomic number.
    (c) K-electron capture shows an increase in mass number.
    (d) K-electron capture shows an increases in $\frac{n}{p}$ ratio.

Section C : Statement-Explanation Type Problems

Choose the correct choice from the codes (a), (b), (c) and (d) given below for each question :

(a) **S** is correct but **E** is wrong.
(b) **S** is wrong but **E** is correct.

(c) Both **S** and **E** are correct and **E** is correct explanation of **S**.

(d) Both **S** and **E** are correct but **E** is not correct explanation of **S**. [3×4 = 12]

14. **S:** Activation energy for nuclear fusion is very high.
E: Nuclear fusion are made at high temperature to overcome electrostatic repulsion between two nuclei.

15. **S:** VIBGYOR is a continuous spectrum.
E: In continuous spectrum each colour fades into next colour.

16. **S:** Ionisation energy of Li is higher than that of sodium.
E: It is easier to oxidise Li(s) to $Li^+(aq)$ as compared to Na(s) to $Na^+(aq)$.

17. **S:** A nucleophile Nu^- : adds to $C=C$ of $-\overset{|}{C}=C-\overset{|}{C}=O$ but not to ordinary alkenes.
E: Nu^-: adds to the α-carbon leaving a resonance stabilized carbaion enolate.

Section D : Single Integer Answer [4 × 10 = 40]

18. The basicity of $K_X H_Y (PO_4)_Z$ in the reaction is :
$K_X H_Y (PO_4)_Z + KOH \longrightarrow K_{X+1} H_{Y-1} (PO_4)_Z + H_2O$

19. The acidity of $K_2H_Y(PO_4)_2$ is :

20. The ratio of mole of H^+ furnished to 90 g $H_2C_2O_4$ and 126 g $H_2C_2O_4 \cdot 2H_2O$ is :

21. A bottle is labelled 122.5% oleum. 22.7 mL of $Ca(OH)_2$ of unknown molarity are used to completely neutralise 1 g oleum. The normality of $Ca(OH)_2$ is :

22. No. of electrons in the redox change :
$NO_2^- + H^+ + ne \longrightarrow NO + H_2O$

23. Most probable speed of butane at 348 K is same as root mean square speed of H_2 at T K. The value of T is :

24. 8 g of CH_4 diffuses through a pin hole in 2 sec. At the same temperature and pressure mass of He diffuses through same pin hole is 4 sec is :

25. For the given reaction : $RNH_2 + H_2O \rightleftharpoons RNH_3^+ + OH^-$; the pOH value for 10^{-2} N RNH_2 solution is : (Given pK_a for RNH_3^+ is 10)

26. van't Hoff's factor for very dilute solution of $NaHSO_4$ is :

27. Total number of aromatic isomers of the formula C_7H_8O are :

SOLUTION OF MODEL PAPER 4-A

Section A

1. (b) Both are Lewis acid.
2. (d) Each atom shows a characteristic line spectrum.
3. (d) It is a fact.
4. (a)
$$\frac{n}{n+N} = X$$
$$\frac{N}{n+N} = 1 - X$$
$$\therefore \quad \frac{n}{N} = \frac{X}{1-X}$$
$$\frac{n \times M \times 1000}{w \times 1000} = \frac{X}{1-X}$$
$$\therefore \quad \text{Molality} = \frac{X}{1-X} \times \frac{1000}{18} = \frac{500X}{9(1-X)}$$
5. (d) Others are facts about N_2Cl_4.
6. (a) $\underset{20}{PCl_5} \rightleftharpoons \underset{40}{PCl_3} + \underset{40}{Cl_2}$
Total mole or volume = 100 ($\because V \propto n$ at constant P, T)
$$\therefore K_p = \frac{n_{PCl_3} \times n_{Cl_2}}{n_{PCl_5}} \times \left[\frac{P}{\Sigma n}\right]^1$$
$$K_p = \frac{40 \times 40}{20} \times \frac{2}{100} = \frac{16}{10} = 1.6 \text{ atm}$$
7. (c) $2NH_4OH + H_2SO_4 \rightleftharpoons (NH_4)_2SO_4 + 2H_2O$

Meq. at $t = 0$	30	10	0	0
Meq. after reaction	20	0	10	10

$$\therefore [(NH_4)_2SO_4] = \frac{10}{2 \times 100} M$$
$$\therefore \quad [NH_4^+] = \frac{10 \times 2}{2 \times 100} M = 0.1\ M$$
$$[NH_4OH] = \frac{20}{100} = 0.2\ M$$
$$pOH = pK_b + \log \frac{[NH_4^+]}{[NH_4OH]} = 10^{-5} + \log \frac{0.1}{0.2}$$
$$= 5 - 0.3010 = 4.6989$$
$$\therefore \quad pH = 9.3010$$
8. (d) The process of step (d) involves exchange of proton, *i.e.*, Bronsted acid-base reaction.
9. (d) 
(Methylation of phenol)

Section B

10. (a,c) The $ROOR$ dissociates to $^\bullet OR + {}^\bullet OR$
11. (a, b, c) $\overset{a}{CH_3}-\overset{b}{CH}=\overset{b}{CH}-\overset{c}{CH_2}-\overset{d}{CH_2}-\overset{e}{CH}(\overset{f}{CH_3})_2$

a—Allylic 1°	d—2°
b—Vinyl	e—3°
c—Allylic 2°	f—1°

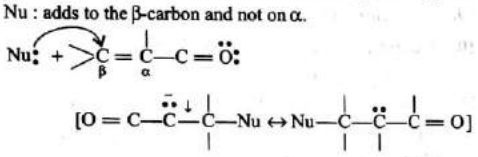
The reactivity order is : $c > a > e > d > f > b$
12. (c) It is a fact.
13. (b, d) $^1_1p + {}^0_{-1}e \longrightarrow {}^1_0n$ + X - rays
e.g., $^{133}_{56}Ba + {}^0_{-1}e \longrightarrow {}^{133}_{55}Cs$ + X - rays
Mass no. remains same; at. no. decrease, $\frac{n}{p}$ increases.

Section C

14. (c) Explanation is correct reason for statement.
15. (c) –do–

16. (d) Due to more hydration energy of Li^+; Thus $E^\circ_{RP}Li > E^\circ_{RP}Na$.

17. (a) Nu : adds to the β-carbon and not on α.



Section D

18. **One :** No. of replaced H atom = 1

19. **Two :** Total charge on cation (other than H)

20. **One :** Both gives 2 mole H^+

21. **Two :** (100 + 22.5)% oleum means 222.5 g H_2SO_4

$$H_2O + SO_3 \longrightarrow H_2SO_4$$

$\because$ 18 g H_2O gives = 98 g H_2SO_4

$\therefore$ 22.5 g H_2O gives $= \frac{98 \times 22.5}{18} = 122.5$ g H_2SO_4 in 100 g oleum

$\therefore$ Total $H_2SO_4 = 100 + 122.5$ g $= 222.5$ g

1 g oleum $\equiv 2.225$ g $H_2SO_4 = \frac{2.225}{49} \times 1000 = 45.41$ meq.

$\therefore$ Meq. of $H_2SO_4 = 45.41$

$\therefore$ $22.7 \times N = 45.41$

$N = 2$

22. **Three :** $NO_2^- + 4H^+ + 3e \longrightarrow NO + 2H_2O$

23. **Eight :** $\frac{2R \times 348}{58} = \frac{3RT}{2}$

$\therefore$ $T = \frac{4 \times 348}{58 \times 3} = 8$ K

24. **Eight :** $\frac{8}{2} \times \frac{4}{w} = \sqrt{\frac{16}{4}} = 2$

$w = 8$ g

25. **Three :** $RNH_2 + H_2O \rightleftharpoons RNH_3^+ + OH^-$

$$[OH^-] = C\alpha = \sqrt{\frac{K_b}{C}} \cdot C = \sqrt{K_b \cdot C}$$

$$= \sqrt{\frac{K_w}{K_a} \cdot C} = \sqrt{\frac{10^{-14}}{10^{-10}} \times 10^{-2}}$$

$$= \sqrt{10^{-6}} = 10^{-3}$$

$\therefore$ pOH = 3

26. **Three :** $\underset{1}{NaHSO_4} \rightleftharpoons \underset{0}{Na^+} + \underset{1}{H^+} + \underset{1}{SO_4^{2-}}$

27. **Four :** *o*-, *m*-, *p*-cresol and anisole and benzyl alcohol.

IIT-JEE MODEL PAPER CHEMISTRY 4-B

Time : 60 minutes **M.M. : 82**

Section A : Only One Answer Correct **[2×9 = 18]**

1. Which of the following statement about chemical equilibrium are correct ?
   (I) For gaseous reaction, the equilibrium can be established in open container
   (II) The state of equilibrium is dynamic and not static
   (III) If temperature is kept constant, the colour of the reacting system changes with time
   (IV) For gaseous reaction, the equilibrium can be attained at constant volume or constant pressure
   (a) I, II and IV (b) II and III
   (c) II and IV (d) I, II and III
2. At 1 atm b.pt. of aqueous solution is greater than 100°C because :
   (I) non volatile solute on dissolution in water lowers the vapour pressure of solvent
   (II) non electrolyte solute on dissolution in water lowers the vapour pressure of solvent
   (III) electrolyte solute on dissolution in water lowers the vapour pressure of solvent
   (IV) chemical potential of water in solution is more than the chemical potential of water in pure state
   (a) I, II and III (b) I, II and IV
   (c) I, II, III and IV (d) I, III and IV
3. According to Lewis concept, which of the following is correct acidic order ?
   (a) $Fe^{3+} < Fe^{2+}$ (b) $Na^+ < K^+$
   (c) $Be^{2+} < B^{3+}$ (d) None of these
4. Which of the aqueous solution will act as buffer ?
   (I) $CH_3COOH + CH_3COONH_4$
   (II) $NH_4OH + CH_3COONH_4$
   (III) $NaH_2PO_4 + Na_2HPO_4$
   (IV) $H_3BO_3 + Na_2B_4O_7$
   (a) III only (b) III and IV
   (c) I and II (d) I, II, III and IV
5. Which of the following statement are correct about H atom ?
   (I) It can form a covalent bond with other atoms
   (II) It can form an ionic bond with other atoms, it self changing to H^+
   (III) It can form an ionic bond with other atoms, it self changing to H^-
   (IV) It can form co-ordinate bond with other molecule
   (a) I and II (b) I, II and III
   (c) I, II, III and IV (d) I and III
6. Which of the following statements are correctly reported ?
   (I) α-D(+)-glucose and β-D(+)-glucose are anomers
   (II) Fructose is reducing sugar and sucrose is not reducing sugar
   (III) Glucose is non reducing sugar
   (IV) Maltose shows mutarotation
   (a) I, II and III (b) I, II and IV
   (c) I, III and IV (d) II, III and IV
7. The correct order of stability of the given carbanions is :
   1. $CH_3—\overset{-}{C}H_2$ 2. $CH_2=\overset{-}{C}H$
   3. $CH\equiv\overset{-}{C}$ 4. $C_6H_5—\overset{-}{C}H_2$
   (a) 1 > 2 > 3 > 4 (b) 4 > 3 > 1 > 2
   (c) 4 > 3 > 2 > 1 (d) 1 > 2 > 4 > 3
8. I_2 can be obtained from chili salt peter as :
   $$2X + 6HSO_3^- \longrightarrow 2Y + 6SO_4^{2-} + 6H^+$$
   $$5Y + X \longrightarrow 2Z + 3H_2O$$
   In these reactions *X*, *Y* and *Z* respectively are :
   (a) I^-, IO_4^- and I_2 (b) I^-, IO_3^- and I_2
   (c) IO_3^-, I^- and I_2 (d) IO_4^-, I^- and I_2
9. Which of the following gives NH_3 on heating to decomposition ?
   (I) $(NH_4)_2Cr_2O_7$ (II) $(NH_4)_2SO_4$
   (III) NH_4NO_3 (IV) NH_4NO_2
   (a) II, III and IV (b) III and IV
   (c) II only (d) IV only

Section B : More Than One Correct Answers **[3 × 4 = 12]**

10. Select the correct choices :
    (a) Cu_2O is added to glass to give ruby red colour
    (b) Normal domestic glass for windows is calcium alkali silicate
    (c) Glass is categorised amorphous solid on cooling its solution
    (d) Composition of glass may vary
11. Select the correct answers :
    (a) *p*-hydroxy phenol has higher b.pt. than *o*-hydroxy phenol
    (b) *o*-hydroxy phenol has higher b.pt. than phenol
    (c) *p*-hydroxy phenol has higher b.pt. than phenol
    (d) The order of m.pt. of cresols is *p*-cresol > *o*-cresol > *m*-cresol
12. Which of the following cells do not need liquid junction potential ?
    (a) $Fe(s) \mid FeO(s) \mid KOH(aq) \mid + Ni_2O_3(s) \mid Ni$
    (b) $Cd \mid CdO(s) \mid KOH\ (aq) \mid NiO_2(s) \mid Ni$
    (c) $Pb \mid PbSO_4(s) \mid H_2SO_4 \mid PbO_2(s) \mid Pb$
    (d) H_2 | Porous carbon road (with Pt or Pd in finely divide state) | NaOH | Porous carbon rod with Co, Pt or Ag finely divided state | O_2

13. K_p for the reaction : $PCl_5 \rightleftharpoons PCl_3 + Cl_2$ is given by $K_p = \frac{n^2}{1-n} \times \left[\frac{P}{1+n}\right]$ where P is the pressure at equilibrium and n is degree of dissociation of PCl_5. Select the incorrect statement about this reaction if N_2 is added at equilibrium :
(a) On adding N_2 at constant volume, 'n' decreases
(b) On adding N_2 at constant volume, 'n' increases
(c) On adding N_2 at constant pressure, 'n' increases
(d) On adding N_2 at constant pressure, the K_p changes

Section C : Matching Type Problems

14. **Match the following : Only one match is possible :** [1 × 4 = 4]

	List A Reaction		List B Product
(A)	Heating glycerol with conc. H_2SO_4	1.	Glyoxal as one of the products
(B)	Hydrogenation of carbon	2.	2-hydroxy ethanoic acid
(C)	Action of glyoxal with NaOH	3.	Synthetic petrol
(D)	Reductive ozonolysis of ethyne	4.	Acrolein

15. **Match the following : Only one match is possible :** [1 × 4 = 4]

	List A		List B
(A)	Amatol	1.	Explosive
(B)	Bronsted acid	2.	$B(OH)_3$
(C)	Hypo	3.	H_3PO_4
(D)	Lewis acid	4.	Photography

Section D : Statement-Explanation Type Problems [3 × 4 = 12]

Acid salt are the substances which possess one or more replaceable H-atom. The acid salts possess acidity as well as basicity. The basicity of acid salts depends on the nature of reaction whereas acidity refers for the total charge on metal cation.

16. The acidity of $Ba_X H_Y (PO_4)_2$ is :
(a) 2 (b) 3
(c) 4 (d) 6

17. Which of the following is not acid salt ?
(a) KH_2PO_3 (b) $Ba(HPO_3)$
(c) $Ba(H_2PO_4)_2$ (d) KHC_2O_4

18. Which one is correct about $Al_X H_Y (PO_4)_Z$:
(a) $Y = 3(Z - X)$ (b) $Y = Z - 2X$
(c) $Y = X - Z$ (d) $Y = 3Z - 2X$

19. The basicity of $Ba_X H_Y (PO_4)_2$ in the reaction is

$$Ba_X H_Y (PO_4)_2 + \frac{Y}{2} Ba(OH)_2 \longrightarrow Ba_{\left(X+\frac{Y}{2}\right)}(PO_4)_2 + H_2O$$

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

Section E : Single Integer Answer [4 × 8 = 32]

20. Number of anti bonding electrons in CO^+ according to molecular orbital theory are :

21. The heat of reaction of a redox change is 9.65×10^5 J. If the same redox change is made in the working of cell showing cell efficiency 60% and e.m.f. of 1.2 volt. What was the number of electrons involved in cell reaction ?

22. Mole fraction of a solute (in a solvent of molar mass 250) is 0.02. If elevation constant of solvent is 24.5 K molality^{-1}, the elevation in b.pt. will be :

23. A drop of solution (volume 0.05 mL) contains 3×10^{-2} mole of H^+. If the rate constant of disappearance of H^+ is 1.0×10^2 mol litre^{-1} minute^{-1}. How long (in minute) will it take to disappear all the H^+ ions ?

24. If $2H_2O(g) \rightleftharpoons 2H_2(g) + O_2(g)$; $K_1 = 2 \times 10^{-13}$
and $2CO_2(g) \rightleftharpoons 2CO(g) + O_2(g)$; $K_2 = 7.2 \times 10^{-12}$
The equilibrium constant for :
$CO_2(g) + H_2(g) \rightleftharpoons H_2O(g) + CO(g)$ is :

25. Number of optical isomers for 1,3-dimethylalene $(CH_3CH = C = CHCH_3)$ are :

26. C_4H_5N has degree of unsaturation a^0. The value of a is :

27. How many H atoms are bonded to a chiral methyl gp. ?

SOLUTION OF MODEL PAPER 4-B

Section A

1. (c) These are facts.
2. (c) –do–
3. (d) Smaller in size of cation more is Lewis acid nature.
4. (d) All these acts as buffer (An acid + its conjugate base – acidic buffer) and (A base + its conjugate acid – basic buffer)
5. (b) H—H; H^+Cl^-, Na^+H^-; H^+ can form co-ordinate bond and not H.
6. (b) Glucose is reducing sugar.
7. (c) Benzylic carbanion is most stable due to resonance stabilization. Also stable structures of carbanions possess –ve charge on more electronegative atom. Order of electronegativity of C in $\bar{C}\equiv CH$, $H\bar{C}=CH_2$, $H_2\bar{C}-CH_3$

   $sp > sp^2 > sp^3$
8. (c) $\underset{Y}{5I^-} + \underset{X}{IO_3^-} \longrightarrow \underset{Z}{3I_2} + 3H_2O$
9. (c) $(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} N_2 + 4H_2O + Cr_2O_3$

   $NH_4NO_3 \longrightarrow N_2O + 2H_2O$

   $NH_4NO_2 \longrightarrow N_2 + 2H_2O$

   $(NH_4)_2SO_4 \longrightarrow NH_3 + NH_4HSO_4$

Section B

10. (b, c, d) Cu_2O is added to impart blue colour to glass.
11. (a,c,d) *o*-hydroxy phenol shows intramolecular H-bonding, *p*-hydroxy phenol shows and phenol inter molecular H-bonding (more stronger). The given order to m.pt. of cresol is experimental value.

    $\underset{35°C}{p\text{-cresol}}$ $\underset{31°C}{o\text{-cresol}}$ $\underset{11°C}{m\text{-cresol}}$
12. (a, b, c, d) First three shows redox reaction and do not involve any solution state in it. The fourth is a fuel cell. Thus junction of two liquids is not present in any cell.
13. (a, b, d) If $\Delta n \neq 0$ and addition is made at constant V, then no effect. No doubt P increases but Σn (total mole) also increase. K_p remains constant in both cases either constant P or constt. V. If addition of inert gas is made at constant P, Σn *i.e.*, $(1 + n)$ increases and to have K_p constant n increases.

Section C

14. A—4; B—3; C—2; D—1
15. A—1; B—3; C—4; D—2

Section D

16. (c) Ba, H and PO_4 are bivalent monovalent and trivalent respectively.

    $2X + 1\times Y - (3\times 2) = 0$

    $2X + Y = 6$

    X and Y are positive integers.

    if $Y = 1$ then $X = 5/2$

    $Y = 2$ then $X = 2$

    $Y = 3$ then $X = 3/2$
17. (b) H_3PO_3 is dibasic acid.
18. (a) $3\cdot X + Y\cdot 1 - 3\cdot Y = 0$

    $\therefore\ Y = 3Z - 3X$
19. (b) For $Ba_XH_Y(PO_4)_2 : 2X + Y = 6$

    For $Ba_{\left(X+\frac{Y}{2}\right)}\cdot(PO_4)_2 : 2X + Y = 6$

    Also the salt obtained is derivative of H_3PO_4. Ba is bivalent and thus, $2X$ should be even number thus, Y should be 2.

    or $2X + 2 = 6$

    $X = 2$

Section E

20. **Three :** CO^+ is $\sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma 2p_x^2 \begin{bmatrix}\pi 2p_y^2 \\ \pi 2p_z^2\end{bmatrix} \sigma^* 2s^1$

    Bond order of CO^+ is 3.5.
21. **Five :** $\eta = \dfrac{\Delta G}{\Delta H} = \dfrac{nEF}{\Delta H}$

    $0.6 = \dfrac{n\times 1.2\times 9.65\times 10^4}{9.65\times 10^5}$

    $\therefore\quad n = \dfrac{6}{1.2} = 5$
22. **Two :** $\dfrac{n}{n+N} = 0.02$

    $\dfrac{N}{n+N} = 0.98$

    $\dfrac{n}{N} = \dfrac{1}{49}$

    $\dfrac{w\times M\times 1000}{m\times W\times 1000} = \dfrac{1}{49}$

    $\text{Molality} = \dfrac{1}{49}\times\dfrac{1000}{M} = \dfrac{1000}{49\times M}$

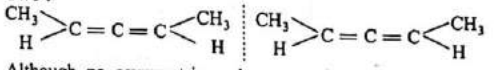
    $\Delta T_b = K_b' \times \text{molality}$

    $\Delta T_b = \dfrac{1000\times 24.5}{49\times 250} = 2$
23. **Six :** 0.05 mL has 3×10^{-2} mol of H^+

    1000 mL has $\dfrac{3\times 10^{-2}\times 1000}{0.05} = 600$ mol H^+

    $K = \dfrac{X}{t}$ (zero order, follow unit of K)

    $t = \dfrac{600}{1\times 10^2} = 6$ minute
24. **Six :** $K_c = \sqrt{\dfrac{K_2}{K_1}} = \sqrt{\dfrac{7.2\times 10^{-12}}{2\times 10^{-13}}} = \sqrt{36} = 6$
25. **Two :**

    Although no asymmetric carbon atom but it shows a pair of enantiomers. In other words chirality and not the presence of asymmetric carbon atom is the criteria for enantiomerism.
26. **Three :** Disregard N but remove an H for each N. Thus, C_4H_4 which has 3° unsaturation.
27. **One :** D—C(H)(T)—chiral methyl gp.

APPENDICES

Appendix-1

S. No.	Physical quantities	Symbol	SI units	Symbol of units
1.	Area	A	Square meter	m^2
2.	Volume	V	Cubic meter	m^3
3.	Density	d	kilogram meter^{-3}	$kg\ m^{-3}$
4.	Velocity	u	meter per sec	$m\ s^{-1}$
5.	Acceleration	g	meter per sec^2	$m\ s^{-2}$
6.	Energy	E	joule	$J(kg\ m^2\ s^{-2})$
7.	Force	F	newton	$N(kg\ m\ s^{-2})$
8.	Power	—	Watt	$W(kg\ m^2\ s^{-3}$ or $Js^{-1})$
9.	Pressure	P	Pascal	$Pa(N\ m^{-2})$
10.	Frequency	v	Hertz	$Hz(s^{-1})$
11.	Electric charge	Q	Coulomb	C(Ampere second)
12.	Electrical potential difference	V	Volt	$V(kg\ m^2\ s^{-3}\ A^{-1})$
13.	Electrical resistance	R	Ohm	$\Omega(kg\ m^2\ s^{-3}\ A^{-2})$
14.	Electrical conductance	S	Siemens	$S(\Omega^{-1})$
15.	Amount	mole	mole	$mole\left(\frac{Mass}{Molar\ mass}\right)$

Appendix-2

Numerical Prefixes

S.No.	Prefixes	Value	S.No.	Prefixes	Value
1.	Hemi	$\frac{1}{2}$	12.	Deca	10
2.	Mono	1	13.	undeca	11
3.	Sesqui	$1\frac{1}{2}$	14.	Dodeca	12
4.	Di or Bi	2	15.	Trideca	13
5.	Tri	3	16.	Tetra deca	14
6.	Tetra	4	17.	Penta deca	15
7.	Penta	5	18.	Hexa deca	16
8.	Hexa	6	19.	Hepta deca	17
9.	Hepta	7	20.	Octa deca	18
10.	Octa	8	21.	Nona deca	19
11.	Nona	9	22.	Eicosa	20

Appendix-3

Fractions Prefixes, symbols and their multiples

S.No.	Prefix	Symbol	Multiples	S.No.	Prefix	Symbol	Multiples
1.	Atto	a	10^{-18}	9.	deca	da	10
2.	Femto	f	10^{-15}	10.	hecto	h	10^2
3.	Pico	p	10^{-12}	11.	kilo	k	10^3
4.	Nano	n	10^{-9}	12.	mega	M	10^6
5.	Micro	μ	10^{-6}	13.	giga	G	10^9
6.	Milli	m	10^{-3}	14.	tera	T	10^{12}
7.	Centi	C	10^{-2}	15.	peta	p	10^{15}
8.	Deci	d	10^{-1}	16.	exa	E	10^{18}

Appendix-4

Traditional Units with SI and CGS Values

S.No.	Quantity	Traditional Units	SI and CGS Value
1.	Mass	amu	1.6605×10^{-27} kg = 1.6605×10^{-24} g = 1 amu
2.	Length	Å	10^{-10} meter = 10^{-8} cm = 1Å
3.	Volume	litre	10^{-3} m^3 = 10^3 cm^3 = 1 litre
4.	Force	dyne	10^{-5} Newton = 1 dyne
5.	Energy	erg	10^{-7} joule = 1 erg
		cal	4.184 joule = 1 cal
		electron volt	1.602×10^{-19} joule = 1 eV
		kilo watt hour	3.6×10^{6} joule = 1 kWh
		horse power	2.6845×10^{6} joule = 1 np
6.	Pressure	atmosphere	101325 N m^{-2} or pascal = 1 atm
		cm	1333.2237 N m^{-2} = 1 cm
		mm or torr	133.32237 N m^{-2} = 1 mm
		bar	101325 N m^{-2} = 1 bar
7.	Temperature	centigrade	273.15 K = 0°C
8.	Electric charge	esu	3.3356×10^{-10} C = 1 esu
9.	Work	litre atm	101.3 J = 1 litre atm
10	Radioactivity	curie or Ci	3.7×10^{10} dps or Bq = 1 curie
		Rutherford	10^{6} dps = 10^{6} Bq = 1 rd

Appendix-5

Greek Alphabets and their Symbols

Greek alphabets	Symbol	Greek alphabets	Symbol
Alpha	α	Nu	ν
Beta	β	Xi	ξ
Gamma	γ	Omioron	Θ
Delta	δ or Δ	Pi	π
Epsilon	ε	Rho	ρ
Zeta	ζ	Sigma	σ or Σ
Eta	η	Tau	τ
Theta	θ	Upsilon	υ
Iota	ι	Phi	ϕ
Kappa	κ	Chi	χ
Lambda	λ	Psi	ψ
Mu	μ	Omega	ω

Appendix-6

Wavelengths and Frequencies of Electromagnetic Radiations

S. No.	Radiations	Wavelength λ (in Å)	Frequency(γ) (in Hz or sec^{-1})
1.	Radio wave	3×10^{9} to 3×10^{13}	1×10^{5} to 1×10^{9}
2.	Micro wave	6×10^{6} to 3×10^{9}	1×10^{9} to 5×10^{11}
3.	Infra red	3×10^{9} to 7.6×10^{3}	1×10^{11} to 3.95×10^{14}
4.	Visible rays	3800 to 7600	3.95×10^{14} to 7.9×10^{14}
5.	Ultra violet rays	150 to 3800	7.9×10^{14} to $2\times2\times10^{16}$
6.	X-rays	0.1 to 150	2×10^{16} to 3×10^{19}
7.	Gamma rays (γ)	0.01 to 0.1	3×10^{19} to 3×10^{20}
8.	Cosmic rays	0.00 to 0.001	3×10^{21} to infinite

Appendix-7

Some Physical Constants

S. No.	Name	Symbol	CGS value	SI unit value
1.	Universal Gas constant	(R)	8.314×10^{7} erg K^{-1}	8.314 J K^{-1} mol^{-1}
2.	Boltzmann constant	(k)	1.380×10^{-16} erg K^{-1}	1.380×10^{-23} JK^{-1}
3.	Planck's constant	(h)	6.626×10^{-27} erg sec	6.626×10^{-34} J sec
4.	Speed of light	c	2.9979×10^{10} cm sec^{-1}	2.9979×10^{8} m sec^{-1}
5.	Molar volume at STP	$\bar{v}$	22414 cm^3	0.0224 m^3
6.	Avogadro's No.	N	6.022169×10^{23} mol^{-1}	6.022169×10^{23} mol^{-1}
7.	Charge on electron	e	4.80291×10^{-10} esu	1.60210×10^{19} C
8.	Atomic mass unit	amu	1.660531×10^{-24} g	1.660531×10^{-27} kg
9.	Mass of electron in rest	m_e	9.109558×10^{-28} g	9.109558×10^{-31} kg
10.	Mass of proton	m_p	1.67261×10^{-24} g	1.67261×10^{-27} kg
11.	Mass of neutron	m_n	1.67492×10^{-24} g	1.67492×10^{-27} kg
12.	Rydberg constant	R_H	1.097373×10^{5} cm^{-1}	1.097373×10^{7} m^{-1}
13.	Faraday	(F)	2.89461×10^{14}	9.6487×10^{7} C / kg
14.	Accelaration due to gravity	(g)	980.665 cm sec^{-2}	9.80665 m sec^{-2}
15.	I. Bohr's radius (for H)	η_H	0.529×10^{-8} cm	0.529×10^{-10} m
16.	Atmospheric pressure	(P)	1.013250×10^{6} dyne cm^{-2}	1.013250×10^{5} N m^{-2}
17.	Specific charge of electron	(e/m)	5.2764×10^{17} esu / g	1.75880×10^{11} C kg^{-1}
18.	Ice point	(m.pt.)	273.150 K	273.150 K
19.	Triple point of H_2O		273.16 K	273.16 K

Appendix-8

Element	Symbol	Atomic number	Atomic mass	Known Isotopes
Actinium	Ac	89	(227)	—
Aluminium	Al	13	25.9815	1
Amercium	Am	95	(243)	—
Antimony	Sb	51	121.75	2
Argon	Ar	18	39.948	3
Arsenic	As	33	74.9216	1
Astatine	At	85	(210)	—
Barium	Ba	56	137.34	7
Berkelium	Bk	97	(247)	—
Beryllium	Be	4	9.0122	2
Bismuth	Bi	83	208.980	14
Boron	B	5	10.820	14
Bromine	Br	35	79.904	2
Cadmium	Cd	48	112.40	9
Calcium	Ca	20	40.08	6
Californium	Cf	98	(251)	—
Carbon	C	6	12.01	2
Cerium	Ce	58	140.12	4
Cesium	Cs	55	132.905	5
Chlorine	Cl	17	35.453	3
Chromium	Cr	24	51.996	4
Cobalt	Co	27	58.9332	2
Copper	Cu	29	63.546	2
Curium	Cm	96	(247)	—
Dysprosium	Dy	66	162.50	4
Einsteinium	Es	99	(294)	—
Erbium	Er	68	167.26	4
Europium	Eu	63	152.00	2
Fermium	Fm	100	(253)	—
Flurine	F	9	19.0	1
Francium	Fr	87	(223)	—
Gadolinium	Gd	64	157.25	5
Gallium	Ga	31	69.72	2

† Values in parentheses are mass numbers of the most stable or the best known isotopes.

Element	Symbol	Atomic number	Atomic mass	Known Isotopes
Germanium	Ge	32	72.60	5
Gold	Au	79	196.67	—
Hafnium	Hf	72	178.49	5
Helium	He	2	4.0026	2
Holmium	Ho	67	164.930	1
Hydrogen	H	1	1.00797	3
Indium	In	49	114.81	2
Iodine	I	53	126.9044	1
Iridium	Ir	77	192.2	2
Iron	Fe	26	55.847	4
Krypton	Kr	36	83.80	6
Kurchatovium	Ku	104	(260)	—
Lanthanum	La	57	183.91	1
Lawrenchium	Lw	103	(257)	—
Lead	Pb	82	207.19	16
Lithium	Li	3	6.94	2
Lutetium	Lu	71	174.97	1
Magnesium	Mg	12	24.312	3
Manganese	Mn	25	54.9380	7
Mendelevium	Md	101	(256)	—
Mercury	Hg	80	200.59	8
Molybdenum	Mo	42	95.94	8
Neodymium	Nd	60	144.24	5
Neon	Ne	10	20.183	3
Neptunium	Np	93	(237)	—
Nickel	Ni	28	58.71	5
Niobium	Nb	41	92.906	1
Nitrogen	N	7	14.0067	2
Nobelium	No	102	(254)	—
Osmium	Os	76	190.2	6
Oxygen	O	8	15.9994	3
Palladium	Pd	46	106.4	6
Phosphorus	P	15	30.9738	1

Element	Symbol	Atomic number	Atomic mass	Known Isotopes
Platinum	Pt	78	195.09	5
Plutonium	Pu	94	(242)	–
Polonium	Po	84	(210)	–
Potassium	K	19	39.102	3
Praseodymium	Pr	59	140.007	1
Promethium	Pm	61	(147)	–
Protactinium	Pa	91	(231)	–
Radium	Ra	88	(226)	4
Radon	Rn	86	(222)	–
Rhenium	Re	75	186.2	2
Rhodium	Rh	45	102.905	2
Rubidium	Rb	37	85.47	2
Ruthenium	Ru	44	101.07	7
Samarium	Sm	62	150.35	7
Scandium	Sc	21	44.956	1
Selenium	Se	34	78.96	6
Silicon	Si	14	28.086	3
Silver	Ag	47	107.868	2
Sodium	Na	11	22.9898	3
Strontium	Sr	38	87.62	4
Sulphur	S	16	32.064	1
Tantalum	Ta	73	180.948	1
Technetium	Tc	43	(99)	–
Tellurium	Te	52	127.60	8
Terbium	Tb	65	158.924	1
Thallium	Tl	81	204.37	8
Thorium	Th	90	232.038	8
Thulium	Tm	69	168.934	1
Tin	Sn	50	118.69	10
Titanium	Ti	22	47.90	5
Tungusten	W	74	183.85	4
Uranium	U	92	238.03	8
Vanadium	V	23	50.942	1
Xenon	Xe	54	131.30	9
Ytterbium	Yb	70	173.04	5
Yttrium	Y	39	88.905	1
Zinc	Zn	30	65.37	5
Zirconium	Zr	40	91.22	5

Appendix-9
Some direct conversion factors

1 erg	$= 10^{-7}$ joule $= 2389 \times 10^{-8}$ cal $= 6.242 \times 10^{11}$ eV
1 calorie	$= 4.184 \times 10^{7}$ erg $= 4.184$ joule $= 2.613 \times 10^{19}$ eV
1 electron volt	$= 1.6021 \times 10^{-12}$ erg $= 1.6021 \times 10^{-19}$ joule $= 3.827 \times 10^{-20}$ calorie
1 litre	$= 1000$ mL or cm^3 $= 10^{-3} m^3$
1 angstrom	$= 10^{-8}$ cm $= 10^{-10}$ m
1 nanometer	$= 10^{-9}$ m $= 10^{-7}$ cm
1 coulomb	$= 2.9979 \times 10^{9}$ esu
1 faraday	$= 9.6487 \times 10^{4}$ coulomb
1 curie	$= 3.7 \times 10^{10}$ disintegration sec^{-1}
1 rutherford	$= 10^{6}$ dps

Appendix-10

Electrochemical Series

Half reactions	Standard reduction potential at 25°C(In volt)
$Li^+ + e \longrightarrow Li$	–3.04
$K^+ + e \longrightarrow K$	–2.92
$Ba^{2+} + 2e \longrightarrow Ba$	–2.90
$Sr^{2+} + 2e \longrightarrow Sr$	–2.89
$Ca^{2+} + 2e \longrightarrow Ca$	–2.87
$Na^+ + e \longrightarrow Na$	–2.71
$Mg^{2+} + 2e \longrightarrow Mg$	–2.37
$Al^{3+} + 3e \longrightarrow Al$	–1.66
$Mn^{2+} + 2e \longrightarrow Mn$	–1.18
$Zn^{2+} + 2e \longrightarrow Zn$	– 0.76
$Cr^{3+} + 3e \longrightarrow Cr$	– 0.74
$Fe^{2+} + 2e \longrightarrow Fe$	– 0.44
$Cd^{2+} + 2e \longrightarrow Cd$	– 0.40
$Co^{2+} + 2e \longrightarrow Co$	– 0.27
$Ni^{2+} + 2e \longrightarrow Ni$	– 0.25
$Sn^{2+} + 2e \longrightarrow Sn$	– 0.13
$Pb^{2+} + 2e \longrightarrow Pb$	– 0.12
$2H^+ + 2e \longrightarrow H_2$	0.00
$Sn^{4+} + 2e \longrightarrow Sn^{2+}$	+0.15
$Cu^{2+} + 2e \longrightarrow Cu$	+0.34
$Fe^{3+} + e \longrightarrow Fe^{2+}$	+0.77
$Hg_2^{2+} + 2e \longrightarrow 2Hg$	+0.79
$Ag^+ + e \longrightarrow Ag$	+0.80
$Hg^{2+} + 2e \longrightarrow Hg$	+0.85
$Pt^{2+} + 2e \longrightarrow Pt$	+1.20
$Cl_2 + 2e \longrightarrow 2Cl^-$	+1.36
$Au^{3+} + 3e \longrightarrow Au$	+1.50
$Co^{3+} + 1e \longrightarrow Co^{2+}$	+1.84
$F_2 + 2e \longrightarrow 2F^-$	+2.87

Appendix-11
Some Important discoveries

1.	Law of electrolysis	Faraday
2.	Law of conservation of mass	Lavoisier
3.	Law of constant proportion	Prout
4.	Law of multiple proportion	Dalton
5.	Law of reciprocal proportion	Ritcher
6.	Law of gases	Boyle, Charles, Gay Lussac
7.	Law of gaseous diffusion	Graham
8.	Law of partial pressure	Dalton
9.	Law of mass action	Guldward and Waage
10.	Electron	Thomson
11.	Proton	Gold Stein
12.	Neutron	Chadwick
13.	Neutrino	Pauli
14.	Mesons	Yukawa
15.	Nucleus	Rutherford
16.	Wave nature of electron	de Broglie
17.	Wave nature of light	Plancks
18.	Uncertainty principle	Heisenburg
19.	Multiplicity rule	Hund
20.	Exclusion principle	Pauli
21.	Radioactivity	Becquerrel
22.	Artificial radioactivity	Irene Curie and F. Joliot
23.	Radium	Marie Curie and P. Curie
24.	Radioactive dating	Libby W.F.
25.	Group displacement law	Soddy-Fajan
26.	Cyclotron	Lawrence E.O.
27.	Charge on electron	Millikan
28.	Periodic law	Mendeleeff (old); Mosley (new)
29.	Atomic number	Mosley
30.	X-rays	Roentzen
31.	Photoelectric effect	Thomson
32.	Electrovalence	Kossel and Lewis
33.	Covalence	Lewis
34.	Co-ordinate valence	Sugden
35.	Valence bond theory	Heitler and London
36.	Molecular orbital theory	Hund and Mulliken
37.	Deuterium	Urey
38.	Heavy water	Urey
39.	H_2O_2	Thenard
40.	N_2	Scheele
41.	Argon	Rayleigh and Ramsay
42.	Neon	Ramsay and Travers
43.	Krypton	Ramsay and Travers
44.	Xenon	Ramsay and Travers
45.	Radon	Dorn
46.	Helium	Lockyer and Frankland
47.	Compounds of xenon	Bartlett
48.	Theory of dissociation	Arthenius
49.	Theory of strong electrolytes	Debye and Huckel
50.	Theory of relativity	Einstein