Chapter 20
Principles of Qualitative Analysis

Solutions

SECTION - A

Objective Type Questions (One option is correct)

1. Which among the following sulphates is insoluble in water?

(1) $CuSO_4$ (2) $CdSO_4$ (3) $PbSO_4$ (4) $Bi_2(SO_4)_3$

Sol. Answer (3)

$PbSO_4$ is insoluble in water.

2. Which compound will not give positive chromyl chloride test?

(1) $CuCl_2$ (2) $HgCl_2$ (3) $ZnCl_2$ (4) $C_6H_5NH_3^+Cl^-$

Sol. Answer (2)

$HgCl_2$ does not give chromyl chloride test.

3. Which of the following is not a preliminary test used to detect ions?

(1) Borax bead test (2) Flame test

(3) Brown ring test (4) Microcosmic salt bead test

Sol. Answer (3)

Brown ring test is not a preliminary test.

4. When $K_2Cr_2O_7$ crystals are heated with concentrated HCl, the gas evolved is

(1) O_2 (2) Cl_2 (3) CrO_2Cl_2 (4) HCl

Sol. Answer (2)

When HCl is treated with $K_2Cr_2O_7$, Cl_2 goes is evolved.

5. The brown ring test for NO_3^- is due to the formation of the complex ion with formula as

(1) $[Fe(H_2O)_6^{2+}$ (2) $[Fe(NO(CN)_5]^{2-}$

(3) $[Fe(H_2O)_5NO]^{2+}$ (4) $[Fe(H_2O)(NO)_5]^{2+}$

Sol. Answer (3)

The Brown ring test for NO_3^- is due to the formation of the complex ion $[Fe(H_2O)_5NO]^{2+}$.

6. A salt which gives CO_2 with hot H_2SO_4 and also decolourizes acidified $KMnO_4$ on warming is

(1) HCO_3^- (2) CO_3^{2-} (3) Oxalate ion (4) Acetate ion

Sol. Answer (3)

$$\begin{matrix} COO^- \\ | \\ COO^- \end{matrix} + H_2SO_4 \longrightarrow CO_2$$

It also decolourises $KMnO_4$.

7. An aqueous solution of $FeSO_4.Al_2(SO_4)_3$ and chrome alum is heated with excess of Na_2O_2 and filtered. The materials obtained are

(1) A colourless filtrate and a green residue (2) A yellow filtrate and a green residue

(3) A yellow filtrate and a brown residue (4) A green filtrate and a brown residue

Sol. Answer (3)

8. When concentrated H_2SO_4 is added to dry KNO_3, brown fumes evolve. These brown fumes are of

(1) SO_2 (2) SO_3 (3) NO (4) NO_2

Sol. Answer (4)

The brown fumes are of NO_2.

9. A violet colour is obtained on adding Cl_2 water in solution of potassium halide in presence of chloroform and on adding excess of Cl_2 water, violet colour disappears and colourless solution appears. The test shows the presence of

(1) Iodide ion (2) Bromide ion

(3) Chloride ion (4) Iodide and bromide ion

Sol. Answer (1)

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

10. A substance on treatment with dil H_2SO_4 liberates a colourless gas which produces

(i) Turbidity with baryta water and (ii) turns acidified dichromate solution green.

The reaction indicates the presence of

(1) $C_2O_3^{2-}$ (2) S^{2-} (3) SO_3^{2-} (4) NO_2^-

Sol. Answer (3)

SO_2 produce turbidity in Baryta water and turns acidified dichromate solution green.

11. A mixture is known to contain NO_3^- and NO_2^- before performing ring test for NO_3^-. The aq. solution should be made free of NO_2^-. This is done by heating with

(1) NH_4Cl (2) Zn dust (3) Conc. HNO_3 (4) Dil. HNO_3

Sol. Answer (1)

Fact.

12. $PbCl_2 + KI \rightarrow \underset{\text{Yellow ppt}}{[A]} + KCl$

$\underset{\text{Yellow ppt}}{[A]} + \underset{\text{excess}}{KI} \longrightarrow \underset{\text{soluble}}{[B]}$

Compound [A] and [B] are

(1) PbI_4 and $K_2[PbI_4]$ respectively
(2) $K_2[PbI_4]$ and PbI_4 respectively
(3) PbI_2 and $K_2[PbI_4]$ respectively
(4) PbI_2 and $K_2[PbI_2]$ respectively

Sol. Answer (3)

$PbCl_2 + KI \longrightarrow \underset{\text{yellow ppt}}{PbI_2} + KCl$

$PbI_2 + KI \longrightarrow K_2[PbI_4]$

13. The reagent NH_4Cl and aqueous NH_3 precipitate.

(1) Ca^{2+} (2) Al^{3+} (3) Mg^{2+} (4) Zn^{2+}

Sol. Answer (2)

Conc. of OH^- exceeds K_{sp} of $Al(OH)_3$.

14. Mark the correct statement out of the following

(1) Group I basic radicals precipitate as chlorides
(2) Group IV basic radicals precipitate as sulphides
(3) Group V basic radicals precipitate as carbonates
(4) All of the above statements are correct

Sol. Answer (4)

Group I basic radical (Pb^{2+}, Ag^+, Hg_2^{2+}) precipitate as chloride group IV basic radicals $(Ni^+, Co^{2+}, Mn^{2+}, Zn^{2+})$ precipitate as sulphide group V basic radicals (Ba^{2+}, Sr^{2+}, Co^+) precipitate as carbonate.

15. Which of the following sulphides does not dissolve in hot dilute HNO_3?

(1) HgS (2) CuS (3) PbS (4) CdS

Sol. Answer (1)

HgS does not dissolve in hot dilute HNO_3.

16. The only cations present in slightly acidic solution are Fe^{3+}, Zn^{2+} and Cu^{2+}. The reagent that when added in excess to this solution would identify and separate Fe^{3+} in one step is

(1) 2 M HCl (2) 6 M NH_3 (3) 6 M NaOH (4) H_2S gas

Sol. Answer (2)

Zn and Cu can form soluble complexes with NH_3.

17. In the fifth group $(NH_4)_2CO_3$ is added to precipitate out the carbonates, we do not add Na_2CO_3 because

(1) $MgCO_3$ is soluble in Na_2CO_3
(2) Na_2CO_3 increases the solubility of fifth group carbonates
(3) $MgCO_3$ will also be precipitated out in fifth group
(4) Na_2CO_3 will decrease the solubility product of $MgCO_3$

Sol. Answer (3)

$MgCO_3$ will also be precipitated out in fifth group.

18. White substance dissolves in hot water. A black precipitate appears on passing H_2S gas in its aqueous solution. The black precipitate dissolves in hot HNO_3. A white precipitate is obtained on adding concentrated H_2SO_4 in its solution. This white precipitate is of

(1) $BaSO_4$ (2) $SrSO_4$ (3) $PbSO_4$ (4) $CdSO_4$

Sol. Answer (3)

Black precipitates are of PbS which are soluble in hot HNO_3. Precipitate of $PbSO_4$ is white.

19. A salt on treatment with dilute HCl gives a pungent smelling gas and a yellow precipitate. The salt gives green flame when tested. The solution gives a yellow precipitate with potassium chromate. The salt is

(1) $NiSO_4$ (2) BaS_2O_3 (3) PbS_2O_3 (4) $CuSO_4$

Sol. Answer (2)

The salt is BaS_2O_3, $BaCrO_4$ is yellow coloured.

20. Which of the following statement is correct?

(1) Fe^{2+} gives brown colour with ammonium thiocyanate

(2) Fe^{2+} gives blue precipitate with potassium ferricyanide

(3) Fe^{3+} gives brown colour with potassium ferrocyanide

(4) Fe^{3+} gives red colour with potassium ferrocyanide

Sol. Answer (2)

$$Fe^{2+} + K_3Fe(CN)_6 \longrightarrow \underset{\text{Turnbull's Blue}}{KFe[Fe(CN)_6]}$$

21. When H_2S is passed through an ammonical salt solution (x), a white precipitate is obtained. The (x) can be a

(1) Cobalt salt (2) Nickel salt (3) Manganese salt (4) Zinc salt

Sol. Answer (4)

White precipitate is of ZnS.

22. The ion most difficult to remove as precipitate is

(1) Ag^+ (2) NH_4^+ (3) Fe^{2+} (4) Co^{2+}

Sol. Answer (2)

All most all salt of NH_4^+ are soluble.

23. Which of the following white ppts are insoluble in NH_3?

(1) AgCl (2) Hg_2Cl_2 (3) $PbCl_2$ (4) All of these

Sol. Answer (3)

$PbCl_2$ is insoluble in NH_3.

24. The oxidation state of Fe in its brown ring complex is

(1) +1 (2) +2 (3) +3 (4) +4

Sol. Answer (1)

$[Fe(H_2O)_5NO]^{2+}$

25. Choose the correct pair regarding solubility

(1) CuS < MnS (2) CoS > ZnS (3) CdS > NiS (4) CuS > ZnS

Sol. Answer (1)

Mn^{2+} belong with 4^{th} group.

26. A solution of a metal ion when treated with KI gives a red precipitate which dissolves in excess KI to give a colourless solution. Moreover, the solution of metal ion on treatment with a solution of cobalt(II) thiocyanate gives rise to a deep blue crystalline precipitate. The metal ion is **[IIT-JEE-2007]**

(1) Pb^{2+} (2) Hg^{2+} (3) Cu^{2+} (4) Co^{2+}

Sol. Answer (2)

$$Hg^{2+} + 2I^- \rightarrow \underset{\text{red ppt}}{HgI_2 \downarrow}$$

$$HgI_2 + 2I^- \rightarrow \underset{\text{soluble complex}}{[HgI_4]^{2-}}$$

$$Hg^{2+} + Co^{2+} + 4SCN^- \rightarrow \underset{\text{blue ppt}}{CO[Hg(SCN)_4]\downarrow}$$

27. 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-JEE-2011]**

(1) CuS and HgS (2) MnS and CuS (3) MnS and NiS (4) NiS and HgS

Sol. Answer (1)

Cu^{2+} and Hg^{2+} belong with 2^{nd} group of basic radical.

28. Upon treatment with ammoniacal H_2S, the metal ion that precipitates as a sulfide is **[JEE(Advanced) 2013]**

(1) Fe(III) (2) Al(III) (3) Mg(II) (4) Zn(II)

Sol. Answer (4)

Upon treatment with ammoniacal H_2S, Zn^{2+} ion gets precipitated as ZnS. Fe^{3+} ion and Al^{3+} ions also get precipitated as hydroxides but not as sulphide.

SECTION - B

Objective Type Questions (More than one options are correct)

1. Which of the following salts will not give borax bead test?

(1) $Al(NO_3)_3$ (2) $CoCl_2$ (3) CoC_2O_4 (4) $K_2C_2O_4$

Sol. Answer (1, 4)

Al and K do not give borax bead test.

2. Which of the following sulphates are soluble in water?

(1) $CuSO_4$ (2) $PbSO_4$ (3) Ag_2SO_4 (4) $BaSO_4$

Sol. Answer (1, 3)

$$CuSO_4 + H_2O \longrightarrow [Cu(H_2O)_4]SO_4.H_2O$$

Ag_2SO_4 is also soluble.

3. An aqueous solution containing S^{2-} ions will not give

(1) A yellow precipitate with the suspension of $CdCO_3$ in water

(2) Black precipitate with lead acetate solution

(3) White precipitate with $CaCO_3$ suspension

(4) Purple colour with sodium thiosulphate solution

Sol. Answer (3, 4)

Aqueous solution containing S^{2-} ion will not give white precipitate with $CaCO_3$ and purple colour with sodium thiosulphate.

4. Hydrogen sulphide is not a group reagent for (basic radical)

(1) 2nd group radicals (2) 3rd group radicals

(3) 4th group radicals (4) 5th group radicals

Sol. Answer (2, 4)

H_2S is not group reagent for third and fifth group.

5. Which of the following radicals evolve gas or vapour when treated with dil HCl?

(1) SO_3^{2-} (2) $C_2O_4^{2-}$ (3) CH_3COO^- (4) HCO_3^-

Sol. Answer (1, 3, 4)

SO_3^{2-}, CH_3COO^- and HCO_3^- evolve gas or vapours when treated with dil. HCl

$$CH_3COO^- + H^+ \longrightarrow CH_3 - COOH$$

$$HCO_3^- + H^+ \longrightarrow CO_2 + H_2O$$

6. To the aqueous solution of the salt acidified potassium permanganate is added and its colour is discharged. It indicates the absence of

(1) Fe^{2+} (2) NO_3^- (3) Be^{2+} (4) Sn^{2+}

Sol. Answer (2, 3)

Be^{2+} and NO_3^-.

7. Which among the following will be soluble in excess of NaOH?

(1) $FeCl_3$ (2) $CrCl_3$ (3) $AlCl_3$ (4) $ZnCl_2$

Sol. Answer (3, 4)

$$AlCl_3 + \underset{\text{(excess)}}{NaOH} \longrightarrow \underset{\text{water soluble}}{NaAlO_2}$$

$$ZnCl_2 + NaOH \longrightarrow Na_2ZnO_2.$$

8. Which of the following compound will not turn black on adding NH_4OH to it?

(1) $ZnSO_4$ (2) Hg_2Cl_2 (3) AgCl (4) $CuSO_4$

Sol. Answer (1, 3, 4)

$$Hg_2Cl_2 + 2NH_4OH \longrightarrow Hg\begin{matrix}NH_2\\Cl\end{matrix} + NH_4Cl + 2H_2O$$

While other don't turn black.

9. Which pair of compounds is expected to show similar colour in aqueous medium?

(1) $FeCl_2$ and $CuCl_2$ (2) $VOCl_2$ and $CuCl_2$ (3) $VOCl_2$ and $FeCl_2$ (4) $FeCl_2$ and $MnCl_2$

Sol. Answer (1)

$FeCl_2$ and $CuCl_2$ are both green.

10. Brown vapours can be of

(1) Cl_2 (2) I_2 (3) Br_2 (4) NO_2

Sol. Answer (3, 4)

Brown vapours are of Br_2 and NO_2

11. If silver nitrate solution is added to a salt solution and a yellow precipitate is obtained the salt may contain

(1) Br^- (2) I^- (3) Cl^- (4) F^-

Sol. Answer (1, 2)

AgBr ⟶ pale yellow AgCl → white ppt.

AgI ⟶ dark yellow AgF → soluble

12. Which of the following sulphides are yellow?

(1) CdS (2) As_2S_3 (3) SnS_2 (4) ZnS

Sol. Answer (1, 2, 3)

CdS, As_2S_3 and SnS_2 are of yellow colour while ZnS white colour.

13. To an acid solution of an anion, a few drops of $KMnO_4$ solution are added. Which of the following if present will decolourise the $KMnO_4$ solution?

(1) NO_2^- (2) S^{2-} (3) CO_3^{2-} (4) Cl^-

Sol. Answer (1, 2, 4)

$KMnO_4$ solution can be decolourised by NO_2^-, S^{2-} and Cl^-

14. If $Pb[CH_3COO]_2$ and Na_2S are mixed and dissolved in water and the solution is filtered then the filtrate will give test of

(1) Pb^{2+} (2) CH_3COO^- (3) S^{2-} (4) Na^+

Sol. Answer (2, 4)

$$Pb(CH_3-COO)_2 + Na_2S \longrightarrow \underset{\text{ppt.}}{PbS\downarrow} + CH_3COONa$$

So filtrate gives test for CH_3COO^- and Na^+.

15. A solution of salt in HCl when diluted with excess of water turns milky. It indicates the presence of

(1) Al (2) Bi (3) Sb (4) Zn

Sol. Answer (2, 3)

$$BiCl_3 + H_2O \longrightarrow \underset{\text{white milkiness}}{BiOCl}$$

$$SbCl_3 + H_2O \longrightarrow \underset{\text{white milkiness}}{SbOCl}$$

16. The pair(s) of ions where both the ions are precipitated upon passing H_2S gas in presence of dilute HCl, is(are) **[JEE(Advanced)-2015]**

(1) Ba^{2+}, Zn^{2+} (2) Bi^{3+}, Fe^{3+} (3) Cu^{2+}, Pb^{2+} (4) Hg^{2+}, Bi^{3+}

Sol. Answer (3, 4)

Only group II cations precipitate as sulphide with H_2S in acidic medium that is (Cu^{2+}, Pb^{2+}) and (Hg^{2+}, Bi^{3+})

SECTION - C

Linked Comprehension Type Questions

Comprehension-I

$FeCl_3$ is acidic towards litmus. On treatment with excess of NH_4SCN it gives red coloured compound (A) and on treatment with excess of $K_2Cr_2O_7$ in the presence of conc. H_2SO_4, it evolves deep red vapours of (B) on passing the vapours of (B) into NaOH, then adding a solution of acetic acid and lead acetate it gives yellow ppt. of compound of chromium (C)

1. What is the hybridisation of chromium in compound (C)?

(1) sp^3d (2) sp^3 (3) dsp^2 (4) sp^2

Sol. Answer (2)

Hybridization of Cr in 'C' is sp^3.

2. The compound B is

(1) NO_2 (2) Br_2 (3) CrO_2Cl_2 (4) $CrOCl_4$

Sol. Answer (3)

The compound B = CrO_2Cl_2.

3. The compound A is

(1) $Fe(SCN)_2$ (2) $Fe(SCN)_3$ (3) $FeCl_3$ (4) $NH_4[Fe(CN)_4]$

Sol. Answer (2)

The compound A is $Fe(SCN)_3$.

Comprehension-II

Borax [$Na_2B_4O_7.10H_2O$] when heated on platinum loop it gives a dark transparent glass like bead. The hot bead is dipped in the salt till it reacts with transition metal oxide. It produces characteristic bead of meta borate.

	Colour of the bead	**Ion**
(a)	Blue green or light blue	Cu^{2+}
(b)	Yellow	Fe^{2+} or Fe^{3+}
(c)	Green	Cr^{3+}
(d)	Violet	Mn^{2+}
(e)	Dark blue	Co^{2+}
(f)	Brown	Ni^{2+}

1. The hybridisation of B in Borax is

(1) sp^2 (2) sp^3 (3) Both (1) & (2) (4) sp

Sol. Answer (3)

In Borax.

Two Boron atoms show sp^2 hybridisation while rest

Two Boron atoms show sp^3 hybridisation.

2. Glassy bead is of

(1) $B_2O_3 + NaBO_2$ (2) Na_3BO_3 (3) $Na_2B_4O_7$ (4) SiO_2

Sol. Answer (1)

Glassy bead is mixture of B_2O_3 and $NaBO_2$.

3. The colour of bead $Ni(BO_2)_2$ is

(1) Green (2) Brown (3) Violet (4) Blue

Sol. Answer (2)

$Ni(BO_2)_2 \longrightarrow$ Brown colour .

4. The flame used in Borax Bead test is

(1) Reducing (2) Oxidising (3) Both (1) & (2) (4) Neither (1) nor (2)

Sol. Answer (3)

The flame used in Borax bead test may be of both type.

(i) Reducing

(ii) Oxidizing

Comprehension-III

$A \xrightarrow{\Delta} \underset{\text{Blackish brown}}{B} + \underbrace{C + D}_{\text{Oxide of sulphur}}$

$C \xrightarrow{K_2Cr_2O_7/H^+} \text{green solution}$

$B + HCl \xrightarrow{\Delta} \text{deep yellow}$

$E + KCNS \longrightarrow \text{red colour}$

1. The compound A may be

(1) $FeSO_4$ (2) $CoSO_4$ (3) $MnSO_4$ (4) $Na_2S_2O_7$

2. The compound responsible for red colour is

(1) $Fe(SCN)_3$ (2) $Co(CNS)_6^{4-}$ (3) $Mn(CNS)_6^{4-}$ (4) NaSCN

3. The compound responsible for deep yellow colour is

(1) $FeCl_3$ (2) $CoCl_3$ (3) $MnCl_2$ (4) NaCl

Solutions of Comprehension-III

1. Answer (1)
2. Answer (1)
3. Answer (1)

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

$FeSO_4 \xrightarrow{\Delta} Cr_2(SO_4)_3$

$Fe_2O_3 \xrightarrow{HCl} FeCl_3$

$FeCl_3 + SCN \longrightarrow Fe(SCN)_3$

Comprehension-IV

$$\underset{\text{Insoluble in water}}{A} \xrightarrow{\text{dil. } H_2SO_4} B + C_{(g)}$$

$$B \xrightarrow{NaOH} D \text{ white ppt} \xrightarrow{\text{Excess NaOH}} E \text{ soluble}$$

$B \xrightarrow{NH_4OH/NH_4Cl}$ No ppt

$E \xrightarrow{(C)}$ A white ppt

$$E + C \longrightarrow A$$

1. The compound E may be

(1) $NaSnO_2$ (2) $Al(OH)_3$ (3) Na_2ZnO_2 (4) MnO_2

Sol. Answer (3)

$$ZnS \xrightarrow{hSO_4} ZnSO_4 + H_2S$$

2. The gas C may be

(1) SO_2 (2) CO_2 (3) Cl_2 (4) H_2S

Sol. Answer (4)

$$Zn^{2+} + NaOH \longrightarrow Na_2[ZnS_2]$$

3. The salt A may be

(1) $MnSO_4$ (2) ZnS (3) $CuSO_4$ (4) $Al_2(SO_4)_3$

Sol. Answer (2)

Comprehension-V

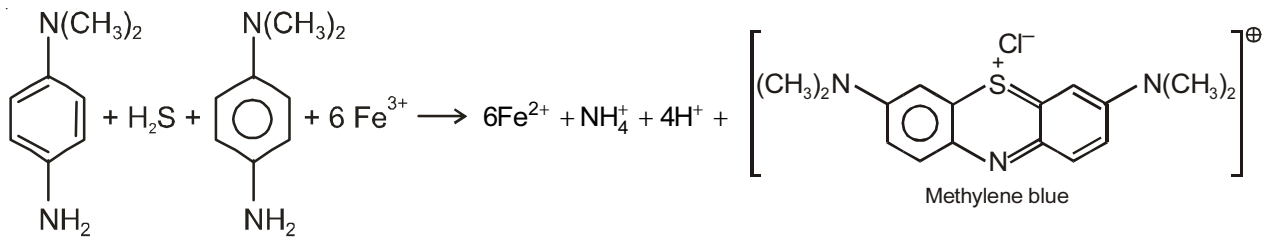
p-Amino-*N*, *N*-dimethylaniline is added to a strongly acidic solution of **X**. The resulting solution is treated with a few drops of aqueous solution of **Y** to yield blue coloration due to the formation of methylene blue. Treatment of the aqueous solution of **Y** with the reagent potassium hexacyanoferrate(II) 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 coloration due to the formation of **Z**.

[IIT-JEE-2009]

1. The compound **X** is

(1) $NaNO_3$ (2) NaCl (3) Na_2SO_4 (4) Na_2S

Sol. Answer (4)



Methylene blue

2. The compound **Y** is

(1) $MgCl_2$ (2) $FeCl_2$ (3) $FeCl_3$ (4) $ZnCl_2$

Sol. Answer (3)

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

3. The compound **Z** is

(1) $Mg_2[Fe(CN)_6]$ (2) $Fe[Fe(CN)_6]$ (3) $Fe_4[Fe(CN)_6]_3$ (4) $K_2Zn_3[Fe(CN)_6]_2$

Sol. Answer (2)

$$Fe^{3+} + [Fe(CN)_6]^{3-} \longrightarrow \underset{\text{Brown colouration}}{Fe[Fe(CN)_6]}$$

Comprehension-VI

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) 2013]**

1. The precipitate P contains

(1) Pb^{2+} (2) Hg_2^{2+} (3) Ag^+ (4) Hg^{2+}

Sol. Answer (1)

Lead salts give white precipitate of $PbCl_2$ with dil. HCl which is soluble in hot water.

2. The coloured solution S contains

(1) $Fe_2(SO_4)_3$ (2) $CuSO_4$ (3) $ZnSO_4$ (4) Na_2CrO_4

Sol. Answer (4)

The filtrate on treatment with ammonical H_2S gives a precipitate which dissolves in aqueous NaOH containing H_2O_2 giving a coloured solution. It contains Cr^{3+} ion.

$$Cr^{3+} + 3NH_4OH \rightarrow \underset{\text{(Green)}}{Cr(OH)_3} \downarrow + 3NH_4^{\oplus}$$

$$2Cr(OH)_3 + 3H_2O_2 + 4NaOH \rightarrow \underset{\text{(yellow colour)}}{2Na_2CrO_4} + 8H_2O$$

SECTION - D

Assertion-Reason Type Questions

1. STATEMENT-1 : SO_2 turns acidified $K_2Cr_2O_7$ green.

and

STATEMENT-2 : SO_2 converts $Cr_2O_7^{2-}$ ion to Cr^{3+} which gives green colour.

Sol. Answer (1)

$$K_2Cr_2O_7 + SO_2 \longrightarrow \underset{\text{(green)}}{Cr_2(SO_4)_3}$$

2. STATEMENT-1 : A dark blue colour is obtained on adding excess of dilute NH_4OH solution in aqueous solution of copper sulphate.

and

STATEMENT-2 : Dark blue colour is due to the formation of $[Cu(NH_3)_4]^{2+}$ complex ion.

Sol. Answer (1)

$$CuSO_4 + NH_4OH \longrightarrow \underset{\text{Blue coloured}}{[Cu(NH_3)_4]SO_4}$$

3. STATEMENT-1 : CdS and As_2S_3 are coloured compounds.

and

STATEMENT-2 : CdS and As_2S_3 can be separated by ammonium sulphide.

Sol. Answer (2)

CdS and As_2S_3 are yellow coloured and these can be separated by $(NH_4)_2S_2$

$$As_2S_3 + (NH_4)_2S_2 \longrightarrow 2(NH_4)_2S + As_2S_5$$

White ppt of CdS does not dissolved in yellow ammonium sulphide.

4. STATEMENT-1 : A mixture of ZnO and CuO can be separated by boiling the mixture with NaOH solution.

and

STATEMENT-2 : ZnO dissolves in NaOH solution while CuO remains undissolved.

Sol. Answer (1)

$$ZnO + NaOH \longrightarrow \underset{\text{soluble}}{Na_2ZnO_2}$$

While CuO is not soluble in NaOH.

5. STATEMENT-1 : Co^{2+} gives green colour with Br_2 water in presence of $KHCO_3$.

and

STATEMENT-2 : Green colour is due to formation of $CoCO_3$.

Sol. Answer (3)

$$Co^{2+} + Br_2 + 2KHCO_3 \longrightarrow \underset{\text{green color}}{CoBr_2}$$

6. STATEMENT-1 : Moistened ammonium salts give the smell of NH_3.

and

STATEMENT-2 : Ammonium salts give NH_3 on heating with conc. NaOH.

Sol. Answer (2)

Moistened ammonium salt produce NH_3. Ammonium salt also produces NH_3 with NaOH.

7. STATEMENT-1 : HCO_3^- and CO_3^{2-} both give colourless gas on addition of dil. HCl.

and

STATEMENT-2 : Both HCO_3^- and CO_3^{2-} gives with ppt with Mg^{2+}.

Sol. Answer (3)

HCO_3^- does not give white ppt with $NaHCO_3$.

8. STATEMENT-1 : Fe^{3+} gives brown coloured ppt with $K_3[FeCN)_6]$.

and

STATEMENT-2 : Formation of undissociated complex $Fe[Fe(CN)_6]$ take place.

Sol. Answer (2)

Colour is due to charge transfer.

9. STATEMENT-1 : Cu^{2+} is unstable in presence of Cl^- ion.

and

STATEMENT-2 : Formation of CuCl is more favourable.

Sol. Answer (2)

Fact.

SECTION - E

Matrix-Match Type Questions

1. Match the following :

Column I (Addition of dil. HCl/dil H_2SO_4)	**Column II** (Observation)
(A) $S_2O_3^{2-}$	(p) Gas evolved turns lime water milky
(B) SO_3^{2-}	(q) Gas turns lead acetate paper black
(C) CO_3^{2-}	(r) Gas turns acidified $K_2Cr_2O_7$ solution green
(D) S^{2-}	(s) Gives white turbidity

Sol. Answer A(p, r, s), B(p, r), C(p), D(q, r)

$SO_3^{2-} + HCl \longrightarrow SO_2$

$S_2O_3^{2-} + 2HCl \longrightarrow \underset{\text{(white turbidity)}}{SO_2 + S}$

$CO_3^{-2} \longrightarrow CO_2$

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

SO_2, CO_2 turns lime water milky.

SO_2 gives green solution with acidified $K_2Cr_2O_7$.

2. Match the following :

Column I	**Column II**
(A) Borax $\xrightarrow{\Delta}$	(p) Inorganic benzene
(B) Borax + $NH_4Cl \xrightarrow{\Delta}$	(q) $NaBO_2 + B_2O_3$
(C) Borax + $NH_3 \xrightarrow{\Delta}$	(r) $(BN)_x$
(D) Borax + $H_2O \rightarrow$	(s) H_3BO_3

Sol. Answer A(q), B(r), C(p, r), D(s)

(A) $\text{Borax} \xrightarrow{\Delta} NaBO_2 + B_2O_3$

(B) $\text{Borax} + NH_4Cl \xrightarrow{\Delta} (BN)_x$

(C) $\text{Borax} + NH_3 \longrightarrow B_3N_3H_6$ and $(BN)_x$

(D) $\text{Borax} + H_2O \longrightarrow H_3BO_3$

3. Match the complex with its oxidation state of central metal

Column I	**Column II**
(A) Chromyl chloride test	(p) S^{2-}
(B) Ring test	(q) NO_3^-
(C) Smell of vinegar	(r) CH_3COO^-
(D) Smell of rotten eggs	(s) Cl^-

Sol. Answer A(s), B(q), C(r), D(p)

(A) Chromyl chloride test $(CrO_2Cl_2) \longrightarrow Cl^-$

(B) Ring test $(FeSO_4.NO) \longrightarrow NO_3^-$

(C) Smell of vinegar $(CH_3 — COOH) \longrightarrow CH_3 - COO^-$

(D) Smell of rotten egg $(HS) \longrightarrow S^{2-}$

4. Match the compound reaction's product given in column I to the properties given in column II

Column I	**Column II**
(A) $NaNO_2 \xrightarrow{HCl} A \xrightarrow{FeSO_4} P$	(p) White ppt
(B) $HgCl_2 \xrightarrow{SnCl_2} P$	(q) Oxidation state of metal in product is +1
(C) $Hg_2Cl_2 \xrightarrow{NH_4OH} P$	(r) Metal-metal bond is present
(D) $Zn \xrightarrow[NH_4OH/NH_4Cl]{H_2S} P$	(s) Colour is due to complex formation
	(t) Black ppt

Sol. Answer A(q, s), B(p, q, r), C(s, t), D(t)

(A) $[Fe(H_2O)_5NO]SO_4$

(B) Hg_2Cl_2

(C) $Hg + HgNH_2Cl$

(D) ZnS

5. Match the following :

Column I	**Column II**
(A) $FeSO_4 \xrightarrow{\Delta}$	(p) A gas which gives green colour with acidified $K_2Cr_2O_7$
(B) $NaNO_2 \xrightarrow{dil} A\,(gas) \xrightarrow{air} B\,(gas)$	(q) A gas which form oleum with H_2SO_4
(C) $Na_2SO_3 \xrightarrow{dil(HCl)} P(gas)$	(r) A gas which is mixed anhydride of HNO_2 and HNO_3
(D) $NaCl \xrightarrow{Con.\ H_2SO_4} P(gas)$	(s) A gas which is also given by $AlCl_3$ in moist air
	(t) Green colour

Sol. Answer A(p, q, t), B(r), C(p, t), D(s)

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

$NaNO_2 \xrightarrow[\text{air}]{\text{dil. HCl}} NO_2$

$Na_2SO_3 \xrightarrow{\text{dil. HCl}} SO_2$

$NaCl \xrightarrow{\text{con. } H_2SO_4} HCl$

SECTION - F

Integer Answer Type Questions

1. How many moles of KCN are required to convert 1 mole of $CuSO_4$ to $[Cu(CN)_4]^{3-}$?

Sol. Answer (5)

$$2CuSO_4 + 10KCN \rightarrow 2K_3[Cu(CN)_4] + 2K_2SO_4 + \begin{matrix} CN \\ | \\ CN \end{matrix}$$

2. The oxidation number of Fe in $[Fe(H_2O)_5NO]SO_4$ is

Sol. Answer (1)

Fact.

3. A metal ion give chocolate coloured ppt with $K_4[Fe(CN)_6]$.

What is the oxidation state of that metal in its ion?

Sol. Answer (2)

$Cu_2[Fe(CN)_6]$ (Chocolate)

4. What will be oxidation state of iron in given complex (Product)?

$Na_2[Fe(CN)_5NO] + Na_2S \longrightarrow Na_4[Fe(CN)_5NOS]$

Sol. Answer (2)

NOS contain $\ominus$ charge.

5. How many cations are placed in 6th group?

Sol. Answer (1)

Only Mg^{2+} is placed in 6th group.

6. During detection of P, we get canary yellow ppt on addition of ammonium molybdate. The number of element in sp^3 hybridisation from 15th group is _____.

Sol. Answer (4)

$(NH_4)_3PO_4 \cdot 12MoO_3$

7. Among PbS, CuS, HgS, MnS, Ag_2S, NiS, CoS, Bi_2S_3 and SnS_2, the total number of **BLACK** coloured sulphides is **[JEE(Advanced)-2014]**

Sol. Answer (7)

Black sulphides are

PbS, CuS, HgS, NiS, CoS, Bi_2S_3 and Ag_2S

MnS is buff

SnS_2 is yellow

SECTION - G

Multiple True-False Type Questions

1. STATEMENT-1 : $NaNO_2$ on treatment with dil. HCl gives brown coloured gas directly.

   STATEMENT-2 : $[Fe(H_2O)_5NO]^{2+}$ is used for the detection of S^{2-}.

   STATEMENT-3 : Precipitate of AgI are of yellow colour.

   (1) F T F (2) F T T (3) T T F (4) T T T

Sol. Answer (2)

$$\left[Fe(H_2O)_5NO\right]^{2+} + S^{2-} \longrightarrow \left[Fe(H_2O)_5NOS\right]^{4+}$$

$$NaNO_2 \xrightarrow{\text{dil. HCl}} NO \xrightarrow{\text{air}} NO_2$$

2. STATEMENT-1 : H_2S in acidic medium is the group reagent for IInd group in basic redical.

   STATEMENT-2 : K_{sp} of sulphides of IInd group ions is less.

   STATEMENT-3 : All sulphides of IInd group element are coloured.

   (1) F T F (2) T T T (3) F F F (4) T T F

Sol. Answer (2)

Fact.

3. STATEMENT-1 : Solubility of sulphide is higher in acidic medium than pure water.

   STATEMENT-2 : Aq. solution of metal sulphides is neutral.

   STATEMENT-3 : Metal sulphides are salt of strong base and weak acid.

   (1) T F F (2) F T T (3) T F T (4) T T F

Sol. Answer (1)

Metal sulphide undergo hydrolysis.

4. STATEMENT-1 : All Pb^{2+} form white ppt with dil. HCl in estimation.

   STATEMENT-2 : Al^{3+} form white ppt with NH_4OH/NH_4Cl.

   STATEMENT-3 : $Fe(OH)_3$ is soluble in excess NaOH.

   (1) T T F (2) T T T (3) F T T (4) F T F

Sol. Answer (3)

Some Pb^{2+} remained in solution.

5. STATEMENT-1 : $NaNO_2$ and $NaNO_3$ give brown ring test.

   STATEMENT-2 : Both give brown coloured gas with conc. H_2SO_4.

   STATEMENT-3 : NO_3^- gives ammonia with NaOH in presence of Cu.

   (1) T F T (2) T T T (3) F T F (4) T T F

Sol. Answer (2)

Fact.

SECTION - H

Aakash Challengers Questions

1. When a white powder (A) is strongly heated, it gives of a colourless, odourless gas (B) which turns lime water milky (C) and if the passage of this gas is continued, the milkiness disappears and gives a solution (D). The solid residue (E) is yellow when hot, but turns white on cooling. Identify (A) to (E) with help of the equations.

Sol. The reaction can be explain if we consider the compound (A) to be $ZnCO_3$

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

$$CaO + CO_2 \rightarrow \underset{\substack{\text{(milky white)}\\(C)}}{CaCO_3}$$

$$CaCO_3 + H_2O + \underset{\text{(excess)}}{CO_2} \rightarrow \underset{\substack{\text{Soluble}\\(D)}}{Ca(HCO_3)_2}$$

ZnO is yellow when hot and white when cold.

2. A solid laboratory reagent (A) give following reactions.

   (i) It impart green colour to flame.

   (ii) Its solution does not give ppt. on passing H_2S.

   (iii) When it is heated with $K_2Cr_2O_7$ and conc. H_2SO_4, a red gas (B) is evolved. The gas when passed in aq. NaOH solution turns it yellow (C). Identify (A), (B), (C) giving chemical reactions.

Sol. A $\rightarrow$ $BaCl_2$

B $\rightarrow$ CrO_2Cl_2

C $\rightarrow$ Na_2CrO_4

3. An aqueous solution of 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 ppt. soluble in dilute HNO_3 is obtained. Identify (X) and give equations for the reaction at step (ii) and (iii).

Sol. The gas (X) is NH_3

$NH_3 + H_2O \rightarrow NH_4OH$

$CuSO_4 + 4NH_4OH \rightarrow [Cu(NH_3)_4]SO_4 + 4H_2O$

Ferric chloride gives brown ppt. of $Fe(OH)_3$

$$FeCl_3 + 3NH_4OH \longrightarrow \underset{\substack{\text{Brown ppt}\\\text{insoluble in } HNO_3}}{Fe(OH)_3} + 3NH_4Cl$$

$$\underset{\text{Brown ppt.}}{Fe(OH)_3} + 3HNO_3 \longrightarrow \underset{\text{(soluble)}}{Fe(NO_3)_3} + 3H_2O$$

4. A black mineral (A) on heating in presence of air gives a gas (B). The mineral (A) on reaction with dilute H_2SO_4 gives a gas (C) and a solution of a compound (D) on passing the gas (C) into an aqueous solution of (B), a white turbidity is obtained. The aqueous solution of (D) on reaction with potassium ferricyanide gives a blue compound (E). Identify (A) to (E) and give chemical equations for the reaction involved.

Sol. A $\rightarrow$ FeS

B $\rightarrow$ SO_2

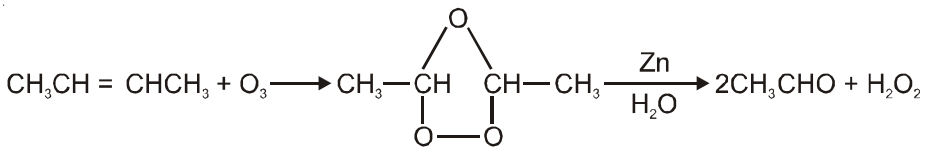
C $\rightarrow$ H_2S

D $\rightarrow$ $FeSO_4$

E $\rightarrow$ $KFe[Fe(CN)_6]$

5. When gas (A) is passed through dry KOH at low temperature, a deep red coloured compound (B) and a gas (C) is obtained. The gas (A), on reaction with but-2-ene, followed by treatment with Zn/H_2O yields acetaldehyde. Identify (A), (B) and (C).

Sol. The reaction of gas (A) with but-2-ene followed by treatment with Zn/H_2O gives CH_3CHO. This shows that the gas (A) is ozone (O_3).



Reaction of O_3 with KOH

$$\underset{\text{(A)}}{2KOH} + \underset{}{5O_3} \rightarrow \underset{\substack{\text{Potassium ozonide}\\\text{(Red colour)}\\\text{(B)}}}{2KO_3} + \underset{\text{(C)}}{5O_2} + H_2O$$

6. 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 of $K_2Cr_2O_7$ 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).

Sol. Let us summarize given facts of question :

Red vapours (A) $\xleftarrow[\text{Conc. } H_2SO_4 \text{ heat}]{K_2Cr_2O_7}$ Mixture of two salts $\xrightarrow[\Delta]{NaOH}$ Gas $\xrightarrow{\text{Alk. } K_2HgI_4}$ Reddish brown ppt.

Deep blue colour (B) $\xleftarrow{K_3[Fe(CN)_6}$ Aq. solution of the mixture $\xrightarrow{BaCl_2}$ white ppt.

The given reaction leads to the following conclusions.

(i) Heating of mixture with NaOH to give NH_3 gas (indicated by reddish brown ppt with alkaline solution of K_2HgI_4) indicates the presence of NH_4^+ ion in the mixture.

(ii) Heating of mixture with $K_2Cr_2O_7$ and conc. H_2SO_4 to give red vapours (of chromyl chloride) indicates the presence of Cl^- ion in the mixture.

(iii) Reaction of aqueous solution of the mixture with barium chloride solution to give white ppt. (of $BaSO_4$) sparingly soluble in conc. HCl indicates the presence of SO_4^{2-} ions in the mixture.

(iv) Reaction of aqueous solution of the mixture with potassium ferricyanide solution to give deep blue colour indicates presence of Fe^{2+} ions in the mixture.

Hence the mixture contains following four ions NH_4^+, Fe^{2+}, SO_4^{2-} and Cl^-.

Equations for the formation of A and B.

$$4NaCl + K_2Cr_2O_7 + 3H_2SO_4 \xrightarrow{\text{Heat}} K_2SO_4 + 2Na_2SO_4 + \underset{\substack{\text{Chromyl chloride}\\(\text{Orange})(A)}}{2CrO_2Cl_2} + 3H_2O$$

$$3Fe^{2+} + 2K_3[Fe(CN)_6] \longrightarrow \underset{\text{blue ppt}(B)}{Fe_3[Fe(CN)_6]_2} + 6K^+$$

7. A certain salt (X) gives the following tests.

(i) Its aqueous solution is alkaline to lithmus.

(ii) On strong heating it melts to give glassy material

(iii) When concentrated sulphuric acid is added to a hot concentrated solution of (X) white crystals of a weak acid separates out.

Identify (X) and write down the chemical equations for reactions at step (i), (ii) and (iii).

Sol. Since the salt (X) smells on heating to give a glassy material, it seems to be borax, $Na_2B_4O_7$, a well known compound showing this property. This is also in accordance with the fact that its aqueous solution is alkaline to litmus and its reaction with conc. H_2SO_4 to give crystals of a weak acid. H_3BO_3(Boric acid) Thus (X) is $Na_2B_4O_7.10H_2O$. Chemical reactions are

(i) $$\underset{\text{Borax}}{Na_2B_4O_7} + 7H_2O \longrightarrow \underbrace{\underset{\text{Strong base}}{2NaOH} + \underset{\text{Weak acid}}{4H_3BO_3}}_{\text{alkaline}}$$

(ii) $$Na_2B_4O_7 \xrightarrow{\text{heat}} \underset{\text{(glassy bead)}}{2NaBO_2} + B_2O_3$$

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

8. An unknown inorganic compound (X) loses it water of crystallisation on heating and its aqueous solution gives the following reaction.

(i) It gives a white turbidity with dilute hydrochloric acid solution.

(ii) It decolourises a solution of iodine in potassium iodide.

(iii) It gives a white precipitate with silver nitrate solution which turns black on standing. Identify the compound (X) and give chemical equations for the reaction at step (i) to (iii).

Sol. Since the compound (X) decolourises a solution of iodine in potassium iodide it should contain thiosulphate ion. $S_2O_3^{2-}$ which also coincides with two other given facts *i.e.* (i) and (iii) hence the compound (X) is sodium thiosulphate, $Na_2S_2O_3.5H_2O$. Which explains the given reaction as below.

$$Na_2S_2O_3.5H_2O \xrightarrow{\text{Heat}} Na_2S_2O_3 + 5H_2O\uparrow$$

(i) $Na_2S_2O_3 + 2HCl \rightarrow 2NaCl + H_2O + SO_2 + S$ (White turbidity)

(ii) $2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI$

(iii) $Na_2S_2O_3 + 2AgNO_3 \longrightarrow \underset{\text{Silver thiosulphate (white ppt.)}}{Ag_2S_2O_3\downarrow} + 2NaNO_3$

$Ag_2S_2O_3 + H_2O \longrightarrow \underset{\text{(black ppt)}}{Ag_2S\downarrow} + H_2SO_4$

9. A compound (X) on heating with an excess of NaOH solution gives a gas (Y) 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 (Y) when heated with Zn powder. However, when the compound (X) is heated alone does not give nitrogen. Identify (X) and (Y).

Sol. $X \rightarrow NH_4NO_3$

$Y \rightarrow NH_3$

$\underset{(X)}{NH_4NO_3} \xrightarrow{NaOH} NaNO_3 + \underset{(Y)}{NH_3} + H_2O$

$NH_3 + HCl \rightarrow NH_4Cl\uparrow$ (white fumes)

$NH_4NO_3 \xrightarrow{\Delta} N_2O + 2H_2O$

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