Topics to be covered

1. Introduction of Salt Analysis

SALT ANALYSIS

- Detection of cation & anion from given mixture is called salt analysis

SALT : Product of acid base neutralization reaction.

- Cation & anion are also called basic and acidic radical respectively.

Reason: During salt formation, cation comes from base and anion comes from acid.

QUESTION

What is the interfering radical.

Sol: Analysis of anion performed first followed by analysis of cation because if any interfering radical present in mixture, then it will interfere test of 3rd group cation or downwards.

Example: (F^-, SiO_4^{4-}, BO_3^{3-}, PO_4^{3-}, AsO_4^{3-}, $C_2O_4^{2-}$)

Soluble Compound in water:

1. All IA and NH_4^+ salts : except $MClO_4$ (Where $M^+ = K^+, Rb^+, Cs^+$).
2. All NO_3^-, MnO_4^-, HSO_3^- and HSO_4^- salts : No exception
3. HCO_3^- salts are water soluble : except Na^+
4. All CH_3COO^- salt : except Ag^+ , Hg_2^{2+}, Cu^+
5. All NO_2^- salt : except Ag^+

6. All SO_4^{2-} salts soluble : except Ba^{2+}, Sr^{2+}, Pb^{2+} are insoluble and Ag^+, Hg_2^{2+} Cu^+ sparingly soluble

7. All Cl^-, Br^-, I^- : except Ag^+, Hg^{2+}, Cu^+, Pb^{2+} are insoluble & BiOCl, SbOCI, BiOI are partially soluble.

8. All $S_2O_3^{2-}$ salts : except Ba^{2+}, Sr^{2+}, Pb^{2+}, Bi^{3+}, Hg^{2+}, Cu^+

9. All BO_3^{3-} : All BO_3^{3-} salts of ammonium, alkali metals and alkaline earth metals are water soluble

Insoluble Compound in water:

1. All carbonates (CO_3^{2-}) : Except – IA carbonate, Li_2CO_3 (s.s.), $(NH_4)_2CO_3$
   ↳ due to $\frac{s}{v}$ ↓
2. All sulphites (SO_3^{2-}) : Except – IA, $(NH_4)_2SO_3$
3. All sulphides (S^{2-}) : Except – IA, IIA, $(NH_4)_2S$
4. All PO_4^{3-} : Except – IA except Li_3PO_4, $(NH_4)_3PO_4$, IA = 1° 2° 3° soluble
   IIA = 1° soluble but 2° 3° insoluble.

5. All hydroxides (OH^-) : Except NH_4^+, IA, $Ba(OH)_2$, $Sr(OH)_2$, $Ca(OH)_2$

6. All oxide O^{2-} : Except $-NH_4^+$ / IA

6. All chromates CrO_4^{2-} : Except IA, $(NH_4)_2CrO_4$, $CaCrO_4$, $MgCrO_4$ soluble & $SrCrO_4$(s.s.).

7. All oxalate ($C_2O_4^{2-}$) : Except IA, FeC_2O_4, $(NH_4)_2C_2O_4$, BeC_2O_4

8. All F^- : except IA, AgF, HgF_2, AlF_3, BeF_2 and NiF_2 soluble (Pb^{2+}, Cu^{2+}, Fe(III) , Ba^{2+}, Li^+) s.s

Types of Reaction

✓ → Soluble
✗ → Insoluble.

1. Ion-exchange reaction

Types:

(a) Ppt formation reaction

$AgNO_3 + NaCl \rightarrow NaNO_3 + AgCl\downarrow$

✓ ✓ ✓ ✗

(b) Double Ppt formation reaction

$BaS + ZnSO_4 \rightarrow ZnS + BaSO_4$

✓ ✓ ✗ ✗

lithophone.

(c) Ppt exchange reaction

$Ca(OH)_2 + Na_2CO_3 \rightarrow NaOH + CaCO_3$

(Gossage process :– preparation of NaOH)

Reaction goes forward if Ksp of A> C

Q.S.P.

(d) Ppt dissolution reaction

$BaCO_3 + HNO_3 \rightarrow Ba(NO_3)_2 + H_2CO_3$

This reaction occurs if used acid is stronger than acid formed in the reaction

Q.S.P.

QUESTION

Which of the following reactions are not possible.

A $BaCO_3 + HCN \rightarrow H_2CO_3 + Ba(CN)_2$

B $BaCO_3 + H_3BO_3 \rightarrow Ba_3(BO_3)_2 + H_2CO_3$

C $BaCO_3 + CH_3COOH \rightarrow (CH_3COO)_2Ba + H_2CO_3$

D $BaCO_3 + HCl \rightarrow BaCl_2 + H_2CO_3$

Ans. **(A, B)**

QUESTION

Which of the following reactions are not possible.

$A + B \longrightarrow C + D$

(A) ✗ ✗ ✗ ✗

(B) ✗ ✗ ✓ ✗

(C) ✗ ✗ ✓ ✓

(D) ✓ ✓ ✓ ✓

2. Complex formation reaction

① 'd' Block + SFL ⟶ Complex

$Cd^{2+} + KCN \longrightarrow Cd(CN)_2 \xrightarrow[KCN]{Ex} K_2[Cd(CN)_4]$

② S/P Block + SFL ⟶ X

$Pb^{+2} + KCN \longrightarrow Pb(CN)_2 \xrightarrow[KCN]{Ex} N.R.$

(3) S/P Block + WFL → Complex

$Pb^{+2} + KI \longrightarrow PbI_2 \xrightarrow[KI]{Ex} [PbI_4]^{2-}$

(4) $M^{+} \rightarrow$ Amphoteric + NaOH → Complex

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

$Pb^{+2} + NaOH \longrightarrow Pb(OH)_2 \rightleftharpoons [Pb(OH)_4]^{2-}$

3. Acid-base neutralization reaction

$$CO_2 + CaO \longrightarrow CaCO_3$$

4. Thermal decomposition reaction

$\phi = \frac{C}{R}$

CO_3^{2-}

$NH_3 + H_2O + CO_2$

$(NH_4)_2CO_3$

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

$MCO_3 \downarrow MO + CO_2$

$Ag|Hg|Au|Pt$

$Ag_2CO_3 \xrightleftharpoons{\Delta} Ag_2O + CO_2$

$Ag_2O \xrightleftharpoons{\Delta} 2Ag + \frac{1}{2}O_2$

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

Na_2CO_3, K_2CO_3, Rb_2CO_3, Cs_2CO_3 $\xrightarrow{\Delta}$ N.R.

$S^+ \uparrow$, $\phi \downarrow$, CV(W), $I(\uparrow) \; T.S \uparrow$

Q.S.P

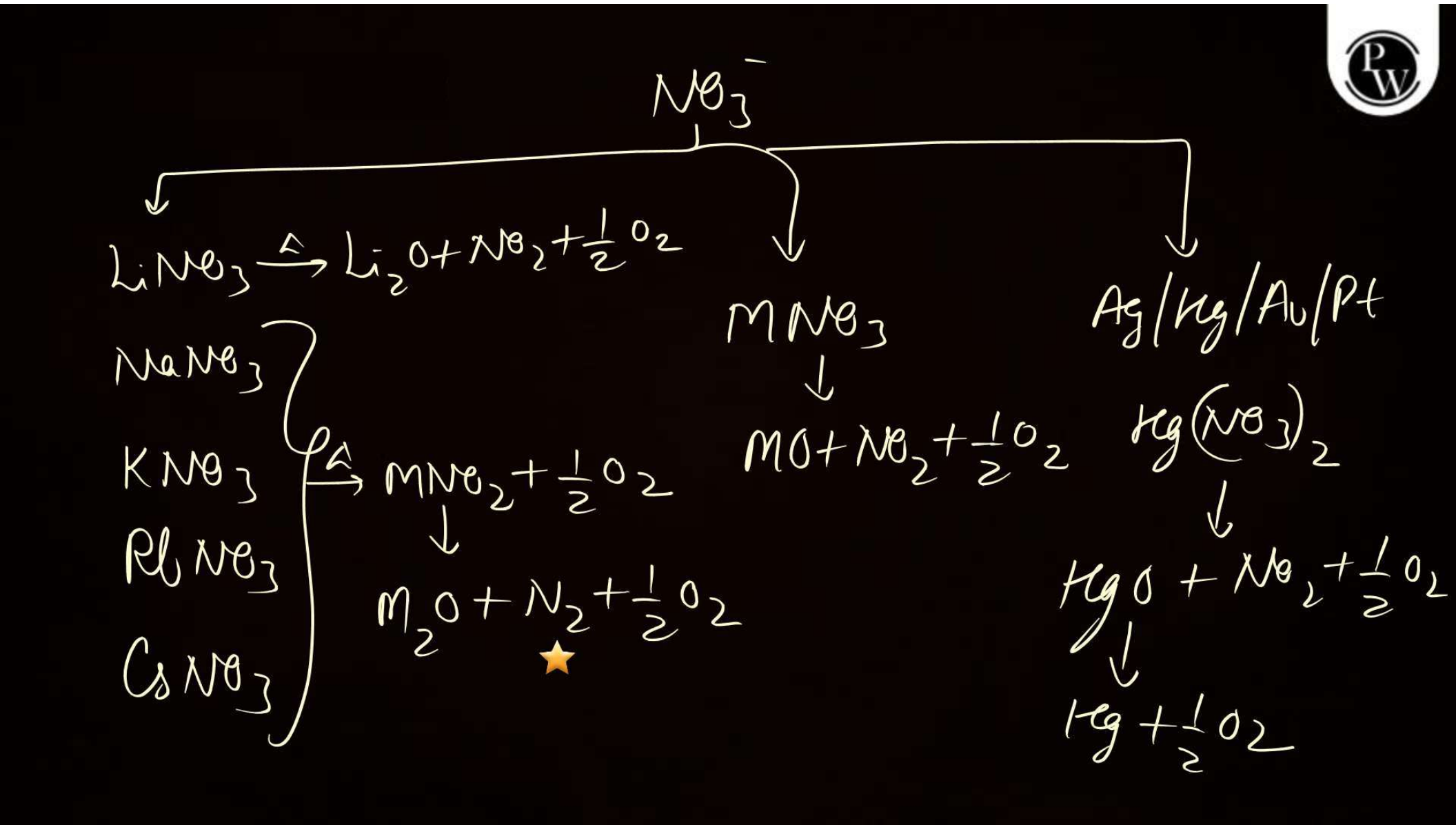
CO_3^{2-}	SO_4^{2-}	OH^-
$\downarrow$	$\downarrow$	$\downarrow$
CO_2	SO_3	H_2O

$$ZnSO_4 \xrightarrow{\Delta} ZnO + SO_3$$

$$Na_2SO_4 \xrightarrow{\Delta} N.R.$$

$$CaCO_3 \cdot MgCO_3 \longrightarrow CaO + MgO + 2CO_2$$

$$CuCO_3 \cdot Cu(OH)_2 \longrightarrow CuO + CO_2 + H_2O$$


NO_3^-
$LiNO_3 \xrightarrow{\Delta} Li_2O + NO_2 + \frac{1}{2}O_2$
MNO_3
$MO + NO_2 + \frac{1}{2}O_2$
$Ag/Hg/Au/Pt$
$Hg(NO_3)_2$
$HgO + NO_2 + \frac{1}{2}O_2$
$Hg + \frac{1}{2}O_2$
$NaNO_3$
KNO_3
$RbNO_3$
$CsNO_3$
$\xrightarrow{\Delta} MNO_2 + \frac{1}{2}O_2$
$M_2O + N_2 + \frac{1}{2}O_2$

HEATING EFFECT OF ACIDS :

(i) $\overset{+5}{HNO_{3(Conc.)}} \longrightarrow H_2O + NO_2 + \frac{1}{2}O_2$

(ii) $HNO_{3(dil.)} \longrightarrow H_2O + NO + 3(O)$

(iii) $\overset{+6}{H_2SO_{4(Conc.)}} \xrightarrow{444°C} H_2O + SO_3$

(iv) $H_2SO_{4(Conc.)} \xrightarrow{800°C} H_2O + SO_2 + \frac{1}{2}O_2$

(v) $\overset{+3}{HNO_2} \longrightarrow H_2O + HNO_3 + NO$

Intermediate oxidation state shows disproportionation.

Q.S.P.

$$2HNO_2 \longrightarrow H_2O + 2NO + \cancel{O}$$

$$HNO_2 + \cancel{O} \longrightarrow HNO_3$$

$$3HNO_2 \longrightarrow H_2O + HNO_3 + 2NO$$

$+3$ $\quad$ $+5$ $\quad$ $+2$

HEATING EFFECT OF ACIDS :

(vi) $2H_3PO_2 \longrightarrow PH_3 + H_3PO_4$

(vii) $4H_3PO_3 \longrightarrow PH_3 + 3H_3PO_4$

★ (viii) $\overset{+5}{H_3PO_4} \xrightarrow{\Delta} H_4P_2O_7 \xrightarrow{\Delta} HPO_3 \xrightarrow{\Delta} P_4O_{10}$

PPM

★ (ix) $H_3BO_3 \xrightarrow{\Delta} HBO_2 \xrightarrow{\Delta} H_2B_4O_7$

$H_2B_4O_7 \xrightarrow{\Delta} B_2O_3$

BMT

Trick

$H_3\overset{+1}{P}O_2 \longrightarrow PH_3 + 2(O)$

$H_3PO_2 + 2(O) \longrightarrow H_3PO_4$

$H_3PO_3 \longrightarrow PH_3 + 3(O)$

$H_3PO_3 + O \longrightarrow H_3PO_4) \times 3$

HEATING EFFECT OF AMMONIUM SALT :

O·A·

$Cr_2O_7^{2-}$ / NO_3^- / NO_2^- / IO_3^-

$NH_4^+ \longrightarrow N_2$

$\rightarrow NH_4^+ \longrightarrow N_2O$

$NH_4NO_3 \longrightarrow N_2O + 2H_2O$

$NH_4NO_2 \longrightarrow N_2 + 2H_2O$

N·O·A· SO_4^{2-}

CO_3^{2-} / OH^- / S^{2-} / Cl^-

$NH_4^+ \longrightarrow NH_3$

$(NH_4)_2CO_3 \rightarrow NH_3 + H_2O + CO_2$

HEATING EFFECT OF PERMANGANATE :

$$2KMnO_4 \xrightarrow{513K} K_2MnO_4 + MnO_2 + O_2$$

dark puple (almost black) — (green) — (black)

HEATING EFFECT OF DICHROMATE & CHROMATE SALTS :

$$2K_2Cr_2O_7 \xrightarrow{\Delta} 2K_2CrO_4 + Cr_2O_3 + \frac{3}{2}O_2\uparrow$$

orange yellow green

5. Redox reaction

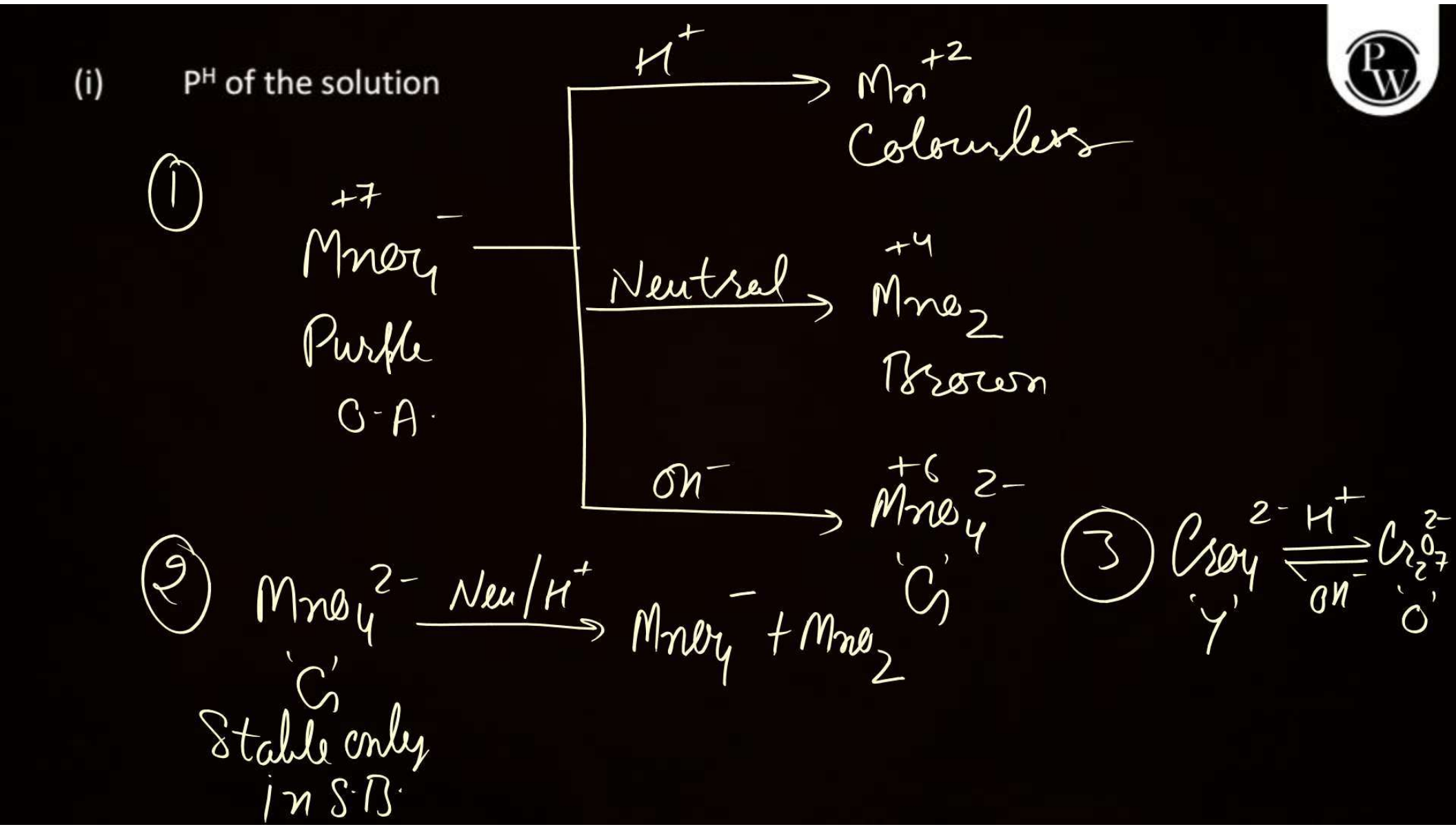
Redox reaction depends upon OP and RP. While OP and RP depend upon following factor.

(i) P^H of the solution

(ii) Temperature

(iii) Concentration

(i) P^H of the solution



(ii) Temperature

OP↓ R.P↑

$Na^{\circ} + H_2O \xrightarrow{\text{Cold}} \overset{+1}{Na}OH + H\uparrow$

$Mg + H_2O \xrightarrow{\text{Warm}} Mg(OH)_2 + H\uparrow$

$Zn + H_2O \xrightarrow{\text{Hot}} Zn(OH)_2 + H\uparrow$

$Fe + H_2O \xrightarrow{\text{Steam}} Fe_3O_4 + H\uparrow$

$$B + H_2O \xrightarrow[\text{Cold/Hot}]{} N.R.$$

$$B + H_2O \longrightarrow B_2O_3 + H\uparrow$$

Red Hot

(iii) Concentration

Li
K
Ca
Na
Mg
Al
Mn
Zn
Cr
Fe
Cd
Co
Ni
Sn
Pb

H_2

Cu
Hg
Ag
Au

Anion → O.A.

Case I Oxi^n acid

HNO_3 Conc

HNO_3 dil

H_2SO_4 → O.A. Conc

Case II Non oxi^n acid

Conc HCl

dil HCl

dil H_2SO_4 → C.A.

Q.S.P

(1) M + N.O.A ⟶ Salt + H

Above the H in R.S

$Zn + dil\ HCl \longrightarrow ZnCl_2 + H\uparrow$

$Zn + dil\ H_2SO_4 \longrightarrow ZnSO_4 + H\uparrow$

(2) M + NOA ⟶ N.R.

Below the H in R.S

(3)

M $\xrightarrow{HNO_3}$

70% $\rightarrow M(NO_3)_3 + NO_2$

20% $\rightarrow$ —"— $+ N_2O$

6% $\rightarrow$ —"— $+ NH_3$

NH_3 (Base) $\rightarrow NH_4NO_3$

Ex $Zn + HNO_3$

- 70% → $Zn(NO_3)_2 + NO_2$
- 20% → —"— $+ N_2O$
- 6% → —"— $+ NH_4NO_3$

III

(4)

M
Below the
Pb or Pbin
R.S

HNO_3

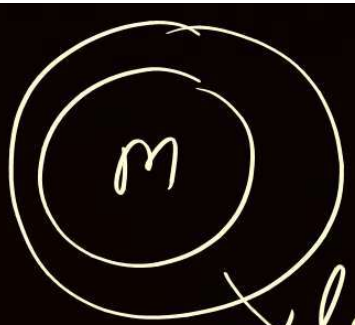
70%
Conc
$\rightarrow M(NO_3) + NO_2$

20%
dil
$\rightarrow$ — $+ NO$

6%
Very dil
$\rightarrow$ N.R.

Ex $\rightarrow Cu + HNO_3 \xrightarrow{70\%} Cu(NO_3)_2 + NO_2$

$Cu + HNO_3 \xrightarrow{20\%} Cu(NO_3)_2 + NO$

(5) $M + 80\%\ HNO_3 \longrightarrow$ 

→ layer of M·O

Al, Cr, Fe, Co, Ni, Be

$Al + \underset{80\%}{HNO_3} \longrightarrow$ 

$\rightarrow Al_2O_3$

(6) $M + \underset{HNO_3}{2\%} \longrightarrow MNO_3 + H\uparrow$

Mg/Mn

(7) $M + HNO_3 + HCl \longrightarrow$ Complex

1 : 3

Au / Hg / Pt

$Au + HNO_3 + HCl \longrightarrow H[AuCl_4]$

★ Ag insoluble in $HNO_3 + HCl$

(8) Non-metal / Or / Metalloids + non oxi^{n} acid $\longrightarrow$ N.R.

(9) Non-metal / Or / Metalloids + O. Acid / HNO_3

- Conc $\longrightarrow$ 'ic' oxy acid + NO_2
- R.T, dil $\longrightarrow$ N.R.
- $\uparrow\uparrow$, dil $\longrightarrow$ 'ic' oxy acid + NO

(10) M + Base ⟶ Salt + H_2

Amphoteric

(11) Non-Metal ⟶ disprop$^{n.}$

+

Base

Ex $P_4 + NaOH + H_2O$

↓

$PH_3 + NaH_2PO_2$

Classification of Anions

Anion are classified into two class on the basis of their volatile product formation tendency on reaction with acids.

Class A :- They form volatile product with acids.
It is further divided into two sub-groups :-
(a) Sub group – I :- dil HCl / dil H_2SO_4
(b) Sub-group – II :- Conc H_2SO_4

Class B:- Don't form volatile product with acid. They are identified by their reaction in aqueous solution.
(a) Sub group – I :- PPT Reaction
(b) Sub-group – II :- Redox

Anion

Class A

Sub gr I

$CO_3^{2-} \xrightarrow{H^+} CO_2$

$HCO_3^{-} \xrightarrow{H^+} CO_2$

$SO_3^{2-} \xrightarrow{H^+} SO_2$

$HSO_3^{-} \xrightarrow{H^+} SO_2$

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

$S_2O_3^{2-} \xrightarrow{H^+} S + SO_2$

$NO_2^{-} \xrightarrow{H^+} NO_2$

$CH_3COO^{-} \xrightarrow{H^+} CH_3COOH$

Sub gr II

$F^- \longrightarrow HF$

$Cl^- \longrightarrow HCl$

$Br^- \longrightarrow Br_2$

$I^- \longrightarrow I_2$

$NO_3^- \longrightarrow NO_2$

$BO_3^{3-} \longrightarrow H_3BO_3$

$C_2O_4^{2-} \longrightarrow CO + CO_2$

Anions of sub-group 1 (class A) will also give test with conc. H_2SO_4

Q.S.P.

Class B

Sub gr I

SO_4^{2-}

PO_4^{3-}

★ CrO_4^{2-}

Sub gr II

★ CrO_4^{2-}

$Cr_2O_7^{2-}$

MnO_4^{-}

MnO_4^{2-}

QUESTION

How many anions of class A will give colorful gases with conc. Acid?

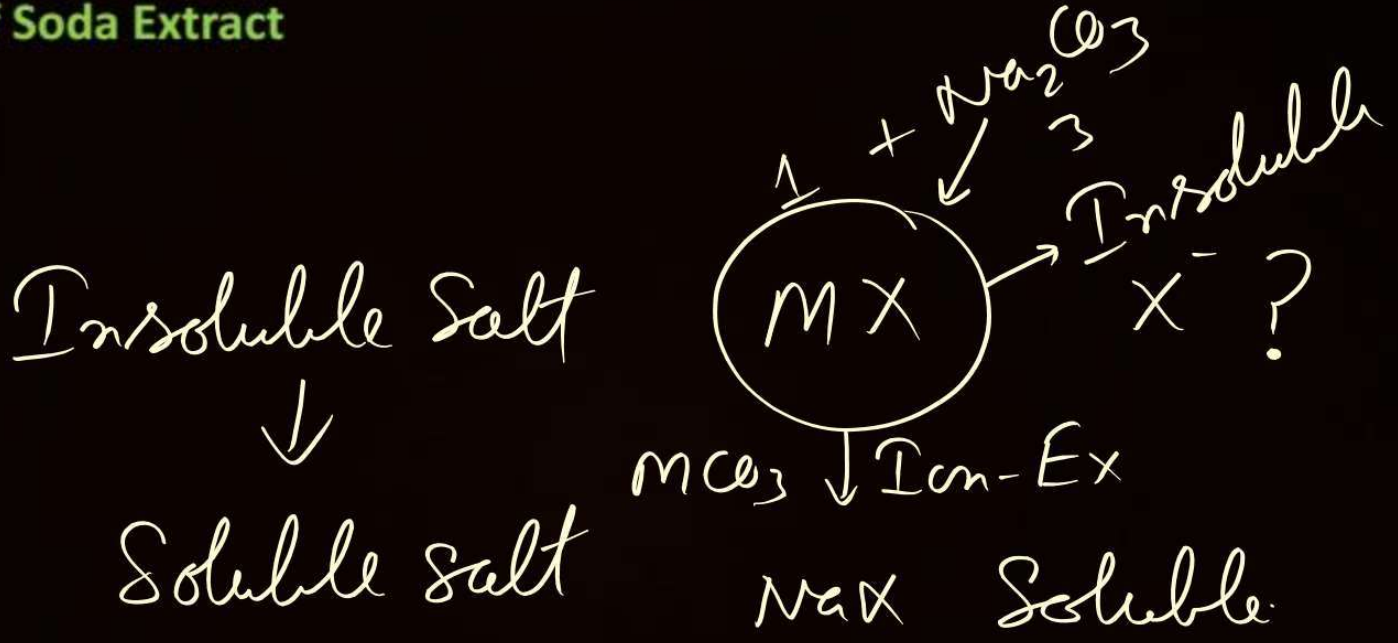
A NO_2^-

B NO_3^-

C Br^-

D I^-

Preparation of Soda Extract



Carbonate (CO_3^{2-})

(1) Test with dil HCl

$$Na_2CO_3 + HCl \longrightarrow NaCl + H_2CO_3$$

$$H_2CO_3 \longrightarrow H_2O + CO_2$$

Prop. of CO_2: Acidic, Released with Brisk effervescence, Colorless, Odorless, Gaseous oxide

IDENTIFICATION OF CO_2: BY LIME WATER TEST

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

When excess of CO_2 is passed

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

$$Ca(OH)_2 \longrightarrow CaO + H_2O$$

$$CaO + CO_2 \longrightarrow CaCO_3$$

QUESTION

Lime water test is possible for identification of SO_2? [True/False]

QUESTION

Which compound can be used in place of $Ca(OH)_2$ for identification of CO_2 or SO_2?

$Ba(OH)_2$

QUESTION

$CO_3^{2-} + CaCl_2 \longrightarrow CaCO_3$ (white Ppt)

$CO_2 + Ca(OH)_2 \longrightarrow H_2O + CaCO_3$ (white turbidity)

CO_3^{2-} is formed Ppt with $CaCl_2$ and turbidity is formed with $Ca(OH)_2$ in H_2O. Why ?

$CaCl_2 > Ca(OH)_2$

Ca^{+2} ↑ Soluble in H_2O Ca^{+2} ↓

Ppt Reaction:

(i) Reaction with $BaCl_2$ / $CaCl_2$

$Na_2CO_3 + BaCl_2 / CaCl_2 \longrightarrow BaCO_3$ (white)

(ii) Reaction with $Pb(NO_3)_2$

$Na_2CO_3 + Pb(NO_3)_2 \longrightarrow PbCO_3$ (white)

(iii) Test with $AgNO_3$

$Na_2CO_3 + AgNO_3 \longrightarrow Ag_2CO_3$ (yellow - white)

(iv) Reaction with $Hg_2(NO_3)_2$

$$Na_2CO_3 + Hg_2(NO_3)_2 \longrightarrow \underset{\text{(yellow)}}{Hg_2CO_3}$$

(v) Reaction with $HgCl_2$

$$Na_2CO_3 + HgCl_2 \longrightarrow \underset{\text{(reddish brown)}}{HgCO_3 \cdot 3HgO}$$

Bicarbonate HCO_3^-

- $LiHCO_3$ exists in solution state Na, K, Rb and Cs bicarbonate exist in solid state.
- HCO_3^- of IIA exist in solution state.

Reaction with dil HCl

$$KHCO_3 + HCl \longrightarrow KCl + H_2CO_3$$

$$H_2CO_3 \longrightarrow H_2O + CO_2$$

$$Na_2CO_3 > NaHCO_3$$

CO_3^{2-} of IA group are more soluble then the bicarbonates

Q.S.P.

Ppt Reaction:

Not possible because bicarbonates are soluble. But in some cases ppt reactions are possible.

(i) On heating followed by $BaCl_2$

$$KHCO_3 \longrightarrow K_2CO_3 + H_2O + CO_2$$

$$BaCl_2 + K_2CO_3 \longrightarrow \underset{\text{ppt}}{BaCO_3}\downarrow$$

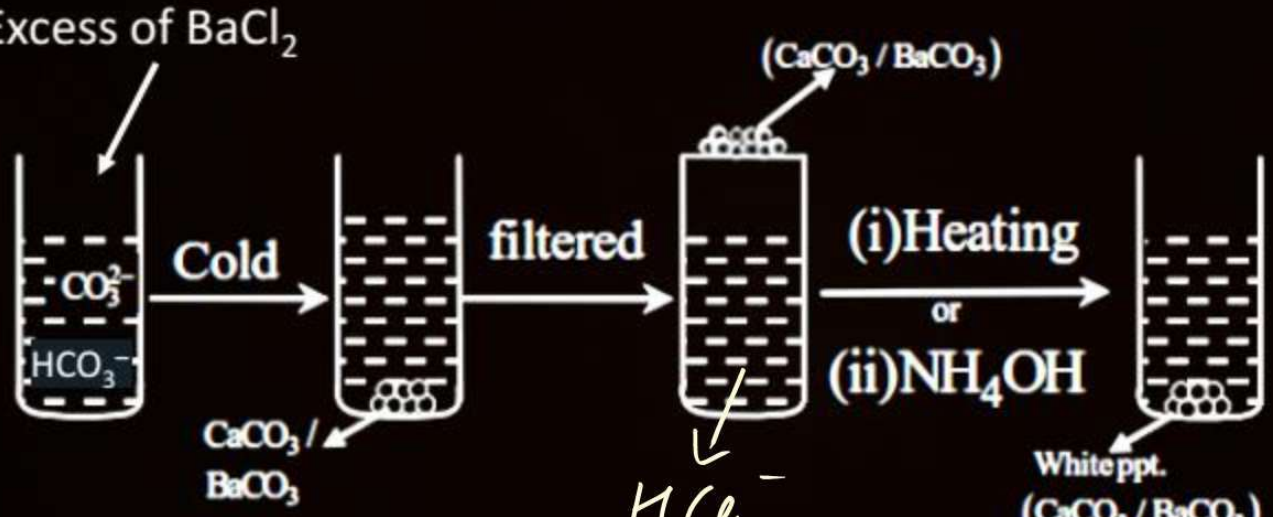
(ii) Test with NH_4OH followed by $MgCl_2$

$$HCO_3^- + NH_4OH \longrightarrow NH_4^+ + CO_3^{2-} + H_2O$$

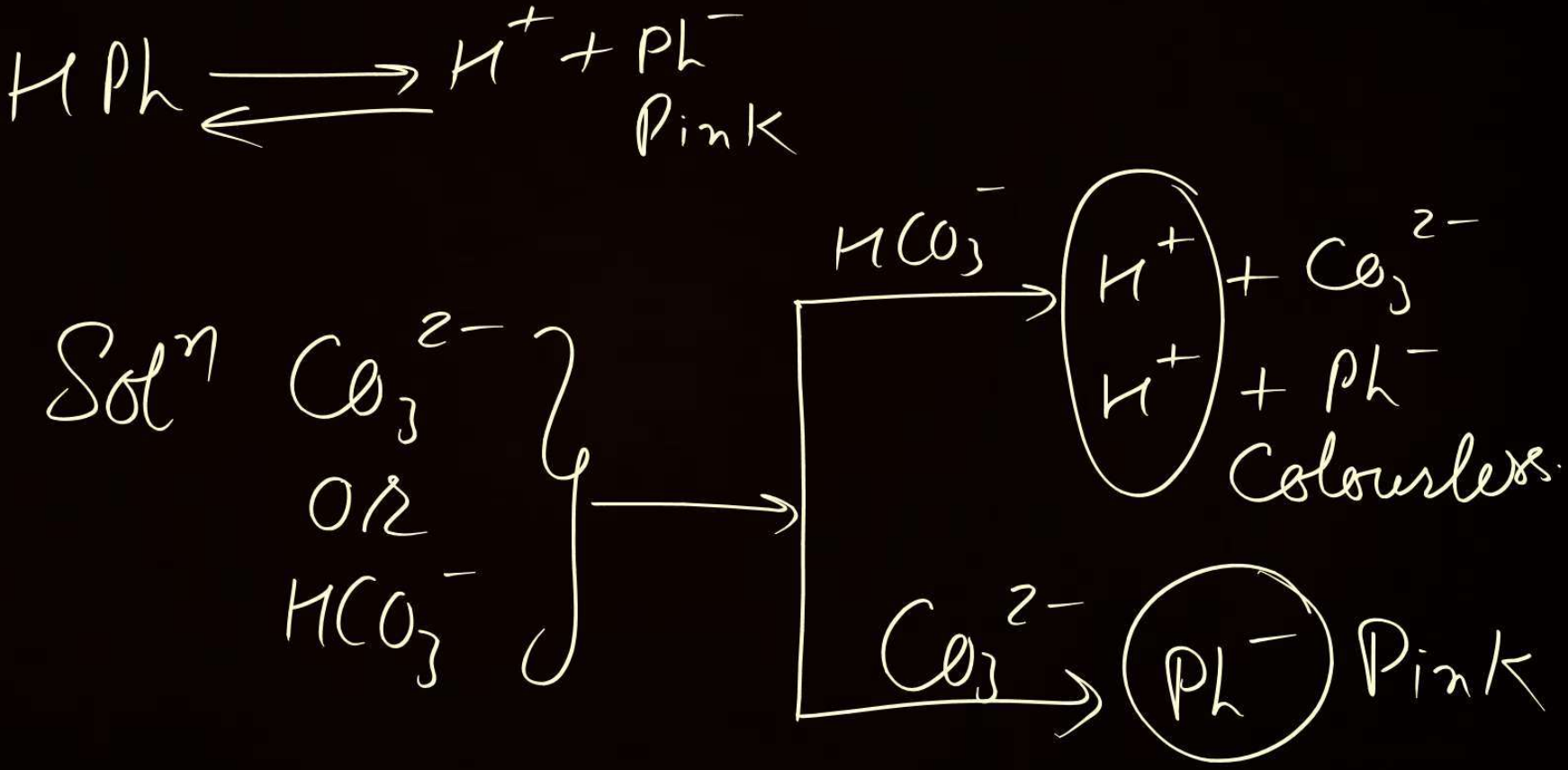
$$CO_3^{2-} + MgCl_2 \longrightarrow \underset{\text{ppt}}{MgCO_3}\downarrow$$

Distinction between carbonate and bicarbonate

(i)



(ii) Phenolphthalein Test



Sulphite (SO_3^{2-})

Test with Acid

$Na_2SO_3 + HCl \longrightarrow NaCl + H_2SO_3$

$H_2SO_3 \longrightarrow H_2O + SO_2$

Properties of SO_2

Suffocating smell of burning Sulphur

Acidic / gas.

Ppt reaction

(1) Reaction with $BaCl_2$ / $CaCl_2$

$Na_2SO_3 + BaCl_2 \rightarrow \overset{+4}{BaSO_3}\downarrow$ (W)

Q.S.P. On standing $BaSO_3$ slowly gets oxidised on reaction with atoms O_2

$BaSO_3 + O_2 \longrightarrow BaSO_4$ (W)

Same reaction with $Br_2 + H_2O$, HNO_3, H_2O_2

$BaSO_4$ in soluble in acid and base, except hot and concentrated H_2SO_4

Q.S.P.

(2) Reaction with $Pb(NO_3)_2$

$$Na_2SO_3 + Pb(NO_3)_2 \longrightarrow PbSO_3\downarrow$$

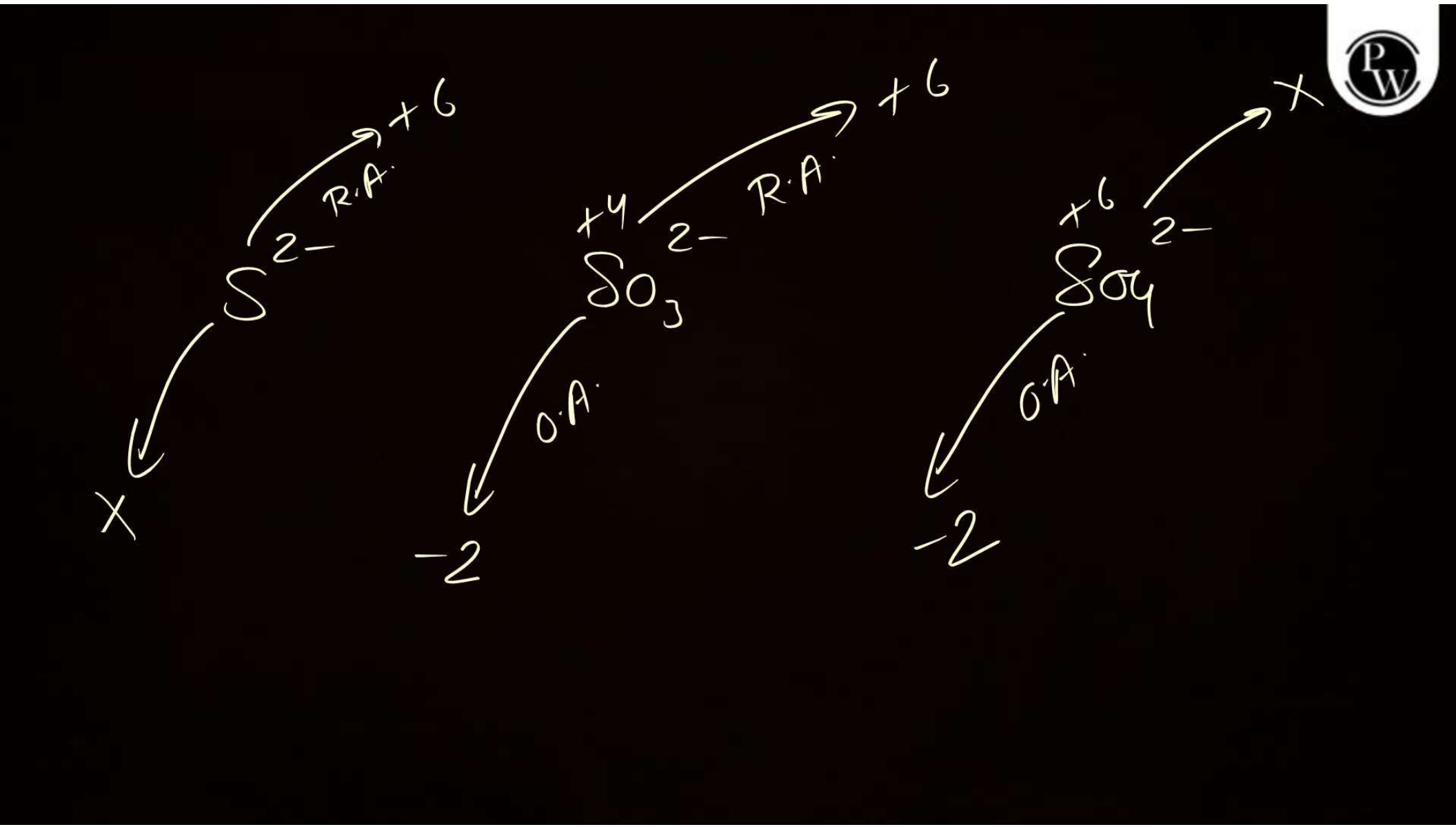
(3) ★ Reaction with $AgNO_3$

- First no visible change colors because of the formation of sulphitoargentate ion.
- On the addition of more reagent, a white crystallize ppt of silver sulphite is formed.
- The ppt dissolves if SO_3^{2-} ions are added in excess.
- On boiling the solution of complex salt or aqueous suspension of ppt, grey metallic silver is precipitated.

$$SO_3^{-2} + AgNO_3 \longrightarrow \underset{\text{Soluble}}{Ag(SO_3)^-} \xrightarrow{Ex\ Ag^+} Ag_2SO_3\downarrow \longrightarrow Ag + H_2SO_4$$

$$Ag(SO_3)^- \xrightarrow{\text{On boiling}} Ag + SO_4^{-2} + SO_2\uparrow$$

$$Ag_2SO_3\downarrow \xrightarrow[SO_3^{2-}]{\text{'w'}} [AgSO_3]^-$$


S
2−
R.A.
+6
X
SO3
+4
2−
R.A.
+6
O.A.
−2
SO4
+6
2−
X
O.A.
−2

Test with oxidizing agent

(1) Reaction with acidified $KMnO_4$

$$2KMnO_4 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5(O)$$

$$SO_2 + O \longrightarrow SO_3 \quad)\times 5$$

$$\hookrightarrow H_2SO_4$$

(2) Reaction with acidified $K_2Cr_2O_7$

$$K_2Cr_2O_7 + 4H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3(O)$$

$$SO_2 + O \rightarrow SO_3 \quad)\times 3$$

(4) Reaction with bromine water

$Br_2 + H_2O \longrightarrow 2HBr + O$

$SO_2 + O \longrightarrow SO_3$

(5) Reaction with acidify KIO_3

$$SO_2 + IO_3^- \longrightarrow I_2 + SO_4^{2-}$$

$I_2 \xrightarrow{\text{starch}}$ Deep blue

Test with reducing agent

(1) Reaction with Zn + dil H_2SO_4

$$Zn + H_2SO_4 \longrightarrow ZnSO_4 + 2H) \times 3$$

$$SO_2 + 6H \longrightarrow H_2S + 2H_2O$$

$+4 \longrightarrow -2$

(2) Reaction with Devarda's alloy (Cu 50%, Al 45%, Zn 5%)

$$Zn + 2NaOH \longrightarrow Na_2ZnO_2 + 2H) \times 3$$

$$SO_2 + 6H \longrightarrow H_2S + 2H_2O$$

Used as reducing agent

Q.S.P.

Bisulphite (HSO_3^{2-})

Test with Acid

$$NaHSO_3 + HCl \rightarrow NaCl + H_2O + SO_2$$

Properties of SO_2

Suffocating smell of burning Sulphur

Distinction in between HSO_3^- / SO_3^{2-}

Reaction with H_2O_2

(A) For SO_3^{2-} : Medium almost neutral

$$H_2O_2 \longrightarrow H_2O + O$$

$$Na_2SO_3 + O \longrightarrow Na_2SO_4$$

(2) For HSO_3^- : Medium almost acidic

$$NaHSO_3 \longrightarrow Na_2SO_3 + SO_2 + H_2O$$

$$H_2O_2 \longrightarrow H_2O + O$$

$$Na_2SO_3 + O \longrightarrow Na_2SO_4$$

$$SO_2 + O \xrightarrow{\text{air}} H_2SO_4$$

Sulphide

Test with Acid

$Na_2S + HCl \rightarrow NaCl + H_2S\uparrow$

Properties of H_2S

Rotten egg smell, gives blue colour to flame

★ **Note:** Some sulphide salts like Cr^{+3}, Al^{+3}, Mg^{+2} are readily hydrolysed.

$Cr^{+2} + S^{-2} \longrightarrow Cr_2S_3 \xrightarrow{H_2O} Cr(OH)_3\downarrow$

(green ppt)

$Al^{+3} + S^{-2} \longrightarrow Al_2S_3 \xrightarrow{H_2O} Al(OH)_3\downarrow$

(white ppt)

Sulphide

Ppt Reaction

(1) $S^{2-} + AgNO_3 \longrightarrow Ag_2S \downarrow$ Black

(2) $S^{2-} + Cd(NO_3)_2 \longrightarrow CdS \downarrow$ 'y'

(3) $S^{2-} + Pb(NO_3)_2 \longrightarrow PbS \downarrow$

(4) $S^{2-} + Hg(NO_3)_2 \longrightarrow HgS \downarrow$

} Black

Test with oxidizing agent

(1) Reaction with Acidify $KMNO_4$

$MnO_4^- / H^+ + H_2S \rightarrow S\downarrow$

(2) Reaction with Acidify $K_2Cr_2O_7$

$H^+ / Cr_2O_7^{2-} + H_2S \rightarrow S\downarrow$

Other Reactions

(1) Test with sodium nitroprusside:

(a) $S^{2-} + Na_2[Fe(CN)_5NO] \longrightarrow Na_4[Fe(CN)_5(NOS)]$

(Brownish-red) Purple/violet colour

Sodium thionitroprusside

Na_2S

$S^{2-} + NO^+ \longrightarrow NOS^-$

QUESTION

Which of the following reaction is possible :

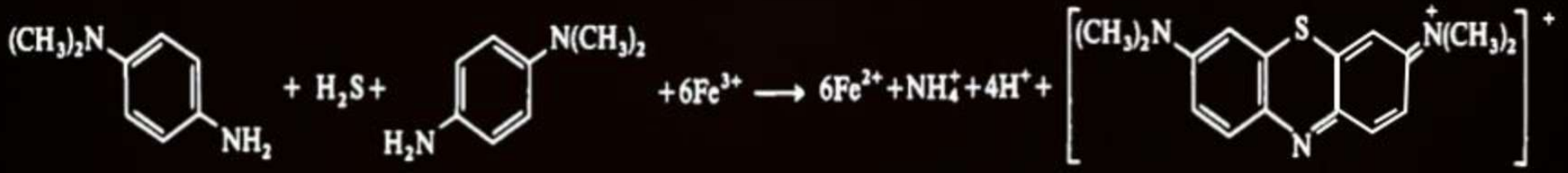
$$H_2S \xrightarrow{Na_2[Fe(CN)_5NO]} N.R.$$

$$H_2S \xrightarrow[OH^-]{Na_2[Fe(CN)_5NO]} [Fe(CN)_5(NOS)]^{-4}$$

Other Reactions

(2) Test with para amino dimethyl aniline:

p-amino dimethylaniline is converted by $FeCl_3$ and H_2S in strongly acid solution into the water soluble dye stuff methylene Blue.



Thiosulphate ($S_2O_3^{-2}$)

Test with Acid

$$Na_2S_2O_3 + HCl \longrightarrow NaCl + SO_2 + S\downarrow$$

Heating effect

$$Na_2S_2O_3 \cdot 5H_2O \xrightarrow{\Delta} Na_2SO_4 + Na_2S_5$$

Ppt Reaction

(1) Test with $CaCl_2/BaCl_2$:

$$BaCl_2 + Na_2S_2O_3 \longrightarrow \underset{\text{White}}{BaS_2O_3\downarrow}$$

(2) Test with $AgNO_3$:

$$Na_2S_2O_3 + AgNO_3 \longrightarrow \underset{\text{Soluble}}{\left[Ag(S_2O_3)_2\right]^{3-}} \xrightarrow{Ag^+} \underset{\text{White}}{Ag_2S_2O_3}\downarrow \xrightarrow[\text{Boil}]{HOH} Ag_2S + H_2SO_4$$

QUESTION

$S_2O_3^{-2} + AgNO_3 \longrightarrow$

Which of the following statement is correct for above the reaction.

(A) At first, no precipitation occurs because soluble disulphatoargentate complex is formed.

(B) The ppt is unstable turning dark on standing where Ag_2S is formed.

(C) This hydrolytic decomposition can be accelerated on warming.

(D) None of these

(3) Test with $Pb(NO_3)_2$:

$$Na_2S_2O_3 + Pb(NO_3)_2 \longrightarrow \left[Pb(S_2O_3)_2\right]^{2-} \xrightarrow{Pb^{2+}} PbS_2O_3\downarrow$$

$PbS_2O_3 \xrightarrow{\text{Boil}} PbS + H_2SO_4$

Black

(4) Test with $Bi(NO_3)_3$:

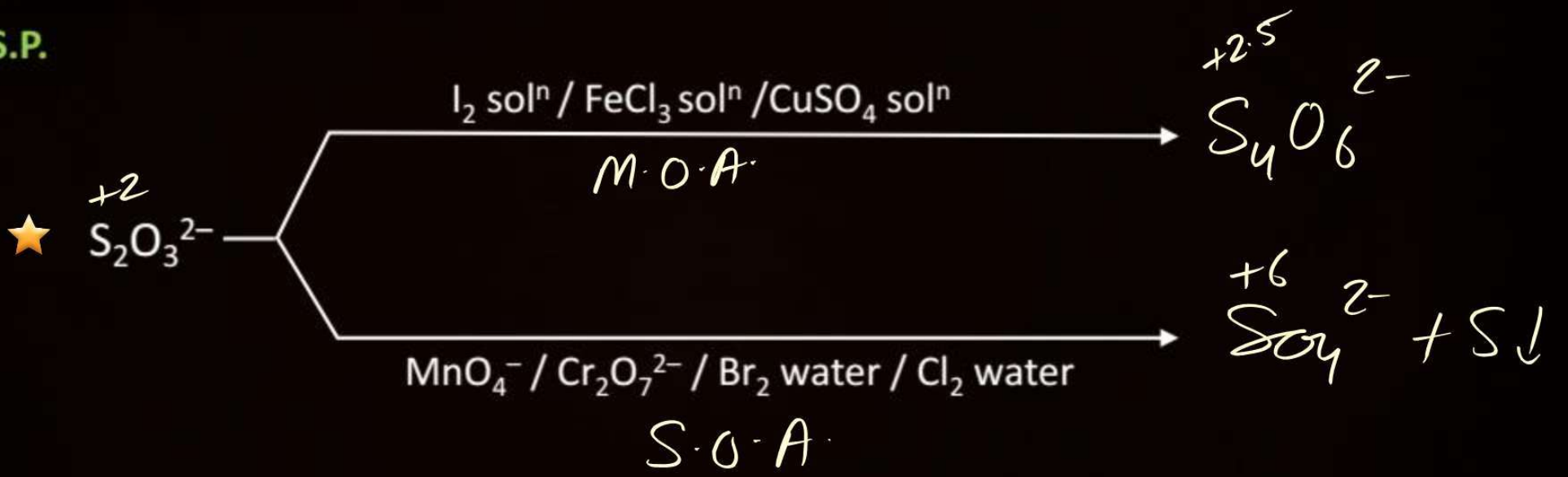
$$Na_2S_2O_3 + Bi(NO_3)_3 \longrightarrow \left[Bi(S_2O_3)_2\right]^{-} \xrightarrow{Bi^{+3}} Bi_2(S_2O_3)_3$$

$Bi_2(S_2O_3)_3 \xrightarrow{\text{Boil}} Bi_2S_3 + H_2SO_4$

Black

Redox Reaction

Q.S.P.



(a) Test with I_2 solution :

I_2 is non-polar so it is insoluble in water.

$$KI + I_2 \rightarrow KI_3$$

Its solubility increases on addition of KI.

$$KI_3 \longrightarrow KI + I_2$$

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

(b) Test with $CuSO_4$: Redox followed by precipitation

$$\overset{+2}{Cu}SO_4 + Na_2S_2O_3 \longrightarrow \overset{+}{Cu}S_2O_3 \downarrow \xrightarrow{Ex} Na_4[Cu_6(S_2O_3)_5]$$

'ω'

$+ Na_2S_4O_6$

Sod. Cuproo thiosulphate

(c) **Test with $FeCl_3$ solution:**

$$FeCl_3 + Na_2S_2O_3 \longrightarrow FeCl_2 + Na_2S_4O_6$$

(d) **Test with acidify $KMnO_4$:**

$$H^+/MnO_4^- + S_2O_3^{2-} \longrightarrow Mn^{+2} + SO_4^{2-} + S\downarrow$$

(e) **Test with acidify $K_2Cr_2O_7$:**

$$H^+/Cr_2O_7^{2-} + S_2O_3^{2-} \longrightarrow Cr^{3+} + SO_4^{2-} + S\downarrow$$

(f) **Test with Bromine water :**

$$Br_2 + H_2O + S_2O_3^{2-} \longrightarrow HBr + SO_4^{2-} + S\downarrow$$

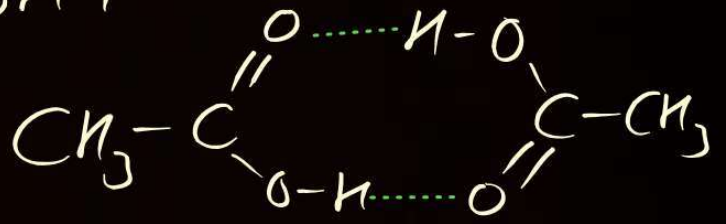
(g) **Test with Chlorine water :**

$$Cl_2 + H_2O + S_2O_3^{2-} \longrightarrow HCl + SO_4^{2-} + S\downarrow$$

CH_3COO^- (Acetate)

1. Test with acid

$$CH_3COONa + HCl \longrightarrow CH_3COOH\uparrow$$



Properties

Vinegar like smell, acidic, Hydrogen bonding possible (exist in dimer form)

Ppt Reaction

Test with $AgNO_3$:

$$AgNO_3 + CH_3COONa \longrightarrow \underset{\text{'W'}}{CH_3COOAg}\downarrow$$

Other reactions

1. Test with Neutral $FeCl_3$:

$$3FeCl_3 + 2HOH + 6CH_3COONa \longrightarrow [Fe_3(OH)_2(CH_3COO)_6]Cl + 6NaCl + 2HCl$$

$$[Fe_3(OH)_2(CH_3COO)_6]Cl \longrightarrow 3Fe(OH)_2CH_3COO\downarrow + 3CH_3COOH + HCl$$

(+ 4 HOH)

'Red'

it is neutralized by gradual addition of NH_4OH.

Q.S.P.

QUESTION

Function of neutral $FeCl_3$

(A) Neutral $FeCl_3$ is used because aqueous solution of $FeCl_3$ is acidic and If not neutralized, HCl formed will dissolve ppt.

(B) Neutral $FeCl_3$ is used because aqueous solution of $FeCl_3$ is basic and If not neutralized, HCl formed will dissolve ppt.

(C) Neutral $FeCl_3$ is used because aqueous solution of $FeCl_3$ is amphoteric and If not neutralized, HCl formed will dissolve ppt.

(D) None of these

Other reactions

2. Test with conc. H_2SO_4 + C_2H_5OH :

$$CH_3COONa + H_2SO_4 \longrightarrow CH_3COOH$$

$$CH_3COOH + HOC_2H_5 \xrightarrow[H_2SO_4]{Conc} CH_3COOC_2H_5$$

NO_2^- Nitrite)

Test with Acid

$$NO_2^- + H^+ \longrightarrow NO_2$$

Ppt Reaction

Test with $AgNO_3$

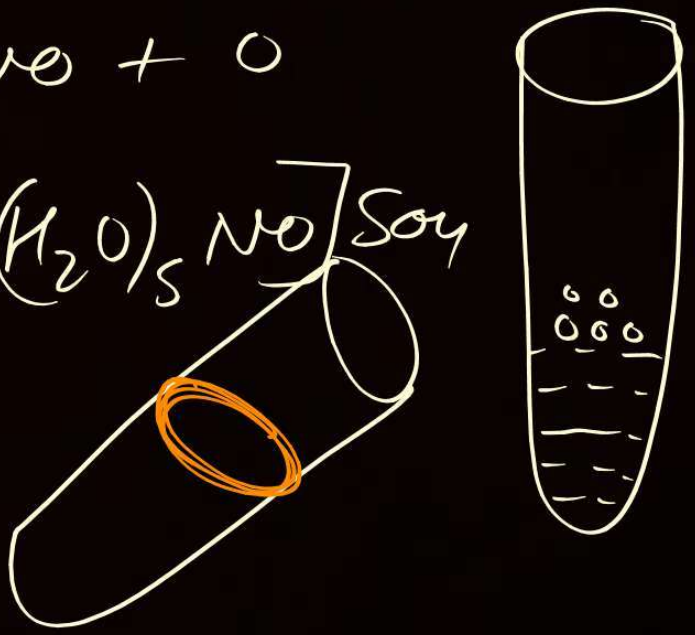
$$AgNO_3 + NaNO_2 \longrightarrow \underset{\text{White}}{AgNO_2}\downarrow$$

Brown ring test

$$NaNO_2 + H_2SO_4 \xrightarrow{\Delta} Na_2SO_4 + HNO_2$$

$$2HNO_2 \longrightarrow H_2O + 2NO + O$$

$$FeSO_4 + NO \xrightarrow{aq} [Fe(H_2O)_5NO]SO_4$$



QUESTION

Best absorber of NO

A $FeSO_4$

B $Fe_2(SO_4)_3$

C Both (A) & (B)

D None of these

QUESTION

In above reaction freshly prepared $FeSO_4$ is used why.

$FeSO_4$ $Fe^{+2} \longrightarrow Fe^{+3}$

$FeSO_4 + NO \xrightarrow{aq} [Fe(H_2O)_5NO]SO_4$

$Fe^{+3} + NO \longrightarrow \times$

QUESTION

Why $FeSO_4$ is not directly added in test tube.

$[Fe(H_2O)_5(NO)]SO_4$

$Fe^{+1} \rightarrow$ Unstable

QUESTION

If $Ba(NO_3)_2$, $Sr(NO_3)_2$, $Pb(NO_3)_2$ are present in mixture.

Ba^{+2}
Sr^{+2} } SO_4^{2-} Insoluble
Pb^{+2}

Reaction with oxidizing agent

(1) Reaction with acidify $KMnO_4$

$$H^+ / MnO_4^- + NO_2^- \longrightarrow NO_3^-$$

(2) Reaction with Acidify $K_2Cr_2O_7$

$$H^+ / Cr_2O_7^{2-} + NO_2^- \longrightarrow NO_3^-$$

(3) Reaction with Bromine water

$$Br_2 + H_2O + NO_2 \longrightarrow NO_3^-$$

Reaction with Reducing agent

(1) Test with Zn + dil H_2SO_4

$Zn + H_2SO_4 \longrightarrow ZnSO_4 + 2H)^{\times 3}$ $+3 \longrightarrow -3$

$HNO_2 + 6H \longrightarrow NH_3 + 2H_2O$ | $NO_2^- \longrightarrow NH_3$

(2) Reaction with devarda's alloy

$Zn + NaOH \longrightarrow NH_3$

$+$

HNO_2

Class A

Sub group 2

NO_3^- Nitrite)

Test with Acid

$$NO_3^- + H_2SO_4 \xrightarrow{Conc} NO_2$$

Brown Ring test:

$$NO_3^- + H_2SO_4 + FeSO_4 \longrightarrow [Fe(H_2O)_5(NO)]SO_4$$

QUESTION

Can we perform Brown ring test for NO_2^- ion in presence of NO_3^- ion ?

Yes

$NO_2^- + dil\ H_2SO_4 \longrightarrow \checkmark$

$NO_3^- + dil\ H_2SO_4 \longrightarrow \times$

QUESTION

Can we perform Brown ring test for NO_3^- ion in presence of NO_2^- ion?

NO

$NO_2^- + dil/Conc\ H_2SO_4 \longrightarrow$

Separation of NO_2^- and NO_3^-

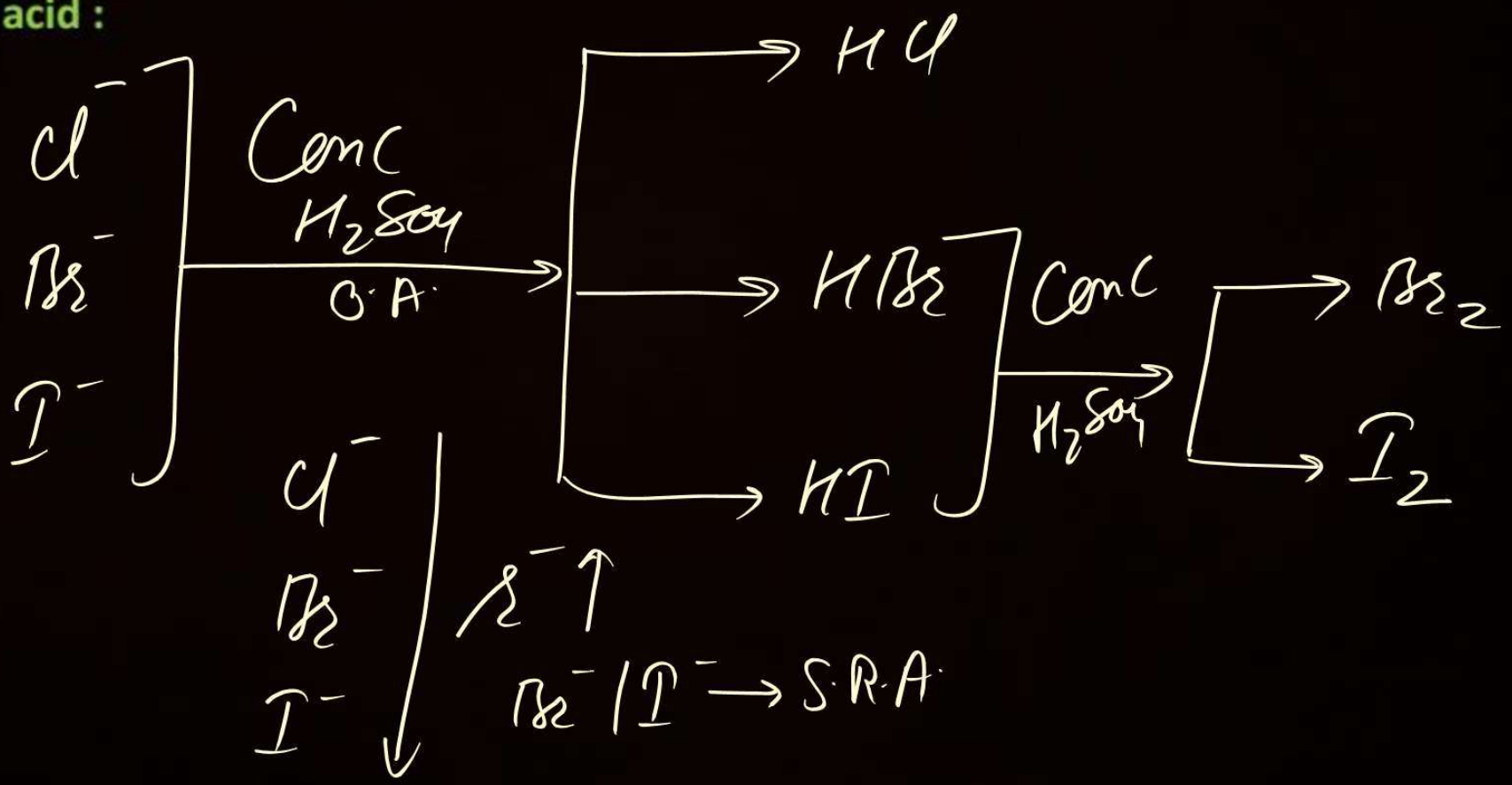
Method-1 $NO_2^- + NO_3^- \xrightarrow{AgF}$ $AgNO_3$ Soln

$AgNO_2 \downarrow$ 'W'

$AgNO_3 \xrightarrow{FeSO_4 + \text{conc. } H_2SO_4}$ B.R.T

Cl^-, Br^-, I^- (Chloride, Bromide, Iodide)

Test with acid :



QUESTION

If we want pure HX as a final product then we will use ?

H_3PO_4 Non oxi^n Acid

QUESTION

If we want X_2 as a final product then we will be use ?

$$NaCl + H_2SO_4 \xrightarrow{MnO_2} Cl_2$$

QUESTION

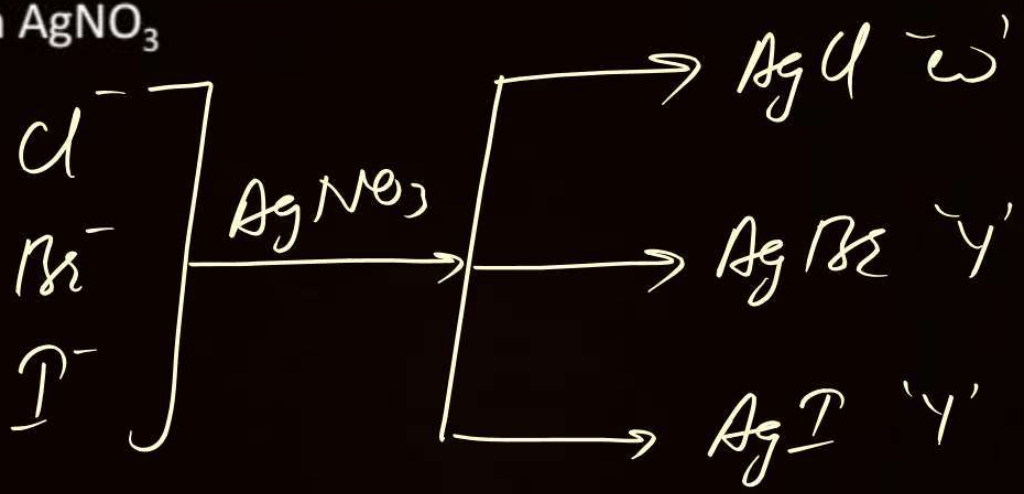
If I_2 gives Blue colour to starch paper then Br_2 gives

↓

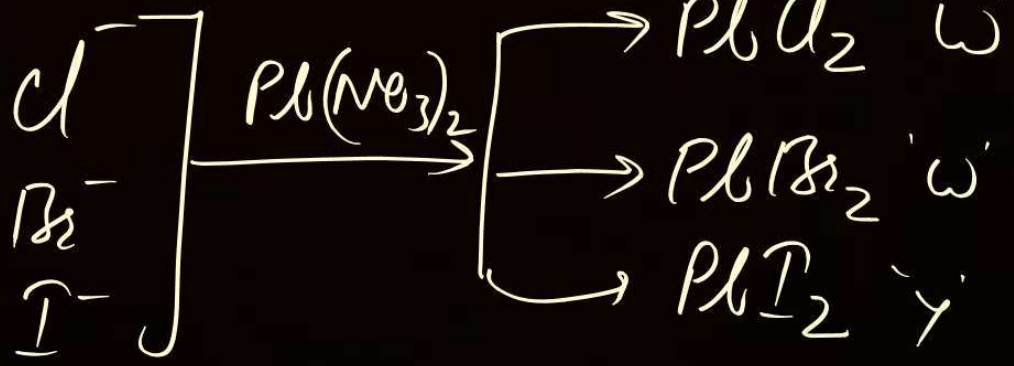
'OR'

Ppt Reaction

(1) Reaction with $AgNO_3$



(2) Reaction with $Pb(NO_3)_2$



(3) Test with $CuSO_4$ (For I^- ion)

$CuSO_4 + KI \longrightarrow CuI_2$ (Not possible) $\longrightarrow CuI\downarrow + I_2$ ('W')

$I_2 \downarrow KI$

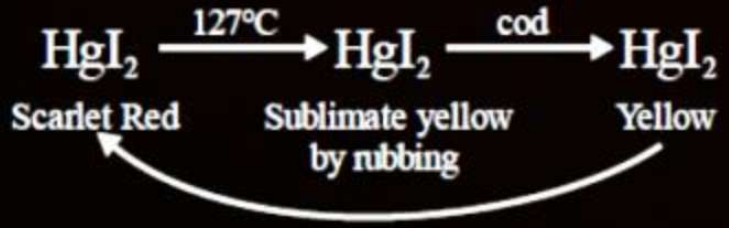
KI_3

Brown

(4) Test with $HgCl_2$ (For I^- ion)

$HgCl_2 + KI \longrightarrow HgI_2$ ('Red') $\xrightarrow[KI]{Ex} K_2[HgI_4]$

(5) Heating effect



Reaction with oxidizing agent

(1) Reaction with acidify $KMnO_4$

$$H^+ / MnO_4^- + HX \longrightarrow X_2$$

$$X \rightarrow Cl, Br, I$$

(2) Reaction with Acidify $K_2Cr_2O_7$

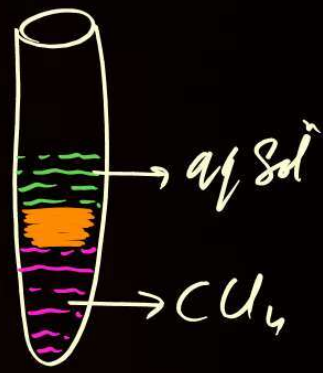
$$H^+ / Cr_2O_7^{2-} + HX \longrightarrow X_2$$

$$X \rightarrow Cl, Br, I$$

Other reaction

(1) Layer Test: Specific Test for Br_2

$$Cl_2 + H_2O + Br^- \longrightarrow Br_2 \xrightarrow[\text{Brown layer}]{\text{0.5 } (CCl_4)}$$



If Chlorine water is an excess.

$$Cl_2 + Br_2 \longrightarrow \underset{\text{Sol}^n}{BrCl}$$

(2) Layer test: Specific test for I_2

$$I_2 + Cl_2 + H_2O \longrightarrow I_2 \xrightarrow[CCl_4]{0.5} \text{Violet}$$

If Chlorine water is an excess then colorless solution will be appeared.

$$\underset{\text{Ex}}{Cl_2} + H_2O + I_2 \longrightarrow \underset{\text{Colourless.}}{HIO_3}$$

QUESTION

If Br^- and I^- ions are present in mixture

A. Violet layer comes first and followed by Reddish-brown layer.

B. Reddish-Brown layer comes first and followed by Violet layer.

C. Only Reddish-Brown layer comes.

D. Only Violet layer comes.

QUESTION

If Reddish-brown layer comes first, it means

(A) Only Br^- ions present

(B) Only I^- ions present

(C) I^- ions absent

(D) Both (A) & (C)

Chromyl chloride test: for Cl^-

① $NaCl + H_2SO_4 + K_2Cr_2O_7 \longrightarrow \underset{\text{'Red'}}{CrO_2Cl_2}\uparrow$

② $CrO_2Cl_2 + \underset{\text{Base}}{NaOH_{aq}} \longrightarrow \underset{\text{'Y' Sol}^n}{Na_2CrO_4}$

③ $Na_2CrO_4 + \underset{\text{Amp.}}{Pb^{+2}} \xrightarrow{CH_3COOH} PbCrO_4\downarrow \text{'Y'}$

Cl_2 may also form in this test so sensitivity of this test decreases.

Q.S.P.

QUESTION

Why acetic acid is used?

(A) To neutralize basic solution otherwise soluble $[Pb(OH)_4]^{2-}$ will be formed.

(B) Other acid is not chosen because being amphoteric Pb^{+2} may be react with other acids. i.e. $PbCrO_4$ is insoluble in CH_3COOH

(C) Both (A) & (B)

(D) None of these

QUESTION

Test tube must be dry why?

Sol. Because CrO_2Cl_2 undergoes hydrolysis and forms H_2CrO_4

QUESTION

During the chromyl chloride test mixture must be free from NO_2^- / NO_3^- ion why?

Sol. To prevent the formation NOCl

$NO_2^-/NO_3^- + Cl^- \longrightarrow NOCl$

QUESTION

ClO_3^- must be absent why?

Sol. To prevent the formation of ClO_2

$ClO_3^- + Cl^- \longrightarrow ClO_2$ (explosive in nature)

QUESTION

Which of the following compound do not give chromyl chloride test

(A) Only $HgCl_2$

(B) Only Hg_2Cl_2

} Insoluble.

(C) Both

(D) None of these

QUESTION

Number of metal halide gives partial test.
Pb, Ag, Au, Pt, Sb, Sn

Sol. 6

BO_3^{-3} (Borate)

(1) Test with Acid

$$BO_3^{3-} + HCl/H_2SO_4 \longrightarrow H_3BO_3$$

QUESTION

Define the property of H_3BO_3 when borax react with conc. H_2SO_4 & conc. HCl

Sol. (1) Boric acid forms H–bonding with H_2SO_4.
On heating, white fumes of H_3BO_3 is obtained.

(2) Boric acid doesn't form H-Bonding with HCl and becomes solid due to intermolecular H-Bonding

Oxalate ($C_2O_4^{2-}$)

Test with Acid

$$C_2O_4^{2-} + H_2SO_4 \longrightarrow CO + CO_2$$

Ppt reaction

Test with $BaCl_2/CaCl_3$

$$BaCl_2 + Na_2C_2O_4 \longrightarrow \underset{\text{White}}{BaC_2O_4}\downarrow$$

Fluoride (F^-)

Test with Acid

$F^- + H_2SO_4 \longrightarrow (HF)_2 \,/\, H_2F_2$ 'gas'

due to H-Bonding

Ppt reaction

Test with $BaCl_2/CaCl_2$

$CaCl_2 + NaF \rightarrow \underset{\text{'w'}}{CaF_2}\downarrow$

Class B (sub group 1)

Sulphate (SO_4^{2-})

Ppt Reaction

	Na_2SO_4	+	$BaCl_2$	$\longrightarrow$ $BaSO_4$	(white)
	Na_2SO_4	+	$Pb(NO_3)_2$	$\longrightarrow$ $PbSO_4$	(white)
	Na_2SO_4	+	$AgNO_3$	$\longrightarrow$ Ag_2SO_4	(white)
★	Na_2SO_4	+	$Hg(NO_3)_2$	$\longrightarrow$ $HgSO_4 \cdot 2HgO$	(yellow)

QUESTION

Define the solubility of $PbSO_4$?

1. $PbSO_4$ + $NaOH$ (ex) $\longrightarrow$ $[Pb(OH)_4]^{2-}$

2. $PbSO_4$ + CH_3COONH_4 $\longrightarrow$ Complex.

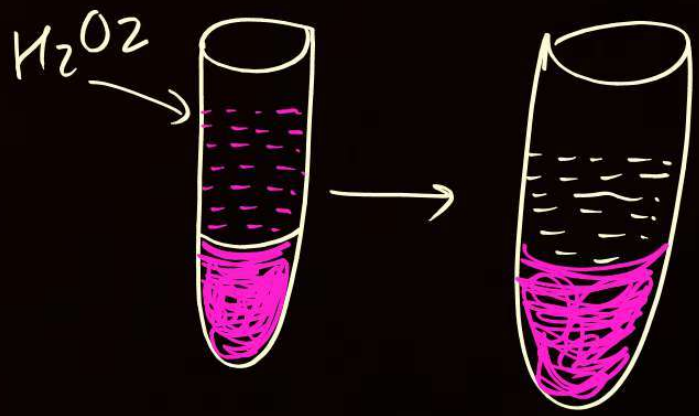
QUESTION

If $BaSO_4$ is precipitated in a solution containing $KMnO_4$ it is coloured pink. Why ?

Sol. $Na_2SO_4 + BaCl_2 \xrightarrow{\text{in presence of } MnO_4^- \text{ solution}}$ pink ppt of $BaSO_4$ (due to adsorption of $KMnO_4$ on $BaSO_4$)

$\downarrow H_2O_2$

Solution decolorized
but PPT remains same



Phosphate (PO_4^{3-})

Test with $(NH_4)_2MoO_4$

$$PO_4^{3-} + (NH_4)_2MoO_4 + HNO_3 \xrightarrow{T \leq 40^\circ C} (NH_4)_3PO_4.12MoO_3$$

or

$(NH_4)_3P(Mo_{12}O_{40})$

or

$(NH_4)_3P(Mo_3O_{10})$

Canary yellow ppt

On boiling above 40°C Arsenic also forms yellow ppt $[(NH_4)_3PO_4.12AsO_3]$

Q.S.P.

QUESTION

Function of HNO_3

Sol. HNO_3 is added and boiled so that if reducing radicals such as S^{2-} and $S_2O_3^{2-}$ are present then they get removed.

$$S^{2-} / S_2O_3^{2-} + Mo^{+6} \longrightarrow Mo_3O_8 \cdot xH_2O \text{ (Blue ppt)}$$

Class B (sub group 2)

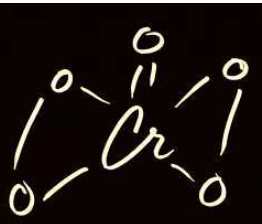
Chromate (CrO_4^{2-})

Ppt Reaction

Na_2CrO_4	+	$Ca(NO_3)_2$	$\longrightarrow$	$CaCrO_4$	(yellow)
Na_2CrO_4	+	$Sr(NO_3)_2$	$\longrightarrow$	$SrCrO_4$	(yellow)
Na_2CrO_4	+	$BaCl_2$	$\longrightarrow$	$BaCrO_4$	(yellow)
Na_2CrO_4	+	$Pb(NO_3)_2$	$\longrightarrow$	$PbCrO_4$	(yellow)
Na_2CrO_4	+	★ $AgNO_3$	$\longrightarrow$	Ag_2CrO_4	(red) ★
Na_2CrO_4	+	★ $Hg_2(NO_3)_2$	$\longrightarrow$	Hg_2CrO_4	(red) ★

Identification of CrO_4^{2-} and $Cr_2O_7^{2-}$

Test with H_2O_2 in presence of organic solvent



(1) CrO_4^{2-} ('Y') $\xrightarrow[H_2O_2 \text{ and } O.S]{H^+}$ CrO_5 Blue

(2) $Cr_2O_7^{2-}$ ('O') $\xrightarrow[H_2O_2 \text{ and } O.S]{H^+}$ CrO_5 Blue

Its blue colour remains same in organic solvent due to adduct formation.

Q.S.P.

$(CH_3)_2O$ is highly in Inflammable so amyl alcohol ($C_5H_{11}OH$) is used.

Q.S.P.

Redox reaction of $Cr_2O_7^{2-}$

$Cr_2O_7^{2-} + SO_2 \xrightarrow{H^+} SO_4^{2-}$

$Cr_2O_7^{2-} + H_2S \xrightarrow{H^+} H_2O + S\downarrow$

$Cr_2O_7^{2-} + NO_2^- \xrightarrow{H^+} NO_3^-$

$Cr_2O_7^{2-} + Fe^{2+} \xrightarrow{H^+} Fe^{+3}$

$Cr_2O_7^{2-} + H_2O_2 \xrightarrow{H^+} H_2O + O_2$

$Cr_2O_7^{2-} + I^- \xrightarrow{H^+} I_2 + H_2O$

$Cr_2O_7^{2-} + S_2O_3^{2-} \xrightarrow{H^+} SO_4^{2-} + S\downarrow$

Redox reaction of MnO_4^-

MnO_4^-	+	SO_2	⟶	SO_4^{2-}
MnO_4^-	+	H_2S	⟶	$H_2O + S$
MnO_4^-	+	NO_2^-	⟶	NO_3^-
MnO_4^-	+	Fe^{2+}	⟶	Fe^{+3}
MnO_4^-	+	H_2O_2	⟶	$H_2O + O$
MnO_4^-	+	I^-	⟶	$I_2 + H_2O$
MnO_4^-	+	$S_2O_3^{2-}$	⟶	$SO_4^{2-} + S\downarrow$

Dry Test

1. Flame test – s block metal cations
2. Borax bead test ⟶ 'd' block

Flame Test

This test is performed with the help of a platinum wire as follows :

Step - 1 Take a of platinum wire.

Step - 2 Clean the loop : Dip it into conc. HCl and hold it in a flame.

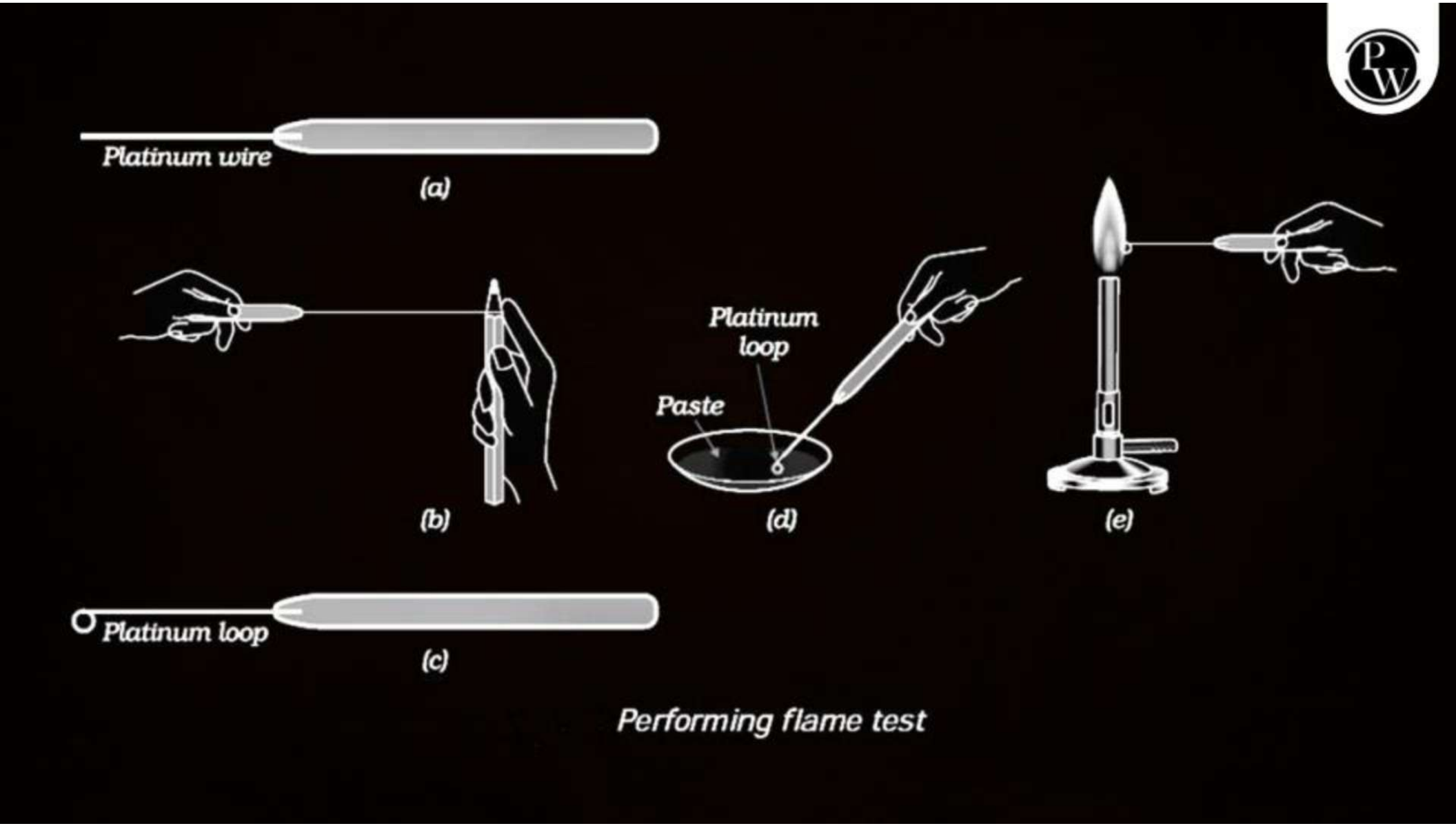
Step - 3 Repeat step (ii) until the wire imparts no colour to the flame.

Step - 4 Put 2-3 drops of conc. HCl and small quantity of the salt on a clean watch glass.

Step - 5 Dip the loop in this paste and introduce the loop in the non-luminous (oxidising) flame.

Step - 6 Observe the colour of the flame.

1. First with the naked eye
2. Second with blue glass and identify the metal ion.



Performing flame test

QUESTION

Identify the colour of given metal :

Li = Carmine Red

Na = Golden yellow

K = Lilac (pale violet)

Rb = Reddish violet

Cs = Blue

Ca = Brick red

Sr = Crimson red

Ba = Apple green

QUESTION

Be and Mg do not show flame test because Why ?

Size ↓

IE ↑

QUESTION

Pt wire is used in flame test why?

M.P ↑

I.E ↑

less reactive

QUESTION

Which of the following statement is correct

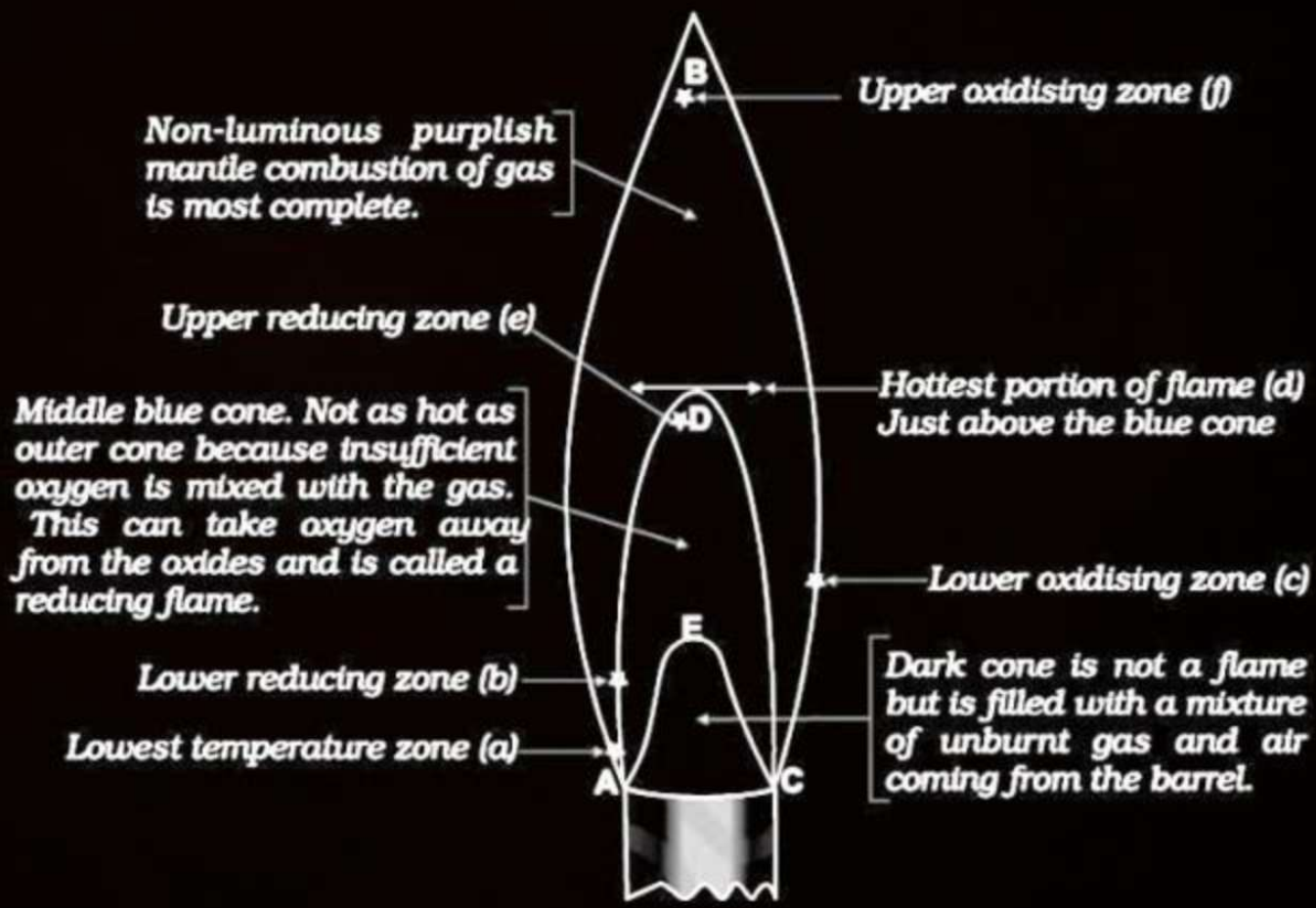
A Nichrome wire can be used in place of Pt wire.

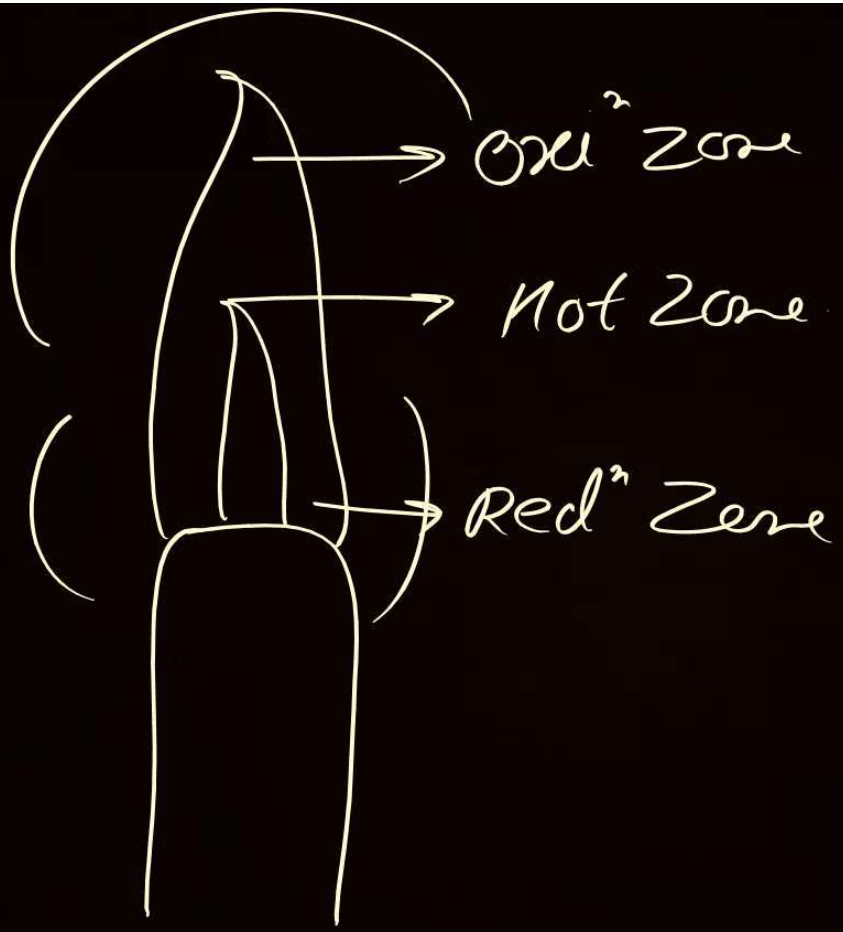
B Nichrome is an alloy of Ni, Cr and Fe.

C Both (A) & (B)

D None of these

Three distinctly visible parts of the Bunsen flame are described below :




Oxi² Zone
Not Zone
Red² Zone

Borax Bead Test

Test is applicable: 'd' Block

Heating effect

$$Na_2B_4O_7 \cdot 10H_2O \longrightarrow Na_2B_4O_7 + 10H_2O$$

$$Na_2B_4O_7 \longrightarrow NaBO_2 + B_2O_3$$

QUESTION

Transparent glassy bead is :

$NaBO_2 + B_2O_3$

Identification of Cu :

Step-1 In oxidizing flame

$$CuSO_4 \longrightarrow CuO + SO_3$$

$$CuO + B_2O_3 \longrightarrow Cu(BO_2)_2 \text{ Blue}$$

Step-2 In reducing flame

$$\overset{+2}{Cu}(BO_2)_2 + C + NaBO_2 \longrightarrow CuBO_2 + Na_2B_4O_7 + CO$$

$$CuBO_2 + NaBO_2 + 2C \longrightarrow Cu + Na_2B_4O_7 + CO$$

Colour Table of Borax bead test

Metal ion	Oxidizing flame (Non-Luminous)		Reducing flame (Luminous)		Product ($M(BO_2)_x$)
	In cold ★	In hot	In cold ★	In hot	
Cr^{+3}	Green	Yellow	Green	Green	$Cr^{+3} \rightarrow Cr^{+3}$
Mn^{+3}	Violet	Violet	Colorless	Colorless	$Mn^{+3} \rightarrow Mn^{+2}$
Fe^{+3}	Yellow	Yellow	Green	Green	$Fe^{+3} \rightarrow Fe^{+2}$
Co^{+2}	Blue	Blue	Blue	Blue	$Co^{+2} \rightarrow Co^{+2}$
Ni^{+2}	Brown	Violet	Gray	Gray	$Ni^{+2} \rightarrow Ni$
Cu^{+2}	Blue	Green	Red	Colorless	$Cu^{+2} \rightarrow Cu$

GVY B 3 GCG BGR

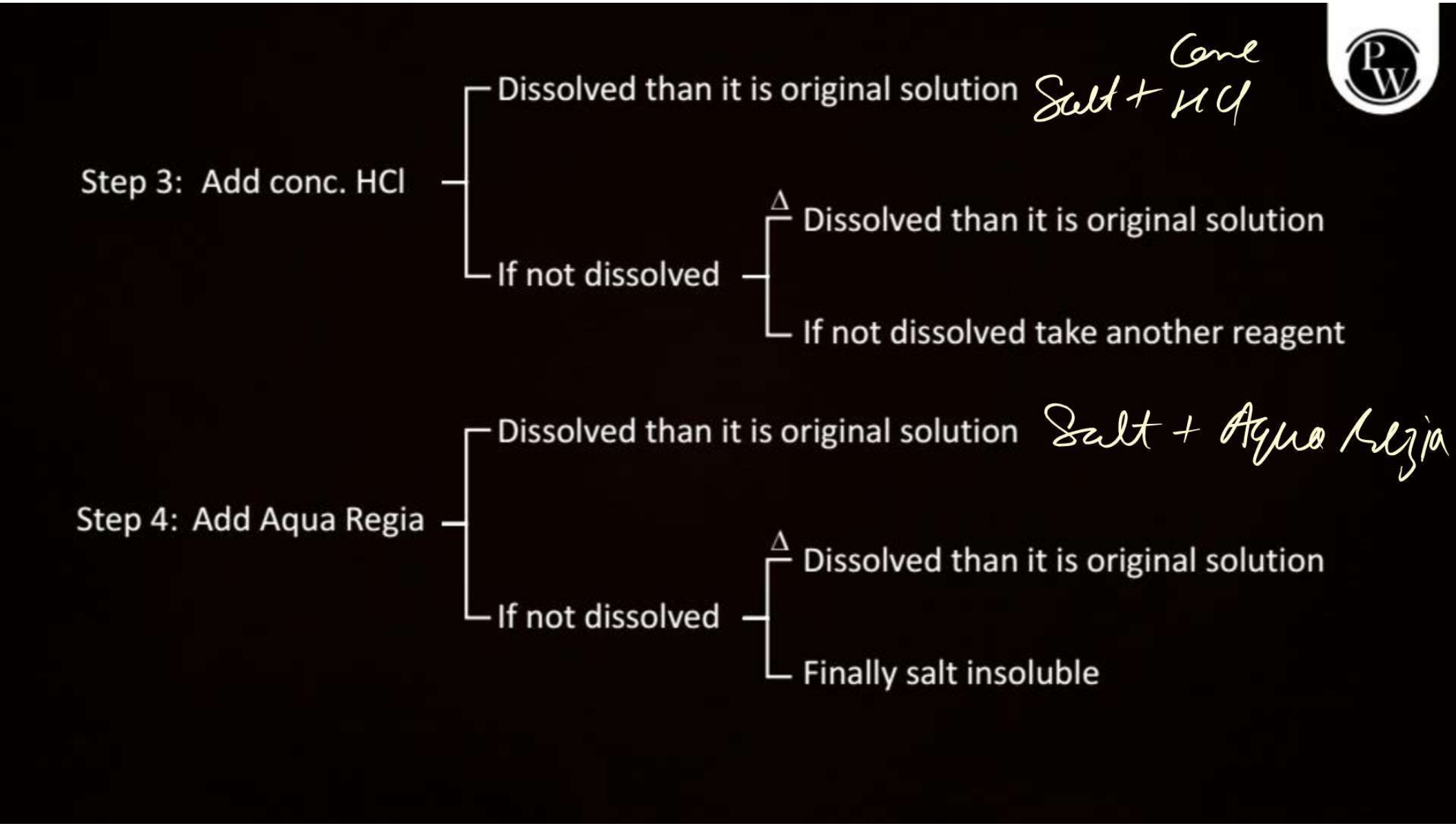
Wet Test

- The first essential step is to prepare a clear and transparent solution of the salt.
- This is called original solution.
- It is prepared as follows:

Preparation of Original Solutions

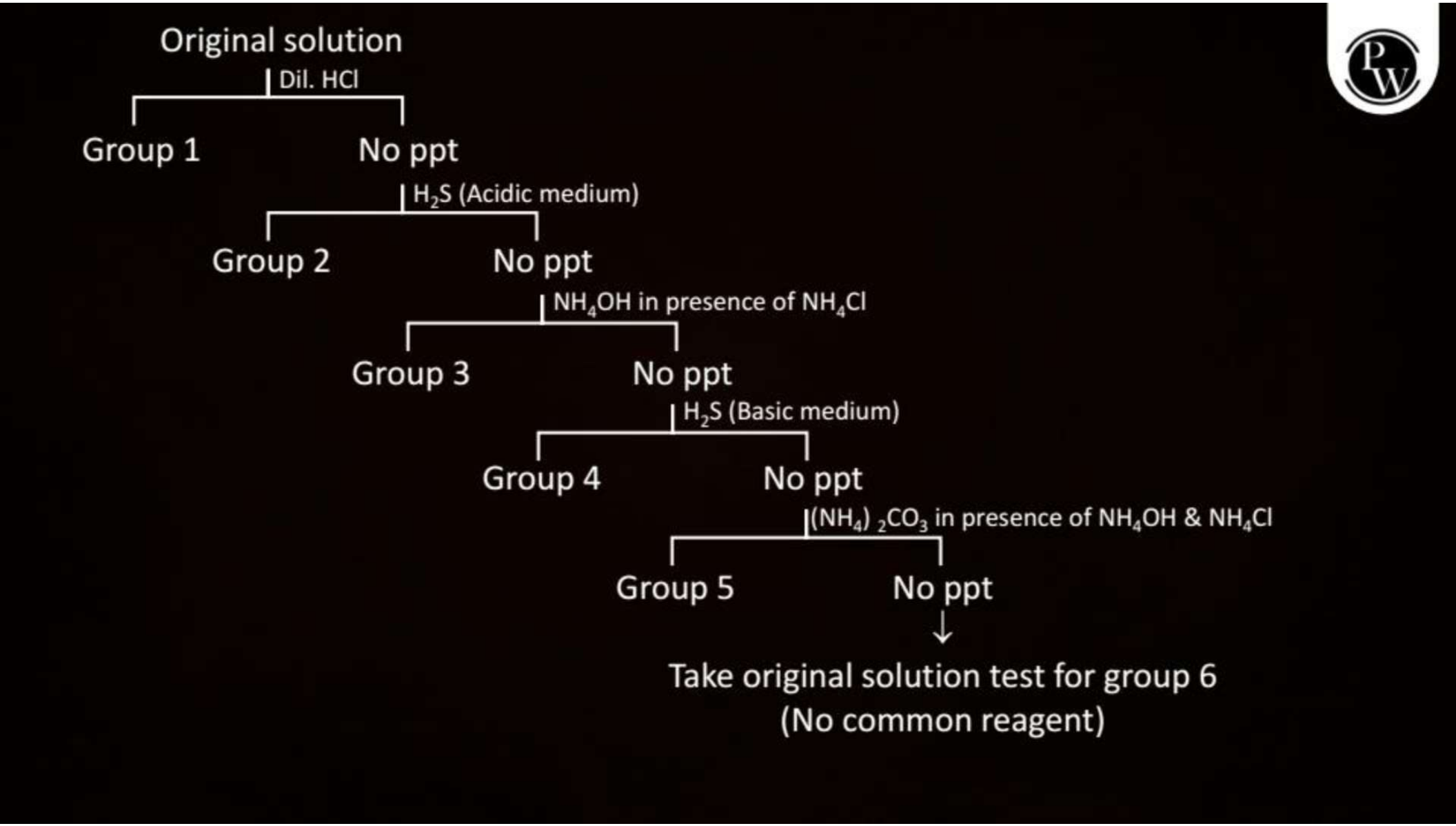
Take salt in test tube

- Step 1: Add H_2O
  - Dissolved than it is original solution — Salt + H_2O
  - If not dissolved
    - Δ
      - Dissolved than it is original solution
      - If not dissolved take another reagent
- Step 2: Add dil. HCl
  - Dissolved than it is original solution — Salt + HCl
  - If not dissolved
    - Δ
      - Dissolved than it is original solution
      - If not dissolved take another reagent


Step 3: Add conc. HCl
Dissolved than it is original solution
Conc
Salt + HCl
If not dissolved
Δ
Dissolved than it is original solution
If not dissolved take another reagent
Step 4: Add Aqua Regia
Dissolved than it is original solution
Salt + Aqua Regia
If not dissolved
Δ
Dissolved than it is original solution
Finally salt insoluble

Classification of Cation :

Group No.	Cation	Reagent	PPT
0	NH_4^+	NaOH	NH_3(g)
I	Ag^+, Hg_2^{2+}, Pb^{2+}	Dil HCl	AgCl (white), $PbCl_2$(white), Hg_2Cl_2 (white)
II (A)	Hg^{2+}, Pb^{2+} Cu^{2+} Cd^{2+} Bi^{3+}	H_2S (Acidic medium)	HgS (black), PbS (black), CuS(black), CdS(yellow), Bi_2S_3 (brownish black)
II (B)	As^{3+}, As^{5+}, Sb^{3+}, Sb^{5+} Sn^{2+}, Sn^{4+},	H_2S (Acidic medium)	As_2S_3 (yellow), As_2S_5(yellow), Sb_2S_3(Orange), Sb_2S_5(Orange) SnS (Brown), SnS_2(yellow).
III	Al^{3+}, Cr^{3+}, Fe^{3+}	NH_4OH in presence of NH_4Cl	$Al(OH)_3$ (White), $Cr(OH)_3$(Green), $Fe(OH)_3$ (Brown)
IV	Ni^{2+}, Co^{2+}, Mn^{2+}, Zn^{2+}	H_2S (Basic medium)	NiS (Black), CoS (Black), MnS (Buff), ZnS (White)
V	Ba^{2+}, Sr^{2+}, Ca^{2+}	$(NH_4)_2CO_3$ in presence of NH_4OH & NH_4Cl	$BaCo_3$ (White), $SrCo_3$ (White), $CaCo_3$ (White)
VI	Na^+, Mg^{2+}, K^+	No common reagent	–


Original solution
Dil. HCl
Group 1
No ppt
H_2S (Acidic medium)
Group 2
No ppt
NH_4OH in presence of NH_4Cl
Group 3
No ppt
H_2S (Basic medium)
Group 4
No ppt
$(NH_4)_2CO_3$ in presence of NH_4OH & NH_4Cl
Group 5
No ppt
Take original solution test for group 6
(No common reagent)

QUESTION

In group I dil. HCl is used as a group reagent but not a conc. HCl why ?

Ag^+

AgCl is soluble in Conc HCl

$[AgCl_2]^-$

QUESTION

Pb^{2+} ion is present in two different group why ?

$PbCl_2 \downarrow$ Soluble in Boil water 'W' But Insoluble in Cold water

QUESTION

Before the test of group III filtrated solution must be boiled in presence of conc. HNO_3.

$$Fe^{2+} \xrightarrow[\text{Boil}]{HNO_3} Fe^{+3}$$

QUESTION

NH_4OH is used as a group III reagent but in presence of NH_4Cl why ?

NH_4OH

$NH_4OH \longrightarrow NH_4^+ + OH^-$

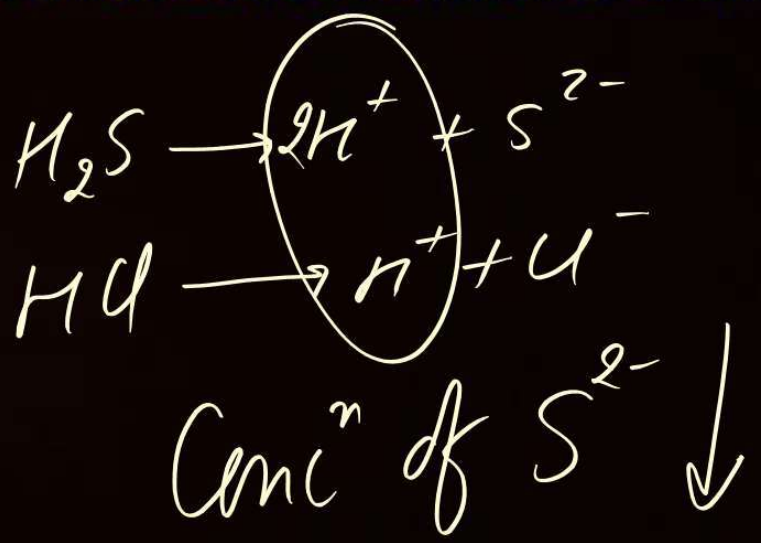
$NH_4Cl \longrightarrow NH_4^+ + Cl^-$

Conc^n of OH^- ↓

only gr 3 cation → reaction

QUESTION

H_2S gas is used as a group II reagent but in presence of acidic medium why ?



QUESTION

H_2S gas is used as a group IV reagent but in presence of basic medium why ?

S^{2-} ↑

QUESTION

NH_4^+ is present in separate group why ?

$NH_4^+ \longrightarrow NH_3$ gas

Test for Group-I cation :

Test for Pb^{+2}

1. $Pb^{+2} + KI \longrightarrow \underset{\text{yellow}}{PbI_2} \xrightarrow[KI]{\text{excess}} [PbI_4]^{2-}$

2. $Pb^{+2} + KCN \longrightarrow \underset{\text{white}}{Pb(CN)_2} \xrightarrow[KCN]{\text{excess}} N.R$

3. $Pb^{+2} + NaOH \longrightarrow \underset{\text{'w'}}{Pb(OH)_2} \xrightarrow[NaOH]{\text{excess}} [Pb(OH)_4]^{2-}$

4. $Pb^{+2} + NH_4OH \longrightarrow Pb(OH)_2 \xrightarrow[NH_4OH]{\text{excess}} N.R$

5. $Pb^{+2} + H_2S \longrightarrow \underset{\text{(red)}}{Pb_2SCl_2} \xrightarrow{\text{Dilution}} \underset{\text{black}}{PbS} + \underset{\text{'w'}}{PbCl_2}$

Test of Ag^+

1. $Ag^+ + KI \longrightarrow \underset{\text{yellow}}{AgI} \xrightarrow[KI]{\text{excess}} N \cdot R$

2. $Ag^+ + KCN \longrightarrow \underset{\text{(white ppt)}}{AgCN} \xrightarrow[KCN]{\text{excess}} [Ag(CN)_2]^-$

3. $Ag^+ + NaOH \longrightarrow \underset{\text{Brown}}{Ag_2O} \xrightarrow[NaOH]{\text{excess}} N \cdot R$

4. $Ag^+ + NH_4OH \longrightarrow Ag_2O \xrightarrow{\text{excess}} [Ag(NH_3)_2]^+$

5. $Ag^+ + H_2S \longrightarrow Ag_2S$ (Black)

Q.S.P

Noble metal + Base → no

Test of Hg_2^{2+}

1. ★ $Hg_2Cl_2 + NH_4OH \longrightarrow Hg(NH_2)Cl + Hg$
   Calomel (white)
   (White) (Black) → Black

Q.5.P

$Hg_2^{2+} \longrightarrow Hg + Hg^{2+}$

2. $Hg_2^{+2} + NaOH \longrightarrow Hg_2O \xrightarrow[NaOH]{\text{excess}} N.R.$
   (Black)
   Boil → Grey: $HgO + Hg$
   (yellow) (Black)

3. ★ $Hg_2(NO_3)_2 + NH_4OH \longrightarrow HgO \cdot Hg(NH_2)NO_3 + Hg$
   Basic mercury (II) amido nitrate + black ppt
   (white)

QUESTION

Define the solubility of metal sulphide ?

PPT	YAS	Dil HNO_3
HgS	✗	✗
PbS	✗	✓
CuS	✗	✓
CdS	✗	✓
Bi_2S_3	✗	✓

PPT	YAS	CAS	Non oxidizing acid	Alkaline solution
As_2S_3	✓	✓	✗	✓
As_2S_5	✓	✓	✓	✓
Sb_2S_3	✓	✓	✓	✓
Sb_2S_5	✓	✓	✓	✓
SnS	✓	✗	✓	✓
SnS_2	✓	✓	✓	✓

YAS (Yellow Ammonium Sulphide) : $(NH_4)_2S_x$ (x = 2 to 6)

CAS (Colourless Ammonium Sulphide) : $(NH_4)_2S$

Test for Group-II cation :

Test of Cu^{2+}

1. $Cu^{+2} + I^- \longrightarrow CuI_2 \longrightarrow$ not possible

$\downarrow Cu_2I_2 + I_2 \xrightarrow{KI} KI_3$

(white ppt) (brown colour)

Brown Colouration

2. $Cu^{+2} + KCN \longrightarrow Cu(CN)_2 \longrightarrow CuCN + (CN)_2 \uparrow$ Cyanogen

(yellow ppt)
decompose quickly

(white ppt)

$\downarrow$ Ex KCN

$K_3[Cu(CN)_4]$
perfect complex w.r.t. H_2S

$\xleftarrow{H_2S}$ No PPT

3. $Cu^{+2} + NaOH \longrightarrow Cu(OH)_2 \xrightarrow{\text{excess}} N.R.$

light blue ppt

$\downarrow \Delta$

$CuO + H_2O$

(Black)

4. $CuSO_4 + NH_4OH \longrightarrow CuSO_4 \cdot Cu(OH)_2 \xrightarrow{\text{excess}} [Cu(NH_3)_4]^{2+}$

basic copper sulphate (blue ppt)

deep blue solution

Test of Cd^{2+}

1. $Cd^{2+} + NaOH \longrightarrow \underset{\text{white}}{Cd(OH)_2} \xrightarrow{\text{excess}} N.R.$

2. $Cd^{2+} + NH_4OH \longrightarrow Cd(OH)_2 \xrightarrow{\text{excess}} [Cd(NH_3)_4]^{2+}$

3. $Cd^{+2} + KCN \longrightarrow \underset{\text{white}}{Cd(CN)_2} \xrightarrow{\text{excess}} K_2[Cd(CN)_4]$ [Imperfect complex w.r.t. H_2S]
   $\downarrow H_2S$
   CdS (yellow ppt)

4. $Cd^{+2} + H_2S \longrightarrow CdS$ (yellow)

Test of Hg^{2+}

1. $Hg^{2+} + KI \longrightarrow \underset{\text{(scarlet red)}}{HgI_2} \xrightarrow{\text{excess}} [HgI_4]^{2-}$

2. $Hg^{2+} + CN^- \longrightarrow \underset{\text{soluble}}{Hg(CN)_2}$

3. $Hg^{2+} + NaOH \longrightarrow \underset{\text{(yellow)}}{HgO} \xrightarrow{\text{excess}} NR$

4. $Hg(NO_3)_2 + NH_4OH \longrightarrow \underset{\substack{\text{basic mercury (II)} \\ \text{amido nitrate}}}{HgO \cdot HgNH_2NO_3} \xrightarrow{\text{excess}} NR$

6. $Hg^{2+} + 2Co(SCN)_2 \longrightarrow \underset{\text{(blue ppt)}}{Co[Hg(SCN)_4]}$

Test of Bi^{+3}

1. $Bi^{+3} + I^- \longrightarrow \underset{\text{(black)}}{BiI_3} \xrightarrow{\text{excess}} \underset{\text{(orange)}}{K[BiI_4]}$

   On hydrolysis

   $BiI_3 + H_2O \longrightarrow BiOI + 2HI$

   Orange turbidity

2. $Bi^{+3} + CN^- \longrightarrow Bi(CN)_3 + HCN\uparrow$

3. $Bi^{+3} + NaOH \longrightarrow Bi(OH)_3 \xrightarrow{\text{excess}} N.R$

4. $Bi(NO_3)_3 + NH_4OH \longrightarrow \underset{\text{white}}{Bi(OH)_2(NO_3)} \xrightarrow{\text{excess}} N.R.$

5. $Bi^{+3} + H_2S \longrightarrow Bi_2S_3$

   black)

Test for Group-III cation :

Test for Al

1. $Al^{+3} + NaOH \longrightarrow \underset{\text{(white)}}{Al(OH)_3} \xrightarrow{\text{excess}} [Al(OH)_4]^-$

2. $Al^{+3} + NH_4OH \longrightarrow Al(OH)_3 \xrightarrow{\text{excess}} N.R.$

Q.S.P. (i) Al^{+3}, Cr^{+3}, $Mg^{+2} \rightarrow$ Their sulphide salts do not exist in their aqueous solution because they are readily hydrolyzed

(ii) Fe^{+3}, Cr^{+3}, $Al^{+3} \rightarrow$ Their carbonate salts do not exist in their aqueous solution because they are readily hydrolyzed.

3. $Al^{+3} + H_2S \longrightarrow$ N.R

4. $Al^{+3} + H_2S \xrightarrow{\text{basic}} Al_2S_3 \longrightarrow Al(OH)_3 + H_2S\uparrow$

5. $Al^{+3} + (NH_4)_2S \longrightarrow Al_2S_3 \longrightarrow Al(OH)_3$

6. $Al^{+3} + Na_2CO_3 \longrightarrow Al(OH)_3 \downarrow$ 'W'

7. $Al^{+3} + CH_3COO^- + H_2O \longrightarrow Al(OH)_2CH_3COO\downarrow$

'W'

Test for Cr^{+3}

1. $Cr^{+3} + NaOH \longrightarrow Cr(OH)_3 \xrightarrow{\text{excess}} [Cr(OH)_4]^-$
2. $Cr^{+3} + NH_4OH \longrightarrow Cr(OH)_3 \xrightarrow{\text{excess}} [Cr(NH_3)_6]^{3+}$ (pink colour)
3. $Cr^{+3} + H_2S \longrightarrow$ N.R.
4. $Cr^{+3} + H_2S \xrightarrow{\text{Basic}} Cr_2S_3 \longrightarrow Cr(OH)_3 \downarrow + H_2S \uparrow$
5. $Cr^{+3} + (NH_4)_2S \longrightarrow Cr_2S_3 \longrightarrow Cr(OH)_3 \uparrow$
6. $Cr^{+3} + Na_2CO_3 \longrightarrow Cr(OH)_3$ (green)
7. $Cr^{+3} + CH_3COO^- + H_2O \longrightarrow Cr(OH)_2CH_3COO \downarrow$

Test for Fe^{+3}

1. $Fe^{+3} + NaOH \longrightarrow Fe(OH)_3 \xrightarrow{excess} N.R$
2. ★ $Fe^{+3} + NH_4OH \longrightarrow \underset{\text{Brown}}{Fe(OH)_3} \xrightarrow{excess} N.R$
3. $Fe^{+3} + H_2S \longrightarrow Fe^{2+} + S\downarrow$
4. $Fe^{+3} + H_2S \xrightarrow{basic} Fe_2S_3$
5. $Fe^{+3} + (NH_4)_2S \longrightarrow S + Fe^{+2} \xrightarrow{S^{2-}} FeS$
6. $Fe^{+3} + CH_3COO^- + H_2O \longrightarrow Fe(OH)_2CH_3COO$
7. $Fe^{+3} + CN^- \longrightarrow \underset{\text{brown}}{Fe(CN)_3} \xrightarrow{excess} K_3[Fe(CN)_6]$

Test for Group-IV cation

Test for Zn

1. $Zn^{+2} + NaOH \longrightarrow \underset{\text{(white)}}{Zn(OH)_2} \xrightarrow{\text{excess}} [Zn(OH)_4]^{2-}$

2. $Zn^{+2} + NH_4OH \longrightarrow Zn(OH)_2 \xrightarrow{\text{excess}} [Zn(NH_3)_4]^{2+}$

3. $Zn^{+2} + H_2S \longrightarrow$ N R

4. $Zn^{+2} + H_2S \xrightarrow{\text{basic}} ZnS$

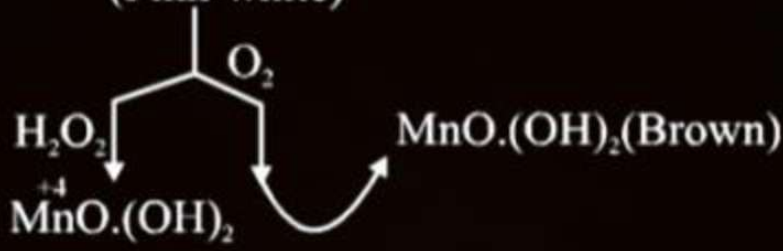
5. $Zn^{+2} + (NH_4)_2S \longrightarrow ZnS$

6. $Zn^{+2} + Na_2CO_3 \longrightarrow 2Zn(OH)_2 \cdot ZnCO_3 \xrightarrow{\Delta} ZnO + H_2O + CO_2$

Q.S.P. ZnO Philosopher's wool, Purest form — Pure

Test for Mn

1. $Mn^{+2} + NaOH \longrightarrow Mn(OH)_2$ (Pink-white) $\xrightarrow{\text{excess}}$ insoluble



$(MnO_2 \cdot H_2O)$

2. $Mn^{+2} + NH_4OH \rightleftharpoons Mn(OH)_2 + NH_4^{\oplus}$

3. $Mn^{+2} + H_2S \longrightarrow X$

4. $Mn^{+2} + H_2S \xrightarrow{\text{basic}} MnS$(pink / Buff)

5. $Mn^{+2} + (NH_4)_2S \longrightarrow MnS$

Test for Ni

1. $Ni^{2+} + NaOH \longrightarrow Ni(OH)_2$ 'G'

2. $Ni^{2+} + NH_4OH \longrightarrow Ni(OH)_2 \longrightarrow [Ni(NH_3)_6]^{2+}$ Blue

3. $Ni^{2+} + (NH_4)_2S \longrightarrow NiS$ Black

4. $Ni^{2+} + KCN \longrightarrow Ni(CN)_2 \xrightarrow{Ex} [Ni(CN)_4]^{2-}$ dsp^2
   Green Yellow

5. $Ni^{2+} + 2\,dmg^- \longrightarrow [Ni(dmg)_2]$ Rosy red ↓

6. Ni sheet + $dmg^- \longrightarrow N.R.$

QUESTION

Fe^{2+}, Bi^{3+}, Co^{3+} must be absent during the test of Ni^{2+} ion.

(a) Fe^{+2} → Red Colouration
(b) Bi^{+3} → yellow ppt
(c) Co^{+3} → Brown Colourtion

} Must be absent in the test of $Ni^{\oplus 2}$

Test for Co

1. $Co^{+2} + NaOH \longrightarrow$ $Co(OH)_2$ (Blue) $\xrightarrow{Ex}$ N.R.

2. $Co^{+2} + NH_4OH \longrightarrow$ $Co(OH)_2$ (Blue) $\longrightarrow$ $[Co(NH_3)_6]^{2+}$ (Yellowish Brown)

3. $Co^{+2} + (NH_4)_2S \longrightarrow$ CoS (Black)

4. $Co^{+2} + KCN \longrightarrow$ $Co(CN)_2$ (Reddish) $\longrightarrow$ $[Co(CN)_4]^{2-}$ (Brown)

Other Reaction

Step-1

$Co^{+2} + NO_2^- + H^+ \longrightarrow Co^{+3} + NO$

Step-2

$Co^{+3} + NO_2^- + K^+ \longrightarrow K_3[Co(NO_2)_6]$

Test for Group-V cation

Test for Ca^{+2}, Sr^{+2}, Ba^{+2}

	Ca^{+2}	Sr^{+2}	Ba^{+2}
$(NH_4)_2CrO_4$	—	—	$BaCrO_4$ ↓
$(NH_4)_2SO_4$	—	$SrSO_4$ ↓	$BaSO_4$ ↓
$(NH_4)_2C_2O_4$	CaC_2O_4 ↓	SrC_2O_4 ↓	BaC_2O_4 ↓

Test for Group-VI cation

PPT Reaction

$K^+ + HClO_4 \longrightarrow$ KClO4 ↓ 'w'

Test for K^+

$K^+ + Na_3[Co(NO_2)_6] \longrightarrow$ $K_3[Co(NO_2)_6]$ 'y' fisher Complex

$K^+ + H_2[PtCl_6] \longrightarrow$ $K[PtCl_6]$ 'y'

$K^+ + NaC_4H_5O_6 \longrightarrow$ $KC_4H_5O_6$ 'w'

Test for Na^+

$Na^+ + KH_2SbO_4 \longrightarrow NaH_2SbO_4$ 'y'wl

Test for Mg^{+2}

$Mg^{+2} + NH_4OH + NH_4Cl + HPO_4^{2-} \longrightarrow MgNH_4PO_4 \longrightarrow Mg_2P_2O_7 + NH_3$

Test for Group-o

Reaction with NaOH

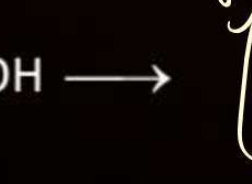
$NH_4X + NaOH \longrightarrow NH_4OH \downarrow NH_3 + H_2O$

Identification of NH_3

$NH_3 + HCl \longrightarrow NH_4Cl$ ↑ (White)

$NH_3 + CuSO_4 \longrightarrow [Cu(NH_3)_4]$ Sky Blue (Switzer)

$NH_3 + NiCl_2 \longrightarrow [Ni(NH_3)_6]^{2+}$ Blue

$NH_3 + K_2(HgI_4) + KOH \longrightarrow$  ↓ Brown Milon's Base

PPT Reaction

$NH_4^+ + Na_3[Co(NO_2)_6] \longrightarrow (NH_4)_3[Co(NO_2)_6]$ 'Y'

$NH_4^+ + H_2[PtCl_6] \longrightarrow (NH_4)_2[PtCl_6]$ 'Y'

$NH_4^+ + NaC_4H_5O_6 \longrightarrow NH_4C_4H_5O_6$ 'W'

$NH_4^+ \mid K^+$

Charge same

Size Same

Identification of $\overset{\oplus}{N}H_4$ & $K^{\oplus}$ if present together