Qualitative inorganic analysis

part (II)

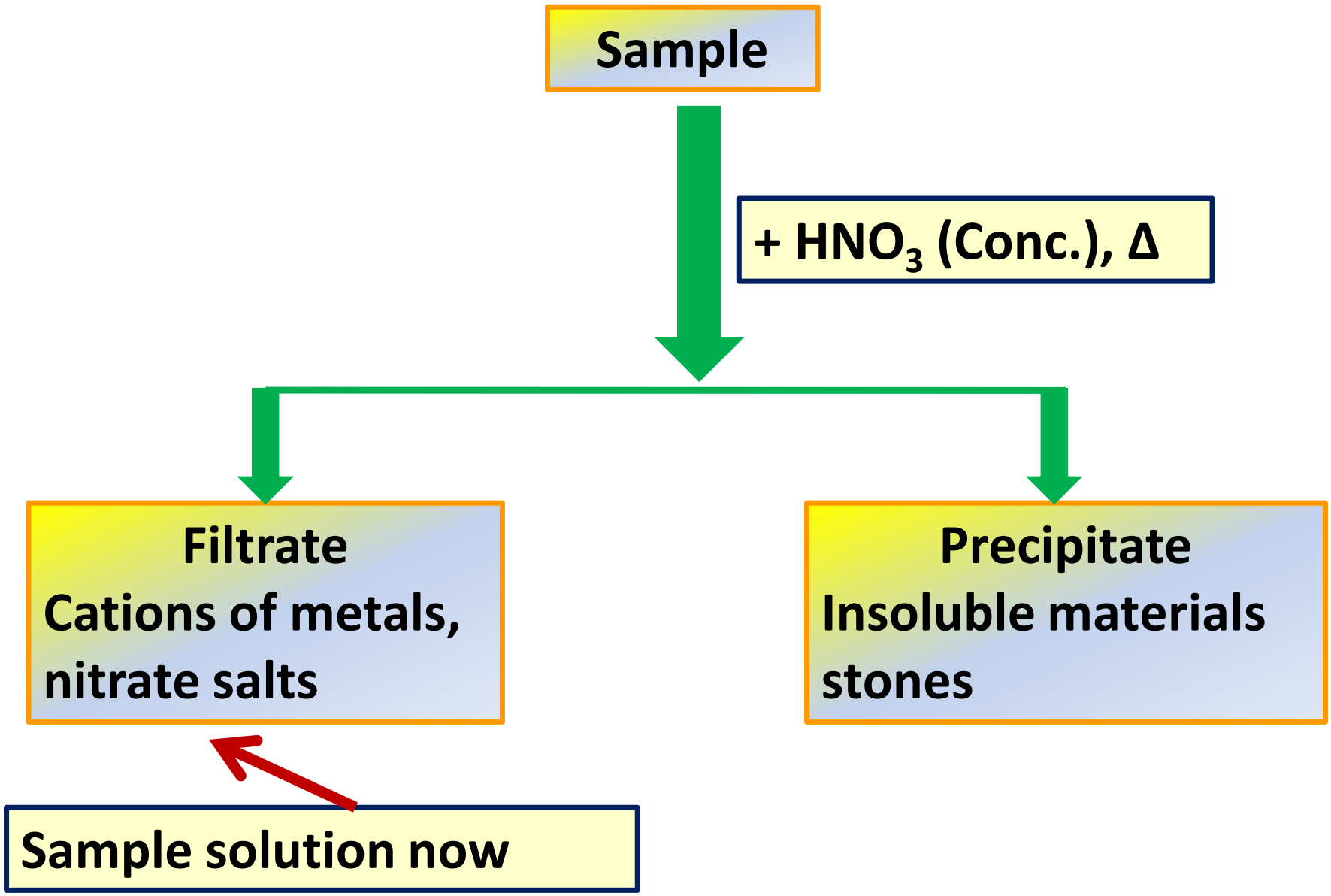
Cations

Classification of cations

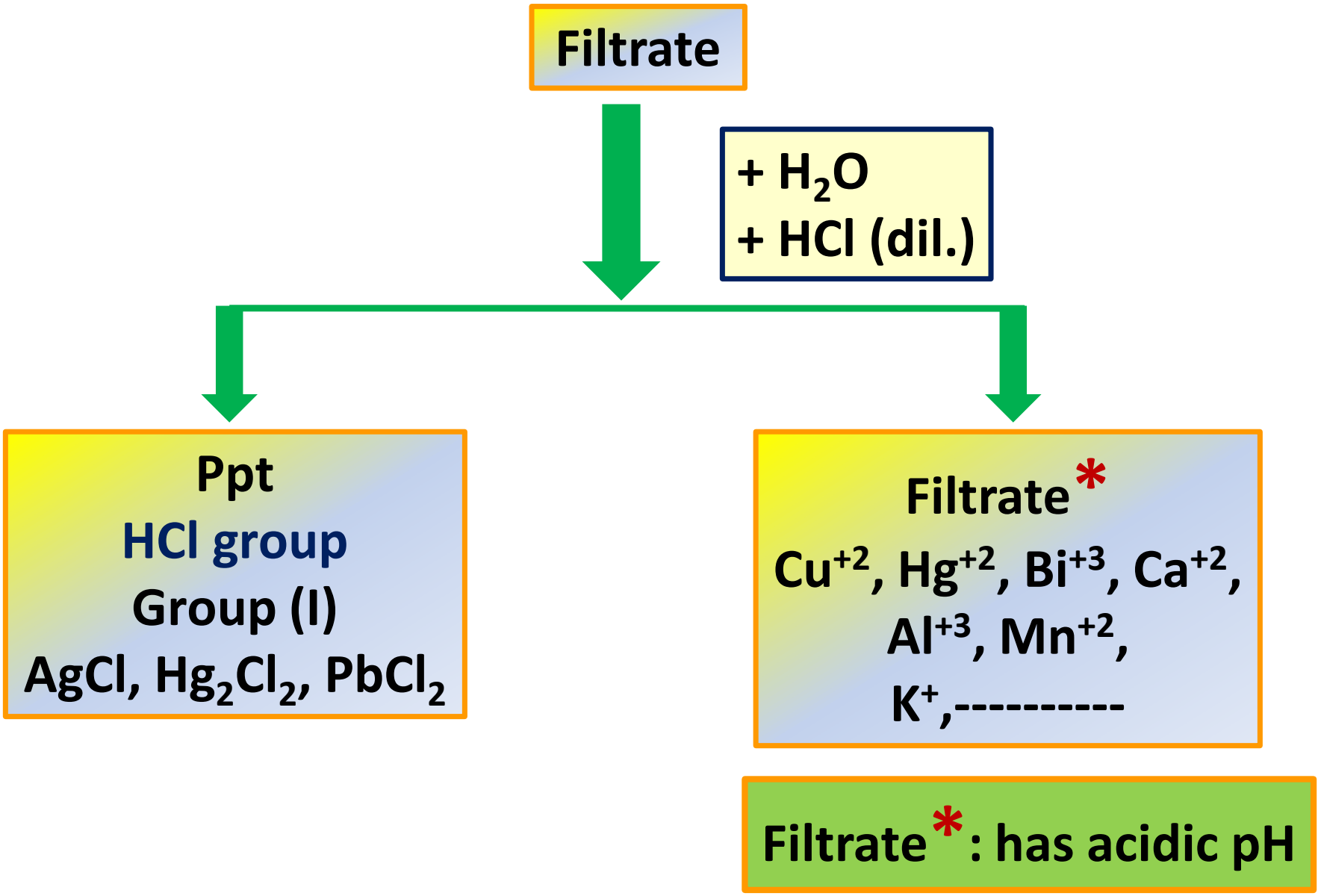
If you have an alloy??? What are the components???

The first step is dissolution of metals and separation of any insoluble materials e.g. stones, wood,----

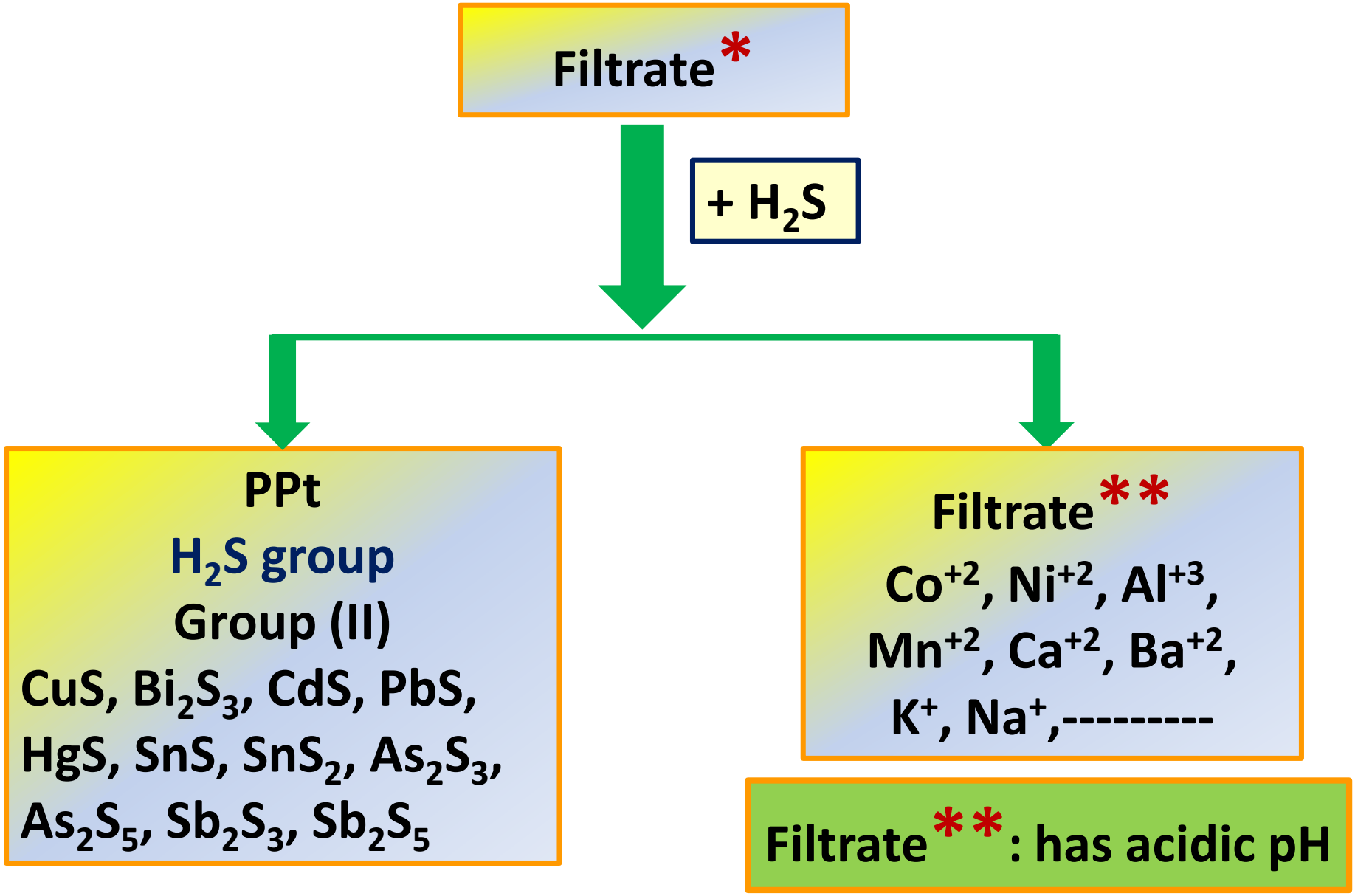
Classification of cations



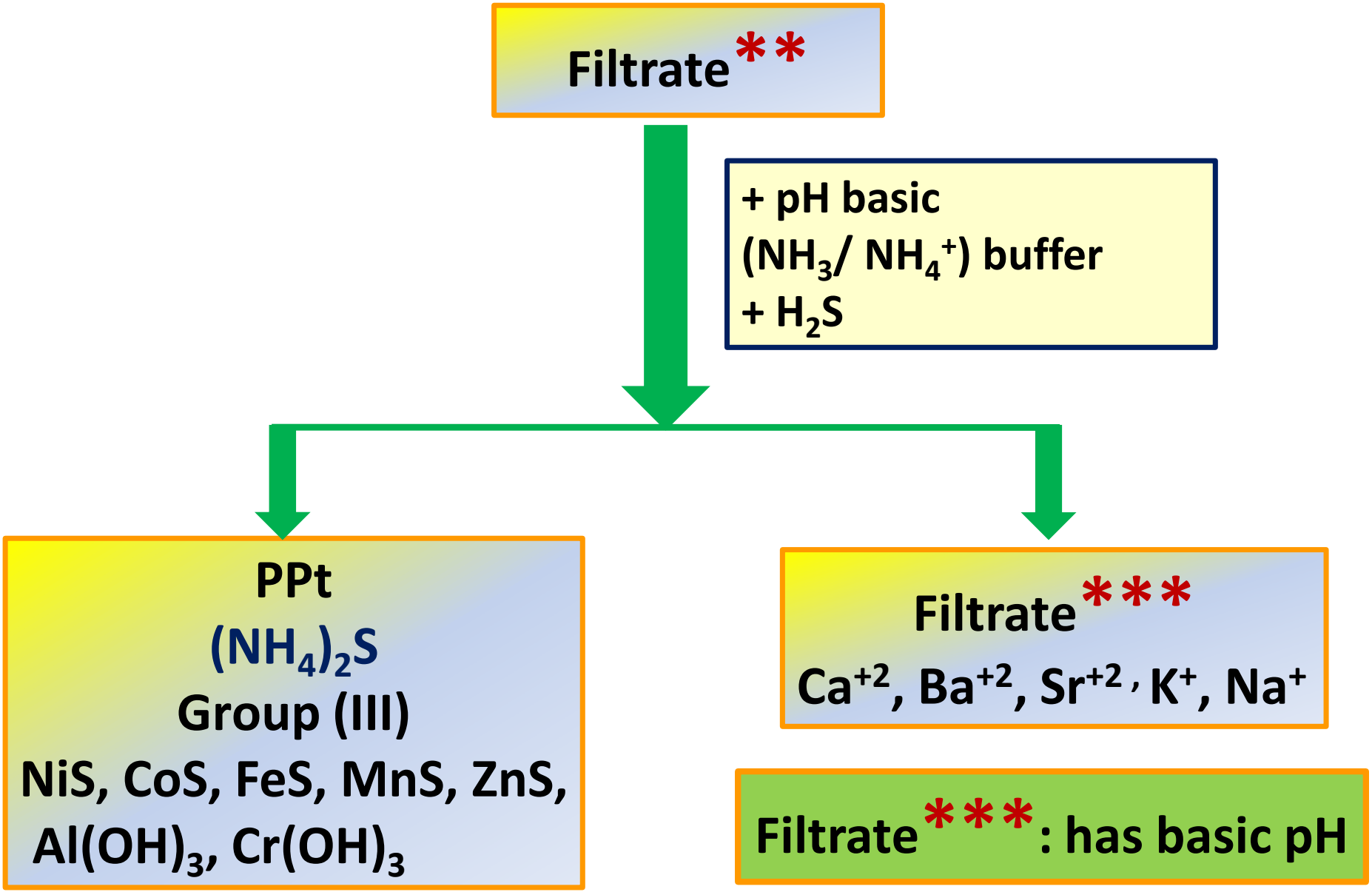
Classification of cations



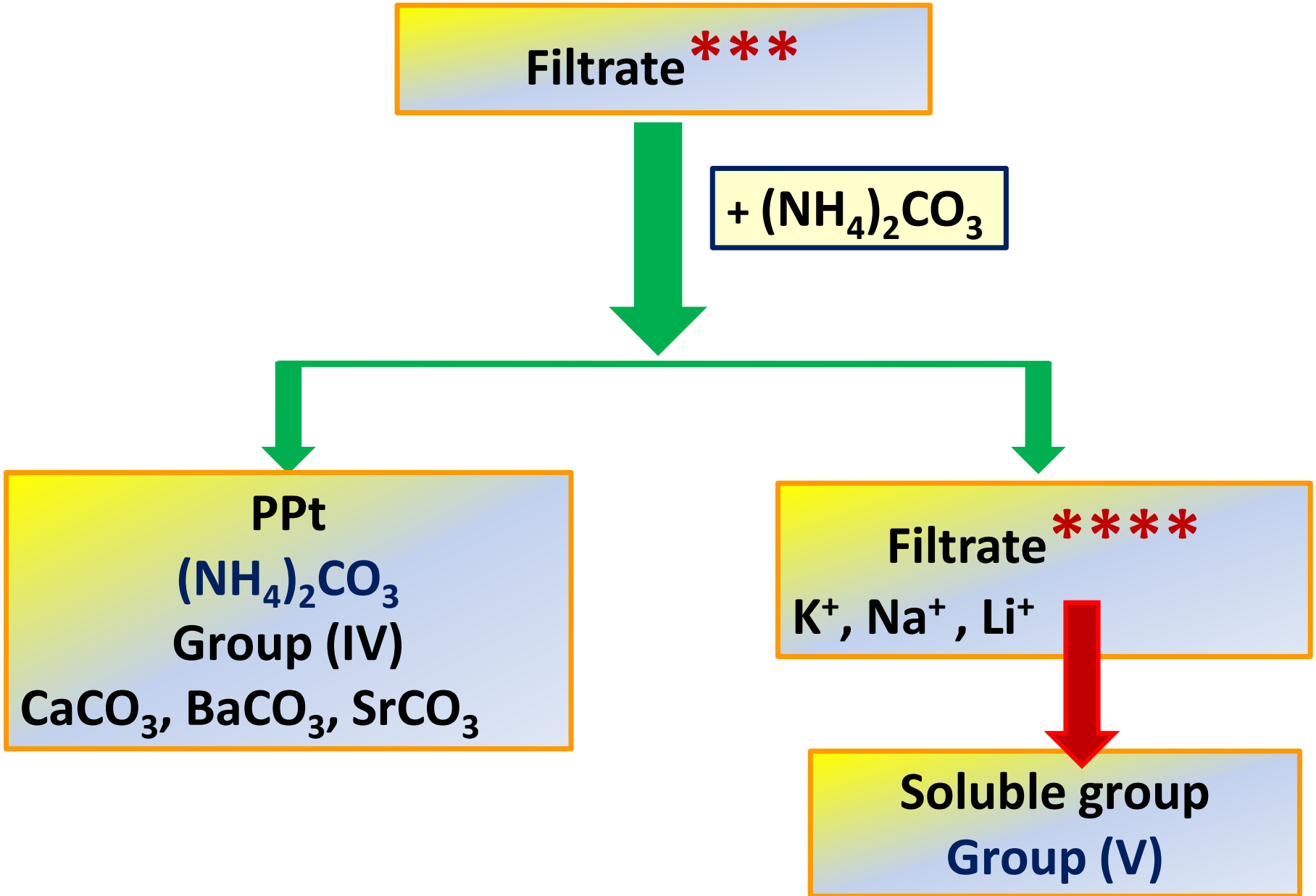
Classification of cations



Classification of cations



Classification of cations



Classification of cations

Cations are classified in 5 groups:

Group	Common reagent	Examples
Group (I)	HCl group	Ag^{+}, Pb^{+2}, Hg_2^{+2}
Group (II)	H_2S group	Cu^{+2}, Cd^{+2}, Pb^{+2}, Hg^{+2}, Bi^{+3}, As^{+3}, As^{+5}, Sb^{+3}, Sb^{+5}, Sn^{+2}, Sn^{+4}
Group (III)	$(NH_4)_2S$	Co^{+2}, Ni^{+2}, Mn^{+2}, Zn^{+2}, Fe^{+2}, Al^{+3}, Cr^{+3}
Group (IV)	$(NH_4)_2CO_3$	Ca^{+2}, Ba^{+2}, Sr^{+2}
Group (V)	Soluble group	K^{+}, Na^{+}, Li^{+}

HCl group

Cations precipitate in acidic media as chloride salts belong to this group. Group (I)

This means also chloride salts of cations of group (II) - (V) are soluble

HCl group

Detection of Ag^+:

Complete, mention properties of ppt:

$Ag^+ + HCl \longrightarrow$

$Ag^+ + Br^- \longrightarrow$

$Ag^+ + I^- \longrightarrow$

$Ag^+ + CN^- \longrightarrow$

$Ag^+ + SCN^- \longrightarrow$

$Ag^+ + SO_3^{-2} \longrightarrow$

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

$Ag^+ + PO_4^{-3} \longrightarrow$

HCl group

Detection of Pb^{+2}:

With HCl:

$$Pb^{+2} + 2\,HCl \longrightarrow PbCl_2\downarrow + 2\,H^+$$

white ppt, soluble on heating , reformed on cooling [ppt has high Ksp]. Pb^{+2} is found again in Group (II)

HCl group

Detection of Pb^{+2}:

With NaOH:

$$Pb^{+2} + 2\ OH^{-} \longrightarrow \underset{\text{white ppt}}{Pb(OH)_2\downarrow} \xrightarrow{+\ 2\ OH^{-}} \underset{\text{soluble complex}}{[Pb(OH)_4]^{-2}}$$

$[Pb(OH)_4]^{-2}$: tetrahydroxoplumbate(II) ion

HCl group

Detection of Pb^{+2}:

With H_2S:

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

black ppt, soluble in HNO_3 (Conc.)

Redox reaction: Balance equation

$$PbS + HNO_3 \longrightarrow Pb^{+2} + NO + S + NO3^{-} + H_2O$$

HCl group

Detection of Pb^{+2}:

Redox reaction:

$$3\ PbS + 8\ HNO_3 \longrightarrow 3\ Pb^{+2} + 2\ NO + 3\ S\downarrow + 6\ NO3^{-} + 4\ H_2O$$

HCl group

Detection of Pb^{+2}:

With H_2SO_4 (dil.):

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

white ppt, soluble in H_2SO_4 (conc.), NaOH (Conc.)

$$PbSO_4\,(s) + H_2SO_4\,(conc.) \longrightarrow Pb^{+2} + 2\,HSO_4^{-}$$

$$PbSO_4\,(s) + 4\,OH^{-} \longrightarrow [Pb(OH)_4]^{-2} + SO_4^{-2}$$

HCl group

Detection of Pb^{+2}:

With KI: Complete?????

$$Pb^{+2} + 2\,I^{-} \longrightarrow PbI_2\downarrow$$

yellow ppt, soluble in boiling water, on cooling golden yellow plates are formed.

HCl group

Detection of Hg_2^{+2}:

Mercury is a silver-white liquid metal at 25 °C, it is 13 times heavier than water.

With HCl (dil.):

$$Hg_2^{+2} + 2\,Cl^- \longrightarrow Hg_2Cl_2\downarrow$$

White ppt, (Calomel) insoluble in HNO_3 (dil.), insoluble in NH_3

$$Hg_2Cl_2 + 2\,NH_3 \longrightarrow Hg\downarrow + Hg(NH_2)Cl\downarrow + NH_4^+ + Cl^-$$

HCl group

Detection of Hg_2^{+2}:

With H_2S:

$$Hg_2^{+2} + H_2S \longrightarrow Hg\downarrow + HgS\downarrow + 2\,H^+$$

black ppt, dissolves by adding sodium sulfide

$$HgS + S^{-2} \longrightarrow [HgS_2]^{-2}$$

HCl group

Detection of Hg_2^{+2}:

With NaOH:

$$Hg_2^{+2} + 2\,OH^- \longrightarrow \underset{\text{black}}{Hg\downarrow} + \underset{\text{yellow}}{HgO\downarrow} + H_2O$$

HCl group

Detection of Hg_2^{+2}:

With KI:

$$Hg_2^{+2} + 2\,I^- \longrightarrow Hg_2I_2\downarrow$$

greenish-yellow

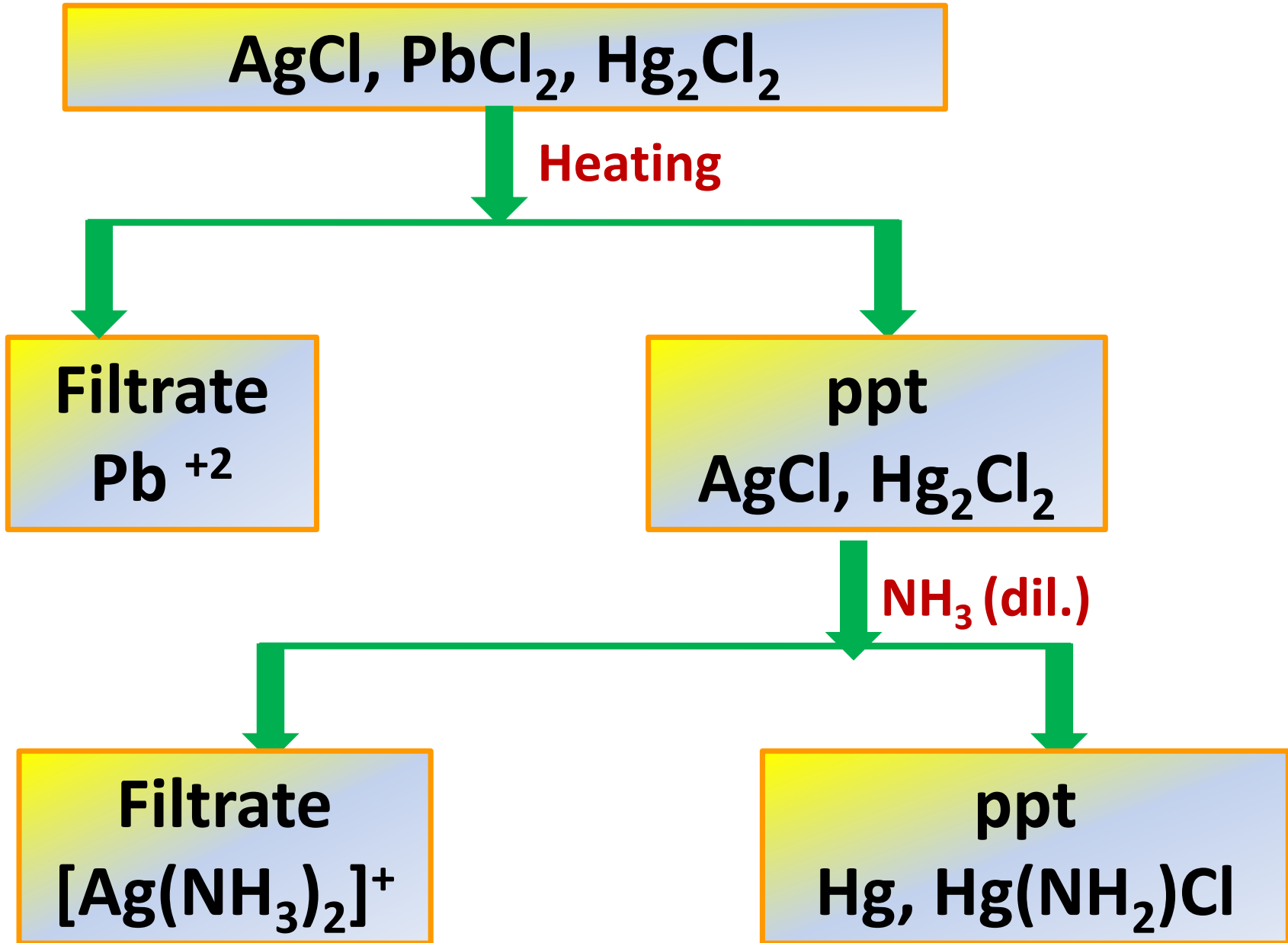
$$Hg_2I_2 \xrightarrow{\Delta} Hg\downarrow + HgI_2\downarrow$$

red ppt

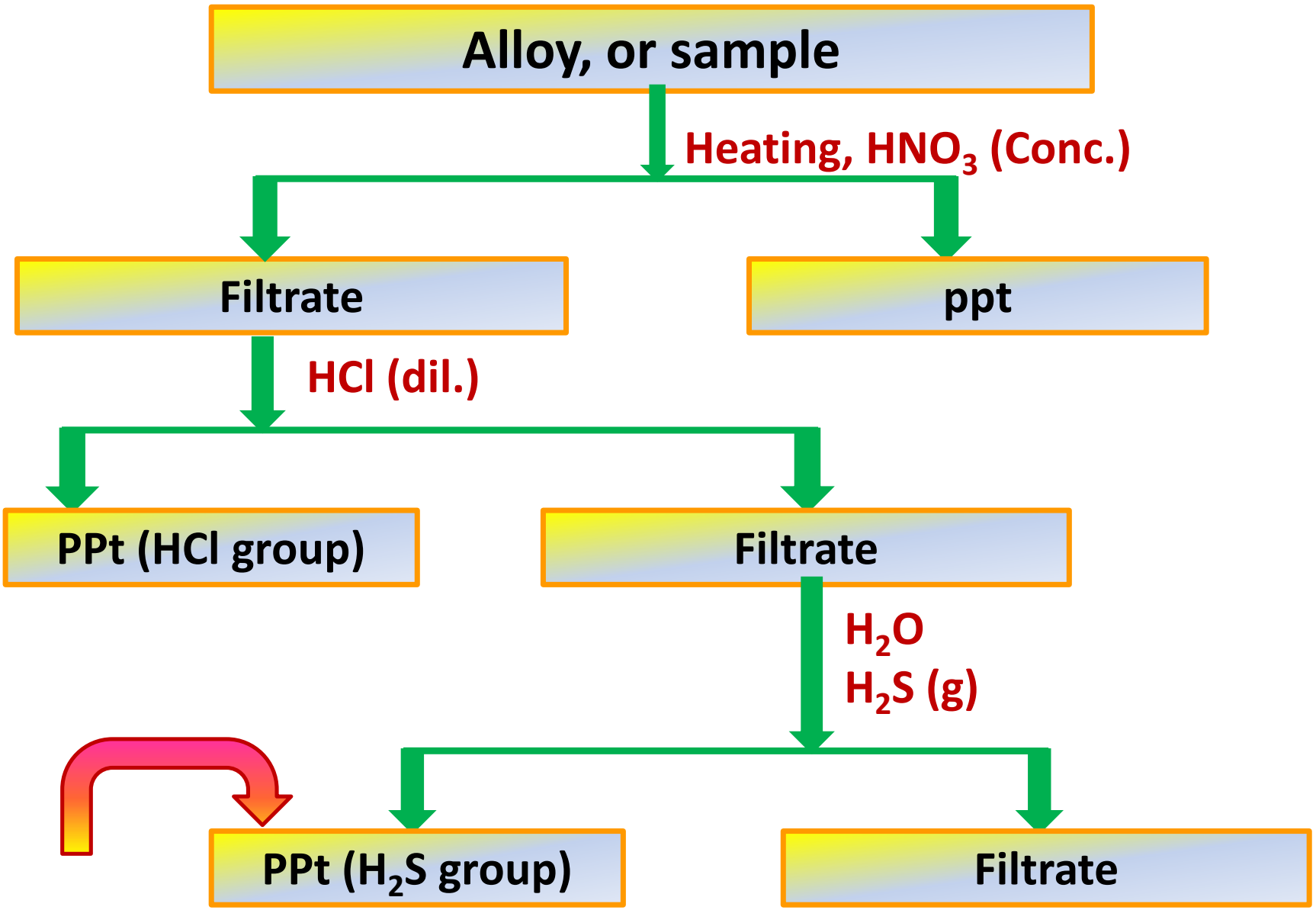
↓ with KI excess

$[HgI_4]^{-2}$ Nessler's reagent

HCl group


AgCl, PbCl2, Hg2Cl2
Heating
Filtrate
Pb +2
ppt
AgCl, Hg2Cl2
NH3 (dil.)
Filtrate
[Ag(NH3)2]+
ppt
Hg, Hg(NH2)Cl

Group (II): H_2S group



Group (II): H_2S group

PPt

H_2S group, Group (II)

CuS, Bi_2S_3, CdS, PbS, HgS,
SnS, SnS_2, As_2S_3, As_2S_5, Sb_2S_3, Sb_2S_5

H_2S group, Group (II)

Cations form insoluble sulfide salts in acidic media , since they have a very low Ksp.(?)

H_2S group is divided into two subgroups according to solubility in ammonium polysulfide $(NH_4)_2S_x$

Group (II): H_2S group

PPt H_2S group

CuS, Bi_2S_3, CdS, PbS, HgS,

SnS, SnS_2, As_2S_3, As_2S_5, Sb_2S_3, Sb_2S_5

Δ, $(NH_4)_2S_x$

Filtrate

Arsenic subgroup

(Thiosalts)

AsS_4^{-3}, SbS_4^{-3}, SnS_3^{-2}

ppt

Copper subgroup

CuS, Bi_2S_3, CdS, PbS, HgS

AsS_4^{-3}: Thioarsenate ion

SbS_4^{-3}: Thioantimonate ion

SnS_3^{-2} : Thiostannate ion

H_2S group: Arsenic subgroup

Arsenic subgroup: AsS_4^{-3}, SbS_4^{-3}, SnS_3^{-2}

Dissolution of sulfide salts in ammonium polysulfide is due to formation of thiosalts.

Dissolution is accompanied by a redox reaction.

$$As_2S_3 + 2\,S + 3\,S^{-2} \longrightarrow 2\,AsS_4^{-3}$$

$$Sb_2S_3 + 2\,S + 3\,S^{-2} \longrightarrow 2\,SbS_4^{-3}$$

$$SnS + S + S^{-2} \longrightarrow SnS_3^{-2}$$

H_2S group: Arsenic subgroup

Filtrate Arsenic subgroup

AsS_4^{-3}, SbS_4^{-3}, SnS_3^{-2}

HCl (dil.)

$$AsS_4^{-3} + 3\,H_3O^+ \longrightarrow H_3AsS_4 + 3\,H_2O$$

$$2\,H_3AsS_4 \longrightarrow As_2S_5 + 3\,H_2S$$

Thioarsenic acid

ppt

SnS_2, As_2S_5, Sb_2S_5

H_2S group: Arsenic subgroup

ppt

As_2S_5 , Sb_2S_5, SnS_2

HCl (Conc.)

ppt

As_2S_5

Filtrate

$[SbCl_6]^-$, $[SnCl_6]^{-2}$

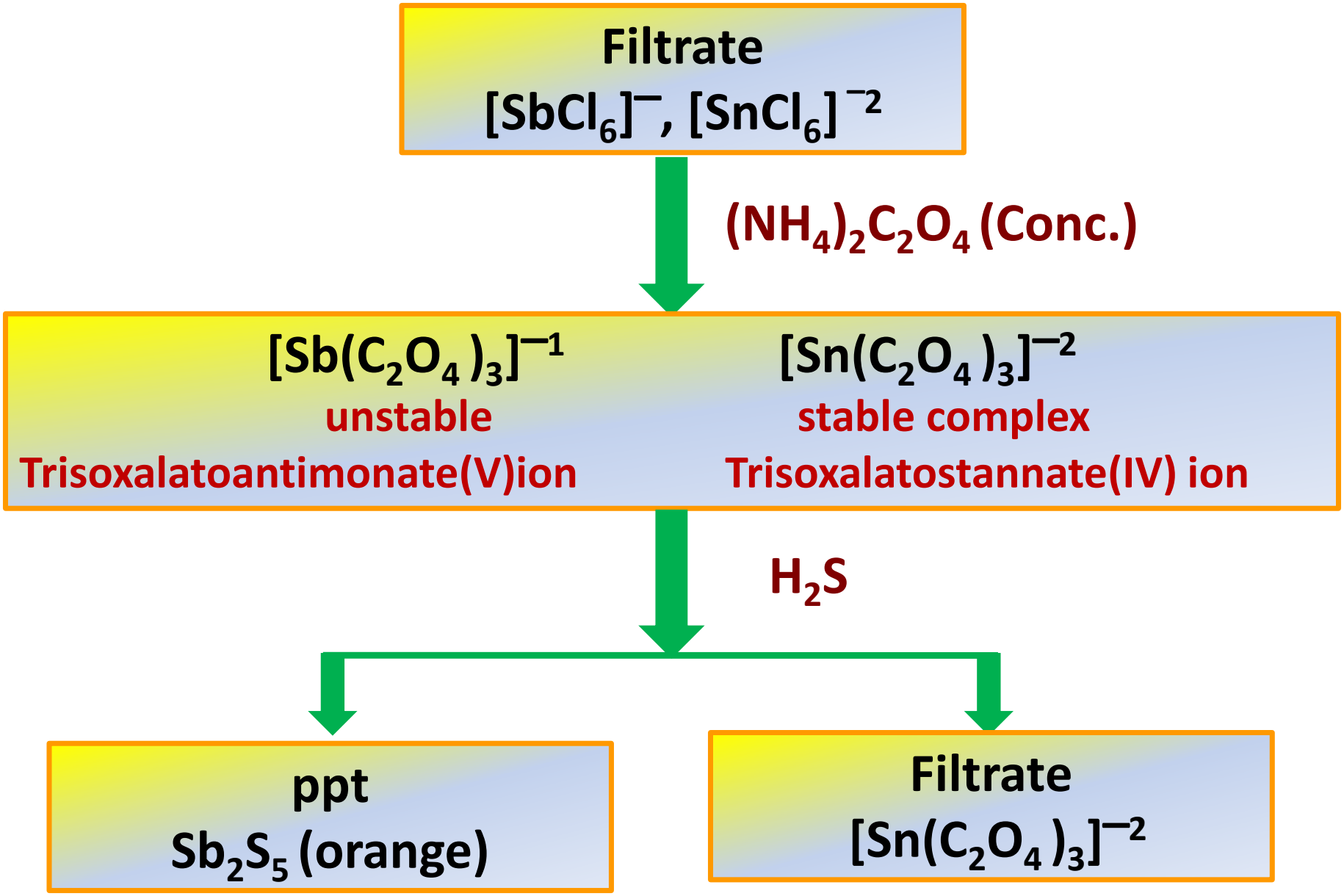
$$SnS_2 + 6\ HCl \longrightarrow [SnCl_6]^{-2} + 2\ S^{-2} + 6\ H^+$$

$$SnS_2 \rightleftharpoons Sn^{+4} + 2\ S^{-2}$$

$$Sn^{+4} + 6\ HCl \rightleftharpoons [SnCl_6]^{-2} + 6\ H^+$$

Hexachlorostannate(IV) ion

H_2S group: Arsenic subgroup



H_2S group: Arsenic subgroup

Equations and Explanation

$$[SbCl_6]^- + 3\ C_2O_4^{-2} \rightleftharpoons [Sb(C_2O_4)_3]^{-1} + 6\ Cl^-$$

unstable Complex, dissociate rapidly

$$2\ [Sb(C_2O_4)_3]^{-1} + 5\ H_2S \longrightarrow Sb_2S_5\downarrow + 6\ C_2O_4^{-2} + 10\ H^+$$

$$[SnCl_6]^{-2} + 3\ C_2O_4^{-2} \rightleftharpoons [Sn(C_2O_4)_3]^{-2} + 6\ Cl^-$$

Stable Complex

$$[Sn(C_2O_4)_3]^{-2} + H_2S \longrightarrow \text{No reaction}$$

H_2S group: Arsenic subgroup

Ppt

As_2S_5

Arsenic (V) sulfide

Dissolution Using Oxidizing Agent

HNO_3 (Conc.) OR H_2O_2/ NH_3

AsO_4^{-3}

Arsenate ion, soluble

Note: As_2S_5 is insoluble in acid, insoluble in HCl (Conc.), soluble in ammonium poly sulfide .

H_2S group: Arsenic subgroup

Equations and Explanation

$$As_2S_5 \rightleftharpoons 2\,As^{+5} + 5\,S^{-2}$$

Oxd. Half RXN:

$$5\,S^{-2} + 60\,H_2O \longrightarrow 5\,SO_4^{-2} + 40\,e^- + 40\,H_3O^+$$

Red. Half RXN:

$$HNO_3 + 3\,e^- + 3\,H_3O^+ \longrightarrow NO + 5\,H_2O$$

$$3\,As_2S_5 + 40\,HNO_3 + 52\,H_2O \longrightarrow 15\,SO_4^{-2} + 40\,NO + 6\,AsO_4^{-3} + 48\,H_3O^+$$

H_2S group: Arsenic subgroup

Equations and Explanation

$$As_2S_5 \rightleftharpoons 2\,As^{+5} + 5\,S^{-2}$$

Oxd. Half RXN:

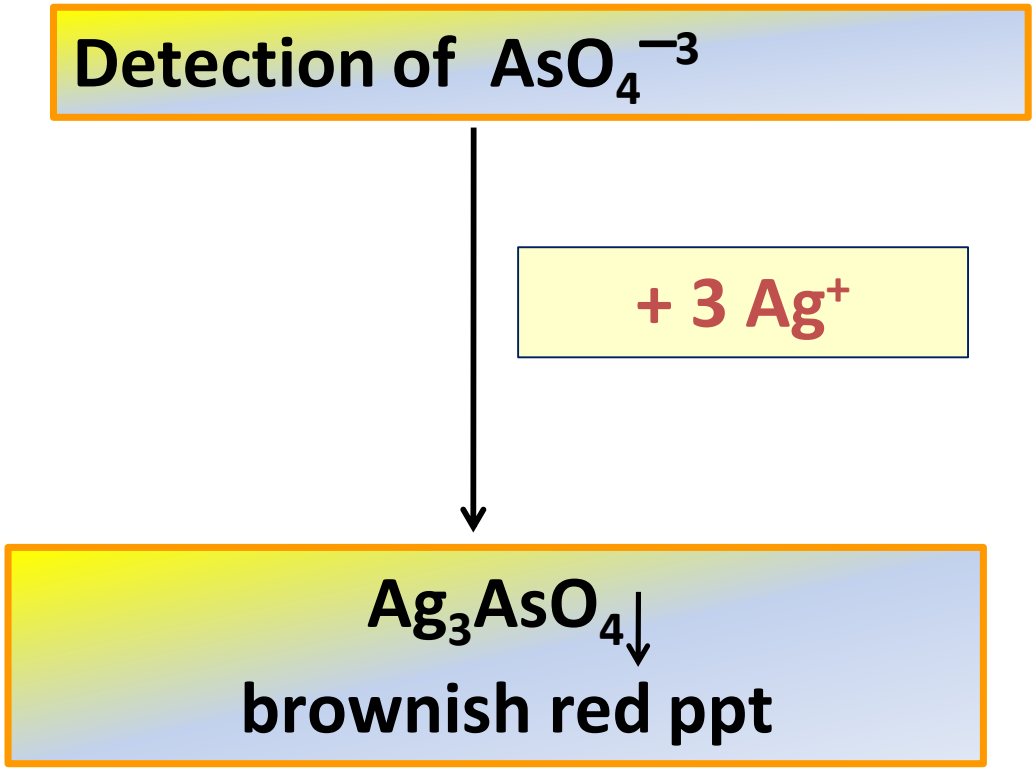
$$5\,S^{-2} + 60\,H_2O \longrightarrow 5\,SO_4^{-2} + 40\,e^- + 40\,H_3O^+$$

Red. Half RXN:

$$H_2O_2 + 2\,e^- + 2\,H_3O^+ \longrightarrow 4\,H_2O$$

$$As_2S_5 + 20\,H_2O_2 + 4\,H_2O \longrightarrow 5\,SO_4^{-2} + 2\,AsO_4^{-3} + 16\,H_3O^+$$

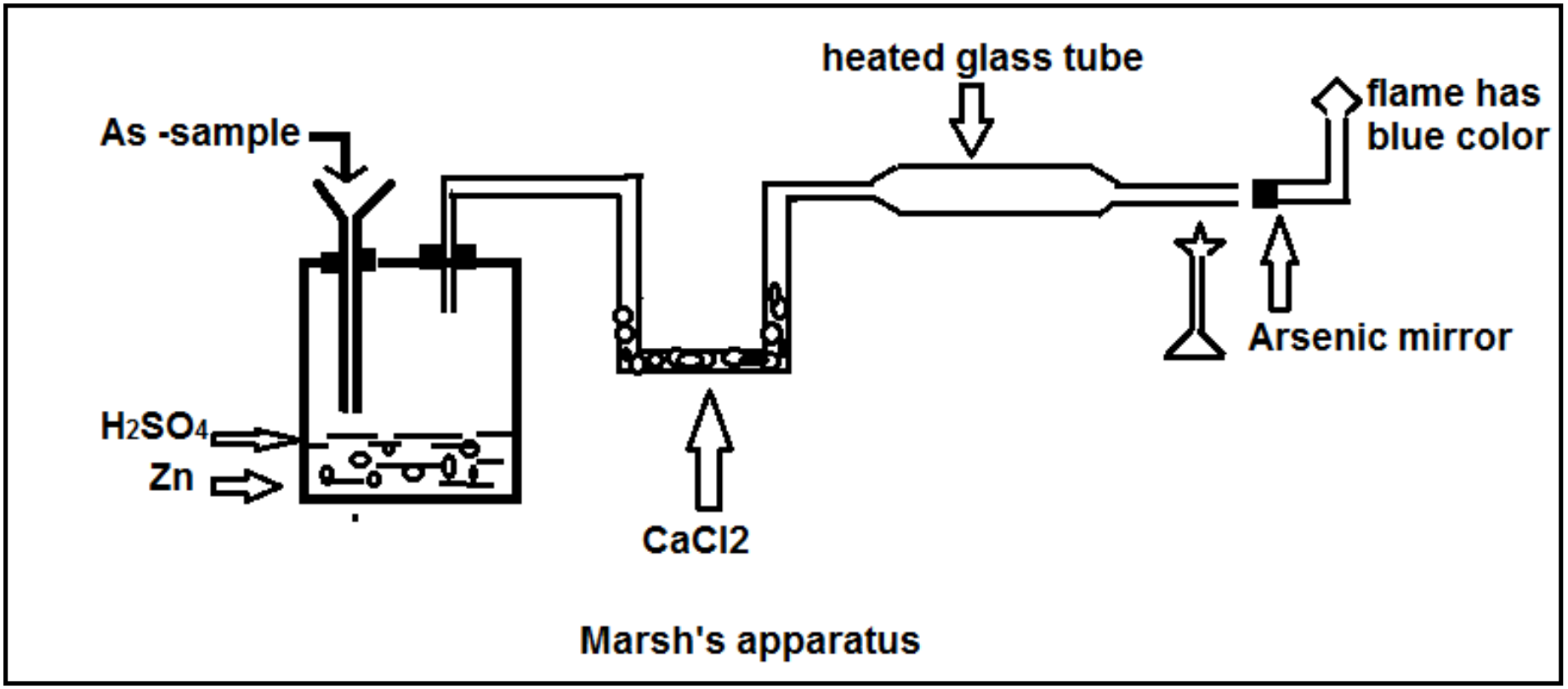
H_2S group: Arsenic subgroup



H_2S group: Arsenic subgroup

Detection of Arsenic in very small amount (Forensic medicine)

Marsh's Test



Marsh's apparatus

H_2S group: Arsenic subgroup

Marsh's Test

Equations:

$$Zn + 2\,H_3O^+ \longrightarrow Zn^{+2} + H_2 + 2\,H_2O$$

$$6\,H_2 + As_2O_3 \longrightarrow 2\,AsH_3\uparrow + 3\,H_2O$$

Arseine gas (toxic, garlic like odor)

$$4\,AsH_3 \xrightleftharpoons{\Delta} 4\,As\downarrow + 6\,H_2$$

brownish black (Arsenic mirror)

$$AsH_3 \xrightarrow{\text{ignition}}$$ blue colored flame with white fumes

H_2S group: Arsenic subgroup

Marsh's Test

Malfunction is Sb.

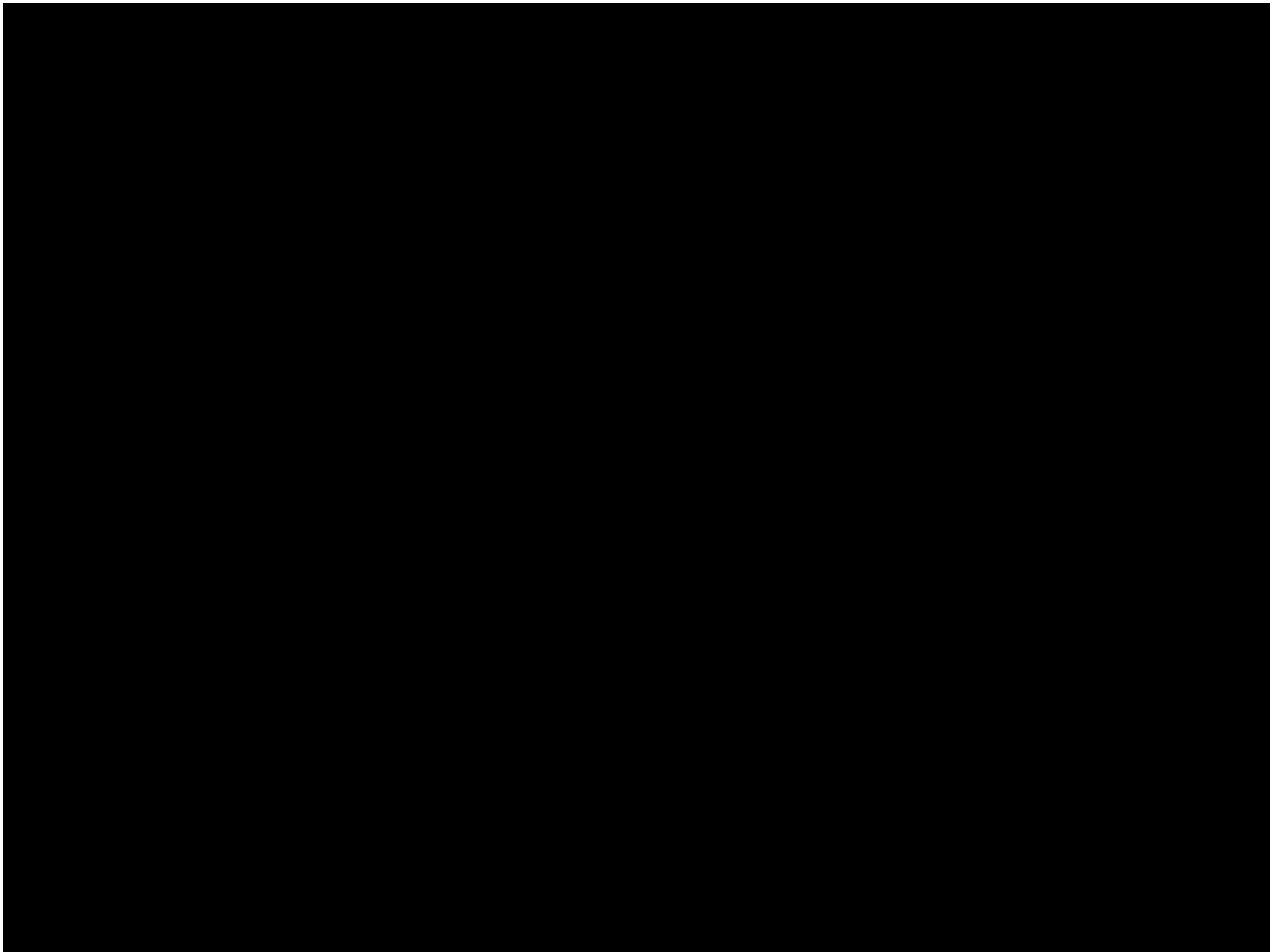
To distinguish the results in Marsh's test

Arsenic mirror is soluble in H_2O_2/ NH_3

Anitmony mirror is insoluble in H_2O_2/ NH_3

See the following video

Marsh's Test



Group (II): H_2S group

PPt H_2S group

CuS, Bi_2S_3, CdS, PbS, HgS,

SnS, SnS_2, As_2S_3, As_2S_5, Sb_2S_3, Sb_2S_5

Δ, $(NH_4)_2S_x$

Filtrate

Arsenic subgroup

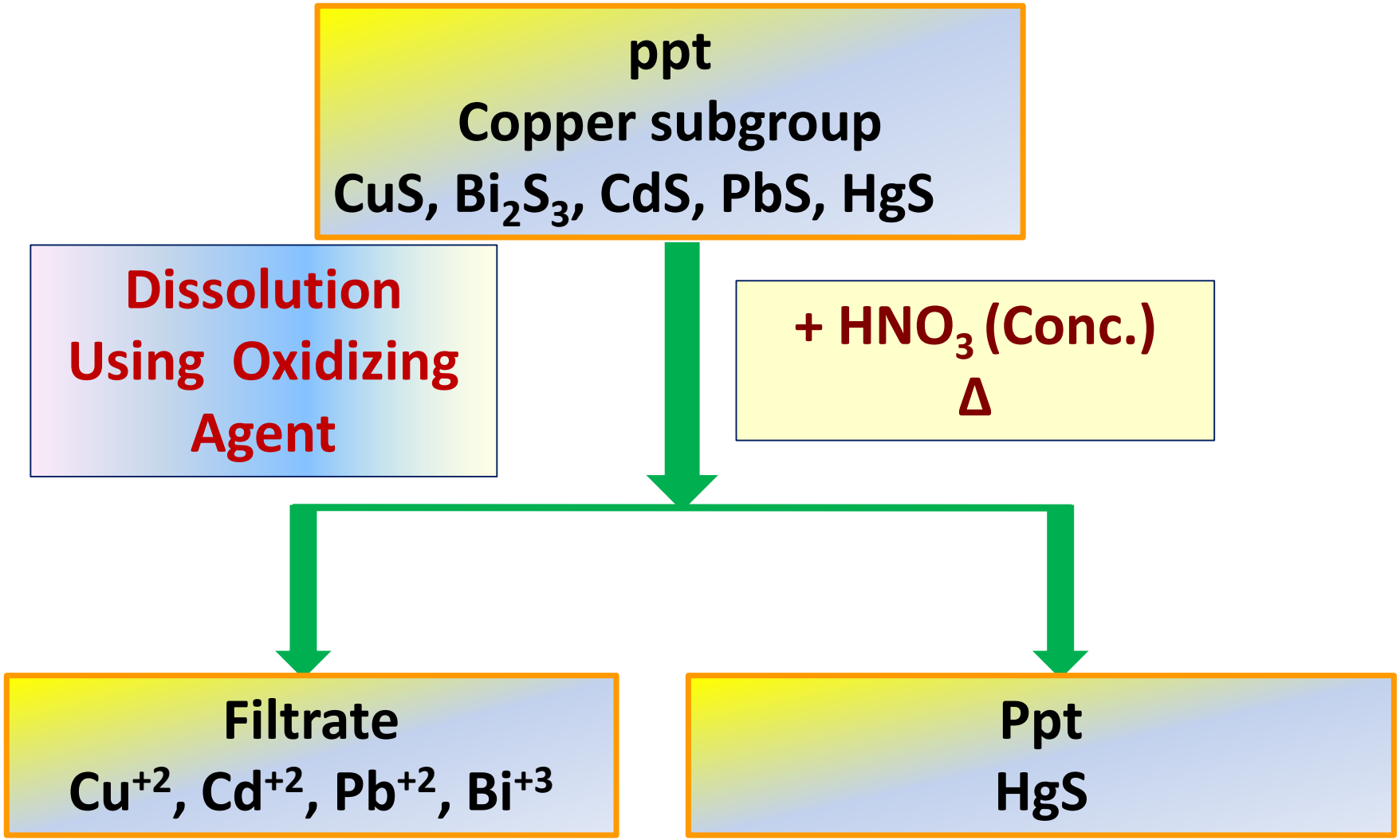
(Thiosalts)

ppt

Copper subgroup

CuS, Bi_2S_3, CdS, PbS, HgS

H_2S group: Copper subgroup



H_2S group: Copper subgroup

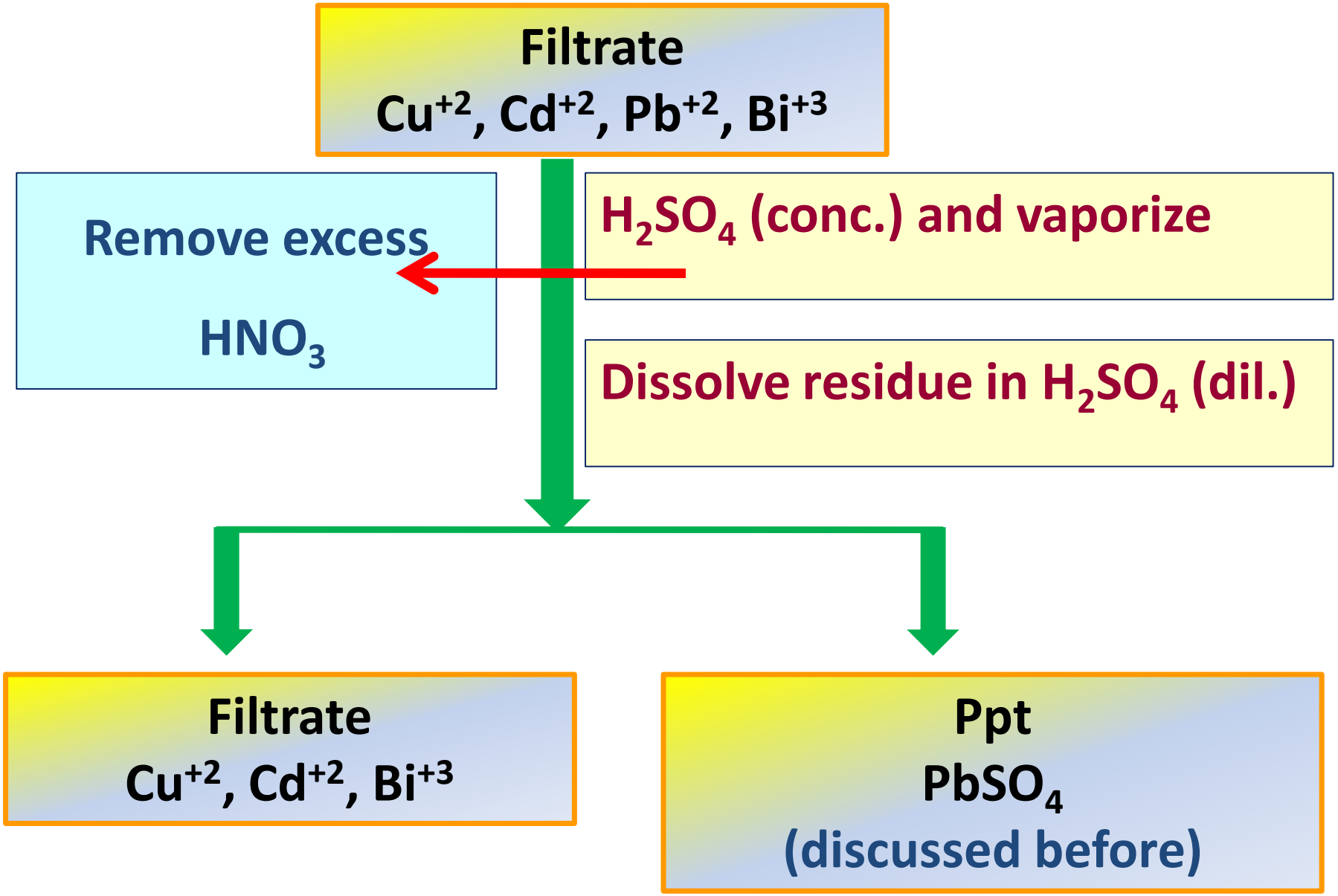
Remember:

H_2S group are sulfide salts insoluble in acids. Dissolution in HNO_3 (Conc.) due to its' oxidizing agent property.

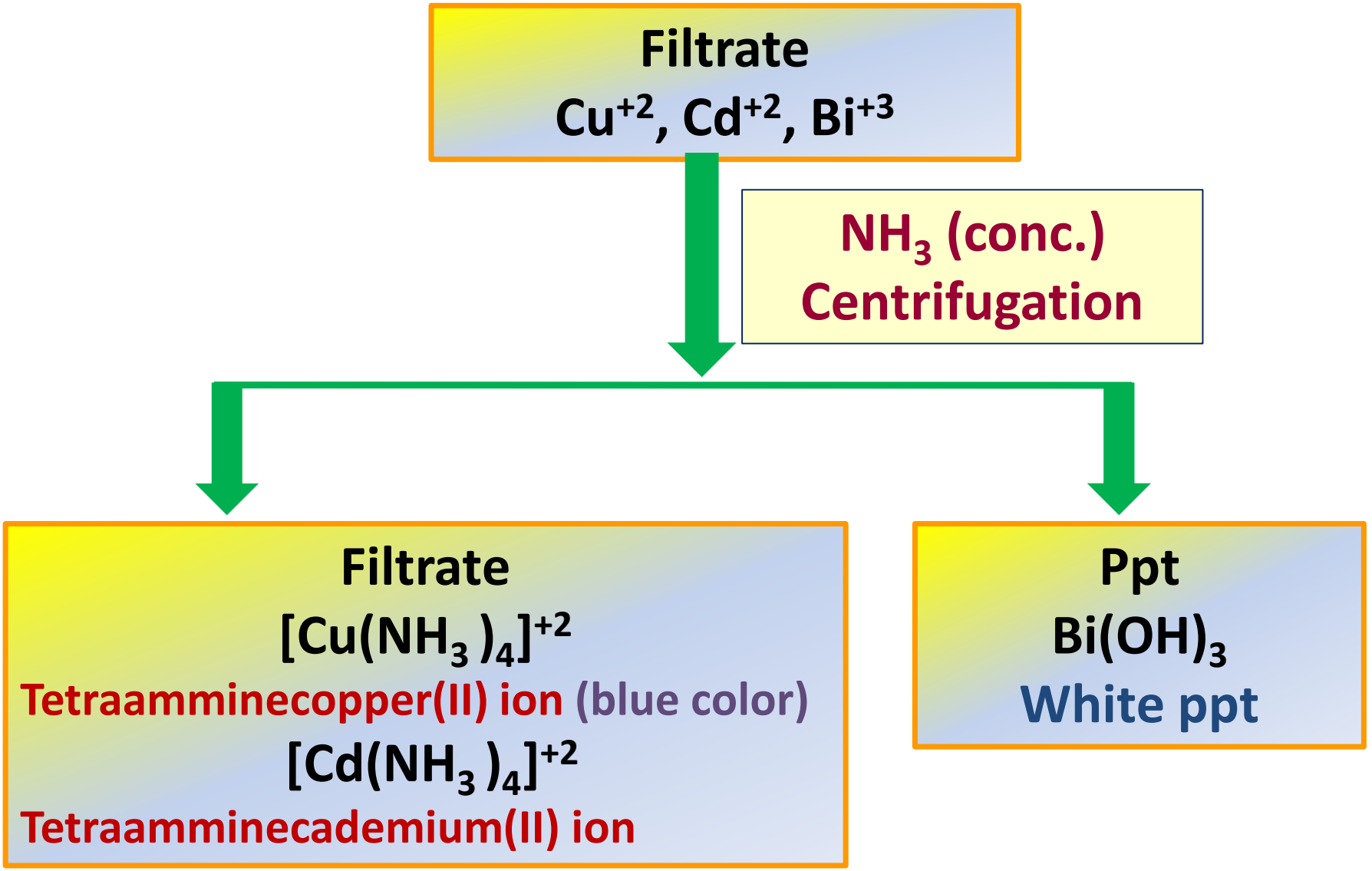
Redox reaction:

$$3\ CuS + 8\ HNO_3 \longrightarrow 3\ Cu^{+2} + 2\ NO + 3\ S + 6\ NO3^{-} + 4\ H_2O$$

H_2S group: Copper subgroup



H_2S group: Copper subgroup



H_2S group: Copper subgroup

Filtrate

$[Cu(NH_3)_4]^{+2}$, $[Cd(NH_3)_4]^{+2}$

+ KCN

$[Cu(CN)_4]^{-2}$,
colorless
Tetracyanocuprate(II) ion

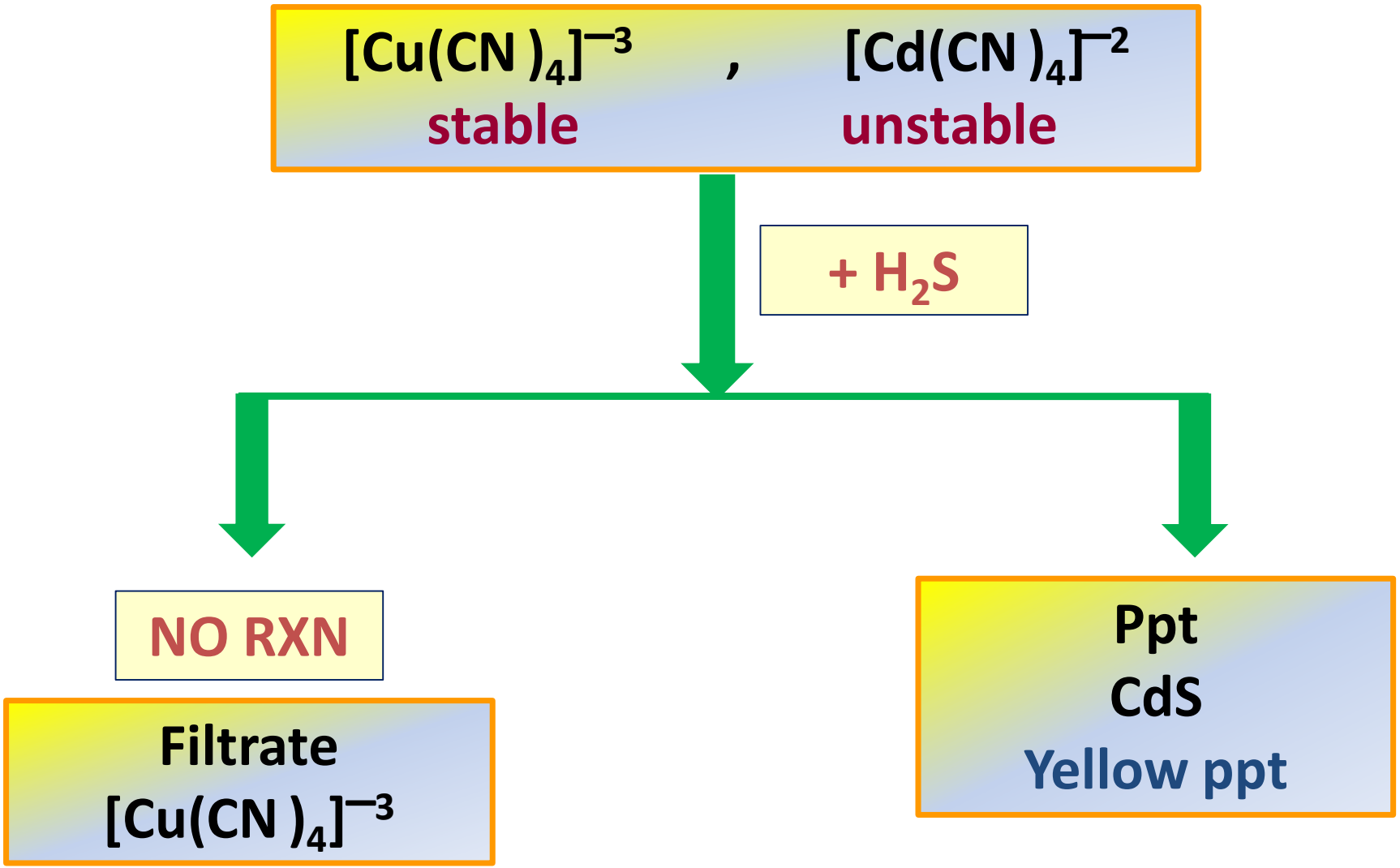
$[Cd(CN)_4]^{-2}$
colorless
Tetracyanocadimate (II) ion

decomposition

$[Cu(CN)_4]^{-3}$ + $(CN)_2\uparrow$
(stable)

$[Cd(CN)_4]^{-2}$
(unstable)

H_2S group: Copper subgroup



H_2S group: Copper subgroup

Ppt

$Bi(OH)_3$

White ppt

$Bi(OH)_3 \rightleftharpoons Bi^{+3} + 3\ OH^-$

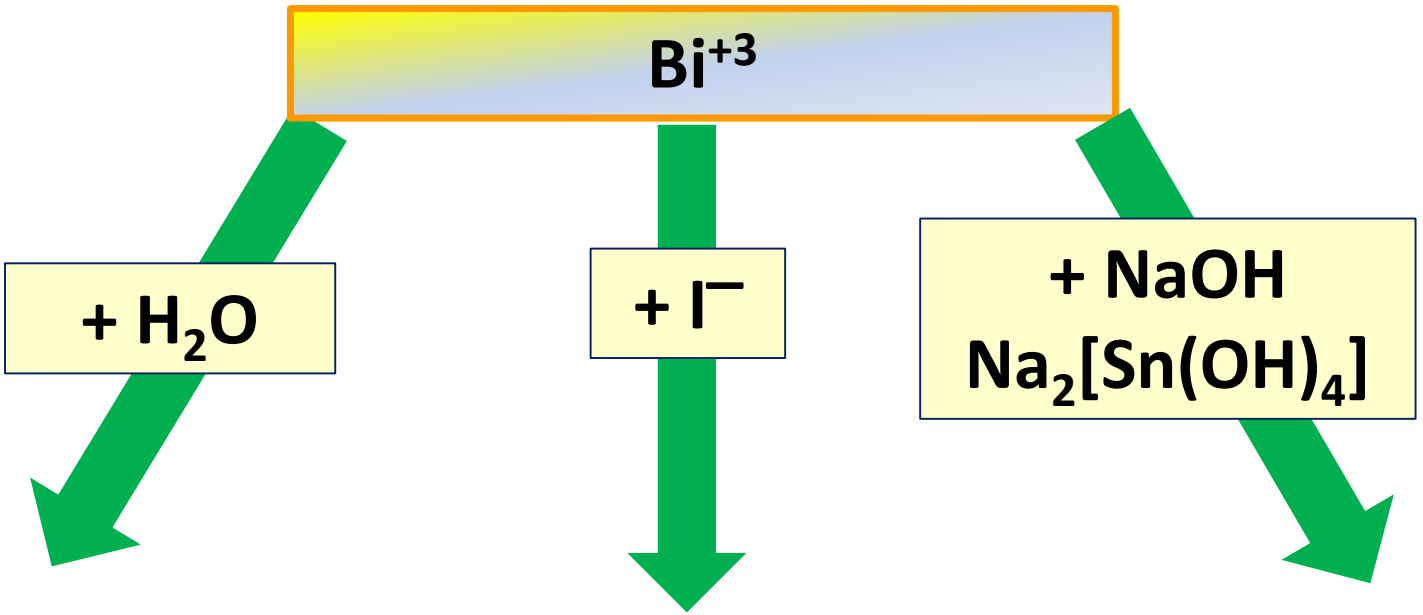
$OH^- + H_3O^+ \longrightarrow 2\ H_2O$

+ HCl for dissolution

Bi^{+3}

$Bi(OH)_3 + 3\ HCl \longrightarrow Bi^{+3} + 3\ Cl^- + 3\ H_2O$

H_2S group: Copper subgroup

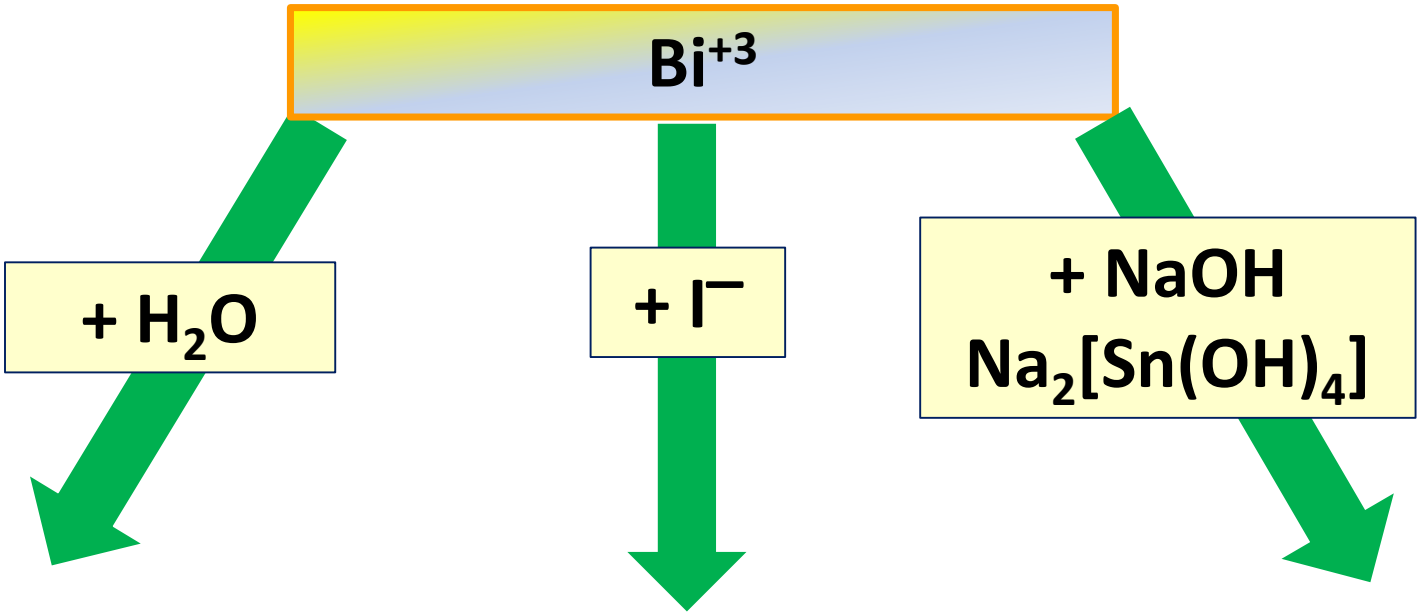


$$Bi^{+3} + Cl^- + H_2O \longrightarrow BiOCl\downarrow + 2\,H^+$$

Bismuthyl chloride

Upon dilution with water turbidity appears (BiOCl), when mineral acid is dded turbidity disappears.

H_2S group: Copper subgroup

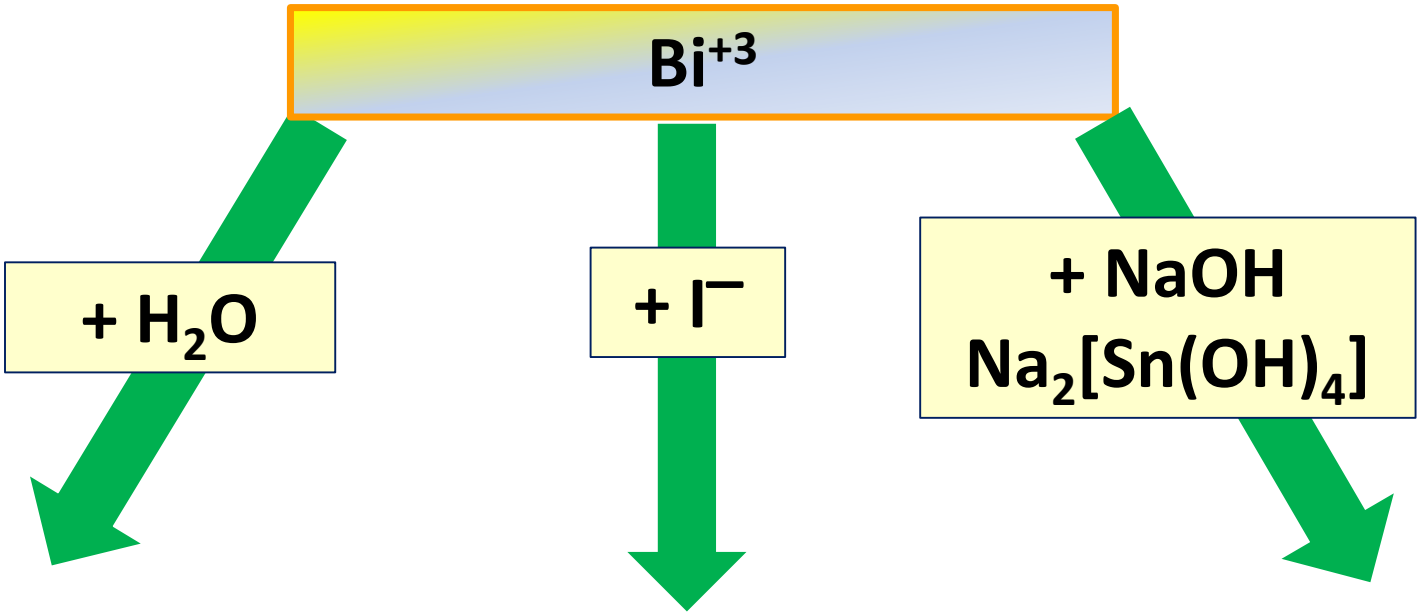


Bi^{+3} + 3 I^- ⟶ $BiI_3\downarrow$ + 3 I^- ⟶ $[BiI4]^-$

black ppt

Dragendorf's reagent

H_2S group: Copper subgroup

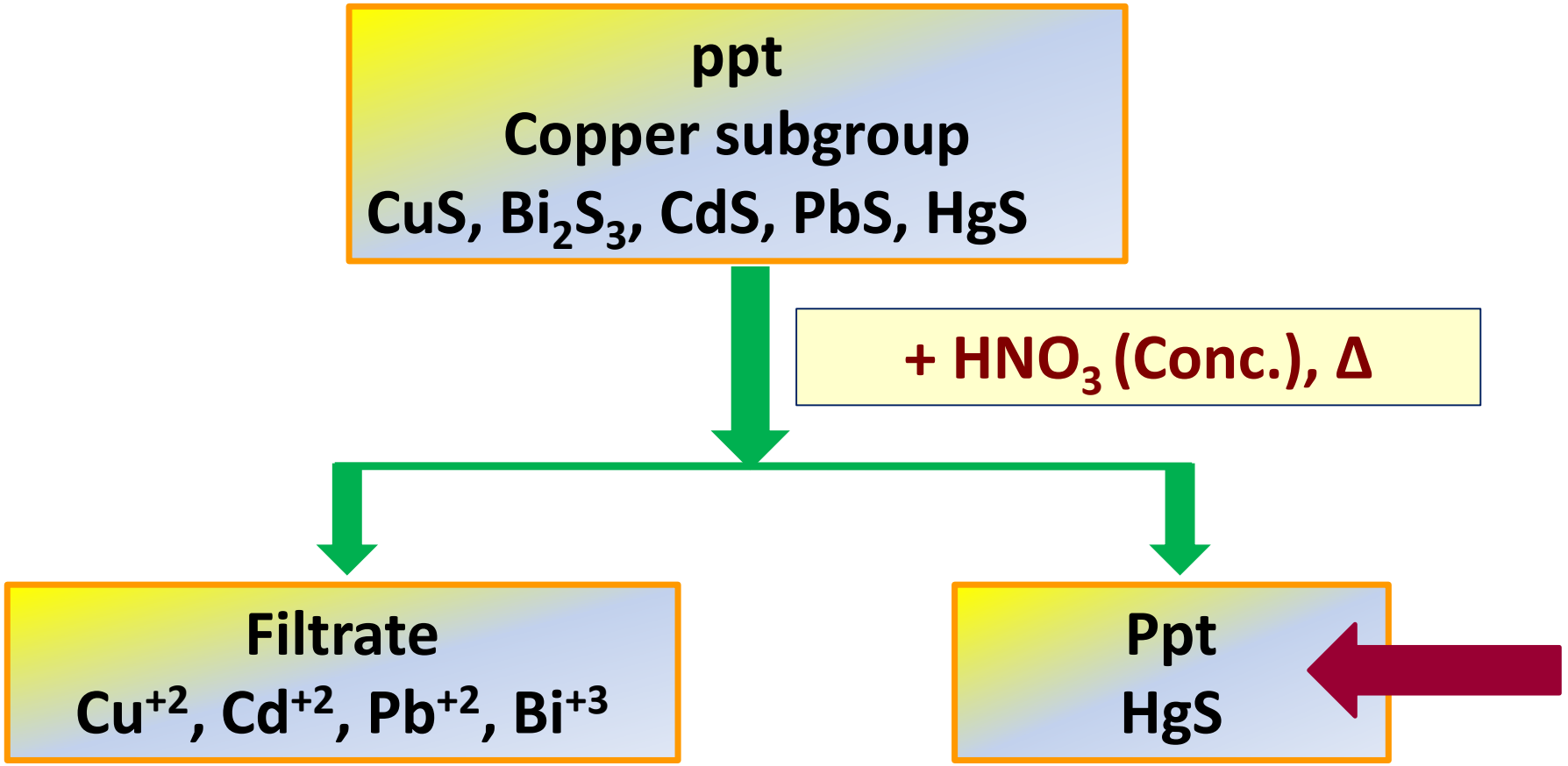


$$Bi^{+3} + 3\,OH^- \longrightarrow Bi(OH)_3 \downarrow$$

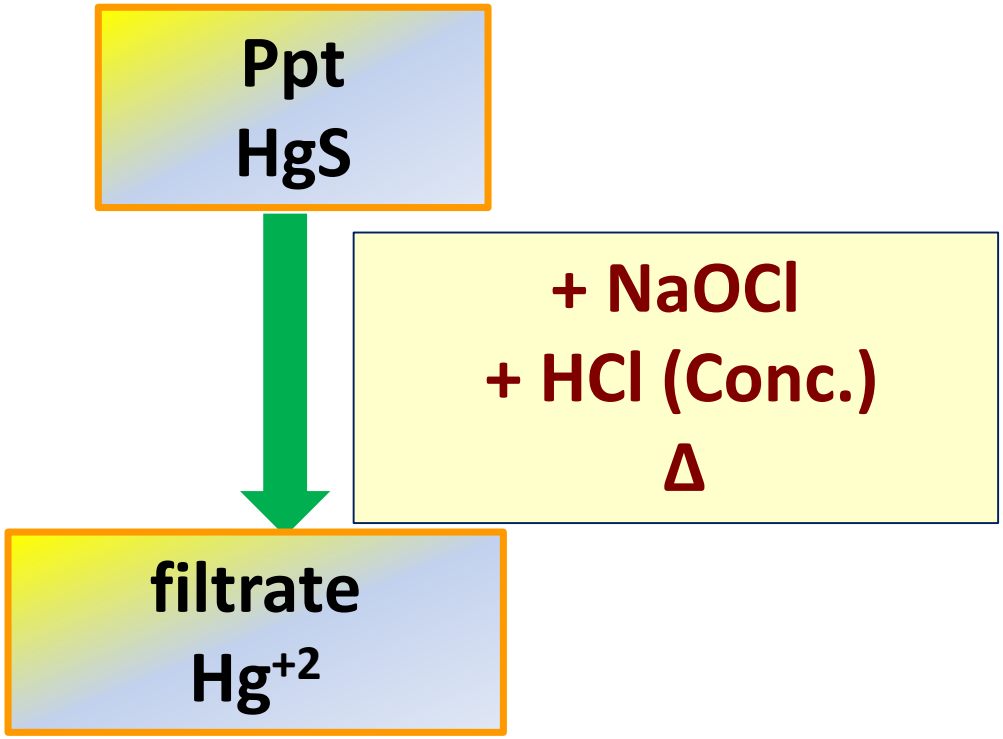
$$2\ Bi(OH)_3 + 3\,[Sn(OH)_4]^{-2} \longrightarrow 2\,Bi \downarrow + 3\ [Sn(OH)_6]^{-2}$$

black ppt

H_2S group: Copper subgroup



H_2S group: Copper subgroup

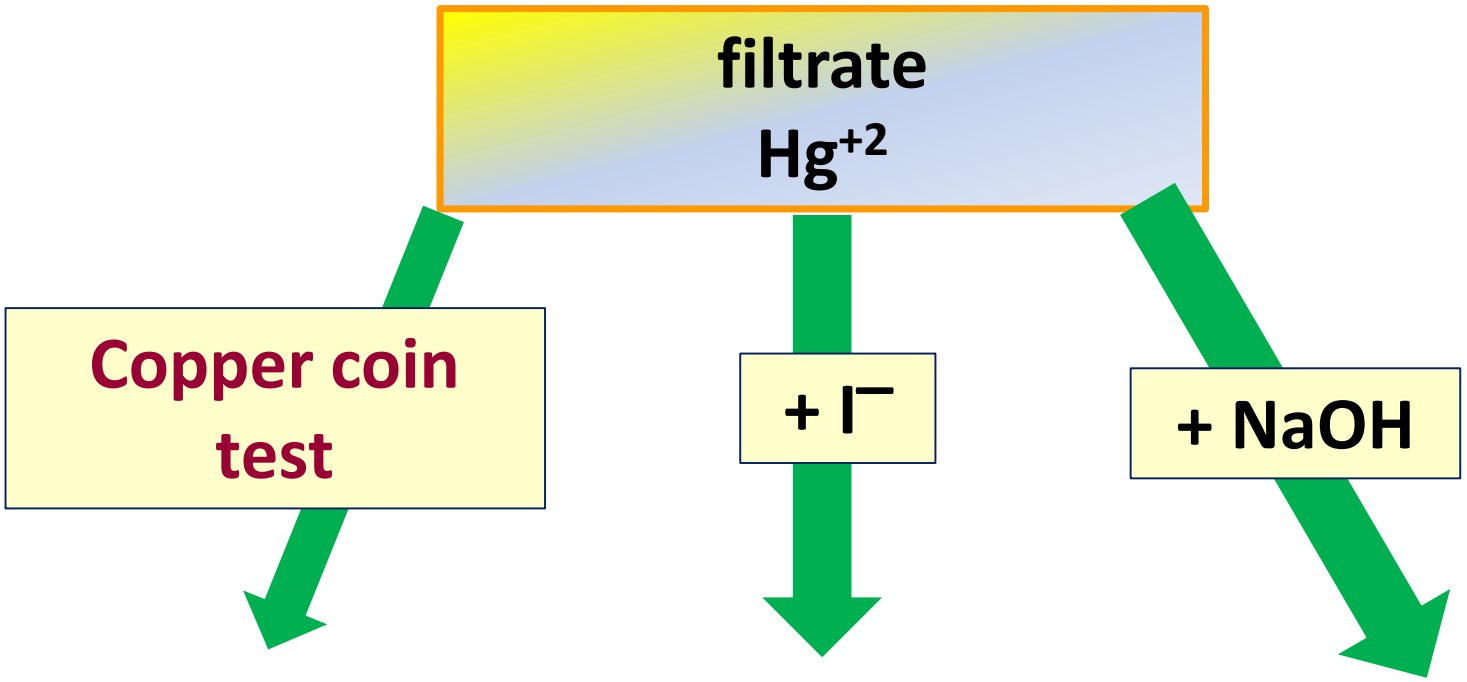


$$HgS \rightleftharpoons Hg^{+2} + S^{-2}$$

$$OCl^{-} + Cl^{-} + 2H_3O^{+} \longrightarrow Cl_2 + 3\,H_2O$$

$$4\,Cl_2 + S^{-2} + 12\,H_2O \longrightarrow SO_4^{-2} + 8\,Cl^{-} + 8\,H_3O^{+}$$

H_2S group: Copper subgroup

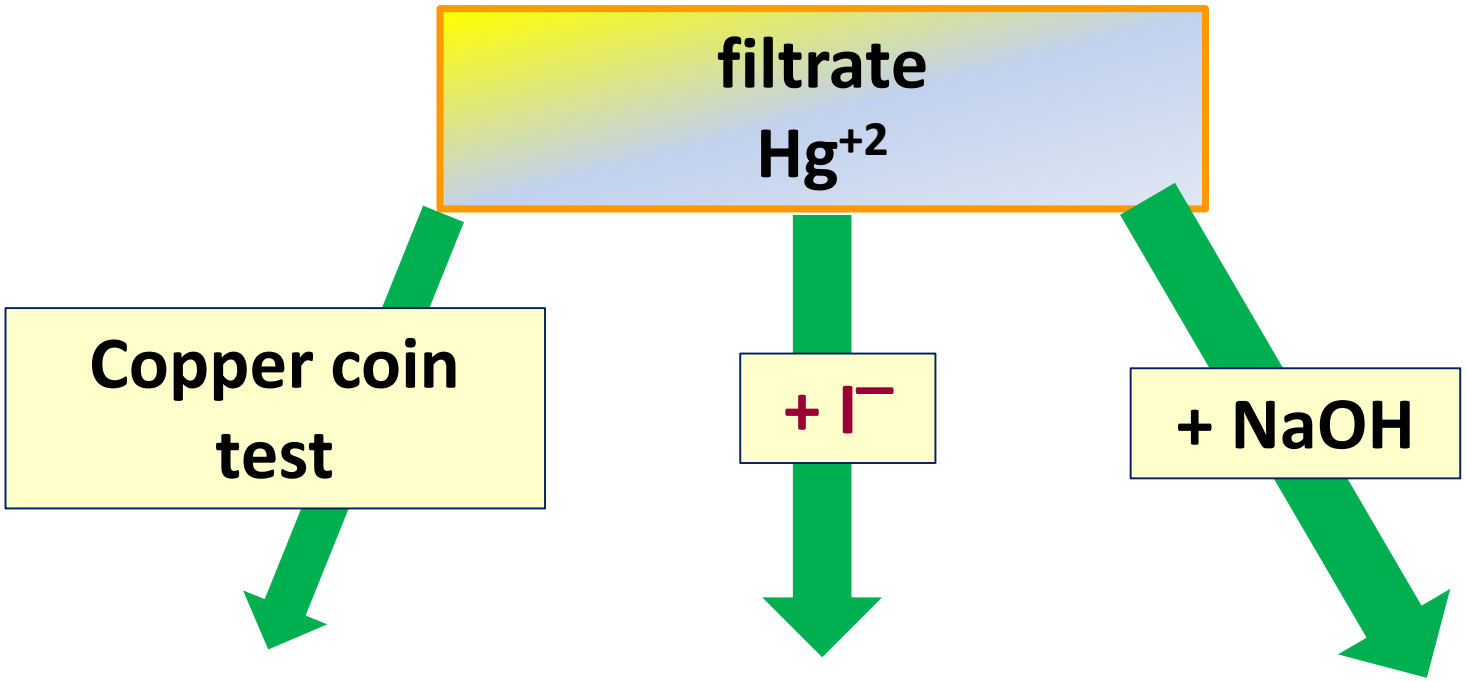


$Hg^{+2} + Cu \longrightarrow Cu^{+2} + Hg^0\downarrow$

silverish spot $\xrightarrow{\Delta}$ spot on flame disappear because Hg sublimate.

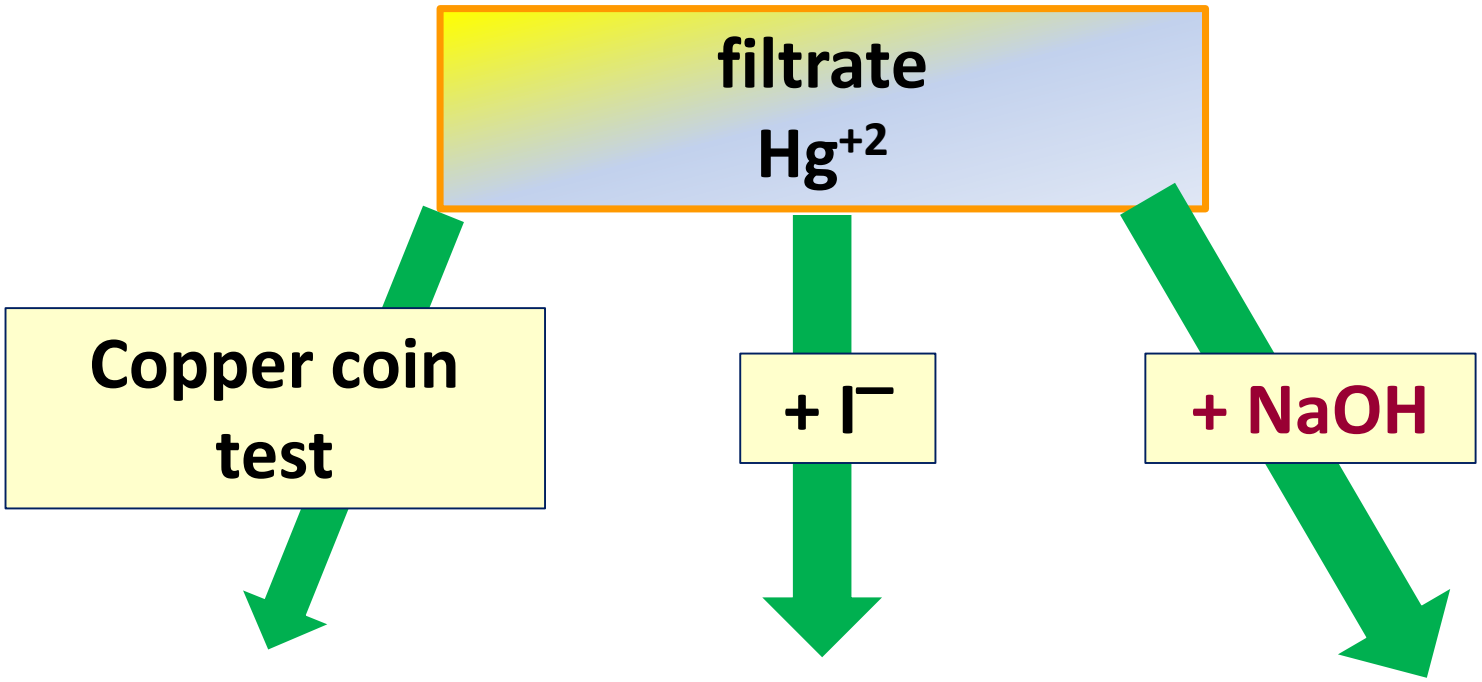
Hg_2^{+2} is a malfunction

H_2S group: Copper subgroup



$$Hg^{+2} + 2I^- \longrightarrow \underset{\text{Red ppt}}{HgI_2\downarrow} \xrightarrow{+\,2\,I^-} \underset{\text{Nessler's reagent}}{[HgI_4]^{-2}}$$

H_2S group: Copper subgroup



$$Hg^{+2} + 2OH^- \longrightarrow HgO\downarrow + H_2O$$

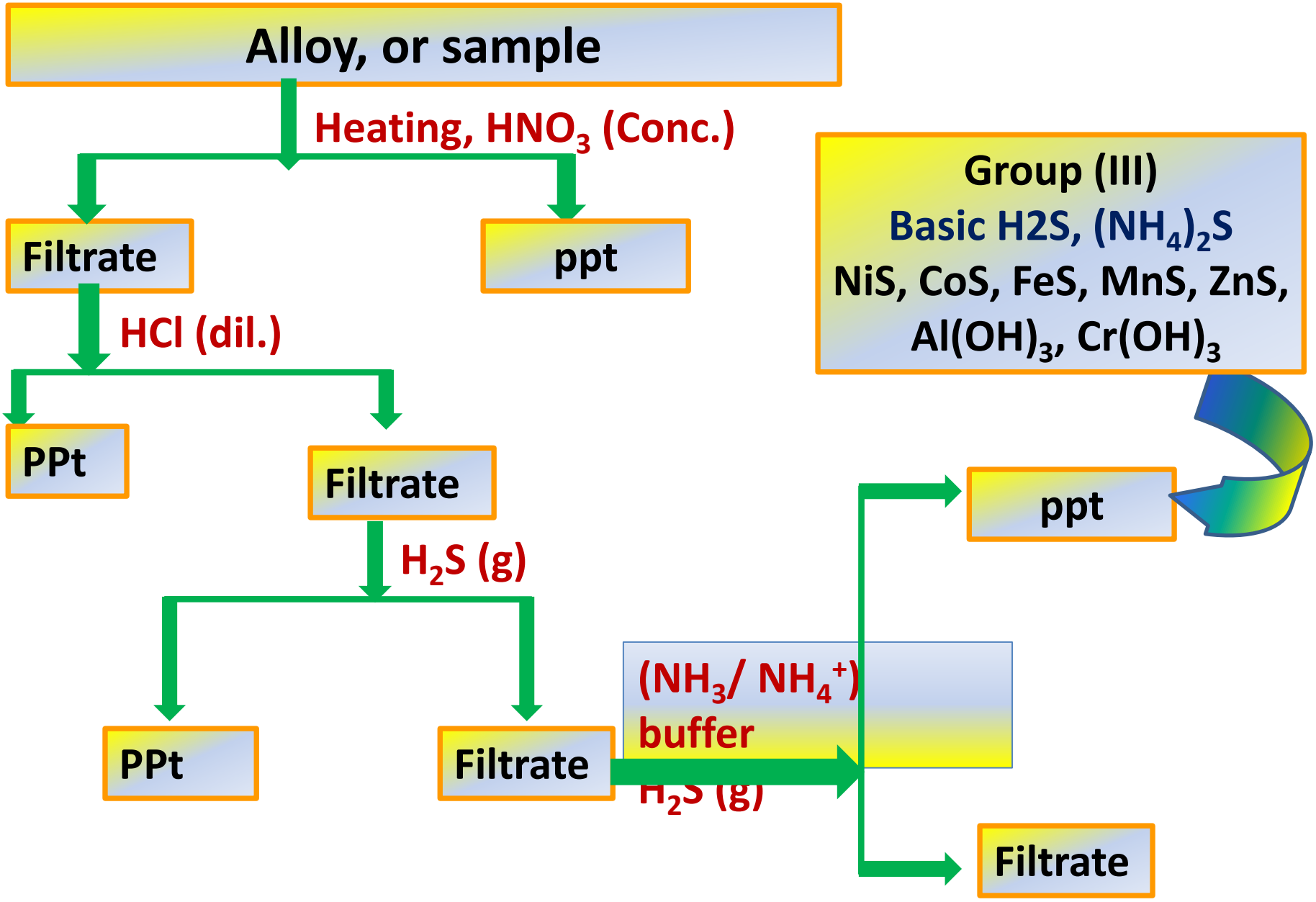
yellow-brown ppt

Qualitative inorganic analysis

part (II)

Cations

Group (III): Basic H_2S group



Group (III): Basic H_2S, $(NH_4)_2S$ group

Group (III)

Basic H2S, $(NH_4)_2S$

NiS,	CoS,	FeS,	MnS,	ZnS,	$Al(OH)_3$,	$Cr(OH)_3$
Black,	black,	black,	red,	white,	white,	green

Group (III)

Cations form insoluble sulfide or hydroxide salts

Ksp of sulfide salts is high, that they were soluble in acidic media

Group (III): Basic H_2S, $(NH_4)_2S$ group

Group (III)

Basic H2S, $(NH_4)_2S$

NiS, CoS, FeS, MnS, ZnS, $Al(OH)_3$, $Cr(OH)_3$

Digestion of ppt for 30 min.
Add HCl (dil.)
Centrifugation

Ppt

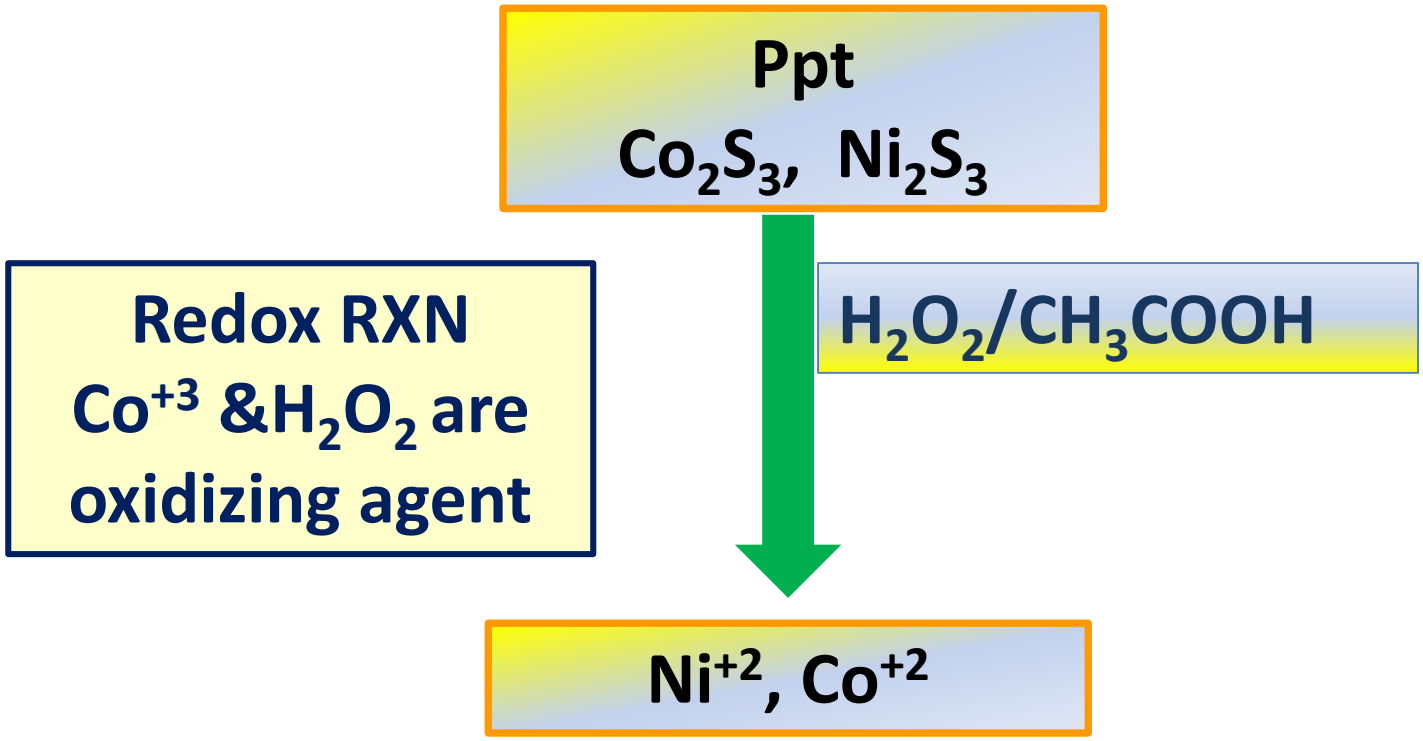
Co_2S_3, Ni_2S_3

Filtrate

Mn^{+2}, Zn^{+2}, Fe^{+3}, Al^{+3}, Cr^{+3}

Sulfide salts of this group are soluble in acidic media.
Co_2S_3, Ni_2S_3 are insoluble in acids [HCl (dil.)]

Group (III): Basic H_2S, $(NH_4)_2S$ group



Notice: Co_2S_3, Ni_2S_3 have cation in oxidation state +3
The products are in oxidation state +2

Group (III): Basic H_2S, $(NH_4)_2S$ group

Equations and Explanation

$$Co_2S_3 \rightleftharpoons 2\,Co^{+3} + 3\,S^{-2}$$

Oxd. Half RXN:

$$3\,S^{-2} + 36\,H_2O \longrightarrow 3\,SO_4^{-2} + 24\,e^- + 24\,H_3O^+$$

Red. Half RXN:

$$2\,Co^{+3} + 2\,e^- \longrightarrow 2\,Co^{+2}$$

$$11\,H_2O_2 + 22\,e^- + 22\,H_3O^+ \longrightarrow 44\,H_2O$$

$$Co_2S_3 + 11\,H_2O_2 \longrightarrow 2\,Co^{+2} + 3\,SO_4^{-2} + 8\,H_2O + 2\,H_3O^+$$

$$Co_2S_3 + 11\,H_2O_2 \longrightarrow 2\,CoSO_4 + 10\,H_2O + H_2SO_4$$

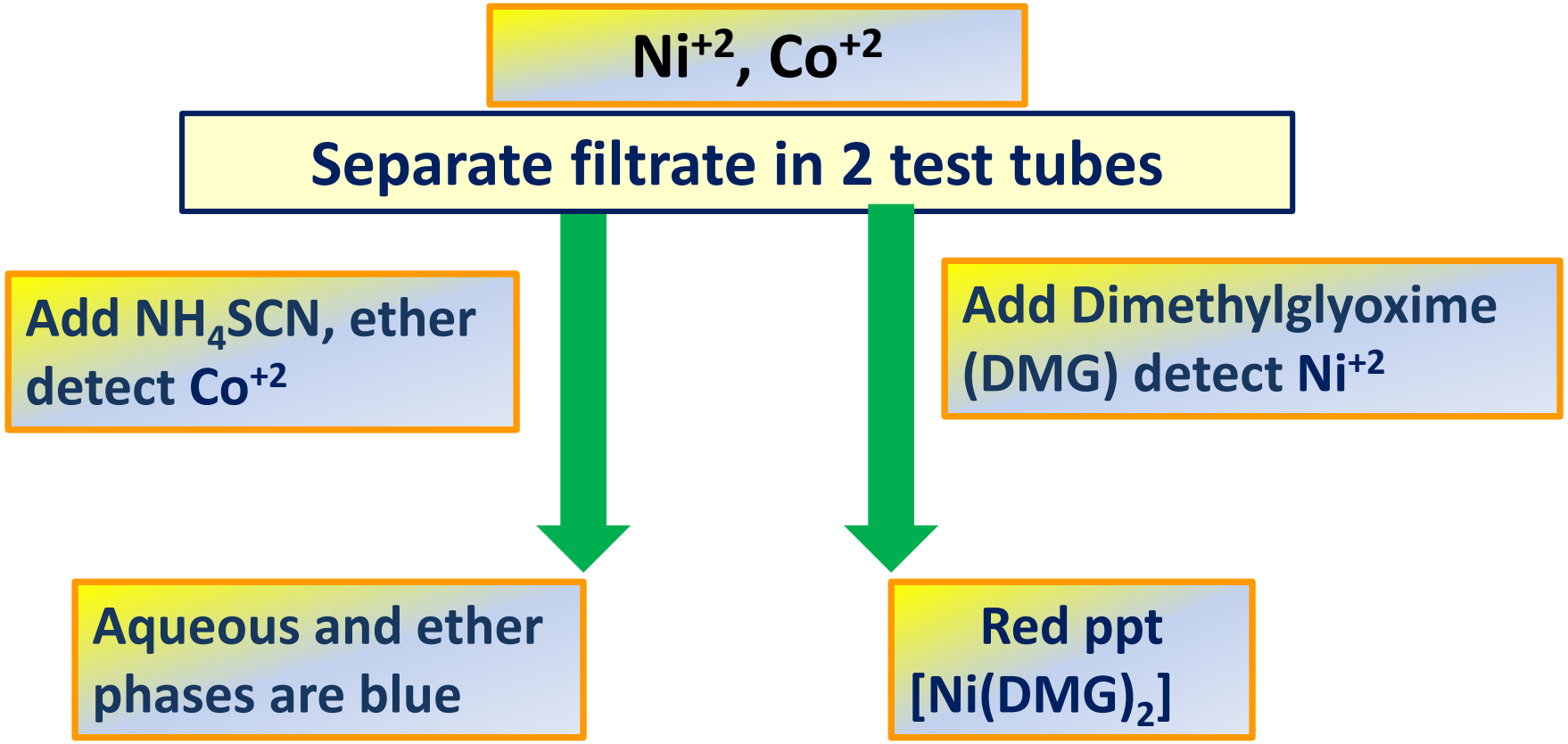
Group (III): Basic H_2S, $(NH_4)_2S$ group

Equations and Explanation

$$Co_2S_3 + 11\ H_2O_2 \longrightarrow 2\ CoSO_4 + 10\ H_2O + H_2SO_4$$

$$Ni_2S_3 + 11\ H_2O_2 \longrightarrow 2\ NiSO_4 + 10\ H_2O + H_2SO_4$$

Group (III): Basic H_2S, $(NH_4)_2S$ group



Group (III): Basic H_2S, $(NH_4)_2S$ group

Equations and Explanation

$2\ SCN^- + Co^{+2} \longrightarrow Co(SCN)_2$

soluble in ether with blue color

$4\ SCN^- + Co^{+2} \longrightarrow [Co(SCN)_4]^{-2}$

soluble in water, blue color

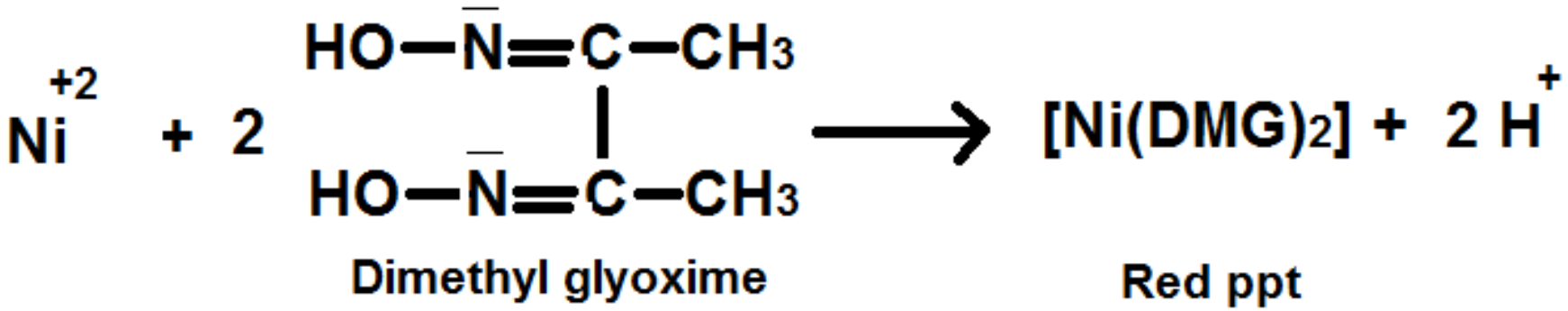
Group (III): Basic H_2S, $(NH_4)_2S$ group

Equations and Explanation

$$Ni^{+2} + 2\ DMG \longrightarrow [Ni(DMG)_2]\downarrow + 2\ H^+$$

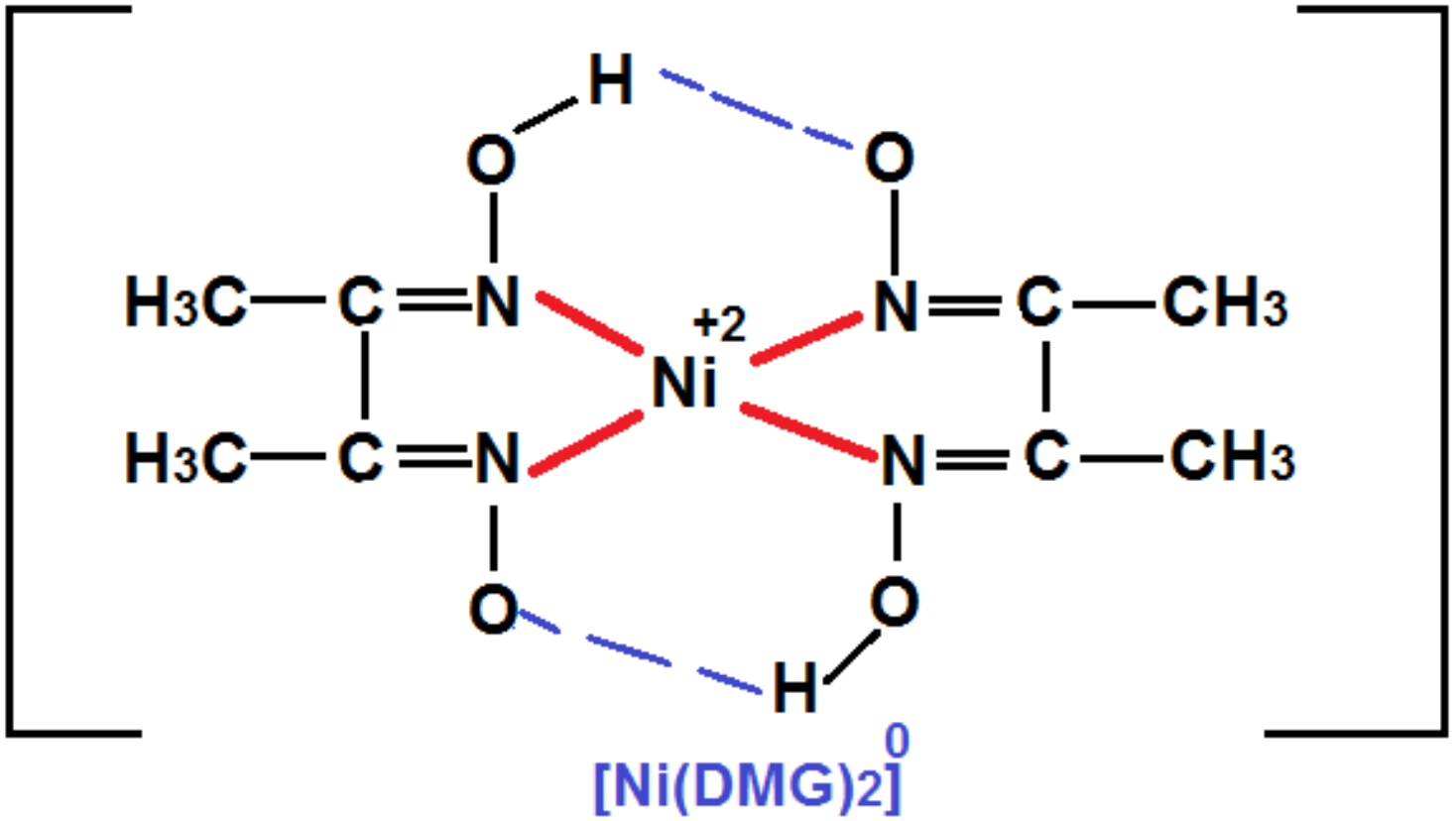
Red ppt

Bidendate ligand **(Neutral Chelate)**

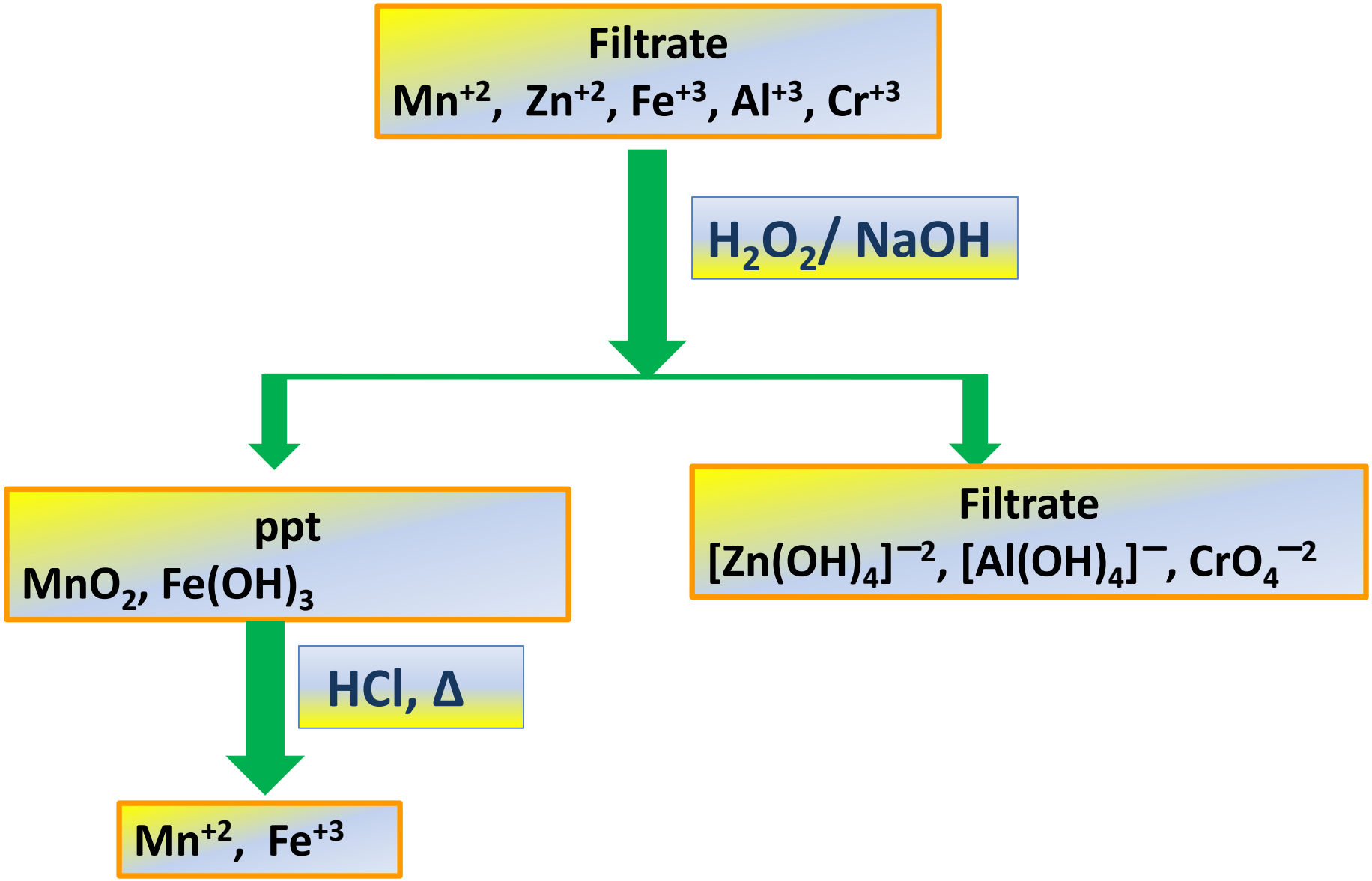


Group (III): Basic H_2S, $(NH_4)_2S$ group

$[Ni(DMG)_2]$



Group (III): Basic H_2S, $(NH_4)_2S$ group



Group (III): Basic H_2S, $(NH_4)_2S$ group

ppt

MnO_2, $Fe(OH)_3$

HCl

Δ

Mn^{+2}, Fe^{+3}

Equations and Explanation

$$MnO_2 + 4\,HCl \longrightarrow MnCl_2 + Cl_2\,(g) + 2\,H_2O$$

$$Fe(OH)_3 + 3\,HCl \longrightarrow Fe^{+3} + 3\,Cl^{-} + 3\,H_2O$$

Group (III): Basic H_2S, $(NH_4)_2S$ group

Mn^{+2}, Fe^{+3}

Separate filtrate in 2 test tubes

Detect Fe^{+3}

Add NH_4SCN, ether

↓

Ether phase is red

Add $K_4[Fe(CN)_6]$

↓

Prussian blue ppt

Detect Mn^{+2}

Add PbO_2 + HNO_3

↓

Violet color of solution

MnO_4^-

Group (III): Basic H_2S, $(NH_4)_2S$ group

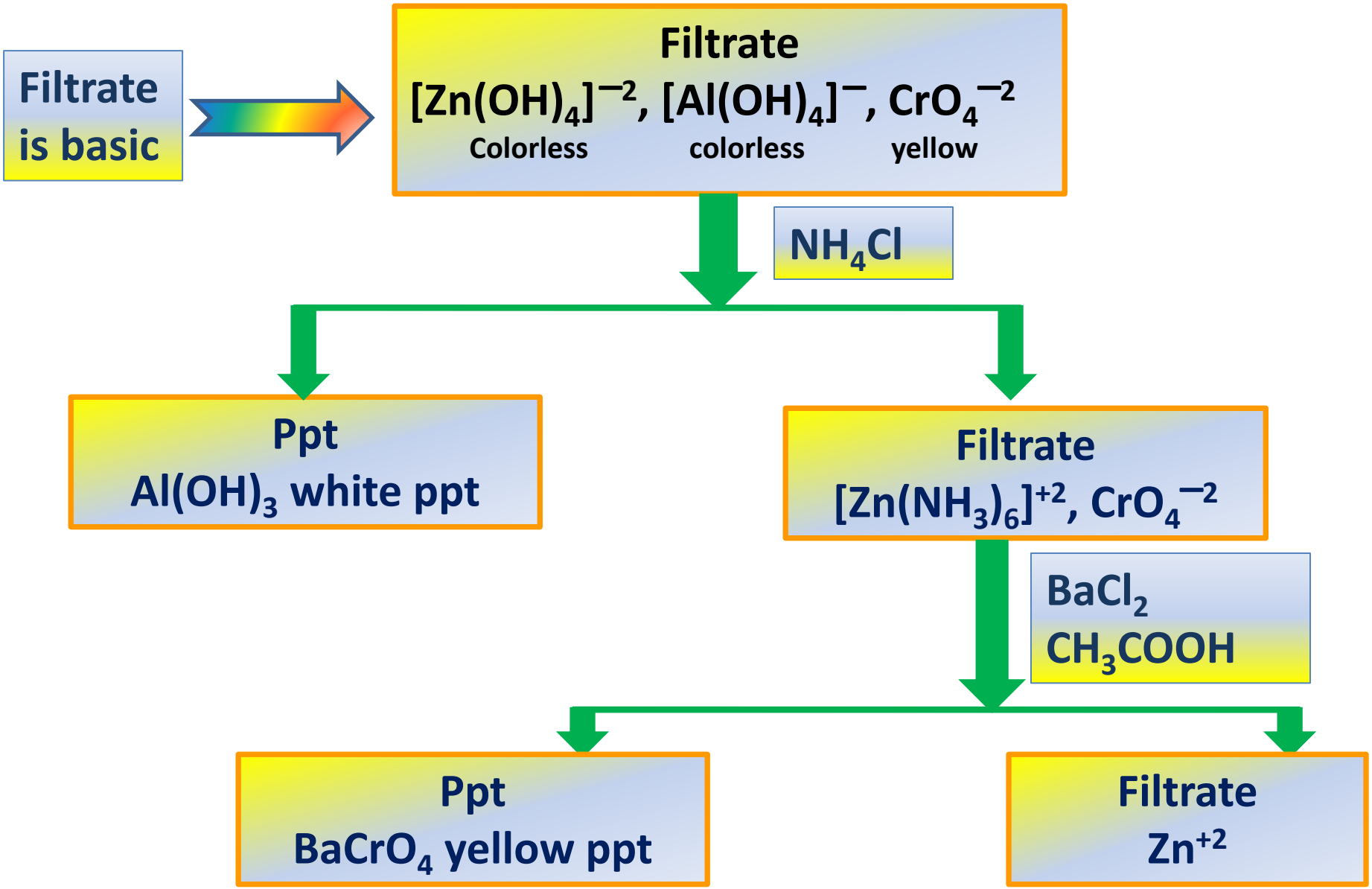
$$PbO_2 + Mn^{+2} + H_3O^+ \longrightarrow MnO_4^- + Pb^{+2}$$

Which is oxidizing agent, and reducing agent???

In this RXN HNO_3 was not the oxidizing agent. It is just acidic media.

MnO_4^- has violet color and it decolorizes when e.g. S^{-2} (reducing agent) is added, since it converts to colorless in acidic pH (Mn^{+2}).

Group (III): Basic H_2S, $(NH_4)_2S$ group



Group (III): Basic H_2S, $(NH_4)_2S$ group

Equations and Explanation

$$[Al(OH)_4]^- \rightleftharpoons Al^{+3} + 4\ OH^-$$

$$OH^- + NH_4^+ \longrightarrow NH_3 + H_2O$$

$$Al^{+3} + 3\ OH^- \longrightarrow Al(OH)_3$$

$$[Al(OH)_4]^- + NH_4^+ \longrightarrow Al(OH)_3 + NH_3 + H_2O$$

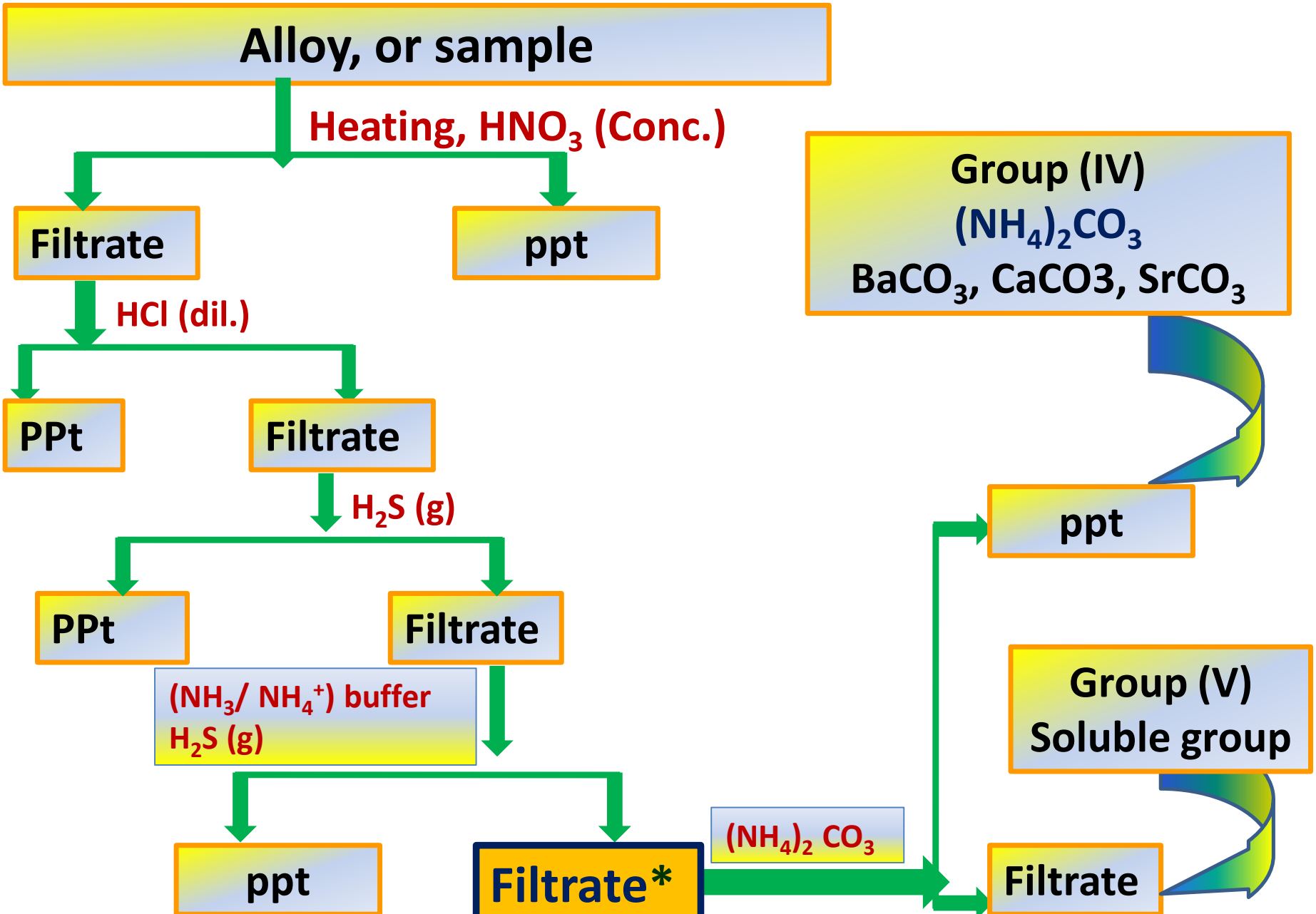
Qualitative inorganic analysis

part (II)

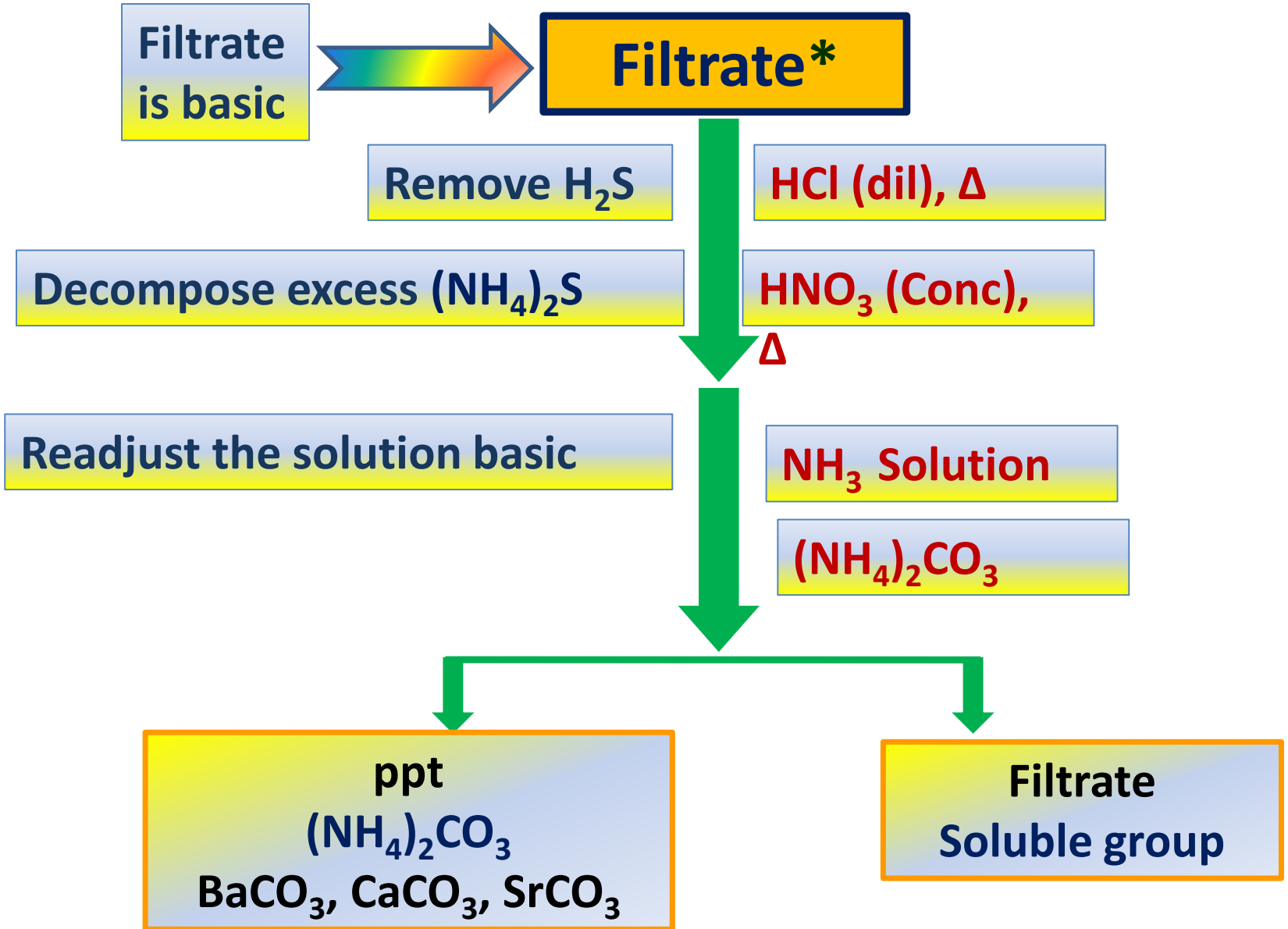
Cations

Dr. Mai Ramadan

Group (III): Basic H_2S group



Group (IV): $(NH_4)_2CO_3$ group



Group (IV): $(NH_4)_2CO_3$ group

Group (IV)

$(NH_4)_2CO_3$

$BaCO_3$, $CaCO_3$, $SrCO_3$

Group (IV)

Cations form insoluble carbonate salts

Note:

Mg^{+2} is not precipitated in this stage as $MgCO_3$ or $Mg(OH)_2$, due to the presence of NH_4^+-salts.

Group (IV): $(NH_4)_2CO_3$ group

$MgCO_3$ has a high ksp

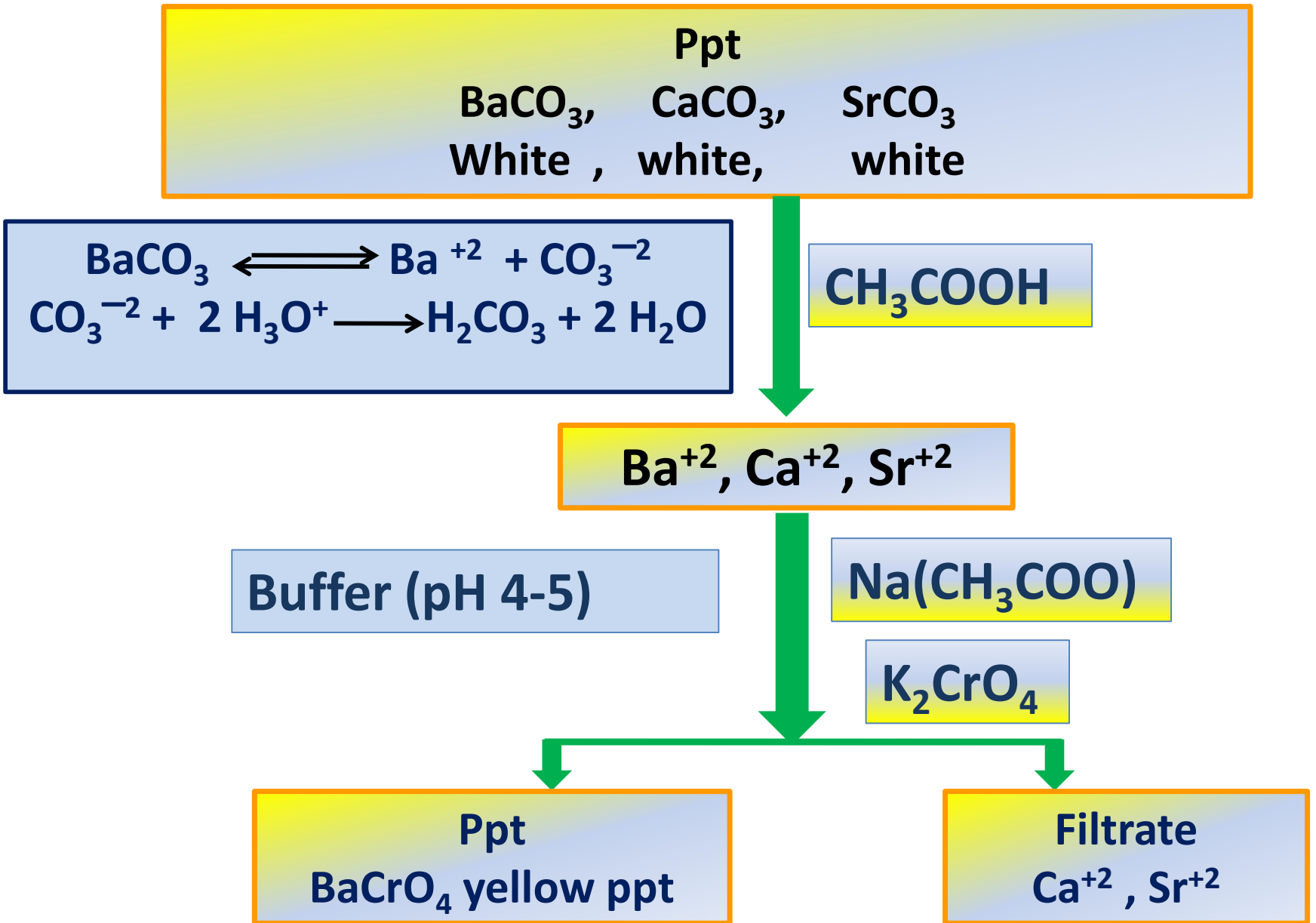
$$MgCO_3 \rightleftharpoons Mg^{+2} + CO_3^{-2}$$

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

Mg^{+2} forms soluble complex with NH_3

$[Mg(NH_3)(H_2O)_5]^{+2}$

Group (IV): $(NH_4)_2CO_3$ group



Group (IV): $(NH_4)_2CO_3$ group

Equations and Explanation

Buffer system (pH 4-5) is important

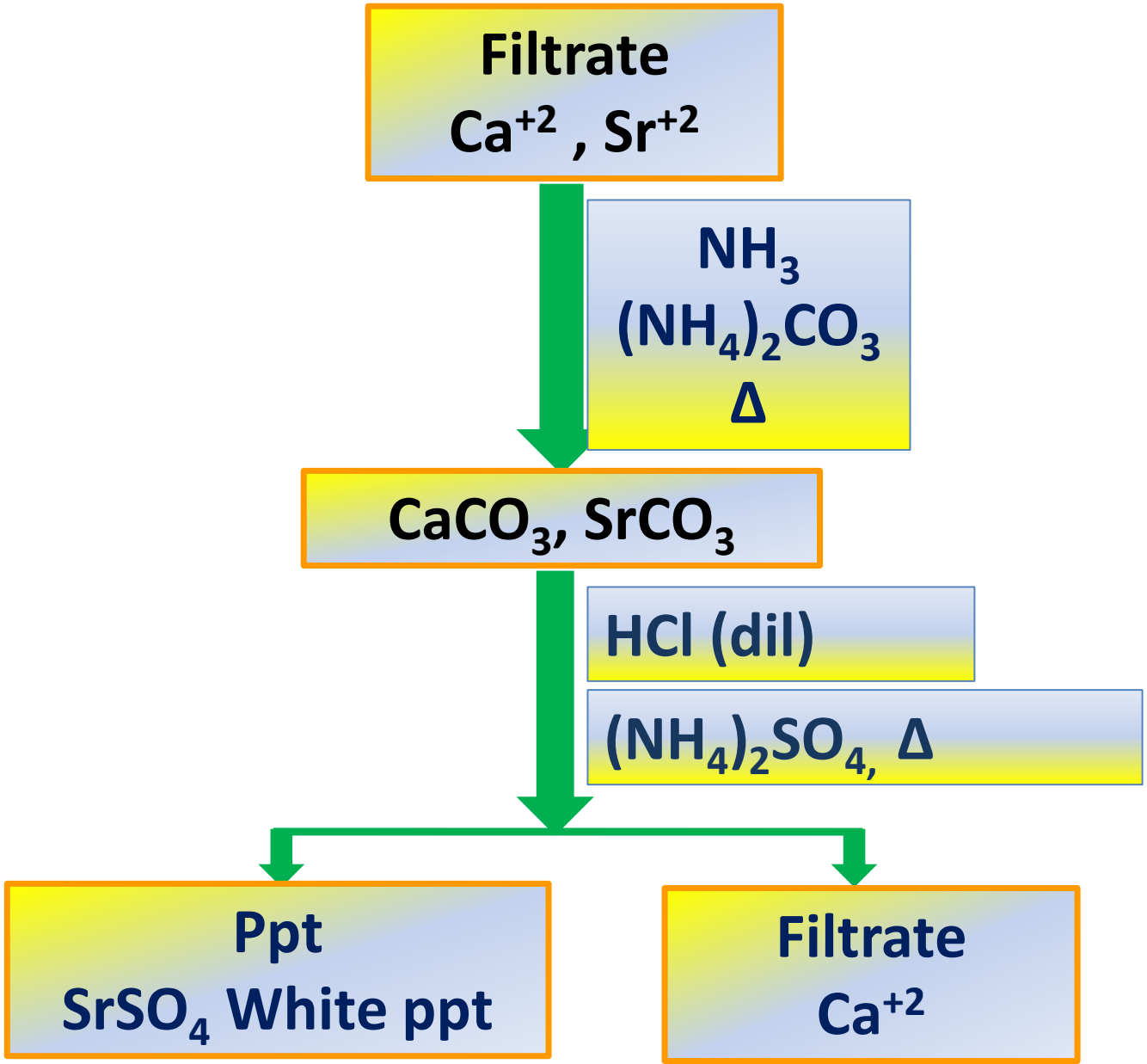
pH < 4

$$2\ CrO_4^{-2} + 2\ H_3O^+ \rightleftharpoons Cr_2O_7^{-2} + 3\ H_2O$$

pH > 5

Ca^{+2} , Sr^{+2} are precipitated.

Group (IV): $(NH_4)_2CO_3$ group



Group (IV): $(NH_4)_2CO_3$ group

Ca^{+2} is not precipitated as sulfate salt in this condition, by adding $(NH_4)_2SO_4$.

Equations and Explanation

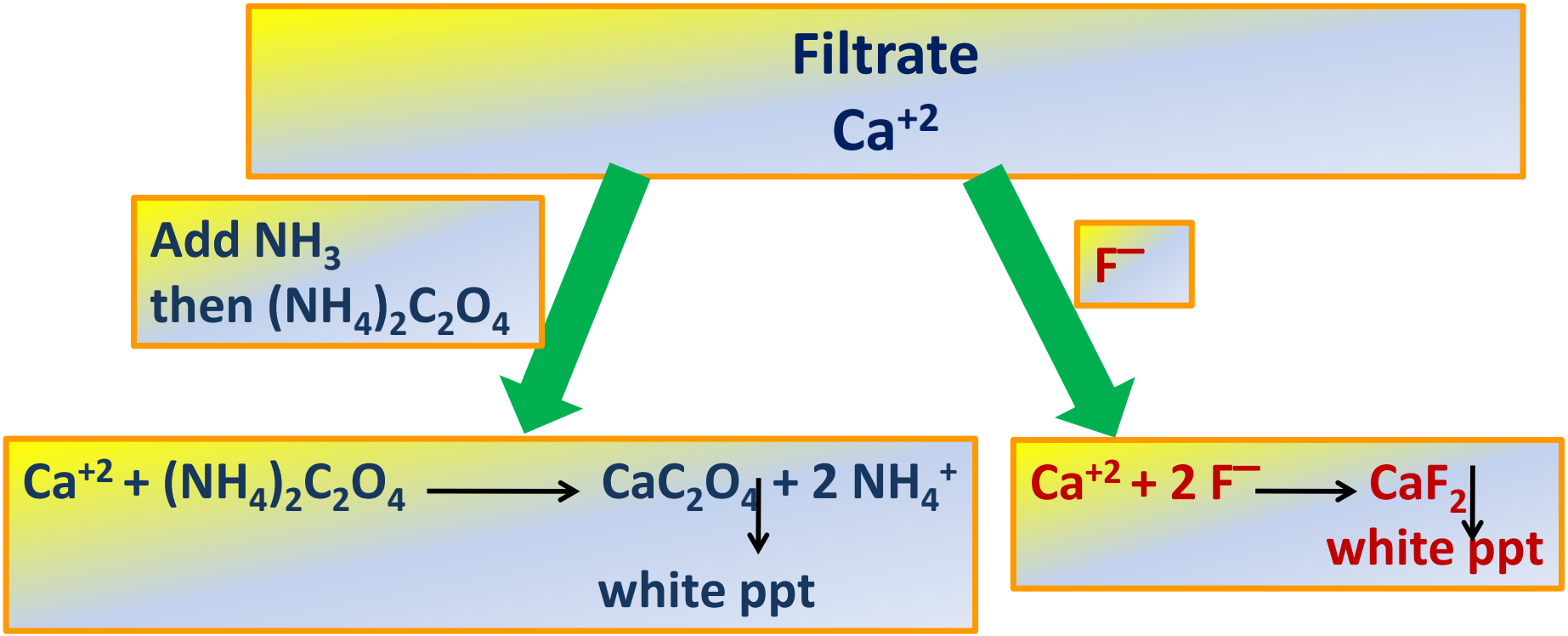
$$Ca^{+2} + SO_4^{-2} \rightleftharpoons CaSO_4 \downarrow$$

white ppt

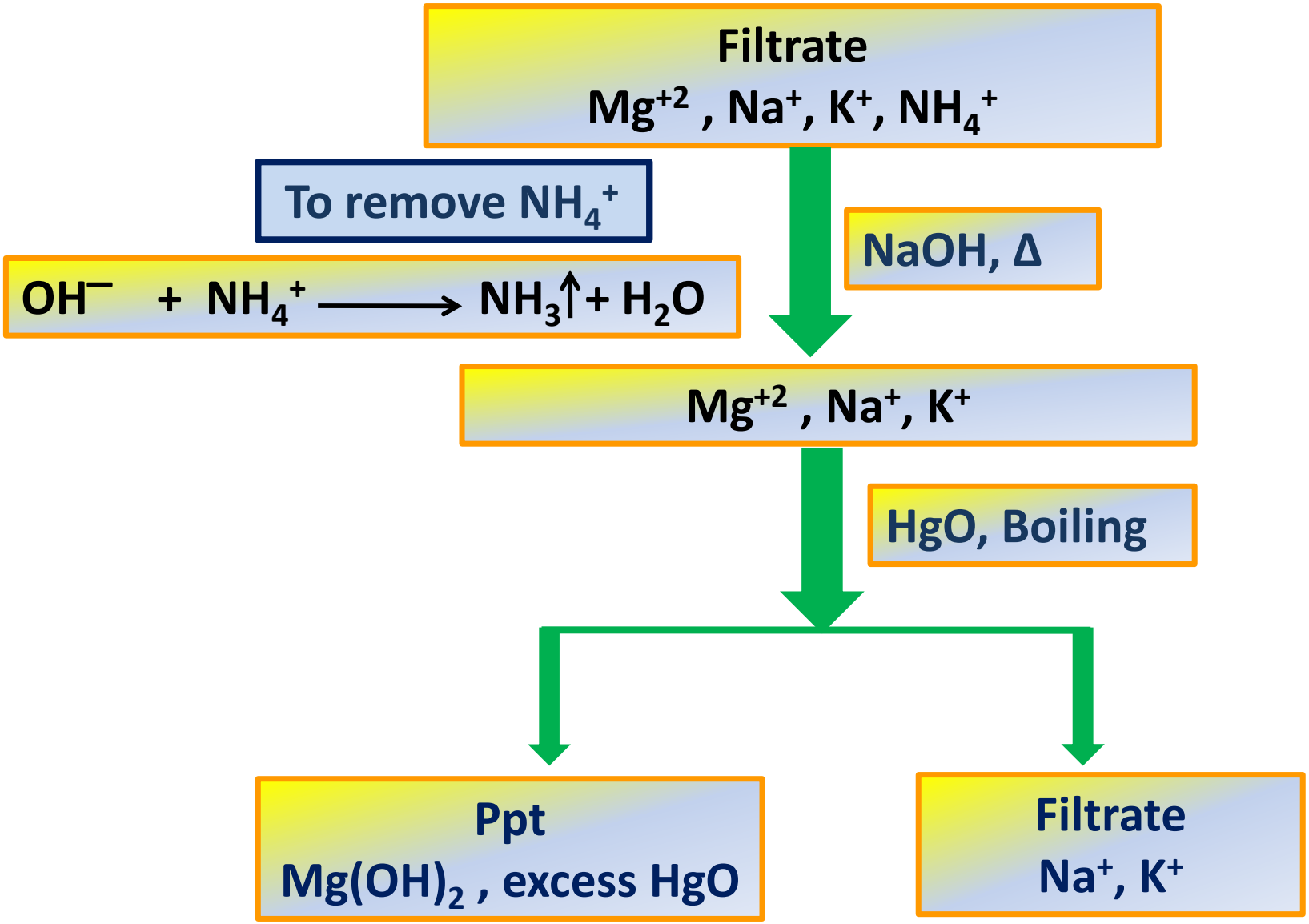
$$CaSO_4 + 2\,(NH_4)_2SO_4 \longrightarrow [Ca(SO_4)_2]^{-2} + 2\,NH_4^+$$

soluble complex

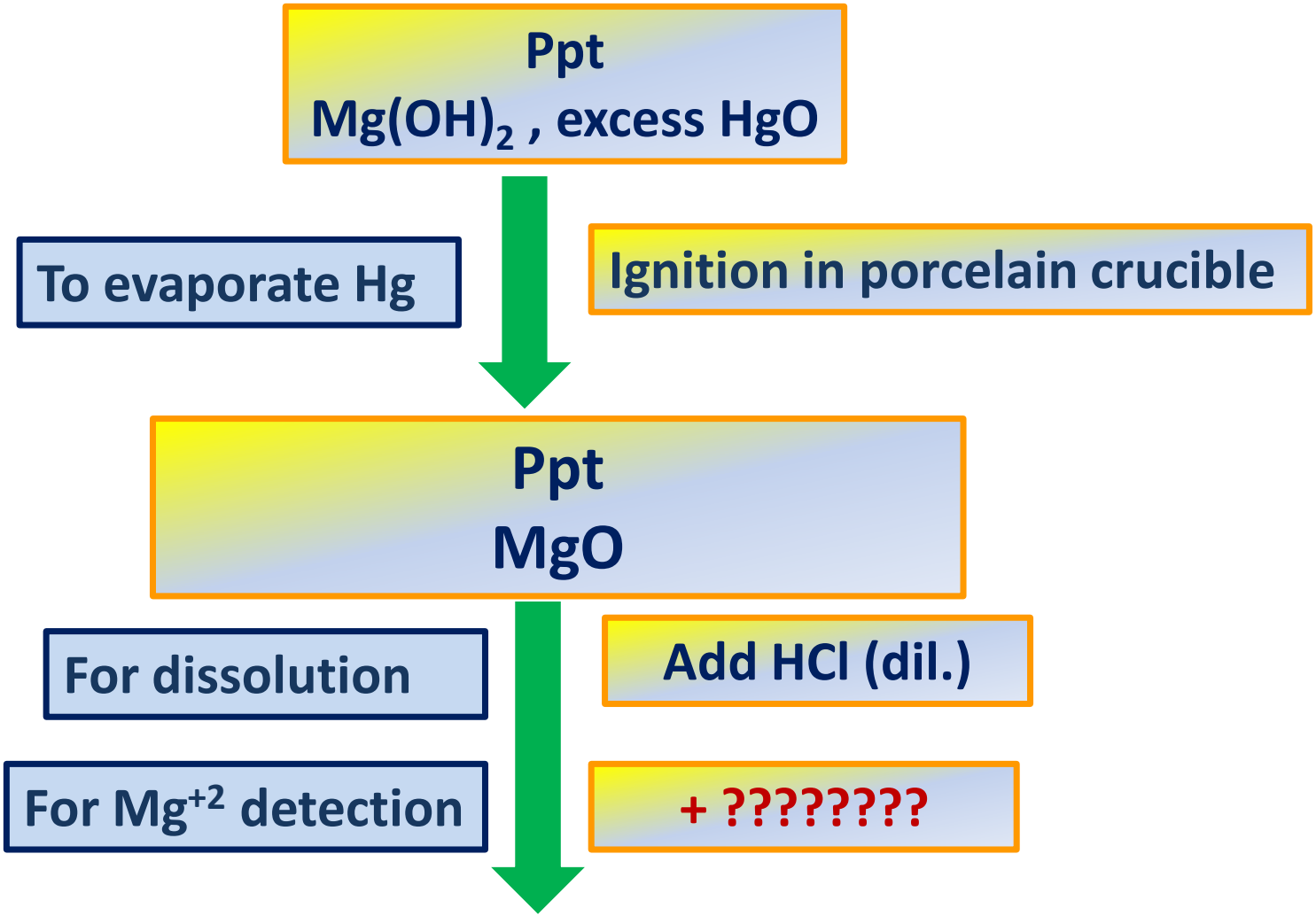
Group (IV): $(NH_4)_2CO_3$ group



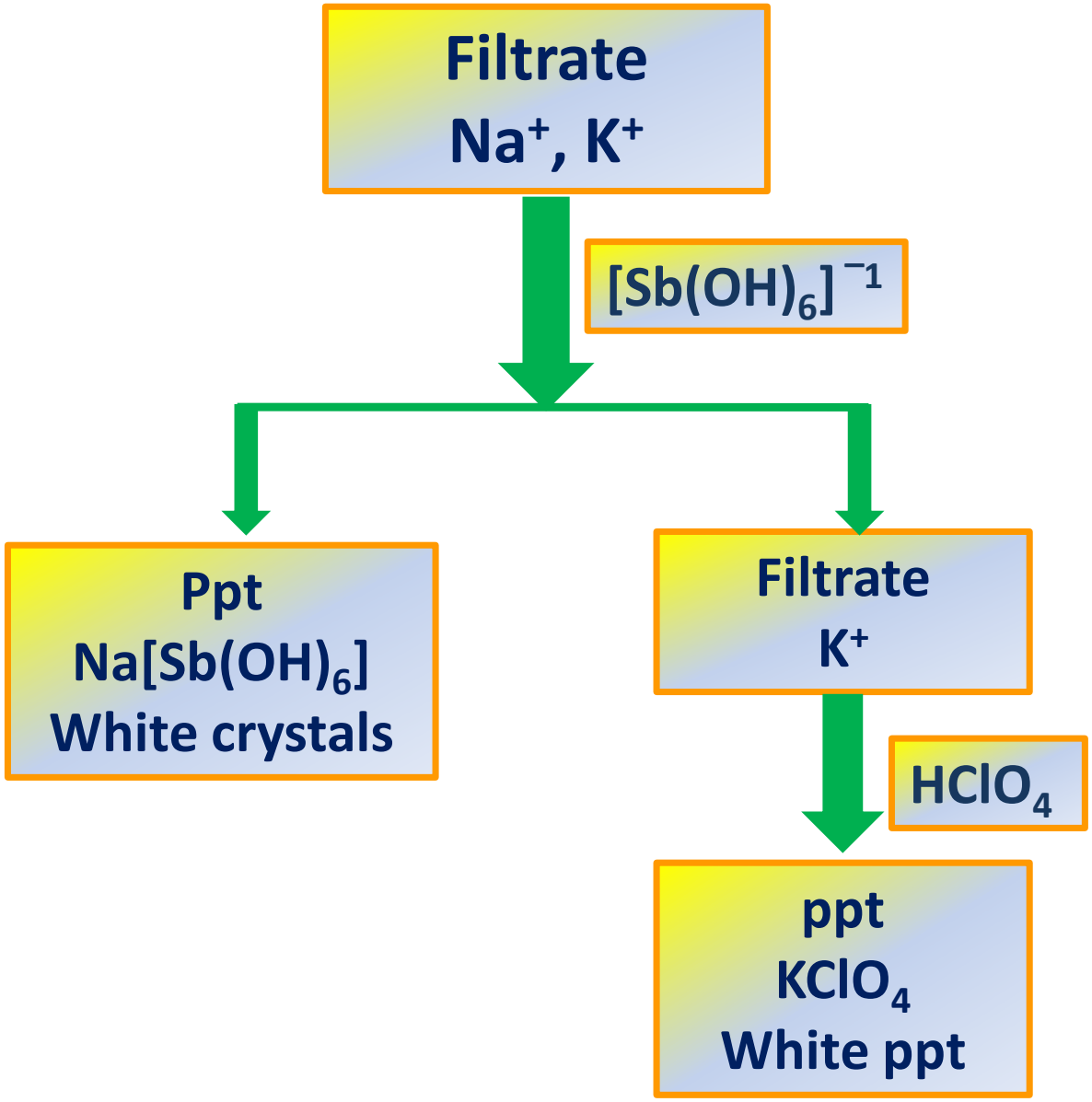
Group (V): Soluble group



Group (V): Soluble group



Group (V): Soluble group



Exercise

Describe only schematic how could the following ions be separated:

Ag^{+}, Pb^{+2}, Cu^{+2}, Bi^{+3}, As^{+3}, Sn^{+2}, Fe^{+2}, Ni^{+2}, Ca^{+2}, Na^{+}, K^{+}.

Exercise

A chemist has the following results for analysis of a salt:

A- Pulverize the sample with $KHSO_4$ a vinegar odor was characterized.

B- Upon adding HCl (dil) to sample solution a white ppt was formed which was soluble upon heating

C- Upon passage of H_2S to acidified solution of sample a black ppt was formed , which was soluble in HNO_3 (conc.)

D- Upon addition of KI solution to sample a yellow crystals was formed.

1. What is the salt?

2. Explain your judgment with equations?

3. Give a malfunction for test (A)? Then explain how to be removed (One solution)?