Qualitative inorganic analysis

Part (I)
Anions
(Direct anions)

Dr. Mai Ramadan

Classification of anions

Anions are classified in two groups:

Direct analysis of anions

Indirect analysis of anions (Soda extraction)

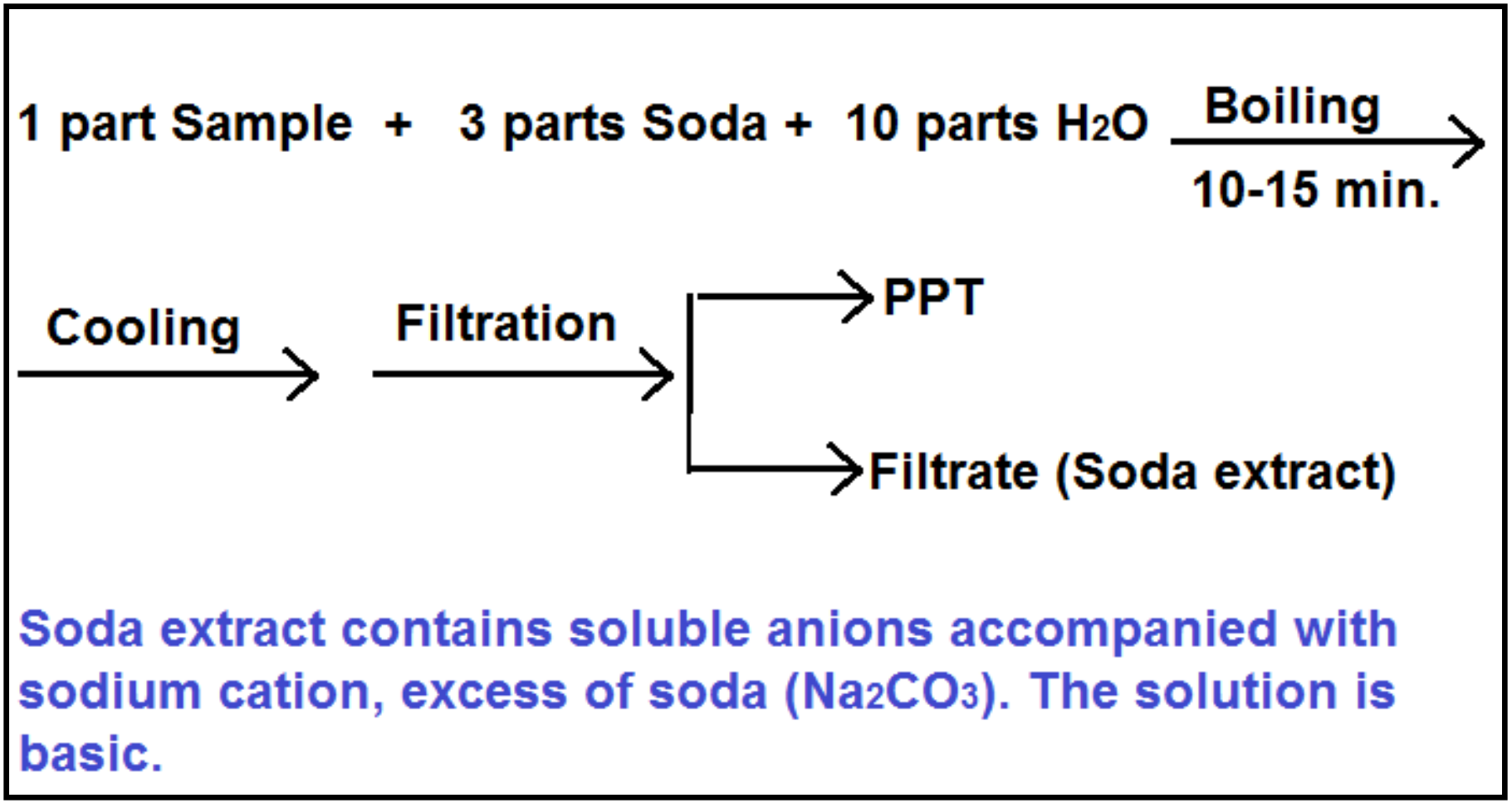
Classification of anions

Direct analysis of anions:
Perform detection test using the sample directly as the test described in book**.**

Indirect analysis of anions (Soda extraction):
Perform detection test using soda extract (prepared from sample) as described in book

Classification of anions

Soda extraction:



Soda extract contains soluble anions accompanied with sodium cation, excess of soda (Na_2CO_3). The solution is basic.

Classification of anions

Aim of soda extraction:

Removal of heavy metal cations in the sample by precipitating them through boiling with soda (Na_2CO_3). Cations precipitated as carbonate, hydroxide, and or oxide which are separated by filtration. While anions remain soluble in soda extract accompanied with sodium cation.

Classification of anions

Soda extraction:

Why should cations be removed from the sample before performing detection test of anions????

What is the problem caused by a cation??

Classification of anions

Suppose you have unknown sample to detect sulfate anions. The sample in fact contains

$$Na_2SO_4 + BaCl_2$$

Direct analysis

No sulfate (Why?)

Test is done using the sample

Indirect analysis

Sulfate is present

The test is done using soda extract.

Classification of anions

Direct analysis

No sulfate (Why??)

$$Ba^{+2} + SO_4^{-2} \longrightarrow BaSO_4\downarrow$$

Cation in the sample (Ba^{+2}) reacts with sulfate -anion to be detected- to form a precipitate.

Classification of anions

Indirect analysis
Sulfate is present

Ba^{+2} interferes with detection test of SO_4^{-2}. It should be removed by soda extraction and sulfate is detectable in soda extract.

$$Ba^{+2} + CO_3^{-2} \longrightarrow BaCO_3 \downarrow$$

Ba^{+2} ion is precipitated by reacting with soda as carbonate salt.

Classification of anions

Suppose you have unknown sample to detect cyanide anion. The sample in fact contains

$KCN + FeCl_3$

Direct analysis

No cyanide (Why?)

Test is done using the sample

Indirect analysis

cyanide is present

The test is done using soda extract.

Classification of anions

Direct analysis

No cyanide (Why?)

$$Fe^{+3} + 6\,CN^{-} \longrightarrow [Fe(CN)_6]^{-3}$$

stable complex

Cation in the sample (Fe^{+3}) reacts with cyanide -

anion to be detected- to form a stable complex.

Classification of anions

Indirect analysis
cyanide is present

Fe^{+3} interferes with detection test of CN^-. It should be removed by soda extraction (precipitate as hydroxide and oxide). CN^- is detectable in soda extract.

$$2\,Fe^{+3} + 3\,CO_3^{-2} \longrightarrow Fe_2(CO_3)_3\downarrow \xrightarrow{\Delta} Fe_2O_3\downarrow + 3\,CO_2$$

Soda is basic (why???)

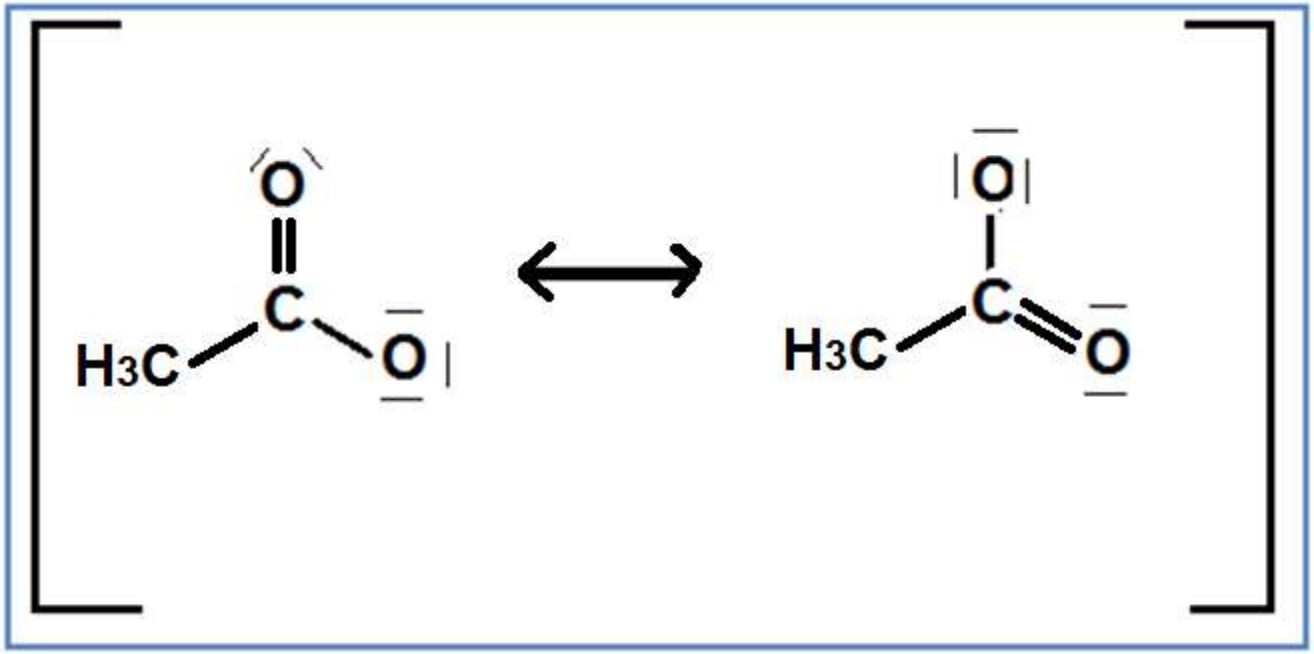
$$Fe^{+3} + 3\,OH^- \longrightarrow Fe(OH)_3\downarrow$$

Direct Analysis of Anions

This group includes anions like:
Acetate, carbonate, fluoride, silicate, borate, ------ etc

Acetate ion (CH_3COO^-)

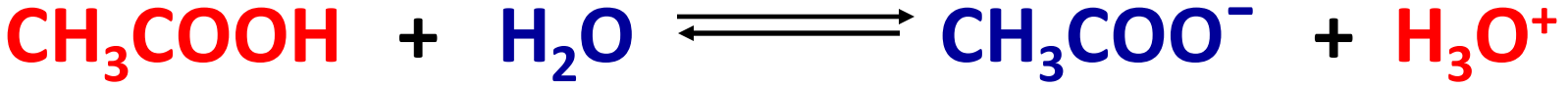
Acetate is used in preparation of acetate buffer, pharmacy industry, acetic acid main component of vinegar.



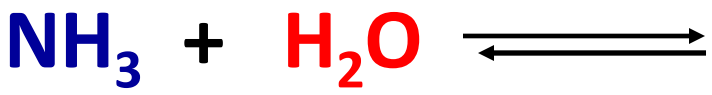
Define:

Strong acid, Strong base, Weak acid, Weak base, buffer, Brönsted-lowery acid, lewis acid, lewis base, amphoteric

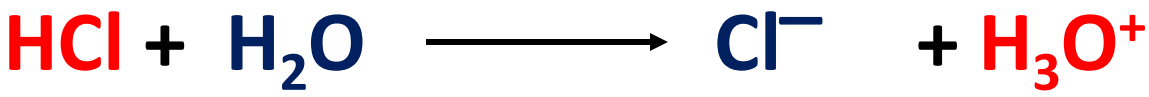
Acetate ion CH_3COO^-



Weak acid Conjugated base



Weak base Conjugated acid



Acetate ion CH_3COO^-

Test:

Sample(s) + $KHSO_4$ (s) $\xrightarrow{\text{pulverize}}$ Smell of vinegar

CH_3COO^- + HSO_4^- $\longrightarrow$ CH_3COOH + SO_4^{-2}

acetic acid, volatile, smell of vinegar

Malfunctions of test:

S^{-2}, SO_3^{-2}, $S_2O_3^{-2}$, CN^-

Acetate ion CH_3COO^-

Malfunctions:

$$S^{-2} + 2\,HSO_4^- \longrightarrow H_2S\uparrow + 2\,SO_4^{-2}$$

rotten egg odor

$$SO_3^{-2} + 2\,HSO_4^- \longrightarrow H_2SO_3 + 2\,SO_4^{-2}$$

$$H_2SO_3 \longrightarrow SO_2\uparrow + H_2O$$

Unstable

pricing odor

$$S_2O_3^{-2} + 2\,HSO_4^- \longrightarrow H_2S_2O_3 + 2\,SO_4^{-2}$$

$$H_2S_2O_3\,(\text{unstable}) \longrightarrow SO_2\uparrow + S\downarrow + H_2O$$

pricing odor

$$CN^- + HSO_4^- \longrightarrow HCN + SO_4^{-2}$$

bitter almond odor

Acetate ion CH_3COO^-

Removal of malfunctions:

Sample(s) + Silver salt (Ag_2SO_4) $\xrightarrow{\text{pulverize}}$ + $KHSO_4$ (s) $\xrightarrow{\text{pulverize}}$ Smell of vinegar

Malfunctions react with Ag^+, forming **stable salts** which do not interfere with acetate test.

$S^{-2} + 2\,Ag^+ \longrightarrow Ag_2S\downarrow$

$SO_3^{-2} + 2\,Ag^+ \longrightarrow Ag_2SO_3\downarrow$

$S_2O_3^{-2} + 2\,Ag^+ \longrightarrow Ag_2S_2O_3\downarrow$

$CN^- + Ag^+ \longrightarrow AgCN\downarrow$

Acetate ion CH_3COO^-

Removal of malfunctions:

Sample(s) + $KMnO_4$ (s) $\xrightarrow{\text{pulverize}}$ + $KHSO_4$ (s) $\xrightarrow{\text{pulverize}}$
Smell of vinegar

Malfunctions (S^{-2}, SO_3^{-2}, $S_2O_3^{-2}$) react with $KMnO_4$ in a redox reaction forming SO_4^{-2} , which is **not malfunction**.

$$3\,S^{-2} + 8\,MnO_4^- + 8\,H_3O^+ \longrightarrow 3\,SO_4^{-2} + 8\,MnO_2\downarrow + 12\,H_2O$$

$$3\,SO_3^{-2} + 2\,MnO_4^- + 2\,H_3O^+ \longrightarrow 3\,SO_4^{-2} + 2\,MnO_2\downarrow + 3\,H_2O$$

$$3\,S_2O_3^{-2} + 8\,MnO_4^- + 2\,H_3O^+ \longrightarrow 6\,SO_4^{-2} + 8\,MnO_2\downarrow + 3\,H_2O$$

Acetate ion CH_3COO^-

$KMnO_4$ is a strong oxidizing agent

Define:

Redox RXN

Oxidation

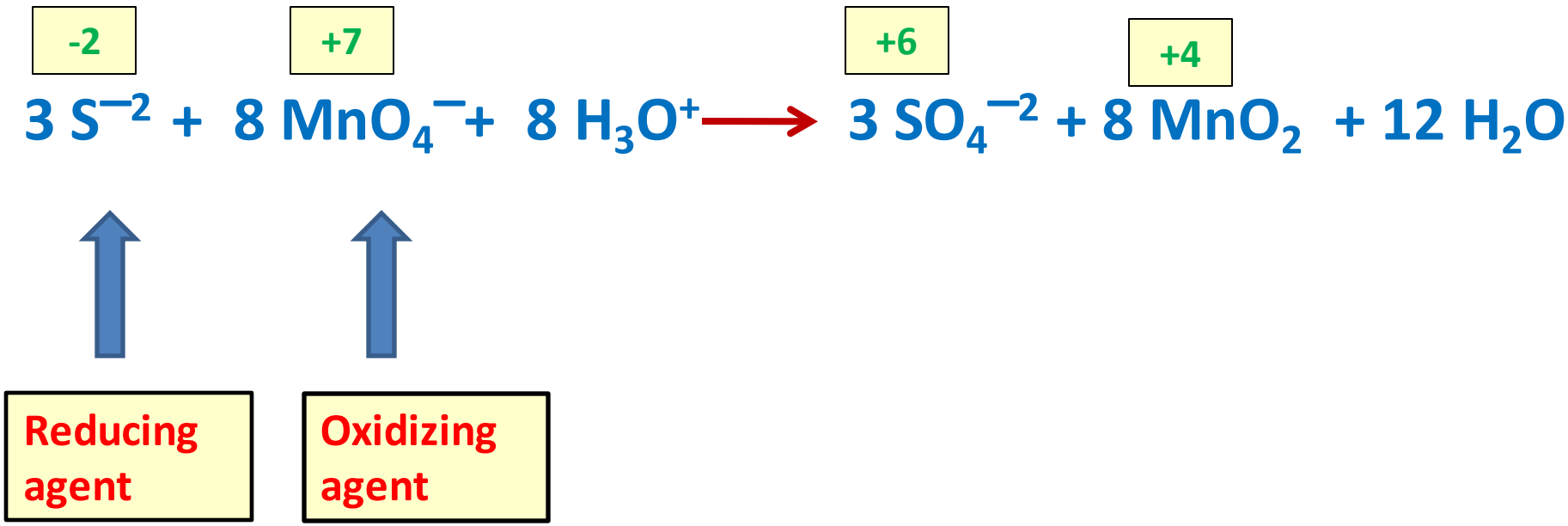
Reduction

Oxidizing agent

Reducing agent

Acetate ion CH_3COO^-

$KMnO_4$ is a strong oxidizing agent



Balance of redox RXN is subject of next lecture

Carbonate ion CO_3^{-2}

Carbonate used in preparation of carbonate buffer, effervescent tablet, carbonate beverages, food industry

Carbonate is a weak base

Test :

Sample (s) in watch glass + HCl (dil) ⟶ Effervescence due to development of CO2 gas (it has no physical characters e.g. no color, no odour)

Carbonate ion CO_3^{-2}

$$HCl + H_2O \longrightarrow Cl^- + H_3O^+$$

$$CO_3^{-2} + 2\,H_3O^+ \longrightarrow CO_2\,(g) + 3\,H_2O$$

$$CO_3^{-2} + H_3O^+ \longrightarrow HCO_3^- + H_2O$$

$$HCO_3^- + H_3O^+ \longrightarrow H_2CO_3 + H_2O$$

$$H_2CO_3\ (\text{unstable}) \longrightarrow CO_2\,(g) + H_2O$$

Malfunctions: S^{-2}, SO_3^{-2} , $S_2O_3^{-2}$, CN^-, F^- (write the reactions)

Carbonate ion CO_3^{-2}

Specify and detect CO_2 by chemical reaction

Put sample in test tube 1, add HCl (dil) and close tightly. Tube 1 is connected through a U glass tube with a clear solution of $Ba(OH)_2$

When CO_2 (non polar, acidic gas) passes into $Ba(OH)_2$ solution , turbidity will appears due to formation of insoluble $BaCO_3$

Malfunction: Excess of CO_2 gas

Carbonate ion CO_3^{-2}

Specify and detect CO_2 by chemical reaction

Test tube 1: $CO_3^{-2} + 2\ H_3O^+ \longrightarrow CO_2\ (g) + 3\ H_2O$

Test tube 2: $CO_2 + Ba(OH)_2 \longrightarrow BaCO_3\ (s) + H_2O$

white ppt causes turbidity

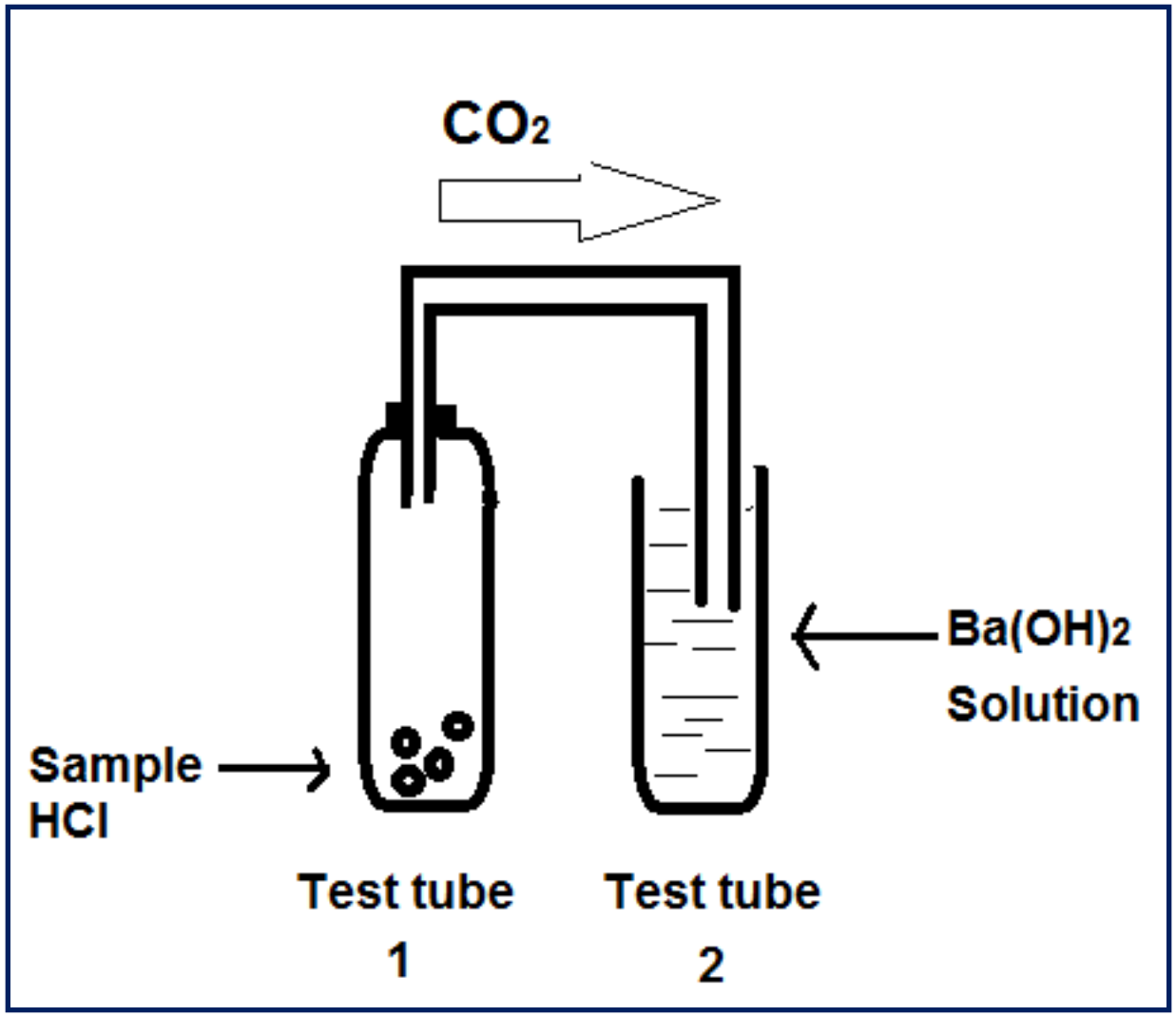
Malfunction:

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

soluble salt

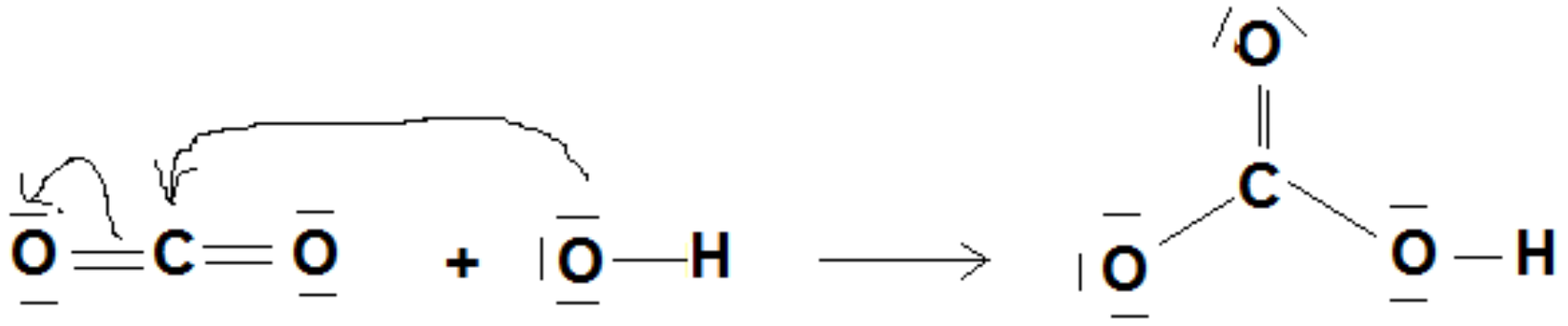
Carbonate ion CO_3^{-2}

Specify and detect CO_2 by chemical reaction



Carbonate ion CO_3^{-2}

Specify and detect CO_2 by chemical reaction



Lewis Acid Lewis Base HCO_3^-

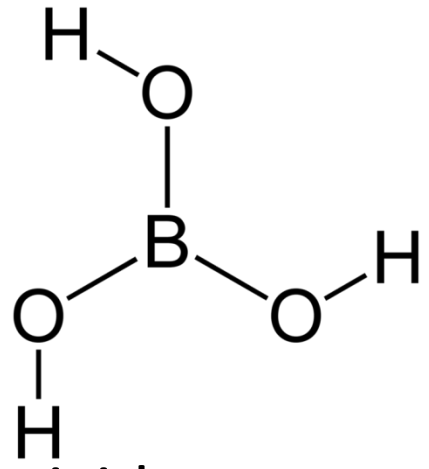
$HCO_3^- + H-O-H \longrightarrow CO_3^{-2} + H_2O$

Acid Base

$Ba^{+2} + CO_3^{-2} \longrightarrow BaCO_3\downarrow$

White ppt

Boric acid



Boric acid, ortho-boric acid

H_3BO_3 , $B(OH)_3$

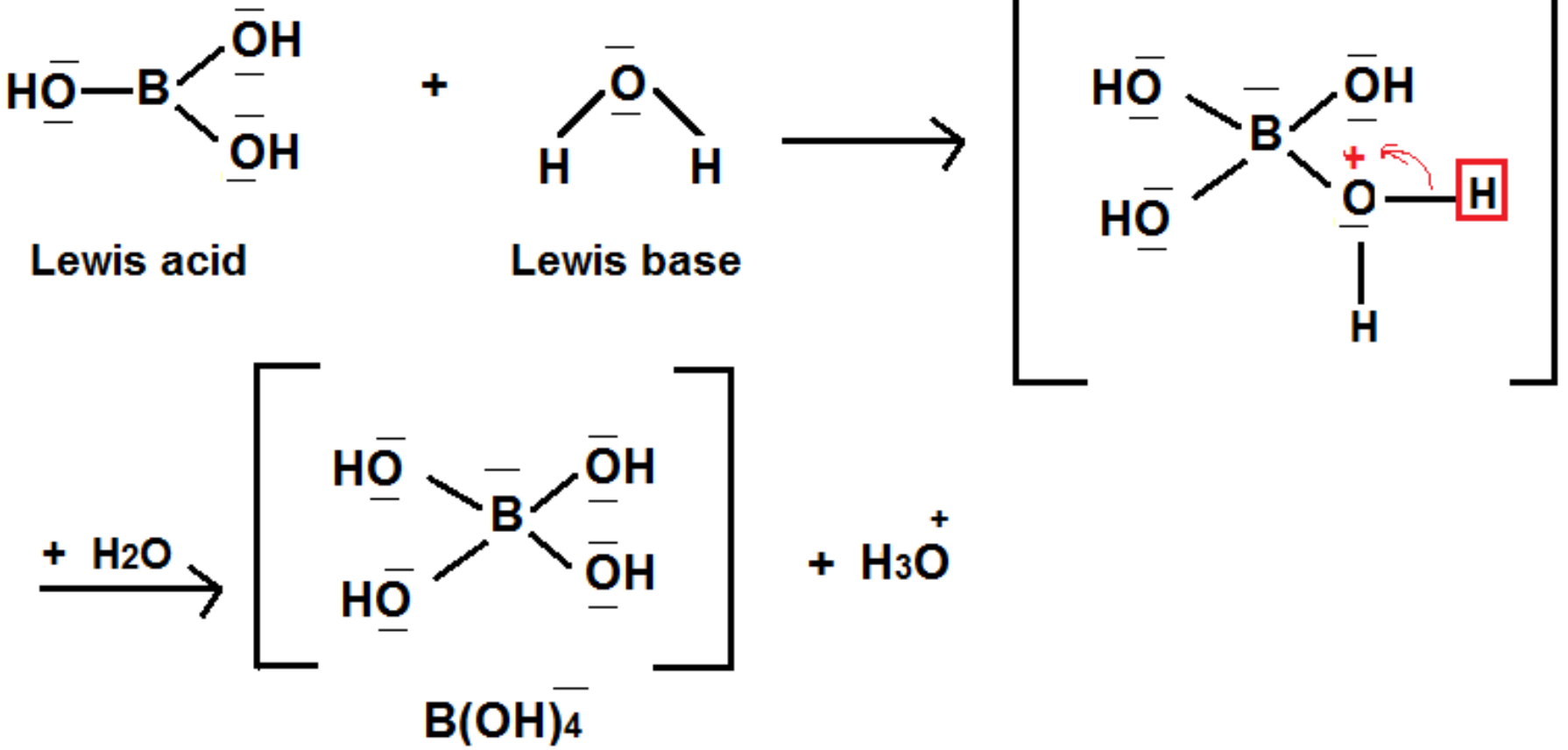
is used as antiseptic in ear drops and as insecticide.

Boron has valence electron = 3 that it has an incomplete octet

Boric acid is a weak monoprotic lewis acid

$$H_3BO_3 + 2\,H_2O \longrightarrow B(OH)_4^- + H_3O^+$$

Boric acid



Detection of borate

Borates ion BO_3^{-3}, $B_4O_7^{-2}$, BO_2^-

The salt used in test is **borax** (sodium tetraborate decahydrate, $Na_2B_4O_7 \cdot 10H_2O$)

Test: with sulphuric acid and alcohol (Flame test)
Sample + 1 mL H_2SO_4 (Conc) + 5 mL CH_3OH heat in water bath, then direct the upper edge of test tube to the bunsen flame, the flame colored green

Detection of borate

$$Na_2B_4O_7 + H_2SO_4 + 5\,H_2O \longrightarrow 4\,H_3BO_3 + SO_4^{-2} + 2\,Na^+$$

Acid + alcohol ⟷ Ester + water

$$H_3BO_3 + 3\,CH_3OH \xrightarrow{+\,H_2SO_4\,(conc)} B(OCH_3)_3 + 3\,H_2O$$

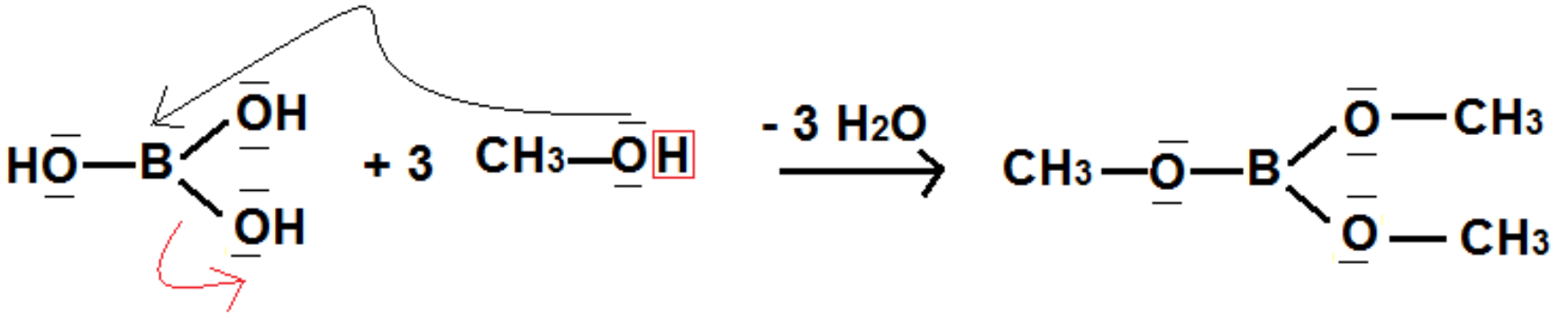
methyl alcohol

trimethylborate ester, volatile, colored the flame green

Water hydrolyzed ester back to its component

H_2SO_4 (conc) is hygroscopic , it adsorbs water resulted in reaction and prevent hydrolysis.

Detection of borate



Methylester of boric acid

Trimethylborate ester

Flouride ion

Bubble test:

Sample + H_2SO_4 (Conc.) warm in water bath small bubbles are formed which collect to form larger bubbles

$$F^- + H_2SO_4\ (Conc) \longrightarrow HF\ (g) + HSO_4^-$$

H_2SO_4 (Conc.) is viscous

Flouride ion

Etching test:

Sample + H_2SO_4 (Conc) in new test tube,warm in water bath, then move sulphuric acid out of the test tube, put water in tube then move it out. Sulphuric acid move like water on oil and particles of water remain attached to the inner surface of test tube because it is rough.

$$F^- + H_2SO_4\,(Conc) \longrightarrow HF\,(g) + HSO_4^-$$

corrosive gas

$$4\,HF\,(g) + SiO_2 \longrightarrow SiF_4\uparrow + 2H_2O$$

glass tube

silicon tetraflouride , volatile

Silicate ion SiO_3^{-2}

Test of silicate can not be performed in glass test tube. (Why?)

Importance: Silica gel in chromatography, glass industry, Cosmetic, ----

Test:

Sample is put in platin or lead crucible followed by H_2SO_4 (Conc) and NaF and put on the upper edge of crucible black Filter paper saturated (soaked) with water then warm in a water bath $\longrightarrow$ a white spot appears on the filter paper (SiO_2)

Silicate ion SiO_3^{-2}

$$SiO_3^{-2} + 4\ F^- + 6\ H_3O^+ \longrightarrow SiF_4\uparrow + 9\ H_2O$$

SiF_4 is volatile and reaches the filter paper, where the following reaction takes place

$$SiF_4 + 2\ H_2O \longrightarrow SiO_2\downarrow + 4\ HF$$

Silicon dioxide, white spot on black filter paper

Malfunction: Excess of Flouride

$$SiO_3^{-2} + 6\ F^- + 6\ H_3O^+ \longrightarrow [SiF_6]^{-2} + 9\ H_2O$$

soluble complex, not volatile
hexafluorosilicate (IV) ion

Questions of this week

SiO_2 is **not like CO_2 .** It is a polymer what is the structure?

How can you keep a solution of flouride or hydroflouric acid since it attacks glass container?

How is AgF differs from other silver halides e.g. AgCl?
(Hint : p 180, 174 in Vogel's qualitative inorganic analysis)

What is lime water and baryta water chemically ?
(hint p 150)

What should happen if CO_2 passes into lime water?

Questions of this week

The following are sparingly soluble salts. which solubility (as you expect) is improved by changing pH acidic with explanation? AgCl, AgBr, CaC_2O_4, $BaCO_3$, $CaCO_3$, CuS, Ag_3PO_4

$AgCl\ (s) \xleftrightarrow{Ksp} Ag^+ + Cl^-$

$Cl^- + H^+ \longrightarrow$ no reaction

because Cl^- is extremely weak base, that it can not be consumed in the second reaction with acidic media and accepts proton

AgCl is not dissolved in acidic pH

Questions of this week

$CaCO_3$ (s) $\xleftrightarrow{Ksp}$ Ca^{+2} + CO_3^{-2}

CO_3^{-2} + H^+ $\longrightarrow$ HCO_3^-

HCO_3^- + H^+ $\longrightarrow$ H_2CO_3 $\longrightarrow$ CO_2 (g) + H_2O

$CaCO_3$ (s)+ 2 H^+ $\longrightarrow$ Ca^{+2} + CO_2 (g) + H_2O

$CaCO_3$ solubility is improved in acidic pH

Carbonate of the first equilibrium is a base which starts reaction with acidic media

Qualitative inorganic analysis

Part (I)

Anions
(Indirect anions)

Indirect analysis of anions

The anions should be detected in soda extract

Chloride, iodide, bromide, sulfide, sulfite, sulfate, nitrate, nitrite, phosphate, cyanide, --------

Dr. Mai Ramadan

Chloride ion

With $AgNO_3$ Solution:

Soda extract + acidify with HNO_3 (dil) + then add $AgNO_3$ Solution $\longrightarrow$ white ppt, insoluble in HNO_3 (conc.), soluble in NH_3 (dil.)

Soda extract had basic pH, it should be acidified before adding Ag^+ reagent to prevent its precipitation as Ag_2O

$$Ag^+ + OH^- \longrightarrow Ag(OH)$$

$$2\,Ag(OH) \longrightarrow Ag_2O\downarrow + H_2O$$

black ppt

(Can you acidify with HCl? Explain)

Chloride ion

Reactions:

$Cl^- + Ag^+ \longrightarrow AgCl\downarrow$

white ppt

$AgCl\ (s) + H^+ \longrightarrow$ insoluble as discussed before

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

Diamminesilver(I) ion, soluble complex

$AgCl\ (s) \xleftrightarrow{Ksp} Ag^+ + Cl^-$

$Ag^+ + 2\ NH_3 \longrightarrow [Ag(NH_3)_2]^+$

Chloride ion

Question:

when HNO_3 (dil) is added after dissolution of AgCl in ammonia, the precipitate is reformed (hint: p 66, 174)

$$[Ag(NH_3)_2]^+ + Cl^- + 2\ H^+ \longrightarrow AgCl\ (s) + 2\ NH_4^+$$

Malfunction:

Br^- , I^- , S^{-2}, CN^-, SCN^-

Ag^+ + ions mentioned previously $\longrightarrow$ give ppt. of different colors

Chloride ion

Potassium dichromate and sulphuric acid: (Chromyl chloride test)

Soda extract + $K_2Cr_2O_7$ + H_2SO_4 (Conc.) warm gently in water bath $\longrightarrow$ a colored gas is evolved (CrO_2Cl_2), this gas is identified by a filter paper soaked with NaOH/ Diphenylcarbazide solution (colorless), the filter paper turns violet due to formation of diphenylcarbazone.

There are 3 reactions one in the test tube and the next two on filter paper

Chloride ion

Chromyl chloride test:

1] In the test tube:

$$4\,Cl^- + Cr_2O_7^{-2} + 6\,H_3O^+ \longrightarrow 2\,CrO_2Cl_2\uparrow + 9\,H_2O$$

chromyl chloride, colored gas

Note:

This reaction is **not a redox**

The oxidation number of **Cr** in $Cr_2O_7^{-2}$ and CrO_2Cl_2 is +6

Chloride ion

Chromyl chloride test:

2]on the filter paper

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

Chromyl chloride → sodium chromate

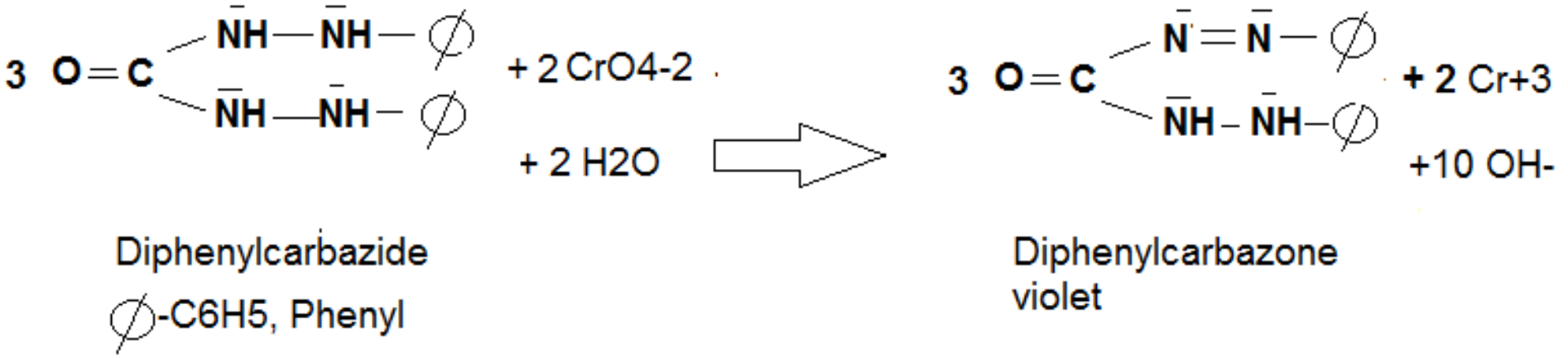
Note:

Remember chromate , dichromate and permanganate are strong oxidizing agent

Chloride ion

Chromyl chloride test:

3] On the filter paper

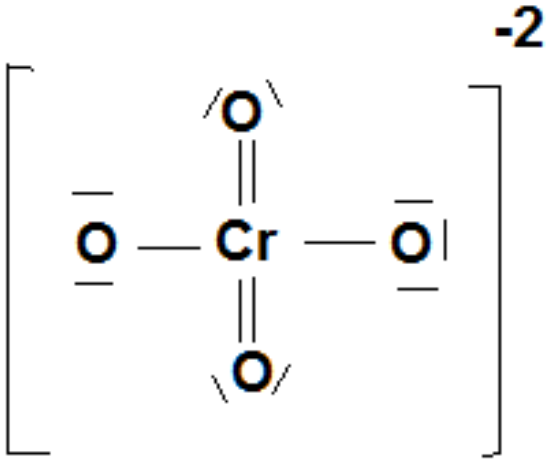


Note:

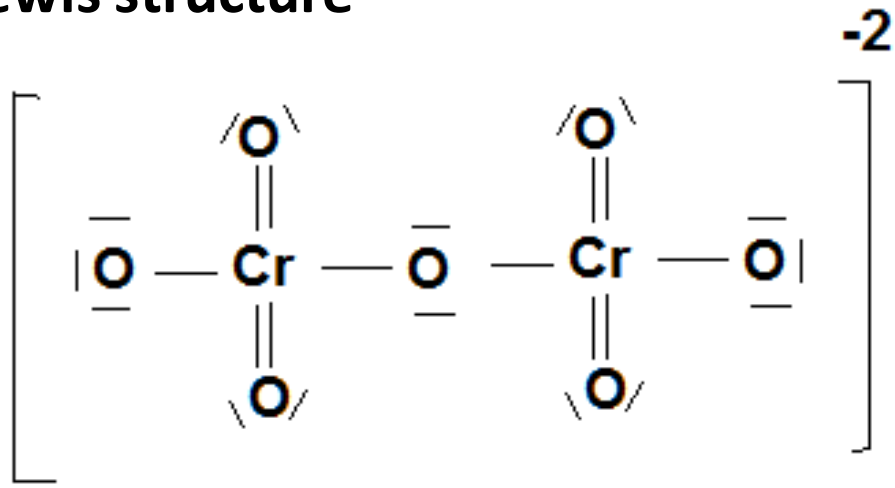
Redox reaction: Diphenylcarbazide (colorless) is oxidized by chromate to diphenylcarbazone (violet color)

Chloride ion

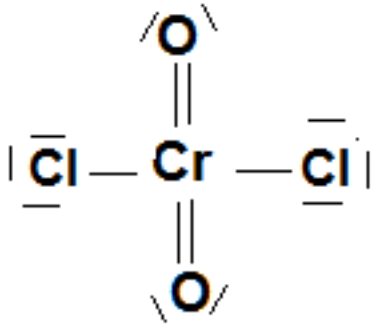
Lewis structure



CrO4-2



Cr2O7-2

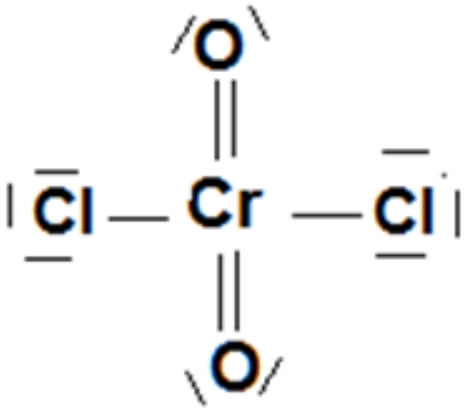


CrO2Cl2

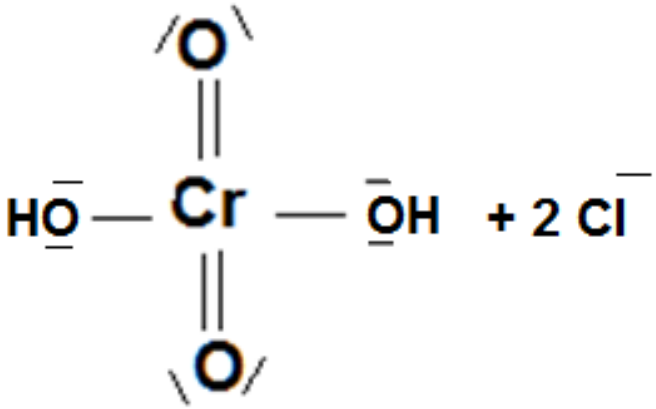
Chloride ion

Chromyl chloride test in details

$$\underset{\text{Chromyl chloride}}{CrO_2Cl_2} + 4\,NaOH \longrightarrow \underset{\text{sodium chromate}}{Na_2CrO_4} + 2\,NaCl + 2\,H_2O$$

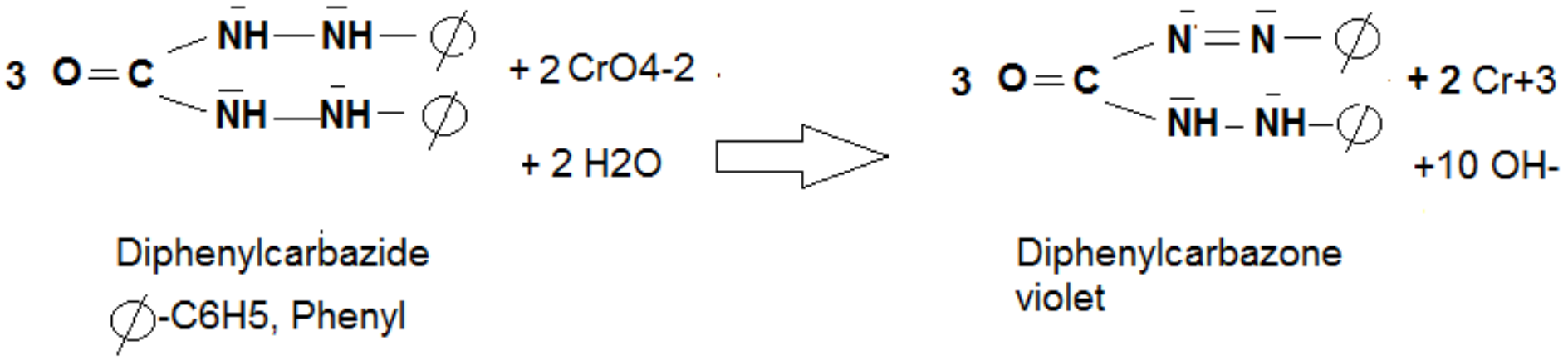


CrO2Cl2

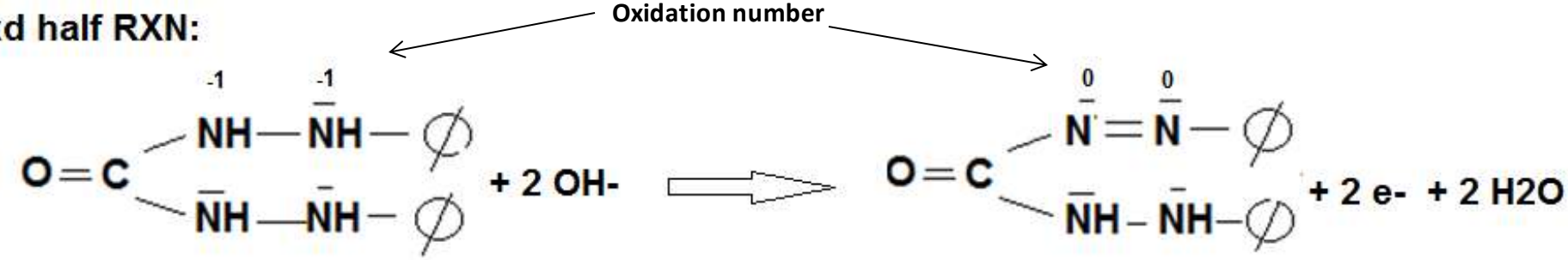


H2CrO4

Chloride ion



Oxd half RXN:



Red half RXN:

$$CrO_4^{-2} + 3e^- + 4\,H_2O \longrightarrow Cr^{+3} + 8\,OH^-$$

Bromide ion

With $AgNO_3$ Solution:

Soda extract + acidify with HNO_3 (dil) + then add $AgNO_3$ Solution $\longrightarrow$ yellowish-white ppt, insoluble in HNO_3 (conc.), insoluble in NH_3 (dil.), soluble in NH_3 (conc.)

Soda extract had basic pH, it should be acidified before adding Ag^+ reagent to prevent its precipitation as Ag_2O (discussed before)

Reactions:

$$Br^- + Ag^+ \longrightarrow AgBr\downarrow$$

yellowish-white ppt

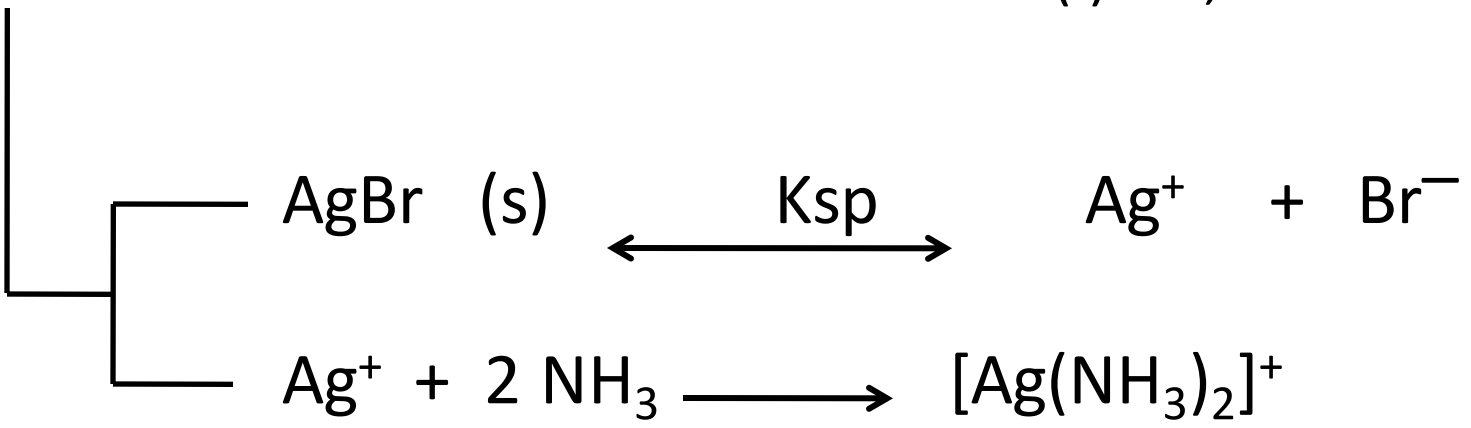
Bromide ion

Reactions:

$AgBr\ (s) + H^+ \longrightarrow$ insoluble as discussed before

$AgBr\ (s) + 2\ NH_3 \longrightarrow [Ag(NH_3)_2]^+ + Br^-$

Diamminesilver(I) ion, soluble complex



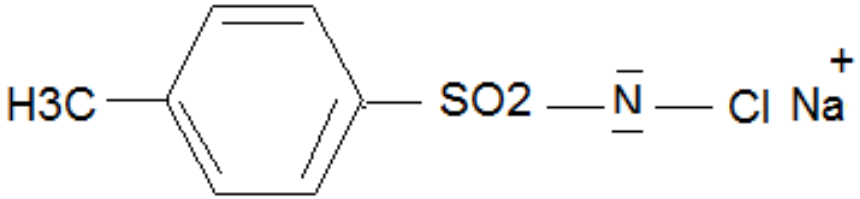
Bromide ion

With Chloramine-T solution:

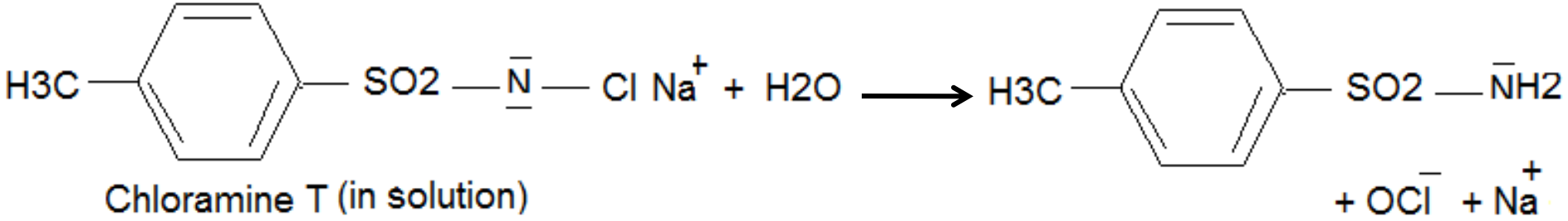
Soda extract + acidify with HCl + 3-4 ml $CHCl_3$ or CCl_4 (two immiscible phases are formed) then add drop wise freshly prepared chloramine T (dil.) ⟶ the organic phase ($CHCl_3$ or CCl_4) is colored brown ⟶ when excess chloramine T reagent is added the organic phase is colored yellow.

Bromide ion

Reactions:



Chloramine T (solid state)



Chloramine T (in solution)

OCl^- : hypochlorite ion

Bromide ion

Reactions:

Note:
This reaction is **synproportionation** reaction (Redox, Auto-oxidation reaction).

Cl atom in hypochlorite has oxidation number +1, in chloride ion is -1. The product chlorine (halogen) has oxidation number of 0.

Cl^- , H_3O^+ originate from HCl. Do not use another acid in test

Bromide ion

Reactions:

$Cl_2 + 2\,Br^- \longrightarrow Br_2 + 2\,Cl^-$

Br_2 (bromine , non polar molecule) dissolves in organic phase with brown color.

Excess chloramine T solution is added:

$Cl_2 + Br_2 \longrightarrow 2\,BrCl$

BrCl dissolves in organic phase with yellow color

Do you remember?

Halogens

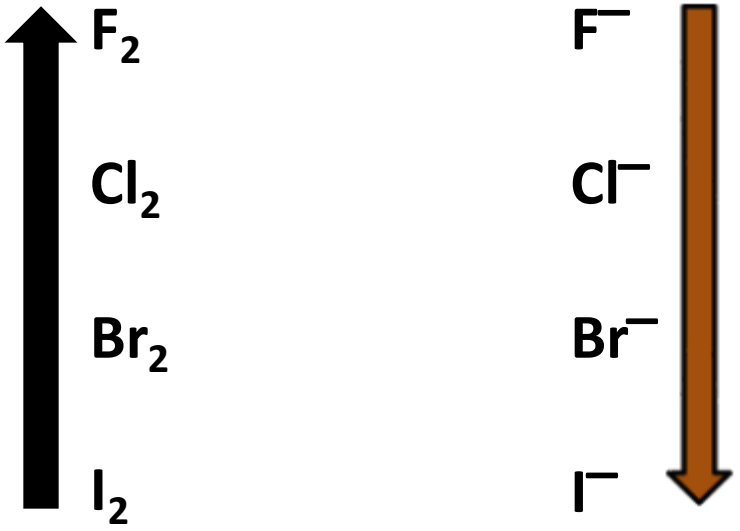
Chlorine	Bromine	Iodine
$Cl_2(g)$	$Br_2(l)$	$I_2(s)$

Increasing molecular weight

Do you remember?

Oxidizing agent

Reducing agent



Which reaction occurs spontaneously?

Cl_2 (aq) + KBr (aq) ⟶ ✓

Br_2 (aq) + NaCl (aq) ⟶ ✗

Bromide ion

With potassium dichromate and sulphuric acid:

Soda extract + $K_2Cr_2O_7$ + H_2SO_4 (Conc.) warm gently in water bath ⟶ Br_2 is produced (reddish brown vapor)

To identify the vapor put a filter paper soaked with fluorescein solution (yellow) ⟶ the filter paper acquires red color (Eosin).

Malfunction:

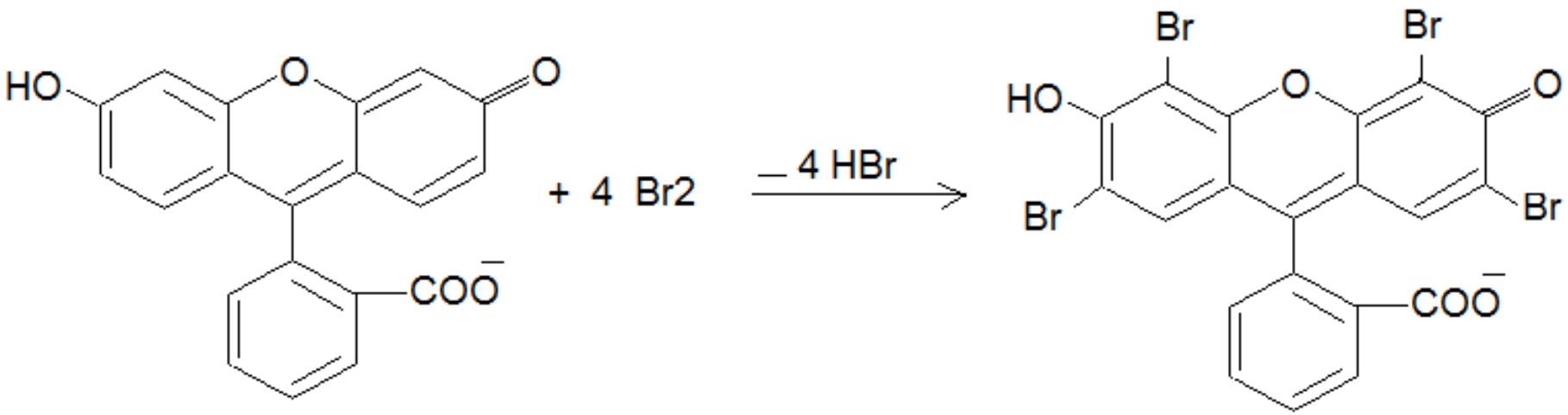
I^- produces I_2 turns the filter paper to red-brown color (tetraiodofluorescein).

Bromide ion

With potassium dichromate and sulphuric acid:

Reaction:

$$6\,Br^{-} + Cr_2O_7^{-2} + 14\,H_3O^{+} \longrightarrow 3\,Br_2\uparrow + 2\,Cr^{+3} + 21\,H_2O$$



Fluorescein (Yellow)

Eosin (violet-red)

Bromide ion

Remember:

$$6\,Br^- + Cr_2O_7^{-2} + 14\,H_3O^+ \xrightarrow{\triangle} 3\,Br_2\uparrow + 2\,Cr^{+3} + 21\,H_2O$$

$$6\,I^- + Cr_2O_7^{-2} + 14\,H_3O^+ \xrightarrow{\triangle} 3\,I_2\uparrow + 2\,Cr^{+3} + 21\,H_2O$$

Halides Br^- , I^- are oxidized by dichromate to corresponding halogen(Redox).

Br_2 is liquid and volatile, **I_2** is solid and sublimate

Cl^- reacts with dichromate to produce chromyl chloride (Not redox).

Questions

Name the following oxoanions and their corresponding acids:

ClO^- : ***hypo***chlor***ite*** ion

HClO: ***hypo***chlor***ous acid***

ClO_2^- : chlor***ite*** ion

$HClO_2$: chlor***ous acid***

ClO_3^- : chlor***ate*** ion

$HClO_3$: chlor***ic acid***

ClO_4^- : ***per***chlor***ate*** ion

$HClO_4$: ***per***chlor***ic acid***

Remember:

NO_3^-: nitr***ate ion***

NO_2^-: nitr***ite ion***

Questions

Name the following:
IO^- , HIO_3, ClO_2^- , BrO_2^- , $HBrO_3$, IO_4^- , PO_4^{-3}, SO_4^{-2} , SO_3^{-2} , HNO_2, HNO_3.

Define Synproportionation and disproportionation reaction. Give example per each one?

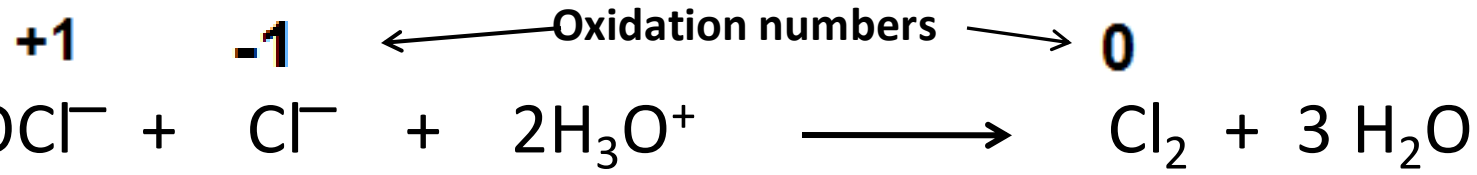
What is the oxidation number of Cl atom in the following
Cl_2, ClO^- , CrO_2Cl_2, $HClO_4$, NaCl

What is chlorine water, how can it be replaced with a more convenient reagent in laboratory (Hint: p 176)?

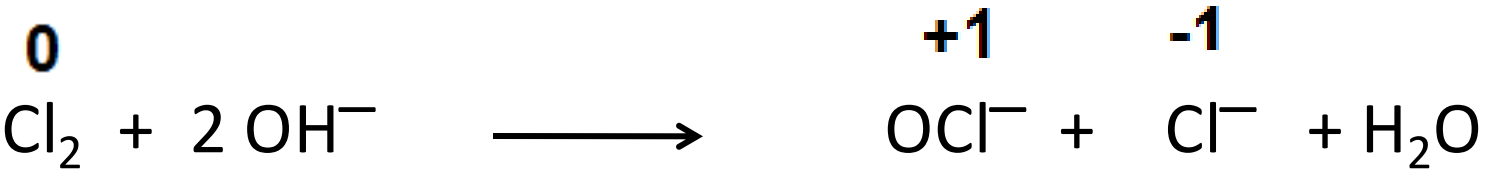
Questions

Synproportionation vs Disproportionation

Synproportionation



Disproportionation



Iodide ion

With $AgNO_3$ Solution:

Soda extract + acidify with HNO_3 (dil) + then add $AgNO_3$ Solution $\longrightarrow$ yellow ppt, insoluble in HNO_3 (conc.), insoluble in NH_3 (dil.), insoluble in NH_3 (conc.)

Soda extract had basic pH, it should be acidified before adding Ag^+ reagent to prevent its precipitation as Ag_2O (discussed before)

Reactions:

$$I^- + Ag^+ \longrightarrow AgI \downarrow$$

yellow ppt

Iodide ion

With $AgNO_3$ Solution:

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

$$AgBr\ (s) + 2\ NH_3\ (Conc) \longrightarrow [Ag(NH_3)_2]^+ + Br^-$$

$$AgI\ (s) + NH_3\ (dil,\ or\ conc) \longrightarrow \text{No reaction}$$

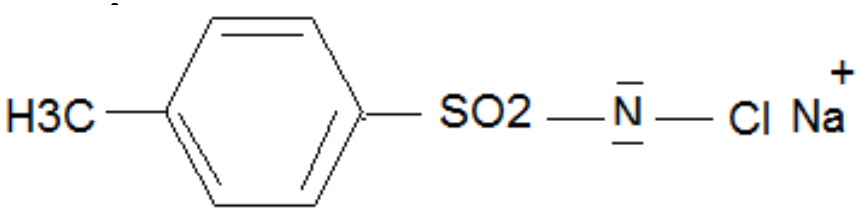
Ksp: AgCl > AgBr > AgI

Iodide ion

With Chloramine-T solution:

Soda extract + acidify with HCl + 3-4 ml $CHCl_3$ or CCl_4 (two immiscible phases are formed) then add drop wise freshly prepared chloramine T (dil.) ⟶ the organic phase ($CHCl_3$ or CCl_4) is colored violet ⟶ with excess of reagent the color disappear.

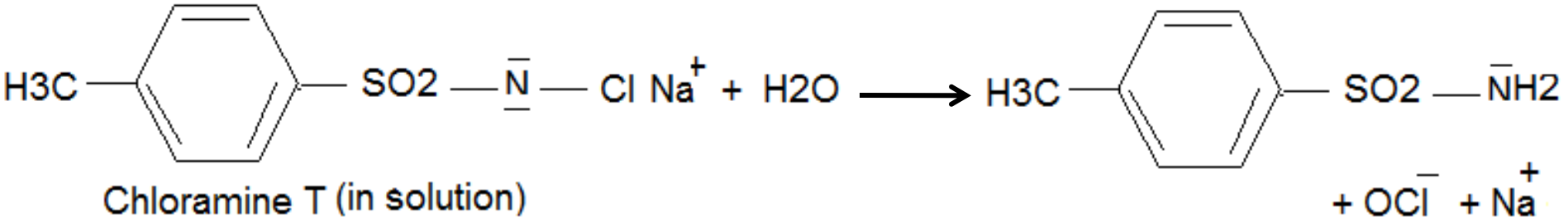
R



Chloramine T (solid state)

Iodide ion

Reactions:



Chloramine T (in solution)

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

$$Cl_2 + 2\,I^- \longrightarrow I_2 + 2\,Cl^-$$

I_2 (Iodine , non polar molecule) dissolves in organic phase with violet color.

Iodide ion

With copper (II) solution:

$$2Cu^{+2} + 4\,I^{-} \longrightarrow I_2 + 2\,CuI\downarrow$$

I_2 brown color in aq. solution

With iron (III) solution:

$$2\,Fe^{+3} + 2\,I^{-} \longrightarrow I_2 + 2\,Fe^{+2}$$

I_2 brown color in aq. solution

I_2 has brown color in aq. solution

I_2 is identified by deep blue coloration of starch solution

Iodide ion

With lead (II) acetate solution:

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

bright yellow crystals, dissolves upon heating and reformed when cooled

With mercury (II) chloride solution:

$Hg^{+2} + 2\,I^- \longrightarrow HgI_2 \downarrow \xrightarrow{+\,2\,I^-} [HgI_4]^{-2}$

red ppt soluble complex, colorless

$[HgI_4]^{-2}$: Nessler's reagent, tetraiodomercurate(II) ion

Iodide ion

With Bismuth (III) solution:

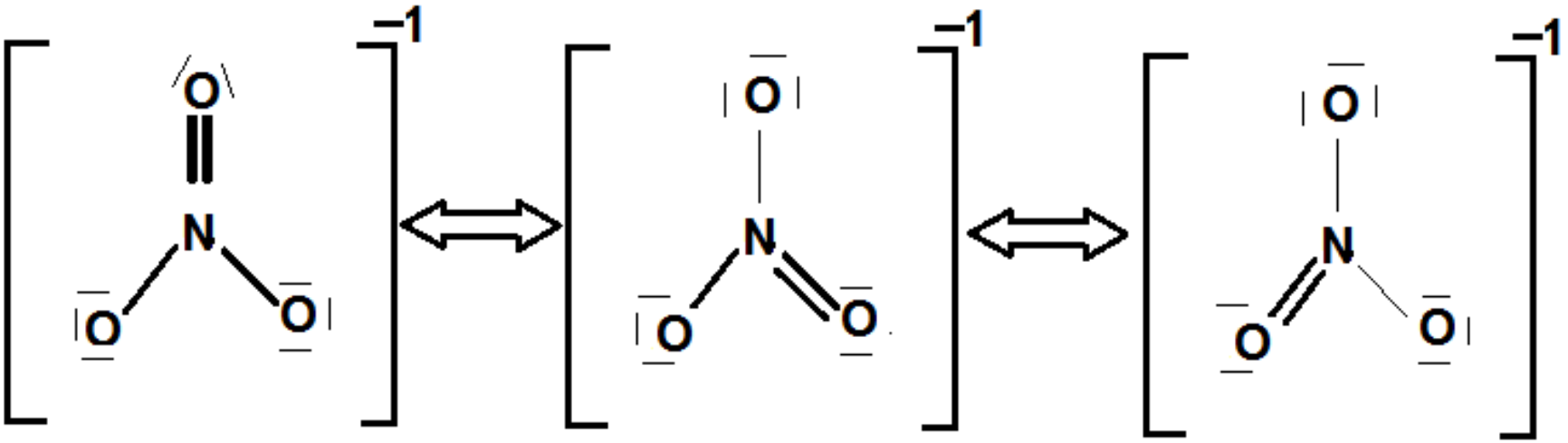
$$Bi^{+3} + 3\,I^- \longrightarrow BiI_3\downarrow \xrightarrow{+\,I^-} [BiI_4]^{-1}$$

black ppt soluble complex, orange color

$[BiI_4]^{-1}$: Dragendorf's reagent, tetraiodobismuthate(III) ion

nitrate ion

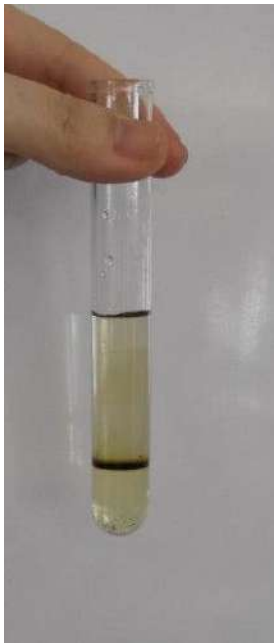
Lewis structure: NO_3^-



nitrate ion

Ring test:

Soda extract + acidify H_2SO_4 (dil)+ $FeSO_4$ solution then add H_2SO_4 (Conc.) on the inner edge of test tube slowly **without shaking** ⟶ two layers are formed (aqueous layer and sulphuric acid conc. layer due to difference in density, but they are miscible) ⟶ brown ring will be formed between two layers.



nitrate ion

Ring test:

Reactions:

$$3\,Fe^{+2} + NO_3^- + 4\,H_3O^+ \longrightarrow 3\,Fe^{+3} + NO + 6\,H_2O$$

$$[Fe(H_2O)_6]^{+2} + NO \longrightarrow [Fe(H_2O)_5(NO)]^{+2} + H_2O$$

Hexaaquairon(II) ion — Pentaaquanitrosyliron(II)ion, brown color

The brown color is concentrated on the upper surface of Sulphuric acid (Conc.), because $[Fe(H_2O)_6]^{+2}$ is adsorbed on H_2SO_4 (Conc.) the hygroscopic layer.

nitrate ion

Azo-test:

Soda extract + acidify with HCl (dil) + Zn (powder) then add sulfanilic acid + α- naphthylamine ⟶ red color (azo compound)

Reactions:

1- NO_3^- + $Zn + H_3O^+$ ⟶ ⟶ NO^+ (Nitrosyl cation)

2- NO^+ + sulfanilic acid ⟶ Diazonium salt

3- Diazonium salt + α- naphthylamine ⟶ Azo-compound

nitrate ion

Azo-test:

Reaction:

$Zn + 2\ H_3O^+ \longrightarrow Zn^{+2} + H_2\ (g) + 2\ H_2O$

$H_2 + NO_3^- \longrightarrow NO_2^- + H_2O$

$NO_2^- + H_3O^+ \longrightarrow HNO_2 + H_2O$

$HNO_2 + H_3O^+ \longrightarrow H_2NO_2^+ + H_2O$

$H_2NO_2^+ \longrightarrow NO^+ + H_2O$

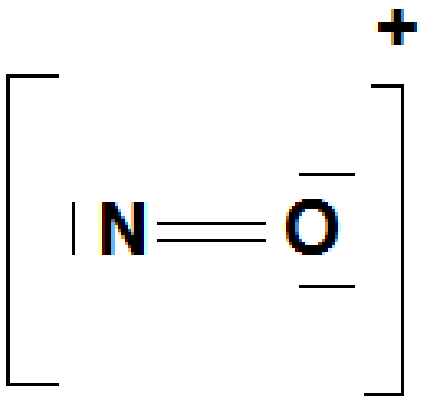
(Nitrosyl cation, lewis acid , reactive species)

nitrate ion

Azo-test:

Reaction:

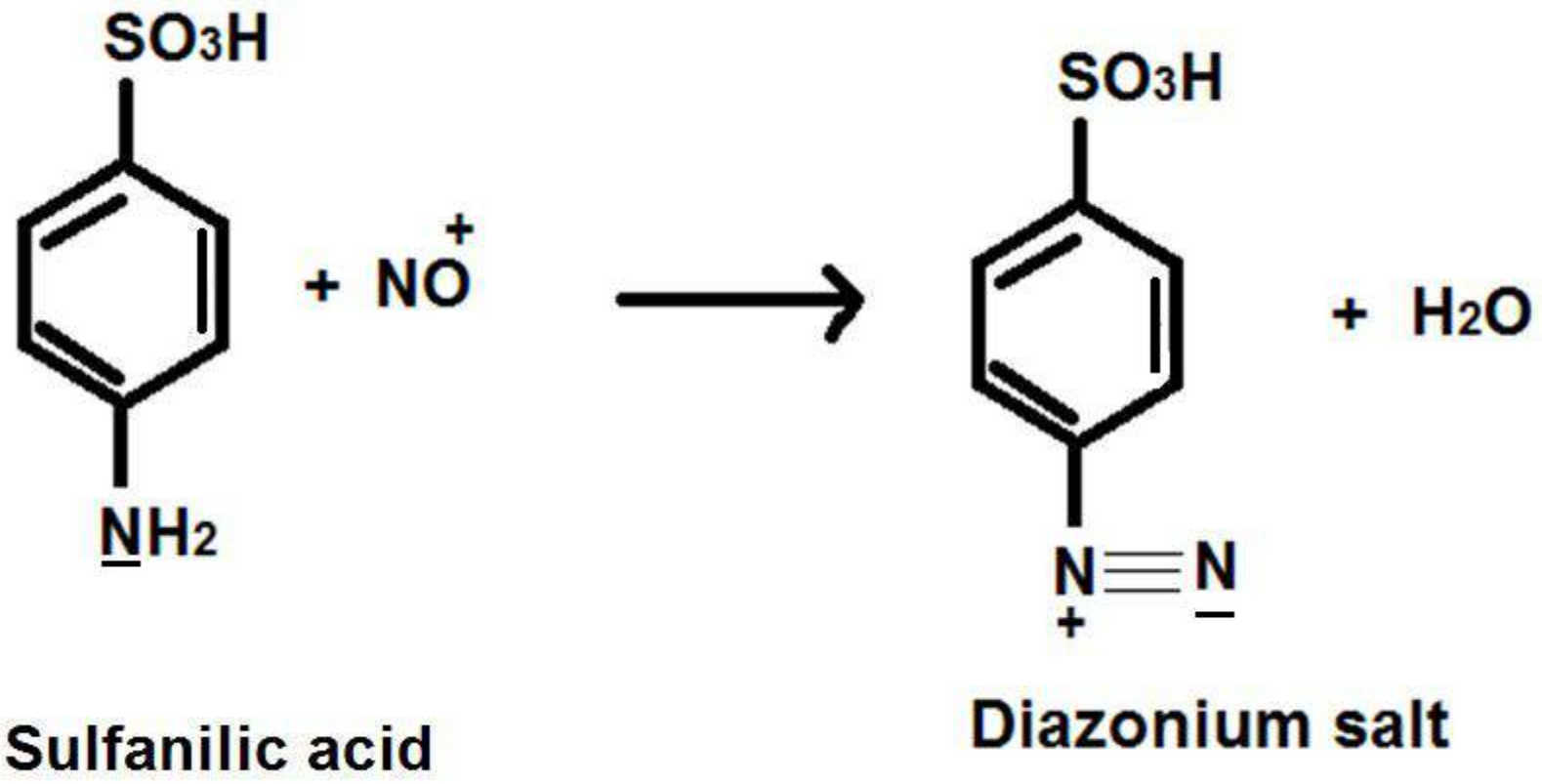
Lewis structure of NO+



VE = 5 +6 -1= 10e

N atom is surrounded only with 6 e

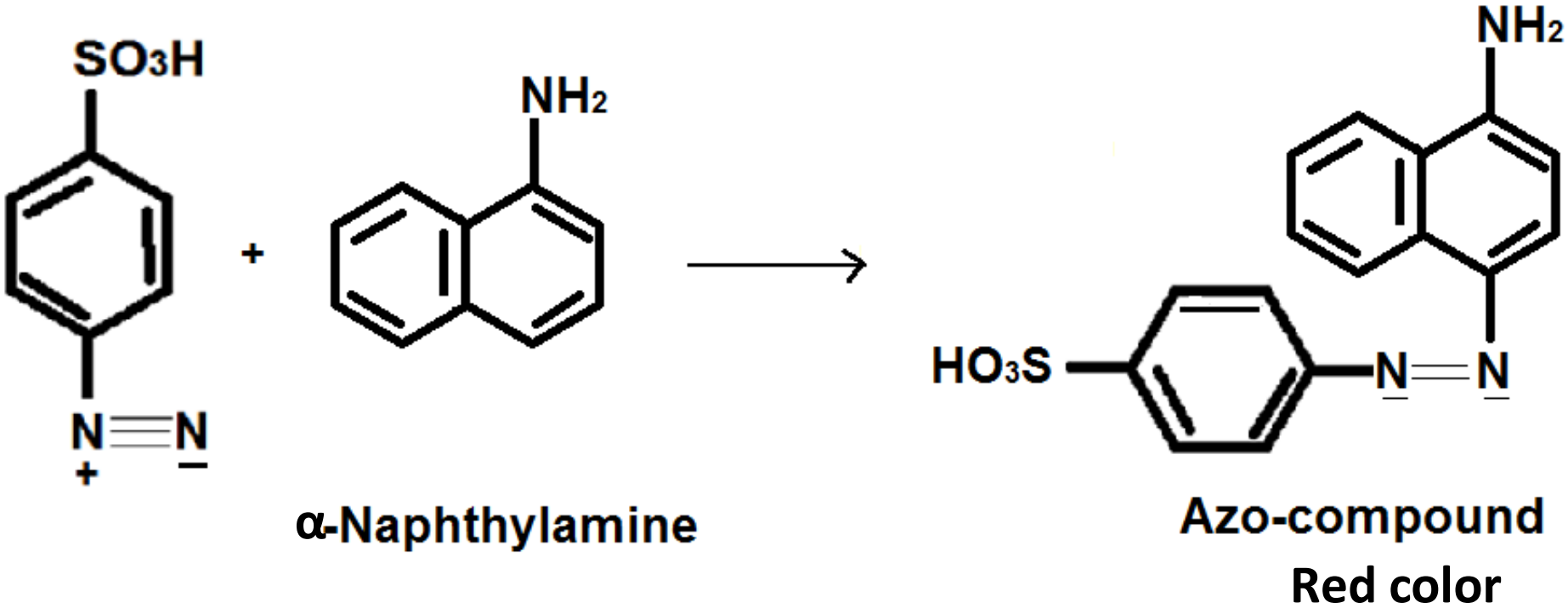
nitrate ion



nitrate ion

Azo-test:

Reaction:



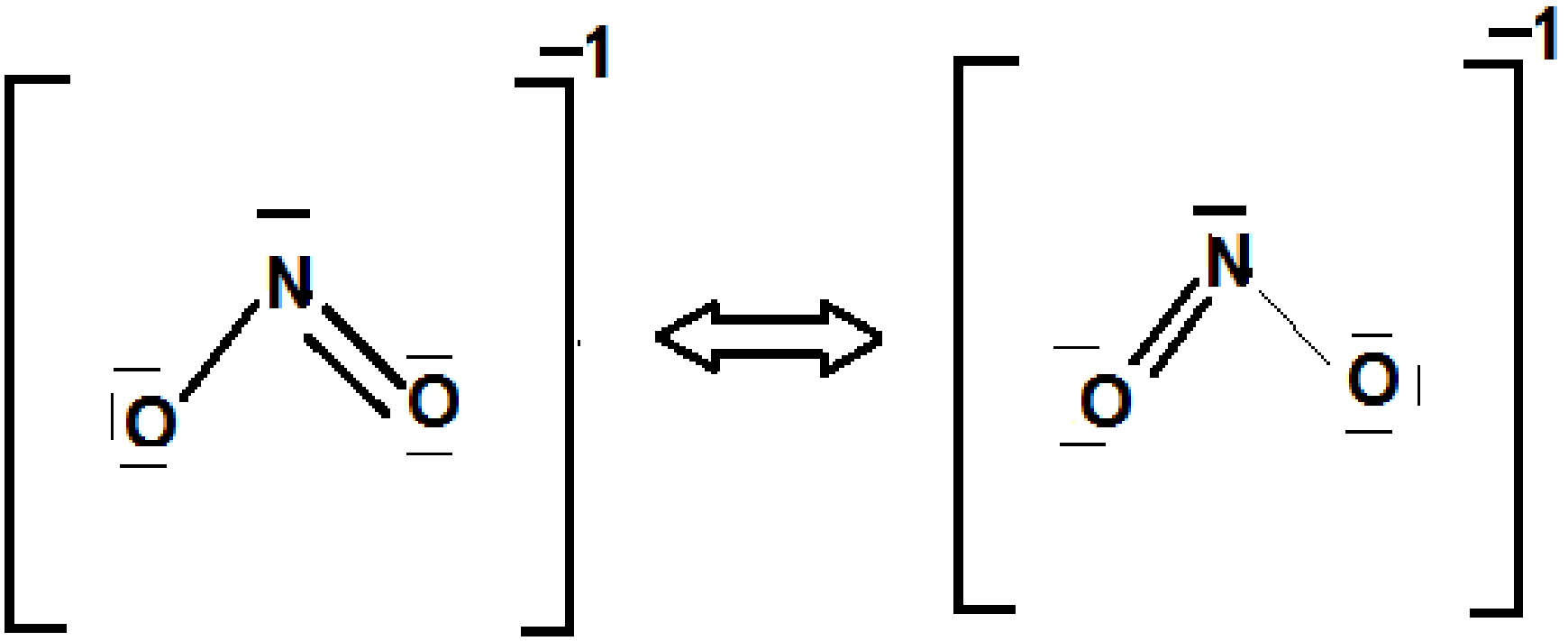
α-Naphthylamine

Azo-compound

Red color

nitrite ion

Lewis structure: NO_2^-



nitrite ion

Azo-test:

Soda extract + acidify with HCl (dil) **[Without Zn powder]** then add sulfanilic acid + α- naphthylamine ⟶ red color (azo compound)

Reactions: **[discussed before]**

1- NO_2^- + H_3O^+ ⟶ ⟶ ⟶ NO^+ (Nitrosyl cation)

2- NO^+ + sulfanilic acid ⟶ Diazonium salt

3- Diazonium salt + α- naphthylamine ⟶ Azo-compound

nitrite ion

With Antipyrine:

Soda extract + HCl (dil) + antipyrine ⟶ green color

Reactions:

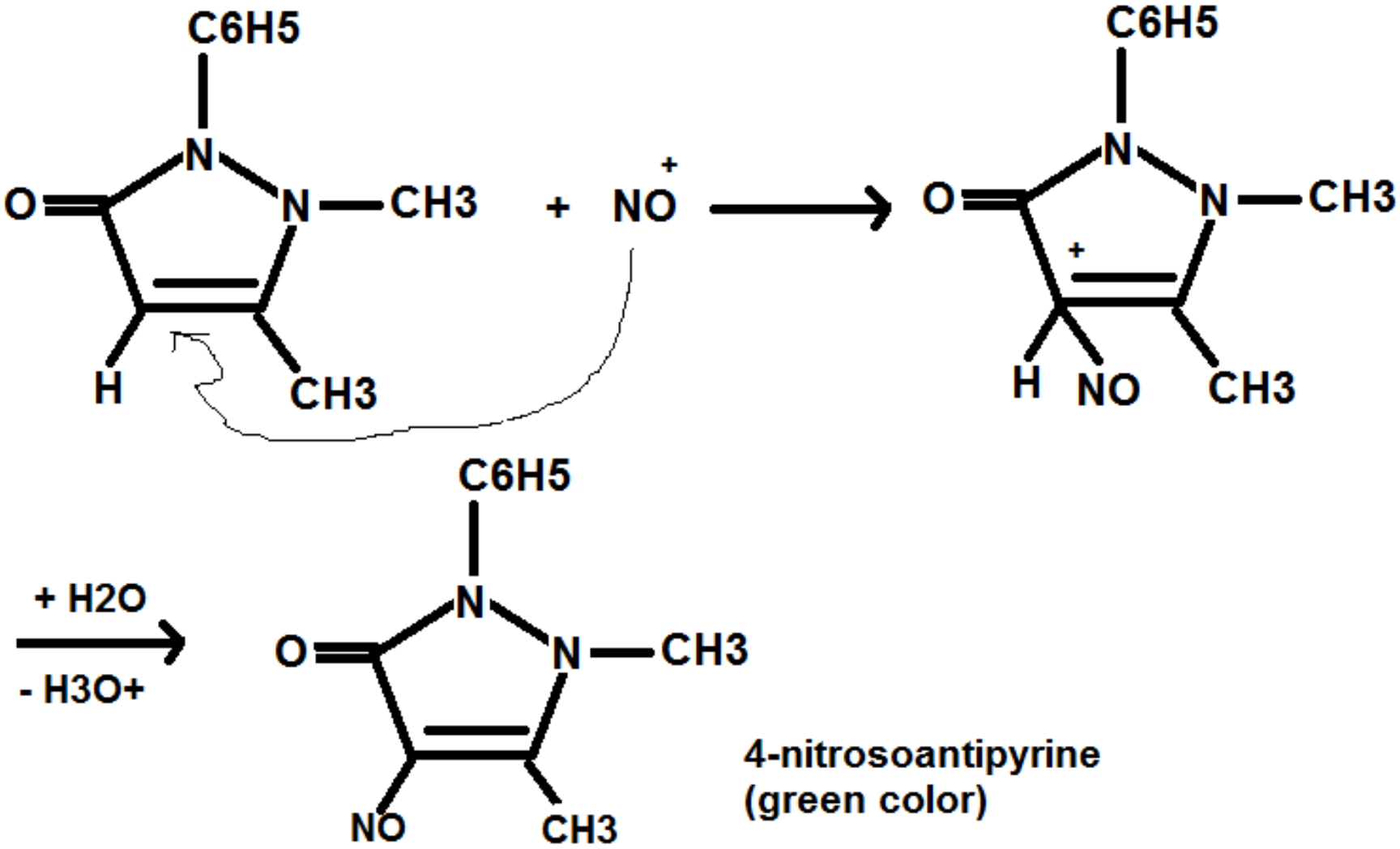
NO_2^- + H_3O^+ ⟶ ⟶ NO^+ (Nitrosyl cation)

Nitrosyl cation is a lewis acid reacts with antipyrine to produce 4-nitrosoantipyrine (green color)

nitrite ion

With Antipyrine:

Reactions:



4-nitrosoantipyrine
(green color)

nitrite ion

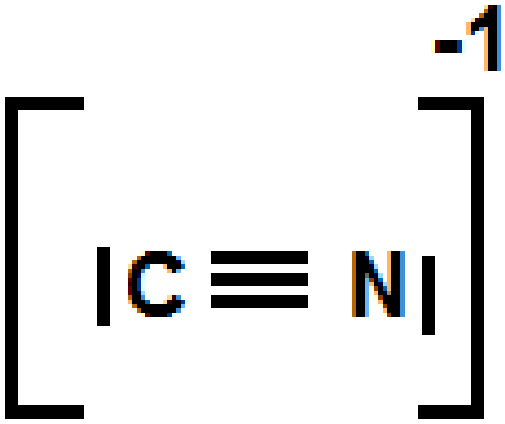
How to remove nitrite from a sample before detection of nitrate???

By addition of one of these compounds: urea, sulfamic acid or ammonium chloride.

These compounds reacts with nitrite in syn-proportionation reactions to eliminate nitrogen of both substances as nitrogen gas.

cyanide ion

Lewis structure of CN^-:



With HCl (dil):

Soda extract + HCl (dil) ⟶ bitter almond odour, toxic

$$CN^- + H_3O^+ \longrightarrow HCN\uparrow + H_2O$$

bitter almond odour, toxic

cyanide ion

With $AgNO_3$ solution:

Soda extract + $AgNO_3$ ⟶ white ppt, soluble by excess of cyanide

$CN^- + Ag^+ \longrightarrow AgCN \downarrow$

White ppt

$AgCN + CN^- \longrightarrow [Ag(CN)_2]^{-1}$

Dicyanoargenate (I) ion

cyanide ion

Prussian blue test:

Soda extract in basic solution + add $FeSO_4$ ⟶ then acidify and add $FeCl_3$ ⟶ Blue ppt is formed (Prussian or Berliner blue)

$$6\ CN^{-} + Fe^{+2} \longrightarrow [Fe(CN)_6]^{-4}$$

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

Prussian (Berliner) blue

blue ppt

cyanide ion

How could you eliminate a toxic solution of cyanide from laboratory???????

To a strong alkali solution of cyanide add H_2O_2. cyanide is oxidized to cyanate ion, which is non-toxic.

$$CN^- + H_2O_2 \longrightarrow OCN^- + H_2O$$

OCN^- : cyanate ion, nontoxic, since it dissolved in water and produces carbonate and ammonium ions

$$OCN^- + 2\,H_2O \longrightarrow CO_3^{-2} + NH_4^+$$

Sulfate ion

SO_4^{-2}:

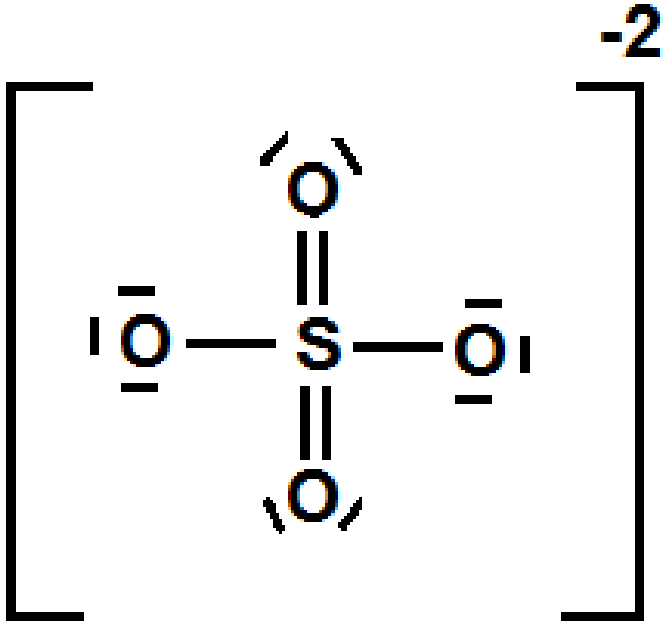
What is hybridization state and molecular geometry of sulfate ion?

$MgSO_4$ is English salt.

Bone fracture.

Salts of drugs.

In organic chemistry to synthesize sulfonic acids (RSO3H).



sulfate ion

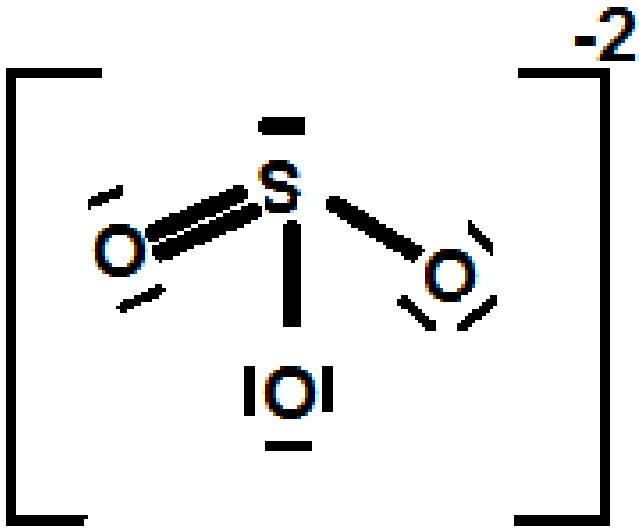
Test of SO_4^{-2}:

Soda extract + acidify with HCl (Conc.) + $BaCl_2$ $\longrightarrow$
White ppt is formed which is insoluble in HCl(Conc) and HNO_3(Conc)

$Ba^{+2} + SO_4^{-2} \longrightarrow BaSO_4\downarrow$
white ppt

Sulfite ion

SO_3^{-2}:



What is hybridization state and molecular geometry of sulfite ion?

Draw lewis structure of SO_2?

S atom in sulfate is surrounded with 12 electrons. Explain?

sulfite ion

Test of SO_3^{-2}:

With HCl(dil):

Soda extract + acidify with HCl (dil.) ⟶ Pricing odor

$$HCl + H_2O \longrightarrow H_3O^+ + Cl^-$$

$$SO_3^{-2} + 2\,H_3O^+ \longrightarrow SO_2\,(g) + 3\,H_2O$$

Pricing odor

Note:

$$SO_2\,(g) + H_2O \longleftrightarrow H_2SO_3$$

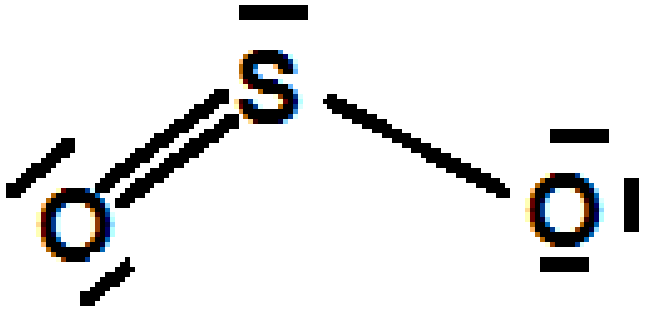
sulfite ion

Test of SO_3^{-2}:

Note:

SO_2 (g) + H_2O ⟷ H_2SO_3

SO_2 : is acid anhydride , Lewis acid



sulfite ion

Test of SO_3^{-2}:

With $AgNO_3$ solution:

Soda extract + acidify to be neutral or slightly acidic then add Ag-solution ⟶ white ppt is formed, **soluble** in hot HNO_3 (dil), in NH_3 solution, by excess of sulfite.

$$SO_3^{-2} + 2\ Ag^+ \longrightarrow \underset{\text{white ppt}}{Ag_2SO_3\downarrow}$$

Why acidification is restricted to be slightly acidic?

sulfite ion

Test of SO_3^{-2}:

Dissolution of Ag_2SO_3 (s) :

$$Ag_2SO_3\,(s) \underset{\text{Ksp}}{\longleftrightarrow} 2\ Ag^+ + SO_3^{-2}$$

$$SO_3^{-2} + H_3O^+ \longrightarrow HSO_3^- + H_2O \text{ (soluble in } HNO_3 \text{ (dil.))}$$

$$Ag^+ + 2\ NH_3 \longrightarrow [Ag(NH_3)_2]^+ \text{ (soluble in } NH_3 \text{ solution)}$$

$$Ag^+ + 2\ SO_3^{-2} \longrightarrow [Ag(SO_3)_2]^{-3} \text{ (soluble in excess } SO_3^{-2})$$

Disulfitoargenate (I) ion

sulfite ion

Test of SO_3^{-2}:

With I_2 solution:

Soda extract + acidify to be neutral or slightly acidic then add I_2-solution ⟶ Decolorization of iodine solution

$$SO_3^{-2} + I_2 + 3\,H_2O \longrightarrow SO_4^{-2} + 2\,I^- + 2\,H_3O^+$$

I_2 solution is an oxidizing agent has brown color, when reduced converted to I^-, Which is colorless.

The resulted sulfate can be identified with Ba^{+2}.

(See your book)

sulfite ion

Test of SO_3^{-2}:

With malachite green:

Soda extract + acidify to be neutral or slightly acidic then add add malachite green ⟶ Decoloriation of malachite green.

SO_3^{-2} reacts with malachite green in **lewis acid lewis base** reaction.

sulfite ion

Test of SO_3^{-2}:

With malachite green:

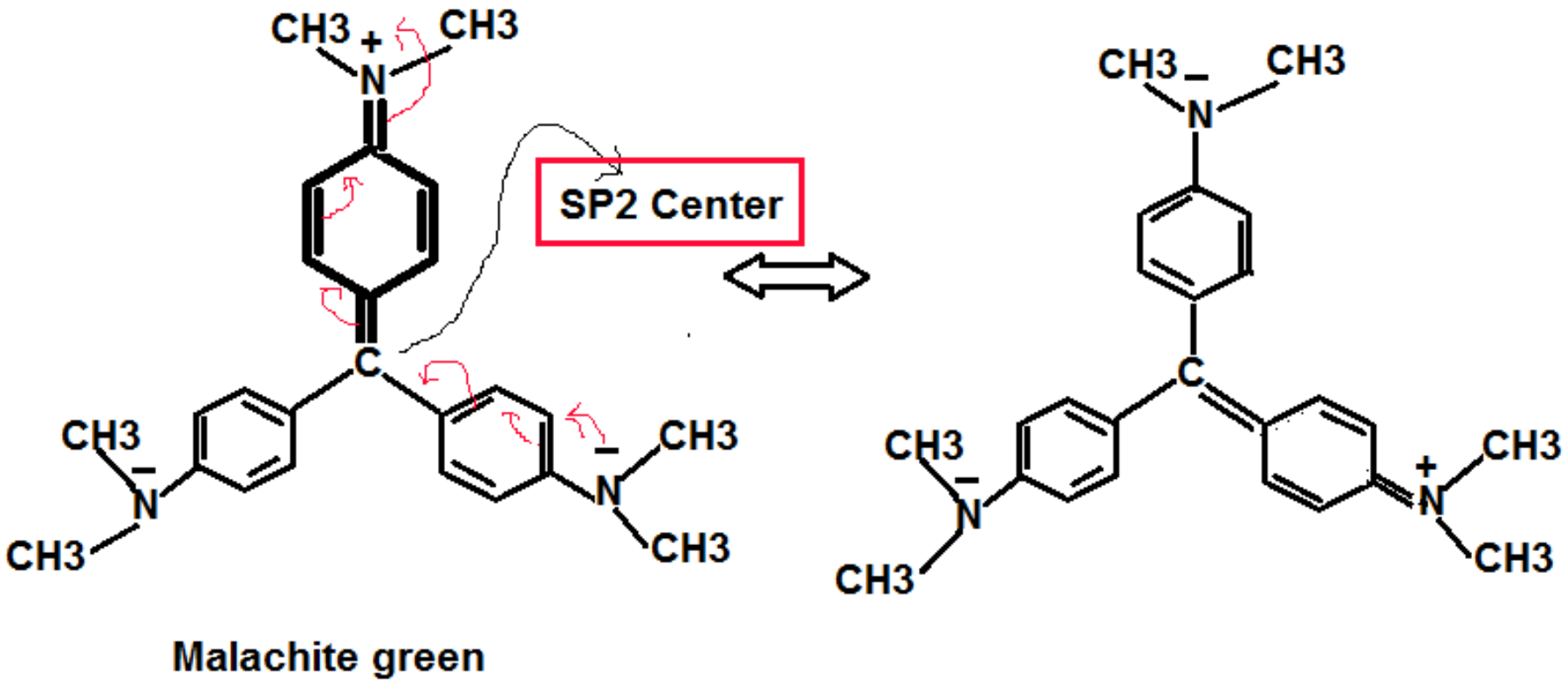
SO_3^{-2} decolorize I_2 solution by redox reaction but decolorization of malachite green due to a lewis acid-lewis base reaction.

Malachite green has a central carbon atom in sp2 allowing a long resonance among 3 phenolic groups. When this carbon converted to sp3 state the compound becomes colorless.

sulfite ion

Test of SO_3^{-2}:

With malachite green:

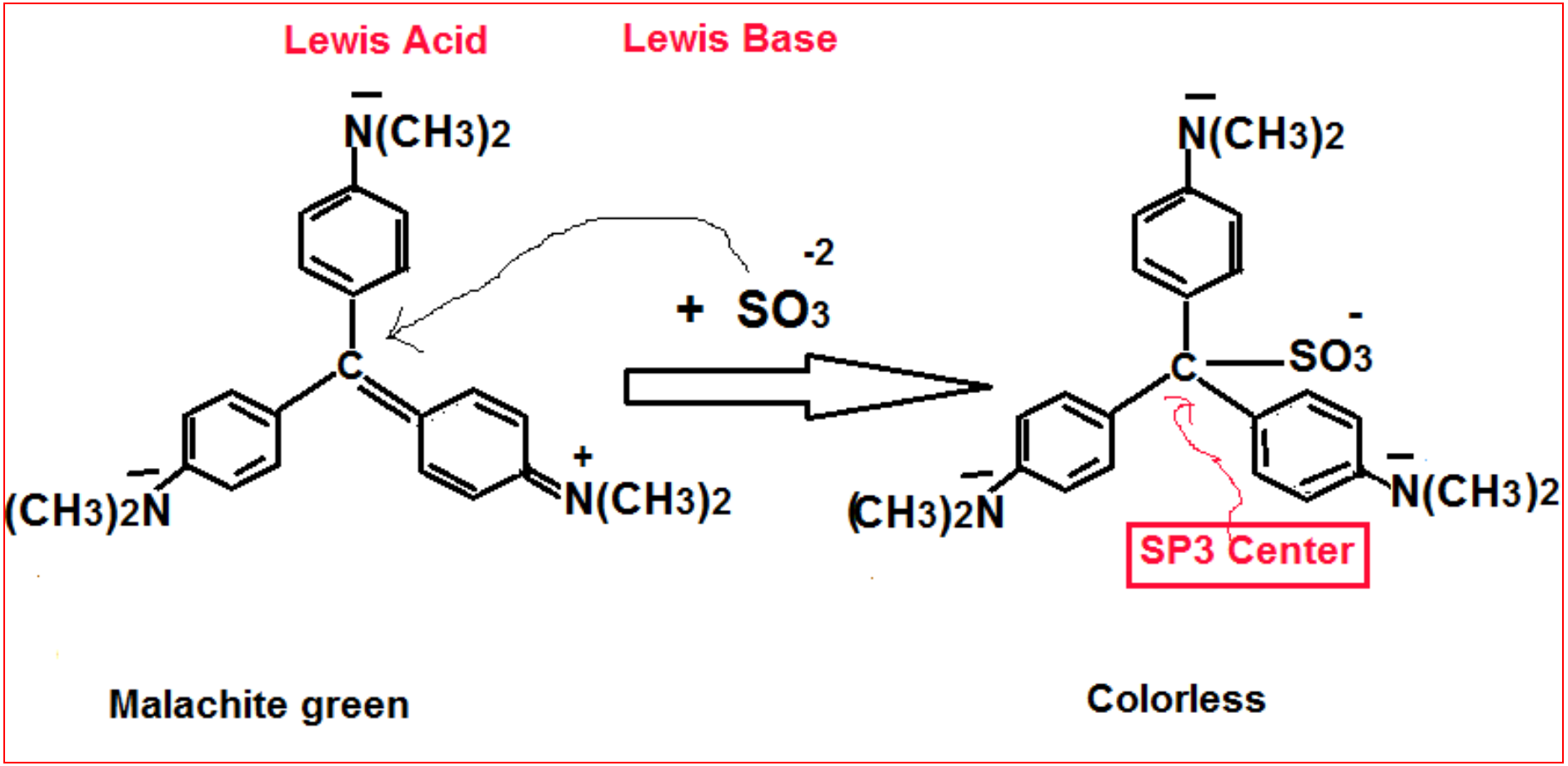


Malachite green

sulfite ion

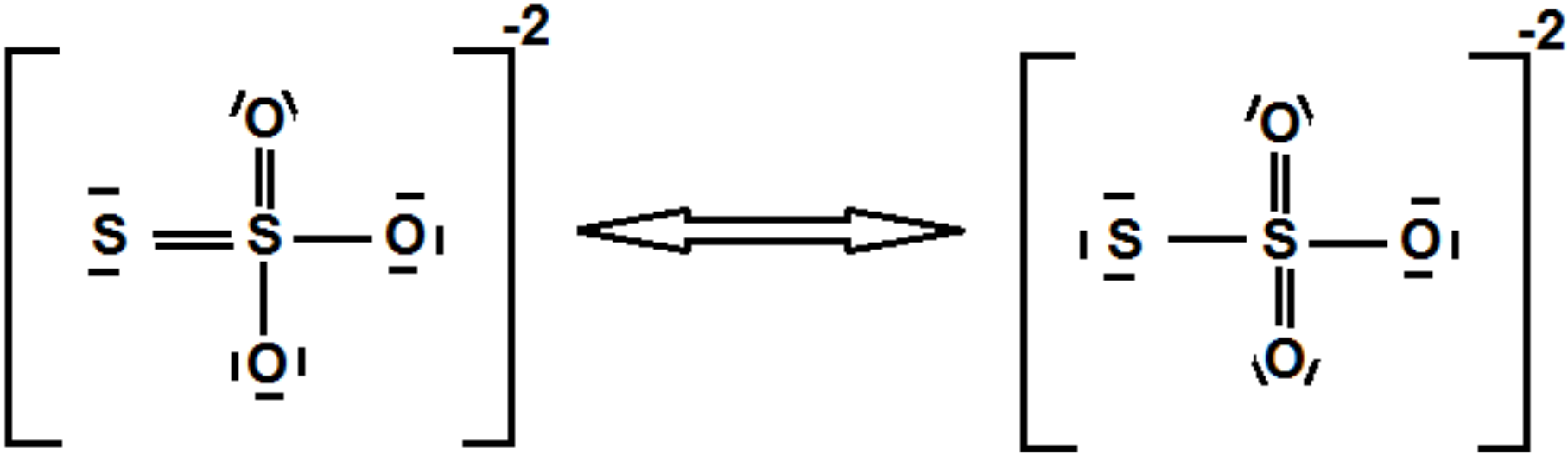
Test of SO_3^{-2}:

With malachite green:



Thiosulfate ion

Lewis structure $S_2O_3^{-2}$:



Minimum

Thiosulfate ion

Test of $S_2O_3^{-2}$:

With HCl (dil):

Soda extract + HCl (dil.) ⟶ Pricing odour with yellow ppt

$$S_2O_3^{-2} + 2\,H_3O^+ \longrightarrow SO_2\,(g) + S\downarrow + 3\,H_2O$$

Pricing odor

Thiosulfate ion

Test of $S_2O_3^{-2}$:

With $AgNO_3$ solution: (Sunset reaction)

Soda extract + acidify to neutral or slightly acidic then add Ag+ solution ⟶ white ppt which on standing the color of ppt changes to yellow ⟶ orange ⟶ brown ⟶ black (Ag_2S).

$$S_2O_3^{-2} + 2\ Ag^{+} \longrightarrow Ag_2S_2O_3$$

white ppt, changes in color upon standing.

Thiosulfate ion

Test of $S_2O_3^{-2}$:

With I_2 Solution:

Soda extract + acidify to neutral or slightly acidic + Add I_2 solution $\longrightarrow$ I_2 solution is decolorized (Redox)

$$2\ S_2O_3^{-2} + I_2 \longrightarrow S_4O_6^{-2} + 2\ I^-$$

Thiosulfate ion — **Tetrathionate ion**

brown — colorless

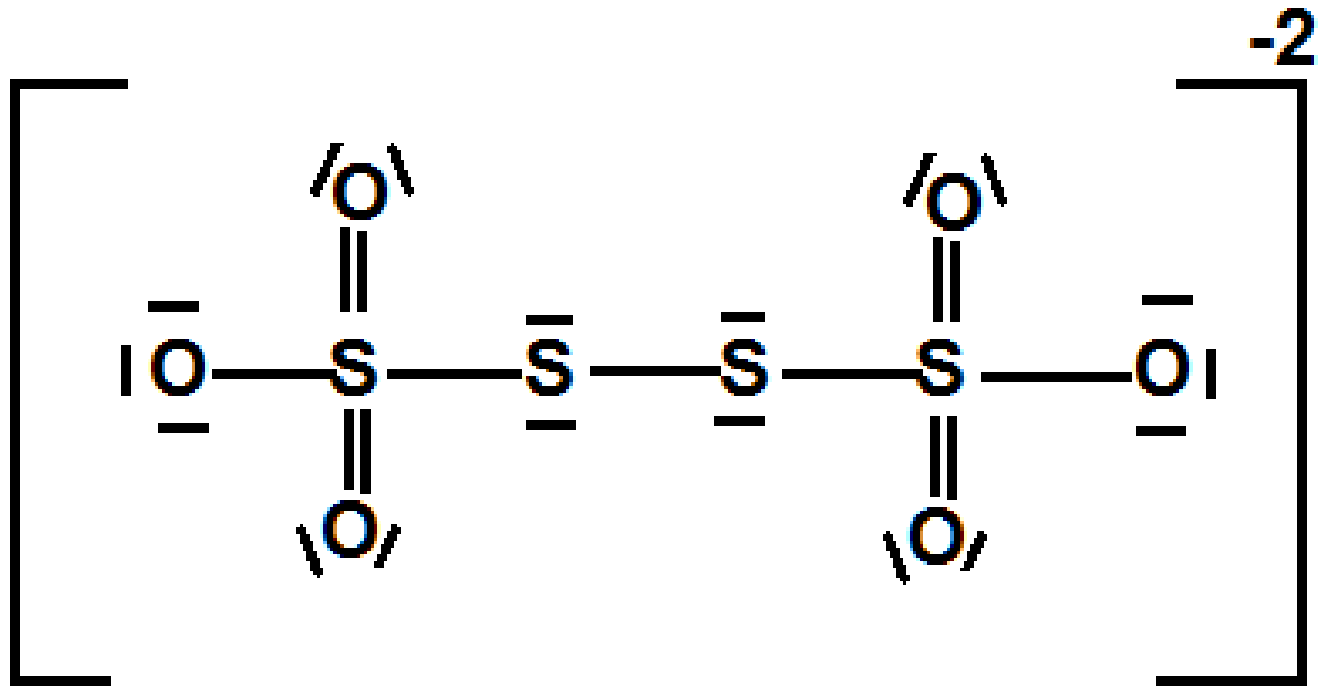
Note:

Iodine oxidizes sulfite and thiosulfate to different products.

Thiosulfate ion

Test of $S_2O_3^{-2}$:

With I_2 Solution:



Tetrathionate ion

Thiosulfate ion

Test of $S_2O_3^{-2}$:

With I_2 – Azide Solution:

$I_2 + N_3^- \longrightarrow$ No reaction

Soda extract + acidify to neutral then add (I_2+ N_3^- - reagent)

$\longrightarrow$ **Development of colorless, odorless gas (N_2)**

Reactions: (Sulfide is a catalyst in RXN, present as impurity in thiosulfate samples)

$S^{-2} + I_2 \longrightarrow S + 2\ I^-$ **(Redox)**

$S + 2\ N_3^- \longrightarrow S^{-2} + 3\ N_2 \uparrow$

sulfide ion

Test of S^{-2}:

With HCl (dil):

Soda extract + HCl (dil.) ⟶ rotten egg odor

$$S^{-2} + 2\,H_3O^{+} \longrightarrow H_2S\,(g) + 2\,H_2O$$

rotten egg odor

sulfide ion

Test of S^{-2}:

With $AgNO_3$ solution:

Soda extract + acidify to be neutral or slightly acidic then add Ag-solution ⟶ black ppt is formed.

$$S^{-2} + 2\ Ag^{+} \longrightarrow Ag_2S$$

black ppt

With I_2 solution:

Soda extract + acidify to be neutral or slightly acidic then add I_2-solution ⟶ Decolorization of iodine solution

$$S^{-2} + I_2 \longrightarrow S\downarrow + 2\ I^{-}$$

sulfide ion

Test of S^{-2}:

With I_2 – Azide Solution: (sulfide, thiosulfate, thiocyanate)

$I_2 + N_3^- \longrightarrow$ No reaction

Soda extract + acidify to neutral then add ($I_2 + N_3^-$ - reagent)

$\longrightarrow$ **Development of colorless, odorless gas (N_2)**

Reactions: (Sulfide is a catalyst in RXN)

$S^{-2} + I_2 \longrightarrow S + 2\ I^-$ **(Redox)**

$S + 2\ N_3^- \longrightarrow S^{-2} + 3\ N_2 \uparrow$

sulfide ion

Test of S^{-2}:

Specify H_2S chemically:

Soda extract + HCl (dil.) ⟶ gas is evolved then put on the upper edge of test tube filter paper soaked with lead(II)acetate solution $Pb(CH_3COO)_2$ ⟶ a black ppt is formed on the filter paper.

$$S^{-2} + 2\,H_3O^{+} \longrightarrow H_2S\,(g) + 2\,H_2O$$

rotten egg odor

$$H_2S\,(g) + Pb^{+2} \longrightarrow PbS\downarrow$$

black ppt

sulfide ion

Test of S^{-2}:

With Zn^{+2}:

Soda extract + acidify to be neutral or slightly acidic then add Zn^{+2}-solution ⟶ white ppt is formed.

$$S^{-2} + Zn^{+2} \longrightarrow \underset{\text{white ppt}}{ZnS\downarrow}$$

With Mn^{+2}:

Soda extract + acidify to be neutral or slightly acidic then add Mn^{+2}-solution ⟶ red ppt is formed.

$$S^{-2} + Mn^{+2} \longrightarrow \underset{\text{red ppt}}{MnS\downarrow}$$

sulfide ion

Test of S^{-2}:

With sodium nitroprusside:

Soda extract (basic) + sodium nitroprusside ⟶ violet color which disappears gradually

Sodium nitroprusside is sodium pentacyanonitrosylferrate(II) dihydrate **$Na_2[Fe(CN)_5(NO)].2H_2O$**

$$S^{-2} + [Fe(CN)_5(NO)]^{-2} \longrightarrow [Fe(CN)_5(NOS)]^{-4}$$

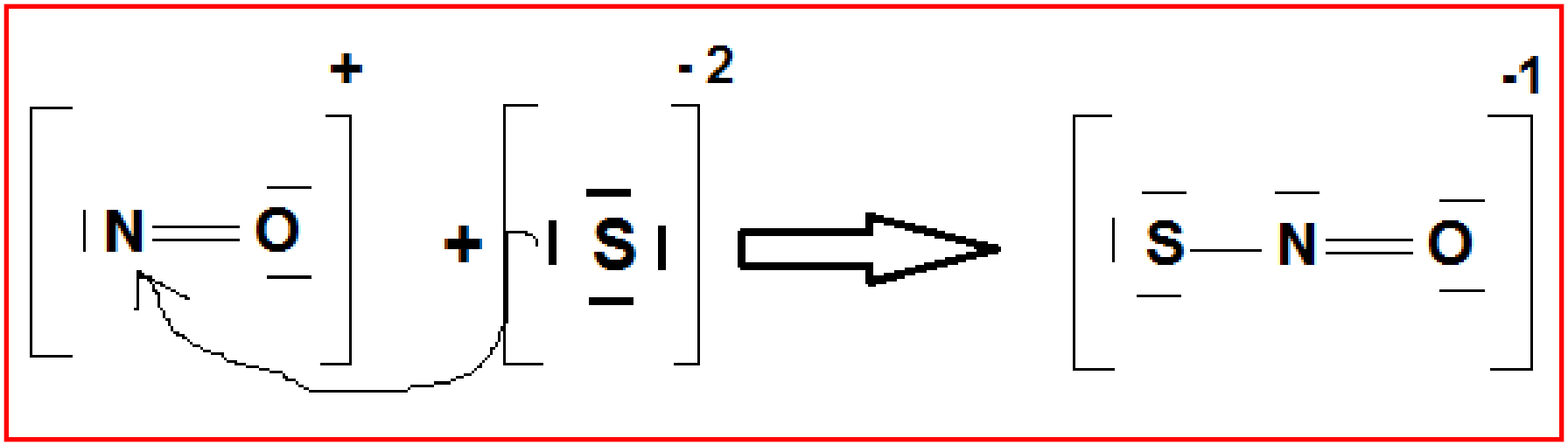
violet color disappears gradually

sulfide ion

Test of S^{-2}:

With sodium nitroprusside:

The reaction is lewis acid-lewis base



Remember

I_2 is an oxidizing agent.

$$SO_3^{-2} + I_2 + 3\ H_2O \longrightarrow SO_4^{-2} + 2\ I^- + 2\ H_3O^+$$

$$2\ S_2O_3^{-2} + I_2 \longrightarrow S_4O_6^{-2} + 2\ I^-$$

$$S^{-2} + I_2 \longrightarrow S\downarrow + 2\ I^-$$

Remember

I_2 should not be added to basic solution. Why?

$I_2 + 2\,OH^- \longrightarrow$????????

What you expect, is the solubility of ZnS improved by adding an acid . Explain?

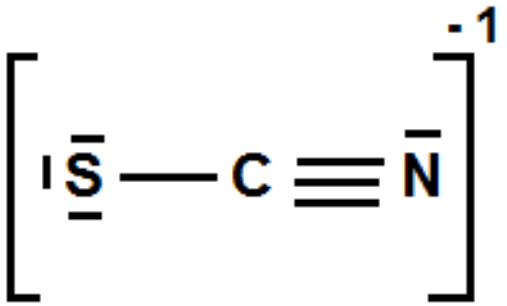
$ZnS\ (s) \underset{\text{Ksp}}{\longleftrightarrow} Zn^{+2} + S^{-2}$

$S^{-2} + H_3O^+ \longrightarrow$ **?????????? (Complete)**

Thiocyanate ion

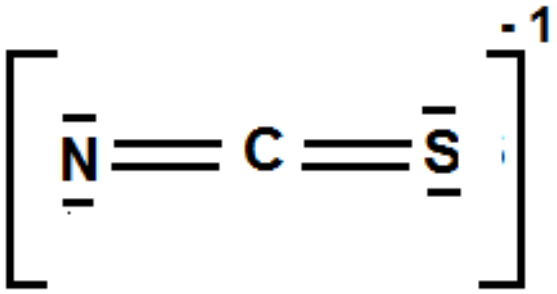
Lewis structure thiocyanate SCN^- and isothiocyanate NCS^-

SCN^-



Formal charges -1 0 0

NCS^-



Formal charges -1 0 0

Thiocyanate ion

With $AgNO_3$ solution:

Soda extract + acidify with HNO_3 (dil) then add $AgNO_3$ solution ⟶ white ppt is formed, **insoluble** in HNO_3 (dil), **soluble** in NH_3.

$$SCN^- + Ag^+ \longrightarrow AgSCN$$

white ppt

$$AgSCN\ (s) + 2\ NH_3 \longrightarrow [Ag(NH_3)_2]^+ + SCN^-$$

Thiocyanate ion

With $FeCl_3$ solution:

Soda extract + acidify with HCl (dil) then add $FeCl_3$ solution

$\longrightarrow$ bloody red color , which is extractable with ether

A series of complexes are formed , among which one is neutral responsible for bloody red color and extractable with ether [Fe $(SCN)_3(H_2O)_3$], triaquatrithiocyanatoiron(III).

Thiocyanate ion

With $FeCl_3$ solution:

Reaction:

$$[Fe(H_2O)_6]^{+3} + SCN^- \longrightarrow [Fe(SCN)(H_2O)_5]^{+2} + H_2O$$

$$[Fe(SCN)(H_2O)_5]^{+2} + SCN^- \longrightarrow [Fe(SCN)_2(H_2O)_4]^{+1} + H_2O$$

$$[Fe(SCN)_2(H_2O)_4]^{+1} + SCN^- \longrightarrow \mathbf{[Fe(SCN)_3(H_2O)_3]} + H_2O$$

bloody red color, extractable with ether

$$[Fe(SCN)_3(H_2O)_3] + SCN^- \longrightarrow [Fe(SCN)_4(H_2O)_2]^- + H_2O$$

$$[Fe(SCN)_4(H_2O)_2]^- + SCN^- \longrightarrow [Fe(SCN)_5(H_2O)]^{-2} + H_2O$$

$$[Fe(SCN)_5(H_2O)]^{-2} + SCN^- \longrightarrow [Fe(SCN)_6]^{-3} + H_2O$$

Thiocyanate ion

With $FeCl_3$ solution:

Malfunctions of test:

Flouride:

$$[Fe(SCN)_3(H_2O)_3] + 6\ F^- \longrightarrow [FeF_6]^{-3} + 3\ SCN^- + 3\ H_2O$$

colorless

Mercury (II):

$$4[Fe(SCN)_3(H_2O)_3] + 3\ Hg^{+2} \longrightarrow 3\ [Hg(SCN)_4]^{-2} + 4\ Fe^{+3} + 3\ H_2O$$

Thiocyanate ion

With I_2 – Azide Solution: (sulfide, thiosulfate, thiocyanate)

$I_2 + N_3^- \longrightarrow$ No reaction

Soda extract + acidify to neutral then add ($I_2 + N_3^-$ - reagent)

$\longrightarrow$ **Development of colorless, odorless gas (N_2)**

Reactions: (Sulfide is a catalyst in RXN)

$S^{-2} + I_2 \longrightarrow S + 2\ I^-$ **(Redox)**

$S + 2\ N_3^- \longrightarrow S^{-2} + 3\ N_2\uparrow$

Thiocyanate ion

With $Co(NO_3)_2$ solution:

Soda extract + acidify with HNO_3 (dil) then add $Co(NO_3)_2$ solution and ether ⟶ aqueous and ether phases are blue.

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

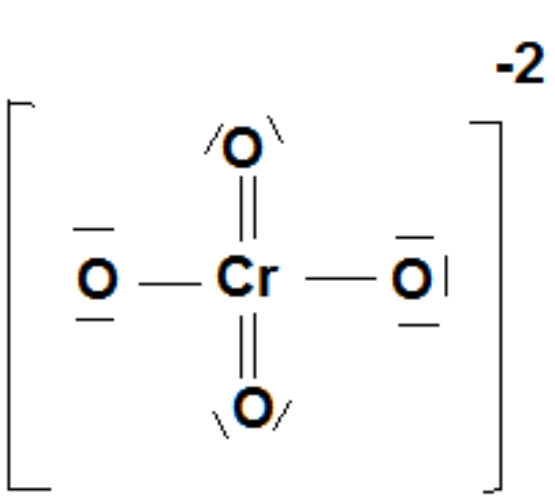
soluble in ether with blue color

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

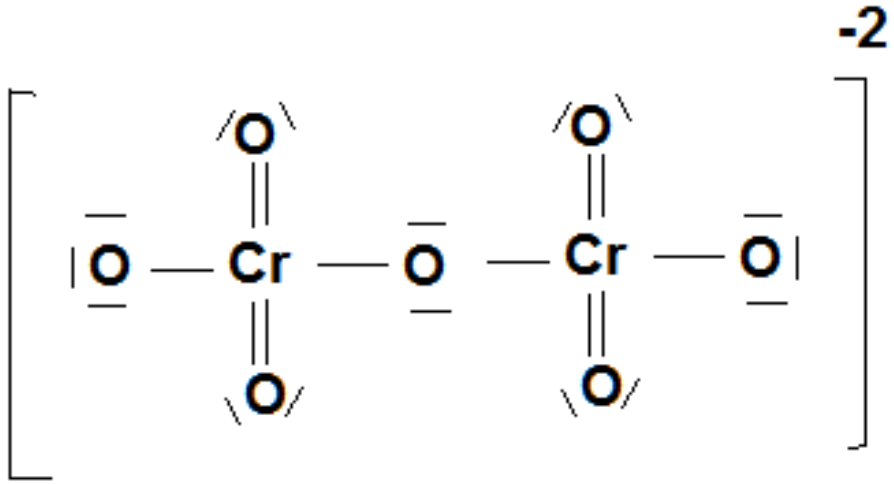
soluble in water, blue color

Chromate ion

Lewis structure of CrO_4^{-2}



CrO4-2



Cr2O7-2

Chromate ion

Test of CrO_4^{-2}

Chromate-dichromate equilibrium:

In acidic solution:

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

Yellow — orange

$$Cr_2O_7^{-2} + CrO_4^{-2} + 2\ H_3O^+ \longleftrightarrow Cr_3O_{10}^{-2} + 3\ H_2O$$

$$Cr_3O_{10}^{-2} + CrO_4^{-2} + 2\ H_3O^+ \longleftrightarrow Cr_4O_{13}^{-2} + 3\ H_2O$$

$$\downarrow$$

$$\downarrow$$

$$(Cr_nO_{3n+1})^{-2}$$

Chromate ion

Test of CrO_4^{-2}

Chromate-dichromate equilibrium:

In basic solution: The equilibrium is reversed

$$Cr_2O_7^{-2} + 2\ OH^- \longleftrightarrow 2\ CrO_4^{-2} + H_2O$$

Orange Yellow

Chromate ion

Test of CrO_4^{-2}:

With $AgNO_3$ solution:

Soda extract + acidify to neutral or slightly acidic then add $AgNO_3$ ⟶ a red brown ppt is formed, which is soluble in HNO_3(dil.) and NH_3 (dil.).

$$2\ Ag^+ + CrO_4^{-2} \longrightarrow Ag_2CrO_4\downarrow$$

red-brown ppt

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

$$2\ Ag_2CrO_4 + 2\ H_3O^+ \longrightarrow Cr_2O_7^{-2} + 4\ Ag^+ + 3\ H_2O$$

Chromate ion

Test of CrO_4^{-2}

With NaCl & H_2SO_4 (Conc.):

Soda extract+ NaCl + H_2SO_4 (Conc.) $\xrightarrow{\Delta}$ colored gas is evolved (chromylchloride) $\longrightarrow$ put filter paper soaked with NaOH/Diphenylcarbazide solution $\longrightarrow$ the filter paper colored violet due to diphenylcarbazone

The reactions were discussed in chloride anion.

Chromate ion

Test of CrO_4^{-2}

With H_2O_2 in acidic media:

Soda extract + acidify with H_2SO_4 or HNO_3 (dil.) + 2-3 mL diethyl ether then add H_2O_2 ⟶ a blue color in ether phase.

(CrO_5 is chromium pentoxide, blue color, unstable, decomposes rapidly in aq. solution) . CrO_5 is extractable with diethyl ether, where it is more stable.

$$CrO_4^{-2} + 2\ H_2O_2 + 2\ H_3O^+ \longrightarrow CrO_5 + 5\ H_2O$$

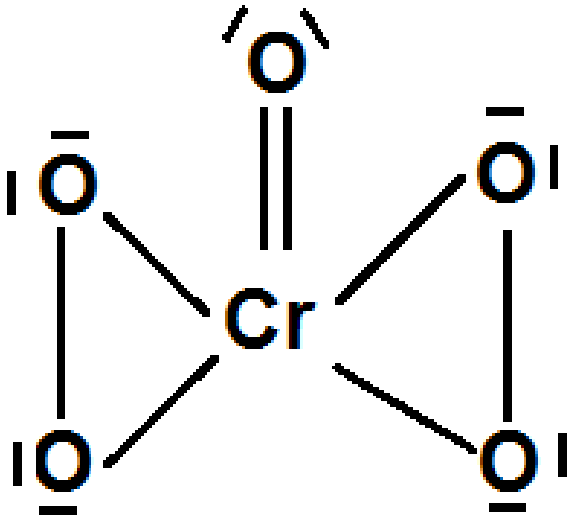
The reaction is not a redox

Chromate ion

Test of CrO_4^{-2}

With H_2O_2 in acidic media:

The reaction is not a redox



CrO_5

oxidation number of Cr: +6

oxidation number of O: 1* (-2)

4* (-1)

Chromate ion

Test of CrO_4^{-2}

With H_2O_2 in acidic media:

CrO_5 is unstable in aq. Solution, decomposes to Cr^{+3} (green color) and O_2 is liberated.

To increase stability put the reaction mixture in ice bath and add organic solvent like ether, which extracts CrO_5 and colored blue and it is more stable in it.

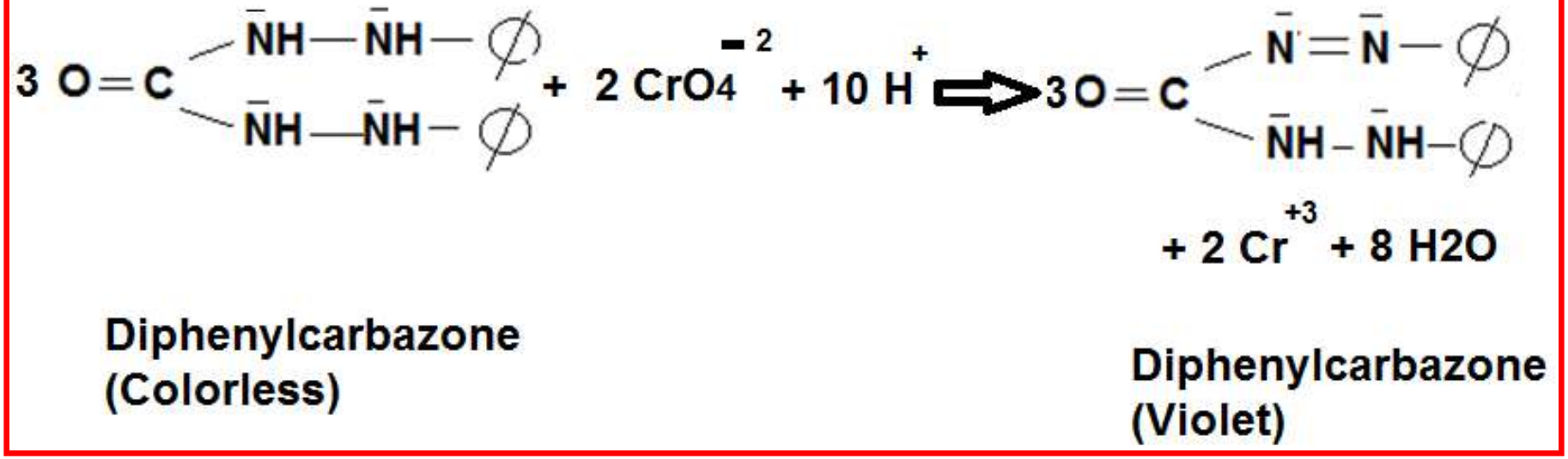
$$4\ CrO_5 + 12\ H_3O^+ \longrightarrow 4\ Cr^{+3} + 7\ O_2 + 18\ H_2O$$

Chromate ion

Test of CrO_4^{-2}

With diphenylcarbazide in acidic media:

Soda extract + acidify with H_2SO_4 or HNO_3 (dil.)+ diphenylcarbazide solution ⟶ the solution colored violet (Diphenylcarbazone) **[Redox reaction]**



Questions

Questions:

What should happen if iodide is added to chromate in acidified media??? [Hint p 209]

H_2O_2 is an oxidizing agent, which contains peroxides. How they are formed, how can be removed? [Hint p 208]

You have some salts in laboratory of Ni^{+2}, Co^{+2}, Fe^{+3}, which were colored. Why have these transition element cations colors?

Questions

Give the IUPAC name, Coordination and oxidation-number:

$[CrI_2(NH_3)_4]^+$

$[Co(C_2O_4)(en)_2]^+$

$[CuBr_4]^{-2}$

$[Co(NCS)_4]^{-2}$

$[PtCl_3(NH_3)]^{-1}$

$[Co(C_2O_4)_3]^{-3}$

$[Co(en)_3]^{+3}$

$[Fe(OH)(H_2O)_5]^{+2}$

Questions

See this video

Questions

Write the chemical formula for the following:

Triaquatrithiocyanatoiron (III)

tetraflourooxocobaltate(III) ion

Bis(ethylenediamine)dinitroiron(III) ion

Bromochlorodicyanonickelate(II) ion

Sodium dithiosulfatoargenate(I)

Diaquadichlorodithiocyanatochromate(III) ion

Tetrahydroxozincate(II) ion

Hexaaquachromium (III) hexacyanoferrate (III)

Diamminediaquadichlorocobalt(III) ion

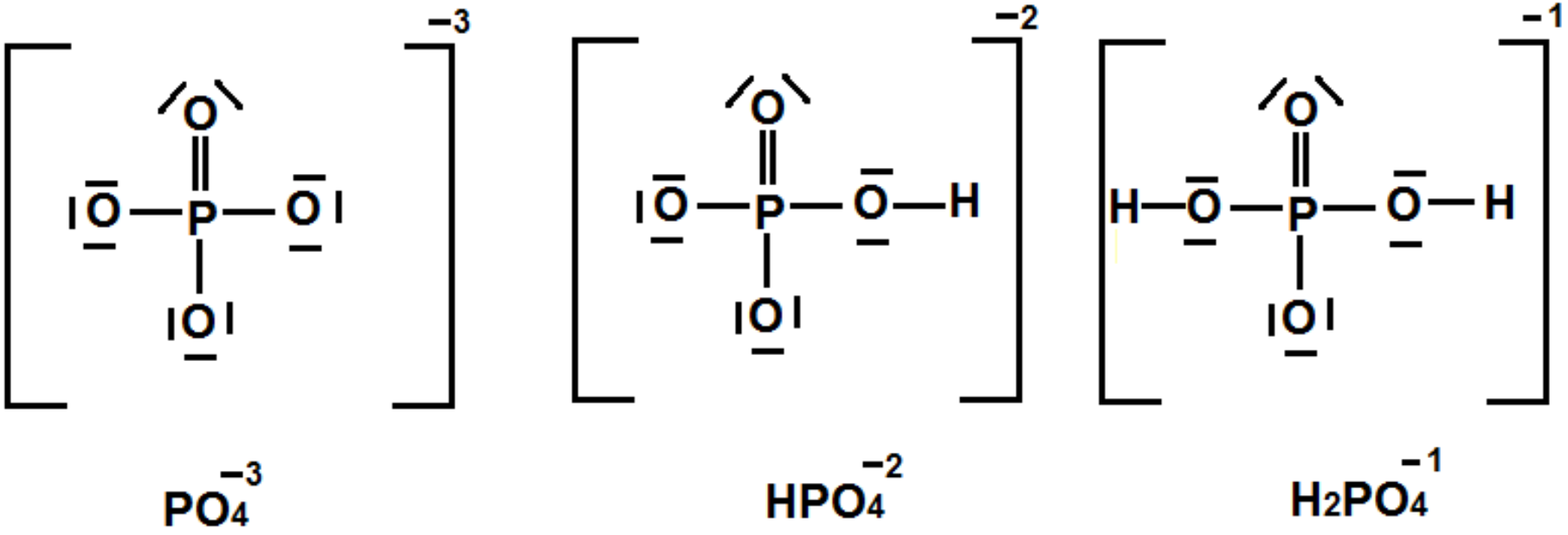
Ammonium carbonylpentacyanomanganate(II)

Hexaaquanickel(II) phosphate

Calcium diaquatetracyanocobaltate(III)

Phosphate (Orthophosphate) ion

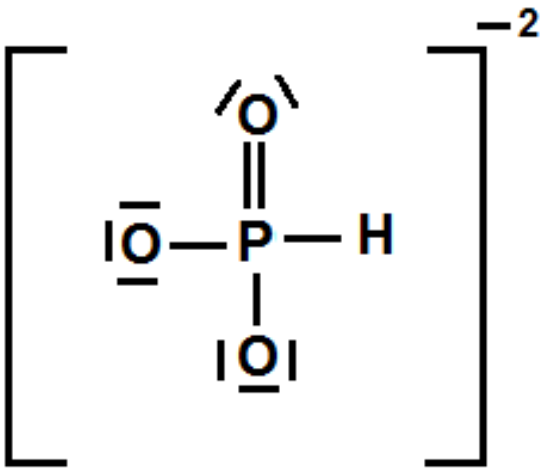
Lewis structure of PO_4^{-3}



PO_4^{-3} HPO_4^{-2} $H_2PO_4^{-1}$

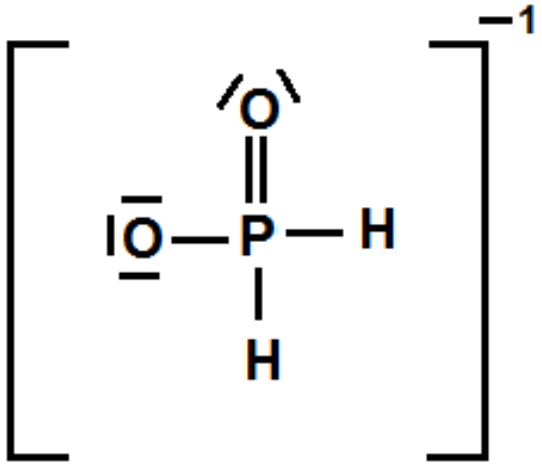
Phosphate (Orthophosphate) ion

Lewis structure :



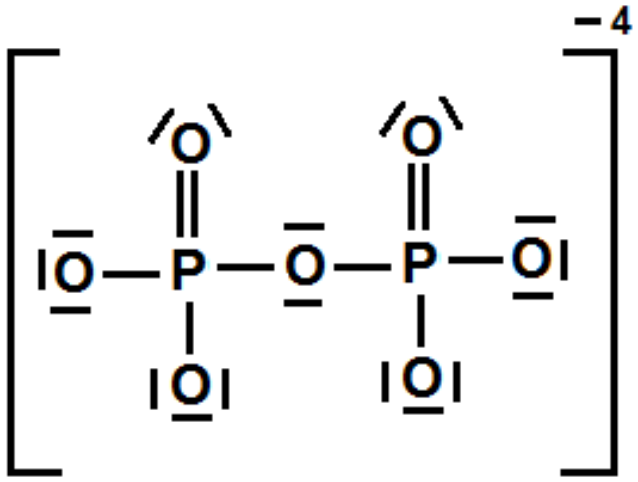
HPO_3^{-2}

Phosphite



$H_2PO_2^{-1}$

Hypophosphite



$P_2O_7^{-4}$

Diphosphate
(Pyrophosphate)

Phosphate ion

Test of PO_4^{-3}:

With $AgNO_3$ solution:

Soda extract + acidify with CH_3COOH (dil)+ $AgNO_3$ solution $\longrightarrow$ yellow ppt, soluble in NH_3(dil.), in HNO_3 (Conc.)

$$3Ag^+ + PO_4^{-3} \longrightarrow Ag_3PO_4\downarrow$$

yellow ppt

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

$$Ag_3PO_4 + 2\ H_3O^+ \longrightarrow H_2PO_4^- + 3\ Ag^+ + 2\ H_2O$$

Phosphate ion

Test of PO_4^{-3}

With $Zr(NO_3)_4$ solution:

It is used to remove phosphate from a sample

$$3Zr^{+4} + 4\ PO_4^{-3} \longrightarrow Zr_3(PO_4)_4$$

red ppt

Phosphate ion

Test of PO_4^{-3}

With Magnesia mixture [$MgCl_2$+ ammonia buffer]:

$Mg^{+2} + NH_4^{+} + PO_4^{-3} \longrightarrow MgNH_4PO_4$

white ppt, soluble in mineral acids

Phosphate ion

Test of PO_4^{-3}

With NH_4^+/ MoO_4^{-2} solution:

$$3\ NH_4^+ + PO_4^{-3} + 12\ MoO_4^{-2} + 24\ H_3O^+ \longrightarrow$$

$$(NH_4)_3(P(Mo_3O_{10})_4),\ \mathbf{(NH_4)_3(PMo_{12}O_{40})}\downarrow + 36\ H_2O$$

yellow ppt

Ammonium dodecamolybdatophosphate

Phosphate ion

Question:

What are the main differences between white phosphorus and red phosphorus?