

COBALT

Extraction

The chief ores are smaltite, CoAs_2 and cobaltite, CoAsS that occur together with ores of nickel. The ore is crushed and roasted in air to form tricobalttetraoxide which is reduced to cobalt by heating aluminum or carbon



Cobalt is purified by electrolysis of cobalt (II) sulphate solution.

Chemical properties:

It is a bright, bluish-white and very hard metal.

Oxidation states of cobalt include +3 and +2.

Oxidation state of +3 is strongly oxidizing and thus easily reduced to +2, but presence of complexing agents like NH_3 and CN^- considerably stabilize it.

(i) *Reaction with air*

It is not attacked by water and is very stable in air. Cobalt undergoes slow oxidation to form a black solid of tricobalt tetraoxide when heated to red hot.



(ii) *Reaction with acids*

Dilute mineral acids attack cobalt less readily than iron; dilute nitric acid the most reactive while dilute sulphuric acid and dilute hydrochloric acid react slowly to form cobalt (II) salts.



Hot concentrated sulphuric acid oxidizes cobalt to cobalt (III) salts while concentrated nitric acid renders it passive



Cobalt does not react with alkalis

(a) *Cobalt III compounds*

(i) *Cobalt (III) oxide ($\text{Co}_2\text{O}_3 \cdot \text{H}_2\text{O}$)*

It is a dark brown solid which is formed by aerial oxidation of cobalt (II) hydroxide



Blue

Dark brown

The best-known examples of simple cobalt III compounds are the cobalt (III) fluoride CoF_3 and cobalt (III) sulphate $\text{Co}_2(\text{SO}_4)_3$.

Cobalt (III) fluoride is a brown solid made by passing fluorine over cobalt at 3500C



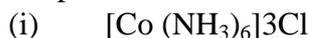
Many complexes of cobalt III ion exist, they are considerably more stable and they are all octahedral in shape examples include;



Isomerism

Cobalt like chromium (III) forms a wide range of complexes which adopt octahedral shape. They exhibit both geometrical and optical isomerism. Cobalt (III)chloride forms isomers with ammonia just like CrCl_3 and water.

The empirical formula of the complex is $\text{CoCl}_3(\text{NH}_3)_6$. The isomers are:



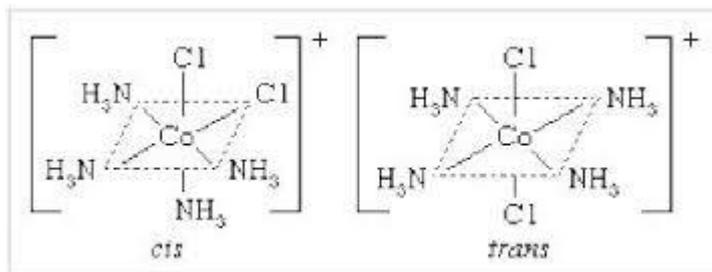
Is a *greenish yellow* isomer where all the 6 ammonia molecules are directly bonded to the Co^{3+} and all Cl^- are free. Therefore all the Cl^- ions are precipitated with silver nitrate solution. It has 4 ions conducting



Is a *violet isomer* in which two thirds of the chloride ions are free. It has 3 ions conducting.



Is a green isomer with only one third of the chloride ions free to be precipitated. It has 2 ions conducting.



(b) Cobalt II compounds

This is the most stable state of cobalt in solution. It is almost impossible to oxidize simple cobalt II compound to cobalt III compounds.

In solution cobalt (II) compounds are pink due to the presence of $\text{Co}(\text{H}_2\text{O})_2^{2+}(\text{aq})$ ion

(i) **Cobalt (II) oxide (CoO)**

It is an olive green solid prepared by heating cobalt (II) carbonate or nitrate in absence of air



In presence of air a mixture of cobalt (II) and cobalt (III) oxides are formed i.e. Co_3O_4 which is black

(ii) **Cobalt (II) chloride**

Anhydrous Cobalt (II) chloride is prepared by action of chlorine on heated metal.



It is a deliquescent salt forming a series of hydrates whose colour becomes increasingly pink as the number of moles of water of crystallization increases from 1, 2 and 6.

(iii) **Cobalt (II) hydroxide**

It can be precipitated as a blue solid by adding sodium hydroxide to cobalt (II) salt in solution



Pink

Blue

On standing the colour turns from blue to brown/pink because of partial aerial oxidation to form hydrated cobalt (III) oxide



Blue

Brown

Qualitative analysis of Co²⁺ ion

(i) *Reaction with sodium hydroxide solution*

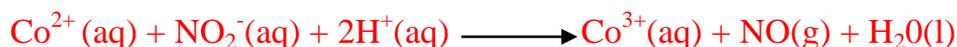
Blue precipitate insoluble in excess sodium hydroxide solution that turns Pink on warming. If left to stand in air the pink precipitate turns dark brown due to formation of hydrated cobalt (III) oxide [Co₂O₃.H₂O(s)]

(ii) *Reaction With aqueous ammonia:*

Blue precipitate that turns pink

(iii) *Reaction with acetic acid and potassium nitrite with shaking in air*

Yellow crystalline precipitate that dissolve in



Yellow

Potassium hexanitrocobalt(III), K₃Co(NO₂)₆ is conveniently precipitated as a yellow solid by addition of ethanol.

(iv) *Reaction with potassium cyanide*

Reddish brown precipitate of cobalt (II) cyanide, soluble in excess of the reagent to form potassium hexacyanocobaltate (II).



(v) *Reaction with concentrated hydrochloric acid*

Pink colour of solution deepens and turns deep blue. If a warm solution of Co²⁺ Ions is treated with concentrated hydrochloric acid; it turns blue and on cooling the solution turns pink. What is the effect of heat on position of equilibrium?



(vi) *Reaction with concentrated hydrochloric acid and potassium thiocyanate in*

presence of pentan-1-ol (amyl alcohol) Blue upper layer



Blue

This test is used as a confirmatory test for cobalt (II) ions