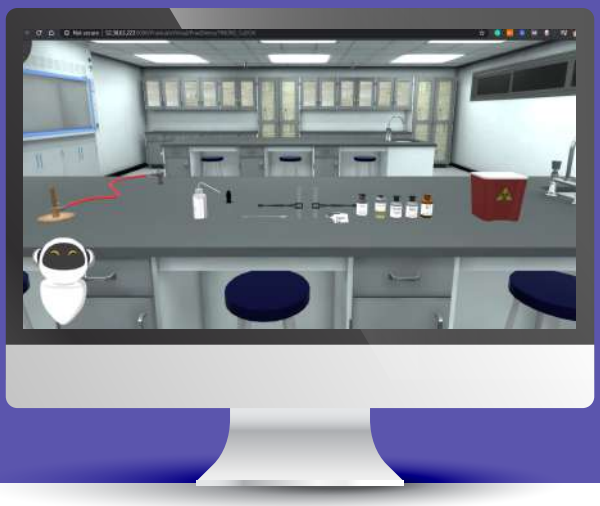
Chemistry | Inorganic Chemistry

Test for Cupric Radical



General Aim

Detection of the presence of cupric ions as base radicals in inorganic salts such as copper sulfate.

Method

Detection of the presence of cupric as a base radical using specific chemical reagents.

Learning Objectives (ILOs)

- Define and differentiate between members of the second group cations and those of other cation groups.
- Classify inorganic salts according to their base radicals.
- Compare between cupric containing salts and other members of the same group in terms of chemical structures, properties and reactions.
- Identify cupric radicals containing salts experimentally.
- Select the appropriate reagents to detect the presence of cupric radical.
- Balance the chemical equations of chemical reactions.

Theoretical Background/Context

Copper was the first and only known metal for over 5000 years. That was around 10,000 years ago when it was discovered for the first time in Iraq and was used in making weapons. Ancient Egyptians have widely used copper in making ships, water pipelines, etc. owing to its robustness and resistance towards water.

Abundance of Copper in Nature: Copper is the 25th most abundant element on Earth. It is located in the periodic table among the first row transition metals. Copper possesses a soft reddish appearance. It is naturally found among sulphide ores that consist also of arsenic, zinc and silver metals. Copper represents around 0.5 – 2 % of the ores. Copper can be extracted from their corresponding ores through either pyrometallurgical or hydrometallurgical methods. In addition, copper is naturally abundant as a prosthetic group of some proteins.

Properties and Uses of Copper: Copper is a reddish soft metal that can be reshaped according to the application. It has been widely used in various industries such as coins, metals, utensils, cooling coils in air conditioners and refrigerators, alloys, etc. In addition, its use in some medical, agricultural and electrical applications has been reported.

Copper Salts: Copper is found as either Cu+ or Cu2+ in chemical compounds. However, copper sulfate is one of the most abundant and used copper compounds. It is considered as an inorganic salt with a molecular formula of CuSO4. Its melting and boiling points are 200 ^{0}C and 650 ^{0}C, respectively. Copper salts possess some toxicity depending on the taken concentration. In large amounts, copper salts can cause nausea, vomiting and damage to the body. Continuous exposure to large quantities of copper could lead to severe damage to body fluids, tissues, blood cells, lung, kidney, liver and consequently death.

Preparation of Copper Sulfate: Copper sulfate can be either prepared through the reaction of copper metal with concentrated sulfuric acid or copper oxide with dilute sulfuric acid as the following reactions:

$$Cu + 2H_2SO_4 (conc.) \rightarrow CuSO_4 + SO_2 + 2H_2O$$

$$CuO + H_2SO_4 (dil) \rightarrow CuSO_4 + H_2O$$

Theoretical Background/Context

Properties and Uses of Copper Sulfate

- Copper sulfate is a white powdered salt when dehydrated. Its color turns into blue upon its hydration, where it attaches to five water molecules to possess a chemical formula of $CuSO_4.5H_2O$.
- Copper sulfate can cause eye irritation, nausea, vomiting, etc.
- Due to its toxicity in certain concentrations, it can be used in killing fungi, bacteria, etc.
- Copper sulfate is used as a mordant in vegetables dyeing.
- Due to its color change according to humidity, it is used as an analytical reagent.
- It has two oxidation states, so it is used in various organic synthesis techniques.
- It is involved in preparation of catalysts.
- It has been used in various applications such as etching, dyeing, electronics, etc.

Principle of Work

- In this experiment, cupric ion in copper sulfate is detected through some identification and confirmatory tests. The cupric radical is among the second group of basic radicals in which hydrogen sulfide is used as group reagents.
- During the experiment, salt solubility in water will be tested. Then the behavior of the salt will be tested with hydrogen sulfide followed by confirmatory tests which will be performed using sodium hydroxide, ammonia, and potassium iodide tests to confirm the presence of cupric radical in the salt.

First: Physical Appearance Test

In this test, a sample of the cupric salt is tested for its color, odor, texture, etc.

Second: Solubility Test

In this test, a sample of the cupric salt is tested for its solubility in water.

Third: Hydrogen Sulfide Test

It depends on the fact that sulfide anions can displace sulfate ions in cupric sulfate salt forming insoluble cupric sulfide as a black precipitate which is soluble in hot dilute nitric acid as the following reactions:

$$H_2S + CuSO_4 \rightarrow H_2SO_4 + CuS \downarrow \text{(Black ppt.)}$$
$$3CuS + 8HNO_3 \rightarrow 3CuNO_3 + 4H_2O + 2NO + 3S$$

Fourth: Sodium Hydroxide Test

Sodium Hydroxide solution is added to aqueous cupric sulfate leading to the precipitation of cupric hydroxide as a blue precipitate due to its low solubility product. Then, upon boiling, the precipitate changes its color into black due to its conversion into copper oxide:

$$CuSO_4 + 2NaOH \rightarrow Na_2SO_4 + Cu(OH)_2 \downarrow \text{(Blue ppt.)}$$
$$Cu(OH)_2 \rightarrow H_2O + CuO \downarrow \text{(Black ppt.)}$$

Fifth: Ammonia Test

Ammonia solution is added to aqueous cupric sulfate leading to the precipitation of cupric hydroxide as a blue precipitate due to its low solubility product. Then, upon adding excess ammonia, the precipitate dissolves again due to the formation of the soluble tetra-amine cupric sulfate complex:

$$CuSO_4 + 2NH_4OH \rightarrow (NH_4)_2SO_4 + Cu(OH)_2 \downarrow \text{(Blue ppt.)}$$
$$NH_4OH + Cu(OH)_2 \rightarrow [Cu(NH_4)_2]^{2+} + 2OH$$

Sixth: Potassium Iodide Test

Potassium iodide solution is added to cupric sulfate aqueous solution resulting in precipitation of cuprous iodide as a white precipitate due to low solubility product as shown in the following chemical reaction:

$$2CuSO_4 + 4KI \rightarrow 2K_2SO_4 + I_2 + 2CuI \downarrow \text{(White ppt.)}$$