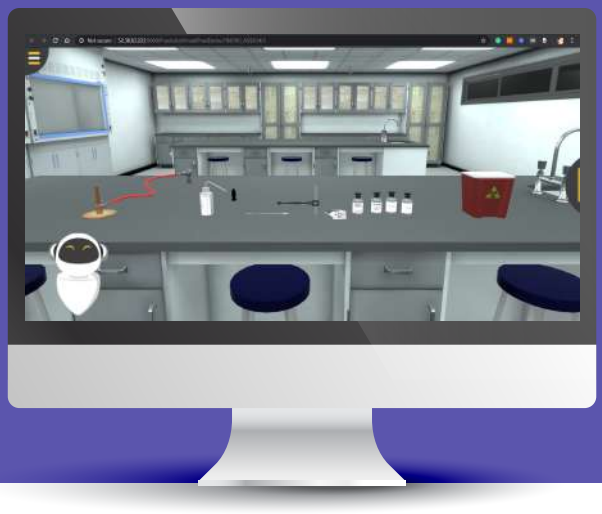
Chemistry | Inorganic Chemistry

Test for Aluminum Radical



General Aim

Detection of the presence of aluminum ion as a base radical in inorganic salts such as aluminum sulfate.

Method

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

Learning Objectives (ILOs)

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

Theoretical Background/Context

- **Aluminum (Al)**, also called Aluminium, possesses an atomic number of 24, where it is located in period 3 and group 6 in the periodic table. Its name is derived from the Latin word alumen.

Abundance of Aluminum in Nature

Aluminum is the 1st most abundant metal and 3rd element in the Earth's crust. Aluminum represents more than 8% of the Earth crust by mass after oxygen and silicon. In addition, aluminum oxide is the 4th abundant compound on Earth. Aluminum was known as one of the most expensive metals until the 1800s, when it was obtained successfully through the electrolysis of aluminum oxide. This helped in decreasing the price of aluminum and increasing its availability to be used commercially.

Properties and Uses of Aluminum

Aluminum is a soft and silvery metal and it is characterized by possessing light weight. Aluminum has three oxidation states which are +1 such as aluminum hydride (AlH), +2 such as aluminum monoxide (AlO), and +3 such as aluminum oxide (Al2O3). It is a good conductor of heat and electricity, so it is used in manufacturing of some types of wires. It has been used widely in various applications.

For instance, it is used as aluminum foil, in cooking utensils and furniture in household purposes, as a dying and pottering agent in crafts, and in alloys for construction purposes. Since, aluminum is too soft to be used in construction purposes, some iron and silicon are added to increase its hardness. Furthermore, aluminum has been used in heavy industries such as the manufacture of automobiles, trucks and aircrafts.

Theoretical Background/Context (Cont')

Aluminum Salts

Although aluminum has three oxidation states, the +3 is the most stable among them. Therefore, most commonly known aluminum salts are AlCl3 and Al2(SO4)3.

Preparation of Aluminum Salts

Aluminum salts can be obtained by either reacting the elemental aluminum with heated concentrated acids such as hydrochloric acid or sulfuric acid directly to produce aluminum chloride or aluminum sulfate, respectively or indirectly through aluminum hydroxide with those acids.

$$2\ Al + 3\ H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3\ H_2 \uparrow$$

$$2\ Al(OH)_3 + 3\ H_2SO_4 \rightarrow Al_2(SO_4)_3 + 6\ H_2O$$

In addition, it can be produced on large scales for commercial purposes through calcination of clays or bauxite, then boiling with sulfuric acid.

Properties and Uses of Aluminum Sulfate

- Aluminum sulfate is a large white crystalline salt. It is rare to be found in an anhydrous form as it gets hydrated easily.
- Aluminum sulfate is a flocculating or coagulating agent causing aggregation of particles or contaminants through neutralizing their charges. This helps in purifying drinking water or treated waste water for plant irrigation.
- Aluminum sulfate is used in the manufacture of papers.
- Aluminum sulfate is used as a bactericide additive to animal food.
- Aluminum sulfate is used as astringent, deodorant and hemostatic agent in some wound treatment preparations.

Principle of Work

- In this experiment, aluminum ion in aluminum sulfate is detected through some identification and confirmatory tests. The aluminum radical is among the third group of basic radical in which ammonia is used as a group reagent.
- During the experiment, salt solubility in water will be tested on cold and hot. Then the behavior of the salt will be tested with ammonia followed by confirmatory tests which will be performed using sodium hydroxide, sodium phosphate, and sodium carbonate reagents to confirm the presence of aluminum radical in the salt.

First: Solubility Test

In this test, a sample of the aluminum salt is tested for its solubility in water on cold and hot.

Second: Ammonia Test

It depends on the fact that ammonia can displace sulfate ions in aluminum sulfate salt forming insoluble gelatinous white precipitate of aluminum hydroxide.

$$Al_2(SO_4)_3 + 6\ NH_4OH \rightarrow 3\ (NH_4)_2SO_4 + 2\ Al(OH)_3 \downarrow \text{(Gel white ppt.)}$$

Third: Sodium Hydroxide Test

Sodium Hydroxide solution is added to aqueous aluminum sulfate leading to the precipitation of aluminum hydroxide as a gelatinous white precipitate. The reaction of the test is:

$$Al_2(SO_4)_3 + 3\ NaOH \rightarrow 3\ Na_2SO_4 + 2\ Al(OH)_3 \downarrow \text{(White ppt.)}$$

Forth: Sodium Phosphate Test

Sodium phosphate solution is added to aluminum sulfate aqueous solution resulting in precipitation of aluminum phosphate as a white precipitate due to low solubility product as shown in the following chemical reaction:

$$Al(SO_4)_3 + 2\ Na_2HPO_4 \rightarrow 2\ Na_2SO_4 + H_2SO_4 + 2\ AlPO_4 \downarrow \text{(White ppt.)}$$

Aluminum phosphate is not soluble in acetic acid but soluble in mineral acids and caustic alkalis.

Fifth: Sodium Carbonate Test

Sodium carbonate test is considered as a confirmatory test for detection of the presence of aluminum ion as the basic radical of a salt. The test depends on adding sodium carbonate solution to aqueous aluminum sulfate solution leading to the formation of white colored precipitate of aluminum hydroxide due to hydrolysis of aluminum carbonate according to the following reaction:

$$Al_2(SO_4)_3 + 2\ Na_2CO_3 \rightarrow 3\ Na_2SO_4 + 3\ Al_2(CO_3)_3$$

$$Al_2(CO_3)_3 + 6\ H_2O \rightarrow 3\ H_2CO_3 + 2\ Al(OH)_3 \downarrow \text{(White ppt.)}$$

Then the precipitate of aluminum hydroxide dissolves in excess of reagent due to formation of sodium aluminate as shown in the following reaction:

$$2\ Al(OH)_3 + Na_2CO_3 \rightarrow 2\ Na[AlO_2] + CO_2 + 3\ H_2O$$