Chemistry | Inorganic Chemistry

Test for Sulphite Radical

General Aim

Detection of the presence of sulfite ion as an acid radical in inorganic salts such as potassium sulfite.

Method

Detection of the presence of sulfite as acid radical using specific chemical reagents.

Learning Objectives (ILOs)

- Define and differentiate between sulfite ions and other acid radicals through their chemical formulas.
- Classify inorganic salts according to their acid radicals.
- Compare between sulfite and other first group members in terms of chemical structures, properties and reactions.
- Identify sulfite radicals containing salts experimentally.
- Select the appropriate reagents to detect the presence of sulfite radical.
- Balance the chemical equations of chemical reactions.

Theoretical Background/Context

- Sulfite is the conjugate base of bisulfite. Although sulfonic acid is not commonly available, its salts are highly abundant naturally in many foods and are commonly utilized as food additives.
- Although sulfite ion is counted as a weak base, it undergoes hydrolysis to produce basic solutions.

$$SO_3^{2-}(aq) + H_2O(l) \leftrightarrow HSO_3^-(aq) + OH^-(aq)$$

- In the presence of an acidic solution, the equilibrium is shifted towards formation of sulfurous acid, leading to sulfur dioxide (SO_2) gas evolution. Sulfur dioxide is a colorless gas with a characteristic pungent odor.

$$HSO_3^-(aq) + 2\,H_2O(l) \leftrightarrow H_2SO_3(aq) + OH^-(aq)$$

$$H_2SO_3(aq) \leftrightarrow H_2O(l) + SO_2(g)$$

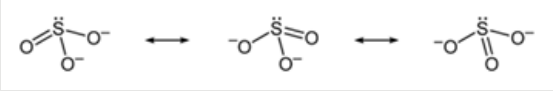
- Sulfite ions get oxidized easily upon exposure to oxygen in air.

$$2\,SO_3^{2-}(aq) + O_2(g) \leftrightarrow 2\,SO_4^{2-}(aq)$$

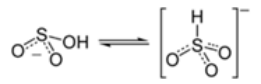
- Therefore, sulfite and sulfur dioxide could decolorize permanganate solution. Therefore, the reaction can be used to test for sulfur dioxide.

$$2MnO_4^-(aq) + 5SO_2(g) + 2H_2O(l) \leftrightarrow 5SO_4^{2-}(aq) + 2Mn^{2+}(aq) + 4H^+(aq)$$

- Sulfite anion possesses three equivalent resonating structures. Each of them has its sulfur atom bonded with one of its oxygen atoms via a double bond and possesses a zero formal charge (neutral). The sulfur atom is bonded to the other two oxygen atoms through single bonds, where each oxygen atom carries a formal charge of 1– indicating the 2– charge on the entire sulfite anion. A non-bonded lone pair of electrons is located on the sulfur atom of the sulfite. Therefore, according to the VSEPR theory, the sulfite anion possesses a trigonal pyramidal configuration like ammonia (NH_3).



- The hybrid resonating structure of the sulfite anion possesses three equivalent S–O bonds as shown below.



Theoretical Background/Context (Cont')

- Sodium, potassium and ammonium sulfite salts are water soluble, although most sulfite salts are water insoluble. On the other hand, all sulfite salts are soluble in acidic solution due to their basicity.
- The sulfite ion is classified as a member of acidic radicals of the first group in which hydrochloric acid is used as the group reagent. Hydrochloric acid displaces sulfite ions in their salts leading to liberation of sulfur dioxide SO2 gas that could be detected using potassium dichromate paper.
- In addition, soluble sulfite salts such as potassium sulfite could be detected through some confirmatory tests using silver nitrate solutions or lead acetate solutions since they react together forming silver sulfite or lead sulfite, respectively as a white precipitate. This returns back to the low solubility product of silver and lead sulfite salts so they precipitates very easily at very low concentrations.
- Finally, iodine and permanganate tests are carried out as specific tests for detection of sulfite ions, where the sulfite ions decolorize both solutions owing to their reducing activity.

Principle of Work

- In this experiment, sulfite ion in potassium sulfite is detected through some identification and confirmatory tests. In addition, these tests can be used to differentiate between the first anionic class and other acid radical classes. Moreover, confirmatory and specific tests are used to differentiate between presences of different members of the first class of anions.

First: Solubility Test

In this test, a sample of the sulfite salt is tested for its solubility in distilled water on cold. Most sulfite salts are water insoluble except sodium, potassium and ammonium sulfites which are soluble in water without need of heating.

Second: Hydrochloric Acid Test

It depends on the fact that hydrochloric acid can displace sulfite ions in its potassium salt forming potassium sulfite salt and sulfur dioxide gas. The evolved gas can react with potassium dichromate paper causing changing its color into green. The two steps of the reactions are:

Step 1: Reaction of Potassium Sulfite with Hydrochloric Acid:

$$K_2SO_3 + 2HCl \rightarrow 2KCl + H_2O + SO_2 \uparrow$$

Step 2: Reaction of SO2 gas with Potassium Dichromate:

$$3SO_2 + K_2Cr_2O_7 + H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + H_2O$$

Third: Silver Nitrate Test

Silver nitrate solution is added to a solution of potassium sulfite leading to the precipitation of silver sulfite salt as a white precipitate due to its low solubility product. The reaction of the test is:

$$K_2SO_3 + 2\ AgNO_3 \rightarrow 2\ KNO_3 + Ag_2SO_3 \downarrow$$

Fourth: Lead Acetate Test

Lead acetate solution is added to potassium sulfite solution resulting in precipitation of lead sulfite as a white precipitate due to low solubility product as shown in the following chemical reaction:

$$K_2SO_3 + Pb(CH_3COO)_2 \rightarrow 2\ CH_3COOK + PbSO_3 \downarrow$$

Fifth: Iodine Test

Iodine test is considered as a specific test for detection of the presence of sulfite ion as the acid radical of a salt. The test depends on the reducing ability of sulfite salt to reduce iodine solution into hydrogen iodide leading to discoloration of its brown color.

$$K_2SO_3 + I_2 + H_2O \rightarrow K_2SO_4 + 2HI$$

Sixth: Potassium Permanganate Test

Permanganate test is considered as a specific test for detection of the presence of sulfite ion as the acid radical of a salt. The test depends on the reducing ability of sulfite salt to reduce permanganate **MnO_4^-** into manganous **Mn^{2+}** leading to discoloration of its purple color.

$$5K_2SO_3 + 2KMnO_4 + 3H_2SO_4 \rightarrow 6K_2SO_4 + 2MnSO_4 + 3H_2O$$