Chemistry | Inorganic Chemistry

Test for Carbonate radical

General Aim

Detection of the presence of carbonate ion as an acid radical in inorganic salts such as sodium carbonate.

Method

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

Learning Objectives (ILOs)

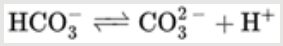
- Define and differentiate between carbonate ions and other acid radicals through their chemical formulas.
- Classify inorganic salts according to their acid radicals.
- Compare between carbonate and other first group members in terms of chemical structures, properties and reactions.
- Identify carbonate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

Theoretical Background/Context

- In inorganic chemistry, carbonate (CO32-) is the conjugate base of bicarbonate (HCO3-) which is the conjugate base of the carbonic acid (H2CO3). Carbonate anion carries a formal charge of -2 and has a molar mass of 60.01 g/mol.
- Carbonic acid is a diprotic acid i.e. has two hydrogen atoms. Therefore, it possesses two dissociation constants. The first one is related to the dissociation of carbonic acid into bicarbonate ions as shown below.

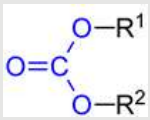
Ka1 = 2.5×10−4, pKa1 = 3.6 at 25 °C.

- On the other hand, the second constant is related to the dissociation of bicarbonate ions into carbonate ions as shown below.

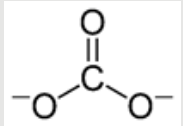


Ka2 = 4.69×10−11; pKa2 = 10.329 at 25 °C

- In organic chemistry, carbonate term refers to the ester group, a functional group consisting of a carbonyl group where the carbon atom of the carbonyl group is linked to two oxygen atoms, one from each side. Then each oxygen atom is linked to R group that could be aliphatic or aromatic potion of organic compounds as shown below.

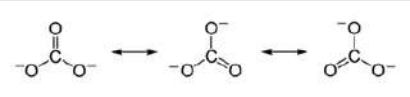


- In inorganic chemistry, carbonate anion, polyatomic ion with the chemical formula of CO32-, is considered to be the simplest abundant oxocarbon anion. It consists of one carbon atom linked to three oxygen atoms in a trigonal planar conformation. The Lewis structure of the carbonate ion suggests the presence of two long single bonds that link the central carbon atom with two negatively charged oxygen atoms, and a shorter double bond that links the central carbon atom to a neutral oxygen as shown below.

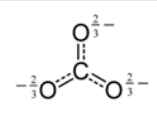


Theoretical Background/Context (Cont')

- However, the previously illustrated suggestion does not match the symmetry of the carbonate ion that has been observed in which the three bonds that link the central carbon atom with the three oxygen atoms are equivalent. This is justified by the resonance among the carbonate structure as shown below:



- This could be summarized by the following resonating model that possesses equivalent fractional charges on the three oxygen atoms:



- Carbonic acid is not commonly used. However, there are various carbonate salts that possess different properties and are used in various applications. For instance, all normal carbonate salts except those of alkali metals (such as sodium and potassium) and ammonia, are insoluble in water.
- One of the most common and widely used carbonate salts is sodium carbonate with a chemical formula of Na_2CO_3 and molar mass of 105.98 gm/mol. Sodium carbonate is a white odorless powder that is highly soluble in water. Sodium carbonate has been used as an additive in some cleansing and cosmetics preparations.
- For example, it has been used as water softener in laundry products and swimming pools. In addition, it has been used as a foaming agent in toothpastes. Furthermore, sodium carbonate has been used in different industrial applications such as soda ash, soda crystals, glass, etc. Additionally, it has various chemical applications. For instance, it is used as either standard in acid-base titrations or as an electrolyte in electrolysis.
- Carbonate ion is classified as a member of acidic radicals of the first group in which hydrochloric acid is used as the group reagent.
- In addition, soluble carbonate salts such as sodium carbonate could be detected through some confirmatory tests using mercuric chloride and magnesium sulfate.

Principle of Work

- In this experiment, carbonate ion in sodium carbonate 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 sodium carbonate salt is tested for its solubility in distilled water on cold. Most carbonate salts are water insoluble except alkali metals such as sodium and potassium in addition to ammonium carbonates which are soluble in water without need of heating.

Second: Hydrochloric Acid Test

It depends on the fact that hydrochloric acid can displace carbonate ions in its sodium salt forming sodium chloride salt and carbon dioxide gas. The evolved gas (CO_2) can pass through lime water causing its turbidity due to conversion of the soluble calcium hydroxide into the insoluble calcium carbonate.

Step 1: Reaction of Sodium Carbonate with Hydrochloric Acid

$$\mathbf{Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2 \uparrow}$$

Step 2: Reaction of CO_2 gas with lime water

$$\mathbf{CO_2 + Ca(OH)_2 \rightarrow H_2O + CaCO_3 \downarrow (White\ ppt)}$$

Principle of Work (Cont')

Third: Mercuric Chloride Test

Mercuric chloride solution is added to a solution of sodium carbonate leading to the precipitation of mercuric carbonate salt as a reddish brown precipitate due to its low solubility product. The reaction of the test is:

$Na_2CO_3 + HgCl_2 \rightarrow 2\ NaCl + HgCO_3\downarrow$ (Red brown)

Fourth: Magnesium sulfate Test

Magnesium sulfate solution is added to sodium carbonate solution resulting in precipitation of magnesium carbonate as a white precipitate due to low solubility product as shown in the following chemical reaction:

$MgSO_4 + Na_2CO_3 \rightarrow Na_3SO_4 + MgCO_3 \downarrow$ (White ppt)