Carbonates ions are formed by the reaction of carbonic acid with metals or organic compounds. In this case, the reaction of carbonates with the main group elements and its products, salts, is explained.

![Carbonate ion](image)

**Figure 1: Carbonate ion.**

### Chemical Characteristics

In general, the most common main group elements used as carbonates are the Alkali and Alkaline metals. All main group carbonates, except Na, K, Rb and Cs are unstable to heat and insoluble in water. Usually all carbonates are soluble in acid, because of the formation of bicarbonate ion. Its regular physical appearance is of a white powder. The main uses of carbonates is as raw materials in different industrial processes such as drug development, glass making, pulp and paper industry, sodium chemicals (silicates), soap and detergent production, paper industry, water softener, clay and concrete production, among others. Other carbonates such as Beryllium Carbonate (BeCO$_3$) and Tallium Carbonate (Tl$_2$CO$_3$) are consider toxic and are used in fungicides and poison manufacture.

From main group elements Sodium Carbonate (Na$_2$CO$_3$) and Calcium Carbonate (CaCO$_3$) are the most used.

**Sodium Carbonate**, known as soda ash, is a very important industrial chemical. It is mainly obtained by a method named *Solvay process* by the chemical reaction of limestone (CaCO$_3$) and sodium chloride (NaCl).

$$2 \text{NaCl} + \text{CaCO}_3 \rightarrow \text{Na}_2\text{CO}_3 + \text{CaCl}$$

Na$_2$CO$_3$ common uses are in glass making, pulp and paper industry, sodium chemicals (silicates), soap and detergent production, paper industry and water softener.

**Calcium Carbonate** is the principal constituent of limestone (a sedimentary rock) and its pure state is obtained in three steps by the calcination of limestone and subsequent reaction with water and carbon dioxide.

$$\text{Ca(OH)}_2(s) + \text{CO}_2(aq) \rightarrow \text{CaCO}_3 \ (s) + \text{H}_2\text{O(l)}$$

Calcium Carbonate common uses are in glass, textile, paint, paper and plastic production, caulks industry, to produce ink and sealant. It is also used as a food additive (non toxic), as a drug development and chalk production.
Carbonate Hardness

Hard water is the term used in relation with high amount of inorganic compounds such as carbonates, bicarbonates, sulfates or chlorides in water. The presence of high levels of carbonates and bicarbonates in water is denominated as temporary hardness of water. It is considered hard water when this inorganic compound exceed the 100 mg/L approximated, and it is usually expressed as the amount of calcium carbonate present in water. This is important when water is used for industrial process or cleaning purposes.

The way precipitation is formed is when inorganic compounds in presence of high molecular organic compounds (such as soaps) produce undesirable insoluble precipitation. These precipitations are the responsible of a dirty or grayish white and low efficiency in cleaners.

Other way to form precipitation is when hard water attains high temperatures; its inorganic compounds such as calcium carbonate precipitates leaving a deposited coating in water pipes or over boilers. Here is an example of what happens:

\[
\text{Ca}^{2+}(aq)+2\text{HCO}_3^-(aq) \rightarrow \text{CaCO}_3(s) + \text{H}_2\text{O} + \text{CO}_2
\]

One way to reduce temporary hardness such as calcium ions is by boiling or by the addition of calcium hydroxide (lime), but is not often used. The best way of soften water is by the addition of Soda Ash to the water or using an ion exchanged column.

Carbonates in Detergents

Some carbonates such as sodium carbonate or potassium carbonates are used to elaborate some detergents. Soda Ash (other name for sodium carbonate) is used since in one way it is cheap and also it helps soften water by precipitation of calcium and magnesium carbonates. Potassium carbonates are used because of its solubility.

Carbonates in Glass Manufacture

Some inorganic compounds such as calcium carbonate, sodium carbonate and potassium carbonate are used as unprocessed material to elaborate glass since their chemical characteristics, high quality and low prices. Calcium carbonates and sodium carbonates are used as raw material in the production of paper due to their low cost by using them instead of pulp and to improve the white and gloss of the paper.

Group 1: Alkali Metals and Carbonates (X_2CO_3)

is the reaction between Li, Na, K, Rb and Cs with CO_3. All except Lithium are soluble in water and stable to heat.

Lithium Carbonate (Li_2CO_3)

- Uses: drug development.
- Chemical Characteristics:
- Low solubility in water.
• Unstable to heat.
• Appearance: white powder, fragrance-free

**Sodium Carbonate (Na$_2$CO$_3$)**

• Uses: glass making, pulp and paper industry, sodium chemicals (silicates), soap and detergent production, paper industry and water softener.
• Known as soda ash
• Very important industrial chemical
• Chemical Characteristics:
  • Hygroscopic substance
  • Soluble in water
  • Stable to heat
  • Appearance: crystal white solid

**Potassium Carbonate (K$_2$CO$_3$)**

• Uses: glass making, soft soap production, textile and photography chemicals.
• Characteristics:
  • Hygroscopic.
  • Soluble in water.
• Can be heated to high temperatures.
• Appearance: white solid

**Rubidium Carbonate (Rb$_2$CO$_3$)**

• Uses: glass making, short-chain alcohol production.
• Characteristics:
  • Hygroscopic substance
  • Soluble in water.
  • Can be heated to high temperatures.
• Appearance: white solid.

**Cesium Carbonate (Cs$_2$CO$_3$)**

• Uses: production of other cesium salts.
• Characteristics:
  • Hygroscopic substance.
  • Soluble in water.
  • Can be heated to high temperatures.
• Appearance: white powder.
Group 2: Alkaline Earth Metals and Carbonates (XCO₃)

Is the reaction between Be, Mg, Ca, Sr and Ba with CO₃. All are insoluble in water and unstable to heat.

**Beryllium Carbonate (BeCO₃)**
- Insoluble in water.

**Magnesium Carbonate (MgCO₃)**
- Uses: skin care products, cosmetic, anti-fire products, climbing chalk.
- Characteristics:
  - Insoluble in water.
  - Hygroscopic substance.
  - Appearance: white solid.

**Calcium Carbonate (CaCO₃)**
- Uses: textile, paint, paper, plastic, caulks industry used to produce ink and sealant. It is used as a food additive (non toxic), drug development and chalk production.
- Principal constituent of limestone (sedimentary rock).
- Characteristics:
  - Responsible of hard water.
  - Low solubility in water.
  - Soluble in acids.
  - Appearance: white powder.

**Strontium Carbonate (SrCO₃)**
- Uses: fireworks, magnets and ceramic manufacture.
- Characteristics:
  - Low solubility in water.
  - Reactive with acids.
  - Neutralize acids.
  - Hygroscopic substance.
  - Appearance: white powder, unscented.

**Barium Carbonate (BaCO₃)**
- Uses: glass, cement, ceramic, porcelain, rat poison manufacture.
- Characteristics:
  - Low solubility in water.
  - Appearance: white crystals.
Group 13: The Boron Family and Carbonates ($X_2CO_3$)

Is the reaction between Al and Tl with CO$_3$. Both are insoluble in water and unstable to heat.

**Aluminium Carbonate ($Al_2(CO_3)_3$)**

- **Uses:** drug development.
- **Chemical Characteristics:**
- **Appearance:** white powder.

**Tallium Carbonate ($Tl_2CO_3$)**

- **Uses:** fungicides manufacture.
- **Characteristics:**
- **Toxic.**
- **Appearance:** white crystals, unscented.

Group 14: The Carbon Family and Carbonates ($XCO_3$)

Is the reaction between Pb with CO$_3$. It is insoluble in water and unstable to heat

**Lead Carbonate (PbCO$_3$)**

- **Uses:** glass, cement, ceramic, porcelain, rat poison manufacture.
- **Characteristics:**
- **Toxic.**
- **Low solubility in water.**
- **Appearance:** white powder.

References

4. www.omya.com
5. www.nssga.org
Problems

1) Which are the common carbonates used as raw materials?

   Calcium Carbonate and Sodium Carbonate

2) Are carbonates soluble in water?

   All main group carbonates, except Na, K, Rb and Cs are insoluble in water.

3) Which carbonate is responsible of hard water?

   Most communly Calcium Carbonate

4) Which carbonate can be use as softener of hard water?

   Sodium Carbonate ( Soda Ash)