

# Learn About ...

## LIME: CALCIUM OXIDE

### CaO

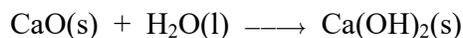
Calcium oxide is a white crystalline solid with a melting point of 2572°C. It is manufactured by heating limestone, coral, sea shells, or chalk, which are mainly CaCO<sub>3</sub>, to drive off carbon dioxide.



This reaction is reversible; calcium oxide will react with carbon dioxide to form calcium carbonate. The reaction is driven to the right by flushing carbon dioxide from the mixture as it is released.

The production of calcium oxide from limestone is one of the oldest chemical transformations produced by man. Its use predates recorded history. Most ancient languages have a word for calcium oxide. In Latin it is *calx*, from which the name of the element calcium is taken. In Old English, its name is *lim*, which is the origin of the modern commercial name for calcium oxide, namely lime. The abundance of limestone in the Earth's crust and the ease of its transformation to calcium oxide do not alone explain why the lime is one of the oldest products of chemistry. Lime has many properties that make it quite valuable. It is so useful, that it is today produced industrially on a vast scale; over 22 million tons were produced in the U.S. in 2000.

The oldest uses of lime exploit its ability to react with carbon dioxide to regenerate calcium carbonate. When lime is mixed with water and sand, the result is mortar, which is used in construction to secure bricks, blocks, and stones together. Mortar is initially a stiff paste that is laid between the bricks. It gradually hardens, cementing the bricks together. At room temperature, the reaction of lime with carbon dioxide is very slow. It is speeded by mixing lime with water. When lime is mixed with water, it forms calcium hydroxide, called slaked lime.



The reaction of calcium hydroxide with carbon dioxide is faster, producing a mortar that hardens more quickly.



Even with the increased reaction speed, mortar requires many years for complete reaction to occur. Other lime-based products used in the construction industry include lime plaster and portland cement.

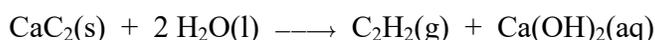
Perhaps the most commercially important property of lime is its ability to form solutions with silicates. When lime is heated with silica sand (SiO<sub>2</sub>) and sodium carbonate (Na<sub>2</sub>CO<sub>3</sub>), a solution is formed that does not crystallize when it is cooled. Instead it hardens to an amorphous, clear, and nearly colorless solid, namely glass. Because it is a mixture and not a pure compound, glass does not have a distinct melting point; it gradually softens as it is heated. Therefore, it can be molded and blown into many useful shapes. The production of glass from lime is another of the ancient uses of lime.

The most important modern use of lime also relies on its ability to form solutions with silicates. Nearly 45% of lime is used in the steel industry. Steel and iron are produced from ores, which are rock that contain iron oxides. Many of these ores also contain a large amount of silicates. When lime is mixed with the ore and the mixture melted, these silicates combine with the lime, forming a liquid solution called slag. Slag is immiscible with molten iron, so the silicates can be removed from the iron by draining off the slag. Approximately 80 kg of lime is used in the production of each metric ton (1000 kg) of iron. Lime is also used in the production of other metals. For example, it is used to remove silicates from alumina ( $\text{Al}_2\text{O}_3$ ) before the alumina is reduced to aluminum metal.

Lime is also an important material in the manufacture of chemicals. Its major use here is in the production of calcium carbide,  $\text{CaC}_2$ . Calcium carbide is manufactured by heating lime with coke.

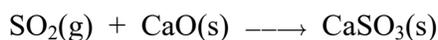


Calcium carbide reacts with water, releasing acetylene,  $\text{C}_2\text{H}_2$ .

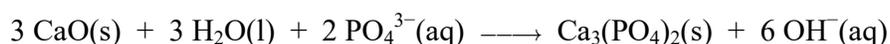


Acetylene is an important fuel for welding and is also a starting material for a range of organic compounds, including vinyl chloride, neoprene, and acrylonitrile, all of which are raw materials for polymers.

Pollution control is a rapidly expanding consumer of lime. Lime is used in stack gas scrubbers to reduce sulfur dioxide emissions from power plants. Sulfur dioxide reacts with lime to form solid calcium sulfite.



Lime is also added to sewage to remove phosphates.



The pretreatment of water supplies involves the use lime to decrease the acidity, to soften, and to clear drinking water.

A variety of other industrial processes also make extensive use of lime. It is used as an opacifier in plastics. The paper industry uses it in pulping wood; because lime is highly alkaline, it dissolves the lignin that binds the fibers together in wood. In the refining of sugar, lime causes coagulation of plant material, allowing it to be more easily separated from the sugar syrup.

One use of lime has disappeared, leaving only its name, suggesting the romance of a bygone era. Because lime has a very high melting point, it can be heated to a very high temperature without melting. When heated to very high temperatures, such as in the flame of a torch, lime emits a brilliant white light. Before the advent of electric lighting, this light was used as theatrical stage lighting, "lime light."