

# The ELEMENTS OF CHEMISTRY

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## THE ELEMENTS OF CHEMISTRY

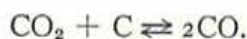
Carbon dioxide is called *carbonic anhydride*. Carbonic acid has never been obtained in the free state, being known only in solution. It is one of the feeblest of acids. With each metal it forms two salts -an acid salt and a normal (neutral) salt. Thus we have sodium acid carbonate,  $\text{NaHCO}_3$  (baking soda), and sodium carbonate (washing soda),  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ ; also calcium bicarbonate,  $\text{Ca}(\text{HCO}_3)_2$ , and calcium carbonate,  $\text{CaCO}_3$ :

- (1)  $\text{Ca}(\text{OH})_2 + \text{H}_2\text{CO}_3 + \text{CaCO}_3 \sim + 2\text{H}_2\text{O}$ ,  
 (2)  $\text{CaCO}_3 + \text{H}_2\text{CO}_3 \rightarrow \text{Ca}(\text{HCO}_3)_2$  (soluble in water).

*An excess of carbonic acid favors the formation of the acid salt.*

## Carbon Monoxide, CO

167. Formation.-Carbon monoxide is formed when carbon burns in a limited supply of oxygen, or by passing  $\text{CO}_2$  over hot charcoal or coke:



This explains the formation of CO in an ordinary grate fire, where reduction takes place in the interior of the grate as the  $\text{CO}_2$  passes

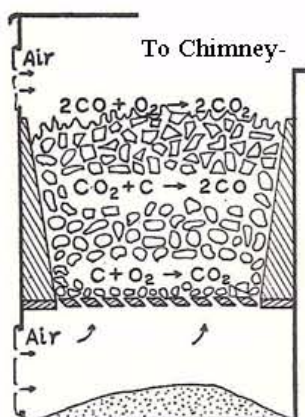


FIG. 67. Section of Kitchen Range Showing the Formation of Carbon Monoxide.

over the heated carbon. CO, on coming in contact with air at the top of the grate, burns with a blue flame to form  $\text{CO}_2$ . Carbon monoxide is formed in ranges and furnaces during incomplete combustion and it may escape into a room in case of insufficient draft (Fig. 67). The gas also is formed in the combustion engine.

Producer gas (approximately 39 per cent of CO and 60 per cent of  $\text{N}_2$ ) is made when air is passed over heated coke.

Water gas is produced on a large scale by passing steam over heated coke or anthracite coal:

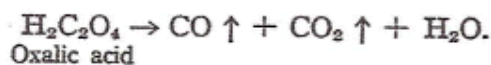
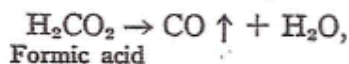


- water gas

Water gas and producer gas are excellent fuels.

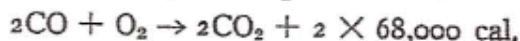
168. Laboratory Preparation.-Carbon monoxide can be prepared conveniently for laboratory use by treating either formic acid.

( $\text{H}_2\text{CO}_2$ ) or oxalic acid ( $\text{H}_2\text{C}_2\text{O}_4$ ) with concentrated sulfuric acid. The sulfuric acid abstracts hydrogen and oxygen, forming water. In the case of oxalic acid carbon dioxide also is formed, which may be dissolved in a solution of sodium hydroxide:

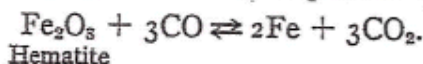


169. *Properties.*—Carbon monoxide is a colorless gas which is virtually odorless and tasteless. Its specific gravity is slightly less than that of air, and it is only slightly soluble in water. The gas may be liquefied more readily than hydrogen, but less readily than carbon dioxide.

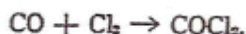
Carbon monoxide is an *unsaturated compound*, i.e., it has a tendency to combine with such substances as oxygen and chlorine in order that carbon may have its maximum valence of 4. The gas burns with a bluish flame, producing much heat:



Carbon monoxide is a good *reducing agent*, and plays an important rôle in the blast-furnace, for at high temperatures it has great affinity for oxygen and therefore robs ores of this element (547). Hematite, or ferric oxide, is our most important iron ore.

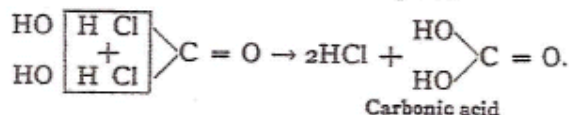


When a mixture of carbon monoxide and chlorine is exposed to sunlight, the gases unite to form *phosgene* (Gk., *generated by light*), or *carbonyl chloride* ( $\text{COCl}_2$ ):



It is manufactured by passing CO and  $\text{Cl}_2$  over porous charcoal (catalyst).

Phosgene is a colorless liquid with a low boiling point ( $8^\circ$ ), and its vapor is very poisonous; it was used very extensively during the Great War. When phosgene comes in contact with water it is decomposed:



When it is inspired, therefore, hydrochloric acid is formed in the lungs.

170. *Physiological Action.*—Carbon monoxide is a very poisonous gas; it unites with the hemoglobin of the blood corpuscles to

form **carbonyl-hemoglobin**, a stable compound, which shuts off the supply of oxygen. One vol. of CO to about 800 vols. of air will produce death in about 30 minutes, while 1 vol. in 100,000 vols. of air produces symptoms of poisoning. Birds and mice are more sensitive to its action than is man.

*In cases of carbon monoxide poisoning the administration of oxygen and of artificial respiration should be resorted to at once, and the patient kept warm and quiet.* Addition of 5 per cent of carbon dioxide to the oxygen stimulates the respiratory centers.

**Hopcalite**, a mixture of metallic oxides, is used in gas masks to oxidize CO, serving as a catalyst.

### Summary

**Carbon dioxide** is a product of combustion, decay, and fermentation; it also is formed by heating carbonates (*e.g.*, limestone) and by the interaction of carbonates and acids.

Carbon dioxide is *used* in the production of low temperatures and for the manufacture of soft drinks, soda, etc., and for extinguishing fire.

*Carbon dioxide produces a white precipitate with limewater, which dissolves upon addition of excess gas; and it furnishes food for green plants, cellulose, starch, and sugar being formed with the liberation of oxygen.*

**Carbonic acid** is a weak, unstable compound, its salts being known as *carbonates*.

**Carbon monoxide** is formed when fuel undergoes incomplete combustion and when either formic or oxalic acid is treated with concentrated sulfuric acid. It is a very poisonous gas and is especially dangerous, for it is colorless and practically odorless and tasteless. It has a tendency to unite with oxygen and chlorine, and is therefore an excellent *reducing agent*.

### Exercises

1. Give the formation and preparation and the physical and chemical properties of carbon dioxide. State the principle involved in the production of "carbonic acid snow."
2. How is carbon dioxide produced for use in the manufacture of soft drinks and soda? Explain the great part played by carbon dioxide in nature.