

## Introduction to Chlorine

The chemical element chlorine (Cl) is described as a poisonous, corrosive, greenish-yellow gas that has a sharp odor and is 2.4 times heavier than air. It is highly reactive and easily combines with other elements because it is short one electron in its outer shell. It has a wide variety of industrial, household, and medical uses. For example, when chlorine is combined with hydrogen, hydrogen chloride is formed. If hydrogen chloride is dissolved in water, hydrochloric acid (an important chemical used in the manufacture of metals, foods, plastics, and many other products) is produced.

Approximately 23 billion pounds of chlorine were produced by 18 companies in the United States in 1992. Currently, the largest industrial users of chlorine are companies that manufacture polyvinyl chloride (PVC) resins, chlorinated solvents, chlorofluorocarbons (CFCs), and propylene oxide.<sup>1</sup> In addition, water and wastewater treatment plants use chlorine to kill water-borne pathogens. It is also commonly used as a bleaching agent in the paper, pulp, and textile industries, and many of us are familiar with the use of chlorine to disinfect swimming pool water.

### USES OF CHLORINE

Chlorine and chlorinated compounds are used in 85 percent of all medicines and 96 percent of all crop-protection chemicals, as well as in hospital and food-handling disinfectants and packaging. An automobile as we know it—made using lightweight, high-performance plastics for energy efficiency—could not be built without chlorine chemistry. Chlorine is also used in the manufacture of many familiar products (see box).

Tents	Nylon	Camera film	Car bumpers	Notebook paper
Luggage	Toothpaste	Dry-cleaning agents	Paint remover	Household glue
Shoes	Sleeping bags	Erasers	Soft drink bottles	Compact discs
Detergents	Fire extinguishers	Pen tips	Gelatin	Automobile tires
Newspaper	Coffee filters	Plastic pipes	Paint	Vinyl
Mirrors	Telephones	Bicycle seats	Watch straps	Polyester fabric
Vitamins	Paper and plastic bags	Audiotapes	Computer parts	Circuit boards

<sup>1</sup>Propylene oxide is used mainly as a chemical intermediate in the production of polyurethane foams, coatings, and adhesives. It is also used in the manufacture of fiberglass-reinforced plastics, food, cosmetics, and pharmaceuticals.

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## Introduction to Chlorine

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Chlorine and chlorinated compounds contribute to the U.S. economy with approximately a \$3 billion net trade surplus. Approximately 1.3 million U.S. jobs and some 100,000 Canadian jobs depend on the chlorine industry. Wages and salaries from the chlorine industry total more than \$30 billion a year. Furthermore, almost 40 percent of all U.S. jobs and income depend in some way on chlorine and the products of the chlorine industry. In addition, around 200 industries use chlorine and chlorine-related compounds, generating 45 million jobs and \$1.6 trillion in economic activity.

### **EXPOSURE TO CHLORINE**

The most common means of exposure to chlorine occurs in the workplace (where chlorine compounds are produced or used to manufacture products) or near places where it is released into the air, water, or land. Exposure to chlorine from swimming pool products or home cleaning agents is so negligible that it is not considered to be a major concern by the Environmental Protection Agency. Even if it gets into the body, chlorine doesn't stay there for any appreciable amount of time. Because of its reactivity, elemental chlorine has not been found to move—to any significant extent—through the ground where it could contaminate groundwater supplies.

### **EFFECTS ON HUMAN HEALTH AND THE ENVIRONMENT FROM EXPOSURE TO CHLORINE**

The effects of chlorine on human health and the environment depend on (1) the chemistry of the chlorine compound, (2) the concentration of the chemical, (3) the duration of exposure to the chemical, and (4) the health of a person or the condition of the environment when exposure occurs.

Respiratory distress, coughing, chest pain, burns, and congestion of the lungs are common symptoms of short-term exposure to chlorine gas by inhalation (although most people do not come into contact with chlorine in its gaseous form). Chlorine gas is also known to irritate the skin and the eyes.

Health effects from long-term exposure to small concentrations of chlorine are currently being investigated. One of the major concerns is the possibility that long-term exposure may cause cancer. In laboratory experiments, repeated exposure to chlorine in air demonstrated adverse effects on the immune system, the blood, the heart, and the respiratory system of animals. In 1995, the Chemical Industry Institute of Technology studied the effects of chlorine gas on mice and rats that were exposed to the chemical for 2 years. The study results indicated that long-term exposure did not cause cancer; however, it did result in irritation to the animals' nasal passages.

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## Introduction to Chlorine

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### **FAMILIARIZE YOURSELF WITH THE FOLLOWING TERMS:**

**bioaccumulation**—the accumulation of a chemical in the fatty tissue of an organism

**biomagnification**—the increase in concentration of a chemical in organisms at successively higher levels of a food web

**carcinogen**—any substance capable of producing or inducing cancer

**chlorinated hydrocarbon**—a compound made up of carbon, hydrogen, and chlorine atoms

**disinfection by-product**—a substance formed as a result of the water disinfection process, usually by combining chlorine or bromine and any organic matter that is in the water

**epidemiological data**—data obtained from the study of patterns of disease in a population

**microbial contaminant**—a microscopic organism that can cause a disease

**residue**—what remains at the end of a process

**solvent**—a substance that can dissolve another substance

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