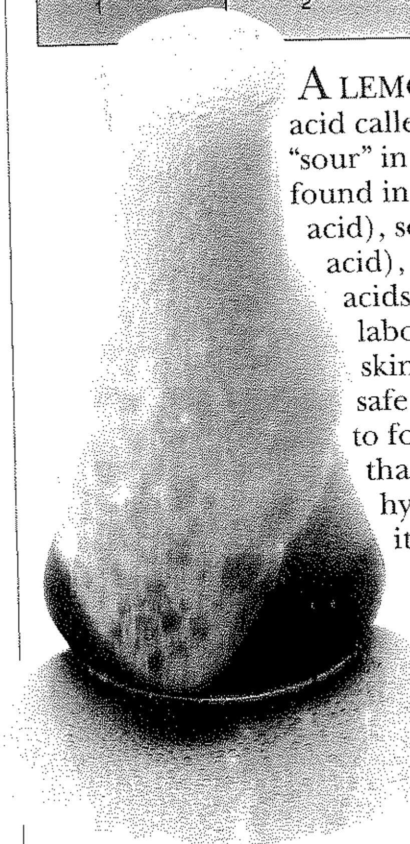
ACIDS

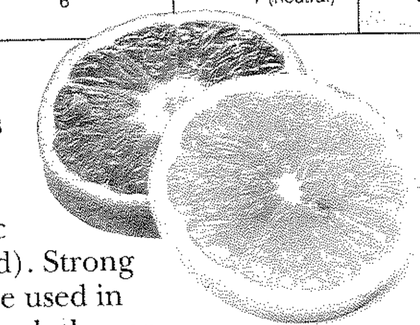
Scientists use the pH scale to describe the strength of acids and alkalis. It runs from 1 to 14. The more hydrogen ions it contains, the stronger it is, and the lower its pH. All acids have a pH of less than 7.

Acid half of the pH scale

1	2	3	4	5	6	7 (neutral)	8

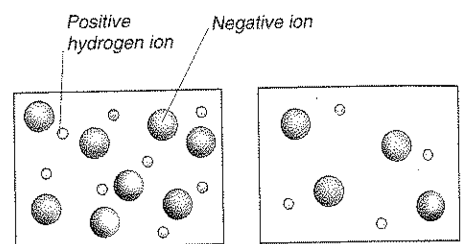


A LEMON TASTES SOUR because it contains an acid called citric acid. In fact, the word acid means "sour" in Latin. Acids are everywhere. They are found in ants (methanoic acid), grapes (tartaric acid), soda (carbonic acid), car batteries (sulfuric acid), and even our stomachs (hydrochloric acid). Strong acids such as sulfuric and nitric acids, which are used in laboratories, are very dangerous and will burn clothes or skin. Some weak acids, such as those found in fruits, are safe to eat. All acids contain hydrogen and dissolve in water to form positively charged hydrogen ions. It is these ions that give acids their special properties. The number of hydrogen ions an acid can form in water is a measure of its strength, known as its pH.



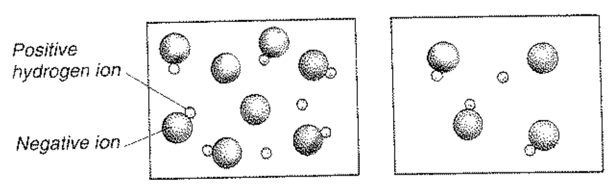
HIGH pH
Citrus fruits such as lemons and oranges contain citric acid. This is a weak acid. It has a fairly high pH, but it is still under 7.

STRONG ACIDS
Some acids, such as nitric acid and sulfuric acid, are strong. Their molecules completely dissociate (split up) into hydrogen and other ions in water. The strength of an acid tells us how many of these split-off hydrogen ions are present in the solution. Just as you dilute orange juice concentrate with water, you can dilute strong acids with water, so there are fewer hydrogen ions in solution. This lowers their acidity (increasing the pH).



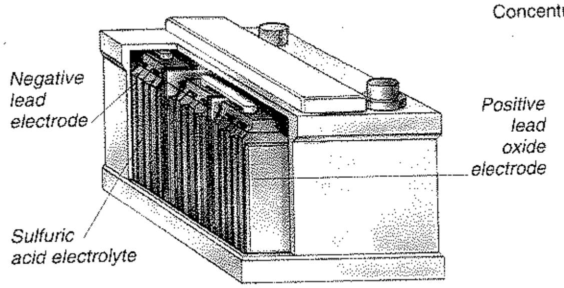
Concentrated strong acid — Dilute strong acid

LOW pH
Acids found in the laboratory, such as sulfuric acid, are strong. They have a low pH. We have a strong acid, hydrochloric acid, in our stomachs to help digest our food. Our stomach lining protects our stomach from the high acidity.

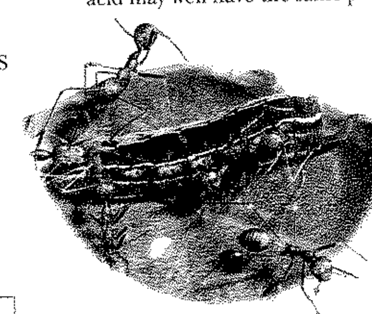


Concentrated weak acid — Dilute weak acid

WEAK ACIDS
Some acids, such as the citric acid found in oranges and lemons, are weak acids. When dissolved in water, only a very small number of their molecules will dissociate to form hydrogen ions. You can make concentrated or dilute solutions of a weak acid by either removing or adding water. A very concentrated solution of a weak acid and a very dilute solution of a strong acid may well have the same pH.

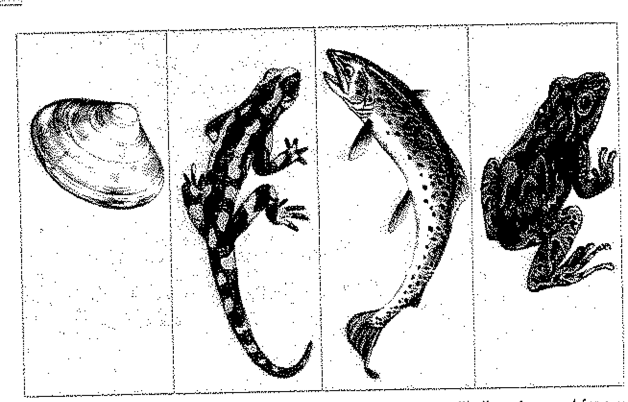


ACID FROM ANTS
An acid called methanoic acid (formic acid) is produced naturally by both stinging ants and stinging nettles. Long ago, people made formic acid by boiling ants in a big pot. Today, it is made from other chemicals. It is used to preserve silage (crops stored for animal fodder) and to make paper and textiles.



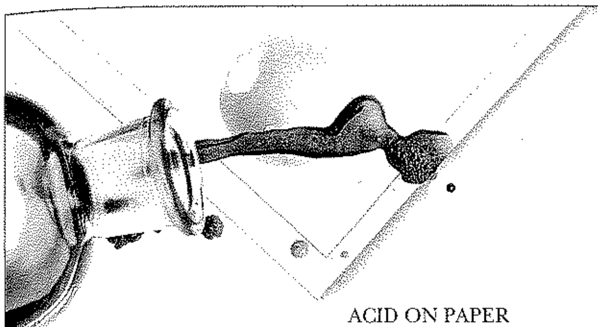
LEAD-ACID BATTERY

Strong acids make good electrolytes (liquids that conduct electricity). This is because in water they are almost completely split up into positive hydrogen ions and negative ions. These electrically charged ions can carry an electric current. Sulfuric acid is used as the electrolyte in the lead-acid batteries found in cars. Lead plates act as the electrodes. These batteries produce the energy to start the car.



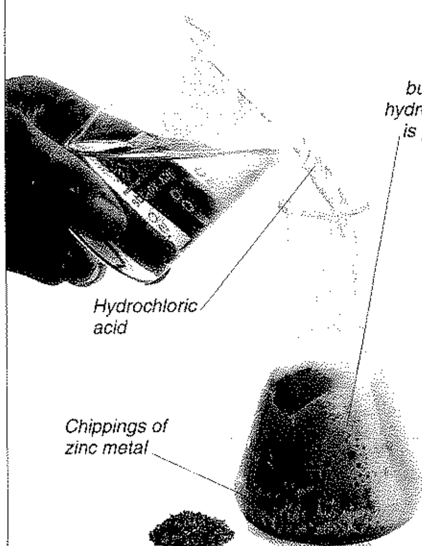
A clam will die if the pH of its water falls below 6. *A salamander will die if the pH of its water falls below 5.* *A brook trout will die if the pH of its water falls below 4.5.* *A wood frog will die if the pH of its water falls below 4.*

ACID WATER
Lakes and rivers can be polluted by acid rain. This increases the acidity, or lowers the pH of the water, so it can be harmful to fish and other aquatic life. Some animals are more sensitive to these pH changes than others. A clam, for example, cannot survive if the pH of its water falls below 6. Wood frogs, on the other hand, can survive in water with a pH as low as 4.



ACID ON PAPER

Concentrated sulfuric acid is very corrosive. It acts as a dehydrating agent, which means that it removes water from any substance it comes into contact with. Paper is made from cellulose, a plant material that contains carbon, hydrogen, and oxygen. When sulfuric acid reacts with paper, it removes the water (hydrogen and oxygen) and leaves the black carbon behind. This is why the paper looks burned.



A furious bubbling of hydrogen gas is given off.

Hydrochloric acid

Chippings of zinc metal

ACID ON METAL

Vinegar should never be stored in a metal bottle. It can create a slight fizzing of hydrogen gas. The hydrogen that all acids contain can be driven off when the acid meets a reactive metal. This is why acids are never kept in metal containers. When hydrochloric acid is poured on zinc (above), there is a fizzing of hydrogen gas. The zinc replaces the hydrogen in the acid to form zinc chloride.

The cork flies out of the bottle. It is pushed by the carbon dioxide gas created during the chemical reaction between the vinegar and baking soda.

Vinegar mixed with baking soda

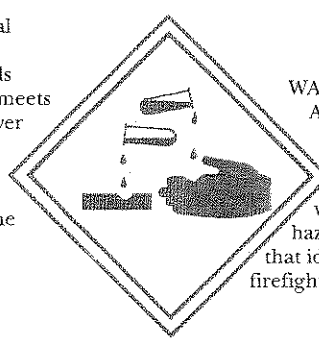
A compound called sodium ethanoate is left behind in the bottle. This is a salt.

YELLOWING PAGES

Have you noticed that the pages in new books look very white, while those in older books have turned yellow? Paper contains tiny amounts of an acid. Over years and years, this acid very slowly starts to break down the cellulose fibers in the paper. This changes the color of the paper from white to yellow. The reaction is speeded up by sunlight, and the paper may turn brown and become brittle.

Acid on carbonate

If you add vinegar (ethanoic or acetic acid) to bicarbonate of soda (sodium hydrogen carbonate) in a corked bottle, a fizzy chemical reaction occurs. The acid breaks down the carbonate to make carbon dioxide gas. So much gas is produced that it fills up the bottle, forcing the cork out like a cannonball. Acids will always break down carbonates to form carbon dioxide. This reaction is used in cooking. Baking powder is a mixture of cream of tartar (a form of tartaric acid) and bicarbonate of soda. In water, they make carbon dioxide, which is the gas that makes cakes rise.



WARNING SYMBOL

Although acids often look like water, strong acids are corrosive and cause severe burns. To prevent this from happening, the containers in which acids are transported carry a hazard warning sign. This has a code that identifies the acid and tells firefighters how to deal with a spillage.

PICKLING

Since acids are dangerous to living things, they can be used as preservatives to kill bacteria. Many foods, such as onions and cucumbers, are preserved by soaking in vinegar (ethanoic acid). This process is called pickling. The acid kills any microorganisms and stops the food from going bad. Pickling was widely used before the invention of refrigerators.

ACID DISCOVERIES

11th century Arabic chemists find out how to make sulfuric, nitric, and hydrochloric acids.

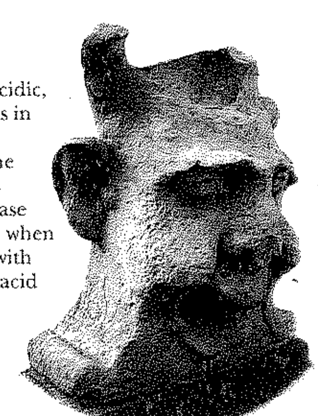
1675 Irish chemist Robert Boyle wrongly suggests that acids contain special particles that squeeze into gaps in metals, breaking them apart.

1854 The writing of French chemist Auguste Laurent proves that all acids contain hydrogen.

1887 Swedish chemist Svante Arrhenius proposes that all acids contain hydrogen ions and these give acids their special properties.

ACID IN RAIN

Rainwater has always been slightly acidic, as carbon dioxide in the air dissolves in rain to form carbonic acid. But the acidity of rain has increased since the world became industrialized. This is because fossil fuels such as coal release sulfur dioxide and nitrogen dioxide when they are burned. These gases react with the water in clouds to form sulfuric acid and nitric acid. Acid rain threatens many buildings, especially those made of limestone (calcium carbonate). This is because acids easily break down carbonates into carbon dioxide gas.



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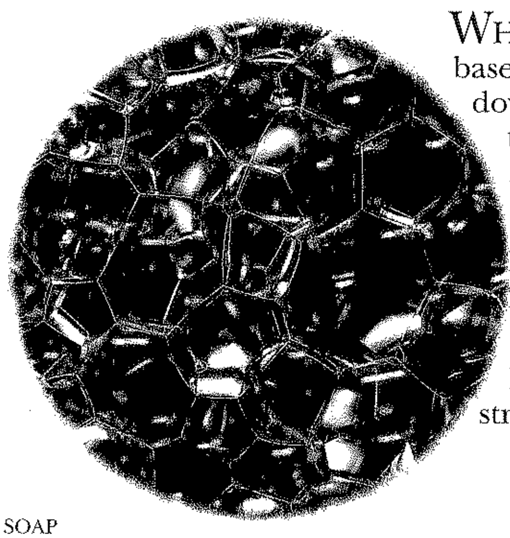
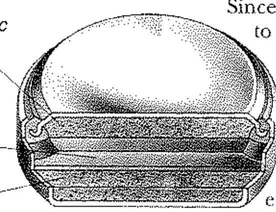
ALKALIS AND BASES



WHEN YOU BRUSH YOUR TEETH with toothpaste, you are using a base to get rid of the acids that form in your mouth when foods break down. Bases are substances that can cancel out acidity. They are said to neutralize acids. Alkalis are bases that can dissolve in water. Bases and alkalis are all around us – in oven cleaners, polish, baking powder, indigestion tablets, common plants, saliva, and chalk. Like acids, some alkalis are very dangerous and can cause burns if splashed onto the skin. All alkalis dissolve in water to form hydroxide ions (OH^-). These ions react with the hydrogen ions (H^+) in acids to cancel out acidity. The number of hydroxide ions an alkali can make in water is a measure of its strength. This is measured on the pH scale.

SOAP
Alkalis feel soapy when rubbed between the fingers. This is because they react with the oils in our skin and start to dissolve them. Soap is made by boiling animal fats or vegetable oils with the strong alkali sodium hydroxide.

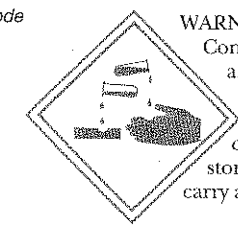
ALKALI FROM ASHES
The word alkali is Arabic and means the "ashes of a plant." Alkalis used to be made by burning wood and other plants – sodium carbonate from sea plants and potassium carbonate from land plants. Alkalis are now made by electrolysis.



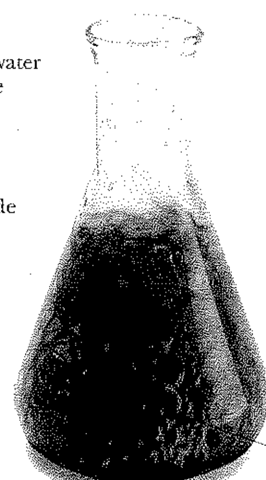
This is a type of alkaline battery you might find in a watch or a calculator.

ALKALI CONDUCTORS
Since alkalis break up in water to form ions, alkalis are good conductors of electricity. In an alkaline battery, the strong alkali potassium hydroxide is used to conduct electricity between two electrodes.

ALKALIS IN SPACE
Astronauts in the Apollo space missions used the alkali lithium hydroxide to neutralize the dangerous levels of carbon dioxide gas they were breathing out. This type of neutralization is also used to remove carbon dioxide from air-conditioned buildings.



WARNING SYMBOL
Concentrated solutions of alkali are corrosive and can cause severe burns. Because of this, the containers in which they are stored and transported always carry a hazard warning sign.

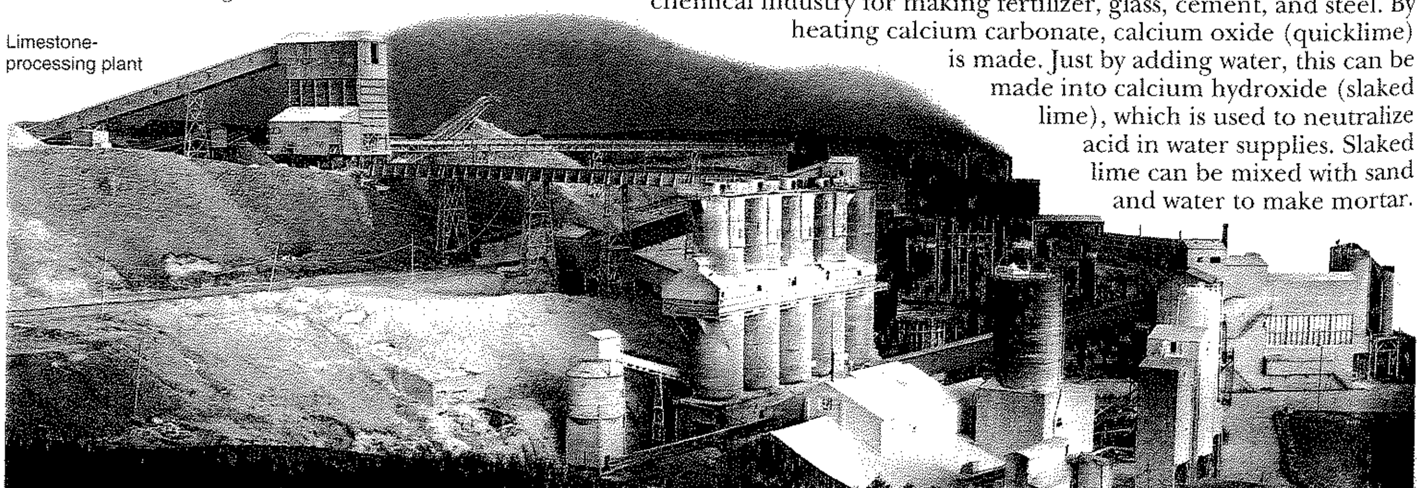


Sodium hydroxide mixed with magnesium pieces

ALKALI ON METAL
When a solution of sodium hydroxide is poured onto some pieces of magnesium metal, there is a tremendous fizzing. This is hydrogen gas that has formed during the reaction. Magnesium hydroxide is left in the flask. This is the active ingredient in milk of magnesia, which people take to cure indigestion – it works by neutralizing excess acid in the stomach.

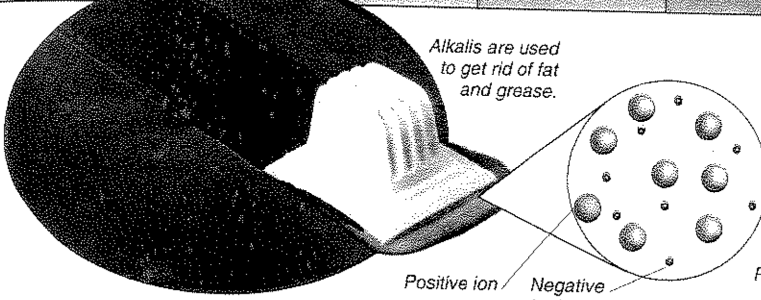
CALCIUM CARBONATE

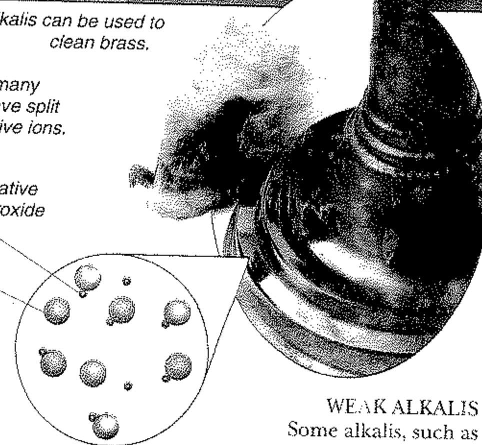
Seashells, coral, chalk, limestone, and marble are all made of the base calcium carbonate. It is a very important and useful compound in the chemical industry for making fertilizer, glass, cement, and steel. By heating calcium carbonate, calcium oxide (quicklime) is made. Just by adding water, this can be made into calcium hydroxide (slaked lime), which is used to neutralize acid in water supplies. Slaked lime can be mixed with sand and water to make mortar.



Limestone-processing plant

The more hydroxide ions an alkali contains, the stronger it is, and the higher its pH. All alkalis have a pH greater than 7.





STRONG ALKALIS

Some alkalis, such as sodium hydroxide and potassium hydroxide, are called strong alkalis. When they dissolve in water, all their molecules dissociate (split up) into ions. This means they contain many hydroxide ions, and so have a high pH. Oven cleaners, for example, contain the strong, corrosive alkali sodium hydroxide. This reacts with the burned, fatty deposits that form on the oven walls during cooking.

WEAK ALKALIS

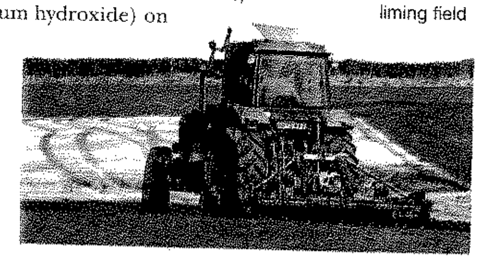
Some alkalis, such as ammonium hydroxide and bicarbonate of soda (sodium hydrogen carbonate), are weak alkalis. In solution, only a few molecules dissociate into ions. They therefore contain only a few hydroxide ions, which gives them a low pH. Brass cleaner is a weak alkaline solution. It works by breaking down the oxide layer that forms on the surface of the brass when brass is left exposed to the air.

A bee sting is very painful as it contains an acid. This can be neutralized by adding an alkali.

Close-up view of the sting of a bee

LIMING FIELDS AND LAKES

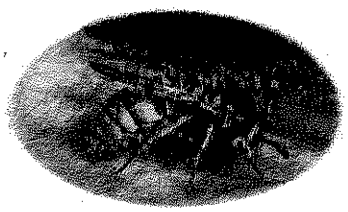
Acid rain increases the acidity of the lakes and soils on which it falls. This takes out essential nutrients from the soil. To fix this, farmers spread powdered lime (calcium hydroxide) on their fields. The lime is a base which neutralizes the acidity. Lime can also be added to lakes, to reduce acidity. Adding lime to lakes and fields can relieve the damage caused by acid rain, but it does not stop the cause of the pollution.



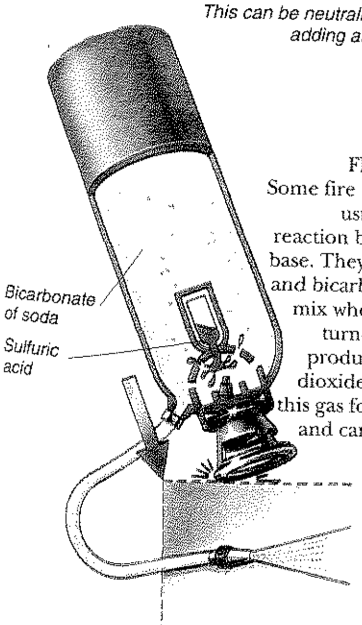
Farmer liming field

Neutralization

Every time a base meets an acid, neutralization occurs, and water and a compound called a salt are produced. This reaction can be used to treat some animal and plant stings. If you are stung by a wasp's basic sting, you can neutralize it with an acid such as lemon juice or vinegar. If you are stung by a bee or an ant, you can neutralize the acid sting with an alkali such as bicarbonate of soda. Nettles also give acidic stings, which can be treated by rubbing with a leaf of a dock plant, which contains an alkali.



A wasp sting is very painful, because it contains an alkali. This can be neutralized by adding an acid.



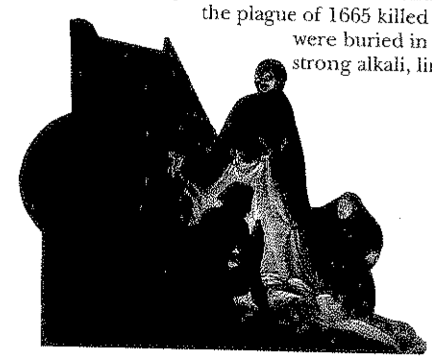
The fizzy reaction between the acid and the alkali forces out a foam, which can be used to put out fires.

FIRE EXTINGUISHER

Some fire extinguishers work by using the neutralization reaction between an acid and a base. They contain sulfuric acid and bicarbonate of soda, which mix when the extinguisher is turned upside down. This produces water and carbon dioxide gas. The pressure of this gas forces a foam of liquid and carbon dioxide bubbles out of the nozzle.

ALKALI IN THE PLAGUE

Seventeenth-century London, England was an unhealthy place to live in and was continually ravaged by plague – the plague of 1665 killed 80,000 people. The bodies were buried in mass graves covered with a strong alkali, lime, to speed up the rate of decomposition (rotting).



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