

Compounds are classified in different ways.

A pigment is a chemical that absorbs some frequencies of light and reflects others, changing the colour of light an object reflects. The blue pigment in blue jeans is made from a chemical called phthalocyanine, a covalent compound that contains many carbon atoms. As well as dyeing cloth, pigments are also used to colour paint, food, cosmetics, and plastic. Pure pigments reflect light in a very specific way. Some pigments change colour depending on the mixture to which they are added.

What You Will Learn

In this chapter, you will

- **distinguish** among acids, bases, and salts by examining their chemical formulas and properties
- **explain** the significance and uses of the pH scale, with reference to common substances
- **write** names and formulas of acids, bases, and simple organic compounds
- **examine** chemical reactions that involve acids, bases, and organic compounds
- **describe** organic compounds

Why It Is Important

You encounter acids, bases, and salts in your everyday life. You also encounter organic compounds, which make up more than half of all known chemical compounds. Understanding organic chemistry helps us to understand the world around us and the processes that occur within us as well.

Skills You Will Use

In this chapter, you will

- **predict** whether materials are acidic, basic, or neutral
- **measure** the pH of solutions
- **model** the bonding in organic molecules
- **classify** a compound as organic or inorganic from its name, formula, a diagram, or a model

Make the following Foldable. Use it to record notes about what you learn in Chapter 5.

STEP 1 Take two sheets of notebook or 22 cm by 28 cm paper and **fold** them in half.



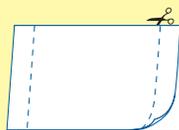
STEP 2 Use a pencil to **mark** each fold 2.5 cm in from the left and right edges.



STEP 3 On one of the folded sheets, **cut** the top edge of the fold in to the marks or margins.



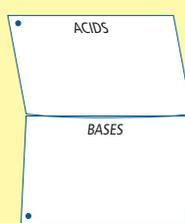
STEP 4 On the other folded sheet, start at one of the marked spots and **cut** the fold in between the two marks or margins, creating a slit in the centre of the fold.



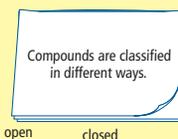
STEP 5 Take the cut sheet from Step 3, **roll** it into a tube, and **insert** it through the other sheet and then open. **Fold** the bound pages in half to form a six-page book.



STEP 6 **Label** the exterior with the chapter title.



Label each of the six pages with the following titles: Acids, Bases, Salts, Organic, Inorganic, and Vocabulary.



As you progress through the chapter, **record** information, write formulas, and define key terms on the appropriate pages.

5.1 Acids and Bases

Many common pure substances can be classified according to whether they are acids or bases. Some acids and bases are corrosive and poisonous, whereas others add flavour to food or are vitamins. Acid-base indicators are chemicals that change colour in response to acidic or basic conditions. The pH scale is a number scale for measuring how acidic or basic a solution is. A pH value below pH 7 is acidic, pH 7 is neutral, and a pH value above pH 7 is basic. Generally, the chemical formula for an acid starts with H (hydrogen) on the left of the formula. Bases generally have OH on the right of their chemical formulas.

Words to Know

acids
bases
bromothymol blue
concentration
indigo carmine
litmus paper
methyl orange
pH indicators
phenolphthalein

Did You Know?

The whip scorpion is also known as the vinegaroon because it smells like vinegar. In self-defence, the whip scorpion sprays a combination of concentrated acetic acid and caprylic acid from glands near the rear of its abdomen.



You have learned that one way to classify compounds is to determine whether they have ionic bonds or covalent bonds. There are other ways you can use to classify compounds. For example, you can classify some compounds as acids or bases.

You are very familiar with acids and bases because you see them, use them, and even eat them every day. The sour taste of grapefruit, the tart taste of carbonated drinks, and the tangy taste of salad dressings all come from acids. We add acidic juices to our foods to improve taste as well as to help absorb nutrients. For example, lemon juice contains ascorbic acid, which is another name for vitamin C, which may help our bodies absorb iron. Very strong acid in your stomach (Figure 5.1) helps digest what you eat. Acids dissolved in rainwater can form enormous caverns and destroy valuable buildings and statues over time. Because of their corrosive properties, we use some acids to remove rust and to purify and process metals.



Figure 5.1 The pits in the lining of your stomach secrete hydrochloric acid (HCl) to break down the food you eat. The surface cells on your stomach lining secrete mucus to protect your stomach from the acid.

Bases are bitter-tasting compounds with a slippery feel. Many cleaning products, such as soap and oven cleaner, are bases. Some medical drugs, such as lidocaine, a local anesthetic used by dentists, are bases. Eggs and baking soda are two examples of bases that are found in foods we eat.

Acids and bases have useful properties, but they should be handled with care. Some acids and bases are **corrosive**, which means they can burn your throat or stomach if swallowed and will burn your skin or eyes on contact. You should never attempt to identify an acid or a base, or any substance in the laboratory by its taste or feel.

The **pH scale** is a number scale for measuring how acidic or basic a solution is. One simple definition of **acids** is that they are chemical compounds that produce a solution with a pH of less than 7 when they dissolve in water. **Bases** are compounds that produce a solution of pH of more than 7 when they dissolve in water. If a solution has a pH of 7, it is said to be **neutral** (neither acidic nor basic). Notice that the “p” in pH is always lower case, and the “H” is always upper case. pH values do not have a unit of measurement written after the number.

5-1A Acidic, Basic, or Neutral?

Find Out ACTIVITY

In this activity, you will use pH paper or universal indicator to determine whether common liquids are acidic, basic, or neutral.

Safety



- Follow your teacher’s recommendations for which fluids to bring to class and how to transport them safely.
- Never taste or eat anything in the science room.
- Wash your hands and equipment thoroughly after completing this activity.

Materials

- a variety of common liquids that you bring in from home or that are provided by your teacher, such as shampoo, detergent, juice, tonic water, bottled water
- spot plate
- pH paper or universal indicator
- indicator colour chart provided by your teacher

What to Do

1. Read this entire activity. Then, create a data table with several columns to record your results. Give your table a title.
2. Predict whether each of the test liquids is acidic, basic, or neutral.

3. Place a small amount of each liquid in a well of the spot plate, keeping track of where each is placed. Take care not to mix any of the substances.
4. Place a few drops of acid-base indicator or a piece of pH paper in each spot plate well that contains a test liquid.
5. Use the indicator colour chart to determine the pH of each liquid.
6. Create a pH number scale to display your results. Draw a horizontal line across a piece of paper. On the middle of the line, write 7 (neutral). On the left end, write a 0. On the right end, write a 14. Enter the name and pH of each liquid in the appropriate position on your number scale.
7. Clean up and put away the equipment you have used. Follow your teacher’s instructions for disposal of wastes.

What Did You Find Out?

1. (a) Which liquids were acidic?
(b) How do you know?
2. (a) Which liquids were basic?
(b) How do you know?
3. (a) Which liquids were neutral?
(b) How do you know?

internet connect

The Richter scale of earthquake intensity and the decibel scale of sound intensity are other number scales in which a one unit change represents a much larger change. You can find out more about number scales. Start your search at www.bcsience10.ca.

pH Values of Common Substances

You can see the pH values of some common substances in Figure 5.2. Notice that the more acidic a substance is, the lower the pH is. For example, a solution of lemon juice, with a pH of about 2, has a greater acidity than a solution of tomato juice, which has a pH of about 4.

Substances that have a pH greater than 7 are said to be basic, or alkaline. You may recognize the term alkaline from the family of metals called the alkaline earth metals (group 2 on the periodic table), which includes calcium and magnesium. These metals are not basic by themselves, but they react with water to produce basic solutions. For solutions containing bases, the greater the pH, the more basic or alkaline the solution is. For example, an oven cleaner with a pH of 13 is more basic than a soap that has a pH of 10.

Substances that are neither basic nor acidic are neutral. Pure water is neutral and has a pH of 7. Human saliva is close to neutral, ranging from a pH of 6.5 to a pH of 7.4. Human blood is slightly basic with a pH of 7.3 to 7.5.

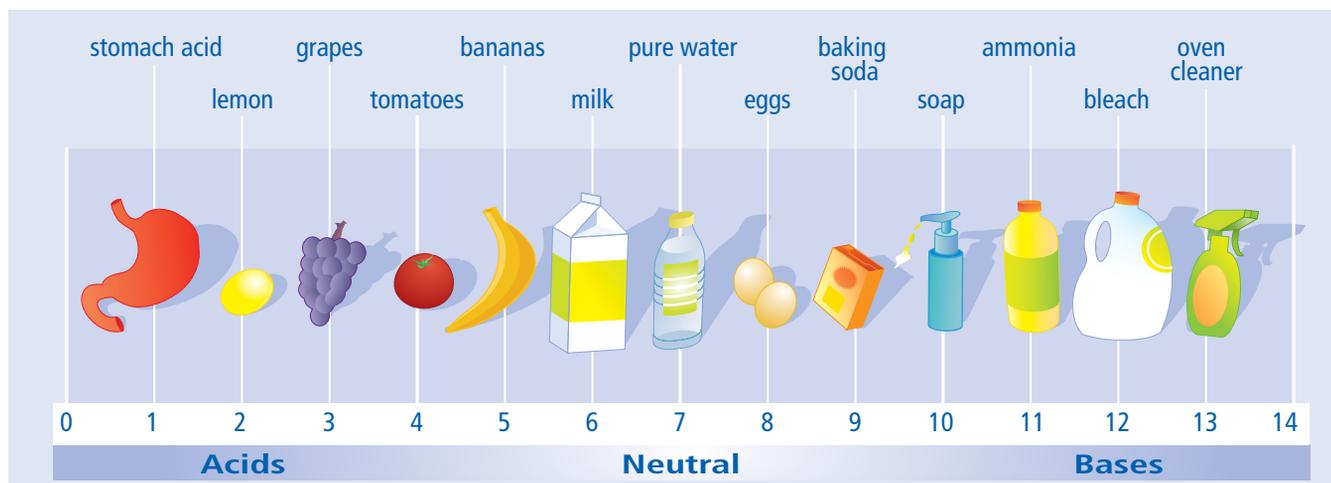


Figure 5.2 pH values of common substances

Using the pH Scale

The pH scale allows chemists to express a wide range of measurements using a small and easily understood range of numbers. On the pH scale, one unit of change represents a 10 times change in the degree of acidity or basicity.

What is the increase in acidity if the pH drops from pH 6 to pH 4? A two unit drop in pH is a 10^2 or 100 times increase in acidity. For example, normal precipitation has a pH of about 6 and acid precipitation has a pH of about 4. This means the acidity levels are increased by 100 times or more in acid precipitation as compared with normal precipitation. A delicate balance between acids and bases is vital for organisms to survive. Even a small increase in acidity harms coral reefs and organisms that require a specific pH level to use calcium to make their shells.

pH Indicators

Many common acids and bases form colourless solutions. These solutions look just like water but may be hazardous. One safe way to tell whether a solution is acidic or basic is to use a pH indicator. **pH indicators** are chemicals that change colour depending on the pH of the solution they are placed in.

One common pigment used as an indicator is litmus, a compound that is extracted from various lichens. Litmus is especially useful when dried onto thin paper strips called **litmus paper**. You can use litmus paper to determine whether a solution is acidic or basic (Figure 5.3). Litmus paper comes in two forms, red and blue. When blue litmus is placed in a solution that is acidic (below pH 7), the blue litmus paper turns red. When red litmus paper is placed into a solution that is basic (above pH 7), the red litmus paper changes to blue. You can use both red litmus paper and blue litmus paper to tell if a solution is neutral (pH 7). In a neutral solution, blue litmus stays blue and red litmus stays red.

Universal indicator (Figure 5.4A and B) contains a number of indicators that turn different colours depending on the pH of the solution. A digital pH meter or pH computer probe (Figure 5.4C) measures an electrical property of the solution and uses this to determine the pH.



Figure 5.3 Litmus is red in acids and blue in bases.

Word Connect

You can remember the colour changes of litmus with the following memory device.
BAR = Blue + Acid → Red



Figure 5.4 Universal indicator can be prepared as a liquid and then dropped into a test sample (A), or it can be dried onto paper called pH paper (B). The sensor is measuring the pH of a solution (C).



Figure 5.5 Phenolphthalein indicator in an acidic solution (left) and in a highly basic solution (right).

Other pH indicators

Not all pH or acid-base indicators change colour at pH 7 like litmus does. For example, **phenolphthalein** is a colourless chemical compound in acidic or slightly basic solutions but turns pink in moderately basic to highly basic solutions (Figure 5.5).

There are many other acid-base indicators that you can use. Some acid-base indicators, such as **bromothymol blue**, **indigo carmine**, **methyl orange**, and **methyl red** are named after their colour changes. For example, the pH at which methyl orange changes from red to yellow occurs over the pH range of 3.2 to 4.4. In this range, the methyl orange is mixture of both red and yellow, which makes this colour change orange. Table 5.1 and Figure 5.6 show the colour change of several acid-base indicators.

Table 5.1 Acid-Base Indicators

| Acid-base indicator | pH Range in Which Colour Change Occurs | Colour Change as pH Increases |
|---------------------|--|-------------------------------|
| Methyl orange | 3.2–4.4 | red to yellow |
| Methyl red | 4.8–6.0 | red to yellow |
| Bromothymol blue | 6.0–7.6 | yellow to blue |
| Litmus | 7.0 | red to blue |
| Phenolphthalein | 8.2–10.0 | colourless to pink |
| Indigo carmine | 11.2–13.0 | blue to yellow |

Did You Know?

Natural sources for acid-base indicators include the following.

- beets
- blueberries
- cherries
- curry powder
- grapes
- pansy petals
- poppy petals
- red cabbage
- rose petals
- strawberries
- tulip petals
- violet petals

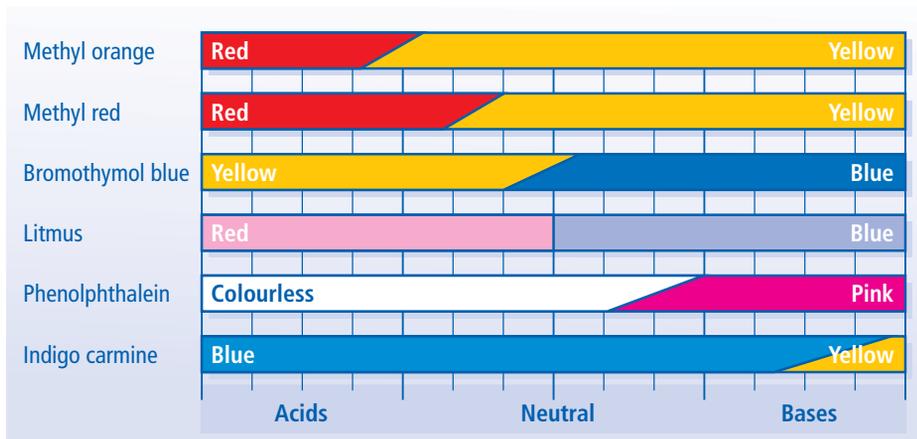


Figure 5.6 Common acid-base indicators and their pH colour change

Reading Check

1. What is the pH scale?
2. Above what pH level is a solution said to be basic or alkaline?
3. When the pH rises from 10 to 12, how many times more basic has the solution become?
4. What colour is litmus paper in an acidic solution?
5. What colour is bromothymol blue at the following pH levels?
 - (a) pH 5
 - (b) pH 7
 - (c) pH 9

Acids

You can sometimes identify acids by their chemical formulas. Many compounds, such as HCl, take on acid properties only when mixed with water. For this reason, acids are often indicated as being dissolved in water when the formula is written. For example, HCl dissolved in water is written as HCl(aq) where the (aq) refers to aqueous, or “dissolved in water to make a solution.”

The chemical formulas for acids are usually written with an H on the left side of the formula, such as HCl(aq). For acids containing the element carbon, the H may be written on the right side, such as with acetic acid or vinegar, CH₃COOH(aq).

Acids can be named in several ways. If no state of matter is given, the name may be given beginning with hydrogen, as in hydrogen chloride (HCl). If the acid is shown as being aqueous, as in HCl(aq), a different name may be used that ends in “-ic acid” as in hydrochloric acid.

Table 5.2 shows the formulas, names, and uses of some common, important acids. All four of these acids are extremely corrosive. Highly corrosive acids can eat into or wear away a variety of materials, such as metals and human tissue. Figure 5.7 shows an application for a highly corrosive acid.



Figure 5.7 The sulfuric acid in this battery has a pH of 1.2, which means it is extremely corrosive.

Table 5.2 Some Common Acids

| Formula | Chemical Name | Common Name | Examples of Uses |
|-------------------------------------|-------------------|---------------|---|
| HCl(aq) | hydrochloric acid | muriatic acid | <ul style="list-style-type: none">• Produced in the stomach to help digest food |
| H ₂ SO ₄ (aq) | sulfuric acid | battery acid | <ul style="list-style-type: none">• Used in automobile batteries• Used to clean metals |
| HNO ₃ (aq) | nitric acid | nitric acid | <ul style="list-style-type: none">• Used to make fertilizers |
| CH ₃ COOH(aq) | ethanoic acid | acetic acid | <ul style="list-style-type: none">• Present in vinegar |

Names of acids

There are many, many different types of acids. Some acids, such as those in Table 5.3, do not contain oxygen. Other acids, such as those shown in Table 5.4, do contain oxygen. There is a basic pattern when oxygen is present in the formula. Names that begin with hydrogen and end with the suffix **-ate** can be changed by dropping “hydrogen” from the name and changing the suffix to **-ic acid**. For example:

H_2CO_3 —hydrogen carbonate

$\text{H}_2\text{CO}_3(\text{aq})$ —**carbonic acid**

When the name begins with hydrogen and ends with the suffix **-ite**, then the name can be changed to end with the suffix **-ous acid**. For example:

H_2SO_3 —hydrogen sulfite

$\text{H}_2\text{SO}_3(\text{aq})$ —**sulfurous acid**

Table 5.3 Some Non-Oxygen Acids

| Formula | Chemical Name | Formula in Solution | Formula Name Can Be Changed to | Examples of Uses |
|---------|-------------------|---------------------|--------------------------------|---|
| HF | hydrogen fluoride | HF(aq) | hydrofluoric acid | • Manufacturing aluminum and uranium |
| HCl | hydrogen chloride | HCl(aq) | hydrochloric acid | • Producing plastic |
| HBr | hydrogen bromide | HBr(aq) | hydrobromic acid | • Extracting metal ore |
| HI | hydrogen iodide | HI(aq) | hydriodic acid | • Taking part in chemical reactions to make other compounds |

Did You Know?

Vitamin C is the common name for ascorbic acid, which is essential for healthy gums, skin, and muscles. Most animals can produce ascorbic acid in their bodies, but humans cannot. We must obtain vitamin C in our diet.

Table 5.4 Some Acids Containing Oxygen

| Formula | Chemical Name | Formula in Solution | Formula Name Can Be Changed to | Examples of Uses |
|-----------------|-----------------------|----------------------------|--------------------------------|---|
| HClO_4 | hydrogen perchlorate | $\text{HClO}_4(\text{aq})$ | perchloric acid | • Manufacturing explosives and speeding up chemical reactions |
| HClO_3 | hydrogen chlorate | $\text{HClO}_3(\text{aq})$ | chloric acid | • Air pollution control |
| HClO_2 | hydrogen chlorite | $\text{HClO}_2(\text{aq})$ | chlorous acid | • Disinfectant |
| HClO | hydrogen hypochlorite | HClO(aq) | hypochlorous acid | • Treating water in swimming pools |

Reading Check

1. How can you recognize an acid by its chemical formula?
2. State which acid is present in:
(a) your stomach; (b) vinegar; (c) automobile batteries
3. State another name for aqueous hydrogen fluoride, $\text{HF}(\text{aq})$.
4. State another name for aqueous hydrogen perchlorate, $\text{HClO}_4(\text{aq})$.
5. What does corrosive mean?

Bases

You can identify bases by their chemical formulas since they are usually written with an OH on the right side of the formula. Common bases are shown in Figure 5.8 and listed in Table 5.5. Some of these bases are much stronger than other bases. For example, the magnesium hydroxide found in an antacid is gentle enough to be taken internally in the correct dose. However, the sodium hydroxide found in a drain cleaner is extremely reactive with human skin and tissues. Solutions made from highly reactive bases, such as drain cleaner and oven cleaner, are called **caustic**. You should be familiar with the safety hazard symbols shown in Figure 5.9.

Figure 5.8 All of these common household bases have warnings on their labels for their handling and use. Never mix household chemicals without first checking the warning labels on the containers. Some combinations can be hazardous.



Figure 5.9 Symbols used on Canadian products to indicate corrosive material

Table 5.5 Some Common Bases

| Formula | Chemical Name | Common Name | Examples of Uses |
|--------------------------|---------------------|-------------------|---|
| NaOH | sodium hydroxide | caustic soda, lye | <ul style="list-style-type: none">• Drain and oven cleaner• Used to manufacture paper, glass, and soap |
| $\text{Mg}(\text{OH})_2$ | magnesium hydroxide | milk of magnesia | <ul style="list-style-type: none">• Active ingredient in some antacids |
| $\text{Ca}(\text{OH})_2$ | calcium hydroxide | hydrated lime | <ul style="list-style-type: none">• Soil and water treatment |
| NH_4OH | ammonium hydroxide | household ammonia | <ul style="list-style-type: none">• Kitchen cleaner• Used to make fertilizer |

Reading Check

1. How can you recognize a base by its formula?
2. State which base is present in:
 - (a) milk of magnesia
 - (b) drain cleaner
 - (c) household ammonia
3. Give an example of a highly reactive base.
4. What is another term used to describe highly reactive bases?

Word Connect

You could think of “pH” as standing for the “power of the hydrogen ion.” Power refers to the number of ions dissolved in a solution. For example, 1 L of a solution with a pH of 1 will contain 1 000 000 or 10^6 times more $H^+(aq)$ than 1 L of a solution with a pH of 7.

Did You Know?

The sting you feel from an ant bite or a bee sting comes from formic acid, which dissolves the ends of the nerves in your skin. When you use a cream containing ammonia, which is a base, to neutralize the acid, you change the acid's properties so it cannot do more damage to the nerve.

Production of Ions

A solution that is either acidic or basic can conduct electricity because it contains freely moving ions. Acids produce **hydrogen ions** (H^+) when dissolved in solution. Bases produce **hydroxide ions** (OH^-) when dissolved in solution. Testing the pH of a solution is a way of measuring its concentration of hydrogen ions, $H^+(aq)$. **Concentration** of hydrogen ions refers to the number of hydrogen ions in a specific volume of solution. Solutions with a high concentration of hydrogen ions are highly acidic (low pH). Similarly, solutions with a high concentration of hydroxide ions are highly basic (high pH). Because H^+ ions and OH^- ions readily react with each other, a solution cannot have a high H^+ concentration and a high OH^- concentration at the same time (Figure 5.10). For this reason, acids and bases are considered to be chemical opposites.

When separate solutions containing H^+ ions and OH^- ions are combined, they react by forming water.



When an acidic solution is mixed with a basic solution, the solutions can *neutralize* each other, which means that the acidic and basic properties are in balance. In many cases (but with some important exceptions), this reaction produces a neutral solution.

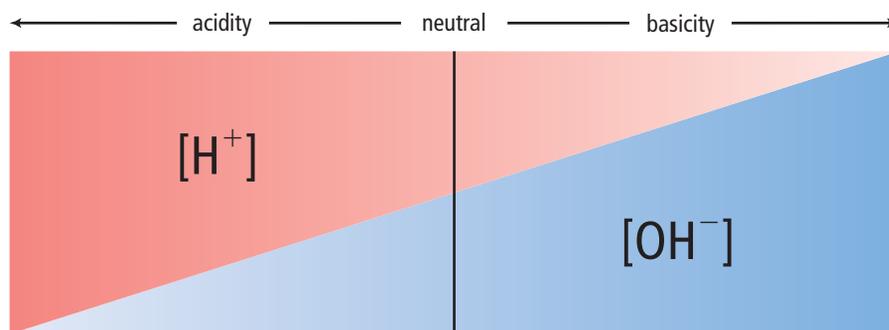


Figure 5.10 Notice how H^+ and OH^- change simultaneously. As H^+ decreases to the right, OH^- increases.

Mining operations in British Columbia result in large volumes of rock being ground up and processed. After the valuable minerals have been removed, the remaining ground rock, called tailings, is usually deposited in a tailings pond (Figure 5.11). Sometimes the tailings release acids, which lower the pH of the water in the pond and affect the surrounding environment. One way to combat this problem is to add a base to the pond to raise the pH to normal levels.



Figure 5.11 A tailings pond

Properties of Acids and Bases

Acids and bases have a number of properties in common and several very important differences, which are summarized in Table 5.6.

Table 5.6 Properties of Acids and Bases

| Property | Acid | Base |
|---|---|--|
| Taste CAUTION: Never taste chemicals in the laboratory. | <ul style="list-style-type: none"> Acids taste sour. Lemons, limes, and vinegar are common examples. | <ul style="list-style-type: none"> Bases taste bitter. The quinine in tonic water is one example. |
| Touch CAUTION: Never touch chemicals in the laboratory with your bare skin. | <ul style="list-style-type: none"> Many acids will burn your skin. Sulfuric acid (battery acid) is one example. | <ul style="list-style-type: none"> Bases feel slippery. Many bases will burn your skin. Sodium hydroxide (lye) is one example. |
| Indicator tests | <ul style="list-style-type: none"> Acids turn blue litmus paper red. Phenolphthalein is colourless in an acidic solution. | <ul style="list-style-type: none"> Bases turn red litmus blue. Phenolphthalein is colourless in slightly basic solutions and pink in moderate to strongly basic solutions. |
| Reaction with some metals, such as magnesium or zinc | <ul style="list-style-type: none"> Acids corrode metals. | <ul style="list-style-type: none"> No reaction |
| Electrical conductivity | <ul style="list-style-type: none"> Conductive | <ul style="list-style-type: none"> Conductive |
| pH | <ul style="list-style-type: none"> Less than 7 | <ul style="list-style-type: none"> More than 7 |
| Production of ions | <ul style="list-style-type: none"> Acids form hydrogen (H^+) ions when dissolved in solution. | <ul style="list-style-type: none"> Bases form hydroxide (OH^-) ions when dissolved in solution. |

Suggested Activity

Conduct an Investigation 5-1B on page 230

Explore More

Your muscles may feel sore after a heavy workout due to the build-up of lactic acid. Find out why your body produces lactic acid and why cooling down after exercise helps prevent a build-up of lactic acid. Begin your research at www.bccscience10.ca.

5-1B Properties of Acids and Bases

SkillCheck

- Observing
- Predicting
- Classifying
- Communicating

Safety



- Wear safety goggles and protective clothing.
- Handle chemicals safely.
- Some of the indicators are also stains. Keep them off clothing.
- Do not remove any materials from the science room.
- Wash your hands and equipment thoroughly after completing this activity.

Materials

- 4 × 6 spot plate
- masking tape
- Solutions A, B, C, and D (CAUTION: Some of the solutions are corrosive.)
- 4 pieces of Mg ribbon
- 4 pieces of red litmus paper
- 4 pieces of blue litmus paper
- bromothymol blue solution
- indigo carmine solution
- methyl orange solution

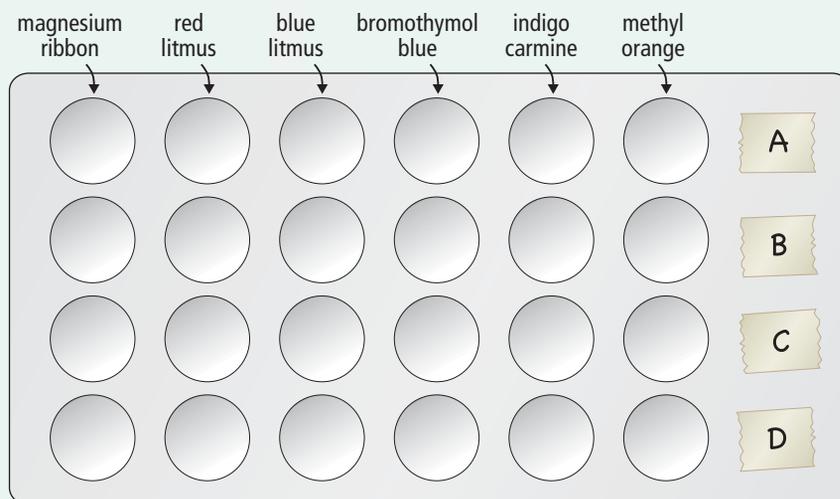
In this activity, you will investigate the acid-base properties of four solutions. Take care in handling the solutions as they may be corrosive. You will test each of the solutions with Mg ribbon and with several pH indicators and look for patterns.

Question

How can the properties of acids and bases be used to classify solutions?

Procedure

1. First, read this entire procedure. Then, design a data table to record your results. Include a title for each column and row in your data table. Make sure your data table clearly indicates each solution you will be using and the indicator it will be mixed with. Give your data table a title.
2. Use masking tape to label the rows on your spot plate A, B, C, and D.
3. Add a few mL of Solution A to each of the six wells of row A of the spot plate. Place Solution B in the next six wells in row B. Repeat for Solution C and Solution D.
4. Place a piece of magnesium ribbon in the first well of each of the four rows.
5. Place red litmus in the second well of each row. Place blue litmus in the third wells of each row.
6. Add five drops of bromothymol blue solution to the fourth well of each row. Add five drops of indigo carmine solution to the fifth well. Add five drops of methyl orange solution to the sixth well.
7. Record your results in your data table. State the colour or other observations.
8. Your teacher may wish to see your spot plate once it is completed. Be sure to check before you begin clean-up.
9. Clean up and put away the equipment you have used. Follow your teacher's instructions for disposal of wastes.



Set-up of spot plates

Analyze

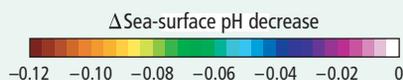
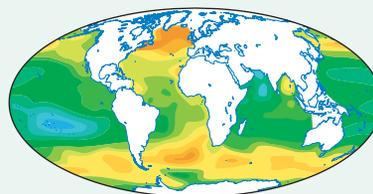
1. List the solutions in order from most acidic to least acidic (most basic).
2. Which solution do you think was neutral? Explain how you know.
3. You used two bases. Explain how you know which solution was more alkaline (more basic).
4. How can magnesium metal be used to distinguish between an acid and a base?

Conclude and Apply

1. (a) What colour would each of the five indicators be in a solution that is pH 3?
(b) What colour would each of the five indicators be in a solution that is pH 10?
2. Suppose you are asked to put together a test kit to determine whether water taken from a factory waste drain is acidic, basic, or neutral. Your kit can contain only three tests. Which tests would your kit contain? Explain.
3. Refer to the photo of the lichen *Roccella tinctoria* on this page, from which litmus is extracted. If this lichen were ground up and then soaked in vinegar, what colour would the solution likely be?
4. What is the colour of seawater that has had bromothymol blue added to it?
5. Consider the colour-coded map of the world's oceans shown to the right.
 - (a) Which regions of the world's oceans appear to be most affected by the drop in pH level?
 - (b) Which regions are the least affected?



Litmus is a mixture of dyes extracted from lichens such as the *Roccella tinctoria* shown here.



Between 1750 and 2000, the pH of the oceans fell from 8.109 to 8.104, likely as a result of human activity that put more carbon dioxide into the air.

Science Watch

Acid Oceans

What do corals, barnacles, clams, and oysters all have in common, besides living in the ocean? They all make protective shells out of calcium carbonate. Ocean water contains dissolved calcium ions and carbonate ions, and many ocean organisms use these ions to build their shells. This remarkable bit of biochemistry is under threat from the activity of humans, not because of what we are doing directly to the oceans but because of what we are doing to the air.

The energy we use for industry, transportation, power, and heating and cooling buildings mostly comes from burning coal, gasoline, and other carbon sources as fuels. The burning of fuels adds large amounts of carbon dioxide to the atmosphere.

Natural absorption of this extra carbon dioxide by the oceans helps to slow down the effects of carbon dioxide build-up and its effects on global warming as a greenhouse gas. This might seem like a good thing.

However, like most ecological damage, this absorption has far-reaching effects. When carbon dioxide gas enters the ocean, it can react with water to form carbonic acid (H_2CO_3).

Some of the dissolved carbonate ions, which are basic, work to neutralize the excess carbonic acid. As a result, carbonate levels drop in the ocean. With lower carbonate concentrations, the ability of sea creatures to make shells also decreases. Even the tiny plankton that form the basis of the marine food chain are affected because many of them produce a skeleton made from calcium carbonate.



Coral can dissolve in acidic water.



A marine biologist collects samples from a coral reef to study how human activity is affecting the reef and how best to protect it.

If the pH of the oceans drops too far, coral reefs may begin to dissolve. Coral reefs are treasure troves of biodiversity. They are the underwater equivalent of tropical rainforests in that they are homes for countless forms of sea life. If we do not bring the problem of carbon dioxide emissions to the atmosphere under control, we may cause irreparable damage to our oceans.

Questions

1. What are two planet-wide environmental problems associated with burning carbon as a fuel source?
2. How does adding excess carbon dioxide gas to the atmosphere result in a decreased ability of shellfish to make shells?
3. How can we halt the acidification of our oceans?

Check Your Understanding

Checking Concepts

- (a) List three solutions commonly found in a kitchen or in a home that are acids.
(b) List three solutions that are bases.
- Use the pH scale to help you define the following terms.
(a) acid
(b) base
(c) neutral
- Why should you never taste a solution to determine whether it is an acid or a base?
- Solution A has a pH of 3. Solution B has a pH of 6.
(a) Which solution is more acidic?
(b) How many times more acidic is it?
- Copy and then complete the following chart in your notebook.

| Indicator | Colour at pH 1 | Colour at pH 7 | Colour at pH 10 |
|-------------------|----------------|----------------|-----------------|
| Red litmus paper | | | |
| Blue litmus paper | | | |

- Refer to Figure 5.6 to find the colour of the following indicators.
(a) phenolphthalein indicator when placed in a solution that is pH 8
(b) bromothymol blue when placed in a solution that is pH 7
(c) indigo carmine when placed in a solution that is pH 13
- Describe the following properties of acids.
(a) taste
(b) reaction to metals
(c) electrical conductivity
- Describe the following properties of bases.
(a) taste
(b) reaction to metals
(c) electrical conductivity
- (a) What is the chemical name of the acid present in vinegar?
(b) What is its chemical formula?
- (a) What is the chemical name of the acid present in automobile batteries?
(b) What is its chemical formula?

- (a) What is the chemical name of the base used as an antacid?
(b) What is its chemical formula?
- (a) What is the chemical name of the base used to clean drains?
(b) What is its chemical formula?

Understanding Key Ideas

- For each of the following compounds, give what its formula name can be changed to when it is present in an aqueous solution.
(a) HClO_4
(b) H_2SO_4
(c) HF
- For each of the following compounds, give what its formula name can be changed to when it is present in an aqueous solution.
(a) hydrogen chloride
(b) hydrogen nitrate
(c) hydrogen acetate
(d) hydrogen sulfate
- The illustration below shows the pH of a solution. Describe each of its following properties.
(a) taste
(b) touch
(c) colour of red litmus
(d) reaction to magnesium metal



Pause and Reflect

You have learned that acids can be corrosive to metals and human tissue and must be handled with care. What gentle acids have you used? How did you use them? In what situations might it be beneficial to apply a gentle acid directly to skin or hair?