What Makes an Acid Different from a Base?

Many compounds in chemistry and in everyday life can be classified as either an acid or a base. Both types of compounds produce ions when dissolved in water. So, what's the difference? Watch the video to find out more about acids, bases, and pH.

Video Text Version

To understand how to test for acids and bases, first consider a substance that's neither—pure water. Water molecules are in constant motion.

Sometimes, the collision between water molecules can be so energetic that a hydrogen ion is transferred from one water molecule to another. This forms one hydronium ion and one hydroxide ion and is called the self-ionization of water. At any given time, some water molecules are being broken down into hydronium and hydroxide ions, while some hydronium and hydroxide ions are bonding together to form water molecules.

When the forward reaction and backward reaction occur at the same rate, the system is said to be in dynamic equilibrium, and the numbers of hydronium ions and hydroxide ions are equal. However, if an acid is added to the water, the number of hydronium ions increases and the hydroxide ions decrease, and vice versa if a base is added. These concentrations always go up and down in tandem, giving chemists a way to measure not just the presence but also the strength of an acid or base.

To measure the acidity of a substance, the pH scale was invented in 1909. It measures levels of hydrogen ion concentration on a scale from 0 to 14 to determine whether a substance is an acid or a base. The pH and hydrogen ion concentration are inversely related.

The higher the hydrogen ion concentration, the lower the pH. When there's a high concentration of hydrogen ions in a solution, it's considered acidic. Therefore, the lower a solution's pH, the more acidic it is, while a higher pH indicates a solution that's more basic.

Litmus paper is used to determine the pH level of a substance. It changes color in the presence of an acid or base. A neutral solution has a pH of 7 and is neither acidic nor basic.

Any pH level below 7 determines the substance to be an acid. The litmus paper turns deep red at the level of 4.5. Litmus paper turns blue at the level of 8.2 and higher and determines the substance to be a base.

Phenolphthalein is another acid-base indicator to measure pH levels. It's a colorless liquid when present in acidic and neutral conditions, but it will turn a deep reddish violet color when the pH level of a substance is 8.3 or higher and is considered a base. But litmus paper and phenolphthalein have limitations and cannot determine an exact pH.

An acid-base indicator called universal indicator can be used to determine exact pH. It produces a wide range of colors to indicate different pHs. A pH meter is also used to get an accurate measurement. It sends an electrical current through a sample to determine the substance's pH.

Show Video

Acids and bases are compounds that have different characteristics. Check out the household items below and test whether each item is an acid or a base by using the pH paper. Record your findings in your notebook.

Acid or Base Activity

Imagine you have some pH paper to test out household items. Identify each of the following household items as either an acid or a base.

Household items	Acid or Base?
Distilled Water	
Dish Soap	
Drain Cleaner	
Vinegar	
Detergent	
Milk	
Deodorant	
Window Cleaner	
Toilet Cleaner	

Household items	Acid or Base?
Orange Juice	

Every day we come into contact with acids and bases. The soap we use to wash our hands contains basic compounds that play a big role in breaking down oils. Many fruits, such as apples, contain acidic compounds that taste tart. Many acids and bases have predictable characteristics that can help you distinguish them from each other.

AcidsAcid Composition and FormulasProperties of Acids

Chemically speaking, an **acid** is a compound that increases the concentration of H^+ (hydrogen) ions when dissolved in water. A hydrogen atom is a proton and an electron. When it loses the electron, it is just a proton. Hydrogen ions are protons, but they do not remain alone in water—they chemically bond to water to form H_3O^+, or **hydronium ions**

. For all intents and purposes, H^+ and H_3O^+ mean the same thing. They both refer to positively charged hydrogen.
Watch how hydrochloric acid (HCl) separates when it is added to water.

HCl and Water Video

This is also an experiment you can do at home.

What you need is you need is a small container that's going to have some water; we are using hydrochloric acid, but you can do your experiment using vinegar; we have pH paper, that you can find if you look in your phone book, a school supply store, or a hobby store; we also have a set of tongs, but you can also use tweezers. The first thing we are going to do is test the pH level of our water. We are going to dip the pH paper in and compare it to the scale that came with the pH paper. Notice that our color is not quite as dark as the pH of 8, it's also not the color of the pH of 6, so it is somewhere in the middle, and this would be a pH of 7, which means it is neutral. We are now going to take another piece and we are also going to just test the pH of our acid. I am going to dip this in and if you look up here it's about the color that is at the top and that says pH 2, a strong acid, and hydrochloric acid is like what is in your stomach. Now when we add the acid to the water, the acid actually breaks apart to form hydrogen ions which are H^+ and chloride ions which are Cl^-. The hydrogen ions are going to react with the water to form a hydronium ion which is H_3O^+. It is the H_3O^+ that makes this an acid. So I am going to take my pH paper again, and I am going to dip it in the water, and see what happens. Notice that here is my original water, which is a very, very, pale yellow. Here is my hydrochloric acid which is a bright, pinkish, purple and here we have the acid with the water. Notice that when we added the acid to the water we got a pH that is between 7, the neutral for the acid, and 2, which is our pure acid. When you get your pH paper, all of them come

with a nice little scale like we see here. The colors on yours may be different than the colors that mine are turning now, but you always just compare them with your scale and it will show you what your pH is.

Most acids contain hydrogen ions, which break off from the compound when it dissolves in water. However, some acids do not contain hydrogen ions. These compounds, called acid anhydrides, increase the H^+ concentration by reacting with water. Examples include CO_2, which creates carbonic acid in water, and SO_3, which creates sulfuric acid in water. Let's look at how CO_2 reacts with water to form carbonic acid, which is the acid present in carbonated soft drinks. CO_2 and H_2O react to form the compound H_2CO_3, some of which then separates into ions.

By tradition, acids that contain hydrogen usually have H as the first element in the chemical formula. Here are some examples:

- H_3PO_4: phosphoric acid (found in colas)
- HNO_3: nitric acid (used in fertilizers)
- HF: hydrofluoric acid (used to clean metal)

Carbon Dioxide Video

The form of carbon dioxide we're using is dry ice which is solid carbon dioxide (CO_2) at a temperature of about negative 80 degrees Celsius. So obviously, this is something you do not want to touch with your bare hands because it will immediately give you cold burns. So we're going to test the pH of our water. It turns out we're at a pH of 7. Now we're going to take our chunk of dry ice and put it in our water. And notice, it is going to bubble all over the place because we are making lots of carbon dioxide. Now carbon dioxide is actually mixing in with the water to form carbonic acid. We are forming hydronium ions and carbonate ions. We are now, instead of being 25 degrees Celsius, we're down to about 18 and it's called sublimating. What it's doing right now is it's going directly from a solid to a gas without a liquid in between. So we use the process of sublimation to cool things when we don't want them to get wet. So should we see if we've actually made an acid? Look at that. Our pH paper turned orange which tells me it is about a pH of 4 which is a fairly strong acid. Coke, Pepsi, Sprite, anything that is carbonated they have put carbon dioxide in, and it reacts with the water to form carbonic acid. So your soft drinks have a pH of about 4 in them as well.

Most acids have some common physical and chemical properties:

- Sour taste (Never taste or smell a substance unless your parent or guardian tells you that it is okay!)
- Corrosive (burns your skin and breaks down other materials)
- Increases the concentration of hydrogen ions when added to water
- Forms hydrogen gas when it comes in contact with a metal
- Forms salt and water when added to a base

Bases

A **base** is a compound that increases the concentration of hydroxide ions (OH^-) when dissolved in water.

Watch in the video how the base called sodium hydroxide (NaOH) separates when it is added to water.

$NaOH + H_2O \rightarrow Na^+ + OH^- + H_2O$

The reaction that you observed in this example is an exothermic reaction. In this type of reaction, energy is released causing the temperature of the solution to rise. Exothermic reactions will be discussed in more detail in an upcoming lesson.

NaOH and Water Video

What we are demonstrating: When sodium hydroxide (NaOH) is added to water, water molecules break the ionic bonds between the sodium and hydroxide ions. We got some sodium hydroxide, and we have it in pellet form; I have a container that has some pure water on it; I have my pH paper and my tongs, and this time we are also going to look at temperature and see what happens to the temperature of the water when I add the sodium hydroxide to it. This water is going to be at room temperature which is just about 25 degrees Celsius. I am going to add my sodium hydroxide and we are going to watch what happens. Mix it while it dissolves. What we are going to see is the solid sodium hydroxide, NaOH, actually dissolving into the ions that make it up. The solid pieces will start to disappear; they are gonna break apart and form sodium NA^+ ions and hydroxide OH^- ions. The OH^- ions are the ones that make this a base. So we are going to see something totally different with our pH this time. Actually, what I can see is that my temperature in this is starting to rise. I know it does not sound like much but it has risen from 25 degrees to 30 degrees, and that is a big change for this little bit of water. This rise in temperature tells us that it is an exothermic reaction.

Look around and identify at least one acid and one base in your house. Foods, household products, and medicines have acidic or basic properties.

Use the Internet, your library, or science textbooks to learn more about acids and bases. Identify important characteristics, chemical properties, physical properties, pH ranges, and examples of acids and bases. Ideas for reporting the information include: make lists, write a paragraph, or use a Venn diagram. Please make sure to review the grading rubric. You will turn your work in to your instructor.

Include the following information about acids and bases in your work:

- Chemical properties
- Physical properties
- pH
- Examples around you