Understanding pH
Introduction

Welcome to the Understanding pH learning module. This section provides information on the following topics:

- ☑ How pH is defined and measured in numbers
- ☑ Why pH is important
- ☑ Natural and human influences on pH

After completing this module you should be able to perform the following:

- ☑ Define the term pH
- ☑ Explain how pH is measured in numbers
- ☑ Explain the difference between acids and bases
- ☑ Explain why pH levels are important to aquatic life
- ☑ List some natural and human influences on pH

To begin the module, click the **Next** button at the bottom right of the screen.

Understanding pH
What is pH?

pH stands for “potential of hydrogen” and refers to the concentration of hydrogen ions (H+) in water or whatever liquid is being measured.

In more everyday terms, pH is a unit of measure for determining if a liquid is acidic or basic (alkaline). Something that is neither acidic nor basic is referred to as neutral.

You may have encountered the term pH in relation to the water in a fish tank or swimming pool. Bad things can happen when pH levels are either too high or too low.

Understanding pH
How is pH measured in numbers?

pH is measured on a scale of 0.0 to 14.0.

- ☑ Numbers < 7.0 = acidic
- ☑ Numbers > 7.0 = basic
- ☑ A pH of 7.0 indicates a neutral liquid

Understanding pH
More about the numbers

For all the mathematicians out there, pH is determined by calculating the negative logarithm of a liquid's H+ concentration. Some examples can help illustrate how this works:

- ☑ pH = -log [10^{-6} moles of H^+ per liter of liquid] = 6.0
- ☑ pH = -log [10^{-7} moles of H^+ per liter of liquid] = 7.0
- ☑ pH = -log [10^{-8} moles of H^+ per liter of liquid] = 8.0

Understanding pH
Pure water is neutral and the midpoint of the pH scale

Pure water is neutral and has a pH of 7.0. Pure water consists of H_20 molecules surrounded by a relatively small number of hydrogen ions and hydroxide ions (H^+ and OH^-).

- ☑ Pure water is considered neutral because it has an equal number of H^+ and OH^- that are freely available for chemical reaction.

- ☑ Pure water has a pH of 7.0 because it contains 10^{-7} moles of H^+ per liter and the negative logarithm of 10^{-7} is 7.0.

Understanding pH
Acids and bases

Adding acids or bases to water changes its pH.

- ☑ Acids lower the pH of water by increasing the H^+ concentration.

- ☑ Bases raise the pH of water by increasing the OH^- concentration.

Understanding pH
Examples of acids

Vinegar and battery acid are examples of acids. Acids have the following properties:

- ☑ Acids taste sour.
- ☑ They react strongly with metals.
- ☑ Strong acids are dangerous and can burn your skin.

Understanding pH
Examples of bases

Baking soda and bleach are examples of basic substances, or bases. Bases have the following properties:

- ☑ Bases taste bitter.
- ☑ They feel slippery.
- ☑ Strong bases can burn your skin.

Understanding pH
Even more about the numbers

As alluded to earlier, the pH scale is logarithmic. What this means is that a change of one pH unit reflects a tenfold change in H+ concentration or acidity. Some examples can help illustrate how this works:

- ☑ Liquid with a pH of 6.0 is ten times more acidic than pure water (pH=7.0). Liquid with a pH of 5.0 is one hundred times (10x10) more acidic than pure water.

- ☑ Liquid with a pH of 8.0 is ten times more basic than pure water. Liquid with a pH of 9.0 is one hundred times more basic than pure water.

Understanding pH
Understanding the numbers

Which of the following statements is false?

A) Liquid with a pH above 7.0 is basic.
B) Liquid with a pH below 7.0 is acidic.
C) Liquid with a pH of 5.0 is ten times more acidic than a liquid with a pH of 7.0.
D) Liquid with a pH of 5.0 is one hundred times more acidic than a liquid with a pH of 7.0.

The correct response is C!

Liquid with a pH above 7.0 is basic and liquid with a pH below 7.0 is acidic. Liquid with a pH of 5.0 is one hundred times more acidic than liquid with a pH of 7.0. This is because pH is expressed on a logarithmic scale, which means that a change of one pH unit reflects a tenfold change in H+ concentration or acidity.

Understanding pH
The importance of pH

Because all living organisms require specific pH ranges in order for their cells to function properly, extreme or sudden changes in pH can directly harm aquatic life. Although pH levels can be too high for aquatic organisms, it is more common for pH levels to be too low. pH values less than 7.1 signify poor conditions for most SCORE restoration sites. Remember, pH is based on a logarithmic scale, so even small changes in pH values indicate very large changes in the alkalinity or acidity of water.

Understanding pH
Understanding the importance of pH

How can changes in pH directly harm aquatic life?

A) By disrupting cellular processes
B) By altering other aspects of water quality
C) Both A and B
D) None of the above

The correct response is A!

Changes in pH can directly harm aquatic life by disrupting cellular processes. Changes in pH can *indirectly* harm aquatic life by altering other aspects of water quality.

Understanding pH
Influences on pH

pH can be affected by both natural and human influences.

Natural influences:

- ☑ Rainfall
- ☑ Water turbulence
- ☑ Seawater mixing
- ☑ Aquatic plants

Human influences:

- ☑ Acid rain
- ☑ Organic wastes

Understanding pH
Natural influences on pH (rainfall)

Rainfall can lower the pH of water. This is because rain is naturally acidic, with an average pH of 5.6.

- ☑ Rainwater is acidic due mainly to the presence of carbonic acid—a common culprit for lowering the pH of water.
- ☑ Carbonic acid forms when carbon dioxide gas reacts with water molecules in the atmosphere.
- ☑ Carbonic acid lowers the pH of rainwater by increasing the H^+ concentration.

Understanding pH
Natural influences on pH (water turbulence)

Water turbulence can lower the pH of water. Turbulence refers to water that is moving rapidly and irregularly due to physical forces like wind, tidal currents, and wave action.

- ☑ Turbulent waters are better able to mix with the atmosphere—thereby causing increased diffusion of carbon dioxide from the air.
- ☑ Carbon dioxide reacts with water molecules to form carbonic acid.
- ☑ Carbonic acid lowers the pH of water by increasing the H^+ concentration.

Understanding pH
Natural influences on pH (seawater mixing)

The mixing of seawater with freshwater raises the pH of water. At the lower reaches of an estuary (closer to where the estuary meets an ocean), pH is typically higher.

- ☑ Seawater is more basic (average pH of 8.2) than freshwater.
- ☑ Seawater has a greater ability to neutralize or buffer acids that may be added to the system (such as carbonic acid).

Understanding pH
Natural influences on pH (aquatic plants)

The pH of an estuary varies throughout the day. One cause of this variation is the presence of aquatic plants, particularly phytoplankton, which are tiny, free-floating organisms that include many types of algae.

- ☑ During the day, aquatic plants remove carbon dioxide (CO_2) from the water through photosynthesis.
- ☑ When the concentration of CO_2 in water decreases, the potential for carbonic acid to form (CO_2 + water) also decreases.
- ☑ Less carbonic acid results in an increase in pH, and the water becomes more alkaline, or basic.

Understanding pH
Understanding natural influences on pH

Which of the following statements is true?

A) Rainfall is naturally acidic and can lower the pH of estuaries.
B) Rainfall is naturally acidic and can raise the pH of estuaries.

The correct response is A!

Rainfall is naturally acidic and can lower the pH of estuaries and other water bodies by increasing the H^+ concentration.

Understanding pH
Understanding Natural Influences on pH

Water turbulence can lower the pH of estuaries.

A) True
B) False

The correct response is A!

Water turbulence can lower the pH of estuaries and other water bodies. This is because turbulent waters are better able to mix with the atmosphere—thereby causing increased diffusion of carbon dioxide from the air. Carbon dioxide reacts with water molecules to form carbonic acid, which lowers the pH of water by increasing the H^+ concentration.

Understanding pH
Understanding natural influences on pH

pH is typically higher (more basic) in the upper reaches of an estuary than in the lower reaches.

A) True
B) False

The correct response is B!

pH is typically higher (more basic) in the lower reaches of an estuary than in the upper reaches. This is because the lower reaches of an estuary are closer to seawater (which has a higher pH and a higher capacity to buffer acids than freshwater).

Understanding pH
Human influences on pH (acid rain)

Acid rain lowers the pH of water. Acid rain is significantly more acidic than natural rain and is primarily caused by the pollution from burning fossil fuels.

- ☑ Acid rain has a pH value of less than 5.0.
- ☑ Burning coal, oil, and gasoline produces sulfur dioxide and nitrogen oxide gases that react with moisture in the atmosphere to form acids.
- ☑ Acids lower the pH of water by increasing the H^+ concentration.

Understanding pH
Human influences on pH (organic wastes)

The decomposition of organic (carbon-based) waste can lower the pH of water by means of bacteria.

- ☑ Bacteria feed off waste materials and create carbon dioxide.
- ☑ Carbon dioxide reacts with water molecules to form carbonic acid.
- ☑ Carbonic acid lowers the pH of water by increasing the H^+ concentration.

Some sources of organic waste:

- ☑ Leaking septic systems
- ☑ Livestock farms
- ☑ Pulp and paper mills
- ☑ Stormwater runoff

Understanding pH
Understanding human influences on pH

Acid rain can significantly lower the pH of estuaries and other water bodies. Which of the following is primarily responsible for causing acid rain?

A) Burning of coal
B) Burning of oil
C) Burning of gasoline
D) All the above

The correct response is D!

Acid rain is primarily caused by the burning of fossil fuels such as coal, oil, and gasoline. This is because fossil fuel combustion produces pollutant gases that react with moisture in the atmosphere to form acids. These acids lower the pH of rainwater by increasing the H^+ concentration.

Understanding pH
Understanding human influences on pH

The decomposition of organic waste can lower the pH of estuaries and other water bodies.

A) True
B) False

The correct response is A!

The decomposition of organic waste can lower the pH of estuaries and other water bodies. This is because organic waste is decomposed by bacteria that produce carbon dioxide during the process. The excess carbon dioxide reacts with water molecules to form carbonic acid (which lowers the pH of water by increasing the H^+ concentration).

Understanding pH
Review

Congratulations! You have completed the Understanding pH learning module. In this section you learned about the following topics:

- ☑ How pH is defined and measured in numbers
- ☑ Why pH is important
- ☑ Natural and human influences on pH

You should now be able to perform the following:

- ☑ Define the term pH
- ☑ Explain how pH is measured in numbers
- ☑ Explain the difference between acids and bases
- ☑ List two reasons why pH levels are important to aquatic life
- ☑ List some natural and human influences on pH

To choose another module, click the drop-down menu at the top of the screen.