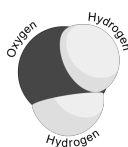


Name: _____ Date: _____

3.1 The Polarity of Water Molecules Results in Hydrogen Bonding

1. What makes water a polar molecule?
2. How many other water molecules can hydrogen bond to water? _____
3. Draw the four water molecules that can hydrogen bond to this water molecule. Show the bonds and the slight negative and positive charges that account for the formation of these hydrogen bonds.



3.2 Four (Five) Emergent Properties of Water Contribute to Earth's Fitness for Life

4. Compounds that have the capacity to form hydrogen bonds with water are said to be hydrophilic (water loving). Those without this capacity are hydrophobic (water fearing).

	<p>Is the molecule on the left hydrophilic or hydrophobic? Explain your answer.</p>
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5. Fill in the table that summarizes the properties of water that contribute to the fitness of the environment for life.

Property	Explanation of Property	Example of Benefit to Life
	Hydrogen bonds hold molecules together and adhere them to hydrophilic surfaces	
High Specific Heat		Temperature changes in environment and organisms are moderated
	Hydrogen bonds must be broken for water to evaporate	
	Water molecules with high kinetic energy evaporate; remaining molecules are cooler	
Less dense as a solid		
		Most chemical reactions in life involve solutes dissolved in water

6. Life as we know it could not exist without water. All the chemical reactions of life occur in aqueous solution. Water molecules are polar and capable of forming hydrogen bonds with other polar or charge molecules. As a result, water has the following properties:
- A. H₂O molecules are cohesive; thus they form hydrogen bonds with each other.
 - B. H₂O molecules are adhesive; they form hydrogen bonds with polar surfaces.
 - C. Water is a liquid at normal physiological (or body) temperature.
 - D. Water has a high specific heat.
 - E. Water has a high heat of vaporization.
 - F. Water's greatest density occurs at 4°C.

Explain how these properties of water are related to the phenomena described below. More than one property may be used to explain a given phenomenon.

- a. During winter, air temperatures in the northern United States can remain below 0°C for months; however, the fish and other animals living in the lakes survive.
- b. Many substances – for example, salt (NaCl) and sucrose – dissolve quickly in water.
- c. Insects, like water striders, can walk on the surface of a pond without breaking the surface.
- d. Sweating and the evaporation of sweat from the body surface help reduce a human's body temperature.
- e. Water drops that fall on a surface tend to form rounded drops or beads.
- f. Coastal areas have milder climates than adjacent inland areas.
- g. Water drops that fall on your car tend to bead or round up more after you polish (or wax) the car than before you polish it.
- h. If you touch the edge of a paper towel to a drop of colored water, the water will move up into (or be absorbed by) the towel.
- i. Ocean temperatures fluctuate much less than air temperatures on land.
- j. If you slightly overfill a water glass, the water will form a convex surface above the top of the glass.
- k. If you put sugar into your coffee it will dissolve, whereas oil and water will stay mixed.

3.3 Acidic and Basic Conditions Affect Living Organisms

7. What is the relationship of H⁺ ions and OH⁻ ions in the following solutions.
- Acidic _____
 - Basic _____
 - Neutral _____
8. In addition to being polar, water molecules can dissociate into hydronium ions (H₃O⁺, often described simply as H⁺) and hydroxide ions (OH⁻). The concentration of each of these ions in pure water is 10⁻⁷. Another way to say this is that the concentration of hydronium ions, or H⁺ ions, is one out of every 10 million molecules. Similarly, the concentration of OH⁻ ions is one in 10 million molecules.
- The H⁺ ion concentration of a solution can be represented as its pH value. The pH of a solution is defined as the negative log₁₀ of the hydrogen ion concentration. What is the pH of pure water? Explain.
 - Refer to the diagram of the molecule of acetic acid in question #4. The COOH group can ionize to release H⁺ ion into solution. If you add acetic acid to water and raise the concentration of H⁺ ions to 10⁻⁴, what is the pH of the solution?
9. Complete the following table to review your understanding of pH.

[H ⁺]	[OH ⁻]	pH	Acid, Base, or Neutral
	10 ⁻¹¹	3	acidic
10 ⁻⁸			
	10 ⁻⁷		
		1	

10. Compared to a basic solution with a pH 9, the same volume of an acidic solution at pH 4 has _____ times as many hydrogen ions (H⁺).
11. What is a buffer? What role does it play in living organisms?
12. The carbonic acid/bicarbonate system is an important biological buffer. Label the molecules and ions in this equation and indicate which is the H⁺ donor and which is the acceptor.



- In which direction will this reaction proceed ...
- when the pH of a solution begins to fall?
 - when the pH rises above normal level?