Chapter 3: Water and the Fitness of the Environment

Use the diagram at the right and LABEL the oxygen (O) and hydrogen (H) on the central molecule. Add + AND - SIGNS to indicate the charged regions of *each* molecule. *COLOR & LABEL* the hydrogen bonds.

1. Water is a *polar molecule*. What does that mean?



2. Explain hydrogen bonding.

3. How many hydrogen bonds can a single water molecule

form?

A Quick Review of the Properties of Water

Life as we know it could not exist without water. Water molecules are polar and are capable of forming hydrogen bonds with other polar or charged molecules All the chemical reactions of life occur in aqueous solution. As a result, water has the following EMERGENT PROPERTIES due to HYDROGEN BONDING

- a. H_2O molecules are cohesive; they form hydrogen bonds with each other.
- b. H_2O molecules are adhesive; they form hydrogen bonds with polar surfaces.
- c. Water is a liquid at normal physiological temperature (ie. 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.

4. USE THE LIST ABOVE to EXPLAIN how these properties of water are related to the phenomena described in parts A-G below. More than one property may be used to explain a given phenomenon.

A. Water will move up a drinking straw or the trunk of a tree.

B. When you pour water into a 25ml graduated cylinder, a meniscus forms at the top of the water column.

C. Sweating and the evaporation of sweat from the body surface help reduce a human's body temperature.

D. A bottle contains a liquid mixture of equal parts water and mineral oil. You shake the bottle vigorously and then set it on the table. Although the law of entropy favors maximum randomness, the mixture still separates into layers of oil and water.

E. Water drops that fall on your car tend to bead or round up more after you polish (or wax) your car than before you polished it.

F. If you touch the edge of a paper towel to a drop of colored water, the water will move into (be absorbed by the towel.

G. Water strider insects have the ability to walk on water.

5. Summarize how water's high specific heat contributes to the moderation of temperature. How is this property important to life?

6. Define evaporation. What is heat of vaporization?

7. Explain at least three effects of this property on living organisms.

Expansion upon Freezing

8. Ice floats! So what? Consider what would happen if ponds and other bodies of water accumulated ice at the bottom. Describe why this property of water is important.

9. Now, explain why ice floats. Why is 4°C the critical temperature in this story?

<u>Solvent of Life</u> 10. Review & define these terms. solvent

solution

solute

11. Consider coffee to which you have added sugar. Which is the solvent? The solute?

12. Explain why water is such a good solvent.

13.Define hydrophobic

hydrophilic

Fig. Areas Acid (CH2COOH) - a have dimensional structural representation. Jonach Scientific Glass Blowing Senices +61.3 (79) 4442

14. Do you think this molecule is hydrophilic or hydrophobic? Explain your answer (Remember, "like dissolves like").

pH- Acids and bases

15. What two ions form when water dissociates? What is the concentration of each ion in pure water at $25^{\circ}C$?

16. The H⁺ ion concentration of a solution can be represented as its pH value.

The pH of a solution is defined as the negative log_{10} of the hydrogen ion concentration [H⁺]

a. What is the pH of pure water?

In other words, in pure water one out of every 10 million (1X10 $^{-7}$) molecules is dissociated into a hydroxide ion and a hydronium ion [H₃O⁺ /often called H⁺ for short]. Pure water has a pH of 7. pH is defined as the negative log of the hydrogen ion concentration [H⁺]. Can you now see how water is assigned a pH of 7?

- 17. If you add acetic acid to water and raise the concentration of $H^{\scriptscriptstyle +}$ ions to $10^{-4},$ a. what is the pH of this solution?
 - b. What is the pH of a solution with a $[H^+] = 10^{-8}$?
- 18. To go a step further, the product of H⁺ and OH⁻ concentrations is constant at 10^{-14} [H+}[OH-} = 10^{-14} . a. What is the pH of a solution with an [OH⁻] = 10^{-4}
- 19. Water, which is neutral with a pH of 7, has an equal number of H+ and OH- ions.
 - Define:

acid

base

20. Because the pH scale is logarithmic, each numerical change represents a 10X change in ion concentration.

- a. So, how many times more acidic is a pH of 3 compared to a pH of 5?
- b. How many times more basic is a pH of 12 compared to a pH of 8?

c. Explain difference between a pH of 8 and a pH of 12 in terms of H⁺ concentration.



21, On the pH chart, label pH 1-14. Label *neutral*, *acid*, *base*. Indicate the locations of pure water, urine, gastric juice, and bleach.

22. Even a slight change in pH can be harmful! How do buffers moderate pH change?

23. Exercise will result in the production of CO_2 , which will acidify the blood. Explain the buffering system that minimizes blood pH changes.

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