Chapter 3: Water and Life

Concept 3.1 The polarity of water molecules results in hydrogen bonding
1. Study the water molecules at the right. On the central molecule, label oxygen (O) and hydrogen (H).

2. Why is water considered polar?

3. Now, add + and – signs to indicate the charged regions of each molecule. Then, indicate the hydrogen bonds.

4. How many hydrogen bonds can a single water molecule form?

Concept 3.2 Four emergent properties of water contribute to Earth’s fitness for life
Hydrogen bonding accounts for the unique properties of water.

Cohesion
5. Distinguish between cohesion and adhesion.

6. Explain how cohesion and adhesion are demonstrated when you see beads of water on a waxed car hood.

7. Which property explains the ability of a water strider to walk on water?

Moderation of Temperature
8. The calorie is a unit of heat. Define calorie.

9. Water has high specific heat. What does this mean? How does water’s specific heat compare to alcohol’s?

10. Explain how hydrogen bonding contributes to water’s high specific heat.
11. Summarize how water's high specific heat contributes to the moderation of temperature. How is this property important to life?

12. What is heat of vaporization? Explain at least three effects of this property on living organisms.

Expansion upon Freezing

13. 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.

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

Solvent of Life

15. Review and define these terms:

   solvent
   solution
   solute

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

17. Explain why water is such a good solvent.

18. Define hydrophobic and hydrophilic.

19. You already know that some materials, such as olive oil, will not dissolve in water. In fact, oil will float on top of water. Explain this property in terms of hydrogen bonding.
20. Now, let's do a little work that will enable you to prepare solutions. Read the section on solute concentrations, and show the calculations here for preparing a 1-molar solution of sucrose. The steps to help you do this are below. The first step is done for you. Fill in the rest.

**Steps to prepare a solution:**

a. Write the molecular formula. \( \text{C}_{12}\text{H}_{22}\text{O}_{11} \)

b. Use your periodic table (Appendix B in the book) to calculate the mass of each element. Multiply by the number of atoms of the element. (For example, O has a mass of 16. Therefore one mole of O has a mass of \( 16 \times 11 = 176 \text{ g/mole} \).)

c. Add the masses of each element in the molecule.

d. To make 1 liter of a 1 M (1 molar) solution, you would add this mass of the compound to water to bring it to a volume of 1 liter.

21. How would you prepare 1 liter of a 0.5-molar glucose solution? Show your work here.

22. Define molarity.

**Concept 3.3 Acidic and basic conditions affect living organisms**

23. What two ions form when water dissociates?

   (By convention, we will represent the hydronium ion as H\(^+\))

24. What is the concentration of each ion in pure water at 25°C?

25. \( pH \) is defined as the negative log of the hydrogen ion concentration \([H^+]\). What is the \( pH \) of water?

To go a step further, the product of H\(^+\) and OH\(^-\) concentrations is constant at \( 10^{-14} \). \([H^+][\text{OH}^-] = 10^{-14}\). Water, which is neutral has an equal number of H\(^+\) and OH\(^-\) ions.

26. Define:
   - acid
   - base
27. 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.


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

30. Exercise will result in the production of CO2, which will acidify the blood. Explain the buffering system that minimizes blood pH changes.

31. Explain the process of ocean acidification.

32. Discuss how ocean acidification affects marine life and ecosystems.