2.1 Matter consists of chemical elements in pure form and in combinations called compounds

Elements and Compounds

1. What are the 6 elements of life?

2. What four elements make up 96% of all living matter?

3. What is the difference between an essential element and a trace element?

essential element

trace element

2.2 An element's properties depend on the structure of its atoms.

4. Below are two models of an atom of helium, showing the electrons, protons, neutrons, and atomic nucleus. Label the diagrams below and define the terms that you label. Determine which is an electron cloud model and which is the Bohr energy level model.

5. What is the atomic number of helium? _________ Its atomic mass? ________

6. The difference between the mass number and the atomic number of an atom is equal to the number of ________. An atom of phosphorus $^{31}_{15}$P contains ____ protons, ____ electrons, and ____ neutrons. The atomic mass of phosphorus is approximately ____.

7. What is an isotope, and what is “special” (useful) about radioactive isotopes?
Consider this entry in the periodic table for carbon.

8. What is the atomic mass? atomic number?

9. How many electrons does carbon have? neutrons?

10. Which is the only subatomic particle that is directly involved in the chemical reactions between atoms?

11. What determines the chemical behavior of an atom?

12. Here is an electron distribution diagram for sodium:
   a. How many valence electrons does it have? ______ Circle the valence electron(s).
   b. How many protons does it have? ______

Concept 2.3 The formation and function of molecules depend on chemical bonding between atoms

13. What is a chemical bond?

14. What type of bond is seen in O₂?
   Explain what this means.

15. What is meant by electronegativity?

16. Compare ionic bonds with covalent bonds?

17. Explain the difference between a nonpolar covalent bond and a polar covalent bond.

18. Make an electron distribution diagram of water.
In a water molecule, which element is most electronegative? Why is water considered a polar molecule? Label the regions in your drawing above that are more positive or more negative. (This is a very important concept. Spend some time with this one!)

19. What is a hydrogen bond? Indicate where the hydrogen bond occurs in this figure.

20. In regard to the three types of chemical bonds, discuss the relative strength of each.

21. What is the difference between a structural and molecular formula?

22. Based on the reading, what is an example, in a living system, of how molecular shape is critical?

2.4 Chemical reactions make and break chemical bonds.
23. Draw a simple chemical reaction and label the reactants and the products.

2.5 Hydrogen bonding gives water properties that help make life possible on earth.
24. Study the water molecules at the right. On the central molecule, label oxygen (O) and hydrogen (H).
25. Why is water considered polar?

26. Now, add + and – signs to indicate the charged regions of each molecule. Then, indicate the hydrogen bonds.
27. Explain hydrogen bonding.

Four emergent properties of water contribute to Earth’s fitness for life. Hydrogen bonding accounts for the unique properties of water. Let’s look at several.

Cohesion

29. How is it that water can be pulled up into the leaves of a tree?
30. Describe what surface tension is and explain what feature of hydrogen bonds causes it.

31. Which property explains the ability of a raft spider to walk on water?

**Moderation of Temperature**
32. Water has high *specific heat*. What does this mean?

33. How does water’s specific heat compare to alcohol’s?

34. Explain how hydrogen bonding contributes to water’s high specific heat.

35. Summarize how water’s high specific heat contributes to the moderation of temperature.

   How is this property important to life?

36. Define *evaporation*.

   What is *heat of vaporization*?

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

**Expansion upon Freezing**
37. 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.

**Water - Solvent of Life**
38. Review and define these terms:
   - solvent
   - solution
   - solute

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

40. Explain why water is such a fine solvent.

41. Define *hydrophobic* and *hydrophilic*. 
**Acidic and basic conditions affect living organisms**

42. Label the diagram below to demonstrate the dissociation (ionization) of the water molecule and then relate this diagram to pH.

![Water molecule dissociation diagram]

43. What two ions form when water dissociates?

You should have answered “hydronium (H$_3$O$^+$) and hydroxide ions (OH$^-$)” in the preceding question. However, by convention, we will represent the hydronium ion as H$^+$.

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

45. Water, which is neutral with a pH of 7, has an equal number of H$^+$ and OH$^-$ ions. Now, define acid base

46. 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.

\[ \text{H}_2\text{CO}_3 \rightleftharpoons \text{HCO}_3^- + \text{H}^+ \]

In which direction will this reaction proceed....

a. when the pH of a solution begins to fall?

b. when the pH rises above normal level?

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

48. Exercise will result in the production of CO$_2$, which will acidify the blood. Explain the buffering system that minimizes blood pH changes.