Name_____Period_____

Chapter 2: The Chemical Context of Life

This chapter covers the basics that you may have learned in your chemistry class. Whether your teacher goes over this chapter, or assigns it for you to review on your own, the questions that follow should help you focus on the most important points.

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

1. Define and give an example of the following terms:

   matter: Anything that takes up space and has mass. Possible examples include rocks, metals, oils, gases, and humans.

   element: A substance that cannot be broken down to other substances by chemical reactions. Possible examples include gold, copper, carbon, and oxygen.

   compound: A substance consisting of two or more different elements combined in a fixed ratio. Possible examples include sodium chloride (NaCl), and water (H_2O).

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

   Oxygen, carbon, hydrogen, and nitrogen.

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

   essential element: Essential elements are elements that an organism needs to live a healthy life and reproduce. Essential elements comprise about 20–25% of the 92 natural elements.

   trace element: Trace elements are required by an organism in only minute quantities. Some trace elements such as iron (Fe) are required by all forms of life, whereas others are required only by certain species, such as iodine (I) for vertebrates.

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

4. Sketch a model of an atom of helium, showing the electrons, protons, neutrons, and atomic nucleus.

   See page 33 of your text for the labeled figure.

5. What is the atomic number of helium? 2 Its atomic mass? 4

6. Here are some more terms that you should firmly grasp. Define each term.
   neutron: Subatomic particle that is electrically neutral.

proton: Subatomic particle with one unit of positive charge.

electron: Subatomic particle with one unit of negative charge.

atomic number: Indicates the number of protons in the nucleus of a specific element, as well as the number of electrons in an electrically neutral atom.

atomic mass: An approximation of the total mass of an atom, measured in Daltons.

isotope: Different atomic formations of the same element, having more neutrons than other atoms of the same element and therefore having greater mass.

electron shells: Represented as concentric circles in diagrams, electron shells represent the average distance from the nucleus and energy level of electrons circling the nucleus of an atom.

energy: The capacity to cause change—for instance, by doing work.

7. Consider the entry in the periodic table for carbon, shown below.

   What is the atomic mass? 12 What is the atomic number? 6

   How many electrons does carbon have? 6 How many neutrons? 6

8. What are *isotopes*? Use carbon as an example.

   Isotopes are different atomic formations of the same element, having more neutrons than other atoms of the same element and therefore having greater mass. In nature, an element occurs as a mixture of its isotopes. For example, carbon (atomic number 6) has three isotopes. Carbon-12, ^{12}C, accounts for about 99% of carbon in nature. This isotope has 6 neutrons. Most of the remaining 1% of carbon consists of atoms of the isotope ^{13}C with 7 neutrons. A third, even rarer isotope, ^{14}C, has 8 neutrons. All three isotopes of carbon have 6 protons; otherwise, they would not be carbon.

9. Explain radioactive isotopes and one medical application that uses them.

   A radioactive isotope is one in which the nucleus decays spontaneously, giving off particles and energy. When the decay leads to a change in the number of protons, it transforms the atom to an atom of a different element. For example, when a radioactive carbon atom decays, it becomes an atom of nitrogen. Possible examples of medical applications that use radioactive isotopes are radioactive tracers used as a diagnostic tool by injection into the blood, and radioactive tracers used with imaging equipment, such as PET scanners, to monitor cancer growth.

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

    Electrons

11. What is *potential energy*?

Energy that matter possessed because of its location or structure.

12. Explain which has more potential energy in each pair:

a. boy at the top of a slide/boy at the bottom

Boy at the top of a slide has more potential energy, because of his location.

b. electron in the first energy shell/electron in the third energy shell

Electron in the third energy shell has more potential energy because of its relative distance from the nucleus.

c. water/glucose

Glucose has more potential energy. Energy is stored in chemical bonds, and there are more bonds in $C_6H_{12}O_6$ than in H_2O.

13. What determines the chemical behavior of an atom?

The chemical behavior of an atom is determined by the distribution of electrons in the atom's electron shells.

14. Here is an electron distribution diagram for sodium:

a. How many valence electrons does it have? 1 Circle the valence electron(s).

b. How many protons does it have? 11

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

15. Define *molecule*.

Two or more atoms held together by a covalent bond.

16. Now, refer back to your definition of a *compound* and fill in the following chart:

	Molecule? (y/n)	Compound? (y/n)	Molecular Formula	Structural Formula
Water	Yes	Yes	H_2O	O-H H
Carbon dioxide	Yes	Yes	CO_2	O = C = O
Methane	Yes	Yes	CH_4	H H- C- H H

O_2	Yes	No	O_2	O = O

17. What type of bond is seen in O_2? Explain what this means.

Double covalent bond. Two oxygen atoms form a molecule by sharing two pairs of valence electrons.

18. What is meant by *electronegativity*?

The attraction of a particular atom for the electrons of a covalent bond.

19. Explain the difference between a *nonpolar covalent bond* and a *polar covalent bond*.

Nonpolar covalent bonds occur between atoms of the same element, the electrons are shared equally, and therefore their polarity is neutral. Polar covalent bonds occur when one atom is bonded to a more electronegative atom, and the electrons of the bond are not shared equally. For example, the bond between the oxygen and hydrogen atoms of a water molecule is a polar covalent bond.

20. Make an electron distribution diagram of water. Which element is most electronegative? Why is water considered a *polar* molecule? Label the regions that are more positive or more negative. (This is a very important concept. Spend some time with this one!)

See page 39 of your text for the labeled figure.

Water is considered a polar molecule because oxygen is more electronegative than hydrogen, and therefore the shared electrons are pulled more toward oxygen.

21. Another bond type is the *ionic bond*. Explain what is happening in the following figure below (Figure 2.14 in your text):

See page 39 of your text for the labeled figure.

This figure represents electron transfer and ionic bonding. The lone valence electron of a sodium atom is transferred to join the 7 valence electrons of a chlorine atom. Each resulting ion has a completed valence shell. An ionic bond can form between the oppositely charged ions, forming sodium chloride, NaCl.

22. What two elements are involved above?

Sodium (Na) and chlorine (Cl)

23. Define *anion* and *cation*. In the preceding example, which is the anion?

Anion is a negatively charged ion. Cation is a positively charged ion. In the preceding example, chloride ions are the anion, and sodium ions are the cation.

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

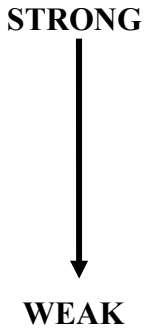
See page 41 of your text for the labeled figure.

A hydrogen bond is a noncovalent attraction between the hydrogen of one molecule with the oxygen or nitrogen of another molecule. There are no hydrogen bonds in a single molecule of water, but the hydrogens of one water molecule will hydrogen bond with the oxygen of another.

25. Explain *van der Waals interactions*. Though they represent very weak attractions, when these interactions are numerous they can stick a gecko to the ceiling!

Molecules with nonpolar covalent bonds may have positively and negatively charged ions. Electrons are not always symmetrically distributed in such a molecule and may accumulate by chance in one part of the molecule, resulting in regions of positive and negative charges. These ever-changing regions of positive and negative charge enable all atoms and molecules to stick to one another. These van der Waals interactions are individually weak, and occur only when atoms and molecules are very close together, but can be powerful when many such interactions occur simultaneously.

26. Here is a list of the types of bonds and interactions discussed in this section. Place them in order from the strongest to the weakest: hydrogen bonds, van der Waals interactions, covalent bonds, ionic bonds.



Covalent bonds
Ionic bonds
Hydrogen bonds
Van der Waals interactions

27. Use morphine and endorphins as examples to explain why molecular shape is crucial in biology.

The precise shape of a molecule is usually very important to its function in the living cell, and crucial in biology because it determines how biological molecules recognize and respond to one another with specificity. Morphine and other opiates have similar shape to endorphins, and can therefore mimic the pain-relieving effect of endorphins by binding to endorphin receptors in the brain.

Concept 2.4 Chemical reactions make and break chemical bonds

28. Write the chemical shorthand equation for photosynthesis. Label the *reactants* and the *products*.

$$6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2$$

Reactants Products

29. For the equation you just wrote, how many molecules of carbon dioxide are there? 6

How many molecules of glucose? 1 How many elements in glucose? 3

30. What is meant by *dynamic equilibrium*? Does this imply equal concentrations of each reactant and product?

Dynamic equilibrium means that reactions are still going on, but with no net effect on the concentrations of the reactants and products. Equilibrium does not mean that the reactants and products are equal in concentration, but only that their concentrations have stabilized at a particular ratio.

Test Your Understanding Answers

Now you should be ready to test your knowledge. Place your answers here:

1. a 2 . e 3. b 4. a 5. d 6. b 7. c 8.e