Answers to Textbook Questions

to accompany

Principles of Life, Second Edition

Hillis • Sadava • Hill • Price

Chapter 2: Reconstructing and Using Phylogenies

Concept Checkpoint Questions

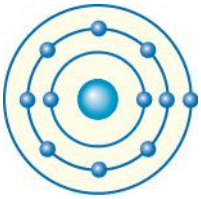
Concept 2.1 Atomic Structure Is the Basis for Life's Chemistry

1. What is the arrangement of protons, neutrons, and electrons in an atom?

Answer: Protons and neutrons are in the nucleus, and electrons orbit the nucleus in shells of space around the nucleus.

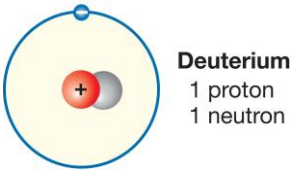
2. Sketch the electron shell configuration of a sodium atom (symbol Na), which has 11 protons. According to the octet rule, what would be the simplest way for a sodium atom to achieve electron stability?

Answer:



The simplest way to achieve stability would be for Na to lose the one electron in its third shell.

3. Many elements have isotopes, which are rare variants of the element with additional neutrons in the nucleus. Deuterium is an isotope of hydrogen that has one neutron (normal hydrogen has no neutrons). Does the neutron change the chemical reactivity of deuterium, compared with normal hydrogen? Explain why or why not.



Answer: Since chemical reactivity is mainly determined by electrons, and the number of electrons in deuterium is the same (1) as in hydrogen, reactivity will be the same.

Concept 2.2 Atoms Interact and From Molecules

1. Compare electron behavior in ionic, covalent and hydrogen bonds. Which is strongest and why?

Answer: In covalent bonds, valence electrons are shared among atoms. In ionic bonds, all valence electrons are transferred from one atom to the other. Hydrogen bonds don't involve shared or transferred electrons –the electronegative atoms (F, O, S, N, etc) attract the partial positive charge of nearby hydrogen atoms.
A hydrogen bond is the strongest intramolecular force, and a covalent bond is stronger than an ionic due to electrons being shared between atoms.

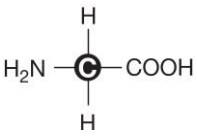
2. How do variations in electronegativity result in the unequal sharing of electrons in polar molecules?

Answer: If one atom (A) participating in a covalent bond is more electronegative than the other atom (B), the electrons participating in the bond will be more attracted to the nucleus of A than of B. So the resulting bond will be polar, with δ^- at A and δ^+ at B.

3. Consider the molecule carbon dioxide (CO_2). Are the bonds between the C and the O ionic or covalent? Is this molecule hydrophilic of hydrophobic? Explain your answers.

Answer: The C and the O in carbon dioxide are bonded covalently, and because it is a linear molecule the electrons are shared equally making CO_2 a non-polar molecule. Because of its polarity, carbon dioxide is hydrophobic.

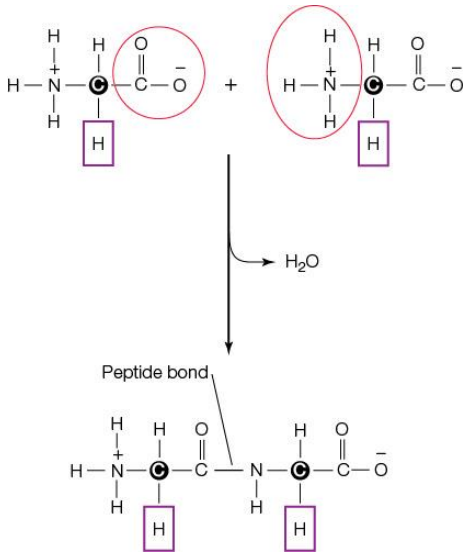
4. Here is the structure of the molecule glycine:



***a*. Is this molecule hydrophilic or hydrophobic? Explain.**

Answer: This molecule iss hydrophobic because the C—H bond is nonpolar.

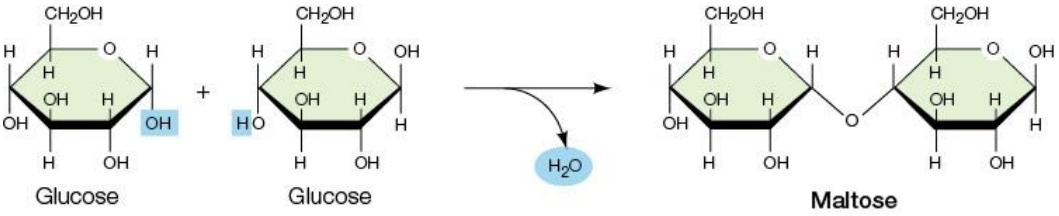
***b*. Draw two glycine molecules and show how they can be linked by a condensation reaction.**
Answer:



Concept 2.3 Carbohydrates Consist of Sugar Molecules

1. Draw the chemical structure of a disaccharide formed from two glucose monosaccharides.

Answer:



2. Examine the glucose molecule shown in Figure 2.9. What are the functional groups on the molecule?

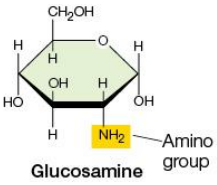
Answer: Hydroxyl

3. Notice the large number of hydrogen bonding groups present in the linear structure of cellulose (see Figure 2.10A). Why is this structure so strong?

Answer: The exposed hydroxyl groups at carbon 2 of each glucose molecule (see Figure 2.9 for the numbering of the carbons) allow for hydrogen bonding with adjacent cellulose chains. The lack of branching in the chains means that many hydrogen bonds can form, resulting in a strong, stable structure.

4. Some sugars have other functional groups in addition to those typically present. Draw the structure of the amino sugar glucosamine, which has an amino group bonded at carbon 2 of glucose. Would this molecule be more or less polar than glucose? Explain why.

Answer:



The amino group in glucosamine makes it more polar than glucose.

Concept 2.4 Lipids Are Hydrophobic Molecules

1. What is the difference between fats and oils?

Answer: Fats have only saturated fatty acids and are solid at room temperature. Oils have unsaturated fatty acids and are liquid at room temperature.

2. Why are phospholipids amphipathic, and how does this result in a lipid bilayer membrane?

Answer: The long fatty acid chains are nonpolar and hydrophobic, whereas the "glycerol end" with an attached phosphate group is polar or charged, and hydrophilic. When put in water, which is polar, phospholipids arrange themselves to maximize hydrophilic-water interactions, so the polar ends with the phosphate groups are exposed to water, and the fatty acid chains are away from water, interacting with one another. This results in two layers.

3. If fatty acids are carefully put onto the surface of water, they form a single molecular layer. If the mixture is then shaken vigorously, the fatty acids will form round structures called micelles. Explain these observations.

Answer: The single layer results from the polar ends of the fatty acids interacting with polar water molecules at the water surface, with the nonpolar chains sticking up above the surface. When the mixture is shaken, water molecules surround the fatty acid molecules. This causes the fatty acids to form spherical structures (micelles). In each micelle, the polar ends of the fatty acid molecules are in contact with the water, and the hydrophobic ends point toward the center of the sphere.

Concept 2.5 Biochemical Changes Involve Energy

1. Describe the forms of energy used, and the changes in energy, that are involved in reading this book

Answer: Chemical energy in food molecules---->electrical energy in the brain -----> mechanical energy to use muscles to turn pages and move eye muscles, etc.

2. What is the difference between potential energy and kinetic energy? Between anabolism and catabolism? Between endergonic and exergonic reactions?

Answer: Potential is stored energy, kinetic energy is released energy (energy of movement/motion). Anabolism stores chemical energy by building up simpler molecules into more complex ones; catabolism releases chemical energy by breaking down complex molecules into simpler ones. Endergonic reactions use energy; exergonic reactions release energy.

3. Predict whether these situations are endergonic or exergonic, and explain your reasoning:

a. The formation of a phospholipid bilayer membrane

Answer: Exergonic: hydrogen-bonded water molecules are in a lower energy state than separated water molecules (see pp. 24–25); this favors aggregation of the nonpolar tails of phospholipids (see Figures 2.5 and 2.13B).

b. Turning on a TV set

Answer: Endergonic: requires mechanical and electrical energy.