

CHAPTER 2 REVIEW QUESTIONS

- Describe the electric charge, mass, and location of the three major subatomic particles in an atom.
The electron has one unit of negative charge and revolves around the atomic nucleus in orbitals. The proton has one unit of positive charge and is found in the nucleus. The neutron has no charge and is also found in the nucleus.
- Which four kinds of atoms are most abundant in the body?
hydrogen (H), oxygen (O), carbon (C), and nitrogen (N)
- Describe the distinguishing characteristics of the three classes of essential chemical elements found in the body.
The four major elements listed above account for 99.3% of the total atoms in the body. There are seven essential mineral elements—calcium (Ca), chlorine (Cl), magnesium (Mg), phosphorus (P), potassium (K), sodium (Na), and sulfur (S). These are the most abundant substances dissolved in the body fluids. Most of the body's calcium and phosphorus atoms make up the solid matrix of bone tissue. Thirteen other elements, called essential trace elements, are present in extremely small quantities but are nevertheless essential for normal body functions, such as growth and the blood's transport of oxygen.
- How many covalent bonds can be formed by atoms of carbon, nitrogen, oxygen, and hydrogen?
Carbon can form four, nitrogen three, oxygen two, and hydrogen one.
- What property of molecules allows them to change their three-dimensional shape?
Molecules are not rigid structures. Atoms can rotate around their covalent bonds to form different shapes.
- Define an ion and an ionic bond.
ion: an atom that has either gained or lost one or more electrons from its outer electron shell, and thereby acquired a net charge.
ionic bond: a bond between two oppositely charged ions, such as Na^+ and Cl^-
- Draw the structures of an ionized carboxyl group and an ionized amino group.
Carboxyl:

$$\begin{array}{c} \text{O} \\ || \\ \text{R} - \text{C} - \text{O}^- \end{array}$$
Amino:

$$\begin{array}{c} \text{H} \\ | \\ \text{R} - \text{N}^+ - \text{H} \\ | \\ \text{H} \end{array}$$
- Define a free radical.
A free radical is an atom that contains a single (unpaired) electron in an orbital of its outer shell, as are molecules containing such atoms.
- Describe the polar characteristics of a water molecule.
Water has the structure:

$$\begin{array}{ccc} (+) & (-) & (+) \\ \text{H} & - \text{O} & - \text{H} \end{array}$$
The bonds between oxygen and each of the two hydrogen atoms are polar, meaning that oxygen, with eight times as many protons as hydrogen, draws the shared electrons closer to its nucleus. Water molecules interact with each other through hydrogen bonds.

10. What determines a molecule's solubility or lack of solubility in water?
For a molecule to dissolve in water (i.e., be hydrophilic), it must be electrically attracted to water molecules. In other words, it must have a sufficient number of polar bonds and/or ionized groups. Nonpolar molecules do not dissolve in water because their electrically neutral covalent bonds are not attracted to water molecules. Nonpolar molecules are thus hydrophobic.
11. Describe the organization of amphipathic molecules in water.
Amphipathic molecules have two parts or domains: a polar or ionized region at one end and a nonpolar region at the other end. In water, such molecules form clusters so that their hydrophilic "heads" are oriented on the outside of the cluster and their hydrophobic "tails" are oriented toward the inside, away from the water molecules.
12. What is the molar concentration of 80 g of glucose dissolved in sufficient water to make 2 L of solution?
Glucose has a molecular weight of 180. Eighty g of glucose is $80/180 = 0.44$ mol/2 L. This is equivalent to 0.22 mol/L.
13. What distinguishes a weak acid from a strong acid?
Molecules that release hydrogen ions in solution are called acids. A strong acid releases 100% of its hydrogen ions, while a weak acid does not ionize completely in solution.
14. What effect does increasing the pH of a solution have upon the ionization of a carboxyl group? An amino group?
Increasing the pH of a solution decreases the concentration of free hydrogen ion in that solution, and thus will favor increasing the ionization of weak acids, such as a carboxyl group. It will decrease the ionization of weak bases, such as an amino group.
15. Name the four classes of organic molecules in the body.
carbohydrates, lipids, proteins, and nucleic acids
16. Describe the three subclasses of carbohydrate molecules.
The basic unit of the carbohydrates is the monosaccharide, which has the chemical formula $C_n(H_2O)_n$, where "n" is any whole number. Two monosaccharides can join together to form a disaccharide. Polysaccharides are polymers of monosaccharides.
17. What properties are characteristic of lipids?
Lipids are composed primarily of carbon and hydrogen atoms, which form nonpolar covalent bonds. Thus, lipids are nonpolar and hydrophobic.
18. Describe the subclasses of lipids.
Fatty acids: Fatty acids consist of a chain of carbon and hydrogen atoms with an acidic carboxyl group at one end; therefore, they contain two oxygen atoms in addition to their complement of carbon and hydrogen atoms. Saturated fatty acids result when all the carbons are linked by single covalent bonds. Unsaturated fatty acids contain one or more double bonds between carbon atoms. If one double bond is present, the fatty acid is monounsaturated, and if there is more than one double bond, it is polyunsaturated.
Triglycerides: Most of the body's lipids are triglycerides, or "fat." Each triglyceride is composed of three fatty acids linked to a three-carbon carbohydrate named glycerol.
Phospholipids: A phospholipid is similar to a triglyceride except that in a phospholipid two fatty acid chains are linked to glycerol, with the sugar's third hydroxyl group attached to a phosphate group. Often a polar or ionized nitrogen-containing molecule is attached to the phosphate. Phospholipids, therefore, have a polar region as well as nonpolar ends and are thus amphipathic.
Steroids: These are composed of four interconnected rings of carbon atoms bound to hydrogen atoms and each other, with a variety of chemical groups attached to different places in the rings.
19. Describe the linkages between amino acids that form polypeptide chains.

Amino acids are linked together when the carboxyl group of one reacts with the amino group of another, forming a peptide bond and releasing a molecule of water (dehydration). The carboxyl group of the second amino acid can react with the amino group of a third, and so on, forming a polymer called a polypeptide.

20. What distinguishes the terms peptide, polypeptide, and protein?

A sequence of amino acids linked by peptide bonds is known as a polypeptide. Strictly speaking, the term polypeptide refers to a structural unit and does not necessarily suggest that the molecule is functional. By convention, if the number of amino acids in a polypeptide is 50 or fewer and has a known biological function, the molecule is referred to as a peptide. When one or more polypeptides are folded into a characteristic shape forming a functional molecule, that molecule is called a protein.

21. What two factors determine the primary structure of a polypeptide chain?

The primary structure of a protein is determined by the number of amino acids in the chain and the specific type of amino acid at each position along the chain.

22. Describe the types of interactions that determine the conformation of a polypeptide chain.

The conformation of a polypeptide is its three-dimensional shape. It is determined by (1) hydrogen bonds between portions of the chain or with surrounding water molecules; (2) ionic bonds between polar and ionized regions along the chain; (3) attraction between nonpolar (hydrophobic) regions; (4) covalent bonds, called disulfide bonds, between the side chains of the amino acid cysteine (not all polypeptides have disulfide bonds); and (5) van der Waals forces, which are very weak and transient electrical interactions between the orbiting electrons in the outer shells of two atoms that are in close proximity to each other.

Hydrogen bonds between the hydrogen linked to the nitrogen in one peptide bond and the oxygen in another occur at regular intervals along the chain and coil it into a helical shape (alpha helix). Hydrogen bonds between peptide bonds running parallel to each other can force a straight structure called a beta pleated sheet.

Some proteins, called multimeric proteins, consist of more than one polypeptide chain.

23. Describe the structure of DNA and RNA.

DNA and RNA are nucleic acids, deoxyribonucleic acid and ribonucleic acid, respectively. The subunits of both nucleic acids are called nucleotides, and consist of a phosphate group, a sugar (deoxyribose in DNA, ribose in RNA), and one of five possible carbon-nitrogen rings called purine or pyrimidine bases. Nucleotides are linked together by covalent bonds between the sugar and phosphate groups of adjacent subunits.

The three-dimensional structure of DNA is a double helix, with the two strands held together by hydrogen bonds between a purine base on one chain and a pyrimidine base on the other. RNA consists of a single chain of nucleotides.

24. Describe the characteristics of base pairings between nucleotide bases.

The bases in DNA are the purines adenine and guanine and the pyrimidines thymine and cytosine. Adenine binds only to thymine and guanine only to cytosine.

RNA can form base pairs with DNA, as above, except that RNA has the pyrimidine uracil instead of thymine. Uracil forms hydrogen bonds with adenine.