Chapter 2 Text Outline (Chemical Foundation for Cells)

A. Selenium from agricultural fertilizer accumulates as selenate in irrigation ponds.

B. Plants can remove this, and other, toxic contaminants in a process known as bioremediation.

I. Regarding the Atoms

A. Structure of Atoms

1. An atom is the smallest unit of matter that retains the properties of a particular element.

2. Atoms are composed of three primary subatomic particles:

a. Protons (p^+) are part of the atomic nucleus and have a positive charge.

b. Neutrons are also a part of the nucleus; they are neutral.

c. Electrons (e^-) have a negative charge. Their quantity is equal to that of the protons. They move around the nucleus.

3. Atomic number equals the number of protons in the nucleus.

4. The mass number of an atom is equal to the number of protons plus the number of neutrons.

B. Isotopes-Variant Forms of Atoms

1. Atoms with the same number of protons (for example, carbon with six) but a different number of neutrons (carbon can have six, seven, or eight) are called isotopes (12_C,13_C, 14_C).

2. Some radioisotopes are unstable and tend to decay into more stable atoms.

a. They can be used to date rocks and fossils.

b. Some can be used as tracers to follow the path of an atom in a series of reactions or to diagnose disease.

II. Focus on Science: Using Radioisotopes to Track Chemicals and Save Lives

III. What Happens When Atom Bonds to Atom?

A. Electrons and Energy Levels

1. Electrons are attracted to protons but are repelled by other electrons.

a. Orbitals permit electrons to stay as close to the nucleus and as far from each other as possible.

b. Each orbital contains one or two electrons.

c. Orbitals can be thought of as occupying shells around the nucleus.

1) The shell closest to the nucleus has one orbital holding a maximum of two electrons.

2) The next shell can have four orbitals with two electrons each for a total of eight electrons.

2. Atoms with "unfilled" orbitals in their outermost shell tend to be reactive with other atoms.

B. From Atoms to Molecules

1. A chemical bond is a union between atoms formed when they give up, gain, or share electrons.

2. A molecule is a bonded unit of two or more (same or different) atoms.

3. Compounds are substances in which two or more different elements are combined in fixed proportions.

4. A mixture contains two or more elements in intermingled proportions that can vary.

IV. Important Bonds in Biological Molecules

A. Ion Formation and Ionic Bonding

1. When an atom loses or gains one or more electrons, it becomes positively or negatively charged—an ion.

2. In an ionic bond, (+) and (-) ions are linked by mutual attraction of opposite charges, for example, NaCl.

B. Covalent Bonding

1. A covalent bond holds together two atoms that share one or more pairs of electrons.

2. In a nonpolar covalent bond, atoms share electrons equally.

3. In a polar covalent bond, because atoms share the electron unequally, there is slight difference in charge between the two poles of the bond; water is an example.

C. Hydrogen Bonding

1. In a hydrogen bond, an atom or a molecule interacts weakly with a hydrogen atom already taking part in a polar covalent bond.

2. These bonds impart structure to liquid water and stabilize nucleic acids and other large molecules.

V. Properties of Water

A. Polarity of the Water Molecule

1. Because of the electron arrangements in the water molecule, a polarity results that allows water to form hydrogen bonds with one another and other polar substances.

2. Polar substances are hydrophilic (water-loving); nonpolar ones are hydrophobic (water-dreading) and are repelled by water.

B. Water's Temperature-Stabilizing Effects

1. Water tends to stabilize temperature because it can absorb considerable heat before its temperature changes.

2. This is an important property in evaporative and freezing processes.

C. Water's Cohesion

1. Hydrogen bonding of water molecules provides cohesion (capacity to resist rupturing).

2. Cohesion imparts surface tension and helps pull water through plants for example.

D. Water's Solvent Properties

1. Water is a great solvent because ions and polar molecules (solutes) dissolve in it.

2. The solvent properties of water are greatest with respect to polar molecules because "spheres of hydration" are formed around the solute molecules.

VI. Acids, Bases, and Buffers

A. The pH Scale

1. pH is a measure of the H^+ concentration in a solution; the greater the H^+ the lower the pH scale.

2. The scale extends from 0 (acidic) to 7 (neutral) to 14 (basic).

3. The interior of living cells is near pH = 7.

B. How Do Acids Differ From Bases?

1. A substance that releases hydrogen ions (H^+) in solution is an acid; for example, HCl.

2. Substances that release ions such as OH^- (hydroxide ions) that can combine with hydrogen ions are called bases.

C. Buffers Against Shifts in pH

1. A buffer system is a partnership between a weak acid and the base that forms when it dissolves in water.

2. Buffer molecules combine with, or release, H^+ to prevent drastic changes in pH.

3. Carbonic acid is one of the body's major buffers.

D. Salts

1. A salt is an ionic compound formed when an acid reacts with a base; example: NaOH $^+$ HCl ——> NaCl $^+$ $H2_O$.

2. Many salts dissolve into ions that serve key functions in cells; nerve function, for example, is dependent on ions of sodium, potassium, and calcium.