

Chapter 3 The Chemistry of Life

Matter— Any substance that has mass and occupies space.

Element— Any substance that cannot be broken down by normal chemical means. An element is comprised only into a single type of atom

Atom—The smallest particle into which a substance can be divided and still retain its chemical properties.

- Subatomic Particles
 - **Neutrons** are found in the nucleus. They have a mass of 1 and have no electrical charge.
 - **Protons** are found in the nucleus. They have a mass of 1 and a positive electrical charge.
 - **Electrons** are found in shells (orbitals) around the nucleus and essentially have no mass. They have a negative charge. Electrons carry energy. Later we will look at energy reactions in which the energy is 'carried' by electrons.
- **Atomic number**
 - The number of protons in the nucleus. It determines what type of atom it is.
Ex. Hydrogen has an atomic number of 1, or has a single proton. It may lose its electron (H⁺) and may have 0, 1 or 2 neutrons.
- **Atomic mass**
 - The "weight" of the atom, the number of protons and neutrons. For this course we are ignoring the mass of the electrons.
- The reactivity of the atom
 - Electrons determine the reactivity of the atom. An atom will react in manner that will fill the outer shell.
- **Ion**
 - An atom that has gained or lost one or more electrons so that it has a charge.
- **Isotopes**
 - Isotopes are atoms with the same number of protons but different number of neutrons or are atoms with the same atomic number but different atomic weights
 - Ex. There are three isotopes of hydrogen. All have an atomic number of 1 (or have 1 proton) but one has no neutron, one has one, and another has 2 so the atomic masses are 1, 2, and 3 respectively.
 - Ex. Carbon typically has 6 protons, 6 neutrons, 6 electrons (C¹²) but C¹⁴ has 6 protons, and 8 neutrons.
 - **Radioisotopes**
 - Isotopes with "extra" neutrons may be unstable. The nucleus will decay and give off radioactivity. They decay at a rate that is specific to the isotope. The half-life is the time it takes half of the isotopes present to decay.

Molecule

- A group of atoms held together by energy (or by chemical bonds). A particular type of molecule will have specific atoms in a set ratio (ex. H₂O).

Chemical Bonds

- **Ionic bonds**
 - Ions are held together by their opposite electrical charges. Ionic bonds are relatively weak
- **Covalent bonds**
 - Atoms are held together by shared electrons. Covalent bonds are relatively strong.
 - **Nonpolar covalent bond**--The electrons are equally shared. Molecules held together by nonpolar bonds is also not polar.
 - **Polar covalent bond**--The electrons are not equally shared. This results in a molecules with areas of charge.

- **Hydrogen Bonds**
 - Hydrogen bonds form between the positive end of one polar molecule and the .negative end of another polar molecule.
 - Hydrogen bonds are important in a number of biologically significant molecules including DNA ‘ and protein.

Water

- Water has a number of unique properties that make it necessary for life.
- **Unique Properties of Water** include heat storage, ice formation, high heat of vaporization, cohesion, and high polarity.
 - **Heat storage**
 - The temperature of water changes lowly. Because organisms contain so much water, their temperature changes more slowly. The temperature of bodies of water changes slowly. This helps moderate temperatures of bodies of water and areas near large bodies of water.
 - **Ice Formation**
 - As water cools, its molecules slow down. As it slows down, more and more hydrogen bonds form. This causes the molecules to move apart and water becomes less dense as it freezes. This causes water to float.
 - **High heat of vaporization**
 - For a molecule of water to evaporate, it must break the hydrogen bonds that hold it. This requires energy. As the molecule evaporates it takes the energy (as heat) with it. As water evaporates, it cools.
 - **Cohesion** (the sticking together of 2 of the same type of molecule)
 - Water molecules form hydrogen bonds to other water molecules. This allows for capillary action. It also allows water to be moved through plants.
 - **High polarity**
 - Because water molecules are polar they will dissolve charged molecules and other polar molecules. Because this, water is the “universal solvent”.
- **Acids and Bases**
 - Water molecules dissociate into hydrogen ions (H+) and hydroxyl ions (OH-). In a liter of pure water only 1 in 10⁷ molecules will ionize. So there will be 1 H+ for every 10,000,000 water molecules. The concentration of hydrogen ions is typically written as {H+} = 1/10,000,000 or 7. The pH is the measure of the hydrogen ion concentration. It is the negative logarithm of the hydrogen ion concentration or $\text{pH} = -\log \{H^+\}$
 - **Acid**
 - Any substance that increases the hydrogen ion concentration is an acid. As the hydrogen ion concentration goes up, the pH goes down.
 - **Base**
 - Any substance that decreases the hydrogen ion concentration (or increases the hydroxyl ion concentration) is a base. As the relative hydrogen ion concentration goes down, the pH goes up .
 - **Buffer**
 - A buffer is a substance that minimizes changes in pH