

## Unit Two: Life, Its Chemical Basis

Upon Completion of this unit you will be able to:

- 1. Define, describe and discuss the following terms:**
  - a. Matter, compound, ion, electrolyte, energy, electron**
  - b. Isotope, ionic bond, atom, proton, acid, covalent bond**
  - c. Element, neutron, base, nonelectrolyte, molecule, pH**
- 2. Give the chemical symbols for the more common elements found in biological materials**
3. Distinguish between chemical formulas, symbols and equations.
- 4. Distinguish between atomic weight and atomic number.**
- 5. Explain why the physical properties of elements are unique but the chemical properties of one element are similar to those of several.**
6. Differentiate between oxidation and reduction.
7. Recognize whether or not a chemical equation is balanced.
8. Identify four types of chemical reactions and give examples.
- 9. List differences between ionic and covalent compounds.**
- 10. Explain what happens when a covalent compound and an ionic compound is placed in water.**
- 11. Discuss ionic, covalent and hydrogen bonding**
- 12. Explain how radioactive isotopes differ from the more commonly occurring isotope of an element.**
- 13. Explain why isotopes of a particular element exhibit the same chemical behavior despite differing in atomic weight.**
14. Provide some uses of radioactive isotopes in biological studies.
- 15. Distinguish between an acid and a base on the basis of pH and state the significance of buffer systems.**
- 16. List some of the unique properties of water and explain their importance to living things.**

Unit References: Text Chapter 2

[McGraw Hill Publishers: Enger 13<sup>th</sup> Edition](#)

[Online Biology Text Book](#)

[Biozone](#) (has podcasts)

[Ology](#) (American Museum of Natural History)

[Chemicool Periodic Table](#)

[Periodic Table of the Elements](#)

[CHEMystery](#)

## Unit Two: Life Its Chemical Basis

### Chemical Terminology (pg 24-28) (objective 1)

**Matter**- anything that occupies space and has mass (solid, liquid, gas, plasma)

-density, activity (energy: Kinetic, potential)

**Elements**- building blocks, **Mother Natures raw materials**. 92 naturally occurring (pg 26)

**Remember!!!** Cells are Factories, what are the raw materials the factory requires to make their products?

Where do we get these raw materials? Where is Mother Natures Home Depot?

Imagine Mother Natures Building Center, materials are called elements

**Smallest unit of each element is Atom (pg 25-28)**

**Nucleus**- Contains two parts

**Proton**- positively charged subatomic particle

**Neutron**- neutral subatomic particle

**Electron Cloud**- Contains **electrons** (negatively charged subatomic particles) in orbits around nucleus

Electrons primarily determine the behavior of an element.

**Elements**- a substance whose atoms all contain the same # of protons (an equal # of electrons make elements electronically neutral)

- # of neutrons can change as we will soon see

Check out: [A Look Inside The Atom](#)

**Common elements and their symbols (Objective 2) (pg 26)**

**C H O P K I N S Ca Fe Mg but don't forget to bring your Na Cl**

There are about 20 elements necessary to support life

**C**- carbon

**H**- hydrogen

**O**- oxygen

**N**- nitrogen

These four elements make up 95% of each of us! Add P, S and Ca to bump that to 99+%

Check out: [What the Heck Do You Mean Oxygen is Harmful?](#)

**Periodic Table of Elements (objective #4) (pg 26)- Mother Natures Catalog of Materials**

*Horizontal rows are Periods*

*Vertical columns are Families, behave similarly*

Three pieces of info always provided (*Check out the Entry for Carbon*)

**Atomic Number**- Tells the **number of Protons** in an atom of the element

**Chemical Symbol/Name**

**Atomic Weight/Mass** (*incorrectly labeled in your book!!*)- Average of all isotopes of the element

**Atomic Mass** (which we will use most) Determined by **adding the # of Protons to the # of neutrons**

**For Carbon:** Atomic # = 6

Symbol = C

Atomic Weight = 12.0 (we will work primarily with whole numbers)

Check Out: [Periodic Table of the Elements](#)  
[CHEMystery](#)

**Isotopes** (objectives 12, 13, 14) (pg 27)

**Different forms of the same atom (element) that differ in the number of neutrons and therefore their atomic weight.**

Ex, Carbon (always has six protons)

Common Notation for Carbon is **C<sup>12</sup>, C<sup>13</sup>, C<sup>14</sup>, C<sup>15</sup>**, etc (there are seven isotopes of Carbon)

**Superscript is the Atomic Weight**, determined by adding protons to neutrons

Therefore **C<sup>12</sup>** has six protons and six neutrons

**C<sup>13</sup>** has six protons and seven neutrons, etc.

**Molecules**- combinations of the atoms of elements, smallest unit of a substance that acts like that

substance

**Compounds**- substance made up of atoms of two or more elements in specific ratios

**Mixture**- contains two or more substances not in proportion

**Solution**

**Solvent**

**Solute**

**Ways to “See” Chemistry**

**Chemical Symbol**

**Empirical Formulas**- ex., Glucose  $C_6H_{12}O_6$

**Structural Formulas**- Glucose [pg 48](#)

**Chemical Equations**- show reactions

$6CO_2 + 6H_2O + \text{sun} \rightarrow C_6H_{12}O_6 + 6O_2$  Equation for Photosynthesis

(reactants)

(products)

## Properties of Elements (Objective #5)

**Physical properties of elements**- properties that can be seen or measured; some are shiny metals, some gases, some liquid, some solid

**Chemical (Behavioral) properties of an element**- the way atoms combine or react with other atoms, show similarities among groups of elements (vertical columns/families, determined by electrons in outer shell)

Check out: [Chemical Bonds](#)

[CHEMystery](#)

[Chemistry Intro](#)

[Chemical Bond Properties](#)

**Chemical Bonds**- how Mother Nature's building materials react with each other to form matter (Objectives 9-11)

**Octet Rule**

**Ionic Bonds-** (pg 31-32) **Electron transfer/donation.** Formation of ions (electrically charged atoms) by gaining or losing electrons

**Ion formation}**     $\text{Na} \rightarrow \text{Na}^+$  an electron is lost  
                          $\text{Cl} \rightarrow \text{Cl}^-$  an electron is gained

Oppositely charged ions attract one another and form an Ionic Bond

$\text{Na}^+ + \text{Cl}^- \rightarrow \text{NaCl}$  ions will seek electrical neutral state through pairing

Why we need them: conduction

**When Ionic substances are placed in water they:**

**-dissociate (break apart)**

**$\text{NaCl}$  into  $\text{H}_2\text{O} \rightarrow \text{Na}^+ + \text{Cl}^-$**

**-when dissociated they recreate positive and negative ions**

**-when dissociated they can conduct electrical current**

**-when dissociated create electrolytic solutions, ions are electrolytes (salts, acids, bases)**

**Covalent Bonds-** (pg 32-34) co- (prefix = share) Co Champion, Co Chairman, etc.

**Electrons shared to satisfy octet, much stronger union**

$\text{H}_2\text{O}$ - oxygen needs two electrons to fill, hydrogen has one electron

**When Covalently bound substances are placed in water they:**

**-do not dissociate**

**-do not create ions**

**-do not conduct electricity, Non-Electrolytes (glucose)**

Carbon, hydrogen, nitrogen and oxygen primarily use covalent bonds, structural

**Hydrogen Bonds (pg 34)**- not considered true chemical bonds because they do not bond atoms together.

-occurs between slightly positive hydrogens and slightly negative oxygens

Hydrogen bonds hold water molecules together to form liquid water.

## **Substances in Living Systems and Chemical Change (pg 35-41) (objectives 6, 8, 15, 16)**

Quick Review: C HOPKINS Ca Fe Mg, Na Cl

Top Six represent building blocks for four major organic molecules

Carbs, Proteins, Fats, DNA

### **Primary Molecules**

#### **Water (H<sub>2</sub>O) (pg 36)**

-universal solvent

-medium for chemical reactions, virtually all chemical reactions in living cells occur in water

-cohesive, adhesive

-resists changes in temperature and state

-less dense as solid

-surface tension/ specific gravity

Check out: [Water Resources](#)

[Water on the Web](#)

### **Carbon Dioxide (CO<sub>2</sub>), Oxygen (O<sub>2</sub>), Ammonia (NH<sub>3</sub>)**

## **Chemical Reactions (pg 35-38) (objectives 6, 8)**

Reactants → Products

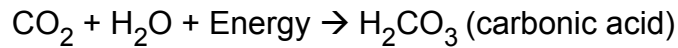
-bonds break, elements combine, compounds reform, equation shows reactants, products

### **Oxidation/Reduction reactions (REDOX)**

**Oxidation** – loss of electrons and/or hydrogens

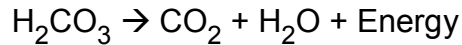
**Reduction** – gain of electrons and/or hydrogens

## Synthesis Reactions- anabolic (building)



**Endothermic** reaction- requires energy (light, heat) Ex. Photosynthesis

## Decomposition Reactions- catabolic (breakdown)

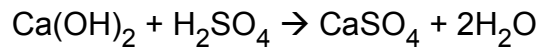


**Exothermic** reaction- energy release Ex. Respiration, decomposition

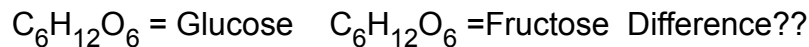
## Dehydration Synthesis

## Hydrolysis

## Exchange Reactions (recombinations)



## Rearrangement Reactions



## Phosphorylation Reactions

## Ionic Dissociation (objective #16) (pgs 38-41)

Ionic Compounds, electrolyte, nonelectrolyte

Check Out: [Chemical bond properties](#)

[Chemtutor](#)

[Acids, Bases and Role of Water](#)

[Acids and Bases](#)

[Experiments with Acids and Bases](#)

## Acid/Base

Ionization of Water  $\text{H}_2\text{O} \rightarrow \text{H}^+ + \text{OH}^-$

$\text{H}^+$  = hydrogen ion

$\text{OH}^-$  = hydroxyl ion

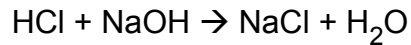
**ACIDS**- molecules that release hydrogen ions ( $\text{H}^+$ ) when they dissociate

Ex. Hydrochloric Acid (HCl) almost completely dissociates in water

**BASES**- molecules that release hydroxyl ions (OH<sup>-</sup>) when they dissociate  
(alternate definition- substances that attract, “neutralize”, H<sup>+</sup> ions

Ex. Sodium Hydroxide NaOH, Sodium bicarbonate NaHCO<sub>3</sub>

When acids and bases combine you get salts



**pH**- indicates relative concentrations of H<sup>+</sup> and OH<sup>-</sup> (pg 41)

Water- neutral pH 7

Acids-[H<sup>+</sup>] is greater than [OH<sup>-</sup>] pH 0 → 6.9

Bases- [OH<sup>-</sup>] is greater than [H<sup>+</sup>] pH 7.1 → 14

**Buffers** (pg 40) (objective 15) chemicals that can both take up and release hydrogen ions  
(sodium bicarbonate, carbonic acid, 7UP, Milk of Magnesia, Tums, etc.

Check out: [pH and Buffers](#)

[pH Buffers in the Blood](#)

[Buffer Solutions](#)