

## Basic Chemistry

- Why do we study chemistry in a biology course?
- All living organisms are composed of chemicals. To understand life, we must understand the structure, function, and properties of the chemicals that make up living organisms.

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## Objective # 1

List the 3 main types of subatomic particles and indicate the mass and electrical charge of each.

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## Objective 1 – Subatomic Particles

Name	Symbol	Charge	Mass (daltons)	Mass Number
Proton	p	+1	1.00728	1
Neutron	n	0	1.00867	1
Electron	e	-1	0.00055	0

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## Objective # 2

Describe the basic structure of the atom and be able to define the following terms: nucleus, energy level, isotope, and ion.

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## Objective 2

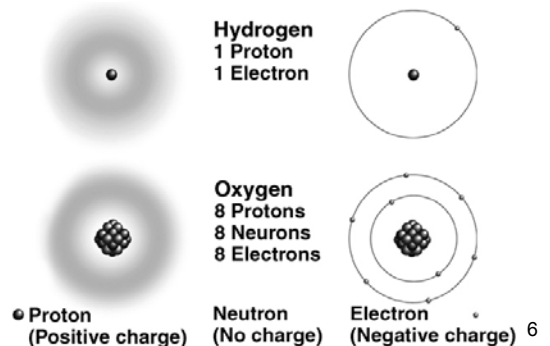
- Atoms are composed mainly of protons, neutrons, and electrons.
- The protons and neutrons are closely packed together in the central part of the atom called the nucleus
- The electrons are in constant, random motion around the nucleus. They are organized into energy levels or shells located different distances from the nucleus:

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## Objective 2

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### Basic Structure of Atoms



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## Objective 2

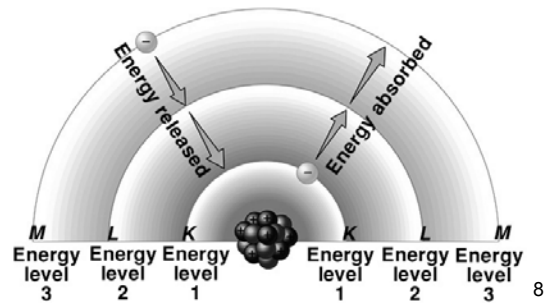
- Energy levels and shells mean the same thing.
- We use numbers to identify the energy levels (1, 2, 3, etc) or letters to identify the shells (K, L, M, etc).
- Electrons in higher energy levels tend to have more energy and tend to be located farther away from the nucleus than electrons in lower energy levels:

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## Objective 2

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### Atomic Energy Levels



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## Objective 2

- Rules for filling energy levels:
  - The first electrons in an atom enter the K shell, up to a maximum of 2.
  - The next electrons enter the L shell, up to a maximum of 8.

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## Objective 2

- The pattern for filling higher shells becomes more complex and will not concern us. However, what you should remember is that even though any shell beyond L can hold more than 8 electrons, it will not hold more than 8 when it is the outermost shell.

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## Objective 2

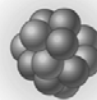
- Atoms that have the same number of protons but different numbers of neutrons are called isotopes.

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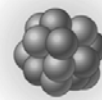
## Objective 2

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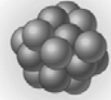
### Carbon Isotopes



**Carbon-12**  
6 Protons  
6 Neutrons  
6 Electrons



**Carbon-13**  
6 Protons  
7 Neutrons  
6 Electrons



**Carbon-14**  
6 Protons  
8 Neutrons  
6 Electrons

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### Objective 2

- Normally, the number of electrons in an atom equals the number of protons and the overall charge of the atom is zero.
- However, atoms may gain or lose electrons:
  - If an atom gains electrons, it will have an extra negative charge for each electron gained.
  - If an atom loses electrons, it will have an extra positive charge for each electron lost.

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### Objective 2

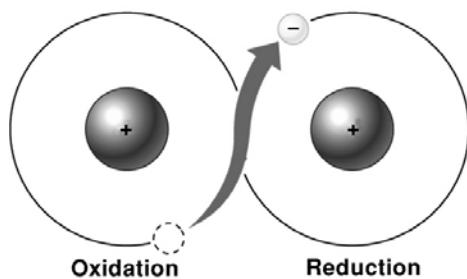
- The gain of electron(s) is called reduction and the loss of electrons is called oxidation.
- Atoms that have gained or lost electrons and are no longer electrically neutral are called ions:
  - positive ions = cations
  - negative ions = anions

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### Objective 2

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### Oxidation and Reduction



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### Objective # 3

Define the term “element” and know the names and chemical symbols of the principle elements found in living organisms.

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### Objective 3

- An element is a substance composed of only one type of atom.
- By “one type of atom”, we mean all the atoms have the same number of protons. However, the number of neutrons and electrons in the atoms that make up an element can vary.

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### Objective 3 – Some Important Elements in Living organisms

Element	Symbol	# of protons
Oxygen	O	8
Carbon	C	6
Hydrogen	H	1
Nitrogen	N	7
Calcium	Ca	20
Phosphorus	P	15
Potassium	K	19

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### Objective # 4

- Be able to determine the number of protons, neutrons, and electrons in an atom if you know its atomic number, atomic mass, and overall charge. Also be able to determine the number of electrons in each energy level of an atom if you know the total number of electrons present.

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### Objective 4

- The number of protons in an atom is called the atomic number. All atoms of the same element ALWAYS have the same atomic number.
- The number of protons plus the number of neutrons in an atom is called the atomic mass or atomic weight. Different isotopes of the same element will have different atomic weights.

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### Objective 4

- # p = atomic number
- # n = atomic mass – atomic number
- # e:
  - If overall charge is 0, #e = #p
  - If overall charge is +, take the #p and subtract one for each overall + charge
  - If overall charge is -, take the #p and add one for each overall - charge

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### Objective # 5

Define the term “molecule” and explain how the molecular formula (or chemical formula) and the structural formula are used to provide information about a molecule.

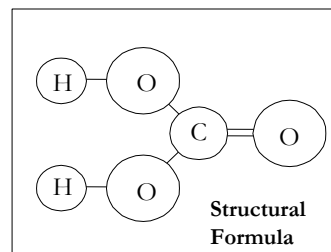
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### Objective 5

- Molecule: a unit composed of two or more atoms joined together by chemical bonds.
- Structural formula: shows us the actual arrangement of the atoms.
- Molecular formula or chemical formula: tells us what types of atoms and how many of each are joined together.

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### Objective 5



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### Objective # 6

Explain the difference between an element, a compound, and a mixture.

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### Objective 6

- Element: a substance composed of only one type of atom (all the atoms have the same number of protons). The atoms may occur singly, or they may be joined to form molecules. The smallest unit of an element that retains the properties of the element is a single atom. e.g. hydrogen

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### Objective 6

- Compound: a substance composed of 2 or more elements that have been joined by chemical bonds. The smallest unit of a compound that retains the properties of the compound is a molecule. e.g. water
- Mixture: a combination of 2 or more substances that do NOT chemically combine and retain their individual properties. e.g. sugar mixed with salt

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### Objective # 7

Explain how the number of electrons in the outermost shell of an atom affects the number and type of chemical bonds the atom can form.

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### Objective 7

- Electrons in the outermost shell are called: valence electrons
- Atoms join together in ways that give each atom a stable outer shell of electrons:
  - If the first shell is the outer shell, it is stable with 2 electrons.
  - If any other shell is the outer shell, it is stable with 8 electrons.

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### Objective 7

- How can an atom obtain a stable outer shell of electrons if it doesn't already have one?
  - Gain electrons
  - Lose electrons
  - Share electrons

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### Objective # 8

- Discuss the mechanism involved in forming the following types of chemical bonds, describe their characteristics, and be able to give examples of each:
  - a) Ionic bond
  - b) Nonpolar covalent bond
  - c) Polar covalent bond
  - d) Hydrogen bond

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### Objective 8a

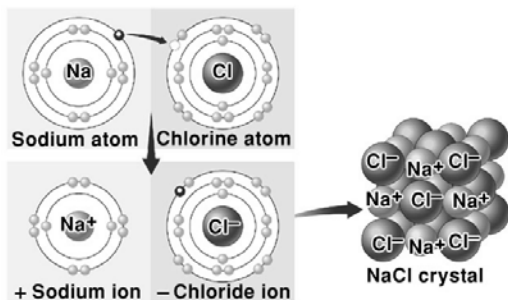
- Ionic bonds:
  - Involve a transfer of electrons from one atom to another in order to give both atoms a stable outer shell.
  - The transfer of electrons produces oppositely charged ions that attract each other to form the ionic bond. e.g. when Na and Cl come near each other, Na loses an electron and Cl gains it.

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### Objective 8a

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### Formation of Ionic Bonds — NaCl



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### Objective 8b & 8c

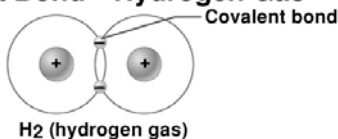
- Covalent bonds involve a sharing of one or more pairs of electrons between 2 atoms in order to give both atoms a stable outer shell.
- In covalent bonds, electrons are always shared in pairs:
  - One pair = single covalent bond
  - Two pairs = double covalent bond
  - Three pairs = triple covalent bond

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### Objective 8b & 8c

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### Covalent Bond—Hydrogen Gas



Hindenburg

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### Objective 8b & 8c

- Nonpolar covalent bonds involve an equal sharing of electrons between atoms. Each atom has an overall charge of zero.
- Polar covalent bonds involve an unequal sharing of electrons between atoms. The atom that attracts the electrons more strongly has a slight negative charge and the atom that attracts the electrons more weakly has a slight positive charge.

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### Objective 8d

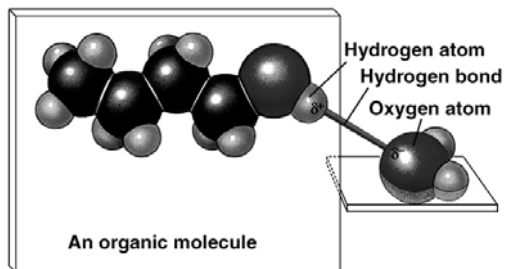
- Hydrogen bond:
  - The weak attraction between a covalently bound H atom with a slight positive charge and another covalently bound atom with a slight negative charge.
  - May occur between different molecules or between different parts of the same molecule.

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### Objective 8d

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### Hydrogen Bond Structure



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