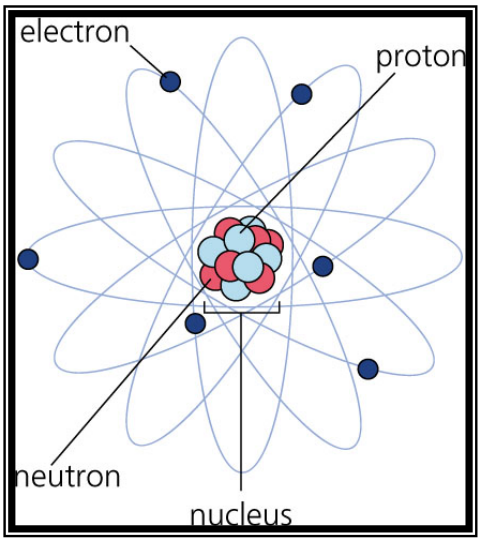
Basic Chemistry

The cell is a complex "biochemical" factory. In addition to organelles, the cell is made up of atoms, elements, compounds, and molecules. To understand the functions of organelles and the biochemical activities that take place in the cell, it is important to have an understanding of chemistry.

Review of Familiar Terms:

1. **Elements:** single substances that cannot be broken down into simpler substances. Ex: iron, helium
2. **Atoms:** building blocks of elements. Elements are made up of **ONE** type of atom. Ex: iron is made up only of iron atoms, helium is made up of only one type of helium atoms.
3. **Compounds: TWO or MORE** elements that are **CHEMICALLY** combined. Compounds have physical and chemical characteristics that differ from their elements. Ex: H_2O, NaCl (salt), $C_6H_{12}O_6$ (glucose), NH_3, CO2
4. **Molecules:** basic unit of structure and function of a compound. Molecules are the smallest units that maintain the chemical and physical characteristics of the compound.

The Structure of an Atom

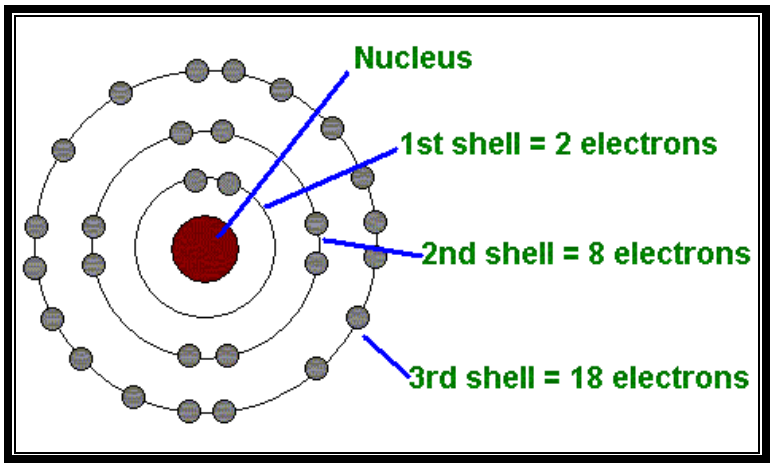


- The atom is made up of:
  a. <u>Central Nucleus</u> which contains:
  -- ***protons*** (+ charge)
  --***neutrons*** (no charge)
  b. ***Electrons*** (- charge) are found circling around the central nucleus in specific paths called **shells or energy levels.** The symbol for electrons is **e-.**
- **<u>Atomic Number</u>**: the **NUMBER OF PROTONS** in the central nucleus of the atom.
  a. Ex: hydrogen has only 1 proton, so its atomic number is 1.
  b. Ex: oxygen has 8 protons in its nucleus, so its atomic number is
- the **number of protons equals the number of electrons in an atom**, so the overall electrical charge of an atom is 0.

The Bohr Model of an Atom

- To keep things simple, let's examine the Bohr model to see how electrons orbit around the nucleus of an atom
- First shell, (K) closest to the nucleus, holds 2 electrons
- The second shell (L) holds a maximum of 8 electrons
- The third shell (M) holds a maximum of 18 electrons
- The 4^{th} shell (N) holds 32 electrons
- Once a shell is complete with its complement of electrons, the atom has a **STABLE** electron arrangement and is considered to be **CHEMICALLY INACTIVE.**

Example of a Bohr Model of an Atom

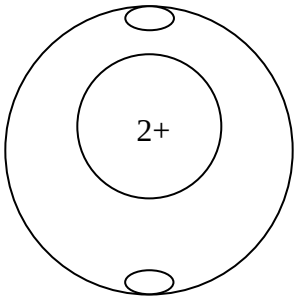


Questions:

1. How do elements differ from one another?

2. How is a molecule similar to a cell?

3. Helium has two protons in its nucleus and 2 electrons as pictured below. Is helium's electron shell stable? Explain.



4. Neon has an atomic number of 10.
   How many protons are found in the nucleus? _____
   How many electrons are found the nucleus? _____
   Draw the electron configuration of neon to the right. Is this atom stable? Explain.

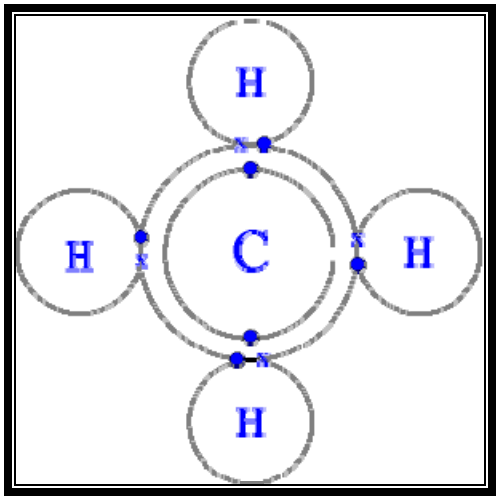
5. From what you have just learned, hypothesize as to what makes an atom chemically active.

How are Compounds Made?

- Elements combine to form compounds by a process called **chemical bonding.**
- Atoms that do not have completely full energy levels or shells are **chemically reactive** and will **form bonds that involve the sharing or transfer of electrons** in order to fill their electronic shells completely.
- **Covalent Bonds:**
  --formed by the sharing of electrons between the two atoms of a compound
  --covalent bonds are **strong** because the electrons **are shared** between the two atoms.

1. Draw the electron configuration of hydrogen (atomic number 1) and carbon (atomic number 6).

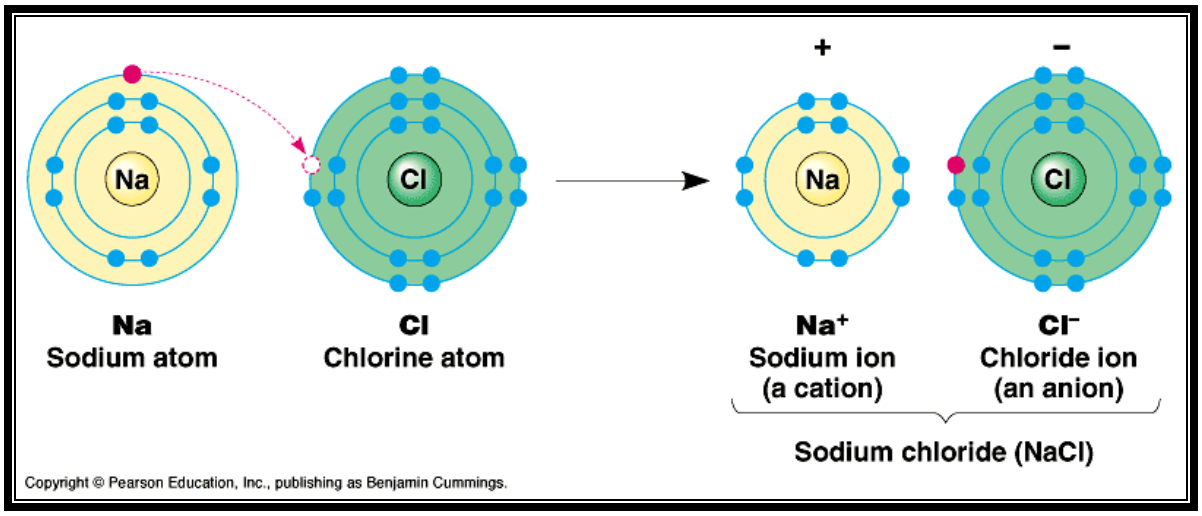
a. How many electrons does hydrogen need to fill its outer shell? _____
b. How many electrons does carbon need to fill its outer shell? _____



2. Examine the electron configuration of a molecule of methane (CH_4) pictured above.
   a. How many bonds were formed in the creation of this compound? _____
   b. What kind of bonds were formed? How do you know?

- **Ionic Bonds:**
  --formed between atoms of a compound as a result of the **transfer of electrons from one atom to another.**
  --the atom that **gains the electron has an overall negative charge**
  -- the atom that **loses the electron has an overall positive charge**
  --**IONS**: atoms that have either **positive (an extra electron) or negative (missing an electron) charge.**
  -- since atoms of an **ionic compound either lose or gain an electron, the bond formed is not as strong as a covalent bond,** where the electrons are equally shared.

Below is an electron configuration diagram of salt (NaCl). Sodium has an atomic number of 10 and chlorine has an atomic number of 17. Please examine it closely.

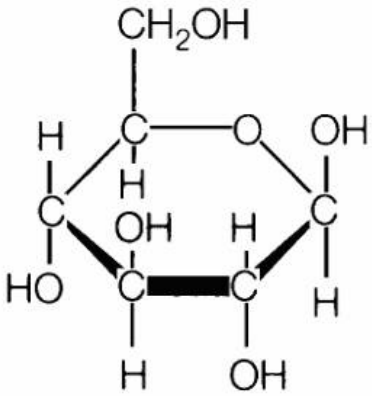


1. Which atom gains an electron when an ionic bond is formed? _____
2. Which atom loses an electron when an ionic bond is formed? _____
3. In the diagram above, draw a circle around the electrons that form the ionic bond.
4. Discuss the similarities and differences between covalent and ionic bonds.

Types of Chemical Formulas

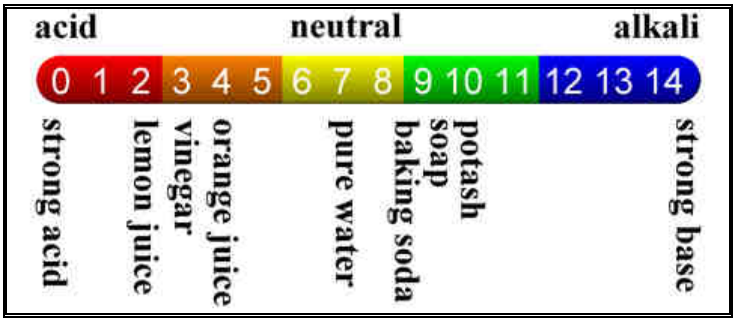
1. **Molecular Formula**: indicates the **actual proportions of the elements in a given compound**. For example, NH3 is the molecular formula for ammonia. It tells us that there is one atom of nitrogen for every three atoms of hydrogen.
2. **Structural Formula:** illustrates how the atoms of a compound are chemically bonded.

Fill in the empirical and molecular formulas for water and glucose in the following table:

Chemical Formula	Water	Glucose
Molecular		
Empirical		
Structural		

Inorganic Compounds:

- DO NOT contain both carbon and hydrogen. H_2O, CO_2, HCl, NH3 are all examples of inorganic compounds.
- The most important inorganic compound in living organics is WATER.
    a. Water is an excellent **SOLVENT** (*dissolves other substances easily*). The cytoplasm is about 90% water making is an excellent site for most of the biochemical reactions that take place in the cell.
    b. **Water has a high heat capacity**. It can absorb large quantities of heat without changing temperature. This capacity is important to living organisms as they must maintain proper body temperature to stay in homeostasis.
    c. Water is important as a **RAW MATERIAL** in many biochemical reactions. Ex. photosynthesis
    d. **Water serves as an excellent transport medium**. In the cell, the cytoplasm moves materials around by **cyclosis.** The plasma of human blood is mostly made up of water, so the blood can easily transport materials throughout the body via **circulation.**
- **ACIDS, BASES, and SALTS** are other important inorganic compounds found in living organisms.
- **pH:** measures the relative strength of an acid or base on a scale of 1-14 with 1 indicating the strongest base, 7 a neutral solution, and 14 indicating the strongest base.



Organic Compounds

- Organic compounds must have **BOTH carbon and hydrogen** as part of their structures.
- Since carbon has an **atomic number of 6, it has four places** on its outer electron shell to bind with other atoms.
  The ability to bond with four other atoms is very unusual for an element. Carbon compounds are also very stable since they share their electrons in their covalent bonds equally. As a result, there is a large variety in the kinds of carbon compounds that can be formed and is why we can have such diversity in the kinds of living organisms found on our planet as well as the variations among members of the same species.

Review:

1. List the four main elements found in all living organisms? Write their chemical symbols next to their names.

2. As you already know, there are trace elements found in all living things. Provide the chemical symbols for the trace elements in the chart below.

Trace Element	Chemical Symbol
Sodium	
Iron	
Magnesium	
Chlorine	
Sulfur	
Potassium	
Calcium	
Phosphorus	

3. Why is water considered to be the most important inorganic compound in living things?