## Atoms

Before we talk about atoms, it is very important to understand elements because atoms are derived from elements, i.e., atoms are the tiny particles existing inside elements. These atoms make the elements to look the way they look. The elements are discussed in the Introduction chapter under Classification of Matter. So before you continue, go back and review that section.

The concept of atom was known to Greeks as early as fifth century B.C. By the way, Greeks were the greater inquisitor of the nature. Greek philosopher Democritus thought that all matter in nature consists of very small, indivisible particles that he called *atomos* (Greek word for indivisible or indestructible). Of course, now we know that it is not true. The Greek's thought was completely lost until 1808 when an English scientist and schoolteacher, John Dalton, picked up the Greek concept of atom and systematically formulated four hypotheses known as Dalton's atomic theory.

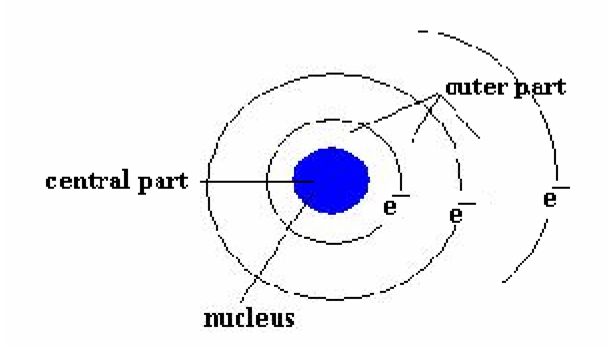
## Dalton's Atomic Theory

1. Elements are made up of very tiny particles, called atoms.
2. All atoms of the given element are identical; same size, mass, and chemical properties.
3. Compounds consisted of atoms of different elements combined together**.** The ratio of the numbers of atoms of any two elements in any compound is either an integer or a fraction.
4. In any chemical reactions, atoms are separated, combined, or rearranged.

The first postulate is the definition of an atom is actually a Greek definition. The second postulate applies to atoms of different elements and tells us that why two elements look different. The third postulate explains how the compounds are formed. And the forth postulate applies to chemical reactions and what happens when the chemical reactions take place.

## Bohr Atom

According to Bohr, the atom is divided into two parts; central part and outer part. The central part is known as *nucleus* and contains two main particles, called proton (p) and neutron (n). Now we know that there many other particles inside the nucleus besides protons and neutrons.




The protons are the positively charged particles, each proton carries one positive (+) charge. Neutrons carry no charges. Due to the presence of protons inside the nucleus, the nucleus has the positive charge; number of positive charges on the nucleus is equal to number of protons inside the nucleus. For example, if there are 10 protons inside the nucleus, the nucleus get charged 10+.

According to the laws of nature, the charge cannot exist by itself as it creates instability in the system. Hence, Bohr put the negatively charged particle known as electrons ($e^-$) in the outer part of the atom in various well-defined paths called *orbits*. In order to maintain electric neutrality the electrons cannot stay in one place but move around in various orbits. The number of electrons must be equal to number of protons. Does this model of an atom looks familiar to you? Surely, it resembles the solar system, the sun (nucleus) in the center and planets (electrons) orbiting around the sun in well-defined paths. Bohr might have borrowed his atomic model from the solar system.

The mass of proton is very close to that of neutron, and the mass of electron is negligible compared to mass or proton or neutron (mass of proton is 1836 times heaver than the mass of electron). Therefore, we can safely say that the entire mass of an atom is concentrated in the nucleus. The following table gives the comparison between masses and charges.

| | | **Charge** | |
|---|---|---|---|
| **Particle** | **Mass(g)** | **Coulomb** | **Charge Unit** |
| Proton | $1.67262 \times 10^{-24}$ | $+1.6022\text{x}10^{-19}$ | +1 |
| Neutron | $1.67493\text{x}10^{-24}$ | 0 | 0 |
| Electron | $9.10939\text{x}10^{-28}$ | $-1.6002\text{x}10^{-19}$ | -1 |

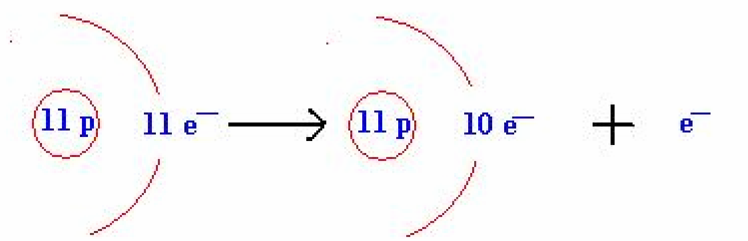
**Ions**

An **ion** is an atom or group of atoms carrying either a net positive charge or a net negative charge. In general, the positive ions are known as **cations** and negative ions as **anions**.

The ions are created by the loss or gain of electron(s). *The positive ions are formed by the loss of electrons.* For example, when sodium (Na) atom loses one electron, it becomes positively charged with net one positive charge, which is analyzed below:

Na atom has 11 protons inside the nucleus and 11 electrons outside the nucleus. When one electron is lost, it is left with 11 protons inside the nucleus and 10 electrons outside the nucleus. The 10 electrons match 10 protons (remember one proton neutralizes one electron) and one proton is left unmatched. Since proton carries a positive charge, the nucleus get charged one +. This situation indicated as $Na^+$ (charge as a supersubscript) and known as $Na^+$ ion:

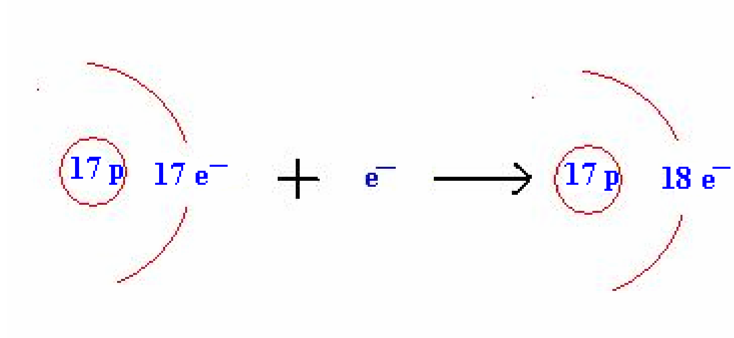
| **Na Atom** | **$Na^+$ Ion** |
|---|---|
| 11 protons<br>11 electrons | 11 protons<br>10 electrons |




Na atom $Na^+$ ion

On the other hand, *the negative ions are formed by the gain of electron(s)***.** For example, the chlorine (Cl) upon gaining one electron becomes negatively charged. To start with, Cl atom has 17 protons inside the nucleus and 17 electrons outside the nucleus. When one electron is gained, it has still 17 protons inside the nucleus but it has 18 electrons outside the nucleus. Seventeen (17) protons match 17 electrons and one electron is left unmatched. Since electron carries a negative charge, Cl becomes negatively charged. This is indicated by the symbol $Cl^-$ (again the charge as a supersubscript) and known as $Cl^-$ ion:

| **Cl Atom** | **$Cl^-$ Ion** |
|---|---|
| 17 protons<br>17 electrons | 17 protons<br>18 electrons |




Cl atom Cl$^-$ ion

In general, the number of charges on an ion indicates number of electrons lost ( or extra protons inside the nucleus) if it is a positive ion or number of electrons gained (or number of extra electrons or number of deficient protons) if it is a negative ion. Study the following ions.

| | |
|---|---|
| $Na^+$ | one electron lost (one extra proton) |
| $Ca^{2+}$ | two electrons lost (two extra electrons) |
| $Al^{3+}$ | three electrons lost (three extra protons) |
| $Br^-$ | one electron gained (one less proton) |
| $O^{2-}$ | two electrons gained (two less protons) |
| $N^{3-}$ | there electrons gained (three less protons) |

All the ions mentioned above are known as **monatomic ions** because they contain only one atom. The following list gives charges on monatomic ions in the periodic table.

1. Hydrogen: either +1 or -1, depending on whether it's hydrogen or hydride.
2. Column 1A metals (Li, Na, K, Rb, Cs, Fr): +1.
3. Column 2A metals (Be, Mg, Ca, Sr, Ba, Ra): +2
4. Column 3A (Al, Ga): +3
5. Column 4A (C, Sn, Pb), can be positive or negative ions : $C^{4-}$, $Sn^{2+}$, $Sn^{4+}$, $Pb^{2+}$, $Pb^{4-}$
6. Column 5A (N, P, As): -3
7. Column 6A (O, S, Se, Te, Po): -2
8. Column 7A (F, Cl, Br, I, At): -1.

In addition, group of atoms together function as a single unit with net positive or negative charge. These are known as **polyatomic ions** for example, $OH^-$ (hydroxide ion), $NH_4^+$ (ammonium ion), $SCN^-$ (thiocyanate ion). Foe more extended list, refer t your tezxtbook.