ATOMS AND ISOTOPES REVIEW

Nuclear waste requires special handling and disposal because it is radioactive and emits radiation. In order to understand radioactivity and radiation, we must first learn about atoms, how atoms react with each other to form "molecules," and about special forms of atoms called isotopes.

2.16 Introduction

What are things made of?

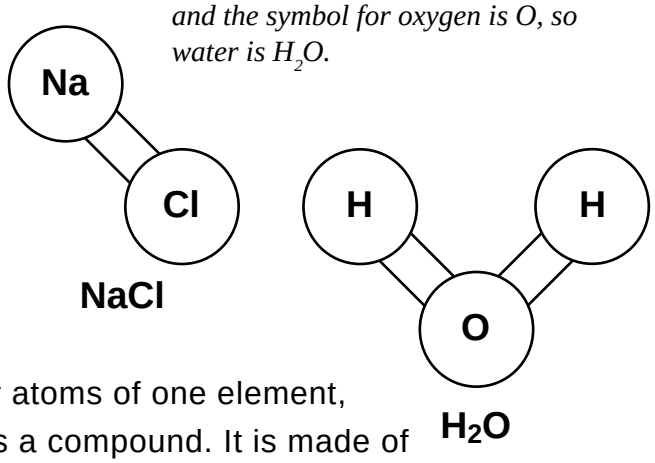
What do you suppose would happen if you took a lump of salt and began to break it up into smaller and smaller pieces? Sooner or later you would get pieces so small that you wouldn't be able to see them. The smallest piece that still is salt is called a *molecule*.

Everything is made of molecules—tables, chairs, sugar, salt, and even the cells of your own body. However, all molecules are **not alike**. A molecule of sugar is different from a molecule of salt.

What is an atom?

But that is not the whole story. Molecules are made of even smaller parts, which are called atoms. Atoms are so small that it takes millions of them to make a speck of dust. We know that at least 92 different kinds of atoms occur in nature. These different kinds of atoms are known as elements. Combining atoms of different elements or atoms of the same element makes molecules. The kind of molecule depends on which atoms combine. This combining of atoms is called a chemical reaction. In chemical reactions, atoms do not change; instead, they combine with other atoms or separate from other atoms.

The symbol for sodium is Na and the symbol for chlorine is Cl, so table salt is Na Cl; the symbol for hydrogen is H and the symbol for oxygen is O, so water is H_2O.



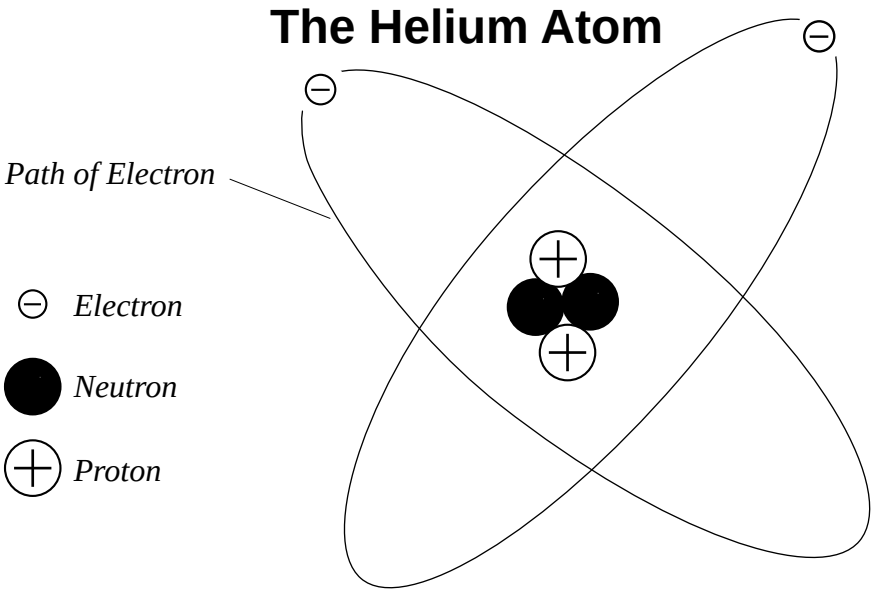
For example, gold is an element, and a bar of pure gold contains only atoms of one element, gold. On the other hand, table salt is a compound. It is made of groups of atoms called molecules. A molecule of table salt has one atom of the element sodium and one atom of the element chlorine. A molecule of water has two atoms of hydrogen and one atom of oxygen. This is why chemists call water H_2O.

So, atoms are basic building blocks of everything in the universe. They are the smallest particles of an element that have all the chemical properties of the element.

2.17 Atoms

What are the parts of an atom?

As small as atoms are, they are made of even smaller particles. There are three basic particles in most atoms—*protons, neutrons,* and *electrons*.



Protons carry a positive electrical charge. Neutrons have no electrical charge. Protons and neutrons together make a bundle at the center of an atom. This bundle is the *nucleus*.

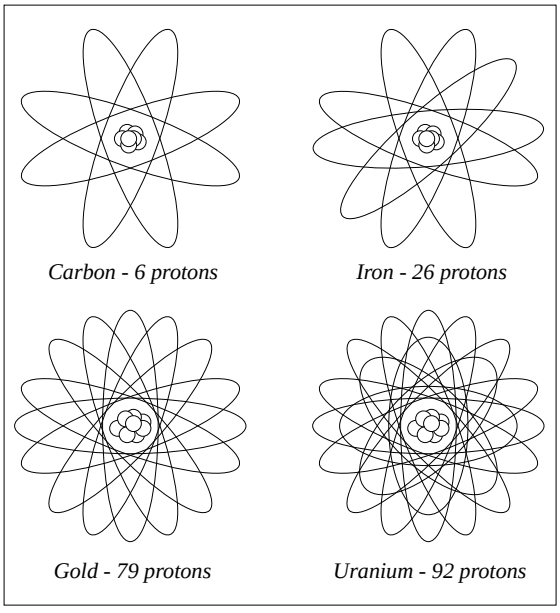
Electrons have a negative electrical charge and move around the nucleus. Normally, an atom has the same number of protons and electrons.

What charges do the parts of the atom carry?

Does the atom have an electrical charge?

If the positively charged protons and the negatively charged electrons are equal in number, they balance each other. As a result, the atom has no electrical charge.

We use protons to identify atoms. For instance, an atom of oxygen has 8 protons in its nucleus. Carbon has 6, iron 26, gold 79, lead 82, uranium 92, and so on.



2.18 Isotopes

The nucleus in every atom of an element always has the same number of protons. However, the number of neutrons may vary. Atoms that contain the same number of protons, but different numbers of neutrons, are called *isotopes* of the element.

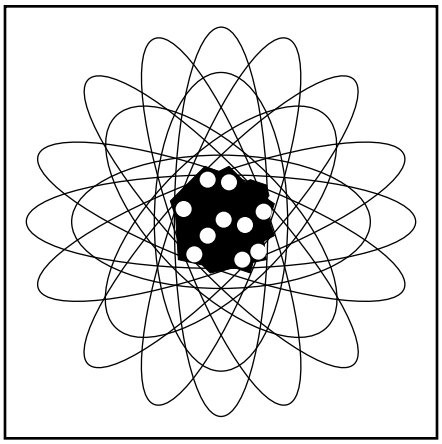
What is an isotope?

All atoms are isotopes. To show which isotope of an element we are talking about, we total the number of protons and neutrons. Then we write the sum after the chemical symbol for the element. For example, in the nucleus of one isotope of uranium there are 92 protons and 143 neutrons. We refer to it as uranium-235 or U-235 (92 + 143 = 235). A second uranium isotope, which contains 3 additional neutrons, is uranium-238 or U-238 (92 + 143 + 3 = 238). (The number may also be written in superscript before the symbol: ^{235}U or ^{238}U.)

How are isotopes identified?

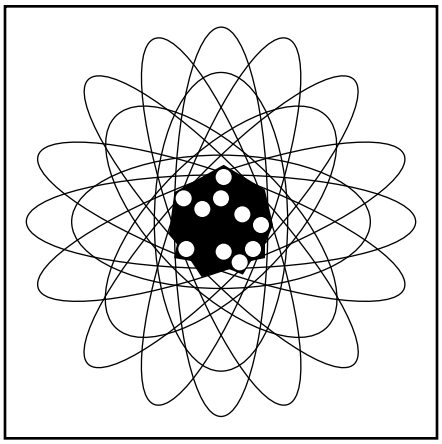
Isotopes of a given element have the same chemical properties, but they may differ in their nuclear properties. Also, isotopes of an element have different numbers of neutrons and the same number of protons. However, some proton-neutron combinations are more stable than others.

Uranium-235



92 + 143 = 235

Uranium-238



92 + 143 + 3 = 238

Some unstable isotopes stabilize themselves by emitting or shooting out energy rays similar to X-rays. Others may emit particles from their nuclei and change into different elements. These rays and particles are called *radiation*, and the process of isotopes emitting them to become more stable is called *radioactive decay*.

2.19 Summary

Everything is made up of small pieces called molecules. Atoms combine to form molecules. Atoms are the smallest units of an element that have all of the chemical properties of the element. Atoms are composed of smaller particles known as protons, neutrons, and electrons.

Protons have a positive electrical charge, neutrons have no electrical charge, and electrons have a negative electrical charge. Protons and neutrons together form the nucleus or "center" of the atom, and electrons move around the nucleus.

The nucleus of each atom of an element contains the same number of protons, but the number of neutrons may vary. Isotopes of an element are identified by adding the number of protons and neutrons together and writing the sum after the chemical symbol for the element. Unstable isotopes can change from one form to another by emitting particles or energy rays in a process called radioactive decay.