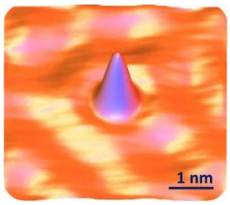
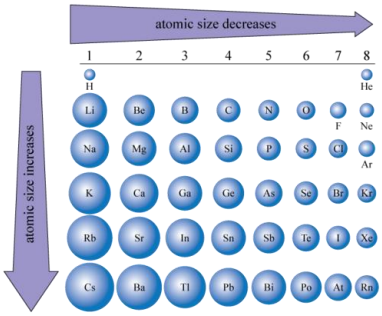
Chemistry Unit 1: Section 2 - Atomic Structure



What could this hilly blue surface possibly be? Do you have any idea?

The answer is a single atom of the element Cobalt. The picture was created using a scanning tunneling microscope. No other microscope can make images of things as small as atoms.

Atoms are extremely small. The radius of an atom is well under 1 nanometer, which is one-billionth of a meter. If a size that small is hard to imagine, consider this: trillions of atoms would fit inside the period at the end of this sentence. Although all atoms are very small, elements vary in the size of their atoms.



The figure at right compares the sizes of atoms of more than 40 different elements. The elements in the figure are represented by **chemical symbols**, such as H for hydrogen and He for helium. Of course, real atoms are much smaller than the circles representing them in the figure.

WHAT ARE ATOMS?

Atoms are the building blocks of matter. They are the smallest particles of an element that still have the element's properties. As we learned in the first section, **elements** are pure substances—such as nickel, hydrogen, and helium—that make up all kinds of matter.

All the atoms of a given element are identical in that they have the same number of protons, one of the building blocks of atoms. They are also different from the atoms of all other elements, as atoms of different elements have different number of protons.

SUBATOMIC PARTICLES

Although atoms are very tiny, they consist of even smaller particles called **subatomic particles**.

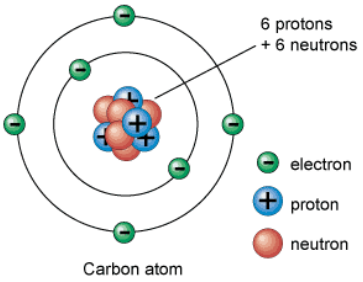
Three main types of particles that make up all atoms are:

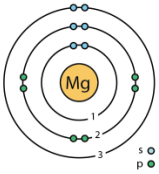
- **Protons** are found in the nucleus of the atom, which is a tiny, dense region at the center of the atom. Protons have a **positive** electrical charge of one (+1) and a mass of 1 atomic mass unit (amu), which is about 1.67×10^{-27} kilograms. Together with neutrons, they make up virtually all of the **mass** of an atom.

- **Neutrons** have no charge and are electrically **neutral**. The mass of a neutron is slightly greater than the mass of a proton, which is 1 atomic mass unit (amu). A neutron also has about the same diameter as a proton, or 1.7×10^{-17} meters.

- **Electrons** are extremely small and it's mass is only about 1/2000 the mass of a proton or neutron, so electrons contribute virtually nothing to the total mass of an atom. Electrons have a **negative** electric charge of -1, which is equal but opposite to the charge of proton, which is +1.

At the center of the atom is a dense area called the **nucleus**, where all the protons and neutrons are clustered closely together. The electrons constantly move around the nucleus in different **energy levels**. Electrons at the outermost energy level of an atom are called **valence electrons**. They determine many of the properties of an element and how it may or may not react with other atoms to form chemical compounds.





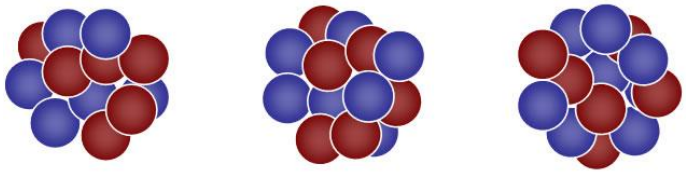
Bohr diagrams are diagrams that show all of an element's electrons using a series of circles to represent the energy levels. The diagram shows the number of electrons in each energy level. In the picture at right, magnesium has 2 electrons in its first shell, 8 in its second shell, and 2 in its third shell.

Electron-dot diagrams (also called **Lewis Structures**) are diagrams in which the valence electrons of an atom are shown as dots distributed around the element's symbol. A magnesium atom, with two valence electrons, would have the electron-dot diagram as shown at left.

WHAT'S THE NUMBER?

An element's **atomic number** is equal to the number of protons it has in its nucleus. Atoms of different elements have different numbers of protons, but the number of protons always equals the number of electrons. For example, a carbon atom has 6 protons and 6 electrons. This makes atoms **neutral** in charge because the positive and negative charges "cancel out."

The number of neutrons will vary and may or may not be the same as the number of protons. Atoms of an element that have a different number of neutrons are called **isotopes**. Almost 99 percent of carbon atoms have six neutrons, but the rest have either seven or eight neutrons. The nuclei of these isotopes of carbon are shown in the figure at right.



carbon-12	carbon-13	carbon-14
98.9%	1.1%	<0.1%
6 protons	6 protons	6 protons
6 neutrons	7 neutrons	8 neutrons

Source: https://socratic.org/questions/how-do-isotopes-differ-in-atomic-structure

The number of protons and the number of neutrons determine an element's **atomic mass** or **mass number**: *mass number = protons + neutrons*. An element's **atomic mass** is equal to the mass of the subatomic particles in the nucleus, which determined by finding the sum of the total protons and neutrons. Since an element's isotopes have different atomic masses, scientists may also determine the **atomic weight** by calculating the average of all an element's isotopes.

PARTICLES IN PROTONS, NEUTRONS, & ELECTRONS

Protons and neutrons consist of fundamental particles known as **quarks** and **gluons**. Each proton and neutron contains three quarks. Gluons are fundamental particles that are given off or absorbed by quarks. They carry the strong nuclear force that holds together quarks in protons and neutrons.

Unlike protons and neutrons, electrons are fundamental particles that do not consist of smaller particles. They are a type of fundamental particles called **leptons**.

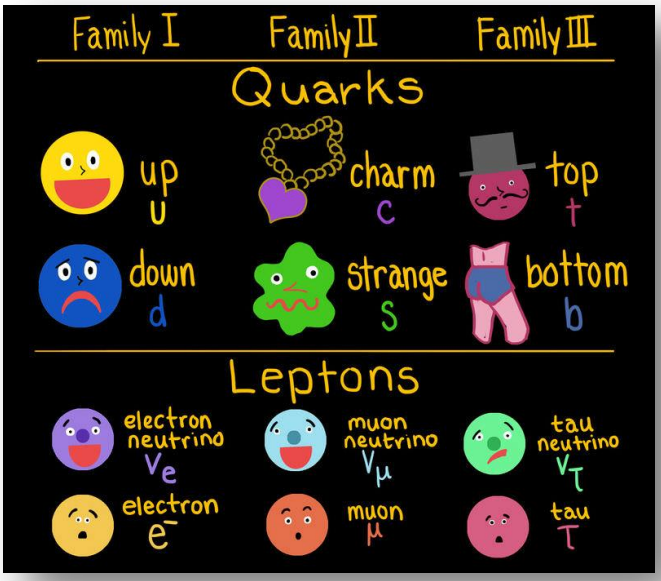


Image Source: https://www.ck12.org/c/physical-science/fundamental-particles/lesson/Fundamental-Particles-MS-PS/