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Atoms—The Inside Story

Can matter be continually divided into smaller and smaller pieces? This question had puzzled scientists for hundreds and hundreds of years. As they tried to find an answer to that question, models of the atom slowly developed. Many of these models were strange and definitely wrong but they all helped scientists develop the model of the atom that we use today.

Types of Subatomic Particles

We now know that the atom is made up of three different types of particles called subatomic particles:

- **Protons** are positively charged particles located in the nucleus, or core, of the atom. Each proton has a mass of 1.
- **Neutrons** are neutral particles also located in the nucleus. They also have a mass of 1.
- **Electrons** are negatively charged particles. They have almost no mass at all—1/2000 of the mass of a proton or neutron. They move rapidly in the space around the nucleus.

All atoms have this basic structure, but not all atoms are alike.

Important Numbers and Atoms

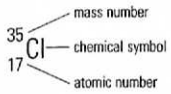
The number of protons in the nucleus, called the **atomic number**, determines the identity of an atom. If you know the atomic number of an atom, you know how many protons and how many electrons that atom contains because each atom must have an equal number of protons and electrons. The element oxygen has an atomic number of 8 (**Figure 1**). This tells us that an atom of oxygen has 8 protons in its nucleus and 8 electrons moving around the nucleus. The number of positive charges equals the number of negative charges, so the overall charge of the atom is zero (**Table 1**).

Another important number is the **mass number**, which represents the sum of the protons and the neutrons in an atom. Therefore, if you know the atomic number (the number of protons) and the atomic mass (the number of protons plus the number of neutrons), you can easily calculate the number of neutrons:

$$\text{mass number} - \text{atomic number} = \text{number of neutrons}$$

Let's use oxygen as an example. Oxygen has a mass number of 16 and an atomic number of 8. $16 - 8 = 8$, so oxygen has 8 neutrons.

Scientists show the numbers of subatomic particles using an internationally recognized system that allows anyone to communicate information about the atom. This is called **standard atomic notation**. In this notation, we write the chemical symbol of the atom and place the atomic number to the lower left and the mass number to the upper left. For example, the atomic notation of chlorine is



This tells us that chlorine has 17 protons and $35 - 17 = 18$ neutrons. Since the atom is neutral, it also tells us that the number of electrons is 17.

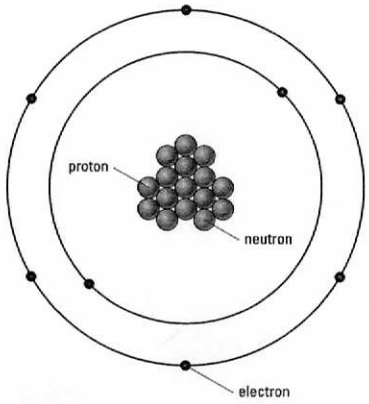


Figure 1
An oxygen model

Table 1

Element	Number of protons	Total positive charge	Number of electrons	Total negative charge	Net charge of atom
hydrogen	1	1+	1	1–	0
oxygen	8	8+	8	8–	0
copper	29	29+	29	29–	0

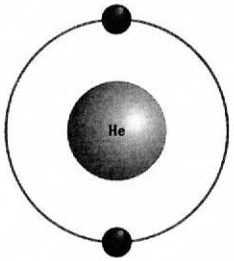
The Bohr Model of the Atom

One of the scientists who helped to develop the model of the atom that we use today (**Figure 2**) was a Danish physicist named Niels Bohr. He suggested that there was a regular pattern to the position and motion of electrons. He believed that:

- Electrons move in definite orbits around the nucleus, much like planets orbit the Sun.
- These orbits are located at certain distances from the nucleus.
- Electrons cannot exist between these orbits, but they can move up and down from one orbit to another.
- The maximum number of electrons in the first three orbits is 2, 8, and 8.
- Electrons are more stable when they are closer to the nucleus.

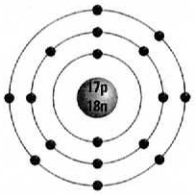
In **Bohr-Rutherford diagrams**, a circle is drawn in the centre to represent the nucleus of the atom. The numbers of protons and neutrons are written in this circle. Electrons are shown in circular orbits around the nucleus. Let's look at a diagram of chlorine (**Figure 3**).

The atomic number of chlorine is 17 and the mass number is 35. There are 17 protons and 18 neutrons in the nucleus. Chlorine has 17 electrons: 2 in the first orbit, 8 in the second orbit, and 7 in the third orbit.



helium

Figure 2
In Bohr's model of the atom, electrons travel around the nucleus in nearly circular orbits, much like planets around the Sun.



chlorine

Figure 3
Chlorine

Challenge

2 How could you create a three-dimensional Bohr model for your time capsule?

3 Many scientists were involved in developing the present-day atomic model. Could one of these be your "famous scientist"?

Understanding Concepts

1. In your notebook, draw and complete the following table:

Particle	Proton	Neutron	Electron
mass			
charge			
location in atom			

2. Write the standard atomic notation for
   - **(a)** an atom of nitrogen with 7 protons and 7 neutrons.
   - **(b)** an atom of sulfur with 16 protons and 16 neutrons.
3. Draw Bohr-Rutherford diagrams for
   - **(a)** oxygen (O): 8 protons, 8 neutrons.
   - **(b)** aluminum (Al): 13 protons, 14 neutrons.
   - **(c)** sodium (Na): 11 protons, 12 neutrons.