8.5A: Atoms

Reflect

Our world is full of diversity, found in all of the materials, substances, and living things that exist on Earth. Take a look at the picture at the right. Even in a small aquarium, there are green plants and orange fish, pink pebbles and clear glass.

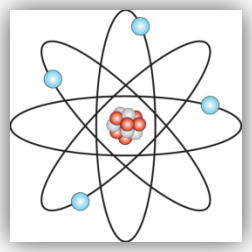
Yet, everything on Earth has something in common: everything is made of matter, and all matter is made of atoms. What are atoms made of? Do all atoms have the same structure?

Atomic Structure

Remember, matter is anything that has mass and takes up space. Suppose you had a piece of pure gold, which is an **element**. The piece of gold contains many millions of individual atoms. An *atom* is the smallest particle of an element that cannot be broken down further without changing the properties of the element. One atom of gold is very small—too small to be seen. However, a single atom of gold has the same properties as every other gold atom has.

element: a substance made of one kind of atom

All atoms have the same general arrangement. An atom contains a *nucleus*, which is in the center of the atom. An atom also has an area of space surrounding the nucleus called an *electron cloud*. Subatomic particles, the small particles within the atom, are known as protons, neutrons, and electrons.



What Do You Think?

Take a look at the diagram of an atom at the right. Can you identify the nucleus and electron cloud? What do you think the blue, red, and gray spheres represent?

Location and Charge of Subatomic Particles

Protons, neutrons, and electrons differ from each other based on their locations in an atom and their electrical charges.

- **Neutron:** Neutrons do not have an electrical charge. They are neutral. Neutrons are found in the nucleus of the atom and are represented by the gray spheres in the atomic diagram above.

- **Proton:** Protons are positively charged particles. They are found in the nucleus of an atom and are represented by the red spheres in the atomic

diagram above. Since protons are the only charged particle in the nucleus, an atom's nucleus is always positively charged.

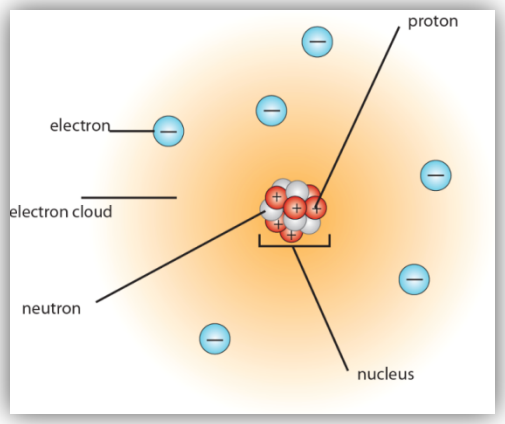
- **Electron:** Electrons are negatively charged particles. They travel in paths called orbits within the electron cloud surrounding the nucleus. Electrons are constantly moving. The blue spheres in the atomic diagram above represent electrons.

Different atoms have different combinations of subatomic particles. However, there are some general rules regarding the electrical charge of an atom. If the number of protons equals the number of electrons, the atom does not have an electrical charge and is neutral. In other words, the positives and negatives balance out. If there are more protons than electrons, the atom is positively charged. If there are more electrons than protons, the atom is negatively charged. The number of neutrons in an atom does not affect the overall charge of the atom because neutrons have no charge.

Let's discuss a specific example. Suppose an atom has 6 protons and 7 neutrons and is neutrally charged overall. We know that the 7 neutrons do not affect the overall charge of the atom. We also know that since the atom is neutral, it must have the same number of protons and electrons. Therefore, we can conclude that this atom has 6 electrons.

Look Out!

As they circle the outside of the nucleus, electrons spin billions of times every second. Due to the extremely fast speed at which they move, the path that electrons travel is not the same each time. As shown in the diagram at the right, rather than travel in an exact path, electrons appear to exist in a cloud around the nucleus.



Atomic Mass

Protons and neutrons have similar masses—each proton and neutron has a mass of approximately 1.67×10^{-27} kg. The mass of one electron is even smaller: 9.11×10^{-31} kg. Remember that the protons and neutrons are located in the atom's nucleus, which is where most of the atom's mass is located. *Atomic mass* is the average mass of all of the protons and neutrons in the atom. Electrons are so small that they not do change the mass of the atom. They do, however, take up a large amount of the volume of the atom.

The following formula can be used to find average atomic mass where P = number of protons and N = number of neutrons:

P + N = average atomic mass

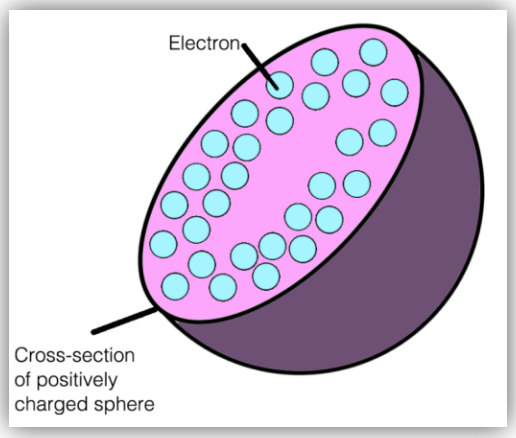
What Do You Think?

Suppose you know the number of protons in an atom. What other information would you need in order to determine the mass of the atom? Explain your reasoning.

Discover Science: The Modern View of the Atom

Because of its size, the atom is very difficult to study. It took many scientists many years to formulate the current model of the atom. In the late 1800s, J. J. Thomson, an English scientist, theorized that atoms were made of particles with different charges. He used a special instrument that could detect charged particles in order to identify the negatively charged electrons.

Thomson proposed a "plum pudding" model of the atom. He thought an atom was made of electrons that were surrounded by a sea of positive charge. In Thomson's model, the electrons were the "plums" and the positive charge was the "pudding."



J. J. Thomson proposed the "plum pudding" model of the atom.

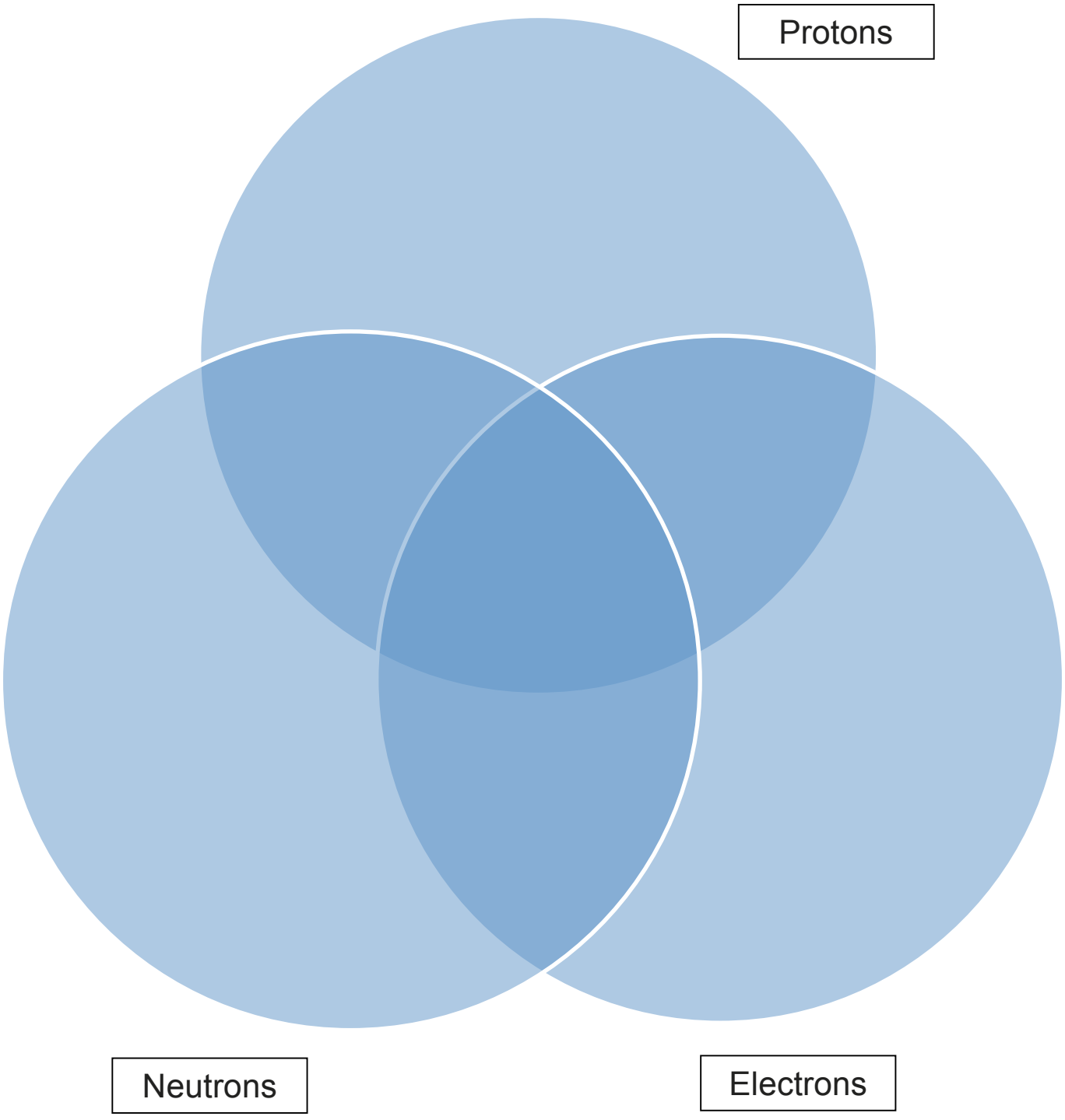
Several years later, another scientist named Ernest Rutherford discovered the nucleus of the atom. Rutherford theorized that if Thomson's model was correct, and that if the electrons and protons are evenly spread throughout an atom, then the mass is also evenly distributed throughout the atom. Rutherford did an experiment in which he shot rays of high-speed particles toward a thin film of gold atoms. Some of the particles rebounded almost directly backward, which led Rutherford to the idea that most of the mass and positive charge of the atom is located at the center.

Niels Bohr and Max Planck contributed to atomic theory when they identified the electron paths, or orbitals, surrounding the nucleus. The combination of the work of many scientists formed what we know today as modern atomic theory.

What Do You Know?

Atoms are made of protons, neutrons, and electrons. Read the characteristics of these subatomic particles in the box below. Decide whether each characteristic describes protons, neutrons, or electrons. Then write each characteristic in the correct section of the Venn diagram on the next page.

Characteristics of Subatomic Particles	
• Are negatively charged • Have the smallest mass of the subatomic particles • When these are equal, the atom is neutral • Are located in orbitals surrounding the nucleus	• Are positively charged • Are located in the nucleus • Are subatomic particles • Were discovered by J. J. Thomson • Make up the mass of the atom • Do not have a charge



Connecting With Your Child: Make an Atomic Model

To help your child learn more about atoms, work together to create your own atomic model. You will need the following materials:

- 1 paper plate
- 1 marker
- Protons: 6 red circular food pieces such as candy-coated chocolates or round cereal pieces
- Neutrons: 6 yellow circular food pieces; use a similar food item as the item you used for protons
- Electrons: 6 green circular food pieces; if possible, use a food item that is slightly smaller than the food items you used for protons and neutrons
- Glue

Have your child draw a circle in the center of the paper plate with the marker and ask what this represents. (It represents the nucleus.) Ask your child what the rest of the paper plate represents. (It represents the electron cloud.) Next, have your child glue the protons, neutrons, and electrons in their proper locations within the atomic model. Then have your child label the nucleus, electron cloud, and at least one proton, one neutron, and one electron.

You may wish to discuss the following questions with your child:

- Where did you place each subatomic particle? Why?
- What is the theoretical charge of your atomic model? Explain your reasoning.
- What mathematical formula could you use to find the atomic mass of your atom?
- What are some of the limitations of your model?