

Electron Cloud Atomic Model

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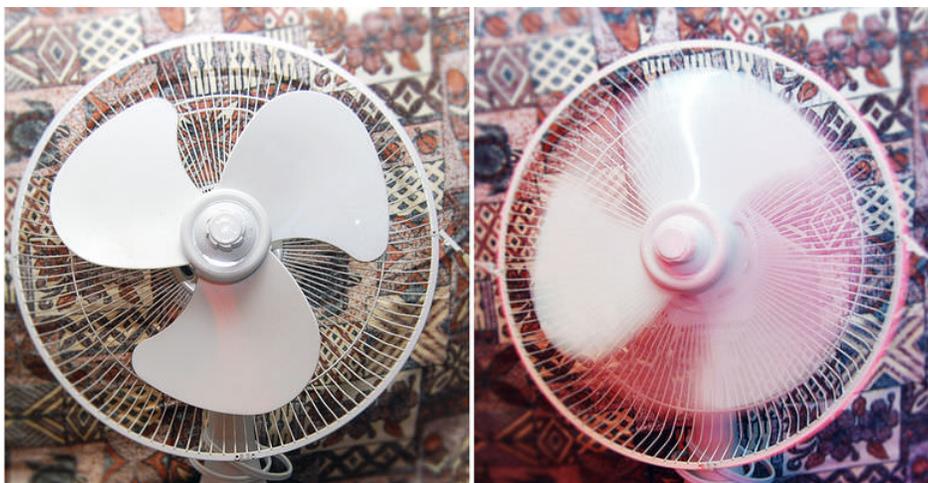


CHAPTER

1

Electron Cloud Atomic Model

- State the main limitation of Bohr's atomic model.
- Describe Schrödinger's work and atomic orbitals.
- Identify the electron cloud model of the atom.



The fan pictured here is turned off in the photo on the left and running at high speed in the photo on the right. In the right-hand photo, the blades are moving too fast for you to see the individual blades. You can't tell where any given blade is at any given moment. In some ways, rapidly moving fan blades are similar to electrons moving about the nucleus of an atom. Like fan blades, electrons move very quickly and we can never tell exactly where they are. If that's the case, how can we represent electrons in models of the atom?

Where Are the Electrons?

Up until about 1920, scientists accepted Niels Bohr's model of the atom. In this model, negative electrons circle the positive nucleus at fixed distances from the nucleus, called energy levels. You can see the model in **Figure 1.1** for an atom of the element nitrogen. Bohr's model is useful for understanding properties of elements and their chemical interactions. However, it doesn't explain certain behaviors of electrons, except for those in the simplest atom, the hydrogen atom.

What Are the Chances?

In the mid-1920s, an Austrian scientist named Erwin Schrödinger thought that the problem with Bohr's model was restricting the electrons to specific orbits. He wondered if electrons might behave like light, which scientists already knew had properties of both particles and waves. Schrödinger speculated that electrons might also travel in waves.

Q: How do you pin down the location of an electron in a wave?

A: You can't specify the exact location of an electron. However, Schrödinger showed that you can at least determine where an electron is most likely to be.

Schrödinger developed an equation that could be used to calculate the chances of an electron being in any given place around the nucleus. Based on his calculations, he identified regions around the nucleus where electrons are

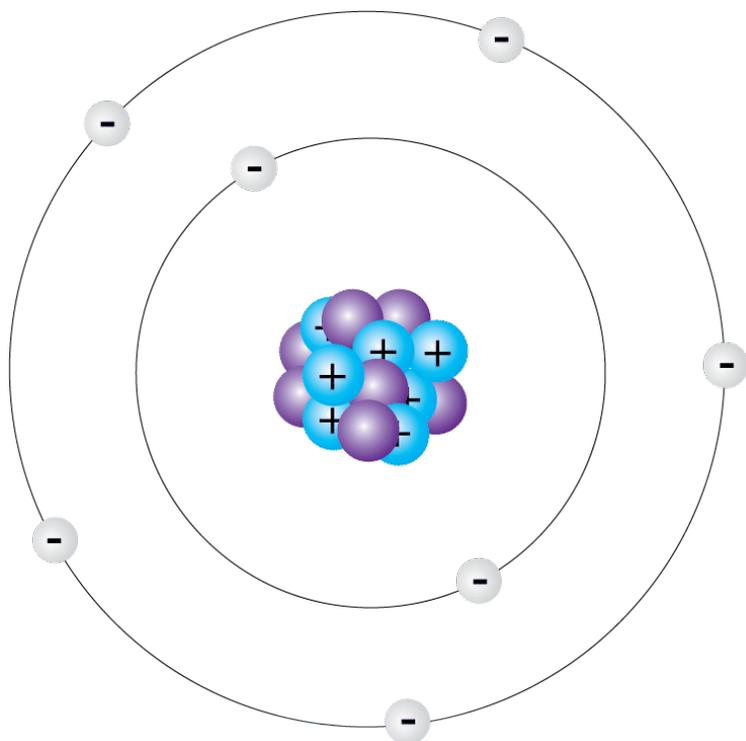


FIGURE 1.1

most likely to be. He called these regions **orbitals**. As you can see in the **Figure 1.2**, orbitals may be shaped like spheres, dumbbells, or rings. In each case, the nucleus of the atom is at the center of the orbital.

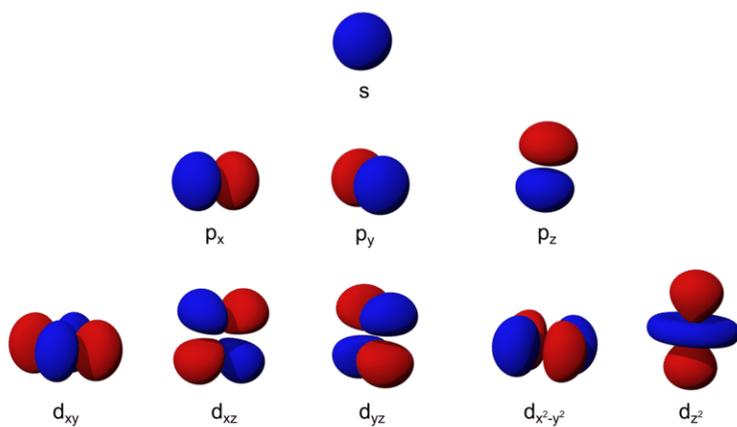


FIGURE 1.2

A Fuzzy Cloud

Schrödinger's work on orbitals is the basis of the modern model of the atom, which scientists call the quantum mechanical model. The modern model is also commonly called the **electron cloud** model. That's because each orbital around the nucleus of the atom resembles a fuzzy cloud around the nucleus, like the ones shown in the **Figure 1.3** for a helium atom. The densest area of the cloud is where the electrons have the greatest chances of being.

Electron Cloud Model of the Atom

Electron cloud ($2e^-$)

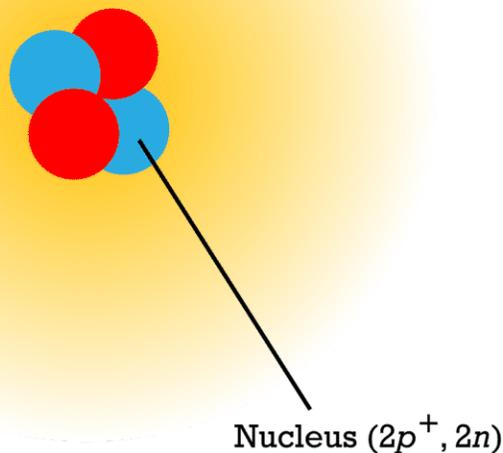


FIGURE 1.3

Q: In the model pictured in the **Figure 1.3**, where are the two helium electrons most likely to be?

A: The two electrons are most likely to be inside the sphere closest to the nucleus where the cloud is darkest.

Summary

- Bohr's model of the atom, in which electrons circle the nucleus at fixed energy levels, cannot explain all the behaviors of electrons.
- In the 1920s, Erwin Schrödinger proposed that electrons travel in waves, which means their exact positions cannot be determined. He developed an equation to calculate the chances of an electron being in any given place. Using his equation, he identified regions around the nucleus, called orbitals, where electrons are most likely to be.
- Orbitals are the basis of the electron cloud model of the atom. This model is still accepted by scientists today.

Review

1. What is the problem with Bohr's model of the atom?
2. How did Schrödinger resolve this problem?
3. Describe orbitals.
4. Outline the electron cloud model of the atom.

Explore More

Watch the video about the electron cloud model below, and then answer the questions that follow.



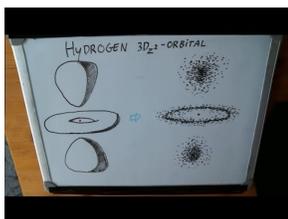
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1. What influences the movement of electrons in atoms?
2. What is the Heisenberg uncertainty principle?
3. How is the Heisenberg uncertainty principle related to electron orbitals?

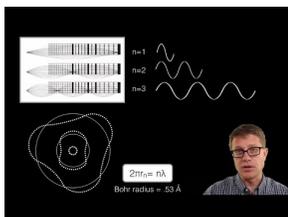
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References

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