Quantum Mechanical Model of the Atom

Unit: Quantum and Particle Physics

MA Curriculum Frameworks (2016): HS-PS4-3

AP® Physics 2 Learning Objectives: 6.G.1.1, 6.G.2.1, 6.G.2.2, 7.C.1.1, 7.C.2.1

Mastery Objective(s): (Students will be able to…)

- Explain the de Broglie model of the atom.
- Explain the Schrödinger model of the atom.
- Explain the wave-particle duality of nature.

Success Criteria:

- Descriptions & explanations are accurate and account for observed behavior.

Language Objectives:

- Explain the important features of each model of the atom.

Tier 2 Vocabulary: model, quantum

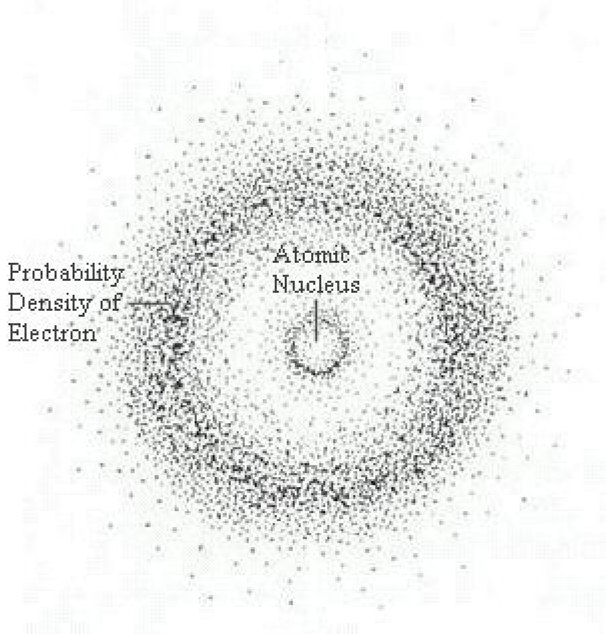
Notes:

In 1925, following de Broglie's research, Austrian physicist Erwin Schrödinger found that by treating each electron as a unique wave function, the energies of the electrons could be predicted by the mathematical solutions to the wave equation*. Schrödinger used the wave equation to construct a probability map for where the electrons can be found in an atom. Schrödinger's work is the basis for the modern quantum-mechanical model of the atom.

* The wave equation in physics is a second-order partial differential equation that mathematically describes the behavior of waves in space and time. The mathematics required are well beyond the scope of a high school physics class.

Use this space for summary and/or additional notes:

To understand the probability map, it is important to realize that because the electron acts as a wave, it is detectable when the amplitude of the wave is nonzero, but not detectable when the amplitude is zero. This makes it appear as if the electron is teleporting from place to place around the atom. If you were somehow able to take a time-lapse picture of an electron as it moves around the nucleus, the picture might look something like the diagram to the right.



Notice that there is a region close to the nucleus where the electron is unlikely to be found, and a ring a little farther out where there is a high probability of finding the electron.

As you get farther and farther from the nucleus, Schrödinger's equation predicts different shapes for these probability distributions. These regions of high probability are called "orbitals," because of their relation to the orbits originally suggested by the planetary model.

Schrödinger was awarded the Nobel prize in physics in 1933 for this discovery.

The implications of quantum theory are vast. Among other things, the energies, shapes and numbers of orbitals in an atom is responsible for each atom's chemical and physical properties and its location on the Periodic Table of the Elements, which means quantum mechanics is responsible for pretty much all of chemistry!

Some principles of quantum theory that are studied explicitly in chemistry include:

- atomic & molecular orbitals
- electron configurations
- the aufbau principle

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