Chapter 7: The Quantum-Mechanical Model of the Atom

7.1 — Schrodinger's Cat

- "quantum" = absolutely small
- In the quantum world, electrons behave differently than in the macroscopic world that we are used to observing.
- When unobserved, absolutely small particles like electrons can be in two different states at the same time.
  - In the quantum world, the unobserved atom can be in a state in which it is doing both—emitting the particle and not emitting the particle—simultaneously.
- **Erwin Schrodinger** (1887-1961) (Australian physicist)
  - He attempted to demonstrate that this quantum strangeness (that electrons can be in two different states at the same time) could never transfer itself into the macroscopic world.
  - So he published a paper in 1935 about a thought experiment about a cat, now known as *Schrodinger's cat*.
- **Schrodinger's cat** (Published paper by Erwin Schrodinger in 1935)
  - Cat in a steel chamber that contains radioactive atoms that demonstrate this quantum strangeness.
  - Chamber is equipped with a hammer that will break a flask of poison if one of the radioactive atoms emits an energetic particle. → If the flask of poison breaks open, the cat dies.

- If the chamber is closed, the whole system remains unobserved, and the radioactive atom is in a state in which it has and has not emitted the particle (with equal probability)
    - Therefore, the cat is both dead and undead. (What a mystery!)
  - When the chamber is opened, the act of observation forces the entire system into one state or the other. → The cat is either dead or alive, not both.
  - However, while unobserved, the cat is both dead and alive.
- ***The absurdity of the both dead and undead cat in Schrodinger's thought experiment was meant to demonstrate how quantum strangeness does not transfer to the macroscopic world.***
- **Quantum-mechanical model** → A model that explains the strange behavior of absolutely small particles such as electrons and photons.
  - We will focus on how the model describes electrons as they exist within atoms, and how those electrons determine the chemical and physical properties of elements.
  - The quantum-mechanical model explains the *why* of the properties of elements and their electrons… It explains the modern periodic table and provides the basis for our understanding of chemical bonding.

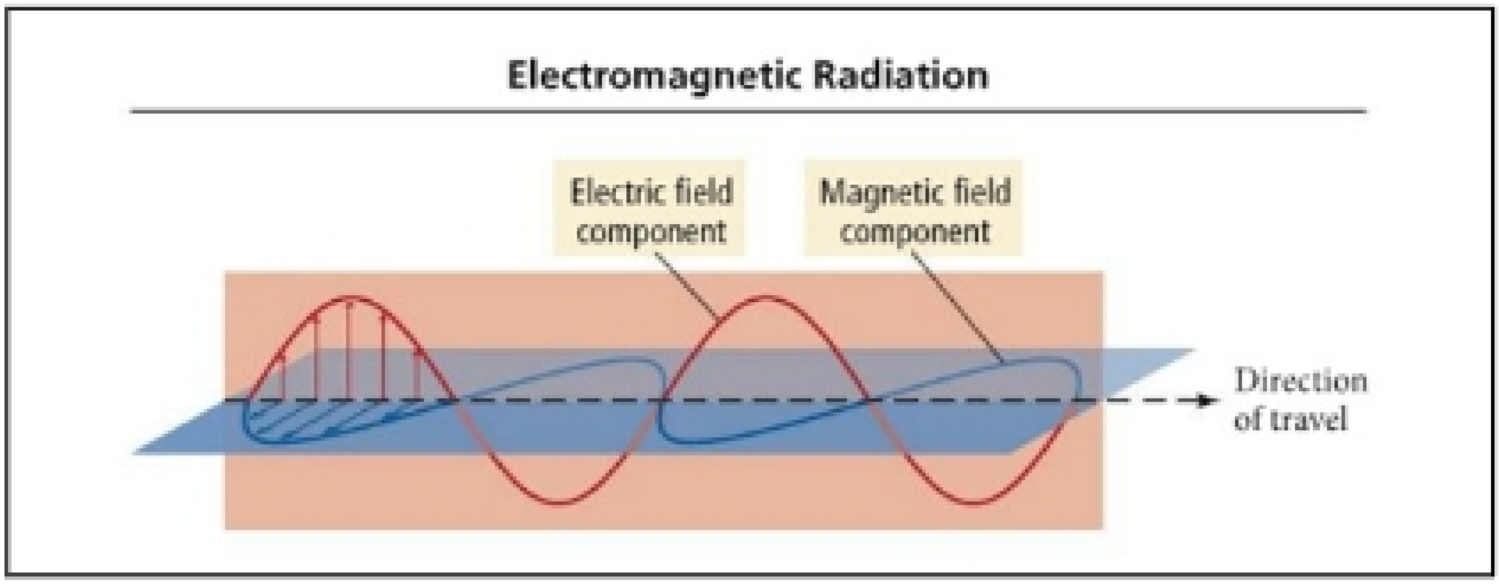
7.2 — The Nature of Light

- In this section, we will first explore the wave behavior of light, and then its particle behavior.
- We will then turn to electrons to see how they also display the same wave-particle duality.

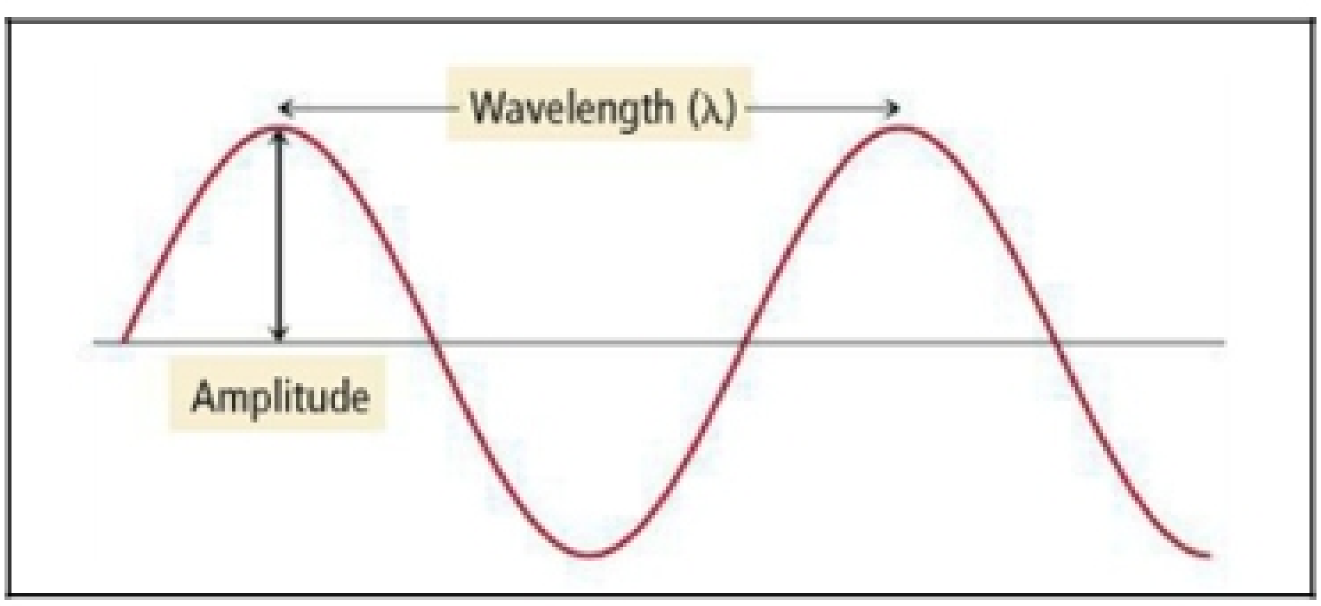
THE WAVE NATURE OF LIGHT:

- Light is **electromagnetic radiation**, a type of energy embodied in oscillating electric and magnetic fields.
  - A **magnetic field** is the region of space where a magnetic particle experiences a force (think of the space around a magnet).
  - An **electric field** is a region of space where an electrically charged particle experiences a force.

- Electromagnetic radiation can be described as a wave composed of oscillating, mutually perpendicular electric and magnetic fields propagating through space.
  - In a vacuum, these light waves move at a constant speed of $C = 3.00 \times 10^8$ m/s… Fast enough to circle the Earth in one-seventh of a second.
  - The **speed of light ($C = 3.00 \times 10^8$ m/s)** is the reason why we see a firework in the sky before we hear the sound of its explosion.
    - *** Sound travels more slowly than light. ***
  - The fields (electric and magnetic) oscillate in perpendicular planes (as shown below).



- We can characterize a wave by its *amplitude* and its *wavelength (λ)*.
  - **Amplitude** = the vertical height of a crest/trough.
    - Determines a light's *intensity* or brightness.
    - Greater amplitude = greater intensity
  - **Wavelength (λ)** = the distance from crest to crest (or trough to trough)
    - Determines a light's *color*



- Light is also characterized by *frequency (v)*.