

The Development of a New Atomic Model

SECTION 1

OBJECTIVES

- Explain the mathematical relationship among the speed, wavelength, and frequency of electromagnetic radiation.
- Discuss the dual wave-particle nature of light.
- Discuss the significance of the photoelectric effect and the line-emission spectrum of hydrogen to the development of the atomic model.
- Describe the Bohr model of the hydrogen atom.

The Rutherford model of the atom was an improvement over previous models, but it was incomplete. It did not explain how the atom's negatively charged electrons are distributed in the space surrounding its positively charged nucleus. After all, it was well known that oppositely charged particles attract each other. So what prevented the negative electrons from being drawn into the positive nucleus?

In the early twentieth century, a new atomic model evolved as a result of investigations into the absorption and emission of light by matter. The studies revealed an intimate relationship between light and an atom's electrons. This new understanding led directly to a revolutionary view of the nature of energy, matter, and atomic structure.

Properties of Light

Before 1900, scientists thought light behaved solely as a wave. This belief changed when it was later discovered that light also has particle-like characteristics. Still, many of light's properties can be described in terms of waves. A quick review of these wavelike properties will help you understand the basic theory of light as it existed at the beginning of the twentieth century.

The Wave Description of Light

Visible light is a kind of **electromagnetic radiation**, which is a form of energy that exhibits wavelike behavior as it travels through space. Other kinds of electromagnetic radiation include X rays, ultraviolet and infrared light, microwaves, and radio waves. Together, all the forms of electromagnetic radiation form the **electromagnetic spectrum**. The electromagnetic spectrum is represented in **Figure 1** on the next page. All forms of electromagnetic radiation move at a constant speed of 3.00×10^8 meters per second (m/s) through a vacuum and at slightly slower speeds through matter. Because air is mostly space, the value of 3.00×10^8 m/s is also light's approximate speed through air.

The significant feature of wave motion is its repetitive nature, which can be characterized by the measurable properties of wavelength and frequency. **Wavelength** (λ) is the distance between corresponding points on adjacent waves. The unit for wavelength is a distance unit. Depending on the type of electromagnetic radiation, it may be expressed in meters,

