SECTION 1

Quantization of Energy

SECTION OBJECTIVES

- Explain how Planck resolved the ultraviolet catastrophe in blackbody radiation.
- Calculate energy of quanta using Planck's equation.
- Solve problems involving maximum kinetic energy, work function, and threshold frequency in the photoelectric effect.

BLACKBODY RADIATION

By the end of the nineteenth century, scientists thought that classical physics was nearly complete. One of the few remaining questions to be solved involved electromagnetic radiation and thermodynamics. Specifically, scientists were concerned with the glow of objects when they reach a high temperature.

All objects emit electromagnetic radiation. This radiation, which depends on the temperature and other properties of an object, typically consists of a continuous distribution of wavelengths from the infrared, visible, and ultraviolet portions of the spectrum. The distribution of the intensity of the different wavelengths varies with temperature.

At low temperatures, radiation wavelengths are mainly in the infrared region. So, they cannot be seen by the human eye. As the temperature of an object increases, the range of wavelengths given off shifts into the visible region of the electromagnetic spectrum. For example, the molten metal shown in **Figure 1** seems to have a yellow glow. At even higher temperatures, the object appears to have a white glow, as in the hot tungsten filament of a light bulb, and then a bluish glow.

Figure 1
This molten metal has a bright yellow glow because of its high temperature.

Classical physics cannot account for blackbody radiation

One problem at the end of the 1800s was understanding the distribution of wavelengths given off by a blackbody. Most objects absorb some incoming radiation and reflect the rest. An ideal system that absorbs all incoming radiation is called a *blackbody*. Physicists study **blackbody radiation** by observing a hollow object with a small opening, as shown in **Figure 2.** The system is a good example of how a blackbody works; it traps radiation. The light given off by the opening is in equlibrium with light from the walls of the object, because the light has been given off and reabsorbed many times.

blackbody radiation

the radiation emitted by a blackbody, which is a perfect radiator and absorber and emits radiation based only on its temperature

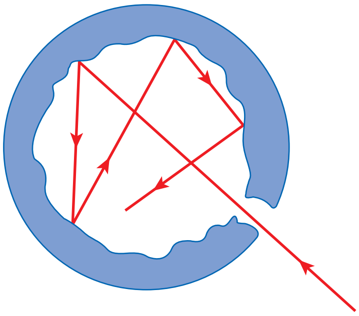

Figure 2
Light enters this hollow object through the small opening and strikes the interior wall. Some of the energy is absorbed by the wall, but some is reflected at a random angle. After each reflection, part of the light is absorbed by the wall. After many reflections, essentially all of the incoming energy is absorbed by the cavity wall. Only a small fraction of the incident energy escapes through the opening.