31 Light Quanta

Solutions to Chapter 31 Exercises

2. To say something is quantized is to say it is composed of elementary units. Electric charge, for example, is composed of multiples of the charge of the electron, so we say charge is quantized. A gram of pure gold is quantized in that it is made of a whole number of gold atoms. In this chapter we learn that light—radiant energy—is also quantized.

4. In accord with $E = hf$, the energy of a photon with twice the frequency has twice the energy. Violet photons are about twice as energetic as red photons.

5. Higher-frequency ultraviolet light has more energy per photon.

16. Protons are held within nuclei deep within atoms. To eject a proton from an atom takes about a million times more energy than to eject an electron. So one would need a high-energy gamma-ray photon rather than a photon of visible light to produce a "photoprotonic" effect.

22. We can never definitely say what something *is*, only how it behaves. Then we construct models to account for the behavior. The photoelectric effect doesn't prove that light is corpuscular, but supports the corpuscular model of light. Particles best account for photoelectric behavior. Similarly, interference experiments support the wave model of light. Waves best account for interference behavior. We have models to help us conceptualize what something *is*; knowledge of the details of how something behaves helps us to refine the model. It is important that we keep in mind that our models for understanding nature are just that: models. If they work well enough, we tend to think that the model represents what *is*. (More about models in the answer to the next exercise.)

32. The cannonball obviously has more momentum than the BB traveling at the same speed, so in accord with de Broglie's formula the BB has the longer wavelength. (Both wavelengths are too small to measure.)

34. The twice-as-fast electron has twice the momentum. By de Broglie's formula, wavelength = *h*/momentum, twice the momentum means half the wavelength. The slower electron has the longer wavelength.

Chapter 31 Problem Solutions

1. Frequency is speed/wavelength: $f = (3 \times 10^8 \text{ m/s})/(2.5 \times 10^{-5} \text{ m}) = 1.2 \times 10^{13}$ Hz. Photon energy is Planck's constant × frequency: $E = hf = (6.6 \times 10^{-34} \text{ J s})(1.2 \times 10^{13} \text{ Hz})$ = **7.9×10^{-21} J.** (In the electron-volt unit common in atomic and optical physics, this is 0.05 eV, about one-twentieth the energy acquired by an electron in being accelerated through a potential difference of 1 V. 1 eV is equal to 1.6×10^{-19} J.)