Do Problems 6, 8, and 10 5 pts each
and Problems 9–14 10 pts each

CONCEPTUAL QUESTIONS

1. If you observe objects inside a very hot kiln, why is it difficult to discern the shapes of the objects?
2. Why is an electron microscope more suitable than an optical microscope for "seeing" objects of atomic size?
3. Are blackbodies black?
4. Why is it impossible to simultaneously measure the position and velocity of a particle with infinite accuracy?
5. All objects radiate energy. Why, then, are we not able to see all the objects in a dark room?
6. Is light a wave or a particle? Support your answer by citing specific experimental evidence.
7. In the photoelectric effect, explain why the stopping potential depends on the frequency of the light but not on the intensity.
8. Which has more energy, a photon of ultraviolet radiation or a photon of yellow light?
9. Why does the existence of a cutoff frequency in the photoelectric effect favor a particle theory of light rather than a wave theory?
10. What effect, if any, would you expect the temperature of a material to have on the ease with which electrons can be ejected from it via the photoelectric effect?
11. The cutoff frequency of a material is f_0. Are electrons emitted from the material when (a) light of frequency greater than f_0 is incident on the material? (b) Less than f_0?
12. The brightest star in the constellation Lyra is the bluish star Vega, whereas the brightest star in Boötes is the reddish star Arcturus. How do you account for the difference in color of the two stars?
13. If the photoelectric effect is observed in one metal, can you conclude that the effect will also be observed in another metal under the same conditions? Explain.
14. The atoms in a crystal lie in planes separated by a few tenths of a nanometer. Can a crystal be used to produce a diffraction pattern with visible light as it does for x-rays? Explain your answer with reference to Bragg's law.

PROBLEMS

ENHANCED WebAssign The Problems for this chapter may be assigned online at WebAssign.

1, 2, 3 = straightforward, intermediate, challenging

GP = denotes guided problem

ecp = denotes enhanced content problem

= biomedical application

☐ = denotes full solution available in *Student Solutions Manual/Study Guide*

SECTION 27.1 BLACKBODY RADIATION AND PLANCK'S HYPOTHESIS

1. (a) What is the surface temperature of Betelgeuse, a red giant star in the constellation of Orion, which radiates with a peak wavelength of about 970 nm? (b) Rigel, a bluish-white star in Orion, radiates with a peak wavelength of 145 nm. Find the temperature of Rigel's surface.
2. (a) Lightning produces a maximum air temperature on the order of 10^4 K, whereas (b) a nuclear explosion produces a temperature on the order of 10^7 K. Use Wien's displacement law to find the order of magnitude of the wavelength of the thermally produced photons radiated with greatest intensity by each of these sources. Name the part of the electromagnetic spectrum where you would expect each to radiate most strongly.
3. The human eye is most sensitive to 560-nm (green) light. What is the temperature of a blackbody that would radiate most intensely at this wavelength?
4. ecp A tungsten filament of a glowing lightbulb has a temperature of approximately 2 000 K. (a) Assuming the operating filament is a blackbody, determine the peak wavelength of its emitted radiation at this temperature. (b) Why does your answer to part (a) suggest that more energy from a lightbulb goes into heat than into light?
5. Calculate the energy in electron volts of a photon having a wavelength (a) in the microwave range, 5.00 cm, (b) in the visible light range, 500 nm, and (c) in the x-ray range, 5.00 nm.
6. Suppose a star with radius 8.50×10^8 m has a peak wavelength of 685 nm in the spectrum of its emitted radiation. (a) Find the energy of a photon with this wavelength. (b) What is surface temperature of the star? (c) At what rate is energy emitted from the star in the form of radiation? Assume the star is a blackbody ($e = 1$). (d) Using the answer to part (a), estimate the rate at which photons leave the surface of the star.
7. An FM radio transmitter has a power output of 150 kW and operates at a frequency of 99.7 MHz. How many photons per second does the transmitter emit?
8. The threshold of dark-adapted (scotopic) vision is 4.0×10^{-11} W/m^2 at a central wavelength of 500 nm. If light with this intensity and wavelength enters the eye when the pupil is open to its maximum diameter of 8.5 mm, how many photons per second enter the eye?

SECTION 27.2 THE PHOTOELECTRIC EFFECT AND THE PARTICLE THEORY OF LIGHT

9. When light of wavelength 350 nm falls on a potassium surface, electrons having a maximum kinetic energy of 1.31 eV are emitted. Find (a) the work function of potassium, (b) the cutoff wavelength, and (c) the frequency corresponding to the cutoff wavelength.
10. Electrons are ejected from a certain metallic surface with speeds ranging up to 4.6×10^5 m/s when light with a