Questions

1. What can be said about the relative temperatures of whitish-yellow, reddish, and bluish stars? Explain.
2. If energy is radiated by all objects, why can we not see them in the dark? (See also Section 14–8.)
3. Does a lightbulb at a temperature of 2500 K produce as white a light as the Sun at 6000 K? Explain.
4. Darkrooms for developing black-and-white film were sometimes lit by a red bulb. Why red? Would such a bulb work in a darkroom for developing color photographs?
5. If the threshold wavelength in the photoelectric effect increases when the emitting metal is changed to a different metal, what can you say about the work functions of the two metals?
6. Explain why the existence of a cutoff frequency in the photoelectric effect more strongly favors a particle theory rather than a wave theory of light.
7. UV light causes sunburn, whereas visible light does not. Suggest a reason.
8. If an X-ray photon is scattered by an electron, does its wavelength change? If so, does it increase or decrease?
9. In both the photoelectric effect and in the Compton effect, a photon collides with an electron causing the electron to fly off. What then, is the difference between the two processes?
10. Consider a point source of light. How would the intensity of light vary with distance from the source according to (*a*) wave theory, (*b*) particle (photon) theory? Would this help to distinguish the two theories?
11. Explain how the photoelectric circuit of Fig. 27–6 could be used in (*a*) a burglar alarm, (*b*) a smoke detector, (*c*) a photographic light meter.
12. Why do we say that light has wave properties? Why do we say that light has particle properties?
13. Why do we say that electrons have wave properties? Why do we say that electrons have particle properties?
14. What is the difference between a photon and an electron? Be specific: make a list.
15. If an electron and a proton travel at the same speed, which has the shorter wavelength? Explain.
16. In Rutherford's planetary model of the atom, what keeps the electrons from flying off into space?
17. How can you tell if there is oxygen near the surface of the Sun?
18. When a wide spectrum of light passes through hydrogen gas at room temperature, absorption lines are observed that correspond only to the Lyman series. Why don't we observe the other series?
19. Explain how the closely spaced energy levels for hydrogen near the top of Fig. 27–27 correspond to the closely spaced spectral lines at the top of Fig. 27–22.
20. Is it possible for the de Broglie wavelength of a "particle" to be greater than the dimensions of the particle? To be smaller? Is there any direct connection?
21. In a helium atom, which contains two electrons, do you think that on average the electrons are closer to the nucleus or farther away than in a hydrogen atom? Why?
22. How can the spectrum of hydrogen contain so many lines when hydrogen contains only one electron?
23. The Lyman series is brighter than the Balmer series, because this series of transitions ends up in the most common state for hydrogen, the ground state. Why then was the Balmer series discovered first?
24. Use conservation of momentum to explain why photons emitted by hydrogen atoms have slightly less energy than that predicted by Eq. 27–10.
25. The work functions for sodium and cesium are 2.28 eV and 2.14 eV, respectively. For incident photons of a given frequency, which metal will give a higher maximum kinetic energy for the electrons?
26. (*a*) Does a beam of infrared photons always have less energy than a beam of ultraviolet photons? Explain. (*b*) Does a single infrared photon always have less energy than a single ultraviolet photon?
27. Light of 450-nm wavelength strikes a metal surface, and a stream of electrons emerges from the metal. If light of the same intensity but of wavelength 400 nm strikes the surface, are more electrons emitted? Does the energy of the emitted electrons change? Explain.
28. Suppose we obtain an emission spectrum for hydrogen at very high temperature (when some of the atoms are in excited states), and an absorption spectrum at room temperature, when all atoms are in the ground state. Will the two spectra contain identical lines?

Problems

27–1 Discovery of the Electron

1. (I) What is the value of e/m for a particle that moves in a circle of radius 7.0 mm in a 0.86-T magnetic field if a perpendicular 320-V/m electric field will make the path straight?
2. (II) (*a*) What is the velocity of a beam of electrons that go undeflected when passing through crossed (perpendicular) electric and magnetic fields of magnitude 1.88×10^4 V/m and 2.90×10^{-3} T, respectively? (*b*) What is the radius of the electron orbit if the electric field is turned off?
3. (II) An oil drop whose mass is determined to be 2.8×10^{-15} kg is held at rest between two large plates separated by 1.0 cm when the potential difference between them is 340 V. How many excess electrons does this drop have?

27–2 Planck's Quantum Hypothesis

4. (I) How hot is a metal being welded if it radiates most strongly at 440 nm?
5. (I) Estimate the peak wavelength for radiation from (*a*) ice at 0°C, (*b*) a floodlamp at 3500 K, (*c*) helium at 4 K, (*d*) for the universe at $T = 2.725$ K, assuming blackbody emission. In what region of the EM spectrum is each?
6. (I) (*a*) What is the temperature if the peak of a blackbody spectrum is at 18.0 nm? (*b*) What is the wavelength at the peak of a blackbody spectrum if the body is at a temperature of 2000 K?