

•4 A helium–neon laser emits red light at wavelength $\lambda = 633 \text{ nm}$ in a beam of diameter 3.0 mm and at an energy-emission rate of 5.0 mW . A detector in the beam's path totally absorbs the beam. At what rate per unit area does the detector absorb photons?

lifetime of 150 ns ?

•14 **GO** A light detector has an absorbing area of $3.00 \times 10^{-6} \text{ m}^2$ and absorbs 50% of the incident light, which is at wavelength 600 nm . The detector faces an isotropic source, 12.0 m from the source. The energy E emitted by the source versus time t is given in Fig. 38-24 ($E_s = 7.2 \text{ nJ}$, $t_s = 2.0 \text{ s}$). At what rate are photons absorbed by the detector?

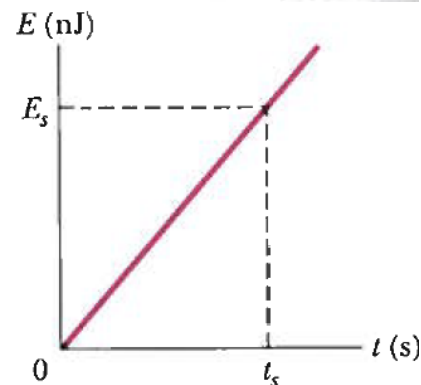


Fig. 38-24 Problem 14.

•15 **SSM** Light strikes a sodium surface, causing photoelectric emission. The stopping potential for the ejected electrons is 5.0 V , and the work function of sodium is 2.2 eV . What is the wavelength of the incident light?

•20 Suppose the *fractional efficiency* of a cesium surface (with work function 1.80 eV) is 1.0×10^{-16} ; that is, on average one electron is ejected for every 10^{16} photons that reach the surface. What would be the current of electrons ejected from such a surface if it were illuminated with 600 nm light from a 3.00 mW laser and all the ejected electrons took part in the charge flow?

•29 What (a) frequency, (b) photon energy, and (c) photon momentum magnitude (in keV/c) are associated with x rays having wavelength 35.0 pm ?

•41 What are (a) the Compton shift $\Delta\lambda$, (b) the fractional Compton shift $\Delta\lambda/\lambda$, and (c) the change ΔE in photon energy for light of wavelength $\lambda = 590 \text{ nm}$ scattering from a free, initially stationary electron if the scattering is at 90° to the direction of the incident beam? What are (d) $\Delta\lambda$, (e) $\Delta\lambda/\lambda$, and (f) ΔE for 90° scattering for photon energy 50.0 keV (x-ray range)?

•51 The highest achievable resolving power of a microscope is limited only by the wavelength used; that is, the smallest item that can be distinguished has dimensions about equal to the wavelength. Suppose one wishes to “see” inside an atom. Assuming the atom to have a diameter of 100 pm , this means that one must be able to resolve a width of, say, 10 pm . (a) If an electron microscope is used, what minimum electron energy is required? (b) If a light microscope is used, what minimum photon energy is required? (c) Which microscope seems more practical? Why?

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••59 Show that Eq. 38-17 is indeed a solution of Eq. 38-16 by substituting $\psi(x)$ and its second derivative into Eq. 38-16 and noting that an identity results.

••64 You will find in Chapter 39 that electrons cannot move in definite orbits within atoms, like the planets in our solar system. To see why, let us try to “observe” such an orbiting electron by using a light microscope to measure the electron’s presumed orbital position with a precision of, say, 10 pm (a typical atom has a radius of about 100 pm). The wavelength of the light used in the microscope must then be about 10 pm. (a) What would be the photon energy of this light? (b) How much energy would such a photon impart to an electron in a head-on collision? (c) What do these results tell you about the possibility of “viewing” an atomic electron at two or more points along its presumed orbital path? (*Hint:* The outer electrons of atoms are bound to the atom by energies of only a few electron-volts.)