Problems 9-14 any Two 27-32 any Two

wavelength of $\lambda = 625$ nm is used. (a) What is the work function of the metal? (b) What is the cutoff frequency for this metal?

11. GP The work function for platinum is 6.35 eV. (a) Convert the value of the work function from electron volts to joules. (b) Find the cutoff frequency for platinum. (c) What maximum wavelength of light incident on platinum releases photoelectrons from the platinum's surface? (d) If light of energy 8.50 eV is incident on zinc, what is the maximum kinetic energy of the ejected photoelectrons? Give the answer in electron volts. (e) For photons of energy 8.50 eV, what stopping potential would be required to arrest the current of photoelectrons?

12. ecp Lithium, beryllium, and mercury have work functions of 2.30 eV, 3.90 eV, and 4.50 eV, respectively. Light with a wavelength of 4.00×10^2 nm is incident on each of these metals. (a) Which of these metals emit photoelectrons in response to the light? Why? (b) Find the maximum kinetic energy for the photoelectrons in each case.

13. When light of wavelength 254 nm falls on cesium, the required stopping potential is 3.00 V. If light of wavelength 436 nm is used, the stopping potential is 0.900 V. Use this information to plot a graph like that shown in Figure 27.6, and from the graph determine the cutoff frequency for cesium and its work function.

14. Ultraviolet light is incident normally on the surface of a certain substance. The binding energy of the electrons in this substance is 3.44 eV. The incident light has an intensity of 0.055 W/m^2. The electrons are photoelectrically emitted with a maximum speed of 4.2×10^5 m/s. How many electrons are emitted from a square centimeter of the surface each second? Assume the absorption of every photon ejects an electron.

SECTION 27.3 X-RAYS

15. The extremes of the x-ray portion of the electromagnetic spectrum range from approximately 1.0×10^{-8} m to 1.0×10^{-13} m. Find the minimum accelerating voltages required to produce wavelengths at these two extremes.

16. ecp Calculate the minimum-wavelength x-ray that can be produced when a target is struck by an electron that has been accelerated through a potential difference of (a) 15.0 kV and (b) 1.00×10^2 kV. (c) What happens to the minimum wavelength as the potential difference increases?

17. What minimum accelerating voltage is required to produce an x-ray with a wavelength of 70.0 pm?

SECTION 27.4 DIFFRACTION OF X-RAYS BY CRYSTALS

18. When x-rays of wavelength of 0.129 nm are incident on the surface of a crystal having a structure similar to that of NaCl, a first-order maximum is observed at 8.15°. Calculate the interplanar spacing of the crystal based on this information.

19. Potassium iodide has an interplanar spacing of d = 0.296 nm. A monochromatic x-ray beam shows a first-order diffraction maximum when the grazing angle is 7.6°. Calculate the x-ray wavelength.

20. ecp The first-order diffraction maximum is observed at 12.6° for a crystal having an interplanar spacing of 0.240 nm. How many other orders can be observed in the diffraction pattern, and at what angles do they appear? Why is there an upper limit to the number of observed orders?

21. X-rays of wavelength 0.140 nm are reflected from a certain crystal, and the first-order maximum occurs at an angle of 14.4°. What value does this give for the interplanar spacing of the crystal?

SECTION 27.5 THE COMPTON EFFECT

22. X-rays are scattered from a target at an angle of 55.0° with the direction of the incident beam. Find the wavelength shift of the scattered x-rays.

23. A 0.001 6-nm photon scatters from a free electron. For what (photon) scattering angle will the recoiling electron and scattered photon have the same kinetic energy?

24. A beam of 0.68-nm photons undergoes Compton scattering from free electrons. What are the energy and momentum of the photons that emerge at a 45° angle with respect to the incident beam?

25. A 0.110-nm photon collides with a stationary electron. After the collision, the electron moves forward and the photon recoils backwards. Find the momentum and kinetic energy of the electron.

26. X-rays with an energy of 300 keV undergo Compton scattering from a target. If the scattered rays are deflected at 37.0° relative to the direction of the incident rays, find (a) the Compton shift at this angle, (b) the energy of the scattered x-ray, and (c) the kinetic energy of the recoiling electron.

SECTION 27.6 THE DUAL NATURE OF LIGHT AND MATTER

27. (a) If the wavelength of an electron is 5.00×10^{-7} m, how fast is it moving? (b) If the electron has a speed equal to 1.00×10^7 m/s, what is its wavelength?

28. Calculate the de Broglie wavelength of a proton moving at (a) 2.00×10^4 m/s and (b) 2.00×10^7 m/s.

29. De Broglie postulated that the relationship $\lambda = h/p$ is valid for relativistic particles. What is the de Broglie wavelength for a (relativistic) electron having a kinetic energy of 3.00 MeV?

30. (a) Calculate the momentum of a photon having a wavelength of 4.00×10^2 nm. (b) Find the speed of an electron having the same momentum as the photon in part (a).

31. The resolving power of a microscope is proportional to the wavelength used. A resolution of 1.0×10^{-11} m (0.010 nm) would be required in order to "see" an atom. (a) If electrons were used (electron microscope), what minimum kinetic energy would be required of the electrons? (b) If photons were used, what minimum photon energy would be needed to obtain 1.0×10^{-11} m resolution?