* 29. (II) An excited H atom is in a $6d$ state. (*a*) Name all the states (n, l) to which the atom is "allowed" to jump with the emission of a photon. (*b*) How many different wavelengths are there (ignoring fine structure)?

* 28–9 X-Rays

* 30. (I) What are the shortest-wavelength X-rays emitted by electrons striking the face of a 33.5-kV TV picture tube? What are the longest wavelengths?

* 31. (I) If the shortest-wavelength bremsstrahlung X-rays emitted from an X-ray tube have $\lambda = 0.030\,\text{nm}$, what is the voltage across the tube?

* 32. (I) Show that the cutoff wavelength λ_0 is given by

$$\lambda_0 = \frac{1240\,\text{nm}}{V},$$

where V is the X-ray tube voltage in volts.

* 33. (II) Use the result of Example 28–6 to estimate the X-ray wavelength emitted when a Co $(Z = 27)$ atom jumps from $n = 2$ to $n = 1$.

* 34. (II) Estimate the wavelength for an $n = 2$ to $n = 1$ transition in iron $(Z = 26)$.

* 35. (II) Use the Bohr theory to estimate the wavelength for an $n = 3$ to $n = 1$ transition in molybdenum $(Z = 42)$. The measured value is 0.063 nm. Why do we not expect perfect agreement?

* 36. (II) A mixture of iron and an unknown material is bombarded with electrons. The wavelength of the K_α lines are 194 pm for iron and 229 pm for the unknown. What is the unknown material?

* 28–11 Lasers

* 37. (II) A laser used to weld detached retinas puts out 28-ms-long pulses of 640-nm light which average 0.68-W output during a pulse. How much energy can be deposited per pulse and how many photons does each pulse contain? [*Hint*: see Example 27–5.]

* 38. (II) A low-power laser used in a physics lab might have a power of 0.50 mW and a beam diameter of 3.0 mm. Calculate (*a*) the average light intensity of the laser beam, and (*b*) compare it to the intensity of a lightbulb producing 40-W light viewed from 2.0 m.

* 39. (II) Estimate the angular spread of a laser beam due to diffraction if the beam emerges through a 3.0-mm-diameter mirror. Assume that $\lambda = 694\,\text{nm}$. What would be the diameter of this beam if it struck (*a*) a satellite 300 km above the Earth, or (*b*) the Moon? [*Hint*: see Section 25–7.]

* 40. (II) What is the wavelength of the He–Ne laser?

General Problems

41. Use the uncertainty principle to estimate the position uncertainty for the electron in the ground state of the hydrogen atom. [*Hint*: determine the momentum using the Bohr model of Section 27–12 and assume the momentum can be anywhere between this value and zero.] How does this result compare to the Bohr radius?

42. An electron in the $n = 2$ state of hydrogen remains there on average about $10^{-8}\,\text{s}$ before jumping to the $n = 1$ state. (*a*) Estimate the uncertainty in the energy of the $n = 2$ state. (*b*) What fraction of the transition energy is this? (*c*) What is the wavelength, and width (in nm), of this line in the spectrum of hydrogen?

43. What are the largest and smallest possible values for the angular momentum L of an electron in the $n = 5$ shell?

44. Estimate (*a*) the quantum number l for the orbital angular momentum of the Earth about the Sun, and (*b*) the number of possible orientations for the plane of Earth's orbit.

45. A 12-g bullet leaves a rifle at a speed of 180 m/s. (*a*) What is the wavelength of this bullet? (*b*) If the position of the bullet is known to an accuracy of 0.60 cm (radius of the barrel), what is the minimum uncertainty in its momentum?

46. Using the Bohr formula for the radius of an electron orbit, estimate the average distance from the nucleus for an electron in the innermost $(n = 1)$ orbit of a uranium atom $(Z = 92)$. Approximately how much energy would be required to remove this innermost electron?

47. An X-ray tube operates at 95 kV with a current of 25 mA and nearly all the electron energy goes into heat. If the specific heat of the 0.085-kg plate is $0.11\,\text{kcal/kg}\cdot\text{C}^\circ$, what will be the temperature rise per minute if no cooling water is used?

48. The ionization (binding) energy of the outermost electron in boron is 8.26 eV. (*a*) Use the Bohr model to estimate the "effective charge," Z_{eff}, seen by this electron. (*b*) Estimate the average orbital radius.

49. Use the Bohr theory (especially Eq. 27–16) to show that the Moseley plot (Fig. 28–12) can be written

$$\sqrt{\frac{1}{\lambda}} = a(Z - b),$$

where $b \approx 1$, and evaluate a.

50. (*a*) Show that the number of different states for a given value of l is equal to $2(2l + 1)$. (*b*) What is this number for $l = 0, 1, 2, 3, 4, 5$, and 6?

51. Show that the number of different electron states possible for a given value of n is $2n^2$. (See Problem 50.)

52. A beam of electrons with kinetic energy 45 keV is shot through two narrow slits in a barrier. The slits are a distance $2.0 \times 10^{-6}\,\text{m}$ apart. If a screen is placed 35.0 cm behind the barrier, calculate the spacing between the "bright" fringes of the interference pattern produced on the screen.