Chapter 30

Problems & Exercises

1.

1.84×10^{3}

3.

50 km

4.

6×10^{20} kg/m^{3}

6.

(a) 10.0 m

(b) It isn't hard to make one of approximately this size. It would be harder to make it exactly 10.0 m.

7.

$\frac{1}{\lambda} = R\left(\frac{1}{n_{\mathrm{f}}^{2}} - \frac{1}{n_{\mathrm{i}}^{2}}\right) \Rightarrow \lambda = \frac{1}{R}\left[\frac{(n_{\mathrm{i}} \cdot n_{\mathrm{f}})^{2}}{n_{\mathrm{i}}^{2} - n_{\mathrm{f}}^{2}}\right];\ n_{\mathrm{i}} = 2,\ n_{\mathrm{f}} = 1,$ so that

$\lambda = \left(\frac{m}{1.097 \times 10^{7}}\right)\left[\frac{(2 \times 1)^{2}}{2^{2} - 1^{2}}\right] = 1.22 \times 10^{-7}\ \mathrm{m} = 122\ \mathrm{nm}$, which is UV radiation.

9.

$a_{\mathrm{B}} = \frac{h^{2}}{4\pi^{2} m_{e} \mathrm{kZ} q_{e}^{2}} = \frac{(6.626 \times 10^{-34}\ \mathrm{J \cdot s})^{2}}{4\pi^{2}(9.109 \times 10^{-31}\ \mathrm{kg})(8.988 \times 10^{9}\ \mathrm{N \cdot m^{2}}/C^{2})(1)(1.602 \times 10^{-19}\ \mathrm{C})^{2}} = 0.529 \times 10^{-10}\ \mathrm{m}$

11.

0.850 eV

13.

2.12×10^{-10} m

15.

365 nm

It is in the ultraviolet.

17.

No overlap

365 nm

122 nm

19.

7

21.

(a) 2

(b) 54.4 eV

23.

$\frac{\mathrm{kZq}_e^2}{r_n^2} = \frac{m_e V^2}{r_n}$, so that $r_n = \frac{\mathrm{kZq}_e^2}{m_e V^2} = \frac{\mathrm{kZq}_e^2}{m_e}\frac{1}{V^2}$. From the equation $m_e \mathrm{v} \mathrm{r}_n = n\frac{h}{2\pi}$, we can substitute for the velocity, giving: $r_n = \frac{\mathrm{kZq}_e^2}{m_e} \cdot \frac{4\pi^2 m_e^2 r_n^2}{n^2 h^2}$ so that $r_n = \frac{n^2}{Z}\frac{h^2}{4\pi^2 m_e \mathrm{kq}_e^2} = \frac{n^2}{Z} a_{\mathrm{B}}$, where $a_{\mathrm{B}} = \frac{h^2}{4\pi^2 m_e \mathrm{kq}_e^2}$.

25.

(a) 0.248×10^{-10} m

(b) 50.0 keV

(c) The photon energy is simply the applied voltage times the electron charge, so the value of the voltage in volts is the same as the value of the energy in electron volts.

27.

(a) 100×10^3 eV, 1.60×10^{-14} J

(b) 0.124×10^{-10} m

29.

(a) 8.00 keV

(b) 9.48 keV

30.

(a) 1.96 eV

(b) $(1240 \text{ eV} \cdot \text{nm})/(1.96 \text{ eV}) = 633$ nm

(c) 60.0 nm

32.

693 nm

34.

(a) 590 nm

(b) $(1240 \text{ eV} \cdot \text{nm})/(1.17 \text{ eV}) = 1.06$ m

35.

$l = 4,\ 3$ are possible since $l < n$ and $\mid m_l \mid \ l$.

37.

$n = 4 \Rightarrow l = 3,\ 2,\ 1,\ 0 \Rightarrow m_l = \pm 3,\ \pm 2,\ \pm 1$, 0 are possible.

39.

(a) 1.49×10^{-34} J $\cdot\, s$

(b) 1.06×10^{-34} J $\cdot\, s$

41.

(a) 3.66×10^{-34} J $\cdot\, s$

(b) $s = 9.13 \times 10^{-35}$ J $\cdot\, s$

(c) $\frac{L}{S} = \frac{\sqrt{12}}{\sqrt{3/4}} = 4$

43.

$\theta = 54.7^{\text{o}}$, 125.3^{o}

44.

(a) 32. (b) 2 in s, 6 in p, 10 in d, and 14 in f, for a total of 32.

46.

(a) 2

(b) $3d^9$

48.

(b) $n \geq l$ is violated,

(c) cannot have 3 electrons in s subshell since $3 > (2l + 1) = 2$

(d) cannot have 7 electrons in p subshell since $7 > (2l + 1) = 2(2 + 1) = 6$

50.

(a) The number of different values of m_l is $\pm l, \pm(l-1), ...,0$ for each $l > 0$ and one for $l = 0 \Rightarrow (2l + 1)$. Also an overall factor of 2 since each m_l can have m_s equal to either $+1/2$ or $-1/2 \Rightarrow 2(2l + 1)$.

(b) for each value of l, you get $2(2l + 1)$

$= 0, 1, 2, ...,(n\text{–}1) \Rightarrow 2\{[(2)(0) + 1] + [(2)(1) + 1] + ... + [(2)(n - 1) + 1]\} = 2\underbrace{[1 + 3 + ... + (2n - 3) + (2n - 1)]}_{n \text{ terms}}$ to see that the expression in the box is $= n^2$, imagine taking $(n - 1)$ from the last term and adding it to first term $= 2[1 + (n\text{–}1) + 3 + ... + (2n - 3) + (2n - 1)\text{–}(n - 1)] = 2[n + 3 + ... + (2n - 3) + n]$. Now take $(n - 3)$ from penultimate term and add to the second term $2\underbrace{[n + n + ... + n + n]}_{n \text{ terms}} = 2n^2$.

52.

The electric force on the electron is up (toward the positively charged plate). The magnetic force is down (by the RHR).

54.

401 nm

56.

(a) 6.54×10^{-16} kg

(b) 5.54×10^{-7} m

58.

1.76×10^{11} C/kg , which agrees with the known value of 1.759×10^{11} C/kg to within the precision of the measurement

60.

(a) 2.78 fm

(b) 0.37 of the nuclear radius.

62.

(a) 1.34×10^{23}

(b) 2.52 MW

64.

(a) 6.42 eV

(b) 7.27×10^{-20} J/molecule

(c) 0.454 eV, 14.1 times less than a single UV photon. Therefore, each photon will evaporate approximately 14 molecules of tissue. This gives the surgeon a rather precise method of removing corneal tissue from the surface of the eye.

66.

91.18 nm to 91.22 nm

68.

(a) 1.24×10^{11} V

(b) The voltage is extremely large compared with any practical value.

(c) The assumption of such a short wavelength by this method is unreasonable.

72.

$E = -\frac{z^2}{n^2}$

$E_3 - E_2 = -\left(\frac{6^2}{3^2} - \frac{6^2}{2^2}\right) 13.6eV = 68.0eV$

$$E_3 - E_2 = -\left(\frac{6^2}{2^2} - \frac{6^2}{1^2}\right) 13.6eV = 367eV$$

(a) $E = 435eV$

(b) $E_3 - E_2 = -\left(\frac{6^2}{3^2} - \frac{6^2}{1^2}\right) 13.6eV = 435eV$

(c) Yes.