3. According to Rutherford, size of nucleus is about \( \frac{1}{100,000} \) that of atom. So if a 1 m nucleus would have an electron 100,000 m away — or 100 km.

13. \( E_n = -\frac{Z^2}{n^2} \) 13.6 eV, \( Z = 1 \), \( E_n = -0.86 \) eV

\[ n = \sqrt{-\frac{Z^2}{E_n}} = \sqrt{\frac{1}{13.6 \text{ eV}}} \]

19. Balmer series, \( n_f = 2 \), \( R = 1.097 \times 10^7 \text{ m}^{-1} \)

\[ \lambda = \frac{1}{R} \left( \frac{1}{n_f^2} - \frac{1}{n_i^2} \right) \]

\( n_i = 1, \lambda = x \)
\( n_i = 2, \lambda = x \)

A more efficient way to do this would be to set \( n \leq 400 \) and solve for \( n_i \).

1st UV \( \rightarrow n_i = 7, \lambda = 397 \) nm

\( \text{Visible} \) \( \begin{cases} n_i = 3, \lambda = 656 \text{ nm} \\ n_i = 4, \lambda = 486 \text{ nm} \\ n_i = 5, \lambda = 434 \text{ nm} \\ n_i = 6, \lambda = 410 \text{ nm} \end{cases} \)

(An infinite \# of \( n \) have UV \( \lambda \)’s)

(Note: I think Wronski uses \( \lambda = 380 \text{ nm} \) for UV, so he gets different answers.)
23a. \( E_n = -\frac{Z^2}{n^2} \) 13.6 eV

So, if \( Z_e = 6 \) and \( Z_H = 1 \), then \( \frac{E_c}{E_n} = \frac{Z_e^2}{Z_H^2} = 36 \)

b. Problems: \( N_f = 3 \), \( N_i = 4 \)

\[
E_n = \frac{-Z^2(13.6 \text{ eV})}{(\frac{1}{3^2} - \frac{1}{4^2})} = 23.8 \text{ eV}
\]

Note: Bok's answer is wrong—it uses the Balmer series with \( n_i = 2 \) and \( n_f = 2 \).

\[
E = \frac{hc}{\lambda} \rightarrow \lambda = \frac{hc}{E} = \frac{1240 \text{ eV nm}}{23.8 \text{ eV}}
\]

This is UV \( \rightarrow 521 \text{ nm} \)

27. \( m_l = 2 \), so the largest \( l \) is \( l = 2 \)

so the smallest \( n \) is \( n = l + 1 = 3 \)

(This takes some thinking. Look at Table 2B.1.)

33. \( l = 2 \)

a. \( \zeta = \frac{m_l h}{2\pi} \) where \( m_l = -2, -1, 0, 1, 2 \) for \( l = 2 \)

b. \( \cos \theta = \frac{L_z}{L} = \frac{m_l h}{2\pi} \)

\[
\frac{\sqrt{L(L+1)}}{m_l} = \frac{2}{\sqrt{6}}
\]

\[\theta = 35.3^\circ\]
37. a. 9 electrons in subshell
\[ 9 = 2(2l+1) \]
\[ \frac{9}{2} = 2l + 1 \]
\[ 9 - 1 = 2l \]
\[ \frac{9 - 1}{2} = l \]
\[ 4 \leq l \]

So \( l = 2 \)

b. \( n = 3 \), \( l = 2 \), \( s \)
\[ 3d \rightarrow 4s^{-1} \]

39.

a. \( 5s^1 \)
\( l = 0 \), \( n = 5 \)
\( 5s \) ok

b. \( 1d^1 \)
\( l = 2 \), \( n = 1 \)
\( 2 \) NO!

\( n = 1 \) is the lowest level.

\( 2(2l+1) = 2(2(2)+1) = 10 \)

\( 2 \) NO!

\( 50 \) ok

\( 10 \) ok

Too many e^\(-1\).

\( \text{Can't have } l > n - 1 \)

d. \( 3p^1 \)
\( l = 1 \), \( n = 3 \)
\( 18 \) ok

\( 50 \) ok

\( 18 \) ok

e. \( 5f^1 \)
\( l = 4 \), \( n = 5 \)
\( 52 \) ok

\( 52 \) ok

49. Energy output would equal the difference in energy levels of some \( Z \)-numbered atom:
\( \text{let } 13.6 \text{ eV } = E_0 \)

\[ E_K = E_f - E_i = -\frac{Z^2}{r^2} E_0 = -\frac{Z^2}{r^2} E_0 = 52.9 \times 10^3 \text{ eV} \]

\( K \) means the transition from \( n = 2 \) to \( n = 1 \)

\[ Z = \sqrt[2]{72} \rightarrow " \text{Hafnium}" \text{ or } \text{Hf} \]
53. From figure 28.42, metastable state is at 20.66 eV, so use photons with this energy:

\[ E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E} = \frac{1240 \text{ eV} \cdot \text{nm}}{20.66 \text{ eV}} \]

\[ \lambda = 60 \text{ nm} \quad \text{(ultraviolet)} \]

55. From figure 28.41, 2nd state → 2.3 eV, 3rd state → 3.0 eV

(from above) \[ \lambda_2 = \frac{hc}{E_2} = \frac{1240 \text{ eV} \cdot \text{nm}}{2.3 \text{ eV}} = 539 \text{ nm} \]

\[ \lambda_3 = \frac{hc}{E_3} = \frac{1240 \text{ eV} \cdot \text{nm}}{3.0 \text{ eV}} = 413 \text{ nm} \]

61. \[ \Delta E = E_1 = -\frac{Z^2}{\pi^2} \quad \text{13.6 eV} = -\frac{1^2}{1^2} \quad 13.6 \text{ eV} \]

So, 13.6 eV necessary to ionize...

(expected) Wavelength: \[ \lambda_0 = \frac{hc}{E} = \frac{1240 \text{ eV} \cdot \text{nm}}{13.6 \text{ eV}} \]

\[ \lambda_0 = 91.2 \text{ nm} \]

But, we have a Doppler Effect:

\[ \lambda_{\text{obs}} = \lambda_0 \sqrt{\frac{1 - u/c}{1 - u/c}} \quad \text{(Solve for } u...) \]
\[
(1 + \text{cosec} \theta) \left( \frac{\lambda_{\text{obs}}}{\lambda_0} \right)^2 = \frac{1 + \frac{u}{c}}{1 - \frac{u}{c}}
\]

\[
\left( \frac{\lambda_{\text{obs}}}{\lambda_0} \right)^2 (1 - \frac{u}{c}) = 1 + \frac{u}{c}
\]

\[
\left( \frac{\lambda_{\text{obs}}}{\lambda_0} \right)^2 = \frac{u}{c} \left( \frac{\lambda_{\text{obs}}}{\lambda_0} \right)^2 = 1 + \frac{u}{c}
\]

\[
\left( \frac{\lambda_{\text{obs}}}{\lambda_0} \right)^2 - 1 = \frac{u}{c} \left( 1 + \left( \frac{\lambda_{\text{obs}}}{\lambda_0} \right)^2 \right)
\]

so \( u = c \left( \frac{\left( \frac{\lambda_{\text{obs}}}{\lambda_0} \right)^2 - 1}{\left( \frac{\lambda_{\text{obs}}}{\lambda_0} \right)^2 + 1} \right) \)

\( \lambda_{\text{obs}} = 91.0 \text{ nm} \), \( \lambda_0 = 91.2 \text{ nm} \)

then \( u = (-2.2 \times 10^{-5}) \frac{c}{c} = \sqrt{6.60 \times 10^5 \text{ m/s}} \)

Away from you

(This is done all the time in astronomy to detect and measure motion, just by measuring \( \lambda \).)
67. This is a little silly, but it gives you an idea of the enormity of the difference in scale that we deal with in physics.

Speed of the moon, \( v = \frac{\text{dist}}{\text{time}} = \frac{2\pi R}{28 \text{days}} \)

Angular momentum:

\[
L = I \omega = (MR^2) \frac{v}{R} = MVR
\]

\[
L = M \frac{2\pi R}{t} R = \frac{2\pi MR^2}{t}
\]

According to this chapter, \( L = \sqrt{I(l+1)} \frac{l}{2\pi} = \frac{2\pi MR^2}{t} \)

This could get ugly with a quadratic, but \( l \) is going to be very large, so that \( l \approx l+1 \), so \( l(l+1) \approx l^2 \)

\[
\sqrt{l(l+1)} = \frac{4\pi^2}{\pi^2} \frac{MR^2}{t}
\]

\[
l = 4\pi^2 \left( \frac{7.35 \times 10^{22} \text{ kg}}{(6.63 \times 10^{-34} \text{ J}) \left( \frac{3.84 \times 10^8 \text{ m}}{2.4 \times 10^6 \text{ s}} \right)^2} \right)
\]

\[
l = 2.7 \times 10^{16} \text{ kg m}^2 \text{ s}^{-1} \text{ when... very big!}
\]