

4-29. $r_n = \frac{n^2 a_0}{Z}$ (Equation 4-18)

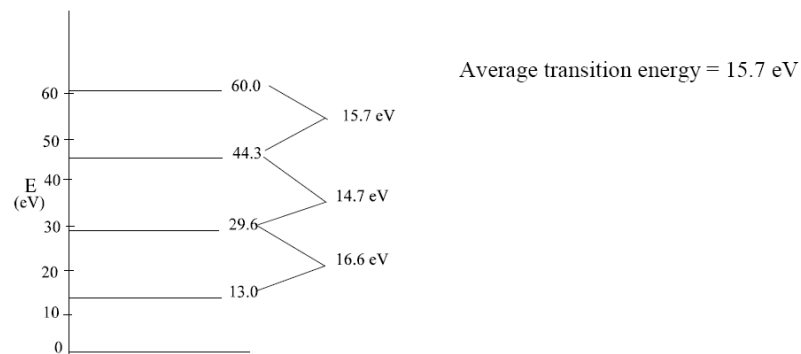
The $n = 1$ electrons “see” a nuclear charge of approximately $Z - 1$, or 78 for Au.

$$r_1 \approx 0.0529 \text{ nm} / 78 = 6.8 \times 10^{-4} \text{ nm} \approx 6.8 \times 10^{-4} \text{ nm} (10^{-9} \text{ m/nm}) (10^{15} \text{ fm/m}) = 680 \text{ fm}$$

or about 100 times the radius of the Au nucleus.

- 4-34. (a) The available energy is not sufficient to raise ground state electrons to the $n=5$ level which requires $13.6 - 0.54 = 13.1 \text{ eV}$. The shortest wavelength (i.e., highest energy) spectral line that will be emitted is the 3rd line of the Lyman series, the $n = 4 \rightarrow n = 1$ transition. (See Figure 4-16.)
- (b) The emitted lines will be for those transitions that begin on the $n = 4$, $n = 3$, or $n = 2$ levels. These are the first three lines of the Lyman series, the first two lines of the Balmer series, and the first line of the Paschen series.

4-34.



4-45. (a) $E_n = -E_0 Z^2 / n^2$ (Equation 4-20)

For Li^{++} , $Z = 3$ and $E_n = -13.6 \text{ eV}(9)/n^2 = -122.4/n^2 \text{ eV}$

The first three Li^{++} levels that have the same (nearly) energy as H are:

$n = 3$, $E_3 = -13.6 \text{ eV}$ $n = 4$, $E_4 = -3.4 \text{ eV}$ $n = 9$, $E_9 = -1.51 \text{ eV}$

Lyman α corresponds to the $n = 6 \rightarrow n = 3 \text{ Li}^{++}$ transition. Lyman β

corresponds to the $n = 9 \rightarrow n = 3 \text{ Li}^{++}$ transition.

(b) $R(H) = R_\infty(1/(1 + 0.511 \text{ MeV}/938.8 \text{ MeV})) = 1.096776 \times 10^7 \text{ m}^{-1}$

$R(\text{Li}) = R_\infty(1/(1 + 0.511 \text{ MeV}/6535 \text{ MeV})) = 1.097287 \times 10^7 \text{ m}^{-1}$

For Lyman α :

$$\frac{1}{\lambda} = R(H) \left(1 - \frac{1}{2^2} \right) = 1.096776 \times 10^7 \text{ m}^{-1} (10^{-9} \text{ m/nm})(3/4) \rightarrow \lambda = 121.568 \text{ nm}$$

For Li^{++} equivalent:

$$\frac{1}{\lambda} = R(\text{Li}) \left(\frac{1}{3^2} - \frac{1}{6^2} \right) Z^2 = 1.097287 \times 10^7 \text{ m}^{-1} (10^{-9} \text{ m/nm}) \left(\frac{1}{9} - \frac{1}{36} \right) (3)^2$$

$\lambda = 121.512 \text{ nm} \quad \Delta\lambda = 0.056 \text{ nm}$

4-48. (a) $E_\alpha = hc/\lambda = 1240 \text{ eV}\cdot\text{nm}/0.071 \text{ nm} = 17.465 \text{ keV}$

$E_\beta = hc/\lambda = 1240 \text{ eV}\cdot\text{nm}/0.063 \text{ nm} = 19.683 \text{ keV}$

(b) Select Nb ($Z = 41$)

The $\text{K}\beta$ Mo X rays have enough energy to eject photoelectrons, producing 0.693

keV electrons. The $\text{K}\alpha$ Mo X rays could not produce photoelectrons in Nb.