1. Calculating the wavelength of a line in the spectrum of hydrogen

The energy $E$ of the electron in a hydrogen atom can be calculated from the Bohr formula:

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

In this equation $R_y$ stands for the Rydberg energy, and $n$ stands for the principal quantum number of the orbital that holds the electron. (You can find the value of the Rydberg energy using the Data button on the ALEKS toolbar.)

Calculate the wavelength of the line in the emission line spectrum of hydrogen caused by the transition of the electron from an orbital with $n = 6$ to an orbital with $n = 5$. Round your answer to 3 significant digits.

You can solve this problem by using a key fact about spectroscopy: when a system makes a transition from one state to another, it emits or absorbs a photon with energy equal to the difference in energy between the states.

That means, in this case, that the energy of the photon emitted when the electron goes from the $n = 6$ orbital to the $n = 5$ orbital must equal the difference in energy between these orbitals. Use the Bohr formula to calculate that difference:

$$\Delta E = E_6 - E_5$$

$$\Delta E = \left( -\frac{R_y}{(6)^2} \right) - \left( -\frac{R_y}{(5)^2} \right)$$

Subtract the lower energy from the higher energy. The orbital with larger $n$ has the higher energy. Use the Bohr formula for each energy. Substitute the value.
\[ \Delta E = \left( \frac{-2.17987 \times 10^{-18} \text{ J}}{(6)^2} \right) - \left( \frac{-2.17987 \times 10^{-18} \text{ J}}{(5)^2} \right) \]

\[ \Delta E = 2.6643 \times 10^{-20} \text{ J} \]

Now you know the energy of the photon. Use the relationship between photon energy and wavelength to calculate its wavelength:

\[ E = \frac{h \cdot c}{\lambda} \]

\[ \lambda = \frac{h \cdot c}{E} \]

\[ \lambda = \frac{(6.62607 \times 10^{-34} \text{ J} \cdot \text{s}) \left( 299792458 \text{ m/s} \right)}{(2.6643 \times 10^{-20} \text{ J})} \]

\[ \lambda = 7.4558 \times 10^{-6} \text{ m} \]

\[ \lambda = 7.46 \mu\text{m} \]

The wavelength of the \( 6 \rightarrow 5 \) emission line is 7.46 \( \mu\text{m} \)