37.21. **Model:** Use Equation 37.9 which is the Balmer formula.
Visualize: Please refer to Figure 37.19 (b).
Solve: **(a)** The wavelengths in the hydrogen emission spectrum are 656.6 nm, 486.3 nm, 434.2 nm, and 410.3 nm. The formula for Balmer series can be written

$$\frac{1}{m^2} - \frac{1}{n^2} = \frac{91.18 \text{ nm}}{\lambda}$$

where $m = 1, 2, 3, \ldots$ and $n = m + 1, m + 2, \ldots$ For the first wavelength,

$$\frac{1}{m^2} - \frac{1}{n^2} = \frac{91.18 \text{ nm}}{656.5 \text{ nm}} = 0.1389 \Rightarrow \frac{n^2 - m^2}{n^2 m^2} = 0.1389$$

This equation is satisfied when $m = 2$ and $n = 3$. For the second wavelength (486.3 nm) the equation is satisfied for $m = 2$ and $n = 4$. Likewise, for the next two wavelengths $m = 2$ and $n = 5$ and 6.
(b) The fifth line in the spectrum will correspond to $m = 2$ and $n = 7$. Its wavelength is

$$\lambda = \frac{91.18 \text{ nm}}{\left(\frac{1}{2}\right)^2 - \left(\frac{1}{7}\right)^2} = \left(\frac{196}{45}\right)(91.18 \text{ nm}) = 397.1 \text{ nm}$$