48. The wavelength λ of the photon emitted in a transition belonging to the Balmer series satisfies

$$E_{\text{ph}} = \frac{hc}{\lambda} = E_n - E_2 = -(13.6\,\text{eV})\left(\frac{1}{n^2} - \frac{1}{2^2}\right) \quad \text{where } n = 3,\, 4,\, 5,\, \ldots$$

Using the result of problem 3 in Chapter 39, we find

$$\lambda = \frac{4hcn^2}{(13.6\,\text{eV})(n^2-4)} = \frac{4(1240\,\text{eV}\cdot\text{nm})}{13.6\,\text{eV}}\left(\frac{n^2}{n^2-4}\right) \; .$$

Plugging in the various values of n, we obtain these values of the wavelength: $\lambda = 656\,\text{nm}$ (for $n = 3$), $\lambda = 486\,\text{nm}$ (for $n = 4$), $\lambda = 434\,\text{nm}$ (for $n = 5$), $\lambda = 410\,\text{nm}$ (for $n = 6$), $\lambda = 397\,\text{nm}$ (for $n = 7$), $\lambda = 389\,\text{nm}$ (for $n = 8$), etc. Finally for $n = \infty$, $\lambda = 365\,\text{nm}$. These values agree well with the data found in Fig. 40-17. [One can also find λ beyond three significant figures by using the more accurate values for m_e, e and h listed in Appendix B when calculating E_n in Eq. 40-24. Another factor that contributes to the error is the motion of the atomic nucleus. It can be shown that this effect can be accounted for by replacing the mass of the electron m_e by $m_e m_p/(m_p + m_e)$ in Eq. 40-24, where m_p is the mass of the proton. Since $m_p \gg m_e$, this is not a major effect.]