3. Assume the speed is exact. Non-relativistically use the energy \( eV = \frac{1}{2}mv^2 \)

\[
V = \frac{mv^2}{2e} = \frac{(9.1094 \times 10^{-31} \text{ kg}) (2.00 \times 10^7 \text{ m/s})^2}{2 (1.6022 \times 10^{-19} \text{ C})} = 1137.1 \text{ V}
\]

Relativistically \( eV = K = (\gamma - 1)mc^2 \)

\[
V = \left[ \frac{1}{\sqrt{1 - \left( \frac{2.00 \times 10^7 \text{ m/s}}{2.9979 \times 10^8 \text{ m/s}} \right)^2}} - 1 \right] \left[ \frac{511 \text{ keV}}{e} \right] = 1141.0 \text{ V}
\]

The results differ by about 4 volts, or about 0.34%. Relativity is required only if that level of precision is needed.
9. Lyman:

\[ \lambda = \left[ R_H \left( 1 - \frac{1}{\infty^2} \right) \right]^{-1} = R_H^{-1} = \left( 1.096776 \times 10^7 \text{ m}^{-1} \right)^{-1} = 91.2 \text{ nm} \]

Balmer:

\[ \lambda = \left[ R_H \left( \frac{1}{2^2} - \frac{1}{\infty^2} \right) \right]^{-1} = 4R_H^{-1} = 4 \left( 1.096776 \times 10^7 \text{ m}^{-1} \right)^{-1} = 364.7 \text{ nm} \]
15. a) Use Equation (3.13) \[ \frac{1}{\lambda} = R_H \left( \frac{1}{n^2} - \frac{1}{k^2} \right) \] with \( R_H = 1.096776 \times 10^7 \text{ m}^{-1} \) and \( n = 3 \) for the Paschen series. With \( k = 4 \) we find
\[ \frac{1}{\lambda} = 1.096776 \times 10^7 \text{ m}^{-1} \left( \frac{1}{3^2} - \frac{1}{4^2} \right); \quad \lambda = 1875.63 \text{ nm}. \]

With \( k = 5 \quad \lambda = 1282.17 \text{ nm} \); with \( k = 6 \quad \lambda = 1094.12 \text{ nm} \); with \( k = 7 \quad \lambda = 1005.22 \text{ nm} \); with \( k = 8 \quad \lambda = 954.86 \text{ nm} \);

b) The observed spectral lines have been Doppler shifted. It might appear as if the wavelengths have been blueshifted since the largest observed wavelength is smaller than the largest expected wavelength using the Paschen series. However, it is more likely that the wavelengths have been redshifted and the calculated wavelength just below 1000 nm in part a) corresponds to the observed wavelength of 1046.1 nm.

c) Using the formula from problem 14 and noting from part b) that the star is receding from the detector
\[
\beta = \frac{\left( \lambda_{\text{observed}} \right)^2}{\left( \lambda_{\text{source}} \right)^2} - 1 = \frac{(1334.5 \text{ nm})^2}{(1282.17 \text{ nm})^2} - 1 = 0.040 \quad \text{or} \quad v = 1.20 \times 10^7 \text{ m/s}.
\]
17. a) \( \lambda_{\text{max}} = \frac{2.898 \times 10^{-3} \text{ m} \cdot \text{K}}{4.2 \text{ K}} = 0.69 \text{ mm} \)

b) \( \lambda_{\text{max}} = \frac{2.898 \times 10^{-3} \text{ m} \cdot \text{K}}{293 \text{ K}} = 9.89 \mu\text{m} \)

c) \( \lambda_{\text{max}} = \frac{2.898 \times 10^{-3} \text{ m} \cdot \text{K}}{2500 \text{ K}} = 1.16 \mu\text{m} \)
33. a) 

energy per photon = \( hf = (6.626 \times 10^{-34} \text{ J} \cdot \text{s}) \times (1100 \times 10^3 \text{ s}^{-1}) = 7.29 \times 10^{-28} \text{ J} \)

\[
(150 \text{ J/s}) \frac{1 \text{ photon}}{7.29 \times 10^{-28} \text{ J}} = 2.06 \times 10^{29} \text{ photons/s}
\]

b) 

energy per photon = \( \frac{hc}{\lambda} = (6.626 \times 10^{-34} \text{ J} \cdot \text{s}) \times \left( \frac{3.00 \times 10^8 \text{ m/s}}{8 \times 10^{-9} \text{ m}} \right) = 2.48 \times 10^{-17} \text{ J} \)

\[
(150 \text{ J/s}) \frac{1 \text{ photon}}{2.48 \times 10^{-17} \text{ J}} = 6.05 \times 10^{18} \text{ photons/s}
\]

c) 

\[
(150 \text{ J/s}) \frac{1 \text{ photon}}{4 \text{ MeV}} \frac{1 \text{ MeV}}{1.60 \times 10^{-13} \text{ J}} = 2.34 \times 10^{14} \text{ photons/s}
\]