Constants and conversions that may or may not be helpful:

- Boltzmann constant: k $= 1.38 \times 10^{-16}$ erg K^{-1}
- 1 Joule (J) $= 10^7$ erg
- sound speed: $c_s = \sqrt{\frac{\gamma P}{\rho}}$; $\gamma = \frac{5}{3}$
- ideal gas law: $P = nkT = \frac{\rho kT}{m_u \mu}$

1. **2 points:** In one or two sentences, explain qualitatively what the scale height is.

   Answer: The scale height is the distance over which a quantity decreases by a factor of $1/e$.

   (*1 point for something about a quantity changing over a distance, 1 point for knowing the dropoff is exponential.*)

2. **3 points:** § 2.1 gives the pressure scale height as $H_P = c^2/(\gamma g)$. Show that this is equal to $H = kT/m_u g$.

   Answer: Using the sound speed $c_s = \sqrt{\frac{\gamma P}{p}}$,

$$\begin{aligned} H &= \frac{c_s^2}{\gamma g} \\ &= \frac{(\gamma P/\rho)}{\gamma g} \\ &= \frac{P}{\rho g} \\ &= \frac{\rho kT}{m_u \rho g} \\ &= \frac{kT}{m_u g} \end{aligned}$$

   (*2 points for using correct equations (if math errors led to wrong expression), 1 more for deriving correct expression.*)

3. **5 points:** Use the expression given for scale height ($H_P = c^2/(\gamma P)$) and the values given at the bottom of the second column of page 2, calculate the scale height at the photosphere (the visible surface of the sun). Does the number make sense? Why or why not?

   Answer: c is given as 7.2 km s^{-1}, and g can be calculated from the equation for gravitational force:

$$
\begin{aligned}
mg &= \frac{GMm}{r^2} \\
g &= \frac{GM}{r^2} \\
&= \frac{GM_\odot}{R_\odot^2} \\
&= \frac{(6.96 \times 10^{-8})(2 \times 10^{33})}{(6.96e10)^2} \\
&= \sim 10^7 \text{cm} \\
&= 100\text{km}
\end{aligned}
$$