33. (a) Letting $v(r) = Hr \leq v_e = \sqrt{2GM/r}$, we get $M/r^3 \geq H^2/2G$. Thus,

$$\rho = \frac{M}{4\pi r^3/3} = \frac{3}{4\pi}\frac{M}{r^3} \geq \frac{3H^2}{8\pi G} \ .$$

(b) The density being expressed in H-atoms/m^3 is equivalent to expressing it in terms of $\rho_0 = m_{\rm H}/\text{m}^3 = 1.67 \times 10^{-27}\,\text{kg/m}^3$. Thus,

$$\begin{aligned} \rho &= \frac{3H^2}{8\pi G\rho_0}\left(\text{H atoms/m}^3\right) = \frac{3(0.0193\,\text{m/s}\cdot\text{ly})^2(1.00\,\text{ly}/9.460\times10^{15}\,\text{m})^2(\text{H atoms/m}^3)}{8\pi(6.67\times10^{-11}\,\text{m}^3/\text{kg}\cdot\text{s}^2)(1.67\times10^{-27}\,\text{kg/m}^3)} \\ &= 4.5\ \text{H atoms/m}^3 \ . \end{aligned}$$