

24. We can express the ideal gas law in terms of density using $n = M_{\text{sam}}/M$:

$$pV = \frac{M_{\text{sam}}RT}{M} \implies \rho = \frac{pM}{RT} .$$

We can also use this to write the rms speed formula in terms of density:

$$v_{\text{rms}} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3(pM/\rho)}{M}} = \sqrt{\frac{3p}{\rho}} .$$

- (a) We convert to SI units: $\rho = 1.24 \times 10^{-2} \text{ kg/m}^3$ and $p = 1.01 \times 10^3 \text{ Pa}$. The rms speed is $\sqrt{3(1010)/0.0124} = 494 \text{ m/s}$.
- (b) We find M from $\rho = pM/RT$ with $T = 273 \text{ K}$.

$$M = \frac{\rho RT}{p} = \frac{(0.0124 \text{ kg/m}^3) (8.31 \frac{\text{J}}{\text{mol K}}) (273 \text{ K})}{1.01 \times 10^3 \text{ Pa}}$$

This yields $M = 0.028 \text{ kg/mol}$, which converts to 28 g/mol .