18.13. Solve: The average translational kinetic energy per molecule in a gas is

$$\varepsilon_{\text{avg}} = \frac{1}{2}mv_{\text{rms}}^2 = \frac{3}{2}k_{\text{B}}T \Rightarrow v_{\text{rms}} = \sqrt{\frac{3k_{\text{B}}T}{m}}$$

The mass of a helium molecule is

$$m = 4 \text{ u} = 4(1.66 \times 10^{-27} \text{ kg}) = 6.64 \times 10^{-27} \text{ kg}$$

$$\Rightarrow v_{\text{rms}} = \sqrt{\frac{3\left(1.38 \times 10^{-23} \text{ J / K}\right)(1273 \text{ K})}{6.64 \times 10^{-27} \text{ kg}}} = 2820 \text{ m / s}$$

For argon $m = 40$ u, so the root-means-square speed is

$$v_{\text{rms}} = \sqrt{\frac{3\left(1.38 \times 10^{-23} \text{ J / K}\right)(1273 \text{ K})}{40 \times 1.66 \times 10^{-27} \text{ kg}}} = 891 \text{ m / s}$$