41. (a) The root-mean-square speed is given by $v_{\text{rms}} = \sqrt{3RT/M}$. See Eq. 20–34. The molar mass of hydrogen is $2.02 \times 10^{-3}\,\text{kg/mol}$, so

$$v_{\text{rms}} = \sqrt{\frac{3(8.31\,\text{J/mol}\cdot\text{K})(4000\,\text{K})}{2.02 \times 10^{-3}\,\text{kg/mol}}} = 7.0 \times 10^3\,\text{m/s}\ .$$

(b) When the surfaces of the spheres that represent an H_2 molecule and an Ar atom are touching, the distance between their centers is the sum of their radii: $d = r_1 + r_2 = 0.5\times10^{-8}\,\text{cm} + 1.5\times10^{-8}\,\text{cm} = 2.0 \times 10^{-8}\,\text{cm}$.

(c) The argon atoms are essentially at rest so in time t the hydrogen atom collides with all the argon atoms in a cylinder of radius d and length vt, where v is its speed. That is, the number of collisions is $\pi d^2 vtN/V$, where N/V is the concentration of argon atoms. The number of collisions per unit time is

$$\frac{\pi d^2 vN}{V} = \pi(2.0 \times 10^{-10}\,\text{m})^2(7.0 \times 10^3\,\text{m/s})(4.0 \times 10^{25}\,\text{m}^{-3}) = 3.5 \times 10^{10}\,\text{collisions/s}\ .$$