1. Determine the ratios of (i) the mean speeds, (ii) the mean translational kinetic energies of H$_2$ molecules and Hg atoms at 20°C. (Ex. 1B.1(a)).
2. Use the Maxwell-Boltzmann distribution of speed to estimate the fraction of N$_2$ molecules at 400 K that have speeds in the range 200 to 210 m s$^{-1}$. (Hint: use numerical integration of the Maxwell-Boltzmann distribution function by calculating the area of a rectangle with the base of 210 – 200 = 10 m s$^{-1}$ and the height of $f(205$ m s$^{-1}$) in the middle of the range. (Ex. 1B.3(a)).
3. Assume that air consists of N$_2$ molecules with a collision diameter of 395 pm. Calculate (i) the root mean square speed and the mean speed of the molecules, (ii) the mean free path, (iii) the collision frequency in air at 1 atm and 25°C. (Ex. 1B.5(a)).
4. A sample of methane of mass 4.50 g occupies 12.7 L at 310 K. (a) Calculate the work done when the gas expands isothermally against a constant external pressure of 200 Torr until its volume has increased by 3.3 L. (b) Calculate the work that would be done if the same expansion occurred isothermally and reversibly. (Ex. 2A.6(a)).
5. A sample consisting of 1.00 mol of perfect gas atoms, for which $C_{V,m} = (3/2)R$, initially at $p_1 = 1.00$ atm and $T_1 = 300$ K, is heated reversibly to 400 K at constant volume. Calculate the final pressure, $\Delta U$, $q$ and $w$. (Ex. 2A.5(a)).
6. When 229 J of energy is supplied as heat to 3.00 mol Ar(g) at a constant volume, the temperature of the sample increases by 2.55 K. Calculate the molar heat capacities at constant volume and constant pressure of the gas. (Ex. 2B.1(a)).
7. A piece of zinc of mass 5.0 g is dropped into a beaker of dilute hydrochloric acid. Calculate the work done by the system as a result of the reaction. The atmospheric pressure is 1.1 atm and the temperature 23°C.
8. When 2.0 mol CO$_2$ is heated at a constant pressure of 1.25 atm, its temperature increases from 250 K to 277 K. Given that the molar heat capacity of CO$_2$ at constant pressure is 37.11 J K$^{-1}$ mol$^{-1}$, calculate $q$, $\Delta H$, and $\Delta U$. (Ex. 2B.3(b)).
9. Calculate the work done during the isothermal reversible expansion of a gas that satisfies the virial equation of state (you may cut the equation after the second term). Evaluate (a) the work for 1.0 mol Ar at 273 K (for data, see Table 1C.1 ‘Second virial coefficients’) and (b) the same amount of a perfect gas. In each case, the expansion is from 500 to 1000 cm$^3$. (Pr. 2A.3).