

Dynamics and Kinetics. Exercises 8

Problem 1

A vertical wall of a container is hit by 10^{23} molecules of nitrogen per second. Compute the force exerted on this wall if these molecules have an average perpendicular velocity of $450 \text{ m} \cdot \text{s}^{-1}$. Compute the pressure exerted on the wall if its area is 10 cm^2 .

Problem 2

The reaction $\text{H}_2 + \text{I}_2 \rightarrow 2\text{HI}$ depends on collisions between different species in the reactive mixture.

a) Compute the density of collisions between H_2 and H_2 , H_2 and I_2 , and between I_2 and I_2 for a mixture at 400 K if the partial pressures of I_2 and H_2 are both equal to $0,5 \text{ atm}$. Consider $\sigma(\text{H}_2) = 0,27 \text{ nm}^2$ and $\sigma(\text{I}_2) = 1,2 \text{ nm}^2$.

b) Compare the results of (a) with the rate constant $k = 8,3 \times 10^{-3} \text{ M}^{-1} \text{ s}^{-1}$ for the gas phase reaction of the first order with respect to each reactant.

Problem 3

In class, we have derived an expression for the collision flux z_{coll} , i.e. the number of gas molecules striking the surface of a container per unit time and unit area

$$z_{\text{coll}} = \sqrt{\frac{k_B T}{2\pi m}} \rho$$

where ρ the number density of the gas molecules, m their mass, and T the absolute temperature. In our derivation of this expression, we have considered a Maxwell-Boltzmann distribution of molecules striking a small surface element under any angle.

One can simplify this derivation if one realizes that the rate at which molecules impinge on the surface depends only on the distribution of the velocity component in the direction orthogonal to the surface.

Derive the collision flux z_{coll} using only the distribution of this component, not the complete Maxwell-Boltzmann distribution.