

Problem set

Q1

Which fraction of all gas molecules has a free path that is larger than

(a) the mean free path Λ

(b) 2Λ

Q2

Calculate the probability that N_2 -molecules in a gas at $T = 300\text{K}$ have velocities within the interval $900\text{ m/s} \leq v \leq 1000\text{ m/s}$. What is the total number of molecules with these velocities within this interval in a volume $V = 1\text{ m}^3$ at $T = 300\text{K}$ and $p = 10^5\text{ Pa}$?

Q3

What is the square root of mean square relative velocities between two gas molecules

(a) for a Maxwell distribution

(b) if the magnitude of all velocities are equal but directions are uniformly distributed

Q4

The mean free path Λ in a gas at $p = 10^5\text{ Pa}$ and $T = 20^\circ\text{C}$ is for argon atoms $\Lambda_{\text{Ar}} = 1 \cdot 10^{-7}\text{ m}$ and for N_2 molecules $\Lambda_{N_2} = 2.7 \times 10^{-7}\text{ m}$

(a) What are the collision cross sections σ_{Ar} and σ_{N_2} ?

(b) How large are the mean times between two successive collisions?

Q5 In a container there is 0.1 kg Helium at $p = 10^5 \text{ Pa}$ and $T = 300 \text{ K}$. Calculate

- The number of He-atoms
- The mean free path λ
- The sum $\sum s_i$ of all path lengths s_i , which is passed by all molecules in 1s. Give this sum in units m and light years.

Q6 The rotating disc of a velocity selector with a slit allows N_2 molecules with a Maxwellian distribution at $T = 500 \text{ K}$ to pass for a time interval $\Delta t = 10^{-3} \text{ s}$. A detector at a 1m distance from the disc measures the time distribution of all molecules. What is the half width of this distribution?

Q7 In the centre of the sun the density of protons and electrons is estimated as $n = 5 \cdot 10^{29} / \text{m}^3$ at temperature $1.5 \cdot 10^7 \text{ K}$

- What is the mean K.E of electrons and protons. Compare this with ionization energy of H_2 atom (13.6 eV)
- What are the mean velocities
- How large is the pressure.