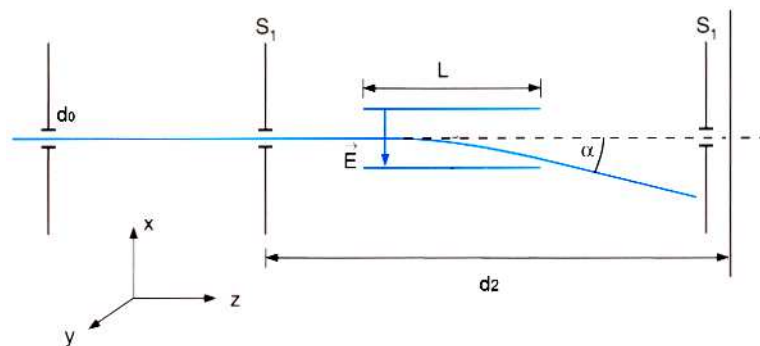


Homework 1 – PHYS626

- 1) In 1m^3 of air there are $2.6 \cdot 10^{25}$ molecules under normal conditions ($p=101,325\text{ Pa}=1\text{ATM}$ and $T=273\text{K}=0\text{C}$). How large is:
 - a. The mean distance between two molecules ?
 - b. The spatial filling factor $\eta = V_{\text{molecule}}/m^3$ when the molecules are described by spheres with a radius $R=0.1\text{nm}$?
 - c. The mean free path length Λ ?
- 2) How many atoms are in :
 - a. 1 g of ^{12}C ?
 - b. 1 cm^3 of helium at a pressure $p = 10^5\text{ Pa}$ and $T=273\text{K}$?
 - c. 1 kg of nitrogen (N_2) gas ?
 - d. In a steel bottle with 10 dm^3 volume of H_2 gas at $p=10^6\text{ Pa}$?
- 3) A particles with $E_{\text{kinetic}} = 5\text{ MeV}$ are scattered by gold atoms in a thin foil ($d = 5 \cdot 10^{-6}\text{m}$, $\rho = 19.3\text{ g/cm}^3$, $M = 197\text{ g/mole}$).
 - a. What is the impact parameter b for particles with a scattering angle $\theta=90$ degrees?
 - b. What is the value of r_{min} for backward scattering at $\theta=180$ degrees ?
- 4) A beam of Cs-atoms with a velocity of $v=300\text{ m/s}$ is emitted into a vacuum through an orifice with a diameter $d_0 = 40\mu\text{m}$. The beam is collimated by a slit S_1 200 cm downstream of the orifice. There is a screen and a second slit S_2 ($d_2 = 200\text{ cm}$) downstream of S_1 .
 - a. Calculate the vertical deflection of the beam from horizontal at the screen/ S_2 caused by gravity.
 - b. The region between S_1 and S_2 is filled by an electric field region 200 cm long. What is the deflection of the atoms if they have a charge q and the electric field is $5 \cdot 10^6\text{ V/m}$.
 - c. If a change in the beam flux $d\dot{N}=10^{-4}\dot{N}$ can be measured when the electric field is flipped (i.e. changed in direction), estimate the accuracy limit for the determination of q , i.e. what is the smallest value of q that may be detected ?



- 5) Derive a_0 from the Rydberg Formula and classical mechanics only for the hydrogen atom.