Problem 1

A hydrogen atom in the ground state, moving with velocity v, collides with another hydrogen atom in the ground state at rest. Using the Bohr model find the smallest velocity v_0 of the atom below which the collision must be elastic.

At velocity v_0 the collision may be inelastic and the colliding atoms may emit electromagnetic radiation. Estimate the difference of frequencies of the radiation emitted in the direction of the initial velocity of the hydrogen atom and in the opposite direction as a fraction (expressed in percents) of their arithmetic mean value.

Data:

$$E_i = \frac{me^4}{2\hbar^2} = 13.6\,\text{eV} = 2.18 \cdot 18^{-18}\ \text{J; (ionization energy of hydrogen atom)}$$

$$m_H = 1.67 \cdot 10^{-27}\ \text{kg; (mass of hydrogen atom)}$$

(m - mass of electron; e - electric charge of electron; $\hbar$ - Planck constant; numerical values of these quantities are not necessary.)