Hint 2

IMPORTANT! The next task is both a hint and an alternative to the main task. Three important points:

1. You can continue to send the solution to the main problem.
2. At any moment before the final deadline you can start to solve the Alternative problem. If you do so, at the beginning of the solution write: *I am doing the Alternative problem!* In this case a penalty coefficient for the Alternative problem is

$$0{,}7 \cdot \sum_i \frac{k_i \cdot p_i}{10},$$

where p_i is a point for the problem item, and k_i is a penalty coefficient for the corresponding problem's item at the moment of moving to the Alternative problem. In other words, maximal points for the alternative problem equals to the maximal points you can gain at the moment of moving to the alternative one multiplied by 0,7. Also, we remind you that a penalty coefficient can't be less than 0,1. Solutions of the main problems from that moment will not be checked. Be careful!

3. The task consists of several items. The penalty multiplier earned by **before** is applied to all points. In the future, each item is evaluated as a separate task. If you send a solution without any item, this item's solution is considered as Incorrect. For more information about scoring points for composite tasks, see the rules of the Cup.

Alternative problem

1. *(3 points)* The rocket moves due to the jet force arising from the release of gas heated to a very high temperature. In the combustion chamber of the rocket (at the entrance to the nozzle) hot gas of high pressure p_1 and temperature T_1 is constantly generated. Having passed through the nozzle the gas flies out through a narrow hole into the atmosphere, where the pressure is p2. The molar mass of the gas is μ. Consider the process of gas flow in the nozzle as equilibrium and adiabatic. Find the gas temperature and the flow rate of the gas at the outlet of the nozzle.
2. (2 points) 1 mol of van der Waals gas is in equilibrium at pressure p_1 and volume V_1. In a quasistatic process, its pressure was increased by 1%, while the volume decreased by 3%. How much will the temperature of the gas change? Find this change up to the linear terms of a and b. **Note.** Here and later consider constants a and b in the Van der Waals equation as known.

3. For an ideal gas, it is correct that the product $pV = \text{const}$ with a constant temperature value. Let's analyze how this product behaves with a constant temperature T of a real gas when its density is changing.

   a. *(0 points)* Find dependency of the product pV on the density of a real (Van der Waals) gas.

   b. *(2 points)* Find the value of the gas density at which the minimum of the product pV is reached.

   c. *(1 point)* Find the value of temperature T at which the minimum of the product pV is reached with a zero value of the gas density.

4. *(2 points)* Solve the problem similar to the previous one for the gas obeying the Dieterici equation. The equation of state for such gas has the form:

$$p(V-b) = RT\exp\left(-\frac{a}{RTV}\right).$$

   Note. 2 points are given for task c.