Question 2.

A vertical glass tube of cross section $S = 1.0\ cm^2$ contains unknown amount of hydrogen. The upper end of the tube is closed. The other end is opened and is immersed in a pan filled with mercury. The tube and the pan are placed in a sealed chamber containing air at temperature $T_0 = 273$ K and pressure $P_0 = 1.334\times10^5$ Pa. Under these conditions the height of mercury column in the tube above the mercury level in the pan is $h_0 = 0.70$ m.

One of the walls of the chamber is a piston, which expands the air isothermally to a pressure of $P_1 = 8.00\times10^4$ Pa. As a result the height of the mercury column in the tube decreases to $h_1 = 0.40$ m. Then the chamber is heated up at a constant volume to some temperature T_2 until the mercury column rises to $h_2 = 0.50$ m. Finally, the air in the chamber is expanded at constant pressure and the mercury level in the tube settles at $h_3 = 0.45$ m above the mercury level in the pan.

Provided that the system is in mechanical and thermal equilibrium during all the processes calculate the mass m of the hydrogen, the intermediate temperature T_2, and the pressure P in the final state.

The density of mercury at temperature T_0 is $\rho_0 = 1.36\times10^4\ kg/m^3$, the coefficient of expansion for mercury $\beta = 1.84\times10^{-4}\ K^{-1}$, and the gas constant $R = 8.314$ J/(mol×K). The thermal expansion of the glass tube and the variations of the mercury level in the pan are not considered.

Hint. If ΔT is the interval of temperature variations of the system then $\beta\Delta T = x << 1$ In that case you can use the approximation: $\frac{1}{1+x} \approx 1 - x$