8. Air in a submarine (6 points) — *Johan Runeson, Jaan Kalda.*

A submarine of unknown nationality is travelling near the bottom of the Baltic sea, at the depth of $h = 300\,\mathrm{m}$. Its interior is one big room of volume $V = 10\,\mathrm{m}^3$ filled with air ($M = 29\,\mathrm{g/mol}$) at pressure $p_0 = 100\,\mathrm{kPa}$ and temperature $t_0 = 20\,^\circ\mathrm{C}$. Suddenly it hits a rock and a large hole of area $A = 20\,\mathrm{cm}^2$ is formed at the bottom of the submarine. As a result, the submarine sinks to the bottom and most of it is filled fast with water, leaving a bubble of air at increased pressure (no air escapes the submarine). The density of water $\rho = 1000\,\mathrm{kg/m}^3$ and free fall acceleration $g = 9.81\,\mathrm{m/s}^2$. Molar heat capacitance of air by constant volume $c_V = \frac{5}{2}R$, where $R = 8.31\,\mathrm{J/Kmol}$ is the gas constant.

i) *(2 points)* What is the volume rate (m^3/s) at which the water flows into the submarine immediately after the formation of the hole?

ii) *(2 points)* The flow rate is so large that the submarine is filled with water so fast that the heat exchange between the gas and the water can be neglected (this applies also to the next question). What is the volume of the air bubble once water flow has stopped?

iii) *(2 points)* The water stream rushing into the submarine creates turbulent water inside the submarine; what is the total kinetic energy of this water turbulence (which later ends up being dissipated as heat), once the inflow has stopped due to equalized pressures?