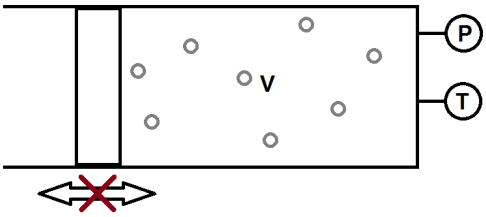
Challenge 2, Thermodynamics

Submission date: 8. November

Under pressure *(16 points)*



A cylinder with initial volume $V = 2\,\mathrm{L}$ is filled with nitrogen. The cylinder is hermetically sealed by a piston. In the first part of the task, the piston is blocked, the gas is heated to different temperatures and the pressure is measured for each temperature. The results of the measurements are shown in the following table.

#	T(°C)	P(Pa)
1	10	168100
2	20	174000
3	50	191800
4	100	221500
5	150	251200
6	250	310600

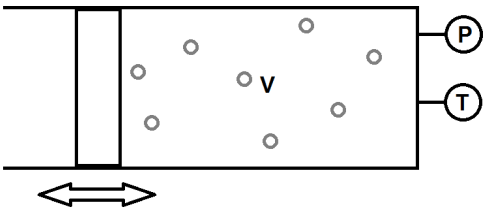
Part A. Determination of the mass *(5 points)*

i. (2 pt.) Draw a graph of the pressure as a function of temperature in the cylinder.

ii. (3 pt.) What is the mass of the nitrogen in the cylinder?

Part B. Equilibrium *(2 points)*

Now the piston can move parallel to the cylinder axis, but it will never leave the cylinder. The heat transfer between the gas and the environment can be neglected, unless otherwise stated.



i. (2 pt.) If the temperature of the gas is 23 °C, how big is the volume of the gas in the cylinder?

Part C. We dive *(9 points)*

A diver brings the cylinder under water, $h = 7\,\mathrm{m}$ below the water surface. The temperature would still be 23 °C and the piston can still move freely.

Constants:

- density of water: $\rho_w = 1.0\,\mathrm{gcm}^{-3}$
- Heat capacity of nitrogen: $c_s = 1.04\,\mathrm{kJkg}^{-1}\mathrm{K}^{-1}$

i. (2 pt.) What volume does the gas occupy if the temperature remains unchanged?

ii. (3 pt.) The cylinder is left under water. What amount of heat must be added to the gas so that its volume becomes 2 L?

iii. (4 pt.) What must be the mass of the cylinder (as a function of the temperature of the gas) so that the cylinder remains in equilibrium at the same depth? (i.e., it neither rises back to the surface nor sinks to the bottom.) The mass of the piston will be neglected. The volume of the piston and cylinder together can also be neglected compared to the volume of the gas.